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STRUCTURAL REALIGNMENT IN AGRICULTURE:

HOW DO WE ANALYZE AND UNDERSTAND IT?

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Introduction

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. The industry is becoming more industrialized, more specialized, more managerially intense.

The massive restructuring of the agricultural sector that is occurring today is a particularly important subject for inquiry. Pressures for change and significant market-based responses to those pressures are occurring simultaneously. The setting in agriculture today is relatively turbulent; with pressures and responses that can have profound future implications for firms and for society. As researchers and managers involved in the food and agricultural sector, we must strive to assist public and private sector decision makers understand the forces for change. In addition we must strive to be proactive in the *ex ante* evaluation of market system alternatives.

This change-oriented role may be somewhat uncomfortable. For much of the second half of the 1900's, market structures were relatively stable with comparatively little pressure for fundamental change. In that setting, analysis to evaluate market performance could appropriately be done with tools that employed an *ex post* evaluatory framework. As long as the future market structure was relatively similar to that of the past, econometric projections based upon historic data were appropriate However, in a period of relatively rapid market structure evolution, alternative tools and approaches are required.

In the next section of the paper, three forces for change will be presented that frame the question of how we analyze and understand structural realignment in agriculture. Then a number of potentially useful concepts for analysis of these issues will be identified. Next, several empirical investigations will be discussed. One of those investigations, a system dynamics based analysis of supplier/customer linkages in the pork sector will be reviewed in some detail. The purpose of this more detailed exposition is not to assert that this single approach is necessarily preferred, but rather to illustrate the challenges and potentials in this type of application.

Forces for Change

Two of the most critical dimensions of this structural change are the industrialization of agriculture and the formation of more tightly aligned supply or value chains. Technological advance is occurring simultaneously and is heavily intertwined with the structural changes under consideration

Industrialization

Industrialization of production means the movement to larger scale production units, that use standardized technology/management and are linked to the processor by either formal or informal arrangements. Size and standardization will be important characteristics in lowering production costs and in producing products 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.

For example, industrialized pork production is now the norm for most expanding firms in the industry. The manufacturing approach to pork production and distribution is essential to maintain quality control as well as to control cost. In many cases, this industrialized model of production and distribution will foster much larger scale firms; in 1988, approximately 5 percent of total pork production was concentrated in the hands of the hands of the 40 largest firms whereas, the 40 largest firms in 1996 produced approximately 31 percent of the total U.S. pork output. Technological advances combined with continued pressures to control assets and improve quality are expected to provide incentives for further industrialization of the industry.

There will be a number of ways in which these industrialized food systems are organized and owned. These alternatives will likely include alliances of formerly independent companies, producer-owned cooperatives, and total vertical integration. Alliances will be formed by firms who originally were independent operations. The system will be formed by combining input industries, producers, processors, distributors, and even retailers. These firms will likely find it necessary to be part of a food system and to specialize their services and skills in a narrow function. Increasingly, producers will identify themselves as a member of the food system of which they are a part.

In summary industrialized agriculture is 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.

Supply chains

An increasing emphasis is being placed on managing and optimizing the food supply chain 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 agricultural industries to quickly respond to changes in consumer demand for food attributes.

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 consumer's food expenditures.

For a food company, a key risk that is difficult to manage is that associated with food safety. The issue of food safety is beyond one of consistent quality—food products that make people ill or even cause death can quickly destroy brand value, the most valuable asset owned by a branded food product company. 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. Trace-back is part of the motivation for controlled origination of raw materials from certified suppliers to implement a supply chain philosophy in the agricultural industries.

The supply chain optimization concepts have a significant implication for the growth of the agricultural industries. In the past, decisions concerning the location of the production, processing, and distribution centers were in a relatively independent fashion; that will no longer be the case in the future. For example, optimal slaughter/processing plant capacity is very large, requiring significant capital outlays and adequate supplies of raw material for efficient operations. It is unlikely that new plants of optimal size will be constructed in the future with the expectations that production systems will develop to supply those plants. Likewise, producers are not expected to invest in production capacity if access to processing plants that can bid competitively for their animals is not assured.

These concerns, combined with the benefits of an integrated system in terms of cost efficiencies, quality control, flow scheduling, and inventory management, will result in the development of production-processing centers and the supporting infrastructure as the optimal strategy for growth and expansion in the agricultural industries. This strategy will not only influence the geographic location of the industries, but further increase the interdependence between the segments of the industries.

Technological change

Rapid adaptation of technology is certainly not due to the agricultural sector. Indeed, one of the hallmarks of U.S. agriculture has been its willingness to adopt technology. However, just as structural change was associated with adoption of technologies such as mechanization and the use of agricultural chemicals, it is likely that structural realignment both will affect and be affected by today's changing technologies. Of primary interest to this discussion are uncertainties introduced by biotechnology and information technology.

The much heralded, much anticipated advent of biotechnology to crop production hit with significant impact in 1996 and 1997. These years saw rapid growth in the adoption of seeds that resist pests or allow weed control with cheaper, more environmentally benign impacts. In these years, availability of seed supply was the limiting factor to adoption. Biotechnology advances that focus on agronomic traits generally are perceived as not having major long term structural effects relating to production agriculture. However, innovations that affect output traits will require modification in the interface between producers and their direct customers. The commodity marketing system with its relatively coarse standards and low cost transactions is ill-suited to respond to the needs of attribute specification from genetics to consumer.

Advances in the potential to employ information technology in agricultural systems are occurring as rapidly as those of biotechnology. Interestingly, these advance may offer the potential to respond to the needs for maintenance of specificity in the production/marketing system that is being required to exploit biotechnology and to respond to other societal trends. Precision agriculture is a summary term that typically refers to a suite of technologies available to more precisely apply inputs, monitor growth and output, and understand agronomic relationships. A recent National Research Council report stresses that precision agriculture will require new linkages to optimally create new knowledge, will lead to an increase in the contribution of information to economic value in the sector, and will evolve with support services from a relatively unique combination of private and public sector sources (National Research Council)

The economic use of electronic communications has redefined numerous sectors and has the potential to make a similar impact in the agricultural sector (Sonka and Coaldrake). Most profoundly, business to business communications between producers, their suppliers, and their customers raises the potential for the elimination of deadweight losses in the agricultural value chain. In other sectors where these technologies have been employed, restructuring of supplier/customer relationships have been the norm.

Some Interesting Policy Issues

The structural realignments in agriculture that are part of the process of industrialization and the formation of food supply chains raises a number of interesting public policy issues and challenges. We will briefly summarize selected issues which we find interesting; numerous other policy issues could be identified and merit analysis.

Competitiveness of product and input markets

How will the structural changes that are occurring impact the competitiveness of the agricultural product and input markets? The development of tighter linkages which is an integral part of the formation of food supply chains may have an impact on market access in both the input and product markets. And the development of larger scale firms that are part of the industrialization of agriculture could result in sufficient concentration to create and enable these firms to exercise oligopolistic if not monopoly power in negotiating prices or terms of trade. How will the structural changes in agriculture impact access to product markets? What are the implications for producers, consumers and competitive markets? How will the structural changes impact access to input markets? More specifically is concentration in the poultry, pork and beef industries sufficiently high to warrant antitrust intervention? What are the consequences of such intervention (or of not intervening) in terms of incentives to innovate, efficiency, externalities and distribution of returns and risks?

Some would argue that the basic nature of competition has changed in recent years, and in particular the definition of the market is vastly different today than previously in terms of the product/service domain, the geographic domain and the entity. With respect to the product domain, particularly in the service market, the increasing importance of information as a resource and the ability to use the same customer information in a wide array of service industries (for example retailing and financial services) has resulted in the integration of many service industries. World-wide sourcing and selling has changed the geographic boundaries of markets from regional or national to global. And some are suggesting that as more industries develop increasingly more tightly aligned supply or value chains from raw material supplier to end-user, competition in the future will not be between firms but among chains.

Risk allocation in value chains

Who bears the risk and captures the reward in the increasingly more tightly aligned food chain? The common perception is that vertical linkages or alliances through ownership or contract production will reduce price, quality and quantity risk. Furthermore investment in value-added activities by producers is appealing because margins are often better in these activities, and more control of the food production-distribution chain can be acquired by involvement in additional activities in the value adding process.

But the implications for financial and strategic risk are less clear. If the margins in the value-added activities are negatively correlated with margins in production activities, risks are reduced from a portfolio perspective. But given that in the long run the same fundamental supply and demand drivers will shape the profitability and margins in the entire production and distribution chain, it is quite possible that these margins are not negatively correlated by positively correlated thereby limiting risk reduction potential. Even if the financial leverage of the vertically integrated firm is no different than the aggregated financial leverage of separate firms involved in the same stages of the food chain, the fact that this equity is supplied only by one firm or a smaller set of equity holders compared to the broader set associated with independent ownership of the stages of the production/distribution system will result in increased absolute risk exposure for those individuals. Policy responses and political pressures to protect producers in particular from these financial risks are likely if significant losses occur. In essence, the dispersion and/or concentration of financial risk as one moves from independent firms to vertical linkages is a critical issue that merits further analysis from a policy as well as a management strategy perspective.

Industrialized agriculture and externalities

Does an industrialized agriculture create more externalities (environmental problems, food safety problems) or fewer externalities? An industrialized agriculture is likely to be increasingly treated like manufacturing or any other industry when it comes to environmental regulation. Agriculture has been exempt in many instances from the environmental regulation faced by much of industry, in part because of the difficulty of regulating and monitoring non-point compared to point sources of pollution, and in part because of the small scale of many farm firms compared to the manufacturing complex. But as farming and agriculture become more industrialized, the rationale for exemption from regulation becomes less persuasive. This does not suggest that the agricultural sector will be subjected to more regulations than those encountered by non-agricultural industries; only that farming will be increasingly brought into the main stream of environmental regulation and have fewer exceptions from the environmental law of the land.

The environmental consequences of the industrialization process are not straight forward. As noted above, a larger proportion of agricultural production and resources might be subject to increasingly stringent environmental regulation, resulting in less potential environmental degradation. But with larger scale units, if there is an environmental accident, the consequences are more severe because of the increased concentration of pollutants as evidenced by the recent lagoon accidents in North Carolina and other states.

Similar to environmental regulation, an industrialized agriculture would be expected to be less except from current labor regulations that impact most other industries. Production agriculture is one of the more hazardous occupations in terms of worker safety, yet much of the industry is not regulated by the Occupational Safety and Health Administration (OSHA) and/or under more recent Worker Protection standards legislation.

The structural realignment in agriculture is in part a response to increasing concerns by food processors and retailers, as well as institutional food service companies, concerning issues of food safety and health as well as nutrition. And as a consequence of this process, food safety regulations may become easier to enforce and lower cost to implement. One of the significant implications of the negotiated linkages, which are part of the realignment process, is the ability to more accurately and easily document the processes used in producing agricultural products, including chemical and feed additive use. Such information is increasingly valuable to comply with nutritional labeling requirements, as well as to document compliance with food safety and health regulations that are increasingly imposed along the entire food chain.

Privatization of intellectual property and innovation

What role does intellectual property right law play in encouraging more tightly aligned supply chains and monopoly or oligopoly power? How does the privatization of research and development and information markets impact the rate of innovation? The distribution of the benefits of innovations? Access to markets? The competitive rivalry in markets? How important are property rights and rent seeking behavior in encouraging firm growth? In encouraging new innovation? In stimulating economic growth?

With the increasing importance of information as a source of strategic competitive advantage, the prospect that the information within a supply chain is superior and unique to that of a less tightly aligned, market coordinated production distribution system, and the opportunity to protect that information say in the form of genetic manipulation or biotechnology with pattern or copyright law, the issue of the potential of market power within a chain or in competitive positioning relative to other chains is increasingly possible.

The public policy issue of the role of the public sector in making information a public good that is broadly available to all potential users, and the more general issue of intellectual property rights, become critical with the formation of more tightly aligned supply chains of agriculture. The intellectual property rights debate has historically focused more on research and development and new innovations protectable under patent or copyright law. Particularly in production agriculture, the public sector has played a major role in the research and development activity, and thus provided broad access to new technology and ideas. In this context, part of the public purpose was developing and disseminating new ideas in a sufficiently broad fashion that a wide spectrum of users benefited, and so that individual firms could not restrict access and capture the value associated with the new idea. The public sector role was that of leveling the playing field so that all participants competed on the same grounds vis-a-vis access to new ideas and information.

But as more and more of the research and development and thus new ideas come from private sector firms compared to the public sector, and more of the information dissemination system becomes privatized, individual firms have more potential to capture value at the expense of end users. They have the potential to restrict access to new ideas and information to particular users, thus favoring some producers and excluding others from the ideas, technology or information necessary for them to be competitive. The concepts of intellectual property rights, including patent and copyright law as applied to agriculture, were developed in an era of domestic markets and national firms; a relatively large public sector research, development and information dissemination system, and a limited role of information as a critical resource. These concepts should be reevaluated in the current context of global markets and multi-national business firms; the shrinking role of the public sector in research and development and disseminating information; and the increasing importance of information compared to other resources as a source of strategic competitive advantage.

How Do We Analysis These Issues?

Discovering truth

The historical approach to discovering truth — to doing research — in the agricultural economics profession has been to follow the fundamental principles of the scientific method. Thus, agricultural economists have identified a problem or issue, developed testable hypotheses, collected data to verify or refute these hypotheses with econometric or other statistical techniques, and then have drawn conclusions based on the statistical characteristics of these tests. When attempting to view the future, this analysis of the relationship between past events and present or past outcomes has been used to draw projections or inferences concerning how the future might unfold. In essence, a fundamental tenant of this approach has been that past events caused past or present outcomes, and this approach to viewing the future is to infer a similar direction of causality.

An alternative approach that is implicit in much of the strategic planning literature and now being embraced by some economists has been referred to as that of "final cause". This approach to discovering truth in essence argues that the future mission or vision drives current actions which then generate current and future outcomes. In essence, the fundamental perspective of this approach to discovering truth about current and future events is that most outcomes result from purposeful decision making on the part of agents (consumers, producers, agribusiness managers, government policy makers, etc.) who have a objective or vision of the future and will attempt to accomplish that vision. This approach does not ignore the potential of acts of God or external events that may influence those actions of the agents, but it gives more credence to purpose - focused explanations of current and future events. This approach is the essence of the strategic planning framework of schools of management. In environments where great structural changes are occurring which are outside the boundaries of the historical data, and when the reasons for these structural changes may be in part the strategic decisions of agents who have a future vision or mission that they are attempting to accomplish, a purpose - focused final cause approach to discovering truth may have more promise.

Conceptual frameworks

So how can we obtain empirical answers and make concrete predictions concerning the numerous hypotheses and questions that are now only the focal point of speculation in most discussions concerning the implications of the structural changes in agriculture. Traditional microeconomic theory provides limited help because it assumes open markets and independent firms that react to market determined prices. Concepts of industrial organization are only partially helpful in that they assist in understanding the relationships between stage structure and performance, but do little to explain the dynamics of firm behavior and the interactions between and among firms at different stages within the production and distribution system.

Concepts from other fields of behavioral science may provide useful components of a conceptual framework to study coordination systems. These four fields are broadly defined as: (1) transaction cost and principal-agent theory, (2) strategic management, (3) negotiation/power and performance incentives, and (4) organizational learning. Each of these fields will be briefly introduced; the challenge is to integrate the appropriate concepts along with those from economics into a comprehensive analytical framework.

The concepts of transaction costs and principal-agent theory as conceived by Coase and expanded by Williamson and others indicate that the form of vertical linkages or coordination in an economic system (impersonal markets versus ownership or contracts) depends not only on economies of size and scope as suggested by conventional theory, but also on costs incurred in completing transactions using various coordination mechanisms. Furthermore, these costs and the performance of various coordination mechanisms depend in part on the incentives and relationships between the transacting parties in the system—the principal and the agent. Under various conditions, the agent may exhibit shirking behavior (i.e., not performing expected tasks) or moral hazard behavior (i.e., the incentives are so perverse as to encourage behavior by the agent and results that are not consistent with, or valued by, the other party to the transaction—the principal).

Given these fundamental behavioral principles, Mahoney suggests that the form of coordination or business linkages will be a function of three characteristics of the transactions and the industry: (1) asset specificity, (2) task programmability, and (3) task separability. Asset specificity refers to the specialized nature of the human or physical assets that are required to complete the transaction; the more idiosyncratic the asset, the stronger the linkage or bond required for the transacting parties to invest in that asset. Task programmability indicates that a transaction is well understood by all parties and often repeated, thus not requiring intense discussions or negotiations and easily accomplished by impersonal coordination mechanisms. Separability refers to the ability to determine and measure the value of the contribution and thus the reward that should be given to each participant in the transaction. If that can be accomplished easily (and thus the transaction is separable), coordination systems that are less personal are relatively more efficient and effective than when separability does not exist.

The second set of arguments that might assist in understanding and predicting structural realignment comes from the strategic management literature. In essence, these concepts are derived from Porter's value chain (the value-added activities that result in the transformation of raw materials into finished goods), strategies to develop a strategic competitive advantage, and the criteria or considerations in the integration (buy versus build) decision. In general, this literature indicates that the buy versus build decision is driven by: (1) internal considerations of costs, technology, and financial and managerial resources, and (2) external competitive considerations of synergies, differentiation, and market power and positioning. Harrigan has captured the essence of the strategic management vertical integration arguments for the build rather than buy decision and, thus, the determinants of the most effective coordination mechanism as summarized in Table 1.

The third set of arguments that may help explain the implications of various relates to the concepts of negotiation and performance incentives. With personal, negotiated coordination among stages in the food chain, the invisible hand of the market is replaced by the very visible hands of buyers and sellers negotiating the terms of trade, in many cases prior to the production or manufacturing process. In such a system, phenomena such as negotiation strategy and skill, power, conflict resolution, trust, and performance monitoring and assessment become central to effective and efficient functioning of the economic system and the sharing of risks and rewards in the system. Concepts of negotiation strategy and tactics as developed by Donohue; Fisher; Putnam and Jones; and others may assist in understanding not only what form a negotiated coordination will take, but also how the risks and rewards will be shared.

Recent work on various approaches to provide performance incentives, as proposed by Casson but rarely referenced in the literature on coordination of economic systems, may also be useful. The basic presumption of Casson's work is that overall economic performance of any system depends on transaction costs, and these costs mainly reflect the level of trust that exists in the economy.

A crucial question in any economic transaction, and particularly in those that are personal and negotiated, is whether the other party to the transaction can be trusted. There are two fundamental approaches to engineering or creating trust. The one most commonly used in much of the Western world is to monitor performance through the institutional and legal system and penalize those parties that do not fulfill their negotiated commitments. An alternative approach to engineering trust is to manipulate the incentive structure sot hat individuals fulfill their commitments based on rewards they receive rather than penalties they incur. These incentives can be economic or emotional; the economic incentives are standard fare for economists. The emotional incentives of guilt or satisfaction have not been the focal point of economic analysis, but are part of the psychology of individuals and influence their participation in business transactions. This is particularly important in personally negotiated transactions in contract markets and less so in impersonal transactions common in open spot markets. Casson argues that emotional rewards and penalties are part of the preference structure, can be manipulated, and thus can be optimized.

Table 1. Some advantages and disadvantages of vertical integration

Advantages	Disadvantages
Internal benefits	Internal costs
Integration economies reduce costs by eliminating steps, reducing duplicate overhead, and cutting costs (technology dependent).	Need for overhead to coordinate vertical integration increased costs. Burden of excess capacity from unevenly

Improved coordination of activities reduces inventorying and other costs Avoid time-consuming tasks, such as price shopping, communicating design details, or negotiating contracts.	balanced minimum-efficient-scale plants (technology-dependent). Poorly organized vertically integrated firms do not enjoy synergies that compensate for higher costs.
Competitive benefits	Competitive dangers
Avoid foreclosure to inputs, services, or markets Improved marketing or technological intelligence. Opportunity creates product differentiation (increased value-added). Superior control of firm’s economic environment (market power). Create credibility for new products. Synergies could be created by coordinating vertical activities skillfully	Obsolete processes may be perpetuated. Creates mobility (or exit) barriers. Links firm to sick adjacent businesses. Lose access to information from suppliers or distributors. Synergies created through vertical integration may be overrated. Managers integrated before thinking through he most appropriate way to do so

Source: Harrigan

The manager has two fundamentally different strategies available to encourage efficiency/productivity/performance—a manipulation strategy and a monitoring strategy. The choice of which strategy to use clearly depends upon cost and effectiveness. Casson argues that, generally, a monitoring strategy is preferred when manipulation is costly. This is more frequently the case if information and communication services are expensive, the manager lacks charisma or persuasive skills, or the manipulation intensity required is very high such as in hazardous situations or those in which personal/emotional safety and health are a consideration. Monitoring may also be more effective in cases of routine/definable tasks common in the manufacturing or distribution process. A manipulation strategy works best when monitoring costs are high, communication costs are low, the manager has persuasive skills and charisma, and performance is more difficult to measure and monitor as is frequently the case in service industries and when intellectual skills are involved in contrast to mechanical/manual skills.

The impossibility of writing a complete contract and asset specificity associated with modern agricultural production accentuates the role of trust in contract coordination. In a continuing game even the large contractor who is recognized as being in control must maintain a reputation for fairness. The contractor needs the set of contractees as much as the contractees need the contractor. And a contractee’s reputation may well determine whether she/he gets the benefit of doubt in an unusual situation.

Strategic management has benefited over the years from two schools; the "design" and the "learning" schools (Mintzberg, 1994). The preceding discussion of strategic management referenced more heavily the design school perspective. In contrast, the 'learning' school of strategy asserts that strategy formulation/implementation must be part of an ongoing process in order to be successful (Mintzberg, 1994). Recent analyses of successful strategy outcomes in the petroleum, electronic, and pharmaceutical industries stress that the strategy making process can be represented as a learning process (De Geus; Nevis *et al.*; Nonaka and Takeuchi; Skivington and Daft). Although learning is a cognitive action performed by individuals, organizational learning (Senge) is a metaphor that characterizes the response of members of an organization to challenges from both the internal and the external environment of the firm. As individuals learn, their responses change assumptions, strategies, and norms of the organization, and these changes have implications for the organizations in which they are members (Simon). Hence, organizational learning ought to be an essential ingredient in linking the strategy formulation and implementation processes. Further methods currently being explored to further organizational learning also ought to have applicability in analyses focused on discovering the marketplace effect of firms that are more effective and of sectors that are being restructured in that process.

Evidence/measurement

Consistent with the purpose focused final cause methodology of analysis, obtaining evidence to refute various propositions or hypotheses may also differ from that used in traditional economic analysis. As has been noted earlier, most economic analyses use historical data to test cause and effect relationships that have been specified as testable hypotheses. Purpose focused final cause analysis requires documentation of current decisions along with future directions that agents have specified as part of their mission or vision; it involves specification of intent. But intent may not show up in actions or actual performance, so final cause analysis also requires event or scenario assessment to determine the consequences of alternative actions as well as the potential interaction of agent actions, competitor response or environmental constraints. Although such analyses may be judged to be suspect by many economists, they are increasingly acknowledged and utilized by not only business firms but even government agencies such as the financial regulators who commonly use various forms of probabilistic stress testing techniques to assess the vulnerability of financial institutions and insurance companies as well as public insurance agencies such as the federal insurance programs for banks and savings associations to defaults and financial stress resulting from management decisions and changes in the business and economic climate. In reality these analyses are based on purpose focused final cause simulation models that project future events based on current actions. No doubt these analyses draw on historical information and relationships in part for specification, but they are not limited to history if new relationships and determinants of the future that are not part of history have become part of the decision nexus and economic environment.

A further challenge in obtaining evidence and measuring the future results of current structural realignments in the agricultural industries is that much of the data needed to understand this phenomena is not part of the accounting or measurement systems used in most economic or financial analyses. Much of this structural realignment we see in the agricultural industries today is not the result of realigning the resources within a firm, but results from realigning the relationships between and among firms. The focus of this realignment is not within firm or within stage performance, but on the transactions that occur between the economic stages in the food production and distribution system. The performance within a firm or stage is not unimportant, but within stage or firm optimization is easier to analyze and understand the traditional concepts of economics than between firm transactions which can be best analyzed with transaction analysis concepts as discussed earlier. Our data sets for doing the former analysis are well developed and include such measurements as those found in standard financial statements secondary data sources; they include primarily physical product and financial flows as illustrated in column one of Table 2. But the structural realignments that focus on transactions between stages or firms require an understanding of relationships and information flows as well as physical product and financial flows. The focus here is on the human or interpersonal dimensions of transactions. As reflected in the second column of Table 2, useful measures of efficiency or effectiveness of relationship and information flows include such phenomena as trust, accuracy of messages, flexibility, commitment, speed of response, strength of signals, equitability of sharing cost/revenue/risk, adaptability and cost. Developing cardinal or ordinal measurement systems to quantify these important determinants of interfirm or interstage linkages and transactions will be crucial to understand and predict or project the structural realignments currently taking place in the agricultural and food distribution industries.

Table 2. Measurement of Economic Performance

Physical Product/Financial Flows	**Relationships/Information Flows**
1. Quality	1. Trust

2. Yield/input-output/physical efficiency	2. Accuracy of messages (information)
3. Economic value	3. Flexibility
4. Market or transfer prices	4. Commitment
5. Time to market	5. Speed of response
6. Errors/mistakes	6. Strength of signals
7. Cost	7. Equitability (fairness)/distributional issues
8. Profits	- cost
9. Return on assets	- revenue
10. Cash flows	- risk
11. Capital turnover	8. Adaptability
	9. Cost

Selected Empirical Studies

Empirical work is beginning to emerge using the conceptual streams discussed above to better understand the policy issues and management challenges resulting from the structural realignments in the food production and distribution industries. In this section of the paper, several empirical investigations will be briefly discussed. One of those investigations, a system dynamics based analysis of supplier/customer linkages in the pork sector will then be reviewed in some detail. The purpose of this more detailed exposition is not to suggest that this single approach is necessarily preferred, but rather to illustrate the challenges and potentials in this type of application.

Den Ouden has analyzed the financial, environmental, and resource utilization implications of different forms of vertical linkages in the Dutch pork supply chain. Her analysis was one of the first to numerically document the tradeoffs between economic, environmental, energy conservation and animal welfare goals as well as the differences between different forms of coordination (loosely aligned markets vs. more tightly aligned alliance and other structures) on effectiveness of accomplishing multiple goals of low cost, energy efficient, environmental friendly, and animal welfare responsive pork production.

Lentz and Akridge analyzed alternative marketing channel configurations to provide soybean peroxidase (a soybean hull enzyme used in industrial markets) ranging from a commodity channel to a sorting channel to a channel involving full identity preservation of the crop. A sorting or segregate channel reduced sourcing cost by 35% compared to standard commodity supply chain approaches, but identity preservation of the crop is not justified at current levels of peroxidase production and identity preservation cost.

Ray evaluated the financial consequences in terms of both risk of contractual vs. open market pork production. This analysis of the return on equity and return on assets indicates that even though the ROA may be lower in contract production, if lenders recognize the reduced operating risk for a contract producer and allow them to increase their financial leverage, the ROE under contract production may in fact be higher than that for an independent producer. In a study of mergers and acquisitions in the agricultural technology industries Inaki is attempting to use the concepts of real options theory to determine the form of vertical linkage (acquisition, joint venture, strategic alliance, licensing agreement) and the financial performance of various firms in the industry. This work builds on that of Miller and Folta who used a similar framework to analyze and predict the form of alliance in the biotechnology industry.

Lajili, et al. report on an innovative experimental analysis that conceptually links principal agent theory and transaction cost economics to explore desired vertical coordination characteristics from the producer perspective. Employing simulated decision and preference ordering techniques with a sample of 25 commercial producers, this analysis clearly documented that producers do not favor a "one-size fits all" contracting approach. Instead, statistical results support conclusions that asset specificity significantly influences farmer choice of contract arrangements, whereas uncertainty and the interaction between asset specificity and uncertainty play a significant role in pricing behavior and the choice of contract form. Among the farmer characteristics, risk aversion and leverage significantly affect bidding behavior and financing preferences, respectively. The results also confirm the need to jointly consider transaction attributes and personal and business characteristics to explain vertical coordination decisions.

Dynamic hypotheses of interorganizational activity coordination

The following discussion explores, in some detail, a system dynamics-based analysis of supplier/customer linkages in the pork sector. The underlying goal of the system dynamics method is to propose a set of hypotheses about how relationships within the structure of a system influence its behavior given a set of interactions among stocks and flow rates (Forrester, 1961; Mass). This approach is consistent with the perspective that a detailed and explicit understanding of system structure is a critical ingredient for creating economic value from successful strategic alignment with the business environment (Porter, 1994).

Model overview: Empirical supply chain investigations often investigate relationships at the sector level or at the level of individual (or small groups) of suppliers and customers. A novel feature of the System Dynamics Pork Coordination Model (SDPCM) developed here is that it endogenously incorporates both a market level, commodity supply/demand system and a single prototypical pork value chain (a group of suppliers serving an individual processor) operating within that commodity system. Figure 1 illustrates this linkage between the business environment and the pork value chain.

This research concentrates on coordination issues at the boundary between hog production and pork packing. It builds upon earlier conceptual work applying system principles to strategic analysis of change factors in today's evolving agricultural sector (Cloutier, et.al., 1997a; Cloutier, et.al., 1997b) Overabstraction and conceptual ambiguity are hazards that can impair the effective development and modeling of problems relating to activities within and across organizations, and the proper characterization of influences from the business environment. To address conceptualization issues, the 'pork chain' specification in this work adapts the business environment terminology of the framework developed by Castrogiovanni.

Depicted in the center of Figure 1, the task environment includes activities that are represented within producer firms and the packer. The model includes three main activities managed by the packer; hog procurement, packing, and pork meat marketing. At the producer level, production and market delivery activities are represented in the model. This depiction of the task environment follows Osborn and Hunt (233) and includes for the subject firm, "those organizations with which it must interact to grow and survive." The business environment concept of Figure 1 is consistent with Castrogiovanni's 'macroenvironment' for a specific industry. Agricultural economists will recognize this concept as supply and demand at a commodity level, in this case the pork sector in the United States.

The tendency in agricultural economic research is to infer behavior based on exogenous factors of industrial economic archetypes (administrative versus market control) for competitive markets relative to vertical or horizontal coordination. In particular, research on interorganizational arrangements emphasizes economic forces that determine exogenous 'causes' for structural changes, including technological or transactional innovation. In contrast, the methodological approach taken in this research emphasizes, not the boundary between firms, but rather boundaries between activities within a firm as well as interaction with activities of other firms.

Porter (1985) broadens the functionality of firms (or strategic business units) to include a set of activities within the firm (Figure 2). Consistent with the system dynamics approach, the representation of the coordination process at the activity level within a firm allows the detailed characterization of activities that yield endogenous responses to the market stimuli of the business environment. The shift in the unit of analysis from market structure to the activity level allows the modeling of endogenous forces within firms that determines dynamic behavior across linkages.

Figure 2 depicts the producer and packer value chain at the activity level. The appropriate amount of detail to include at the activity level, of course, depends on the specific objectives of the research (Porter, 1985). For example 'Hog Production' could be further detailed to include farrowing/nursery/finishing as distinct activities but is not done so in this effort to maintain focus on market coordination between producer/packer activities.

Modeling alternative market coordination mechanisms: Figure 3 depicts supply and demand interaction in the market (capitalized letters denote market level influences). This influence diagram illustrates commodity market oscillatory, or cobweb, behavior taking place between two time delays. In the market, there are a number of producers willing to supply at a given price and there are a number of buyers demanding a certain quantity at a given price. The market price is a single adjustment mechanism equilibrating pressures between supply and demand for the commodity over time.

Oscillations between supply and demand quantities occur because of time delays both for producers to supply the quantities demanded and for buyers to use the quantities available. For example, suppose that there is an exogenous shock that increases demand (B2). At first inventory is depleted. This is based on the assumption that producers follow the 'sell-then-make' tactical process and inventories are used to store the excess supply. When the demand extends long enough to deplete inventory, the market price begins to rise. A rising price has the immediate effect of reducing the quantity demanded. It also gives an incentive to producers to increase supply. There is a further time delay between a change in price and the actual increase in supply (B1). This time delay accounts for the reaction time for producers to perceive the price change being reflected in their profit margins and for administrative delays to bring more resources to production. Time elapses during the actual production period as well. Before the additional supply comes to the market, demand becomes even more sluggish as the upward price trend continues. As the additional supply comes to the market, the price falls to reflect new demand/supply conditions. The immediate consequence is an increase in demand and then a contraction of production as the lower prices affect profits for the supplier and the customer. The oscillatory cycle will start again after inventories begin to deplete.

The aggregate market level supply and demand fluctuations introduced in Figure 3 trigger fluctuations in desired orders and economic shipment capacity that occur at the operational level for a customer and its suppliers. This operational dynamic is represented by the influence diagram in Figure 4 (lower case letters denote firm level endogenous influences). The diagram describes the processes by which market conditions translate into operational decisions. The diagram depicts the generic case, where the bid price used by the customer to place orders is determined 1) by the market supply, demand, and price in conjunction with 2) the desired economic shipment capacity available from potential suppliers and 3) the customer desired order level. The assumption is that the bid price is based on fluctuations in profit margins experienced by the customer. Depending on specific business conditions in a given area, the customer might want to increase or decrease the desired order level of raw material to reflect immediate operating concerns.

The commodity price coordination mechanism: Figure 5 presents the structure of commodity price coordination for the exchange of quantity flows from suppliers to the customer. Commodity price coordination adds operational and tactical level responses to the coordination of activity profit margin changes (Figure 4). The desired economic shipment capacity and orders introduced in Figure 4 (loops B3 and B4) are shown at the center of Figure 5 between supplier/customer reinforcing and equilibrating loops.

The behavior associated with the reinforcing loop B5 comes from the customer coordination of activity margins. Changes in profit margins trigger endogenous coordination adjustments. Two influences pressure customer margins. One influence is the desired economic shipment capacity of suppliers and the other is the downstream price for customer output. There are two responses to these changes in margins. First, at the operational level, the customer can attempt to influence the suppliers' desired economic shipment capacity by adjusting the bid price (R1b). The assumption is, because supplier response to a change in price is positively related, a change in the direction of the bid price results in a change in the same direction in desired orders. Second, the customer tactical response influences expected margins (B5) and adjusts desired orders to levels consistent with the bid price (R1b). But the influence of the tactical response on desired orders takes some time because the current order flow cannot be adjusted instantaneously due to operational rigidities (labor and committed downstream orders).

The structure of the equilibrating loop B7a, which regulates supplier coordination of activity pressures, is influenced by the bid price and input prices. Note that customer orders do not directly influence supplier coordination of activity profit margins within the commodity price coordination mechanism. Instead the customer profit margins influences the operational and tactical behavior of supplier profit margins by adjusting the bid price. Figure 5 depicts two responses. One is the operational adjustment in the desired economic shipment capacity. This is an immediate response to a change in the customer's bid price. Assuming that demand is negatively sloped, a change in the bid price influences desired economic shipment capacity inversely. The tactical response lessens the coordination pressure, by influencing expected margins. The supplier tactical responses influence the shipment capacity. But there is a time delay associated with the implementation of decisions and adjustment of production flows before a change in the desired economic shipment capacity is actually realized. Even though decisions to adjust production levels can be made instantaneously, the effect of those decisions on production throughput levels typically appears several months later.

The component price coordination mechanism: Figure 6 describes the structure of the component price coordination mechanism. The difference between the commodity price and the component price coordination mechanisms is the intraorganizational dimension targeted to enhance conformance in output-specific flows within the system. Component price coordination operates by exchanging quantity flows across an array of conformance characteristics (rather than just one characteristic (quantity)) from suppliers to the customer. Reinforcing (R3) and equilibrating (B6) loops show the structure of tactical components at the customer level. The use of the component price incentive mechanism to influence the conformance of the raw material procured is a tactical response. The customer tactical response forms expectations of conformance needs relative to market conditions. There is an inverse relationship between discrepancies in expected and procured conformance and the perceived need to invest in activity coordination. Investment in activity coordination improves the customer profit margin but the process involves a time delay. Because the effects of investments on profit margins are not felt immediately, the perception of expected profit margins, which also is delayed, can lead to under or over investment in strategic activity coordination. Although information about component prices conveys intentions about the specificity of customer desired orders, it is similar to commodity price coordination in not providing information about the number of expected customer orders or quantities.

In the component price coordination system, the strategic information generated about conformance is used internally to correctly value the material good exchanged. The tactical conformance decision loops of suppliers (B8 and R4) are analogous to the customer loops B6 and R3.

The information feedback coordination mechanism: The structure of the information feedback coordination system is outlined in Figure 7. The main difference between the information feedback coordination and the component price coordination mechanisms is the added interorganizational information feedback dimensions at the strategy level. One structural difference is the addition of a direct information link between customer orders and supplier coordination of activity pressures (R2a). Information feedback coordination allows the customer to influence supplier desired shipment capacity both through the bid price and with information about quantities needed through orders.

Reinforcing loops R5 and R6 represent interorganizational information feedback mechanisms. Reinforcing loop R5 shows that supplier information feedback influences the customer conformance expectations. Similarly, R6 shows that customer information feedback influences supplier conformance expectations. Importantly note that there is no time delay involved between information feedback and its influence on conformance expectations. Time delays for a change in profit margins from improvements in conformance delivered (or procured) come from physical shipment delays. Suppliers and the customer can use information feedback immediately even if shipments are delivered several months later. Suppliers and the customer have less temporal uncertainty because information feedback about price incentives, quantities, conformance, delivery timing, and duration of supply can be used to align procurement, execution, and marketing activities in advance of shipments. This is significantly different from the commodity and component price mechanisms because, in those cases, adjustments are made only after the raw material physically arrives. Reactive adjustments create additional time delays and temporal uncertainty in the system because of unknown quantities, conformance, delivery timing, and duration of supply.

Illustrating The effects of alternative coordination mechanisms on value chain behavior

The modeling tool just described can be employed to explore numerous empirical questions. To do so, of course, requires extensive data acquisition and model verification/validation activities. The associated activities undertaken to create the System Dynamics Pork Coordination Model (SDPCM) are described in detail in Cloutier. The following discussion is meant to illustrate application of the system dynamics approach, not to provide a detailed analysis of supply chain coordination in the pork sector. Again much more information about those results are available in Cloutier.

The following empirical application of the SDPCM will focus on exploring the role of information feedback and time delays between two supply chain coordination mechanisms. The two coordination mechanisms are the component price mechanism and the information feedback mechanism. The traditional price coordination mechanism was included in the previous conceptual discussion because it is interesting and it provides an effective mental bridge for agricultural economists. However, its actual use in the market is diminishing greatly. Therefore results of separate runs for that coordination mechanism will not be reported here.

Two scenarios, that differ in terms of demand and supply assumptions, are employed in the following illustration. A linear growth in demand of 10 % over a period of 80 months is depicted in Figure 8 (line 1). This is a slightly more aggressive growth rate than the eight percent growth in pork consumption reported by the USDA over the 1988-94 period. The oscillating curve in Figure 8 (line 2) depicts a sinusoidal pattern of 0.03 amplitude around the 10 % growth rate with a frequency of eighty months. The oscillating growth pattern is employed in both of the following scenarios.

The second factor considered in the two scenarios is fluctuation in supply. The variable chosen to reflect supply fluctuation is pigs weaned per litter. Historical quarterly data between 1988 and 1994 give a mean of 7.95 pigs per litter and a standard deviation of 0.17. The data also indicate that the number of pigs per litter has grown by five percent over this period. Figure 9 shows the specification of pigs per litter as a normal variable with an assumed standard deviation of 0.5, rather than the documented 0.17 (line 1). This is to amplify the fluctuation effect of pigs per litter in the scenario simulations. The normal variable is specified around the base case model specification of eight pigs per litter and a growth rate of five percent over the 80 months (line 2).

Oscillating Demand Growth: The first of the two illustrative scenarios uses the oscillating demand growth pattern shown in Figure 8 with no uncertainty relative to supply fluctuation. Key results for this scenario are provided in Figures 10 through 13[2] and reveal a number of interesting behavioral patterns. During the initial growth phase of the model, there are no real distinctions between results for the price coordination mechanisms and those for the information feedback mechanisms. However, as demand turns downward after month 25 or so, indicators for the alternative coordination mechanisms begin to exhibit distinctively different frequencies and amplitudes. This emphasizes the notion, that when information repeats itself (as in the steady growth through month 24), there are no real benefits associated with a faster transmission of information. But as soon as the model enters its oscillatory mode, faster information transmission across the production, wholesale and retail boundaries has an impact on behavior as it dampens supply overshoot even when there is upstream biological ('pipeline') time delay. This set of results is consistent with the theoretical observations of Mitchell.

Oscillating Demand Growth and High Frequency Fluctuations in Supply: The second scenario combines oscillating growth in demand with the high frequency supply fluctuation of Figure 9. Results are provided in Figures 14 to 17. The nonlinear and dynamic patterns shown on these graphs are somewhat surprisingly similar to those of the first scenario. Apparently, demand oscillation and its influence on breeding response have a greater influence on the structural dynamics of the system, than do the fluctuations in the existing flow of hogs. However, the flow of hogs does impact the amplitude of the indicators depicted on the graphs. What is key, however, is that although the amplitude is changed, the influence of faster information transmission does impact on the speed of stock fluctuations within the system and, hence on the frequency of the cycle. This results in reduced boundary pressure across the production and wholesale levels (Figure 14) and smoother patterns for all other indicators as well.

Conclusion

The current massive restructuring of the US agricultural sector offers both opportunity and heightened responsibility to agricultural economists interested in the performance of this sector. Important policy issues, a few of which were discussed in this paper warrant thoughtful, empirical investigation. Even when historic data are available, however, the turbulent, rapidly changing environment within which the sector is operating suggests that the applicability of econometric evaluation of that data will be limited Therefore, alternative conceptual and empirical approaches to address these challenges were suggested and explored in this paper.

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Footnotes

1. All coordination mechanisms are presented to outline key features about them. The assumption is that suppliers and the customer have access to general market information from government and private organizations about market trends and outlooks. Expectations addressed here relate specifically to coordination mechanisms that define the relationship between suppliers and the customer.

2. The interface pressure, production expansion and chain speed efficiency are ratios defined as follows:

- **Interface pressure.** Measures the stability of the system and is the ratio of wholesale output to slaughter.

- **Production expansion.** Measures the production throughput volume in each period normalized by its level at the start of the simulation. This indicator can be used to look at indications of production overshoot (or undershoot) during the simulation.

- **Chain speed efficiency.** Measures the percentage capacity utilization of the packing facility. The goal of the packer is to maximize the number of hogs going through the kill and cut floors. This ratio depends on the interaction between disassembly and economic capacity within the value chain. A chain speed efficiency greater (less) than one reflects economic expansion (contraction) relative to the initial level. The ratio is calculated by dividing the packing throughput by the packing capacity.

Figures

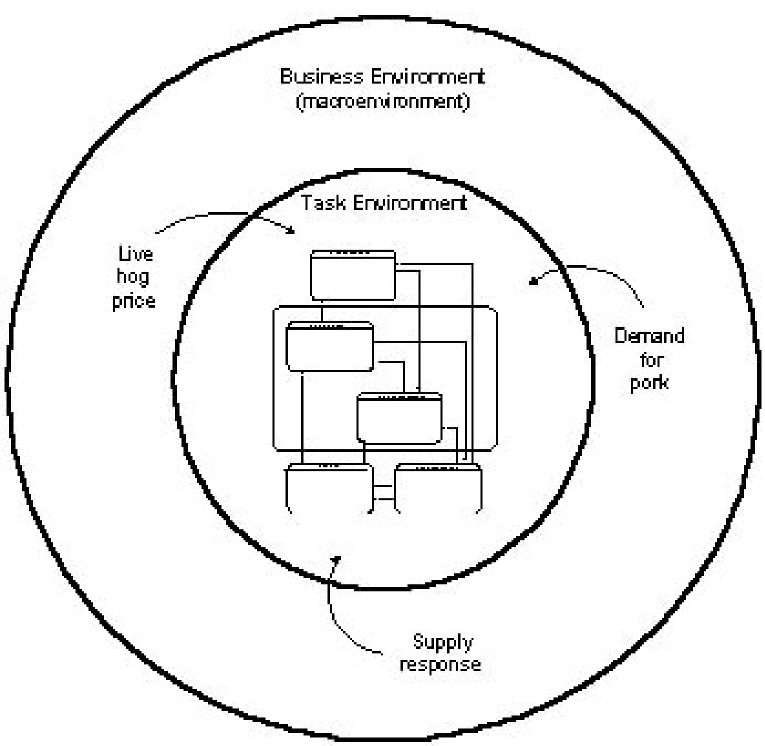

Figure 1. Business environment and value chain conceptualization

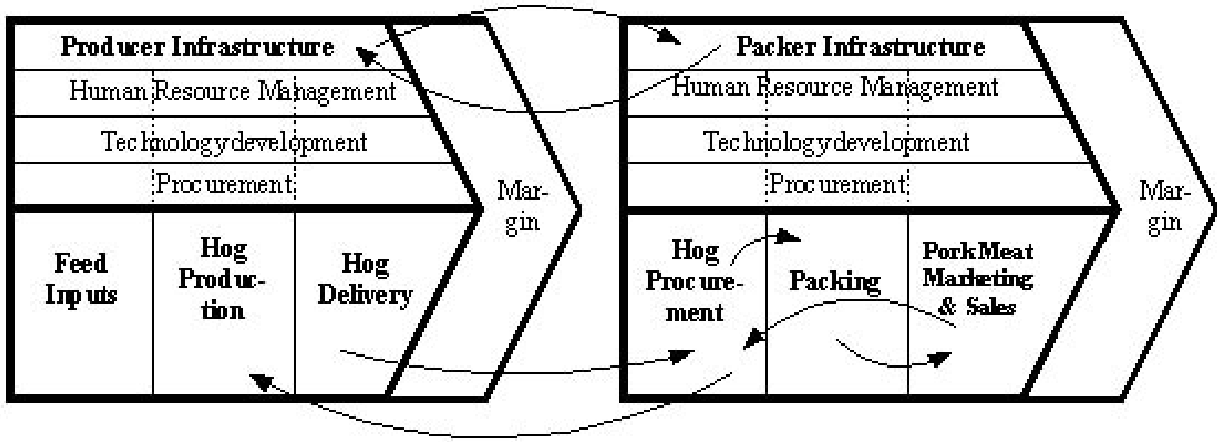

Figure 2. Examples of coordination at the activity level within the 'pork chain' at the producers and packer boundary

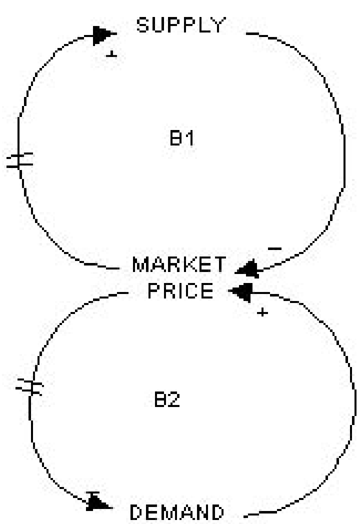

Figure 3. Influence diagram of market dynamics

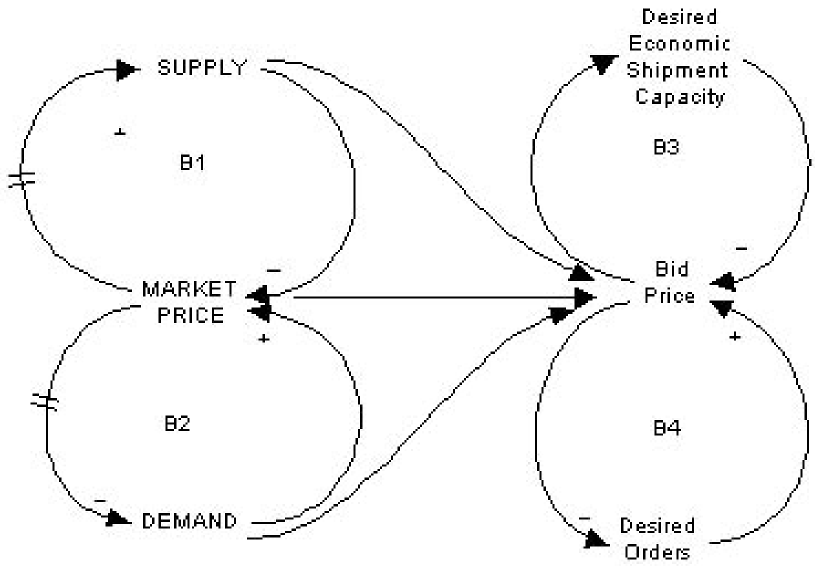

Figure 4. Influence diagram of market and customer interface

Figure 5. Influence diagram of the commodity price coordination mechanism

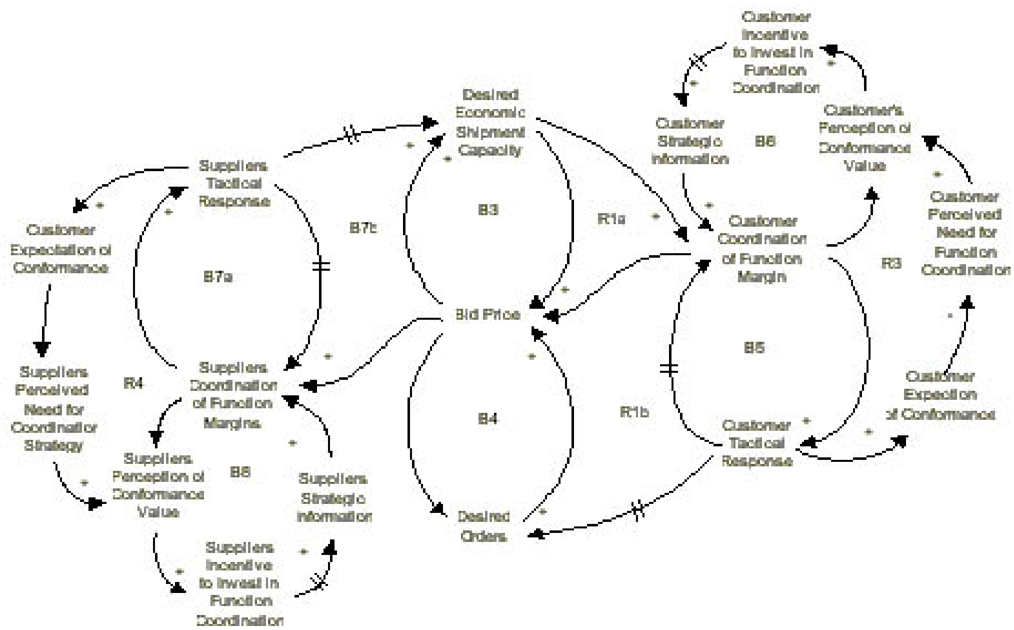

Figure 6. Influence diagram of the component price coordination mechanism

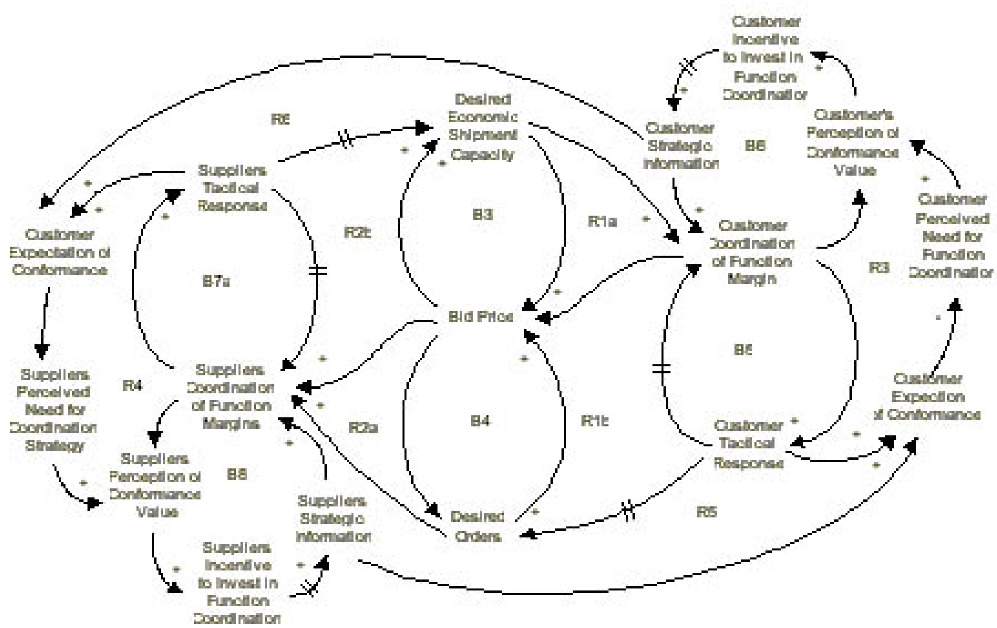

Figure 7. Influence diagram of the information feedback coordination mechanism

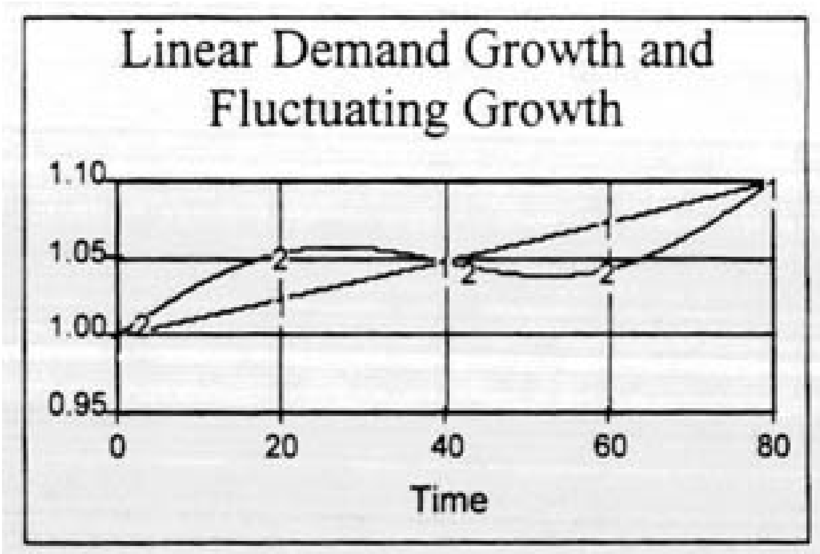

Figure 8. Oscillating Demand Growth

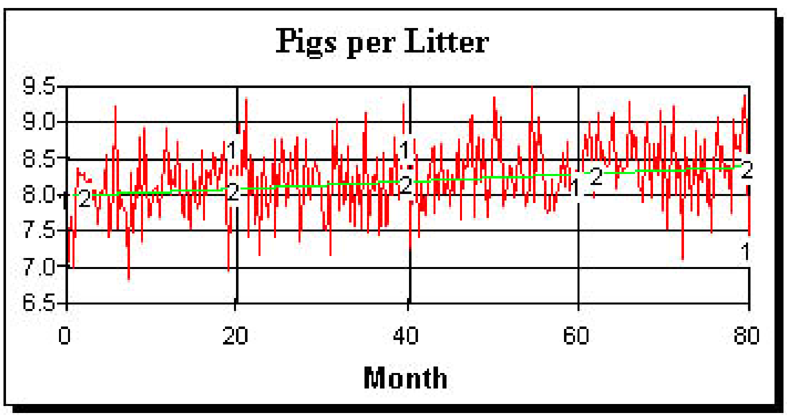

Figure 9. High frequency fluctuations in supply

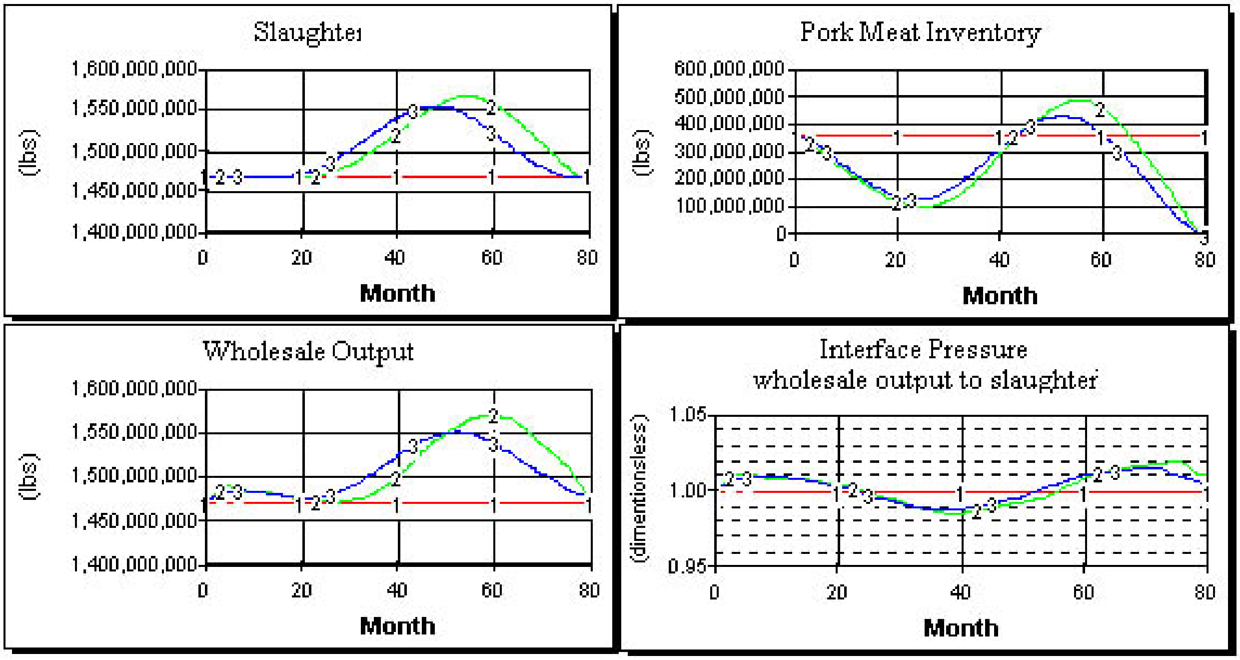

Figure 10. Business environment results for slaughter, output, and inventory for the oscillating demand scenario.

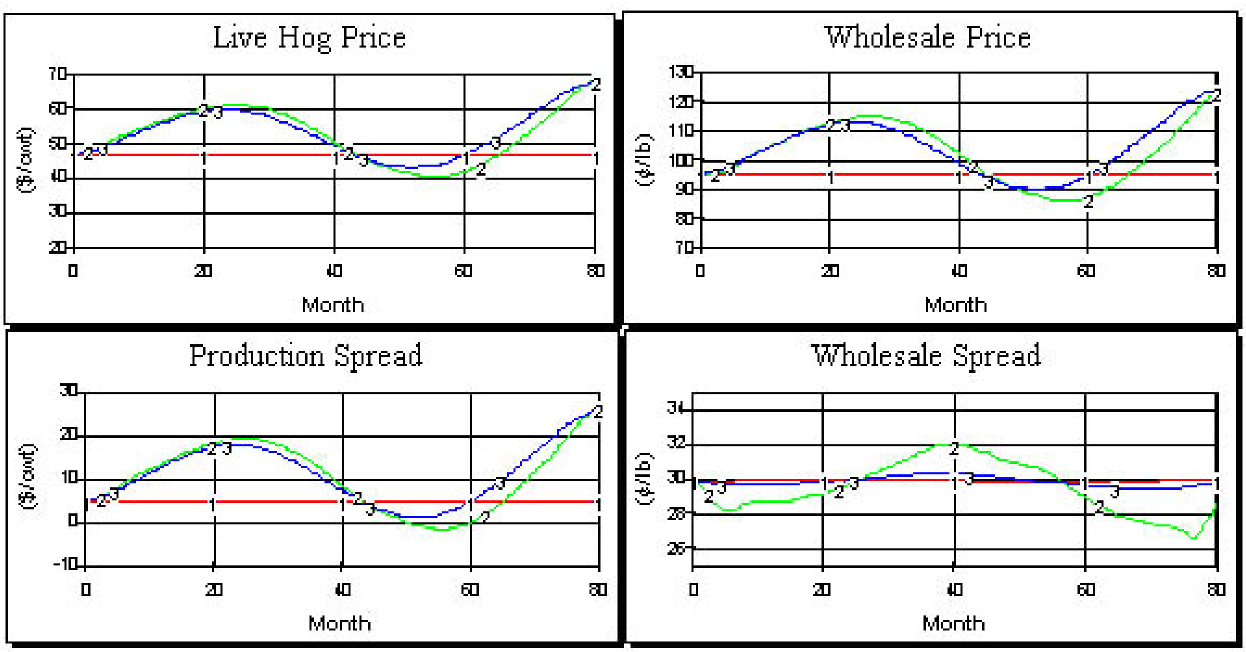

Figure 11. Business environment results for live hog and wholesale prices and spreads for the oscillating demand scenario.

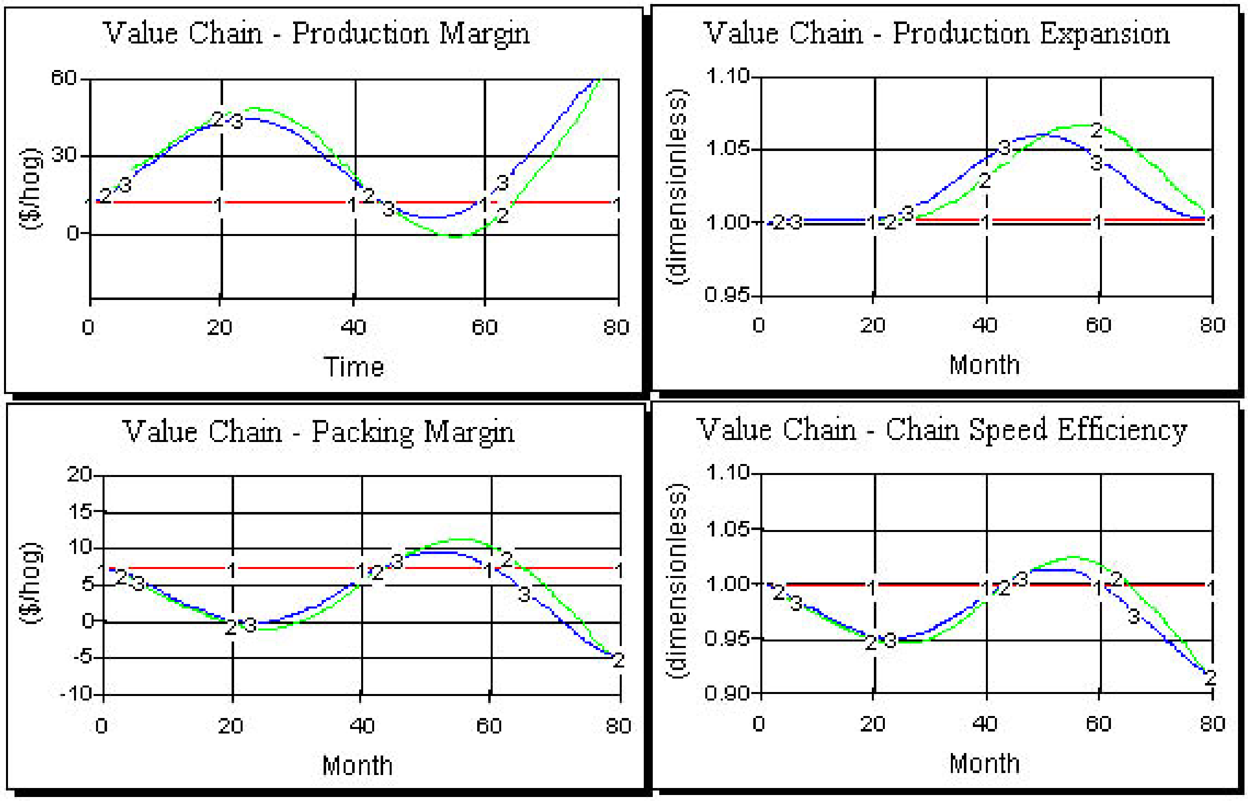

Figure 12. Value chain results for margins and expansions for the oscillating demand scenario.

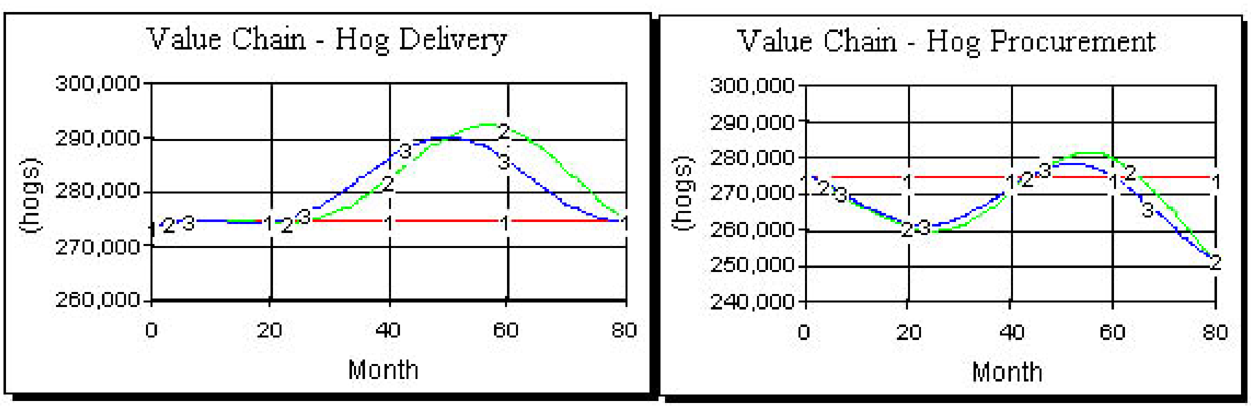

Figure 13. Value chain results for margins and expansions for the oscillating demand scenario.

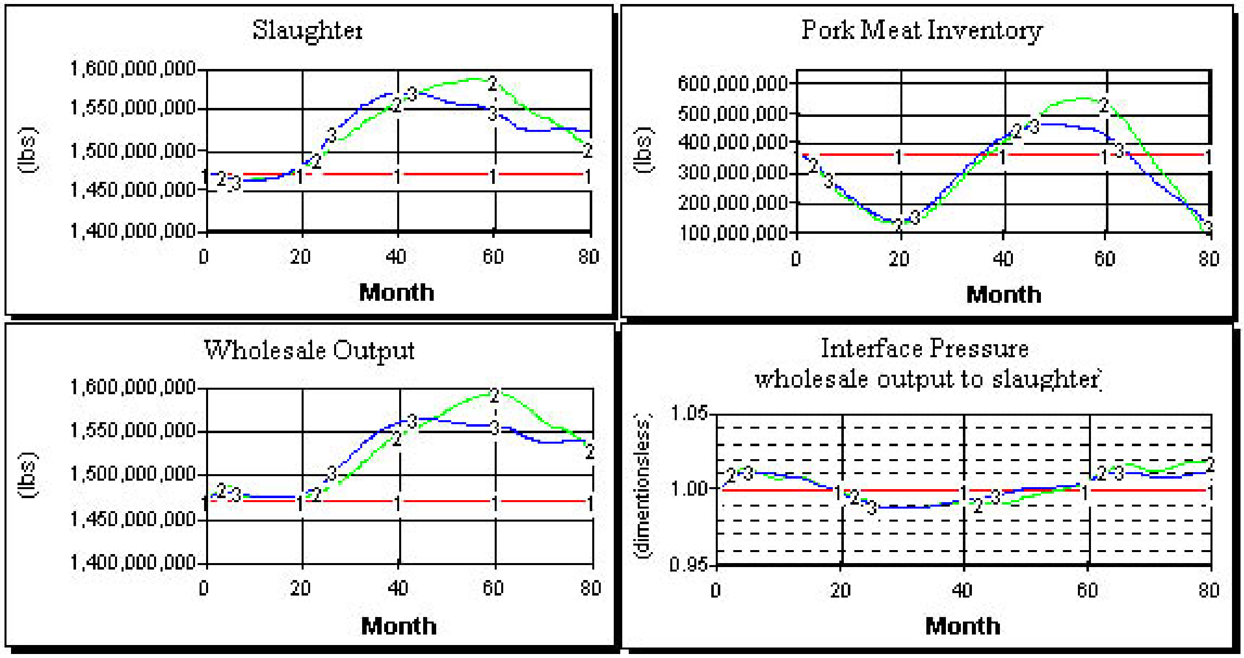

Figure 14. Business environment results for slaughter, output, and inventory for the oscillating demand and fluctuating supply scenario.

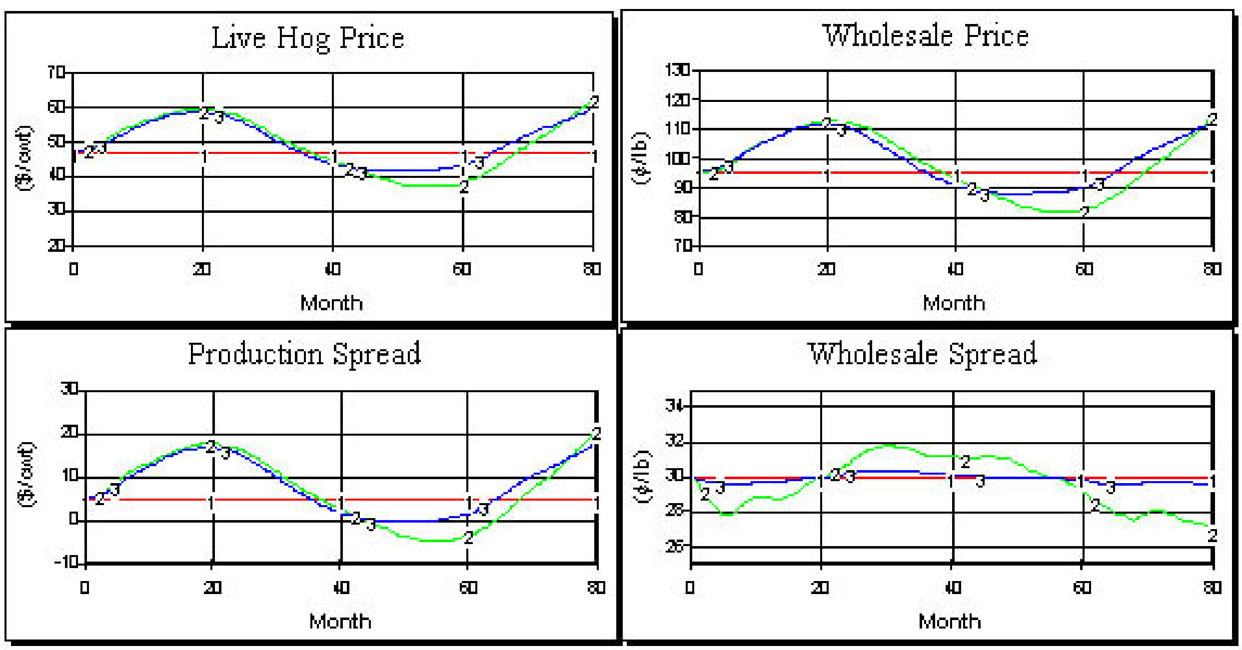

Figure 15. Business environment results for prices and spreads for the oscillating demand and fluctuating supply scenario.

Figure 16. Value chain results for hog delivery and procurement for the oscillating demand and fluctuating supply scenario.

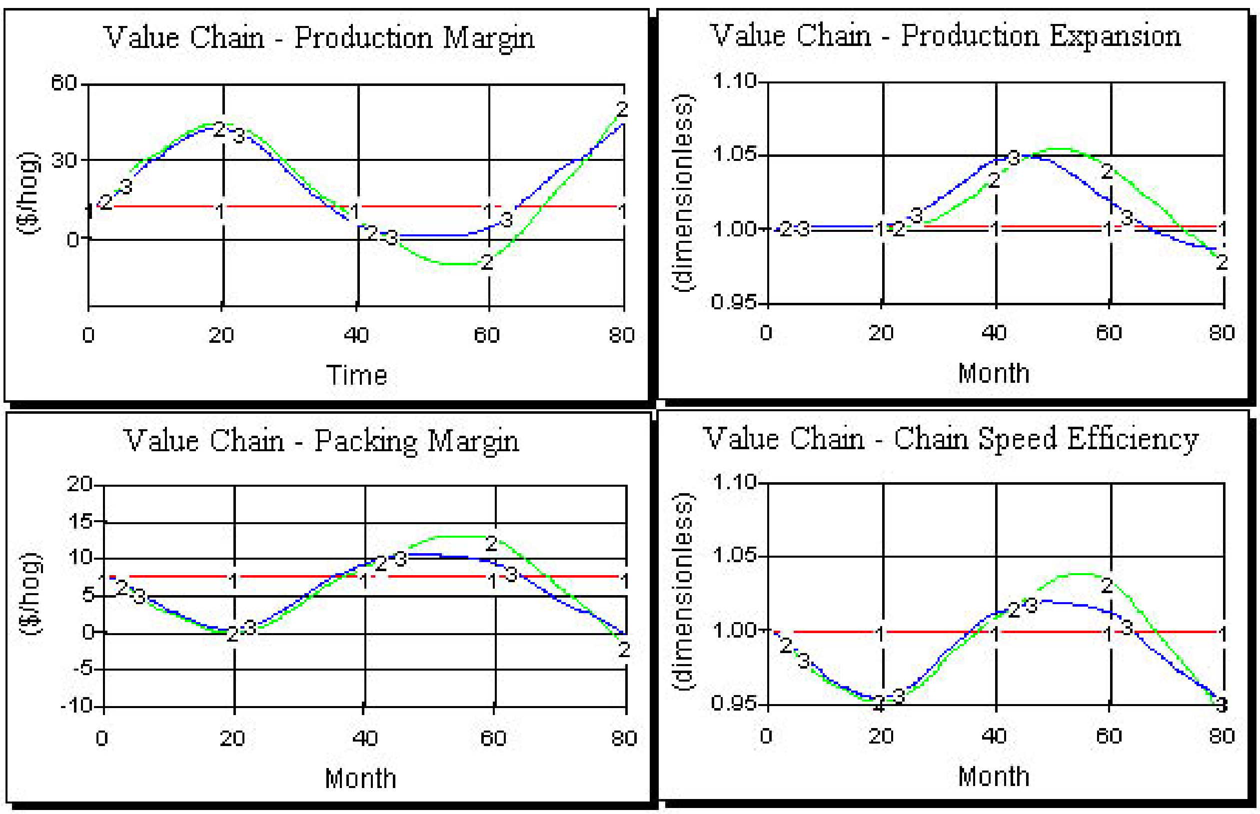

Figure 17. Value chain results for margins and expansions for the oscillating demand and fluctuating supply scenario.