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Future Agribusiness Challenges: Strategic Uncertainty, Innovation and Structural Change

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Abstract

The global food and agribusiness industry is in the midst of major changes, and the pace of change seems to be increasing. These changes suggest three fundamental critical future issues for the sector: 1) decisions must be made in an environment of increasing risk and uncertainty, 2) developing and adopting technology and new innovations is critical to long-term financial success, and 3) responding to changes in industry structure and the competitor landscape and industry boundaries is essential to maintain market position. The focus of this paper is the synopsis and application of conceptual/theoretical frameworks that can be used in managerial decision making and analyzing the implications and consequences of strategic uncertainty, innovation and changing industry structure.

Keywords: Strategic uncertainty, innovation, structural change

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Introduction

The global food and agribusiness industry is in the midst of major changes—changes in product characteristics, in worldwide distribution and consumption, in technology, in size and structure of firms in the industry, and in geographic location of production and processing. And the pace of change seems to be increasing. These changes suggest three fundamental critical future issues for the sector: 1) decisions must be made in an environment of increasing risk and uncertainty, 2) developing and adopting technology and new innovations is critical to long-term financial success, and 3) responding to changes in industry structure and the competitor landscape and industry boundaries is essential to maintain market position.

The agricultural industry exhibits a number of challenging characteristics. First, it is highly volatile, both in production and market conditions. A combination of biological production processes that are subjected to unpredictable biological predators (disease, insects, pathogens, etc.), combined with variable climatic/weather/heat/rainfall patterns, results in significant variability in production and processing conditions and thus efficiency and output. This fluctuation in output or supply combined with the inelastic or non-responsive demand for food products results in dramatic price fluctuations, particularly at the crop and livestock raw materials stages of the supply chain.

The biological production processes for raw materials are also characterized by long production cycles and batch rather than continuous flow of production/processing, which means that in general production adjustments to changing conditions are lethargic. And the time delays between a new idea and a commercially viable product are much longer than in industries characterized by continuous flow processing and short production cycles.

The food and agribusiness industry is also characterized by very complex supply chains that are not well coordinated, particularly among the up-stream stages in that chain. The production sector in general is very fragmented which provides challenges for those firms further downstream that desire traceability or guaranteed and consistent quality attributes. Changes and innovations that require adoption/adjustment across the entire value chain (e.g., systemic innovations) are much more difficult to adopt and implement if that value chain is not only complex, but also fragmented and not well coordinated (Bröring 2008).

These characteristics of the food and agriculture industries challenge the static equilibrium assumptions of traditional economic theory. Instead, the analytical frameworks used to analyze issues in the industry must be dynamic in both time and uncertainty dimensions rather than static. The decision environment is complex and characterized by nonlinear processes, open rather than closed systems, incomplete rather than perfect costless information, errors and biases in decisions, and in constant adjustment -- and thus an evolutionary process. In summary, one should view the decision process in the food and agricultural industry as a complex adaptive process that requires broader and more powerful analytical frameworks than those offered by the traditional equilibrium driven theory of the firm economic concepts (Beinhocker 2006).

The focus of this paper is the synopsis and application of these more powerful adoptive/dynamic conceptual/theoretical frameworks to analyze the implications and consequences of the issues of

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strategic uncertainty, innovation and changing industry structure. For each we present useful conceptual frameworks and then describe recent applications in agribusiness research and educational programs – our goal is to present concepts not just useful in academic research and education programs, but also in actual managerial decision-making.

Future Agribusiness Challenges: Strategic Uncertainty

Historically, most of the risk and uncertainty analyses in agricultural economics has focused on risk attitudes (Binswanger, 1981), operational decisions to manage risk (Mishra and Lence, 2005; Robinson and Barry, 1987; Anderson, et al., 1980), and the implications of risk for policy choices (Just and Pope 2001; Chavas et al. 2010). These analyses have generally used empirical/numerical analysis tools to quantitatively assess choices and consequences. Such analyses are very data dependent, and recent experience with some of the analytical models such as VAR (Value At Risk) in financial markets has undermined the credibility of some of the quantitative modeling and measures of risk. Taleb (2007) has argued that much of the quantitative analyses of the past has assumed that data sets are characterized by normality when in reality many economic phenomena exhibit skewed distributions. And the tails count -- they are the events that dramatically alter the business climate and shape the world.

Knight (1921) argues that risk and uncertainty are different concepts. With risk, the firm would have a *priori* knowledge of the underlying probability distribution, but with uncertainty there is not a *priori* information about that distribution. Managers find the distinction between systematic and residual or diversifiable risk useful because the strategies to manage/mitigate that risk are different for those risks that are associated with the broader market or overall economy than those specific to a particular company or venture. Hillson (2003) notes that uncertainty is any event or set of circumstances that, should it occur, would have an effect on one or more objectives. Thus, firms must utilize all available information to form best-guess estimates about the impacts of these risks through quantitative and qualitative methods to determine the realm of possible outcomes and choose strategies based on these outcomes.

The types and sources of risks and uncertainties faced by agribusiness decision makers have exploded in recent times—“unanticipated surprises” resulting from changes in government policy and regulation; mergers and acquisitions that change the competitive landscape and disease and food safety crises such as H1N1, BSE and salmonella contamination, for example. These new uncertainties are more complex and difficult to analyze and manage than traditional business risks—they are not as predictable in frequency and consequence, and they often create opportunities for gain as well as exposures to financial losses. They are often managed most effectively by business level strategies than by operational risk management tools or procedures. Different analytical concepts and tools than those typically used in risk analyses are needed to assess and manage strategic uncertainty. We briefly review the strategic uncertainties for agribusinesses firms, a decision model for managing those uncertainties and the potential of real options approaches to uncertainty management in this section.

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Assessing Strategic Uncertainty

Firms must be proactive in managing uncertainty to create long-term value because uncertainty has upside potential as well as a downside exposure (Pascale et al. 2000). Focusing only on uncertainty avoidance as is typically the case in analyzing risk could cause a firm to overlook opportunities to create value (Nottingham 1996, Talavera 2004). Table 1 summarizes the key strategic uncertainties faced by agribusiness firms and various potentials and exposures for each. Although objective measurement of risk and uncertainties is preferred to subjective assessments, the increasing relative importance of strategic uncertainties in agriculture suggests that they cannot be ignored because they cannot be quantified. Until more objective evidence is available to build actuarially sound numerical estimates of risk, a systematic procedure to assess the frequency and consequences of these uncertainties may be essential. This, in fact, is the emphasis of recent developments in scorecarding (Thornton 2002).

Table 1. Strategic Uncertainties in Agribusiness

Categories of Strategic Uncertainty		**Examples of**	
		Potentials	*Exposures*
Business/Operational	Operations and Business Practices, People and Human Resources, Strategic Positioning and Flexibility	Superior Cost Control /Operational Efficiency, Superior Workforce, Creating Synergies Through Scope	Business Interruption, Loss Of Key Employees
Financial	Financing and Financial Structure, Financial Markets	Strong Financial Position, Access to Equity Funds/Investors, Attractive Financing Terms (Amounts and Terms), Financial Reserves (Pursue Unanticipated Opportunities, Weather, Financial Shocks, Etc.)	Rising Interest Rates, Loss of Lender, Highly Leveraged
Market Conditions	Market Prices and Terms of Trade, Competitors and Competition Customer Relationships, Reputation and Image	Strong Brand, Strong Complementary Products and Bundling Potential, First Mover Advantages, Create High Switching Costs (Create Loyalty)	Pricing Pressure/ Discounting by Competitors, Loss of Market Share, Consolidation of Customer Industry, Hyper-Competition
Technology	Technological Change	Speed of Innovation and Commercialization, Niches Not Attractive to Others, Enhanced Learning Capacity	Limited Acceptance of Biotechnology, Slow to Commercialize New Products, Competitor has Preferred Standards/Platform
Business Relationships	Business Partners and Partnerships, Distribution Systems and Channels	Strong Market Position of Distributors, Strong Relationship with Processors, Enhanced Learning, Access to Future Opportunities	Dependence on Distributors, Not a Preferred Supplier to Processor, Not a Key Account to Suppliers
Policy & Regulation	Political Climate, Regulatory and Legislative Climate	Increasing Market From More Open Trade, Patent Protection, Speed of Approval	Changes in Intellectual Property Law, Changes in Industry Subsidies or Tax Policies, Local Limits on Technology Adoption

Source. Adapted from Detre et al. (2006)

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The purpose of scorecarding and heat mapping is to use a mental model that frames assessment of uncertainty from both a potential and an exposure perspective. Scorecarding consists of taking qualitative discussions about strategic uncertainties and turning these discussions into ordinal rankings. Heat mapping, a process of taking the rankings from scorecarding utilizing both colors/symbols and generic strategies to communicate the impact of the uncertainty on the business, further operationalizes the assessment process. In essence, these mental models are designed to promote and generate discussion around key areas of uncertainty through a systematic framework that directs the firm in selecting an appropriate uncertainty management strategy (Detre et al. 2006).

Capturing Opportunities from Strategic Uncertainty

(a) A Decision Model

Capturing the potential or opportunities from a strategic uncertainty and simultaneously mitigating the exposures is not easily accomplished. Raynor (2007) argues that for companies to succeed in an unpredictable future, they must develop practical strategies based on multiple choices that respond to the requirements of different possible futures rather than on a single strategic commitment. He suggests that the key to such decisions is strategic flexibility. Courtney (2001) provides a useful conceptual framework for making these complex decisions. Figure 1 recasts Courtney's mental model in the more familiar and structured analytical framework of a decision tree that can be linked to a payoff matrix.

Courtney suggests that developing strategy in an uncertain environment is a two-stage process: first, choosing a strategic posture which defines the intent of strategy; and, second, selecting a portfolio of actions that are the specific moves or activities that can be used to implement the strategy. The strategic postures are contingent upon the level of uncertainty reaching from: 1) a clear, certain future, 2) alternative well delineated futures or scenarios, 3) a range of futures but not scenarios, to 4) true ambiguity. Three strategic postures are identified: 1) shaping the future where the decision-maker attempts to drive the industry toward a new structure of their own design, 2) adapting to the future where one takes the current and future structure of the industry as given and reacts to the opportunities that structure offers, and 3) a wait-and-see approach where one reserves the right to play by making incremental resource commitments to enhance one's ability to be a successful market participant in the future. These different strategic postures are illustrated in the decision tree of Figure 1.

If an adapt or shape strategic posture has been selected, three different types of actions or moves can be made to implement the strategy: 1) no regrets moves that are expected to pay off no matter what future comes to pass: 2) an option which is designed to secure high payoffs in the best-case scenarios while minimizing losses in worst-case scenarios; and 3) a big bet which involves large commitments of resources that will either pay off big or lose big. If the reserve strategic posture is adopted, only an option action may be chosen.

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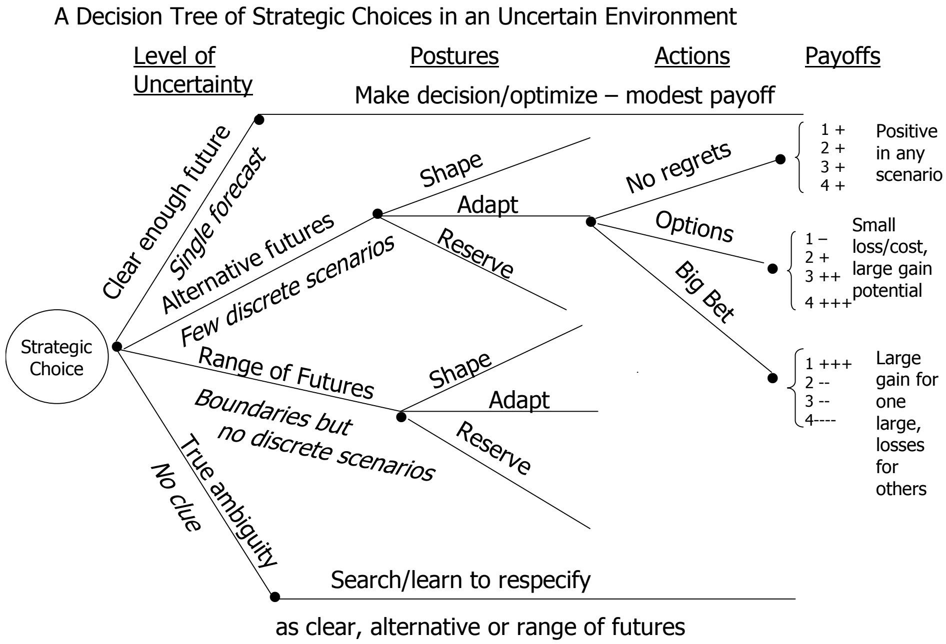

Figure 1. A Decision Tree of Strategic Choices in an Uncertain Environment
Note. The actions for the adapt posture apply to all adapt and shape postures in the decision tree. The action for the reserve posture applies to all reserve postures in the decision tree.
Source. Adapted from Courtney (2001).

An application illustrates the usefulness of this decision framework. A retail agricultural chemical supplier was assessing whether or not to introduce precision farming and variable rate application services to its customers. The level of uncertainty of the effectiveness of variable rate technology was characterized as one of alternative futures with three scenarios: 1) it is not cost-effective in general, 2) it is cost-effective for most customers, and 3) it is cost-effective only for those customers who have highly variable soils. Strategic postures and actions were identified as: 1) shape the market by being a market leader, with the action being a big bet start-up of a new division to provide the full spectrum of precision farming services; 2) adapt to the future with an options action of investing in personnel and equipment for soil testing and yield mapping that could be used to support an expanded precision farming program including variable rate application, or could be used to improve the quality of recommendations, service and application with standard equipment; or 3) reserve the right to play by developing a joint venture with an out-of-market partner who operates in an area with highly variable soils with an option to buy (or sell) the business depending on developing market conditions. Framed as these strategic choices, the company altered its initial choice from being a market leader providing the full spectrum of services to a joint venture with an out-of-market partner.

(b)Real Options

Real options concepts are useful in structuring a decision to manage downside risk while maintaining the possibility to capture upside potential. In essence, a real option is like a financial option – investing a modest amount today to take a position in the future. When the future arrives, the option can be exercised or allowed to expire. This approach is regularly used in making busi-

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ness decisions where option payments are made to maintain the right to acquire a particular parcel of real property in the future, minority investments are made in startup companies with an agreement to have the first right to buy a majority interest in some future time period, or pilot plants are constructed to test an idea before a full scale manufacturing facility is built (McGrath and McMillan 2000; Luehrman 1981; Hyde et al. 2003; Purvis et al. 1995; Boehlje et al. 2005).

An options approach explicitly considers the benefits additional information will have on the value of a decision or investment. A real options framework is appropriate for situations where the manager can make incremental decisions throughout time, thus creating flexibility in the decision. Such options might include deferring, abandoning, or expanding a given project. Thus, real options are a learning model that allows management to make informed and accurate decisions over the course of time (McGrath and McMillan 2000; Luehrman 1998; Boehlje et al. 2005).

As depicted in Figure 2, McGrath and MacMillian (2000) suggest that there are four basic categories of projects when viewed from the perspective of market uncertainty and technical uncertainty[1]. *Positioning options* create the right to wait and observe what technologies or standards will develop to serve a relatively well defined and certain market. *Scouting options* are focused on taking relatively well understood technologies and products to a new and not well understood potential customer base. *Stepping stone options* face both high technical and market uncertainty, and so should be initiated with "experiments" to either gain more information as to customer wants and needs, or increased capability and capacity relative to the preferred technology to respond to those needs. *Launches (platform and enhancement*) involve full blown commitments that can be safely made because both the technology and the customer base are reasonably well understood and less uncertain.

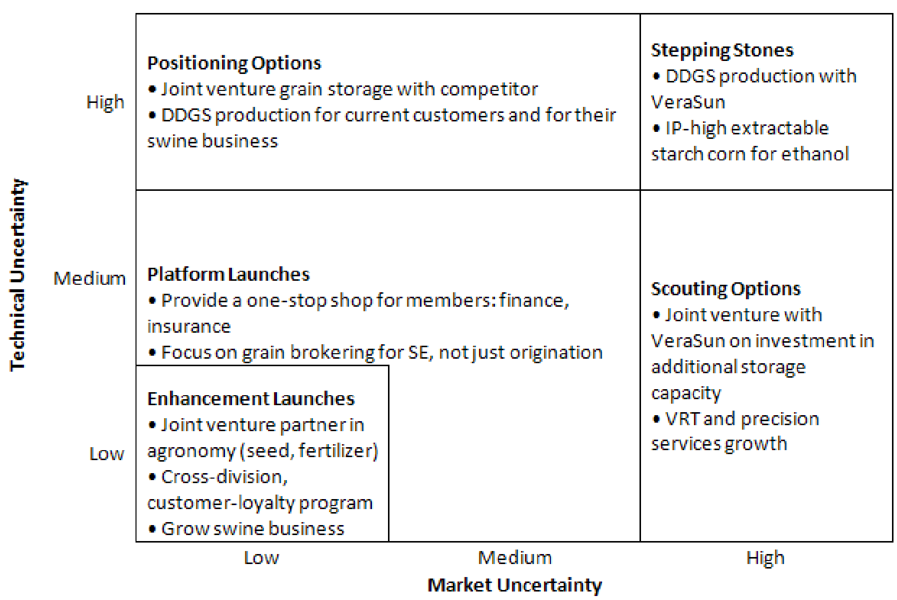

Figure 2. Portfolio of Options for a Retail Farmer Cooperative
Source. Adapted from Roucan-Kane et al. (2010).

[1] Miller and Folta (2002) present an alternative framework for assessing and managing projects and new ventures in an uncertain environment.

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Portfolio arguments can be combined with these option concepts to manage risk through diversification. To reduce the risk of new ventures, a specified percentage of the financial and personnel budget available should be allocated to all four different project categories.

The use of this analytical framework by a retail cooperative responding to the rapidly expanding biofuels industry illustrates its application. The options described in Figure 2 were identified as alternatives to consider to capture the potential and mitigate the exposure of the prospect of an ethanol plant being constructed in the center of the retailer's trade territory, as well as significant expansion of ethanol plant capacity in surrounding communities.

Future Agribusiness Challenges: Innovation

Innovation is critical to the long-term success of a firm as well as the economic health of an industry and the overall economy (Gertner 2004). Brown and Teisberg (2003; p1) state that "Innovation is the lifeblood of successful businesses. […] [It] has become every firm's imperative as the pace of change accelerates". Indeed, innovations are one strategy to develop and maintain a sustainable competitive advantage (Kirwin et al., 2008; Shanahan et al. 2008; Mikkola 2001; Bard et al. 1988).

The literature on technology and innovation management combines a plethora of different streams of themes, frameworks and specific models. From a fundamental theory point of view, this paper follows the resource-based view (RBV) of strategy and firm behavior and decision-making. From a resource-based perspective, innovations are new combinations of existing and/or new resources and competencies (Penrose 1959, 85). Hauschildt argues that such a "new combination" must at least advance to the stage of market introduction as a new product, or must be utilized as a new process in production (Hauschildt 2004, 25). Since R&D endeavors can also be exploited in other terms (e.g. licensing), any new combination of existing and/or new resources and competencies which is commercially exploited is an innovation (Roberts 1988, 11). Hence, commercialization is a critical delineator between an invention and an innovation. Therefore, in this discussion, we define innovation as a product, a service, a process, a new business model, or a management system that solves a problem and has impact.

The food and agribusiness sector is no stranger to innovation. Over the last 150 years, there have been several waves of innovation related to machinery, chemistry, seed, information management (Graff et al. 2003; Gray et al. 2004; Gray and Boehlje 2007; Cloutier and Boehlje 2002) and food (Sporleder et al. 2005). In addition, innovation is and will remain essential in the food and agribusiness sector to respond to the critical concerns of society such as climate change and global warming, food/energy scarcity and security, environmental challenges and resource use/sustainability.

Most of the research on invention and innovation in the agricultural sector in the past has emphasized the issues of technology adoption (e.g., Sunding and Zilberman 2001), productivity increases (e.g., McCunn and Huffman 2000), and induced innovation (e.g., Ruttan 1997). In addition, much of the research has been conducted at the industry level and not at the firm level. In this section, we discuss invention and innovation at the firm level and focus on innovation management with an emphasis on: 1) creativity and innovativeness, 2) selection of invention

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projects and management of the portfolio of inventions and innovations, and 3) organization of innovation. As will be discussed in detail in the next section, an additional important issue concerning agribusiness innovation is created by the length and complexity of the value chain (Bröring 2008; Fritz and Schiefer 2008); the challenge is bringing innovations from the input end of the chain created by the physical and biological sciences of engineering, genetics, nutrition, biotechnology and nanotechnology to successful market acceptance and adoption at the retail consumer end of the value chain.

Assessing Innovation: Creativity and Innovativeness

While innovation management research has encompassed the entire innovation process, the importance of the “front-end” – the stages of ideation and idea evaluation and selection – has drawn much attention in the current management literature (Kuhrana and Rosenthal 1998; Koen 2004; Bröring et al. 2006). Barsh et al. (2008) identify several characteristics essential for a company to successfully build and maintain an innovative culture such as encouraging innovative behaviors; no penalty for failure; openness to new ideas; making innovation part of the strategic-planning process; and implementing a fast innovation process to identify success and failure fast. They also indicate that to advance innovation, leaders should help their employees by defining the type of innovation they expect, by adding innovation to the formal agenda at regular leadership meetings, and by setting performance metrics and targets for innovation (Barsh et al. 2008).

Christensen and Raynor (2003) perceive product/service innovation as serving four potential types of customers: over-served customers, satisfied customers, under-served customers, and non-customers. Raynor (2007) suggests that although innovation projects serving over-served, under-served or non-customers are more uncertain, they potentially are more rewarding.

Roth and Sneader (2006) suggest that companies have to find new ways to learn from customers and consumers. IDEO, an innovation consulting company, assesses how consumers buy and use the products in stores, at work, in restaurants, or at home through observation, in-context interviewing and "living with consumers”. This in-context analysis allows them to understand better the unfulfilled needs of the customers and brainstorm innovative ideas accordingly. For each project, consulting teams consist of employees with different skills, expertise, and cultures to maximize the results of the brainstorming process (Nussbaum 2004; Brown 2005).
Makri et al. (2006) show that technology-intensive firms can bolster innovation by aligning CEO incentives with short-term financial results and behavioral indicators of long-term innovation quality (invention resonance and science harvesting). Invention resonance refers to an invention’s ability to stimulate subsequent inventions. Science harvesting reflects a firm’s commitment to exploiting basic scientific research and new technologies to generate new innovation. Their conclusions are the result of an analysis using a sample of 206 publicly traded firms from 12 U.S. manufacturing industries.

Detre et al. (2009) present a conceptual model (see Figure 3) to help agribusinesses in developing a culture of innovativeness. Innovativeness is defined as a corporate culture where managers push for new, disruptive innovations and make creation their consistent message and focus. The authors provide an illustration of the conceptual model by profiling Land O’Lakes, a

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food company. The vertical axis in the conceptual model in Figure 3 depicts the flexibility (from low to high) firms have to make their decisions in the context of the strengths and weaknesses of their firm, the market, and the competitive environment. The horizontal axis represents progression over time.In the first stage, a firm must commit to making innovation a key focus by establishing a culture of innovativeness throughout the organization. They also indicate that if a firm is highly dependent on its supply chain, the success of their innovation will depend on the level of commitment to innovation by other members of the supply chain. In the second stage of the conceptual model, the firm must first choose how they organize their company. The firm must choose an organizational structure (also called chain of command) that is conducive to innovation and allows for flexibility and fast decision-making. Once an organizational structure is chosen, firms must adopt policies and procedures that will encourage innovativeness and increase the profitability and success rate of innovation.

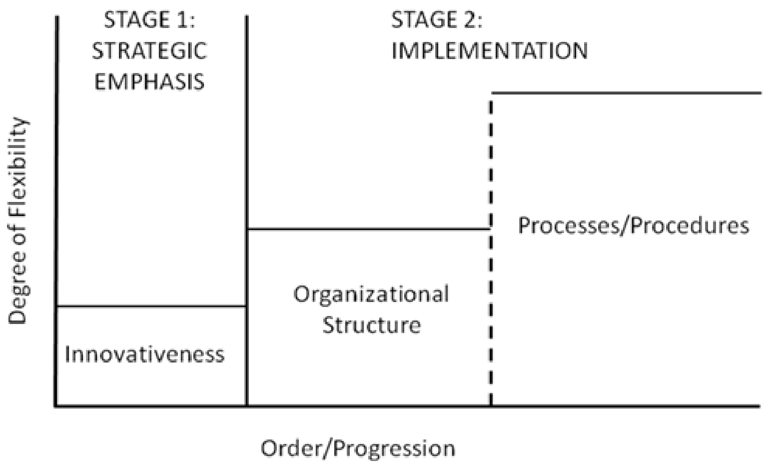

Figure 3. Conceptual Model of Managing for Innovation
Source. Detre et al. (2010)

Capturing Opportunities from Innovation

(a) Selection of Innovation Projects

After identifying innovative ideas, companies' next challenge is to select which ideas they will pursue. Selecting the right innovation projects is challenging for at least three reasons: (1) innovation has a significant impact on a firm's current and future financial position, (2) R&D funds are limited, and (3) the future success of innovation projects is hard to predict accurately (Bard et al. 1988; Hall and Nauda 1988; Tian et al. 2005; Heidenberger and Stummer 1999; Cooper at al. 1999). Most organizations find that they have several good ideas but lack the framework required to select and convert the best ideas into new revenue (Anthony et al. 2006; Huurinainen 2007).

In the past four decades, several selection methods have been proposed to help organizations make better decisions in R&D project selection; Boehlje et al. (2009) summarize and evaluate these methods. Cooper et al. (1998) and Coldrick et al. (2005) found that top performing compa-

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nies use several selection methods with an average of 2.34 selection methods used (Cooper et al. 2001).

Cooper et al. (2001), Meade and Presley (2002), and Kester et al. (2009) found that economic models (such as net present value and internal rate of return analyses) are the most popular selection methods, followed by graphical methods. But Cooper et al. (2001) also found that companies relying heavily on these economic models may not generate portfolios of innovation projects that perform as well as companies incorporating more qualitative analyses (specifically, categorization of projects into strategic buckets). This result might be in part because for potential breakthrough ideas, data is often inaccurate early on and therefore economic methods would underestimate the sales and profits of such innovations (Roth and Sneader 2006).

Roucan-Kane (2010) conducted a survey of food and agribusiness companies and their use of selection methods when pursuing innovation. Companies surveyed use an average of 2.27 selection methods with the most popular being economic models followed by informal methods and more qualitative analyses such as structured peer review, checklists, and scorecarding. Smaller food and agribusiness firms (in terms of revenue) were more likely to use informal methods, while larger firms use more economic and structured methods.

Behind every selection method is a set of criteria being used to select projects. Using a choice experiment, Roucan-Kane (2010) surveyed 85 top executives of U.S. food and agribusiness companies regarding their stated preferences for innovation projects based on five criteria: distribution of potential return/market risk, risk of technical/regulatory failure, time to market, capability, and costs already incurred. She found all criteria to be critically important to this sample of executives in the selection process. She also reported that executives prefer (in decreasing order of importance) projects with low risk of technical/regulatory failure, low relative market risk, short-term to market, in-house capability, and high costs already incurred. This leads her to conclude that the food and agribusiness industry is a conservative and risk averse industry in terms of innovation, and that strategies to manage the risk of technical/regulatory failure and market acceptance merit consideration.

One way to manage the technical/regulatory and market risk is to select a portfolio of innovation projects with varying degrees of risk as suggested by McGrath and MacMillan (2000). Roucan-Kane and Boehlje (2009) illustrate the use of the McGrath and MacMillan framework described in the previous section to Deere and Company's innovation projects (Figure 4). The framework again suggests a diversified portfolio of positioning, stepping stone and scouting options along with platform and enhancement launches to manage market and technical uncertainties.

Roucan-Kane (2010) studied the portfolio of innovation projects for food and agribusiness companies using the same criteria as the one used in her choice experiment. Her survey results indicated that companies tend to diversify their innovation projects in terms of time to market and cost already incurred. They favor projects that are done in-house, and that are not characterized by significant risk of technical/regulatory failure or high relative market risk. Her analysis indicates substantial heterogeneity among the surveyed companies in terms of the time to market, costs already incurred, technical/regulatory risk, and capability considerations. Approximately 50 percent of the firms, primarily smaller firms, are more conservative in their portfolio with a large

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proportion of short-term projects exhibiting low technical/regulatory risk. The remaining 50 percent of the sample is clearly not conservative with most willing to commit to long-term projects. In addition, about 13% of the companies are willing to bet on the highly technically and regulatory risky projects, and 23% are willing to share capabilities with partners to embark in their innovation endeavor.

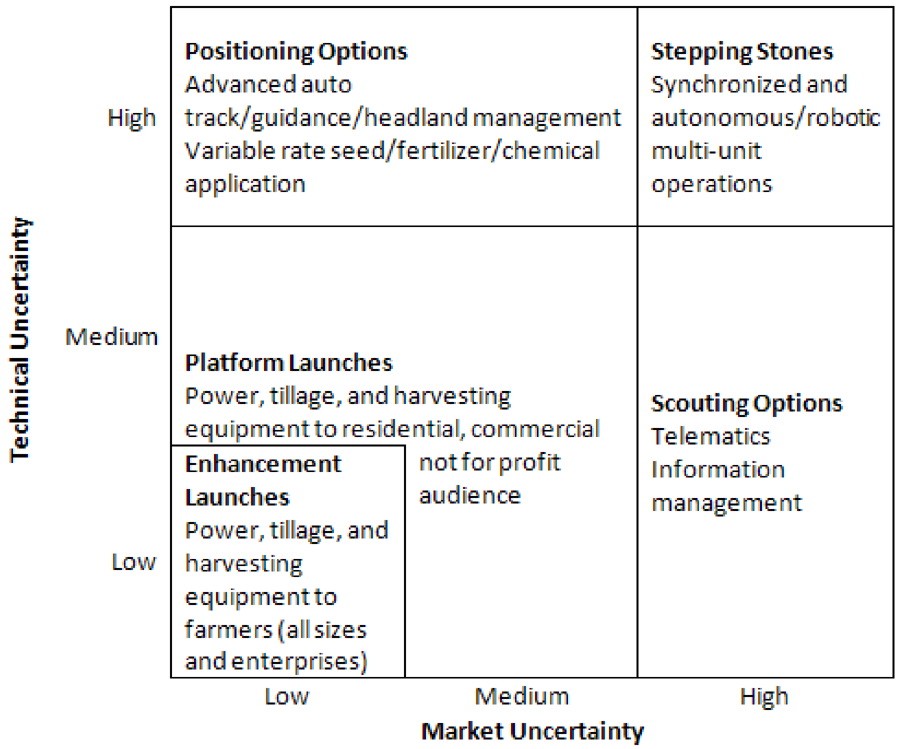

Figure 4. Deere Portfolio of Innovations
Source. Adapted from Roucan-Kane and Boehlje (2009)

(b) Organization of Innovation: The Stage-Gate Process

The selection of innovation projects should be regularly reviewed as uncertainty is resolved and new projects enter the pipeline. Cooper's stage-gate process (Cooper 2001) proposes a structure to continuously analyze the portfolio of innovations and increase the likelihood of success in an uncertain world. His process features five innovation stages (scoping, build a business case, development, testing and validation, launch); each stage (and sometimes within a stage) ends with a gate where the resource allocation and the prioritization of projects is reviewed and changed if needed. Having a stage-gate process facilitates speed to market as the stages are cross functional and involve several activities (research and development, technical, market, financial, operations, etc).

Boehlje and Roucan-Kane (2009) summarize Deere and Company's stage gate processes of the Enterprise Product Development Process (EPDP) and the Accelerated Innovation Process (AIP). EPDP focuses on incremental innovations, insuring that these innovations reach the quality

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standards Deere has set before the product is launched. AIP is targeted towards radical innovations with the use of selection methods such as strategic buckets, structured assessment, and economic models.

To get the most out of the stage-gate process, innovation projects should be evaluated by cross-functional teams (Cooper et al. 2004; Christensen et al. 2004; and Christensen and Raynor 2003). Roucan-Kane (2010) found that food and agribusiness companies use cross-functional teams with an average of 3.36 functional areas involved. She also found that larger firms and firms more committed to innovation are less likely to involve salespersons in the innovation selection and review process as they tend to be too biased towards short-term innovation.

Future Agribusiness Challenges: Structural Change

The impacts and consequences of the structural change (consolidation, vertical integration and changes in the vertical and horizontal boundaries of the firms) now underway in agriculture are dramatic and profound (Rogers, 2001; Stiegert et al. 2009). They will influence almost all the participants in the food production and distribution industries: consumers, food manufacturers and retailers, producers, input supply manufacturers and retailers, and public regulators as well as educators and researchers. Because of the breadth and distributional dimensions of their impact (some will gain while others lose because of these structural changes), the realignment process will be surrounded with great controversy.

Three dimensions of those structural changes are reviewed here: a) the drivers/determinants of structural realignment within the industry; b) the unique role that risk management/mitigation plays in developing sustainable value chain governance structures, and c) industry convergence – the blurring of the boundaries of the agribusiness and related industries driven by advances of knowledge and technology applied across these boundaries.

Assessing Structural Change

(a) Drivers/Determinants of Structural Change

Useful conceptual frameworks that explain the structural changes noted earlier come from the fields of economics and management theory including: *(i) transaction cost economies*, *(ii) negotiation/power and trust*, and *(iii) strategic management*.

(i) Transaction Costs Economies

Transactions cost economic concepts have been effectively applied to structural change and governance issues in the agribusiness industries by numerous analysts (Allen and Lueck 2003; Barry, Sonka and Lajili 1992; Hennessy and Lawrence 1999; Johnson and Foster 1994).

The concepts of *transaction costs* and *principal-agent* theory as conceived by Coase (1937) and expanded by Williamson (1979) and others indicate that structure in terms of the form of vertical linkages or governance in an economic system depend not only on economies of size and scope, but also on costs incurred in completing transactions using various governance structures. Fur-

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thermore, these costs and the performance of various governance structures 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).

Mahoney (1992) suggests that the form of governance structure will be a function of three characteristics of the transactions and the industry: (a) asset specificity (the specialized nature of required assets), (b) task programmability (level of common understanding of the to-be-performed tasks), and (c) task separability (ability to determine and measure the value of each contribution to assign individual rewards). On the basis of these arguments, Martin et al. (1993) build a taxonomy of expected governance structures developed from a case study of the poultry industry as displayed in Table 2.

Table 2. Predicting Organizational Forms of Alternative Business Linkages

Factors	**Low Programmability**		**High Programmability**	
	Low Asset Specificity	**High Asset Specificity**	**Low Asset Specificity**	**High Asset Specificity**
Low nonseparability	Spot market	Long-term contract	Spot market	Joint venture
High nonseparability	Cooperation (strategic alliance)	Cooperation or vertical ownership	Inside contract (hybrid)	Vertical Ownership

Source. Martin et al. (1993)

Innovation strategies can create unique challenges in developing appropriate governance structures. An empirical study by Sampson (2007) evaluated technological diversity among firms allying with each other. She defines technological diversity as the difference between two or several firms' pool of resources in terms of technological backgrounds. She found that alliances are far more innovative and successful between partners that have moderate technological diversity than between firms that have low or high technological diversity. Moderate technological diversity maximizes firms' ability and incentives to transfer knowledge and resources. Sampson also indicates that firms that are highly different from a technological capability standpoint will be more successful with a highly hierarchical governance structure. The empirical work by Ahuja and Katila, 2001 leads to similar conclusions.

(ii) Negotiation/power/trust

More hierarchical governance structures are replacing markets as the coordination mechanism in the agri-food industries. In such systems, negotiation strategy and skill, power, conflict resolution, trust, and performance monitoring and enforcement 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 Cross (1969); Greenhalgh (1987); Neale and Bazerman (1991); and others can assist in understanding not only what form a negotiated governance system will take, but also how the risks and rewards will be shared.

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Trust is becoming an increasingly important consideration in the formation and performance of various forms of governance structure and in the academic studies of these systems (Puranam and Vanneste 2009; Malhotra and Lumineau 2011). Sporleder (1994) argues that "fuzzy expectations and fuzzy prerogatives" that characterize many strategic alliances "has a foundation based on trust, unlike the clearly identified expectations and prerogatives typical under a contractual arrangement between firms." And in the spirit of optimality, Wicks et al. (1999) argues that firms/managers can over-invest (i.e., proceed on faith) or underinvest (i.e., exhibit extreme, maybe even unethical opportunistic behavior) in trust—thus the concept of optimal trust. Often presumed (or ignored) and rarely identified to be managed in studies of market economies and performance, trust management or manipulation and even psychological/emotional incentives (i.e. reputation, prestige, fear, etc.) would appear to impact business arrangements and governance structures in the agricultural sector of the future and thus have a role in our conceptual models of structural change and realignment (Casson 1991).

(iii) Strategic Management

An additional set of arguments that will assist in understanding and predicting structural realignment comes from the strategic management literature. In essence, these concepts emphasize various approaches for firms to develop a strategic competitive advantage and the criteria or considerations in the coordination governance or integration (make or buy) decision. In general, this literature indicates that the coordination governance decision is driven by: (a) internal considerations of costs, technology, risks and financial and managerial resources, and (b) external competitive considerations of synergies, differentiation, and market power and positioning (Harrigan 1985). Much of the recent work builds on the prior writings of Chandler (1962) on strategy and structure. Moreover, Porter's (1980) seminal work on competitive advantages, more specifically his five forces model, provides a rich source to detect and assess structural change in industries. Besides these landmarks in the strategic management literature we eclectically present selected concepts in more detail, which may offer valuable approaches to detect and understand the drivers of structural change in the environment as well as in the firm itself.

First of all, Barney (1991) has made significant contributions to the strategic management literature within the development of the resource-based theory (RBV) of the firm (Wernerfelt 1984). Barney's arguments are especially useful in understanding the recent realignments in coordination systems in the food production and distribution industries from traditional open-access markets to more tightly aligned supply or value chains. Strategic assets relevant for the development of a sustainable competitive advantage can be assessed with Barney´s VRIN framework. Strategic assets are "Valuable" (important), "Rare" (unique), "Imperfectly inimitable" (hard to copy), and "Non-substitutable" (not replaceable). The VRIN framework can be used to foresee or detect impending structural changes.

The more recent RBV literature in strategic management provides a more dynamic perspective, which in important dimensions contradicts the classical "core competences" approach of Prahalad/Hamel (1990). The argument is that core competences can also develop into "core rigidities" preventing a firm from adapting to external structural change (Leonard-Barton 1992). The dynamic capabilities approach of Teece et al. (1997) presents a framework to understand the implications of environmental change and how firms can adapt to it. A dynamic capability is the

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firm's potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change its resource base. The dynamic capabilities approach offers a vehicle to mitigate environmental change and renew a firm's resources for a sustained competitive advantage in fast changing unstable environments (Winter 2003; Baretto 2010) such as those that characterize the agri-food sector. In fact, given an increasingly turbulent business environment, the more recent literature questions the basic concept of a sustainable competitive advantage and suggests a rather "temporary" competitive advantage (O'Shannassy 2008).

In line with the dynamic capabilities argument, the question of how to identify, assimilate and integrate external knowledge to "shape" and renew the competence base to establish a sustainable or even temporary competitive advantage arises. Here, the strategic management literature offers the construct of absorptive capacity (Cohen and Levinthal 1990). This meta-competence to benefit from external developments seems to be a challenge for the often very long and complex agri-food supply chains, e.g. how should a seed company assess the consumer preference and willingness to pay for certain health-food traits. Consumer preferences are often very difficult to evaluate for agri-input suppliers. An answer to this dilemma can be found in Kogut and Zander (1992) who introduce the concept of combinative capabilities in order to synthesize and apply acquired and existing knowledge in a company. However, the question of how many steps in a value chain need to have similar areas of either up or downstream knowledge remains unclear. Questions like: to what extent should a seed company be aware of consumer trends? Or, how much production knowledge a retailer should have will become more important in the future.

(b) Risk and Value Chain Governance Structures

Apgar (2007) argues that value chain partners are critical sources of risk and uncertainty, and they can also provide important opportunities to mitigate risks and capture opportunities that result from uncertainty. Given the difficulty of establishing sustainable risk/reward sharing arrangements, it is not uncommon for one firm in the chain to become the chain "captain". The chain manager or "captain" may choose to become the residual claimant on profits from the chain as well as assuming a major share of the risk, or to share a greater fraction of the profits while shifting more of the risk to the other participants. Failure to find a risk/reward sharing arrangement that provides appropriate incentives and is perceived as fair also encourages ownership integration of stages by one firm.

Gray and Boehlje (2005) evaluated the implications of external transactions costs of risk sharing relative to internal transactions costs of vertical ownership on the choice of value chain governance structure (arms-length transactions, contracts or vertical integration). External transactions costs reflect the additional risk sharing cost borne by the processor when the exchange is between the processor and producers in a vertical arrangement. These costs increase as producer risk aversion increases or risk management skills decrease. If the processor wants to source products from more risk adverse producers, they must design vertical arrangements to either take on more of the risk, or compensate producers more for accepting the same share of the risk.

Internal transactions costs reflect the cost of ownership to a processor that owns both stages of the chain where separate firms are replaced with employees. Internal transactions costs of owner-

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ship (i. e. agency costs) do not change as a function of producer risk aversion and are initially assumed to be greater than external transactions costs.

When producers have better risk management capabilities or have low enough risk aversion that risk sharing transactions costs are low, channel partners are likely to align in an arms-length exchange such as open markets, strategic alliances, or joint ventures. As producer risk aversion rises or management ability declines, the external transactions costs rise for the processor due to increased risk sharing costs. The increase in external transactions costs lead to more formal vertical arrangements such as contracts, where the risks and returns are dictated by the channel captain (processor). As producers' risk aversion/management costs increase further, ownership of the channel (vertical integration) becomes the preferred option because the transactions costs of risk sharing exceed the internal transactions costs of ownership.

Strategies to reduce internal/external transactions costs lead to the formation of supply chains among participants who are less risk averse or have more ability to manage or mitigate risk. This suggests that, in general, most tightly aligned supply chains that seek to share risk and rewards among participants will be increasingly dominated by larger firms at both the buyer and supplier level – leading to more consolidation, particularly at the production end of those industries. However, channel captains that have the willingness and ability to absorb the risk may allow producers with less ability to manage risk to maintain a role in the industry as service providers for these risk absorbing processors.

Poray et al. (2003) in a study of the pork industry found that the primary benefit from more tightly aligned coordination or governance systems is risk reduction. The reduction in risk results from more accurate information transmission between the primal cut market and the live hog market. Primal cut prices transmit information that helps reduce risks in packer/producer systems only if the system is aligned to use this information; the spot market does not allow for accurate information sharing which results in sub-optimal solutions for both producers and packers.

Preckel et al. (2004) in a follow-on study indicate that an optimal sharing arrangement for risk and returns depends on the relative risk aversion of the packer and producers. The risk aversion level of the packer is critical in determining the sharing of expected returns and risk but, surprisingly, producers' risk aversion levels are not relevant to the packer's decision of the optimal amount of risk and reward to share. Instead, producers respond to the packer's choices of proportion of expected returns and risk shared by choosing to increase or decrease the amount of pigs delivered to the packer. If the packer is willing to accept more of the risk, individual producers will want to deliver more pigs, allowing the packer to source pigs from fewer producers. This result is consistent with the trend in the U.S. to fewer and larger pork production and processing firms that are more tightly aligned.

(c) Industry Convergence

Industry convergence is a phenomenon observed in many industries such as telecommunications, computing and consumer electronics (Katz, 1996; Duysters and Haagedorn1997; Prahalad 1998). New technologies and their rapid diffusion across industry boundaries are main drivers for industry convergence, leading to inter-industry segments and, thus, structural change of entire indus-

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tries.The agricultural sector is no stranger to this phenomenon (Bröring 2010) as it is increasingly becoming a source of raw materials for industries or sectors beyond the traditional fiber and nutrition industries—energy in the form of ethanol and biodiesel, industrial products such as polymers and bio-based synthetic chemicals and fibers, and pharmaceutical/health products such as functional foods, growth hormones and organ transplants. Developments and innovations in the bio-economy have important implications for the convergence between the previously relatively independent food, energy/industrial product, and pharmaceutical industries with the potential for competition in resource use, blurring of industry boundaries and dramatic changes in the competitors in the down-stream markets. Hardy has suggested that "the bio-based economy can and should be to the 21st century what the fossil-based economy was to the 20th century" (Hardy 2002).

In this context, industry convergence will play an increasingly pivotal role in shaping markets and industry segments leading to a higher degree of uncertainty. The process of convergence leads to "new competitive landscapes" (Bettis and Hitt 1995); actors from different formerly distinct industries are suddenly becoming competitors or partners in new inter-industry segments. Moreover, due to the application of similar technologies in different sectors (e.g. biotechnology, Sonka (2010)) formerly distinct value chains are becoming increasingly interlinked and interdependent (see Figure 5). At this point it is important to ask; whether old established value chains will fade and imply a singularity of one industry which combines previously separate ones (1+1=1). This possible outcome is called "substitutive" convergence and clearly needs to be distinguished from "complementary" (1+1=3) convergence where a new value chain evolves between established ones (Bröring 2010).

Even though agricultural raw materials still are the main starting point for the value chain of many sectors of the bio-economy, other industries such as energy or chemicals are entering the downstream stages of the value chain. For instance, the chemical industry is devoting substantial R&D budget expenditures to biorenewables in order to build more knowledge and potentially use biobased feedstocks in petrochemical pathways (Lenk et al. 2007).

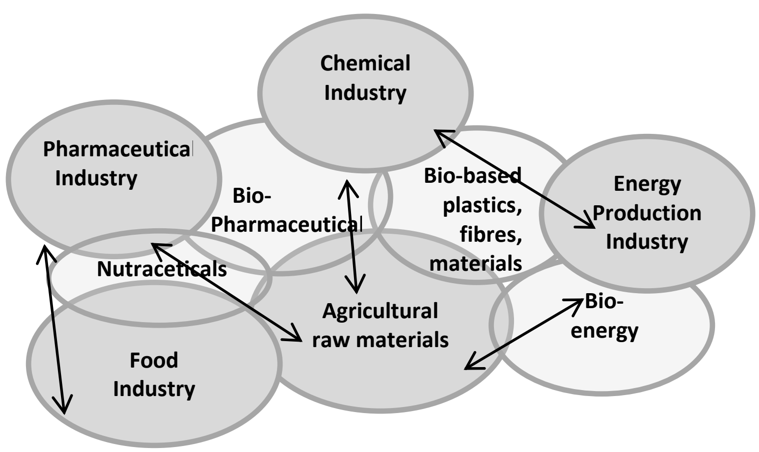

Figure 5. Fields of Industry Convergence in the Bio-economy
Source: Boehlje and Bröring (2010).

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Cross-scientific research is increasingly enabling diverse sectors to utilize the technological developments in neighboring scientific disciplines (e.g. biotechnology and agriculture). Strategic alliances between food and cosmetics and/or pharmaceutical companies are increasing in the emerging subsectors of the bio-economy. These are targeting foods with health benefitting characteristics leading to the production of nutraceuticals and functional foods (a combination of nutrition and pharmaceuticals) (Bröring et al. 2006; Bröring 2005). That this "new inter-industry segment" is no longer just an academic playing field is evidenced by Nestlé´s recent announcements of the creation of "Nestlé Health Science S.A." and the "Nestlé Institute of Health Sciences" to confidently "*…pioneer a new industry between food and pharma…"* (Nestlé 2010).

Capturing Opportunities from Structural Change

(a) Anticipation of Convergence

Companies that may be affected by trends of convergence need to identify whether convergence is of substitutive or complementary nature. In the case of substitutive convergence, where two value chains merge, innovation seems to be imperative for the survival of the company since this form of convergence will lead to a phasing out of the two hitherto distinctly operating industries. Hence, firms must anticipate trends of convergence; otherwise they may vanish since the old industry sector is fading away. On the contrary, in the case of complementary convergence, a firm has the choice to either pursue an active role in the emerging segment or rather concentrate on the existing 'old' industry (Bröring 2010; Curran et al. 2010). New technologies, products, customers and regulations with the promises of substantial growth in unrivalled markets do not come without cost. With the high time-sensitivity of innovation processes, it is of particular importance to realize trends of convergence at the earliest possible moment (Curran et al. 2010).

Bibliographic data and patent data can be used to anticipate industry convergence (Figure 6). This approach is based on the assumption that industry convergence evolves after scientific disciplines (process of scientific convergence), technologies (process of technology convergence)

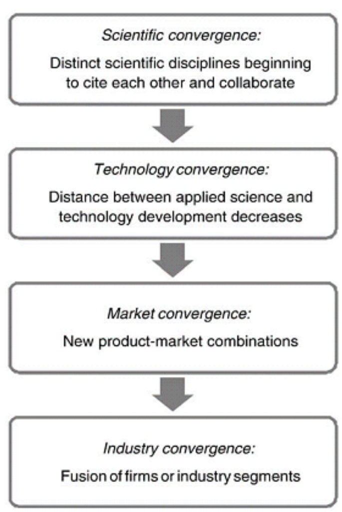

Figure 6. The Process of Convergence
Source. Curran et al. (2010)

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and markets (process of market convergence) have converged (Curran et al. 2010). This means that new technologies are applied across industry boundaries. Before being threatened by industry convergence, firms may use patent and publication data to analyze whether cross-disciplinary patent citations occur and eventually develop into closer research collaborations and ultimately to technology convergence (e.g. nanotechnology and biotechnology). Thereby, firms can assess whether new competitors at the interface of two industry boundaries may emerge and what competences they need to build to be prepared (Bröring 2010' Curran et al. 2010). Bornkessel et al. (2011) have carried out such analyses to better understand the evolving segment of probiotics, a complementary form of industry convergence. This analysis shows a high involvement of agribusiness, chemical and food companies which starts with publications and results in patents, new products and a new inter-industry segment.

(b) Value Chain Analyses

As industry convergence may lead to the emergence of a new industry, value chain analyses may be helpful to further analyze the structural changes that come along with increased interdependencies of two or more related value chains. Hence, an explicit characterization of the *value chain* is an important step in structural change analysis. Boehlje (1999) identifies six critical dimensions of a value chain reaching from (a) the processes and activities that create the products or services demanded by consumers or end users, (b) the product flow features, (c) the financial flows, (d) the information flows across the chain, (e) the incentive systems to reward performance and share risks, and (f) the governance and coordination systems (e.g. strategic alliances).

More differentiation and specification in food and other bio-based products results in more complex production/manufacturing processes and thus the potential for more errors or mistakes in those processes. And as one defines the products/processes more broadly as a result of industry convergence, the complexity increases further. With increased complexity and potential errors, more structured systems of control are essential to reduce those potential mistakes. This increased control is easier to obtain in more tightly aligned supply chains in contrast to open-access markets (Boehlje1999). And due to the increasing complexity of food and agricultural systems, the chain perspective has been extended to a net chain approach (Lazzarini et al. 2001) to account for partners in the net of value creation. Value chain and net chain analyses can be used to understand how complexity increases, who will hold the needed competences, how and why vertical integration will occur, and what is needed for successfully managing systemic innovations (see Bröring 2008) which affect multiple steps of the supply chain.

A Final Comment

The dynamic nature of the agribusiness sector provides significant future business challenges and opportunities. The expected growing demand for food by itself presents potential sales and revenue growth. In addition, the expected future development of the expanding bio-economy with biological based raw materials being used in the energy, industrial and health/pharmaceutical industries adds further potential. The integration of the agricultural sector into the broader overall global industrial economy creates opportunities for innovative new product and service offerings as well as new value chains to deliver those new products and services. It adds further complexity to an already complex value chain. But that future also is highly uncertain.

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Many of the management implications of the challenges of strategic uncertainty, innovation and structural change have been identified earlier – some of them will be highlighted here. Strategic uncertainty requires managers to develop additional capacities to monitor the business climate in which they operate, to anticipate as best one can the impact of the highly improbable, so-called "Black Swans" (Taleb 2007), and to regularly reassess the firm's strategic positioning to capture unexpected opportunities and mitigate potential catastrophic losses. This may require a more flexible rather than focused strategy and a real options mentality embracing more experimentation rather than making "full-blown" or "big bet" commitments.

As to innovations, searching out potentially disruptive technologies or innovations and assessing the risk and rewards of being a first mover vs. fast follower in the commercialization of those technologies or innovations will be critical to capture market potential or defend against new entrants. Systematic and frequent stage-gate processes to evaluate the success potential of innovations as they move from a new idea or invention to commercialization will reduce the risk and enhance the probability of success from innovation. Criteria such as potential return, market uncertainty, technical/regulatory uncertainty, time to market, access to capabilities, and costs already incurred should be included in the selection methods used by companies. Food and agribusiness companies should also rely on several selection methods, and on an assessment of the projects by cross-functional teams as well. Finally, systematically documenting the knowledge created in the innovation process will increase the value created irrespective of whether the product/service offering is a commercial success – learning from and communication on an unsuccessful innovation or venture has the potential to improve the chances of success in future innovations/ventures.

Finally, the significant structural changes in the agribusiness sector suggest that managers need to be increasingly vigilant in assessing the competition they will face as well as the opportunities they may have in shaping the restructuring of their industry. The evolution of new value chain structures and industry convergence will require additional leadership and management skills along with new relationships and linkages outside of what have been historical industry boundaries.

The information, knowledge base and skill set for analyzing and understanding these issues, and making the critical strategic decisions to be successful in an increasingly turbulent business climate, requires integration of concepts from economies, management, finance, decision sciences, organizational behavior, and strategy. Our goal here has been to make a modest contribution to that knowledge base with a focus on strategic uncertainty, innovation and structural change in the agribusiness sector.

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