FARMING IN THE 21ST CENTURY

by

Michael D. Boehlje, Steven L. Hofing

and R. Christopher Schroeder

Staff Paper # 99-9

August 31, 1999

Department of Agricultural Economics

Purdue University

FARMING IN THE 21ST CENTURY

by
Michael D. Boehlje*, Steven L. Hofing** and R. Christopher Schroeder**

Preface

The U.S. agricultural industry is in the midst of major structural change — changes in product characteristics, in worldwide production and consumption, in technology, in size of operation, in geographic location. And the pace of change seems to be increasing. Production is changing from an industry dominated by family-based, small-scale, relatively independent firms to one of larger firms that are more tightly aligned across the production and distribution chain. And the input supply and product processing sectors are becoming more consolidated, more concentrated, more integrated.

Agriculture in the 21st century is likely to be characterized by: 1) adoption of manufacturing processes in production as well as processing, 2) a systems or food supply chain approach to production and distribution, 3) negotiated coordination replacing market coordination of the system, 4) a more important role for information, knowledge and other soft assets (in contrast to hard assets of machinery, equipment, facilities) in reducing cost and increasing responsiveness, and 5) increasing consolidation at all levels raising issues of market power and control.

These profound changes in the agricultural industry present new challenges and new opportunities that require new ideas and concepts to analyze and implement. They require new learning and thinking. Some of those new ideas and concepts are presented here, not as empirically verified truths, but as "thoughts" to stimulate different and better thinking. They have been developed based on observations, analysis and discussions with numerous managers and colleagues in agribusinesses in North America and Europe. This series focuses on Farming in the 21st Century; companion series are also available on Financing and Supplying Inputs to the 21st Century Producer (Staff Paper 99-11), and Value Chains in the Food Production and Distribution Industries (Staff Paper 99-10).

Our purpose in sharing these "thoughts" is to invite discussion, dialogue, disagreement — in general to encourage others to develop better "thoughts".

Keywords: qualified supplier, biological manufacturing, strategic risk, process control, economies of size, franchise grower

*Professor of Agribusiness, Center for Agricultural Business, Purdue University, West Lafayette, IN 47907-1145 and Senior Associate, Ag Education & Consulting, LLC; boehlje@agecon.purdue.edu

** Partners, Ag Education & Consulting, LLC, Savoy, IL 61874, www.centrec.com

Table of Contents

Farming in the Future

Production agriculture is destined to face dramatic changes in the future based on both the globalization of the economic climate and changes in the consumer or end-user of agricultural products. The new agriculture will be characterized by:

1. Global competition
2. Industrialization
3. Differentiated products
4. Precision (information intensive) production
5. Supply chains

More Global Competition

Globalization and internationalization are not new to agriculture — since the 1970's farmers incomes have been heavily dependent on their success in selling products in international markets. More recently the development of agreements such as GATT and NAFTA have been the focal point of much of the globalization discussion with the emphasis on broader access to world markets and expanding exports of agricultural commodities and particularly further processed agricultural and food products.

Expanded market access is not an unimportant dimension of the future of global markets and international trade, but the most important dimension of more open trade is the international transfer of and global access to technology and research and development. Most of the private sector technology transfer and R&D activity has focused on U.S. and Western Europe in the past. Today these are relatively mature markets in terms of acreage growth and expansion of livestock production capacity. Growth opportunities are likely greater outside these regions (i.e. Canada, Mexico, South America, Eastern Europe, Asia, etc.), and with the opportunities for global-oriented companies to expand their markets in these areas, one would expect substantial expansion in the technology transfer and R&D activity of these companies specifically focused on geographic regions outside the U.S. and Western Europe. The longer-run consequences are a narrowing of the gap between the productivity in these parts of the world and that of the traditional dominant production regions, as well as an increase in worldwide production capacity. This increased efficiency, productivity and capacity in other production areas along with the worldwide sourcing and selling strategies of global food companies means that the U.S. and Europe will not be as dominant players and will face increased competition in world markets in the future.

Expansion of Industrialized Agriculture

The current movement toward industrialized production units in the U.S. is nearly complete for some livestock species, but lagging for others. The poultry industry moved to an industrialized model from the 1940s through the 1960s. Cattle feeding moved to the industrialized model in the 1960s and 1970s. The dairy and pork industries are in the midst of a dramatic movement to the industrial model, with the current transition largely to be completed by 2010. The brood cow industry continues to be much less affected by industrialization, as technologies have yet to be found that can greatly increase the productivity of the brood cow through confinement and intensive management. Specialty crops have or are rapidly adopting industrialized production systems. The grain industry is moving more slowly to this type of agriculture, but even segments of the commodity markets are increasingly adopting a biological manufacturing approach.

Industrialization of production means the movement to large scale production units, that use standardized technology and management and are linked to the processor by either formal or informal arrangements. Size and standardization are important characteristics in lowering production costs and in producing more uniform crop products and animals that fit processor specifications and meet consumers' needs for specific product attributes, as well as food safety concerns. Smaller operations not associated with an industrialized system will have increasing difficulty gaining the economies of size and the access to technology required to be competitive, except perhaps in niche markets. Smaller operations can however remain in production for a number of years since they may have facilities that have low debt and are able to utilize family labor. Technological advances combined with continued pressures to control costs and improve quality are expected to provide incentives for further industrialization of agriculture.

Development of Differentiated Products

The transformation of crop and livestock production from commodity to differentiated product industries will be driven by consumers' desire for highly differentiated food products; their demands for food safety and trace-back ability; from continued advances in technology; and from the need to minimize total costs of production, processing, and distribution. Food systems will attempt to differentiate themselves and their products by science and/or through marketing. Ways to differentiate through science include gaining exclusive rights to genetics through patentable biotechnology discoveries; by exclusive technology in processing systems; and by superior food safety integrity. Marketing may include: branding, advertising, packaging, food safety, product quality, product attributes, bundling with other food products for holistic nutritional packages, and presentation of products in non-traditional formats.

In the grain industries, high oil corn acreage has been growing rapidly, and new crops such as high oil corn and soybeans, high protein wheat, and specific amino acid composition soybeans are expanding. In pork, differentiation on lean content is increasingly common. In the future at least two types of pork sire lines will be developed for different markets. One sire line will be selected to produce extremely lean and efficient pigs, with an objective of least-cost for reasonably acceptable lean pork. Other lines destined for export and restaurant markets will be selected for high pork quality. These lines will be darker in color and contain approximately 3 percent intramuscular fat.

Precision (Information Intensive) Production

The management of production is expected to trend toward more micro management of each specific production site, specific room, and possibly even specific acres or animals. The shift will be driven by the influx of information about the environmental and biological factors that affect production. The motivation will be to minimize costs and enhance product quality.

Increased used of monitoring technology will greatly expand the amount of information available regarding what affects plant and animal growth and well-being. This will be made possible by innovations in sensors to use in individual monitoring and control systems. In addition, greater understanding of how various growth and environmental factors interact to affect biological performance will be forthcoming. This understanding will then be designed into management systems which incorporate the optimum combinations and apply them at a micro or localized level.

Precision farming in crop production includes the use of global positioning systems (GPS), yield monitors and variable rate application technology to more precisely apply crop inputs to enhance growth, lower cost and reduce environmental degradation. Examples in animal production include medication treatment by animal rather than by the entire group or the herd; nutritional feeding to the specific genetics, sex, age, health, and consumer market for the individual animal; and continuous adjustment of the ambient environment, including such factors as temperature, humidity, air movement, and dust and gas levels within buildings, to maximize economic returns.

Nutrition management is expected to more closely match the nutrient supply with the needs of individual animals. This will include the matching of specific grains with individual species and perhaps specific genetics, body conformation, gender, phase of life cycle, or even the end-use for the animal. Greater emphasis also will be placed on nutrition to minimize odor and nutrient levels in manure rather than on traditional economic factors such as feed efficiency and rate of gain. For example, phase and split-sex feeding in pork production can reduce total costs of pork production by 4-6 percent. An additional benefit to phase feeding is a 15-percent reduction in nitrogen and phosphorous excretion.

Buildings and equipment will continue to move toward larger scale to fit the industrialized model. Inside the buildings, expect enhancement of monitoring and control systems to help detect gases, temperature, humidity, and disease organisms that could adversely impact the economic performance of animals, and correct problems when they reach critical thresholds. Further advancements can be expected in cleaning systems to maintain higher sanitation, improve conditions for workers and in animal handling systems to reduce injury to animals in movement and marketing.

Formation of Food Supply Chains

Much of U.S. plant and animal agriculture will be a part of industrialized food systems by the year 2020. Industrialized food systems are those which are holistic in production processing marketing, and organized to deliver specific-attribute consumer products by development of optimized delivery systems or through differentiation by science or branding.

An increasing emphasis will be placed on managing and optimizing supply chains from genetics to end-user/consumer. This supply chain approach will improve efficiency through better flow scheduling and resource utilization, increase the ability to manage and control quality throughout the chain, reduce the risk associated with food safety and contamination, and increase the ability of the crop and livestock industries to quickly respond to changes in consumer demand for food attributes.

Food safety is a major driver in the formation of chains. One way to manage food safety risk is to monitor the production/distribution process all the way from final product back through the chain to genetics. A trace-back system combined with HACCP (Hazard Analysis Critical Control Points) quality assurance procedures facilitates control of the system to minimize the chances of a food contaminant, or to quickly and easily identify the sources of contamination.

A supply chain approach will increase the interdependence between the various stages in the food chain; it will encourage strategic alliances, networks, and other linkages to improve logistics, product flow, and information flow. Some have argued that in the not-too-distant future, competition will not occur in the form of individual firms competing with each other for market share, but in the form of supply chains competing for their share of the consumers' food expenditures.

The “New” Agriculture*

During the last two decades, dramatic changes have occurred in the agricultural sector: changes in technology, in the economic climate, in institutional structure, and ways of doing business. This “new” agriculture requires a significant change and new concepts to successfully mange the farm and agribusiness firm, and to formulate agricultural policy. My purpose here is to briefly describe some of the changes and the concepts that will be useful in this new agricultural environment.

I try to capture, in just a few words, the essence of these changes from the old to the new agriculture, and how they influence the way we think about farm and agribusiness management and agricultural policy. Some of these changes have occurred only in recent times; others are continuations of trends started years or even decades ago. In some cases the new concept doesn’t replace the old concept, but is an addition or extension of the concept. Readers may disagree with the magnitude and/or significance of these changes; they are presented not as empirical fact but as informed observations.

---

*Adapted from Boehlje, Michael. “The “New” Agriculture”, *Choices*, pp. 34-35, Fourth Quarter, 1995.

Management of farm and agribusiness firms

Changes in the characteristics of production agriculture and the economic climate for farm and agribusiness firms, combined with new concepts of management and strategic thinking, have changed the management of successful farms and agribusinesses. These changes include the following.

Old Concept	New Concept
Commodities	Specific attribute/differentiated raw materials
Staple products	Fashion/niche products/projects
Assets drive the business	Customer drives the business
Hard assets (land, machinery, buildings) are the prime source of strategic competitive advantage	Soft assets (people, organization, plans) are the prime source of strategic competitive advantage
Blending of commodity product from multiple sources	Separation of identity-preserved raw materials
Geographically concentrated production sites	Geographically dispersed/separated production sites
Owning Assets	Control of assets
Money/finance/assets are the prime source of power and control	Information is the prime source of power and control
Labor is a cost and equipment an investment	Labor is an investment and equipment a cost
Sell product and give away service	Sell service and give away product
Expanding and getting into the business (entry)	Contracting and getting out of the business (exiting)
Impersonal/open markets	Personal/negotiated/closed markets
Adversarial relationship with suppliers and purchasers	Partner with suppliers and purchasers
Impersonal sourcing and selling	Relationship sourcing and selling
Outsourcing (buying) from multiple sources	Single site sourcing
Insourcing (produce your own) inputs	Outsourcing (buy from someone else) inputs
Price premiums for specific attributes and volume purchases	Cost reductions for specific attributes and guaranteed markets
Market (price) risk	Relationship risk
Independence	Inter-dependence/systems
Stability	Change/chaos/flexibility
Agriculture is an art form	Agriculture is primarily science based
Technical skills critical to success	Human/personal/communication skills critical to success
Technological change and innovation	Institutional (ways of doing business) change and innovation
Core competencies	New/different/unique skills and capabilities
Tradition/remembering	New ideas/forgetting
Public/open information and research and development	Private/proprietary/closed information and research and development
Resource users and exploiters	Resource protectors
Produce goods and dispose of bads/by-products	Produce goods and bads; utilize/recycle bads/by-products

Agricultural Policy

In the agricultural policy debate/discussion, many of the changes are more in perception than in reality. But in the policy arena, perception is often as important (maybe more important) as reality. Changes often important to agricultural policy discussions include the following.

Old Concept	New Concept
Agriculture is farming	Agriculture is the food production and distribution system
Family farming and a small business	Industrialized/corporate agriculture
Unstable supply (primarily domestic)	More stable supply (world-wide production)
Unstable domestic demand	Unstable foreign demand
U.S. is prime world supplier (only store in town)	Many suppliers world-wide
Domestic markets are prime markets	Foreign and industrial markets are critical markets
Raising commodities	Manufacturing food products
Consumers fear high food costs and food shortages	Food costs are decreasing part of the consumers budget and world-wide sourcing reduces the prospects of shortage
Consumers believe their food is safe	Consumers question the safety of their food
Significant political influence	Limited political influence
Adequate budget funds for agriculture	Budget deficits and reduced funding for agriculture
Farmers are economically disadvantaged	Farmers have comparable income to others
Farm income measures economic well-being	Farm household income measures economic well-being
Farm program payments are an entitlement	Program payments are conditional and should meet "needs" tests
Operating farmers own most of the farm land	41% of the farmland owned by non-operators
The public trust/believe in farmers as stewards of resources	The public questions farmers as stewards of resources
Conservation of resources to maintain/increase productivity	Environmentally sound use of resources to reduce pollution
Efficiency	Ecology
Private property rights are sacred	Society is reserving more property rights for the public and reducing private property rights
Farming is a healthy/safe lifestyle	Farming is a hazardous occupation
Farmers have higher moral standards, a strong work ethic and generally higher values	Farmers are no different in terms of values, work ethic or moral standards than the rest of society
Economic well-being of rural communities depends upon farming	Economic well-being of rural communities depends more on non-farm activity
Rural areas have a higher quality of life compared to urban areas	Rural areas have a lower or at best the same quality of life as urban areas

So What!

The agricultural sector is changing rapidly and significantly, both in reality and in perception. These changes will have a profound impact on the successful strategy in managing a farm or agribusiness firm and the future shape of agricultural policy. We have attempted to capture the essence of these changes to stimulate discussion and dialogue (or even disagreement) about implications for management and policy. Let the discussions begin!

The Agriculture of 2020: Biological Manufacturing

The agricultural industry, particularly the livestock sectors, is in a period of major change and transition. This transition is commonly referred to as the industrialization of agriculture — the application of modern industrial manufacturing, production, procurement, distribution, and coordination concepts to the food and industrial product chain. What will this industrialized sector characterized by biological manufacturing look like in the year 2020?

Production agriculture today consists of a very diverse set of types and sizes of farm businesses including part-time and full-time farmers. Part-time farming will still persist in the future and some farms for local markets and specialty crops will be only of modest size. But most of the agricultural output will be produced by larger scale businesses producing as qualified suppliers to food processors and manufacturers. Many farms will be multi-plant operations that are geographically dispersed, networked alliances of individual farm units, or systems of franchise production tied to a processor not unlike franchised operations in other industries. Some farmers will remain as independent producers (particularly in commodity production); others will be plant managers or contractors in a tightly vertically aligned or owned system.

Biological manufacturing will be characterized by:

1. Industrialization production which uses modern business principles and manufacturing approaches including procurement, inventory management and process control techniques. This will transform farming from a rural lifestyle to a business in many situations.
2. Precision production which uses science and technology to "real time monitor" the production processes and exercise control over those processes through biotechnology and nutritional technology. Farmers will adopt technology and management practices to standardize, routinize, and generally manipulate and control the biological processes of crop and livestock production.
3. Differentiated products which have transformed farming from an industry that produces commodities (i.e., #2 yellow corn) to one that manufacturers raw materials with specific attributes (high oil corn or specific amino acid composition soybeans). This will also require segregation and identify preservation in the marketing and distribution systems.
4. Supply chains which are tight alliances and linkages in the value chain from input suppliers through producers to processors and retailers. This movement to tightly aligned value or supply chains will result in better quality control, improved product flow scheduling, and stronger qualified supplier arrangements throughout the chain.

This type of production agriculture will develop under a policy environment of limited government intervention and relatively open markets domestically and globally. Farmers generally will not receive significant amounts of government assistance. Because production agriculture looks much like other industries, the regulations that farmers face in terms of the environment, worker safety, etc. will be similar to that of other industries. Policy with respect to market access, anti-trust and commercial transactions will also be similar for the farm and manufacturing sectors; the result will be more consolidation and concentration in the food and other industries.

Concepts of Biological Manufacturing in Production Agriculture

The transition of agriculture from a commodity industry to one with differentiated products, combined with a focus on the end-user and a manufacturing approach to production, is a dramatic paradigm shift in the industry. The produce-and-then-sell mentality of the commodity business is being replaced by the strategy of first asking what end-users want, and then creating or manufacturing those attributes in the raw material. This may require changes in how the raw material is produced and what it doesn't contain (i.e. chemical residues) as well as what it does contain. This manufacturing mentality has become more predominant and has the potential to be increasingly successful as we learn more about the biological production process and have increased capacity to control and manipulate that process through genetics, fertility, equipment design, disease management programs, etc. What are some of the characteristics of this manufacturing mentality as applied to production agriculture?

Systemization and Routinization -- One of the characteristics of the manufacturing process is systemization and routinization. With increased understanding and ability to control the biological production process, routinization becomes increasingly possible. Tasks become more programmable. Routinization generally fosters more efficient use of both facilities and personnel as well as less managerial oversight and overhead. Hourly work schedules that identify specific tasks to be done at specific times on specific days is but one example. Precision crop farming is another example. In essence, agricultural production is becoming more a science and less an art.

Specialization -- An additional manufacturing mentality concept now being utilized in modern agricultural production systems is that of specialization, not only with respect to business venture and focus but also with respect to individual employee tasks or function. For example, an even larger proportion of the grain, swine, dairy, beef and poultry output is being produced by larger scale, specialized units rather than diversified farms. And within these units employees are becoming more specialized in their task or functions with some focusing on agronomic production skills, some on machinery operation and maintenance, some on marketing, etc. This specialization of function of personnel as well as business focus of the firm again is increasingly feasible because of better understanding and control of the biological process.

Scheduling and Utilization -- A further implication of the manufacturing paradigm in agricultural production is increased emphasis on facility utilization, flow scheduling, and process control. In the past, variability associated with the delays in adjustment of output to current and expected prices and inherent lags in the biological production processes have made facility use and scheduling and process control difficult if not impossible. Many production units have in essence maintained excess plant capacity as one means of accommodating the uncertainty of the output of the biological production process. Undoubtedly, rain fed crops will still be subject to weather variability, but increased knowledge of biological production should facilitate prediction as well as control of production processes. With increased ability to predict and control the biological production process, facility use can be more accurately scheduled, and process control concepts to improve efficiency and reduce cost are more applicable and useful than in the past.

Input Packages vs. Mix and Match Strategies -- With the increasing capacity to control and understand the biological process through biotechnology and genetic engineering techniques, producers will be more capable of developing optimal input combinations that match chemical and biological attributes to obtain the optimum quality and characteristics of output. For example, crop genetics are being matched to pesticides for optimal pest control as exemplified by Synchrony STS – a seed/herbicide system. In this situation, the classic mix and match strategy of the past where producers could buy chemicals from one firm and genetic material from a second may become less effective. In some cases the grower will purchase pre-specified input packages that are optimized in terms of their biological and chemical characteristics; in other cases the grower will be warned that certain plant nutrient and genetic inputs respond better when used together and their performance may be sub-optimal if used in other combinations. But this matched inputs strategy has risks -- the risk of reduced flexibility to adjust if supplies of an input decrease and/or prices increase.

Systems/Process Flow -- The manufacturing mentality places increasing emphasis on the entire production and distribution chain from raw materials supplier to end-user. This total system rather than stage or segment focus reduces the chances for sub-optimization within a stage or sector and inefficiency or losses because stages are not well matched in terms of product flow, product characteristics, quality, or other critical attributes. These losses can be particularly large in biological production processes where variation in many attributes is naturally wide because of variation in genetic and other inputs as well as growing conditions. Thus, there is the potential for a very high payoff if manufacturing processes can be used to reduce these losses in the system.

Purchasing Agent -- Part of the manufacturing mentality is a purchasing agent or specification buying approach to acquiring inputs or services. This approach involves the specification of input requirements and in many cases requesting alternative suppliers to bid for the business based on the contract specifications. This purchasing agent approach puts more emphasis on ability to fulfill contract specifications at a competitive price than the personal relationship based purchasing behavior of many of today's agricultural producers. Note that the relationship is not unimportant in a purchasing agent approach to acquiring inputs; instead the relationship is more explicitly defined in the context of meeting and enhancing the features and characteristics the buyer wants as reflected in the contract specifications.

System Cost Control -- Although cost control is critical in any production process, the manufacturing approach focused on end-user products recognizes total production and distribution systems cost as being more critical than the cost in each stage of the chain. As noted earlier, this approach has the potential to eliminate some of the significant inefficiencies in the chain. And as more resources are purchased from others, the cost structure of the business changes with a higher proportion of the cost being variable (i.e. costs change directly as a function of output) and a lower proportion fixed (i.e. do not vary with output). With this changing proportion of fixed and variable cost, each stage becomes more responsive to changing end-user demands and competitive pressures. In the short-run the costs that influence production adjustment decisions are variable costs -- the smaller proportion that variable costs are of total costs, the more prices must decline before firms reduce output. Consequently firms with a high proportion of fixed costs are slower to adjust to lower prices than they are to expand when prices increase. In essence, an industry in which more firms have a higher proportion of their total costs that are variable is more responsive to changing market conditions.

New Venture Expansions -- Much of the expansion of agriculture in the past can be described as that of incremental expansions -- producers would add an additional 40 acres to their 240 base acreage. But increasingly expansion is of the large-scale new venture variety. These new venture projects require substantial capital investments (often in excess of a million dollars) and frequently require significant labor and managerial resources as well to be successful. This new venture approach to production agriculture is a dramatic change in the way of doing business compared to the incremental expansions of the past.

Partnering/Alliances to Reduce Investment and Leverage Volume -- The traditional approach to agricultural production has been that of an independent producer who purchases inputs and sells products through various market mechanisms to other independent businessmen. Increasingly, producers are joining or partnering with other resource suppliers in various ways to expand volume with limited capital outlays. In crop production this is occurring through the growing use of contracting for machinery services, leasing of land, and custom farming. In essence, the grower is leveraging volume by investing his funds in only part of the total fixed assets needed to produce the crop while maintaining a high degree of control of the other phases through the ownership of the crop and the specification of the growing conditions. The critical dimension of such partnering or alliances is that more resources and services are obtained from others if that is a less expensive technique for acquiring production inputs, and more linkages along the chain to the food or industrial product end-user are used to capture value in additional stages of that chain.

Stage Coordination through Negotiation -- As noted earlier, production agriculture in the past has focused primarily on commodity products with coordination through impersonal spot markets. The increased specificity in raw material requirements combined with the potential for producing specific attributes in those raw materials is transforming part of the agricultural market to a differentiated product market rather than a commodity product market. This trend combined with the trend to geographic as well as ownership separation of the various stages of production suggests that personal negotiation is a more effective mechanism of systems coordination than impersonal spot markets. Increasingly, impersonal spot markets find it difficult to convey the full set of information about product attributes that characterize these differentiated products. Contract or ownership coordination will become more dominant in differentiated product markets with impersonal price coordination continuing to dominate the commodity markets.

Biological Manufacturing and Process Control

The transition of production agriculture from an industry that raises livestock and grows crops to one that biologically manufactures raw materials with specific attributes and characteristics for food and industrial use products is well underway. A key element of this transition will be the adoption of process control technology and the management systems that will implement process control in production activities — in farm fields and livestock feedlots and facilities.

Three components of process control technology are critical in biological manufacturing:

1. Monitoring/measuring and information technology,
2. Biotechnology and nutritional technology, and
3. Intervention technology.

Monitoring/measuring and information technology — The focus of this technology is to trace the development and/or deterioration of attributes in the animal and plant growth process, and to measure the impact of controllable and uncontrollable variables that are impacting that growth process. In crop production, yield monitors, global positioning systems (GPS), global information systems (GIS), satellite or aerial photography and imagery, weather monitoring and measuring systems, and plant and soil sensing systems are part of this technology. In animal production, systems to monitor humidity, temperature, air quality and other characteristics of the feedlot or building environment along with systems to monitor feed formulations, water characteristics, and animal waste and feed ingredient composition are included. In future years, in-animal sensors to detect growth rates and disease characteristics may be part of such information and monitoring/measuring systems. And these systems will be tied to growth models to detect ways to improve growth performance, as well as to financial and physical performance accounting systems to monitor overall performance. The computer technology to manipulate the massive amounts of information is readily available; new monitoring/measuring technology including near-infrared (NIR) and electromagnetic scanning is now being developed to measure a broad spectrum of characteristics of the animal and plant growth process.

Biotechnology and nutritional technology — The focus of biotechnology and nutritional technology is to manipulate the attribute development and deterioration process in plant and animal production. An improved scientific base to understand how nutrition impacts not only growth but attribute development is providing additional capacity to manipulate and control that process. And biotechnology is advancing our capacity to control and manipulate animal and plant growth and development including attribute composition through genetic manipulation. By combining nutritional and biotechnology concepts with mechanical and other technologies to control the growth environment (temperature, humidity and moisture, pest and disease infestation, etc.), the process control approach and thinking that is part of the assembly line used in mechanical manufacturing becomes a reality in biological manufacturing.

Intervention technology — The concept of intervention technology is to intervene with the proper adjustments or controls that will close the gap any time actual performance of a process deviates from potential performance. For example, servo mechanisms in a hog building automatically turn on the ventilation system, the coolers or a heating system if the temperature deviates from what is desired for optimal animal growth. Greenhouse production increasingly utilizes such technology to manipulate sunlight, humidity, temperature, and other characteristics of the plant growth environment. Irrigation systems are an example of this technology with respect to field crop production; modern irrigation systems tied to weather stations and plant and soil sensors automatically turn irrigation systems on when moisture becomes a constraint to plant growth, and automatically turn the systems off when moisture levels are adequate for optimum growth.

In confined livestock production, any-time intervention technology to impact the growing environment, change the nutritional regime, or prevent disease outbreaks are conceivable and will likely be commercially available in the near future. Systems for any-time intervention in extensive, land based crop production are more difficult to visualize, although a modified three boom center pivot irrigation system might be one possible any-time intervention technology approach. The first boom of such a system would be the sensing boom that detects what is the cause of the deviation between actual growth and growth potential — is it inadequate nitrogen, not enough water, too many weeds or insects, a missing micro nutrient, a disease outbreak, etc. The second boom would dispense water to resolve soil stress problems; the third boom would dispense whatever other chemical or ingredient is prescribed to eliminate the constraint or close the gap detected by the sensing boom.

Note that if such a technology is developed, it may be less essential to use biotechnology to resist certain insects or larger than necessary fertilizer applications to insure the highest yield if growing conditions are exceptional. Any-time intervention technology allows one to detect a problem when it occurs and real-time solve that problem rather than anticipate a possible problem and dispense control inputs that may be completely unnecessary (and thus costly) and possibly even harmful to the growth environment if that problem does not occur. For example, any-time intervention technology allows the detection of corn borers and the treatment of those borers once they meet an economic threshold during the season, rather than spending funds and using materials in anticipation that a corn borer infestation might occur which are unneeded if the infestation does not reach an economic threshold during the growing season.

It would be unrealistic to expect these process control technologies and methods to be as successful as they have been in mechanical manufacturing in reducing variability and systemizing the processes of producing manufactured goods and services such as automobiles, computers or even chemicals and industrial goods. However, it is also unrealistic to ignore the opportunities and the potential of these process control technologies in reducing variability and obtaining more control over biological growth processes so as to increase efficiency, reduce costs, improve quality, minimize environmental impacts and in general more systematically produce biological based specific attribute raw materials. In essence, this is what the concepts of biological manufacturing are all about — to use monitoring/measuring, biological and nutritional manipulation and any-time intervention technologies to systematically manufacture food and industrial use products.

Decision Structure Alternatives in Production Agriculture

The transition of production agriculture from commodity crop and livestock production to biological manufacturing and more tightly aligned supply chains is challenging the traditional decision structure used in most of mid-western production agriculture — the independent family farm. The value many family farmers place on independence may in many cases be in direct conflict with becoming a qualified supplier in a more tightly aligned supply chain. For some, their perspective of their future role in this new agricultural industry is that of a low income piece-work contractor who has little decision authority and no autonomy. And rightly so, they do not find this prospect very attractive.

But there is a "middle ground" between the independent family farmer on the one end and the low income piece-work contractor on the other end of the decision structure spectrum. One alternative in this middle ground is the multiple-plant entrepreneur. This is the structure that we increasingly see being used in the pork industry as well as in milk production. With this alternative, the farm business is comprised of a general manager and his staff who oversee the strategic, financing, marketing, procurement, and human resource functions of the enterprise; plant managers at each of the production locations who are responsible to implement and oversee the specific activities associated with crop and livestock production; and workers who are responsible to carry out those specific production activities. This decision structure acknowledges the concept that not all farm firms of the future will be comprised of a single production unit or plant, and that in many cases there will be significant efficiency advantages of separating operating management at the plant level from strategic and functional management at the firm level. As suggested earlier, this is not new to production agriculture as evidenced by the adoption of this decision structure in many of the larger as well as modest size pork production systems in the last ten years.

A second decision structure between the two extremes of independent producers and piece-work contractors is that of networked qualified suppliers. In this structure, individual firms develop joint programs for procurement, marketing or other activities to obtain the economies of size and scope as well as market presence without becoming fully merged or integrated. This approach has been the classic way that cooperatives have enabled individual family farmers to more effectively buy inputs and sell products in the past. The additional dimension of such programs that is expected in the future is that participants in a networked qualified supplier program will be required to be more committed, and in many cases jointly decide on program elements such as minimum quality specifications, minimum quantities delivered, scheduling of delivery, and probably even sources of key suppliers of inputs and key product merchandisers.

A third alternative is what might be described as a franchise grower. A franchised grower system would be not unlike the franchised retailer that is common in the fast food industry, but in this case it would be on the raw material rather than the merchandising side of the supply chain. A franchise grower/qualified supplier would be one who has the right and opportunity to supply agricultural raw materials to a particular processor or end-user as long as he or she meets certain specifications. Franchise growers would be given unique or privileged access to superior markets, superior technology, or superior opportunities that would be available on an exclusive basis to them but not to other growers. Franchise growers, like franchised fast food retailers, would be required to use very specific procedures in their business to produce the desired raw material, so in that sense they would lose some of their decision authority and autonomy. But also like the fast food industry where franchisees of a local McDonald's store are compensated well not for their decisions about the proper amount of ketchup to put on a hamburger, but instead for their ability to organize the personnel and other resources to produce the franchise product in a consistent and timely fashion, franchise growers or suppliers would be paid for their implementation and organization skills rather than their strategic decision-making skills. Franchisees in the fast food industry are well compensated for this important task of getting the job done — McDonald's knows that it is more efficient to have that done at the local level than to try to do it from corporate headquarters. One can envision a group of franchise growers in production agriculture in the future who are well compensated to implement qualified supplier programs that deliver specific attribute raw materials to processors and other end-users in the food and industrial use market of the future.

One final point concerning the future decision structures that might exist in production agriculture. Many of these alternatives between the two extremes of independent production and piece-work contractors may be available only for a limited time as the industry is transformed to a more tightly aligned biological manufacturing/qualified supplier structure. You can no longer obtain McDonald's franchises in many locales, and once a company chooses its qualified suppliers, others may find it difficult if not impossible to supply to that firm. The implication is that the opportunities in this "middle ground" may be time limited. Many independent family farmers are committed to maintain their status as an independent businessman who buys and sells on an open market. But if the agricultural production industry moves to more tightly aligned supply chains as has happened in most other industries, those who do not participate in this transformation will not only find that the open markets of the past are increasingly disappearing, but that the opportunities to be a franchise grower or networked qualified supplier are increasingly unavailable. The real strategic risk for these independent producers is that the independent option may not be available in the future, the decision structures associated with being a networked qualified supplier or franchise grower are no longer open to them, they don't have enough capital or other resources to be a multiple plant entrepreneur, and so they (or more likely their heirs) are by default relegated to being piece-work contractors with limited financial opportunities.

Strategic Risk in Agriculture*

Dramatic changes are occurring in the agricultural sector — changes which will result in agricultural industries having many of the characteristics of manufacturing industries. These changes are resulting in new and different risks for the industry as well.

The risks faced by agriculture have often been classified into such categories as production, marketing, financial, legal and human risks. An alternative and possibly more useful taxonomy is to categorize risk as tactical or operational risk and strategic risk. As agriculture becomes more industrialized, strategic risks are likely to become increasingly more important and, as we will note, are typically more difficult to manage.

The focus of strategic risk is the sensitivity of the strategic direction and the ultimate value of a company to uncertainties in the business climate. These uncertainties include: (a) political, government policy, macroeconomic, social, and natural contingencies; and (b) industry dynamics involving input markets, product markets, and competitive and technological uncertainties. Tactical or operational risk is easier to manage than strategic risk, in part because information is generally available to measure these risks, and because of the availability of accepted tools and techniques to transfer risk to others, such as insurance and futures markets.

Most strategic risks cannot be managed or transferred through conventional futures or insurance instruments or markets. Strategic risk is multidimensional, so managers cannot assume the simple one-to-one mapping between exposures and hedging or insurance instruments. Creative strategies must be developed to manage strategic risk exposure; approaches include flexibility, adaptability, and diversification.

One of the strategic risks farmers as well as agribusinesses are facing because of the industrialization of agriculture is contractual or relationship risk. The expanding use of contractual agreements and other forms of negotiation-based linkages between the various stages within the agricultural production and distribution system, combined with the decline in impersonal, market-based transactions, results in price risk being replaced by relationship or contractual risk for many businesses. A grower may have a contract that guarantees a price for the crop, but what happens if the processor goes bankrupt? What happens to the contract next year if the processor finds other suppliers in other areas who can satisfy the requirements at a lower price? This risk is not unlike that of losing a landlord or a lender, but losing access to the product market has typically not been a significant risk in commodity-based agriculture in the past.

Another strategic risk that seems to be increasing in recent years is that of compliance or regulatory risk. Farm and agribusiness firms are facing increasing regulation in all aspects of their business transactions. Added to the traditional areas of regulation concerned with transportation, taxation, and labor use are two rapidly growing regulatory areas: food safety and the environment.

When viewed from the broader perspective of both strategic and tactical or operational

---

*Adapted from Boehlje, Michael and David A. Lins. "Risks and Risk Management in an Industrialized Agriculture", *Agricultural Finance Review*, 58:1-16, 1998.

risks, the total risk that farm and agribusiness firms face is much more complex and more pervasive than is often perceived. In fact, as the agricultural sector increasingly exhibits the characteristics of an industrial model, the types of risks it will face will also change. A taxonomy of the broader dimensions of risk that farm and agribusiness firms will be facing in the future is presented in Table 1. From both an analytical and managerial perspective, a major challenge in the future will be to quantify both the frequency or probability of occurrence and the magnitude of exposure from each of these potential sources of risk.

Table 1. The Universe of Risks: A Taxonomy of Risk Facing Farm and Agribusiness Firms in the Future

Categories of Risk	Illustrative Sources of Risk
Financing and financial structure	Debt servicing capacity, leverage, debt structure, nonequity financing, liquidity, solvency, profitability
Market prices and terms of trade	Product price volatility, input price volatility, cost structure, contract terms, market outlets and access
Business partners and partnerships	Interdependency, confidentiality, cultural conflict, contractual risks
Competitors and competition	Market share, pricing wars, industrial espionage, antitrust allegations
Customers and customer relations	Product liability, credit risk, poor market timing, inadequate customer support
Distribution systems and channels	Transportation, service availability, cost, dependence on distributors
People and human resources	Employees, independent contractors, training, staffing adequacy
Political factors	Civil unrest, war, terrorism, enforcement of intellectual property rights, change in leadership that revises economic policies
Regulatory and legislative factors	Export licensing, jurisdiction, reporting and compliance, environmental
Reputation and image	Corporate image, brands, reputations of key employees
Strategic position and flexibility	Mergers and acquisitions, joint ventures and alliances, resource allocation and planning, organizational agility
Technological factors	Complexity, obsolescence, the year-2000 problem, workforce skill-sets
Financial markets and instruments	Foreign exchange, portfolio, cash, interest rate
Operations and business practices	Facilities, contractual risks, natural hazards, internal processes and controls

Source: Adapted from Teach, "Microsoft's Universe of Risk," *CFO*, March 1997.

The Pay-Off of Precision Farming

Precision farming has the potential to have profound impacts on the agricultural production/distribution system. What are these impacts, or more to the point, what is the payoff of precision farming?

1. **Cost Reduction/Efficiency Increases** - The improved measurement of soil characteristics and weather patterns that is part of precision farming has the most direct and obvious payoff in terms of cost reductions and efficiency increases from more accurate use of inputs such as fertilizer, seed, chemicals and other inputs and the systematic measurement of the impacts of these inputs on yield and profitability. In essence, precision farming is one step closer to the manufacturing mentality of production agriculture. Precision farming combined with creative ways to schedule and sequence machinery use including 24 hour-per-day operations, moving equipment among sites and deployment based on weather patterns has the potential to increase machinery utilization and lower per acre machinery and equipment costs as well.

2. **Span of Control** - A key concern in crop operations is the perceived and in many cases real limit on size of operation because of the difficulty of monitoring progress and performance on large geographically dispersed acreages. The fundamental argument is that if plant growth processes can only be monitored by people with unique skills and those resources are costly or expensive to train, the monitoring process limits the span of control to what one individual (or at least a few) can oversee personally. If electronic monitoring systems can be developed that monitoring the processes of plant growth (whether it be machinery operations or the growth process of the crop or the level of infestation of insects or weeds), fewer human resources are needed for this task and generally larger scale is possible. An analogy is the transformation from the labor intensive corn processing or feed milling plants of the past to the electronically controlled and monitored plants and mills of today with computer based monitoring and control systems and few employees producing significantly more output. Crop production can and will move more and more in that direction with improved electronic monitoring and control systems which expands the span of control.

3. **Differentiated Products** - Part of production agriculture is expected to move from commodity to differentiated product production. One dimension of that differentiation may be the production process itself -- for example the use of chemicals during only certain stages of the plant growth process. And with more specificity required in the raw material to meet qualified supplier requirements, increased measurement and monitoring of both the growth process and the end product will be important for quality control and compliance. In fact, precision farming in its broader context of measuring, monitoring and controlling the plant growth process is expected to have more payoff in differentiated production rather than commodity product production because it has the potential to not only lower cost but to simultaneously enhance revenue by producing a higher valued product.

4. **Food Safety** - One of the most difficult risks for a food processing firm to manage is the potential of contamination in raw materials. And for a branded product food company, a food safety scare can be disastrous. The improved measurement and monitoring of the soil preparation, growth, harvesting, storage and handling and processing processes that have the potential to be part of precision farming in the future will enable trace-back from end-user through the production/distribution chain which is the only secure method of guaranteeing food safety. If food safety concerns continue to increase and consumers demand more documentation that food products are in fact safe, precision farming has the potential to become one of the most effective ways of providing that documentation and reducing the risk of food contamination.

5. **Environmental Benefits** - Much has been asserted about the benefits of site specific farming in terms of more accurate and precise application of chemicals and fertilizer to better match plant needs and thus reduce leaching and runoff into ground and surface water. Undoubtedly this potential exists, but caution should be exercised in these assertions. Without improved measurement and monitoring of chemical and fertilizer uptake by the plant and movement in the soil, we are not sure of the environmental impact. What if the precision farming recommendations are for the highest application of chemicals or fertilizer on the soils closest to a stream or with a shallow water table and heavy rains occur after application? No doubt site specific farming and precision agriculture have the potential to reduce environmental degradation, but we need to measure and monitor this phenomena to be sure we are obtaining the expected results.

On Being a General Manager

Most successful farmers might be best described as hands-on, walk-around managers. Their success comes in large part because of their intimate involvement in the operations of the business. They know the production technology, the farrowing schedule, the field operations, the machinery operational performance and maintenance issues — in essence the daily functioning and operations of the plant better than most foreman in an industrial plant setting. But as farm businesses expand, it becomes increasing difficult for the farm manager to have this level of intimate knowledge about his plant. He no longer runs the combine — an employee does that. He doesn't do all the machinery maintenance; he doesn't run the feed mill or the feed truck to feed the cattle; he doesn't scout the fields for insects or weeds. Increasingly, agriculture is looking a lot like other industries where employees do most of the physical work, herdsmen manage daily operations and are equivalent to the foreman of an industrial plant in terms of responsibility, and the "farmer" — to be successful in this increasingly complex agricultural industry — must function as a general manager.

To be successful in the 20th century the farmer/grower was required to be a good plant manager. If they were able to control cost, increase efficiency and productivity, be timely in operations, and generally operate the farm — the plant — effectively and efficiently, they could be successful. And success was measured primarily by being a low cost producer with high yields and productivity.

But production agriculture is going through a major structural realignment. The changes that are part of this realignment can be characterized as: 1) adoption of manufacturing processes in production as well as processing, 2) a systems or food supply chain approach to production and distribution, 3) negotiated coordination replacing market coordination of the system, 4) a more important role for information, knowledge and other soft assets (in contrast to hard assets of machinery, equipment, facilities) in reducing cost and increasing responsiveness, and 5) increasing consolidation at all levels raising issues of market power and control. In general we are observing the application of modern industrial manufacturing, production, procurement, distribution, and coordination concepts to the food and industrial production supply chain. These changes suggest a new management paradigm will be important to be successful in the future.

The successful farm managers of the 21st century must not just be outstanding plant managers, they must also be successful general managers. General managers are concerned about managing people or personnel; managing money and resources; and negotiating and managing relationships with buyers and sellers, landlords and lenders, and investors and alliance partners. They know how to effectively use not only the skills of plant managers and other personnel within the business, but consultants and advisors from outside the business. General managers worry not only about cost, efficiency and productivity — but about labor productivity, capital turnover ratios, profit margins, return on assets, and return on equity. General managers think strategically — they think about the long-term future of their business.

On Being a Qualified Supplier

The relationship between producers and processors is expected to change dramatically in the future. Whereas producers in the past supplied generic commodities to processors primarily through open markets, the producer of the future will more likely be a qualified supplier of specific attribute raw materials to be used by a particular end-user.

What will processors expect of qualified suppliers? First, they expect them to be cost competitive in producing raw materials. Although processors in the future may source their raw materials from producers through contracts or other longer-term agreements rather than single transactions, they will still expect to buy those raw materials at the lowest cost possible.

The second requirement is consistent quality. Increasing quality expectations of end-users requires processors to source raw materials with more consistent quality characteristics. Producers may be rewarded for quality through premiums (or discounts on those raw materials that don't meet quality standards), or alternatively product that doesn't satisfy quality expectations may simply not be accepted by the processor.

A third requirement of a qualified supplier is that of reliability. Processors will increasingly schedule suppliers to deliver a specific quantity of raw materials at a particular time, and expect that supplier to do so. This reliability expectation will again impose more structure and tighter alignment in the supplier/processor arrangement.

A fourth expectation of the processor from a qualified supplier will be that of flexibility and adaptability. At the same time that the processor wants reliability, he or she will also want to have suppliers that can make adjustments in delivery schedules if needed, or over time change their production system to adapt to different end-user requirements. This balance (or maybe conflict) between reliability and adaptability, and the rewards processors provide the supplier for maintaining that balance, is one of the critical conflicts faced by a qualified supplier.

But being a qualified supplier is not a one-way street. What should a qualified supplier expect from his or her processor? First, a qualified supplier should expect equitable compensation for product and services provided, and equally if not more important, equitable sharing of the risk. In many fixed price contracts used in agriculture today, the risk between the producer/supplier and processor is not equitably shared; some form of revenue or profit-sharing based on resources contributed may be a more equitable risk and reward sharing arrangement then fixed price contracting.

A second requirement a qualified supplier should expect of the processor is market presence. With increased competition in the agricultural markets, a processor who does not have significant size or market presence may not be viable even in the short to intermediate run. Becoming a qualified supplier to such a processor may be committing to a company that may not be a long term player in the market.

A third requirement or expectation of the qualified supplier should have of the processor is dependability — the processor will take deliver of the specified product and compensate the supplier according to the agreement. And this dependability extends beyond a single transaction — the processor must be consistently committed and able to fulfill his or her commitment under the qualified supplier agreement.

Finally, a qualified supplier should expect the processor to provide him or her access to innovative products and services, and to consistently develop new markets. As competition results in substitute products and margin compression over time, the benefits of being a qualified supplier for a processor who does not innovate will be constantly challenged or undercut by competitive forces. So the producer must be willing to adapt to changing market conditions, and should expect his or her processor to not only have the market presence to anticipate these changing conditions, but to assist their affiliated qualified suppliers in adapting to these new markets.

To be successful in the long-run, producers should insist that they are qualified suppliers in an evolving supply chain, one that remains vital by constantly renewing itself through product, technology and market innovation.

Career Opportunities in Production Agriculture

The concentration and consolidation of production agriculture that is part of the current on-going industrialization process has raised numerous questions about the future of family vs. factory farming. One of the controversial issues in this contentious debate is what will happen to the career opportunities in production agriculture — will there be fewer opportunities for a career in this industry or more opportunities?

As the number of commercially viable farm firms declines, opportunities to pursue a career as an independent family farmer are obviously also reduced. But will the expansion of industrial firms in production agriculture result in new and different career opportunities, and will these opportunities be as attractive and accessible as those associated with the traditional family farming structure of the industry.

It is quite possible that industrialized agriculture will offer a broader set of career opportunities, and more accessibility to those opportunities. The traditional career path in production agriculture has been to either join an already ongoing business as a family member, or to start farming as an employee for a current farmer and eventually accumulate enough funds to buy machinery and rent land to start an independent farming business. Both of these approaches — joining a family business or climbing the agricultural ladder — have been quite restrictive in terms of who qualifies and the determinants of success.

Larger, industrialized farms may offer a wider variety of employment opportunities including several levels of managerial positions. The first opportunity is at the immediate production-unit or farm level where local production is managed either by the landowner, or in some sectors such as strawberries, by a non-owner who enters tie-in agreements that include sub-leases, exclusive marketing commitments and financing guarantees. Some landowners that manage local-unit production may have been "family farmers" who have elected to enter a more structured or integrated operation. In some labor-intensive, small-acreage sectors, the non-landowner/sub-lessee/producer has been drawn from the ranks of former employees who are pursuing a more entrepreneurial career in farming.

At a second level coordinating the individual production-units may be found middle-level production management personnel which may include positions such as: crops manager, planting manager, harvest manager, equipment manager, and possibly labor manager or coordinator. Each of these managers would be coordinating specified activities across individual production units. At the third level more senior-level management would be involved in such decisions as evaluating the economics of existing and potential enterprises, choosing quantities and varieties to raise, and implementing fundamental marketing strategies and agreements. These senior level-managers may be responsible for the overall finance, marketing, procurement and operations functions of the business much like in a non-farm business. Overall direction of the enterprise is provided by a chief executive officer (CEO) and his management staff.

Of course, these structures will vary — and may combine two or more of these managerial levels — with size and type of enterprise. Thus, a substantial dairy operation may include hired milkers and field and feed-lot staff, a managerial-level herdsman, and an owner-CEO.

Within industrialized production operations, many tasks (and inputs) may be outsourced to independent contractors such as: fertilizer, pesticide and veterinary service providers, labor contractors, and custom machinery operators — providing additional career and often entrepreneurial opportunities.

As agriculture becomes more integrated upstream and downstream, who performs the management role is changing. Some, owner-operators are becoming contract-producers wherein the discretion for determining both production processes and the timing and conditions of sale are transferred to the integrator. The farmer assumes more of the role of a middle-level or production manager. While this trend may appear to reduce the farmers' need for some entrepreneurial-producer skills (e.g., which variety to crop or livestock to raise; how long to feed or hold), it calls for heightened abilities to analyze complex contractual documents and arrangements and evaluate the long-term advantages of, or returns to, the often greatly increased — and leveraged — real estate investment.

Some former owner-operators may move into middle-level managerial positions such as planting and harvest supervisors, and some may become outside contractors such as pesticide or fertilizer advisors. The extent to which current agricultural education or experience enables individuals to qualify for any of the above-described managerial roles is not clear. Also unclear is the extent to which agriculture's wage-and-benefits structure for these positions is competitive with non-agricultural sectors. To ensure adequate supplies of workers at all skill levels, agriculture will have to compete successfully with other sectors of the U.S. economy.

Economies of Size and the Future of Small Farms

A critical issue in the discussion and debate concerning industrialization of agriculture concerns the economies of size in agricultural production and the shape of the long run average cost curve. The conventional economic model infers a U-shaped long-run cost curve that initially declines as size or scale increases, reaches a minimum, and then rises with further increases in size or scale. The fundamental issue is — does this shape of the cost curve characterize agricultural production?

Empirical studies and farm records appear to verify that the cost curve for agricultural production does decline with increasing size or scale of operation. There is debate about how quickly that cost curve declines — i.e. what size is needed to capture most of the economies of size. Farm record data implies that very small farm businesses have relatively high total costs (although they may also have very low variable cash cost), and that costs decline rapidly with modest increases in size with only slight or little decline in cost as farms increase in size from average or even smaller than average size operations. But that is not the whole story, and maybe not the most interesting part of the story.

The more interesting questions are the following. First, do costs eventually go up with further increases in size? Does the cost curve for agriculture exhibit a steep sided, flat bottom U-shape, or is it instead L-shaped where costs are relatively constant after a particular point as size increases? Second, in a dynamic context, even if costs do rise with increasing size at a particular point in time, over time do new technology and improved management practices combined with innovative entrepreneurship result in reductions in cost for larger scale operations, thus flattening out the right hand tail of the long-run average cost curve. In essence, the question is can smart farmers as they gain experience over time lower their cost such that what might be a steep sided flat bottom U-shape cost curve at a point in time is in reality a L-shaped cost curve over time.

The third question is one of the unit of measurement. Are we measuring the cost curve for the plant, or the cost curve for the firm? Most studies of economies of size in agricultural production using farm record or other data measure the cost curve of the plant (the farm) and conclude that this cost curve also is the cost curve for the firm. But increasingly in agriculture, we are recognizing that the plant and the firm are not the same entity. Just like in the industrial sector, a firm may have many plants with each plant being of optimal size to have the minimum cost. If the plant cost curve did have the classic U-shape form, one strategy farmers might use is to determine the optimal, minimum cost plant size and expand the size of the firm by replicating this size plant. So one strategy to keep cost from rising as a firm expands is to use a replicate strategy where the firm is comprised of multiple minimum cost plants. This in fact appears to be the strategy being used by larger scale integrated hog producers who have chosen plant sizes of 2400 or 3600 sows, and then when they desire to increase the size of their firm do not add additional capacity to the current plant, but instead put in place new plants of 2400 or 3600 sow size.

So the really important questions concerning the trend to larger farm sizes are not whether costs decline as size increases. They are instead whether they rise after a particular size is attained. In fact, even if cost were invariant by size — in other words we had a constant cost industry with a flat cost curve — farm size would likely increase over time if the industry is profitable. Even for constant cost industries, managers who generate profits typically reinvest those profits back in the firm and grow the business. And if there are other barriers to entry such as access to capital or acceptable land rental arrangements as frequently characterizes small farm businesses, it is difficult for smaller operations to enter or be viable even if they have identical costs to those of larger units.

So the real issues in the discussion and debate of the viability of small farms, the trend to larger scale units and the future size structure of agriculture from the perspective of efficiency and cost is not whether small farms are as efficient as moderate size farms. It is first whether in a longer term context larger, multi-plant agricultural production firms have higher cost than moderate and small size single plant agricultural production firms? A second critical question is over time, if a firm is profitable, will the managers of those firms reinvest their earnings back in the business, or will they invest it elsewhere? If one concludes that for the reasons noted above the cost curve for agricultural production probably exhibits a L-shape rather than a steep sided U-shape (i.e. that cost most likely do not rise with increases in firm size), and that managers will likely reinvest earnings back in their core businesses, farm size is likely to continue to increase. Thus, rising costs are not likely to constrain growth in farm size, and the rate at which farms will grow in size over time will be primarily determined by the profitability of the business and the amount of net earnings that are retained and combined with debt capital to expand the business.

<u>Farm Expansions — The Critical Questions</u>

Expansion of the farm business is one of the more strategic decisions that a producer makes. But many producers approach expansion decisions more from an opportunistic perspective than a strategic perspective. All too often an expansion decision is made when an opportunity arises — a parcel of land near-by becomes available to rent or buy, or a machinery dealer comes by with a special deal on a larger combine. Maybe the price is right or the purchase or rental arrangement is so good you can't pass it up, but does it really fit in your overall plan for where you want the farm business to be ten years down the road? What is your expansion strategy, and how can you sort out the good deals that fit that strategy from the equally good deals that don't?

Probably the first issue to consider in developing an expansion strategy is to understand what is meant by the word expansion. When most producers describe their expansion plans, they almost always involve the commitment of additional resources. And if expansion is defined in terms of the size of the resource base of the firm, that perspective makes sense.

But an alternative perspective on expansion is to view it as increased output rather than increased resource commitments. Fundamentally, increased output can be obtained in two different ways: 1) increasing the amount of resources used in the business and thus the total output, or 2) increasing the efficiency of resource use and obtaining more thruput — more output with the same commitment of investment or fixed resources. Undoubtably the thruput strategy will usually require the commitment of some additional resources such as managerial time, labor or operating funds to implement the strategy, but this approach typically is a lower cost, more efficient strategy for expansion than one that requires the commitment of additional capital and other fixed resources.

Assuming that expansion means increased output — however it is obtained — let's look at ten critical questions that will help you shape your expansion strategy. Our focus here is not to provide you the answers to these questions, but to pose them for you to consider in your development of an expansion strategy.

1. What am I really good at? What am I best at? What enterprise? What management function?

2. What will give me the best return on my resources?

3. Can I intensify present resource use? Push my buildings and machinery harder? Increase output without using more resources by increasing efficiency, tighter scheduling?

4. Do I have unused or underutilized resources? Excess labor? Excess managerial resources? Rough land that has timber potential? Land with development or recreational potential?

5. If I increase size, can I lower unit costs? Go from 8 row to 12 row equipment and farm more acres with the same labor? Reduce costs per unit of milk by adding 30 more cows?

6. What are the alternative ways to obtain resources? Rent land? Lease machinery? Custom farm acreage? Hire labor? Create a joint venture? Hire specialized services such as crop scouting or fertility maintenance?

7. Should I diversify? Will it reduce risk? Even if not, will it allow better resource use?

8. How much financing will be available and does this limit my options? Debt capital from lenders? Equity capital from family members or investors? Leased capital?

9. What are the risks of this expansion? Financial risk? The right technology? Errors in projections? Changes in regulations and government policy?

10. What are the start-up problems and costs? Construction delays? Time spent in locating land to buy or rent? Interest cost of buying machinery in anticipation of acquiring more land? Learning costs of a new venture or new enterprise?

Answering these questions will go a long way in helping you develop an expansion strategy and take advantage of those opportunities that fit with that strategy.

Treadmills in Agricultural Production

Change has been a constant part of farming for decades -- new technologies including new machines, new chemicals, new genetics, new feed ingredients, etc. have been continuously introduced into the market at an ever-increasing pace. In fact, some have described the technological changes in agriculture as a treadmill -- you have to adopt new technology just to keep up. But as farming transitions from a commodity to a differentiated product industry, farmers will be faced with additional continuous changes and an additional treadmill -- the differentiated product treadmill. What are these treadmills and how will they impact farm decision-making in the future?

The Technology Treadmill

Technological advances have been a critical source of productivity and efficiency gains in farming, and farmers that are earlier adopters of the right technology have typically been financially successful. Technological progress implies change, and continuous change can be characterized as the technology treadmill. This notion of the technology treadmill actually accelerates the adoption of agricultural technology. As a new technology is introduced, the first few farmers to adopt the practice gain doubly. They increase the volume of their product and, in addition, gain revenue at market prices largely dependent upon the volume of production from the old technology. Thus, there is tremendous incentive to be the early adopter. Subsequently, as more and more farmers adopt the practice, the supply of commodities increases and this drives down the price. This forces the remaining farmers to adopt the new technology to increase their production to compensate for the lower prices. Thus, over time, market forces drive farmers to adopt new technology if they are to stay in farming. The keys to success in technology adoption in this treadmill environment are to continually scan for new technology options, to be early in the adoption process and to be right! You probably don't want to be first in technology adoption, but a close second -- maybe an optimal adopter.

The Product Treadmill

The transformation of production agriculture from a commodity industry to one that produces differentiated products results in an additional treadmill for farmers. This treadmill occurs because although differentiated products have the potential to generate higher profit margins because of the value created by the differentiating attribute, this value typically declines over time. Value decay is a result of numerous forces including,

Substitution in the form of products that are already in the market, or from the development of new products and services over time. For example, the value of high oil corn is significantly dependent upon its ability to compete with fat in feed ration formulation, recent declines in fat prices have resulted in substitution of animal fats for high oil corn in feed rations.

Replacement by new products that make old products less valuable. For example new genetics in pork production produces leaner meat with less fat and thus replaces traditional genetic lines.

Commodization which occurs as increasing numbers of producers enter the market over time, increasing output which results in lower prices and thus value decay. The speed with which a product moves through this commodization process depends to a significant degree on the ability to maintain uniqueness and protect differentiated characteristics from being replicated.

To maintain the higher profit margins that are associated with differentiated product production, farmers must continuously replace those differentiated products that have declining value with new products that have higher profit potential. Thus, another treadmill -- a product treadmill that involves constantly assessing new dimensions for differentiation and adding value. The key to success in differentiated product choices in this treadmill environment are not only the constant scan for new alternatives, but an understanding of the causes of value creation and decay, an estimate of the rate of decay for the old product and the rate of creation for the new, and a set of value chain relationships and a distribution channel that will provide access and incentives to bring new products to market.

So the new agriculture involves continuous and constant change in both choice of technology and choice of differentiated product. This environment of continuous change will provide both new challenges and new opportunities for tomorrow's farmers.

Competing in the New Agriculture

Farming has always been a competitive industry, but important changes are occurring in the competitive environment that farmers will face in the future. How will the new agriculture impact the way farmers compete, and what will be required for producers to have a sustainable competitive advantage?

The agriculture of the past has been primarily a commodity business, and consequently the key to long-term success in farming has been to be a low-cost producer. Although in the short-run prices may be sufficiently above cost to generate handsome, above normal profits as evidenced by $5 corn and $60 hogs only a few years ago, over time a number of producers expand their operations sufficiently that supplies increase and prices decline, thus reducing profit margins. As producers increase their efficiency through better management and adoption of technology, cost declines and margins increase, but over time adoption of the cost saving technologies by more producers again results in increased production and margin pressures. So in the long-run the only way to compete successfully in the farming business dominated by commodity production is to be a low-cost producer.

Some producers are low cost because they do not consider all costs in their decision making. Some producers have been willing to use their equity capital and even their labor in agricultural production and not require market compensation for those contributed resources. Given the significance of capital and labor in the production of most agricultural products, if these resources are assumed to be free or costed at low compensation rates, costs of production are substantially reduced. Consequently, those farmers that are willing to give their time and money away or require low rates of return on their money and low wages for their labor will continue to produce even though prices may not cover cost computed at market rates of return. This puts additional margin pressure on those producers who want market rates of compensation for their resources. Commodity industries where a large proportion of the producers are willing to use their resources to produce, even though they are not fully compensated to do so, will continually suffer from very low or negative margins until those producers exit the industry.

But the basis and dimensions of competition in agriculture are changing. As agriculture is transformed from a commodity to a differentiated product business, competition becomes multi-dimensional -- it is not just being cost competitive that will lead to financial success. Differentiated products typically have a broader spectrum of quality features than commodities, and those quality dimensions or features often improve over time. In most non-food products consumers purchase, quality standards have continuously improved over time, and thus consumers are expecting food products to exhibit similar continuous quality improvement. Furthermore, product differentiation is not a permanent phenomenon. Differentiating attributes become commoditized over time so the successful farmer must constantly evaluate new opportunities for differentiation and be an early adopter or first mover in these new differentiated products before the premiums or margins are pressured by increased numbers of producers who enter the market. Consequently, in differentiated product markets producers not only compete with respect to cost, they also compete with respect to quality attributes of their products and with respect to the speed or response time to introduce new products as consumer demand and market conditions change. And speed of entering new value added or differentiated product markets may be critical not only to obtain the best premiums, but also because those who attempt to enter the market later might find that it is adequately supplied. Contracts and other business arrangements to produce the differentiated product may have already been negotiated and consequently new production and producers are not needed.

This new agriculture profoundly changes the competitive environment in farming. In the commodity agriculture of the past, farmers had to compete only in terms of cost. If you were a low-cost producer and did not expand beyond the sustainable growth rate of the business, you could expect to be a successful producer -- to survive and maybe even thrive in the long - run. In the new agriculture that includes differentiated products and more tightly aligned marketing/distribution systems with producers being raw material suppliers for manufacturers and food processors, competition includes quality features and responsiveness or time to market as well as cost. In the agriculture of the future farmers will need to be better, faster, and cheaper to have a sustainable competitive advantage.

Implications of Biotechnology for Agriculture

Biotechnology has been one of the most profound scientific advances in the last twenty years. And it has moved very rapidly from the scientific laboratory to farmers' fields; for example, bioengineered corn and soybean varieties were first introduced in 1996, and by 1999 almost 25% of the corn and 50% of the soybean acreages were planted to varieties created with biotechnology. Acceptance of biotech food products by consumers has become a controversial issue, so future adoption may be slowed somewhat. But it is unlikely that this significant technological development will be stopped completely.

Biotechnology has the potential to completely change the agricultural industry—to change agriculture's role in the overall economy as well as how agriculture goes about fulfilling that role. In essence, it has the potential to redefine and realign the agricultural industry—change dramatically who we are and how we do it.

Who We Are

Biotechnology will redefine the role of agriculture for two fundamental reasons. First, it replaces and/or complements chemistry and the mechanical sciences as the fundamental science base for new technological and productivity advances. In essence, whereas most of the technological advances that increased productivity and contributed to growth and economic development in the past 50 years have had their science base in the physical and mechanical sciences, the science base for future technological advance, productivity growth and economic development will come from the biological sciences. This places agriculture in the mainstream of productivity growth and economic development in the developed as well as the less developed economies.

The second profound implication of biotechnology in redefining agriculture is that it dramatically expands agriculture's role as a raw material supplier for a broader set of industries. The agriculture of the past 100 years has been a raw material supplier for the food and nutrition industry and, to a limited degree, the fiber and textile industry. But biotechnology and the advances in biochemistry expand dramatically the potential uses for agricultural products. In fact, some are suggesting that in the future agriculture will be a significant supplier of raw materials for: (1)food and nutrition products, (2) health and pharmaceutical products, and (3) industrial products including synthetic fibers, plastics, wall coverings, and other products that have historically been derived from the petrochemical industry. This significant broadening of the economic sectors that will use agricultural products as raw materials increases agriculture's importance in the overall economy. It also provides a broader base for the demand for biologically-based raw materials (i.e., agricultural products) as well as an opportunity to think of agriculture as a core source of integration of the total economy. The end result is that agriculture and the biological sciences that create agricultural products have the potential to not only redefine the sector's role in overall economic systems, but to substantially expand that role.

How We Do It!

Biotechnology also has the potential to profoundly change how agriculture operates in the future—how the industry accomplishes that larger role in the total economy. Biotechnology is a critical component of process control technology that is transforming agriculture from an industry that produces and processes commodity products to one that biologically manufactures specific attribute raw materials for the broader set of end uses noted earlier. Biological manufacturing is characterized by industrialized production which uses modern manufacturing approaches including procurement, inventory management and process control techniques. Three types of process control technology are critical in biological manufacturing:

Monitoring/measuring and information technology — The focus of this technology is to trace the development and/or deterioration of attributes in the animal and plant growth process, and to measure the impact of controllable and uncontrollable variables that are impacting that growth process. In crop production, yield monitors, global positioning systems (GPS), global information systems (GIS), satellite or aerial photography and imagery, weather monitoring and measuring systems, and plant and soil sensing systems are part of this technology. In animal production, systems to monitor humidity, temperature, air quality and other characteristics of the feedlot or building environment along with systems to monitor feed formulations, water characteristics, and animal waste and feed ingredient composition are included. In future years, in-animal sensors to detect growth rates and disease characteristics may be part of such information and monitoring/measuring systems. And these systems will be tied to growth models to detect ways to improve growth performance, as well as to financial and physical performance accounting systems to monitor overall performance. The computer technology to manipulate the massive amounts of information is readily available; new monitoring/measuring technology including near-infrared (NIR) and electromagnetic scanning is now being developed to measure a broad spectrum of characteristics of the animal and plant growth process.

Biotechnology and nutritional technology — The focus of biotechnology and nutritional technology is to manipulate the attribute development and deterioration process in plant and animal production. An improved scientific base to understand how nutrition impacts not only growth but attribute development is providing additional capacity to manipulate and control that process. And biotechnology is advancing our capacity to control and manipulate animal and plant growth and development including attribute composition through genetic manipulation. By combining nutritional and biotechnology concepts with mechanical and other technologies to control the growth environment (temperature, humidity and moisture, pest and disease infestation, etc.), the process control approach and thinking that is part of the assembly line used in mechanical manufacturing becomes a reality in biological manufacturing.

Intervention technology — The concept of intervention technology is to intervene with the proper adjustments or controls that will close the gap any time actual performance of a process deviates from potential performance. For example, servo mechanisms in a hog building automatically turn on the ventilation system, the coolers or a heating system if the temperature deviates from what is desired for optimal animal growth. Greenhouse production increasingly utilizes such technology to manipulate sunlight, humidity, temperature, and other characteristics of the plant growth environment. Irrigation systems are an example of this technology with respect to field crop production; modern irrigation systems tied to weather stations and plant and soil sensors automatically turn irrigation systems on when moisture becomes a constraint to plant growth, and automatically turn the systems off when moisture levels are adequate for optimum growth.

This technological transformation is significantly different from the mechanical and even biological transformations of the past. In essence implementation of the three components of process control technology in production agriculture as well as in the input supply manufacturing and product processing and retailing sectors eliminates the disconnect that has previously occurred at the farm gate in the assembly line from genetic material to the retail food store.

Biotechnology and the science that supports it opens up numerous options and opportunities for agriculture – it has the potential to profoundly change who we are and how we accomplish what we do.

Farm Policy in an Industrialized Agriculture

The significant changes now occurring in production agriculture that are transforming it from the Jeffersonian model of small and modest size family farms to an industry characterized by larger production units that display the characteristics of the industrial model and biological manufacturing has profound implications for the debate concerning the appropriate agricultural policy of the future. This change in the characteristics of the production industry combined with increasing global production and competition, concerns about environmental and other externalities related to production agriculture, and growing interest on the part of consumers for safe as well as healthy foods has the potential to profoundly redirect the focus of agricultural policy debates. What might be some of the key issues in this new agricultural policy debate and discussion? And equally important, will the goals and objectives of agricultural policy be different in the future than they have been in the past?

Let's first look at the potential changes in the goals and objectives of agricultural policy in the future compared to the past. As exemplified and stated by every Farm Bill since the 1930s, the prime goals of agricultural policy have been to enhance or reduce the risk of low incomes for farmers; to keep agriculture from building up unmanageable surpluses; to protect land and other resources from degradation; and to provide U.S. consumers with adequate and nutritious food at reasonable prices and essentially eliminate the prospects of a U.S. food shortage. Generally, these objectives have been accomplished by a variety of farm programs that have buffered production agriculture from market forces, and in essence attempted to minimize the exit or dislocation of resources — both human and capital — from the sector.

In 1996 a profound change in stated public policy concerning agriculture was implemented with passage of the Freedom To Farm legislation. This legislation was predicated on the argument that farmers should not be buffered from market forces, particularly with respect to production decisions and the market clearing prices that would occur as the result of those production decisions. Some have argued that the 1996 Farm Bill initiated a new era in farm policy with respect to buffering the industry from market forces, but did not complement that policy with one that assisted in the adjustment process for those human and other resources that might possibly not receive reasonable compensation from the market. Thus, the transition is incomplete in that the new farm policy is allowing the market to impact the industry, but is not facilitating the resource adjustments that may occur when the market suggests that some of these resources are in excess.

As one views the future from the perspective of a globally competitive, industrialized agriculture, additional goals of public policy with respect to the industry may become relatively more important than those that have been the focus of past policy. These goals might include:

1. Facilitating producers ability to manage the increasing risk and volatility that they will face in a more market-driven industry,

2. Maintaining or protecting the productive capacity of the land, capital and human resource base during periods of short-term surpluses for longer-term world-wide food security,

3. Facilitate the transition out of agriculture of permanently excessive human resources through jobs training and other transition assistance,

4. Maintain market access for producers in both input and product markets,

5. Protect farmers from potential exploitation by processors and input suppliers,

6. Protect farm employees from exploitation by farm entrepreneurs,

7. Maintain adequate food supplies to minimize the probability of a food shortage or significant increases in food prices,

8. Protect consumers from any form of food contamination in the production/distribution channel,

9. Reduce environmental, odor and other externality conflicts between farmers and other members of society,

10. Enhance agricultural productivity, creativity and innovation,

11. Assist farmers and residents of rural communities in adapting to change and adjusting to new social and economic environments.

So if these are some of the potential goals or objectives of farm policy in the future, what might be some of the agricultural policy and program options and alternatives? Our purpose here is not to specifically identify the details of a policy option or the institutional structure to implement a particular farm program, but to identify four critical issues that farm policy of the future must resolve to accomplish the broader set of goals previously identified. These issues or alternatives are generally not part of the current policy debate and are presented not because they are fully developed and analyzed, but to stimulate new ideas and new thinking in policy discussions that have historically been dominated by variations of farm price and income support systems and resource conservation and protection programs.

1. Develop and fund programs for transition/adjustment assistance — As has been indicated earlier, markets sometimes inflict pain in the form of low compensation for resources. One role of public policy is to mitigate that pain through temporary assistance. But if the resources are in permanent surplus, public programs to facilitate transition of those resources to other uses are appropriate. For example, a program to assist farmers who may find permanently lower prices and incomes because of international competition or other forces might be provided jobs training and relocation assistance to transition from farming to some other occupation. This transition assistance approach may be the logical follow-on program to legislation that provides less buffering for farmers from market forces.

2. Develop an institutional structure around vertical market systems and supply chains to reduce the potential of market power and exploitation (similar to the institutional structure around markets) — The development of tighter vertical alliances in agriculture and the formation of supply chains has raised numerous questions about the issues of market power and the potential for exploitation of those with limited size

or market power, particularly producers. One public policy response would be to prohibit the formation of these vertical alliances. Such a policy might not only be difficult to implement, it might eliminate opportunities to develop a more efficient and responsive food production and distribution system. An alternative policy approach is to develop an institutional structure surrounding vertical supply chains (not unlike the institutional structure surrounding markets) that responds to the public policy concerns. Such a structure might include open access to information on prices and terms of trade of all transactions whether they be within a vertically aligned chain or not. It might include redefining anti-trust legislation to acknowledge concerns about market power related to position in a vertical chain as well as market concentration and size. It might include provisions to minimize opportunistic behavior and exploitation by mandating compensation if, for example, contractual obligations in a vertical chain are not fulfilled. Another policy response would be to alter the power potential in negotiation between producers and others in vertical chains by increasing producer bargaining rights. And new arrangements and institutional structures for more equitable sharing of risk and rewards in vertical alliances as an alternative to fixed price contracts might be mandated or encouraged including various forms of profit and loss sharing arrangements. The fundamental principal here is to develop a new institutional structure to surround vertical systems of economic activity to eliminate the potential of power or exploitation so as to accomplish the same goal as the current institutional structure is to accomplish in a market environment.

3. Redefine intellectual property rights — The recent advances in biotechnology and information technology suggest that information and intellectual property will be critical resources to enhance market position and generate economic rewards in agriculture in the future. In the past, much of the information and many of the new ideas for production agriculture were generated by public sector institutions — the Land Grant University System and the US Department of Agriculture. But increasingly, private sector firms are generating new innovations and information and capturing value from that activity by charging farmers technology fees, and generally limiting access to those who have the ability and willingness to pay for information and technology. Our current set of patent and copyright law was developed in an era of open markets and a major role for the public sector in providing new R&D and information. These rules and regulations concerning intellectual property rights and information dissemination should be revisited given that the market is now being characterized by vertical alliances and linkages, global competition, and a significant role of the private sector in the development of new technology and the dissemination of information.

4. Increased support for public sector R&D — As noted earlier the private sector is playing an increasing role in the technology and information markets, and many are concerned about the distributional consequences of restricted or closed access to the latest and best information and technology. A critical public policy issue is the appropriate level of funding for public R&D, technology transfer and information systems and the adequacy of funding of those activities. It is unlikely that current funding sources will be adequate to expand support for public, open access R&D and information programs. New and creative ways of funding such programs are a critical

public policy concern. Creative structures and public sector — private sector joint ventures should be part of this discussion, including the potential for taxing the profits from private sector intellectual property and directly allocating those revenues to public sector, open access research and information programs focused on those who may not have access to the latest private sector technology and information.

The four areas of public policy identified here have not been the focal point of agricultural policy debates and discussion in the past. But they may be equally if not more important than traditional farm price and income support and resource conservation programs in shaping the efficiency and opportunity for the agricultural production and distribution system in an increasingly globally competitive market in the future. The future policy debates in agriculture must be much broader in focus and concept to respond to the critical public policy issues that will face the food production and distribution system in the future.