CHOICES
The magazine of food, farm, and resource issues
4th Quarter 2005 • 20(4)
A publication of the American Agricultural Economics Association

A Frictionless Marketplace Operating in a World of Extremes

by Allen F. Wysocki

Exciting Times in Food Retailing

These are both evolving and challenging times for food distribution and retailing. Never before have the same consumers behaved in so many different ways. Consider Sally, a hypothetical shopper, who may begin her food shopping experience by visiting the neighborhood supercenter, searching for items she perceives to be undifferentiated, seeking larger sizes and the best prices for given products. Sally decides to stop at Whole Foods to satisfy particular nutritional needs, social causes, or deeply-held beliefs such as organic food products are safer. On the way home, she stops by the fresh seafood distributor to pick up today's fresh catch for this evening's meal. Waiting for her when she arrives at home is the wine she ordered on the internet three days ago from her favorite vineyard in another state.

Sixty years ago, Sally's shopping experience would have been quite different. Shopping at a limited number of specialized food retailers like the butcher or general store, she would be greeted by name. The day's current events, and mutual friends would be discussed while the retailer assembled her order based on her list and known purchasing habits. Today, consumers face a much different shopping experience. They have increasing choices regarding where to purchase their meal solutions. Sally could just as easily have decided to stop by the local Boston Market or the neighborhood grocery store deli to pick up a ready-to-eat meal in answer to the question: "what is for dinner?"

Where are we headed and what forces have moved us from the shopping experience of sixty years ago? If the forces and trends identified in this paper hold, there are at least, two, inter-related dimensions to describe what future grocery supply chains might look like in a frictionless marketplace, operating in a world of extremes.

Articles in this Theme:

Frictionless (2000 and beyond)

The "Frictionless Marketplace" is characterized by a renewed emphasis on the individual shopper. Redundant supply chain components such as warehouses are eliminated and the retailer once again becomes the "Agent" for the shopper, facilitating the transfer of goods and services from manufacturers to end-users (Terbeek, 1999).

Greater customer focus must go beyond the superficial by addressing all the basic building blocks of the organization. The status quo must change from disconnected, multiple channels, and silos to a unified orchestration of the customer experience. Retailers need to be capable of delivering a unified seamless customer experience that treats customers as the unique individuals they are. In a frictionless marketplace:

- Core competency arises out of anticipation of shopper needs.
- The internet, the dominate form of technology, links all supply chain participants.
- Information technology is applied to the individual shopping experience in ways never dreamed of in the past.

- Shoppers are the primary source of information, not manufacturers or retailers.
- Retailer orientation is that of an agent, one who uncovers the needs of customers and then facilitates the fulfillment of those needs.
- Grocery stores are organized in whatever manner that better meets the needs of customers, such as local and intimate shopping experiences.
- Grocery store headquarters return to the store-level, where the greatest interaction with customers occurs.
- The power within the system resides with the customer.
- Store employees are the true differentiators between competing retail entities.
- Success is measured by customer loyalty and shopper performance.
- Profitability is based on how well the customer has been satisfied.
- The manufacturer's focus is on the end-user customer, leading to deeper and longer-lasting manufacturer-retailer relationships.

A world of two extremes

Traditional segmentation no longer works in a complex and divergent marketplace filled with diverse customers and individualism. Customer behavior appears at times to be schizophrenic: they will demand low prices for goods that are viewed as commodities, yet be willing to pay sizable premiums for products that mean more to them personally. This will result in two extremes: 1) huge mega-retail formats dominating one end of the spectrum, and 2) focused specialists dominating the other (IBM Business Consulting Services Group, 2004). Retailers and suppliers caught in the middle with undifferentiated concepts are doomed for failure.

What are the forces driving change in the food system? What key factors are impacting current grocery supply chains, and the evolution of grocery retailing in the United States?

Forces Driving Change in Grocery Supply Chains

Primal forces driving change include changes in the marginal cost of time, economies of scale and scope, dietary practices and needs, the use of consumer technology, and demographic shifts.

The marginal cost of time

The need for convenience. In the 1950s, it took an average of two hours to prepare a meal. By the late 1970s, it still took about an hour, but today, even 20 minutes in the kitchen is too much (Saaristo, 2005). Americans spend an average of 32 minutes per day for meal preparation and cleanup (United States Department of Labor-Bureau of Labor Statistics, 2004).

Grocers and restauranteurs recognize the value of convenience. Approximately 35% of meals eaten and not prepared at home in 2004 were provided by fast-food restaurants. Supermarkets have been very aware of this and have increased their share of meals eaten and not prepared at home from 18% in 2000 to 27% in 2004 (The Food Institute, 2004).

Gatekeepers become more guarded. Overwhelmed, time-strapped customers are seeking greater control over their interactions with businesses. Armed with technology and regulation, they will actively protect themselves from "me-too" marketing tactics. Only retailers offering differentiated, relevant value will gain access to customers' mindshare and personal information.

Economies of scale and scope

Mega retailers break the boundaries. The world's top retailers are rapidly expanding across geographies, channel formats, and product/service categories, blurring market segments and devouring market share. Competitors must differentiate themselves in order to survive.

Partnering becomes pervasive. Companies can no longer compete as an island of one. Leading retailers are evolving their enterprises into flexible "value networks" based on strong integration and collaboration with partners. There will be increased pressure to match the responsiveness and agility of these connected and mutually dependent business models.

Dietary practices and needs

Customer value drivers fragment. Customers are fragmenting into micro-segments as a result of pronounced shifts in demographics, attitudes, and patterns of behavior. These patterns of behavior are shaped by increasing consumer awareness of eating healthy, current diet trends, and social causes. Consumers are "trading down" to low-cost commodities on one end and "trading up" to high-value, premium brands and companies on the other. Retailers serving the needs of "average" customers are doomed to failure.

Use of consumer-focused technology

Information exposes all. Customers continue to gain market power and knowledge by access to information – virtually wherever, whenever, and however they want it. Retailers must provide value propositions and shopping experiences that keep customers coming back even in a world of total

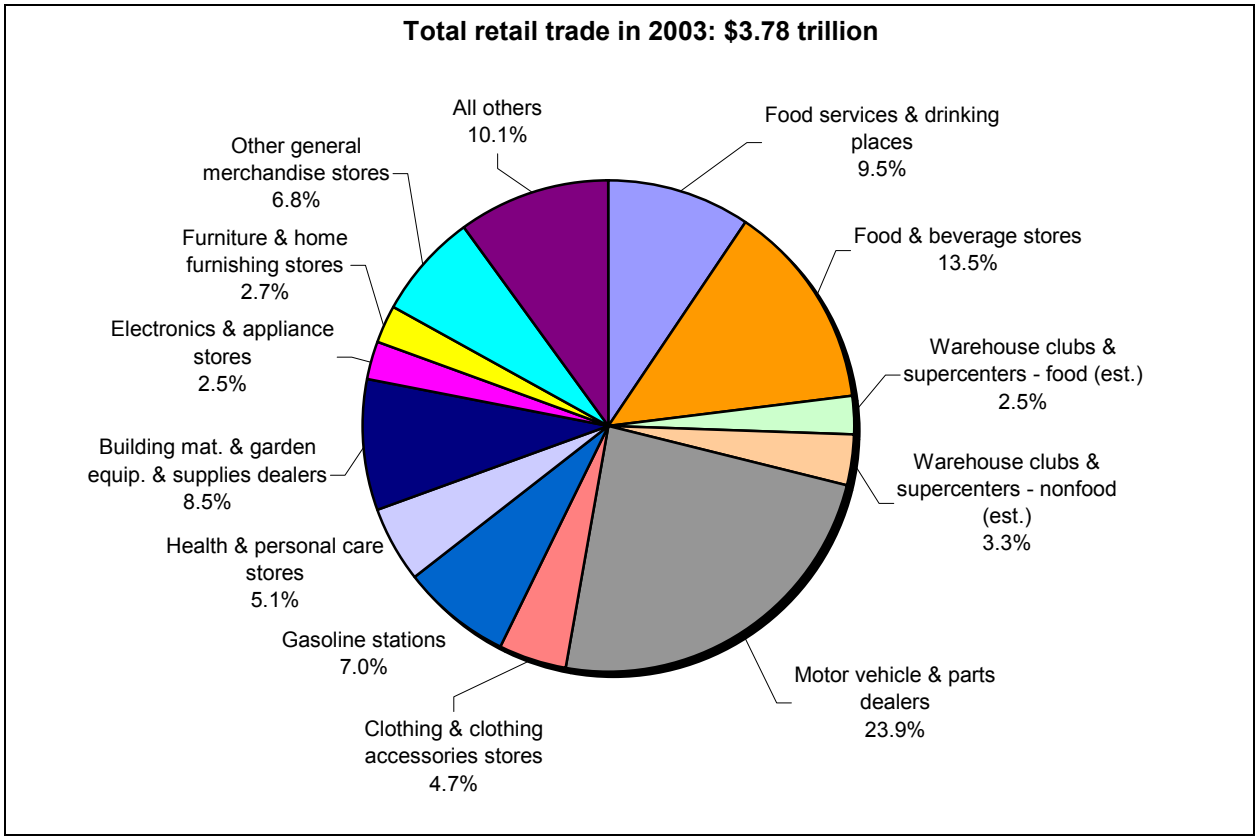


Figure 1. Food-based retailing accounts for 23% of all U.S. retail trade.
Source: 2004 Food Industry Review

information transparency (IBM Business Consulting Services, 2004).

Demographic shifts

Increasingly diverse population. Ethnic diversity continues at an increasing rate. Between 1990 and 2010, the U.S. Hispanic population is projected to grow by 80% and reach nearly 14% of the overall population. The non-Hispanic White share of the U.S. population will decline to 64% by 2020, and by 2030, it will be less than half the population under age 18. The Black population is expected to double by the middle of this century (United States Census Bureau, 1996). Clearly, grocery supply chains can no longer adopt a one-size-fits-all mentality to meeting the needs of an increasingly diverse population.

The population saddle. Those between the ages 15-24 and over 55, the largest age groups, are still growing and they have very different needs. Grocery supply chains must identify needs and deliver value to these demographic segments (The Food Institute, 2004). Long-standing life stage patterns are becoming less predictable. People are marrying later, divorcing more, having second families, starting second careers, and even raising their grandchildren.

Money pressures increase. The average American spent only 10.1% of their disposable income on food in 2003 (USDA-ERS, 2004), the lowest of any country in the world. However, most real income gains have accrued to the top 20% of the population. In particular, cost increases in housing and education are putting pressure on food purchasing. Grocery supply chains must continually find ways to cut costs, while maintaining a distinct value proposition.

What Grocery Supply Chains Look like Today

Grocery supply chain channels are blurring as store formats look more alike. Two sets of counter-veiling forces describe the current state of grocery supply chains in the United States: 1) private label/store brands vs. national brands, and 2) channel push vs. channel pull strategies.

Food-based retailing accounted for a 22.8% (Figure 1) of all U.S. retail trade in 2004 (United States Census Bureau, 2005). This is approximately $888.1 billion in retail trade. While this food share is down from 25.5% in 2003, total food-based retail sales continue to grow each year.

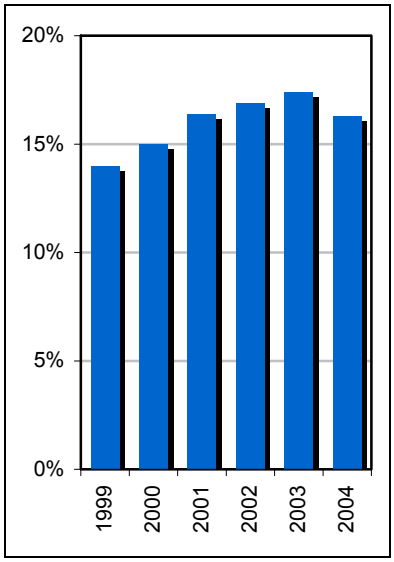


Figure 2. Trade spending as a percent of gross sales.
Source: Cannondale Trade Promotion Study 2005

Private label/store brand growth

Private label products, or store brands, continue to grow in importance in grocery supply chains. Store brand products encompass all merchandise sold under a retail store's private label. Store brands now account for 20% of the items sold in U.S. supermarkets, drug chains, and mass merchandisers. They represent more than $50 billion of current business at retail and are achieving new levels of growth every year (Private Label Manufacturing Association, 2005).

U.S. shoppers save approximately $15.8 billion annually by purchasing store brands over national brands. The difference is the so-called "marketing tax," which consists of advertising and promotional costs incurred by national brand makers that are passed on in the form of higher prices at retail. Store brands remain important to retailers. Retailers use store brands to increase business and win customer loyalty. Store brands give retailers a way to differentiate themselves from competition (Private Label Manufacturing Association, 2005).

National brands

National brands accounted for approximately 83.7% of all grocery sales in 2003 (The Food Institute, 2004). National brand manufacturers have found it necessary to offer trade and promotional dollars to promote their products, to gain access, and maintain shelf space. Manufacturers spent 16.3 % of gross sales on trade promotion (Figure 2) in 2004. For consumer and packaged goods companies this amounted to 48% of their total marketing budget and the ROI on promotion spending continues to be negative (*Forum*, 2005). The sheer size of trade and promotional allowances has led to a literal dependence on them by grocery retailers. Even retailers that are pushing their own store brands, must think twice about any decision to displace national brands and the trade dollars they bring.

Channel push vs. channel pull

In a channel push strategy, the supply chain starts with the input supplier or manufacturer and ends with the end-user. In a channel pull strategy, the supply chain starts with the end-user and ends with the input supplier or manufacturer.

A channel push strategy relies on suppliers and vendors to introduce and promote products and services to supply chain intermediaries. Trade dollars and promotional allowances are the currency of a supply chain utilizing channel push. Channel push is common in grocery supply chains and may account for as much as 17 % of sales in retailers' budgets. The Albertsons and Kroger supply chains utilize channel push strategies.

Channel pull strategies rely on satisfying demand created by end-user requests. Trade and promotional dollars are targeted to end-users and the demand created by end-users pulls products and services through the grocery supply chain. Every day low pricing, end-user coupons, and advertising targeted to end-users are the currency of a supply chain utilizing channel pull. Examples of grocery supply chains utilizing channel pull include Wal-Mart and Sav-A-Lot.

Two Main Food Systems: Grocery and Foodservice

In the mid 1990s, it appeared that food dollars spent away from home would surpass food dollars spent at home in the early part of this century. This has not happened. In 2004, food at home spending was approximately 53.5% of total food expenditures,[1] while food away from home spending accounted for the remaining 46.5% (Table 1). Food at home spending is predicted to decline to 52.0%, leaving food away from home spending at 48.0%. Increased competition from warehouse clubs, supercenters, drug stores, and the increasing emphasis on meals-to-go have tempered this trend.

The Evolution of Grocery Supply Chains

If grocery supply chains do take on the forms described in the frictionless marketplace, they will come full cir-

1. *Total food expenditures exceeded $959.4 billion in 2004, higher than the food-based retailing number ($888.1 billion) cited earlier because it includes all retail outlets such as money spent in hotels for meals, snacks at entertainment facilities, meals in institutions, and airline feeding (USDA-ERS, 2004).*

Table 1. Projected expenditures for food 2001-2013.

	Food at home[a]		Food away from home[b]		
Year	$ million	% of total	$ million	% of total	Total ($ million)
2001	463,600	53.80	398,100	46.20	861,700
2002	485,200	53.90	415,000	46.10	900,200
2003	498,100	53.56	431,900	46.44	930,000
2004	513,000	53.47	446,400	46.53	959,400
2005	526,500	53.18	463,600	46.82	990,100
2006	544,900	53.05	482,200	46.95	1,027,100
2007	562,300	52.86	501,400	47.14	1,063,700
2008	580,900	52.69	521,500	47.31	1,102,400
2009	600,000	52.52	542,400	47.48	1,142,400
2010	619,800	52.35	564,100	47.65	1,183,900
2011	640,500	52.20	586,600	47.80	1,227,100
2012	661,400	52.02	610,000	47.98	1,271,400
2013	688,200	52.04	634,300	47.96	1,322,500

Note. Data from USDA-ERS (2004).
[a] Includes food for off-premise uses.
[b] Includes both meals and snacks.

cle from how they used to be organized. The evolution of the grocery supply chain can be categorized by five phases (Terbeek, 1999): pre-development, development, saturation, and decline. The fifth phase, frictionless, was already discussed.

Pre-development (before 1945)

The pre-development phase was characterized by an individual shopper orientation, where the retailer performed multiple functions. Information resided with the individual employees/owners who knew each customer by name and their shopping preferences. Core competency resulted from creating superior customer satisfaction. Information technology was used for basic bookkeeping, and no single grocer had a technological advantage. Grocery stores were organized locally and the focus was on bulk items. Grocery store headquarters were located at each individual store, while power within the system resided with the shopper. The key industry trend was store performance and profitability based on securing and maintaining customers.

Development (1945-1975)

The development phase spawned the birth of a consumer-segment orientation, where new products were introduced to post World War II consumer-product hungry shoppers. The retailer no longer knew the customer intimately. Core competency resulted from creating superior logistics systems. Information technology moved to the back room to handle logistics of emerging grocery distribution systems. The focus was on national brands. Store headquarters were located at the warehouses, while power within the system resided with the manufacturer. Success was measured in cases moved per hour. The key industry trend was how fast the grocery chain was growing. Profitability was determined by the number of national brands items carried.

Saturation (1975-1990)

Customers became consumers in the saturation phase, and cookie-cutter retail locations signaled cost-efficiencies. The "one size fits all" attitude was as pervasive as Tide™ in grocery aisles. Core competency was measured by how well retailers could buy products. Operations were streamlined by information technology at all levels. Point of sale information was collected, studied, and managed. Store headquarters were moved to buildings no longer connected to the warehouses or stores, and power within the system resided with the retailer. Store employees became expensive to have. Success was measured by the amount of deal money buyers could wrestle from manufacturers, while the key industry trend was consolidation and profitability was determined by how efficiently stores managed categories.

Decline (1990-2000)

In the decline phase, consumers found it difficult to differentiate

between retailers and consumers were taught to switch retailers for the next lowest price on national brands. Core competency became how to run the most effective committee meetings. Information technology focused on fine tuning, and squeezing as much efficiency out of the system as possible to compete with retailers like Wal-Mart. Chains became too big to react to market changes, while smaller, independent grocery chains differentiated themselves by being innovative and in-tune with their customers. Manufacturers were the critical source of information as retailers tried to make sense of the blurring supply and consumer channels. The power within the system resided with investors on Wall Street. Store employees, as a labor pool, were scarce. Success was measured by the share price, while the key industry trend was globalization. Profitability was all too often based on the trade and promotional dollars garnered from manufacturers.

Coming Full Circle

With the dawn of the frictionless marketplace, we have come full circle from the neighborhood grocer of the pre-development phase, to "agents" of the future who utilize technology and systems to once again become "intimate" with customers. Numerous forces are driving change within grocery supply chains. These forces may ultimately determine which supply chains survive. Survival may depend on: 1) supply chains based on channel push and channel pull strategies, and/or 2) supply chains based on huge mega-retail formats and focused specialists.

For More Information

The Food Institute. (2004). *The Food Institute's Food Industry Review-2004 Edition.* Elmwood Park, NJ: The Food Institute.

Forum Magazine. (2005). Cannondale Trade Promotion Study 2005: Saying No to the Status Quo. *Forum, Second Quarter 7*(2), 72-84.

IBM Business Consulting Services. (2004). *The Retail Divide: Leadership in a World of Extremes.* Somers, NY: IBM Global Services.

Private Label Manufacturing Association. (2005). *Market Profile.* Available online: http://www.plma.com/storeBrands/sbt05.html.

Saaristo, T. (2005). *Quick Meals.* Available online: http://tomsaaristo.com/quick.html.

Terbeek, G.A. (1999). *Agentry Agenda: Selling Food in a Frictionless Marketplace.* Chesterfield, VA: Breakaway Strategies and the American Book Company.

United States Census Bureau. (2005). *Annual benchmark report for retail trade and food services: January 1992 through February 2005.* Current Business Reports Series BR/04-A.

United States Census Bureau. (1996). *Population projections of the United States by age, sex, race, and Hispanic origin: 1995 to 2050.* Available online: http//www.census.gov/prod/1/pop/p25-1130/.

USDA-ERS. (2004). *Food CPI, prices, and expenditures: Expenditures as a share of disposable income.* Available online: http://www.ers.usda.gov/Briefing/cpifoodandexpenditures/Data/table7.htm.

United States Department of Labor-Bureau of Labor Statistics. (2004). *American time use survey.* Available online: http://www.bls.gov/tus/.

Allen F. Wysocki (wysocki@ufl.edu) is Associate Professor and Master of Agribusiness Coordinator, Food and Resource Economics, University of Florida, Gainesville, Florida.

The author gratefully acknowledges the ideas received from Jack Allen, Professor Emeritus, Food Marketing Partnerships for Food Industry Development, East Lansing, MI, and from Bob Harris, Chairman of Alliance Foods, Coldwater, MI.

CHOICES
The magazine of food, farm, and resource issues
4th Quarter 2005 • 20(4)
A publication of the American Agricultural Economics Association

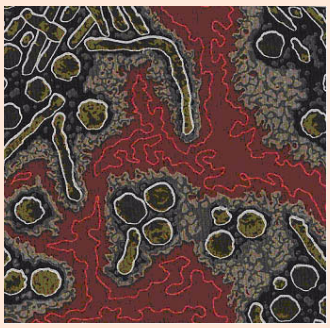
Food Safety in Three Dimensions: Safety, Diet Quality, and Bio-Security

by Jean Kinsey

Food safety in three dimensions refers to the matrix of issues and activities that lead to safe food consumption in today's world. Starting with the first principle that food should nourish the body and not cause illness, debilitation, or death, a broader concept, "safe food consumption," is called for. Food safety typically refers to food that is free from harmful, but naturally occurring microbiological contamination. Safe food consumption includes:

1. safety from known (chemical or biological) substances that lead to known (or unknown) illness or death (botulism, pesticides, cholera)
2. safety from long-term chronic diseases related to quality of diets (diabetes, heart disease)
3. safety from deliberate contamination anywhere along the supply chain of an otherwise safe food supply (bio or chemical terrorism)

Since violating any one of these three safety mandates leads to unsafe food consumption, it takes all three to bring safety, quality, and security to the food system. It takes the cooperation of all parties in the food chain (farmers, manufacturers, retailers, consumers, and all their service providers and regulators) to deliver the safe consumption of food. When food harms people, it is everybody's problem. The immediate victims become ill or die, other consumers' health care costs rise, employers lose employees, and the profitability of the supply chain that handled and sold the food is diminished.



Hepatitis B.

Safety from Known Substances That Lead to Known (or Unknown) Illness or Death

When one thinks about food safety, one usually thinks about natural or accidental microbial contamination of food or water with salmonellae or *E. coli* that results in food "poisoning," a nasty short-term illness associated with foreign travel or imported produce. This stereotype is just the tip of the iceberg when it comes to problems related to safe food consumption. Table 1 lists the ten most well-known and well-tracked pathogens leading to food-borne illnesses in the United States. The Centers for Disease Control (CDC, 2005a) estimates that these pathogens represent only a fraction of the cases and hospitalizations and less than half of the deaths actually caused by food-borne pathogens. Norwalk-like viruses generate the largest number of reported cases of food-borne illnesses per year, *Taxoplasma gondii* (a parasite) generates the largest number of hospitalizations, and campylobacter causes the largest number of deaths (Ropeik & Gray, 2002). Microbial contamination can occur at any node in the food supply chain. For foods that are not processed (cooked) before consumers eat them, sanitation at farm, packing, distribution, retail, and home nodes is critical. The hazard of humans passing microbes to food by dirty hands or coughing is not trivial. The hazards of dirty equipment, trucks, or warehouses are ever present. Keeping cold and frozen food the right temperature throughout the supply chain takes vigilance all along the chain.

The cost of food-borne illnesses caused by microbes is estimated at $6.9 to $33 billion per year (USDA-ERS, 2003). This includes direct medical costs, as well as lost wages, productivity, and estimated value of life years lost to premature death. It does not include these costs for children with food-borne illnesses, costs to employers, or the costs borne by food companies involved in recalls or law suits. Nonreported illnesses account for much of the difference between the low and high number. The low

Table 1. Reported food-borne illnesses from bacteria, viruses, or parasites – United States.

	Cases/Year (millions)	Hospitalization (cases/year)	Deaths (people/year)
Norwalk-like virus	9.200	20,000	124
***Campylobacter spp.* (1/1000 cases lead to Guillain-Barre syndrome)**	2.00	10,500	1000
Salmonella spp.	1.413*	15,600	550
Clostridium perfringens	0.250	50	10
Giardia lamblia	.200	500	1
Escherichia coli	.173	2,800	80
Listeria monocytogenes	.003*	2,500	500
Taxoplasma gondii	.113	22,600	375
Shigella spp.	.090	1,250	14
Total Reported	13.440	75,896	2,654
CDC Estimated Total Incidents	76.00	325,000	5,000

Source: Ropeik and Gray, 2002.
* Adjusted from data on http://www.ers.usda.gov/data/foodborneillness/

number is based on reported cases and the high number is an estimate of what the costs would be if all cases were reported. Profits lost when consumers or stock holders lose confidence in a brand name or a company are more temporary and less than one might expect. Research on meat and poultry recalls has shown that recalls cost less than 1% of sales and that there may actually be some offsetting gains if consumers substitute other products (Shiptsova, Thomsen, & Goodwin, 2002). Stock prices typically fall after a serious recall, but subsequent recalls in the same company and minor recalls elsewhere create no significant stock price declines (Thomsen & McKenzie, 2001; Hooker, 2002).

The relationship between food, diet, and chronic (or delayed) diseases is much less well established compared to knowledge about microbial food-borne illnesses. For example, there is virtually no known link between pesticide residue in food and cancer, antibiotic resistance in humans and eating meat from animals that have been routinely fed antibiotics, human disease and feeding growth hormones to cattle or genetically modifying plants and animals. The link between bovine spongiform encephalopathy (mad cow disease) and variant Creutzfeldt Jakob Disease (vCJD) was confirmed using transgenic mice in 1999 (Acheson, 2001), but as with many chronic and long-term illnesses, the time lag between exposure and illness is several years making epidemiological evidence in humans hard to establish. By June 2005, there were 177 known cases of vCJD in the world; 156 of them in the United Kingdom, 12 in France, 2 in Ireland, and one in each of seven other countries, including the United States (CDC, 2005b).

Most studies have found the benefit-cost ratio of taking steps to reduce the risk of food-borne illnesses to be positive. For example, Ollinger and Mueller (2003) found that Pathogen Reduction/Hazard Analysis and Critical Control Point programs in meat and poultry plants translated into a benefit value (in terms of health cost savings) at least two times the cost to the industry. However, definitive links between the reduction of pathogens in processed meat and poultry and human health incidents are very hard to find. Lakhani (2000) estimated that the benefit-cost ratio from reducing S*almonella* Enteritidis in shell eggs by refrigeration to be 0.65, 3.56, 2.56, and 8.87, depending on the method used to calculate the benefits. A third study showed that for every dollar saved by preventing a premature death from a food-borne illness, there is an economy-wide gain of $1.92 (Golan, Ralston, Frenzen, & Vogel, 2000). Other studies show that consumers are willing to pay more for safer food than the losses that might incur due to illness using the cost-of-illness approach to measure the benefits of safer food (Antle, 2001). In the real world, consumers demonstrate their willingness to pay at the supermarket when they buy organic food to avoid pesticides and "natural" foods to avoid additives. They pay for safer food at tax time by supporting government agencies such as the Food and Drug Administration, Departments of Agriculture, and state health departments. In most developed countries, consumers have come to expect their government to ensure safe (and honest) food and they are generally willing to pay for it.

Safety from Long-Term Chronic Diseases

Even though the relationship between food, diet, and chronic disease is largely unknown and understudied for the food-borne substances discussed above, it is well known that Type 2 diabetes[1] and between 20 and 40% of cancers in adults in the United States are linked to obesity and are rising at a near epidemic rate (Knowler, Barret-Comer, Fowler, Hamman, Lachin, Walker, & Nathan, 2002; Calle, Rodriguez, Walker-Thurmond, & Thun, 2003). The rapid rise in obesity around the world suggests that it must be considered in the same arena as microbiological pathogens when it comes to safe food consumption. Just as it is the quantity of microbes in the food that leads to acute illness, it is the quantity of calories in the diet - relative to energy expended by the body - which contributes to Type 2 diabetes and other obesity-related complications.

In the United States, adult obesity has doubled since 1980 to 30% of the population and overweight adolescents have tripled since 1980 to 15%. (FDA, 2002; CDC, 2005c). Overweight children ages 2-5 have increased from 7 to 10% since 1994. Eight percent of U.S. adults (Knowler et al., 2002) and about 4% of children in America have Type 2 diabetes. The rise in this noninherited diabetes in children is of great concern since diabetes is a chronic disease that absorbs over 10% of all health care dollars. It is growing along with obesity in children; it is a health care disaster in slow motion. Obese children with diabetes will increase our collective health care costs for as long as they (and we) live.

In the *American Journal of Managed Care* (1998), Wolf reported that relative to overweight people (those with body mass indexes [BMI] of 25-30), obese people with body mass indexes of 30-35 cost 1.5 times as much to care for. Those with a body mass index of more than 35 cost 1.75 times as much to care for as those who are merely overweight. One study estimated that health care for overweight and obese people adds an average $732 to the annual medical bills of every American (Connolly, 2003).

What does it cost for obesity-related diseases in the United States? Total and indirect costs are estimated to be $93 billion (Connolly, 2003) to $117 billion in 2000 (FDA, 2002). Table 2 compares the costs of microbial-related food-borne illnesses to health care costs related to obesity. By any comparison you want to select, the costs of obesity are much larger than the costs of microbial pathogen contamination. Using the conservative estimate of $93 billion a year for obesity-related diseases, and comparing it to the low and high estimates for the costs of microbial contamination reveals that obesity-related diseases are between 2.5 and 13.5 times as expensive as microbial-caused food-borne illnesses. The $93 billion for obesity health care costs is 1% of the 2000 U.S. gross domestic product of $10,236.9 billion (Economic Report to the President, 2003) and 10% of the amount spent on food and beverage by U.S. consumers. Even though the CDC has recently recalculated the number of deaths due to obesity and the health-related problems of being overweight, obesity is a major and growing problem for safe food consumption.

Table 2. Costs associated with the unsafe food consumption in the United States, 2000.

Type of Health Care Problem	Health Care Costs	Deaths
Microbial Food-borne Illness	$6.9* - $37 billion (includes losses due to death)	2,654-5,000 Persons per year
Obesity Related Diseases	$93 - $117 billion (direct and indirect costs)	26,000 Persons per year
Ratio of Obesity Costs to Microbial Costs	Low: 93/6.9 = **13.5** High: 93/37 = **2.5**	26/5 = 5.2

*Estimated cost based on four types of microbes: Campylobactor, Salmonella, E.-coli, Listeria http://www.ers.usda.gov

Food Defense: Securing a Safe Food Supply from Deliberate Contamination

Until September 11, 2001, food security meant having access to enough food, at all times, for an active, healthy life (Nord, 2002). Now there is a second and new definition of food security, better referred to as food defense. It means taking actions to secure the production, processing,

1. *Type 2 Diabetes is a disease where insufficient insulin is produced in the body or cells ignore insulin. Before the onset of Type 2 Diabetes in numerous youth, it was called adult-onset diabetes. Type 1 diabetes is a condition where insulin is not produced in the body and is typically considered to be an inherited condition (www.diabetes.org/about-diabetes.jsp).*

and distribution chain from bio (or chemical) terrorists so that food is an unattractive target and unlikely to be *deliberately* contaminated with an agent that would make people ill, cause death, or cause an economic loss to individuals or to industry. Arguably, if food is produced according to good farming and manufacturing practices, the chances of it being compromised by a deliberate terrorist are less, but certainly not zero. U.S. federal government units such as the Food and Drug Administration (FDA) and the United State Department of Agriculture (USDA), and now the Department of Homeland Security (DHS), are actively studying this new hazard, developing educational programs, and encouraging private companies to take precautionary measures to minimize the possibility of a food terrorism event. More regular and rigorous testing on input ingredients and supplies, restricted access to processing areas, or locked trucks and storerooms are among the many activities private companies can do to lessen the attractiveness of food as a target. DHS leads a coordination effort among the private sector and local, state and federal agencies to make the food system less vulnerable to terrorist attacks.

Anthrax.

Food defense is the third dimension of safe food consumption. There are billions of dollars being spent by private companies, public agencies, and universities to learn more about how food and the food system in the United States might be used as a destructive weapon by terrorists. Two Department of Homeland Security Centers of Excellence have been established to focus research and education on the issue of food defense: The National Center of Food Protection and Defense led by the University of Minnesota (http://www.ncfpd.umn.edu) and the National Center for Animal and Zoonotic Disease Defense led by Texas A&M (http://fazd.tamu.edu). The collaborative efforts of these and other centers with their many partners will be instrumental in designing programs and policies that will help to defend the food system. They are helping private companies learn about vulnerable locations and practices. It is vital that food that is already safe not be deliberately contaminated with known and unknown substances that could potentially harm or kill thousands of people in a very short time.

Terrorism does not necessarily have to kill people to succeed. It could create sudden shortages and then panic by disrupting lean supply chains at ports or distribution centers when commercial inventories are maintained on a flow basis. It only needs to create a crisis of confidence in the safety or availability of food from a particular source (a brand or a region). This could mean large economic losses to private food companies as they shut down, clean up, and re-establish their credibility. It only needs to cause consumers/citizens to lose confidence in their government agencies in terms of being able to ensure safe food. This makes food security (defense) a vital part of assuring safe food consumption. A positive externality of all this effort by companies to secure plants, transportation, and retail locations, is that traditional food safety will also be improved.

Food safety in three dimensions refers to a new three part program to try and ensure safe food consumption. Food scientists will tell you that "the dose makes the poison." No food can be guaranteed to be totally free of microbes or other substances that could, in adequate amounts, harm a human being. The issue is controlling the amount of harmful substances be they microbes, chemicals, pharmaceuticals, or simply too many calories. In an era where food travels great distances, through many stages in the supply chain, being handled by many parties before it reaches the fork, the possibility of accidental mishandling or deliberate contamination is real. Safe food consumption demands that the path of food can be traced to its origins. The FDA has new regulations to be in force by December 2005 that mandate all companies that buy and sell food be able to trace that food to the party they bought it from and the party they sold it to. Retail stores and restaurants obviously need not trace it to consumers (FDA, 2005). This will lead to the adoption of new information technologies such as radio frequency identification (RFID) tags and readers and it will add some costs. Compared to the potential losses in the case of a serious foodborne illness outbreak or a terrorist attack, this investment is likely to have a high and positive benefit-cost ratio, just as the investments in food safety practices have had in the past.

Food defense reinforces food safety. It will enhance good manufacturing practices and vigilance along the food supply chain. It will improve consumers' confidence in the food system and in their personal futures. People who live in a secure environment are more likely to invest in

themselves and perhaps even be more likely to eat healthier diets. Safe food consumption means paying attention to the health and economic consequences of food consumption, to a triumvirate of food safety issues and to a plethora of good practices by everyone in the food chain.

For More Information:

Acheson, D. (July/August, 2001). "You are What I Eat." *Food Quality,* July/August, pp. 22-33.

Antle, J. (2001). Economic Analysis of Food Safety. In Bruce Gardner and Gordon Rausser (Eds.), *Handbook of Agricultural Economics*, *Chapter 10, Vol. 1B*. New York: Elsevier.

Calle, E.E., Rodriguez, C., Walker-Thurmond, K., & Thun, M.J. (April 2003). Overweight, obesity, and mortality from cancer in a prospectively studied cohort of U.S. adults. *The New England Journal of Medicine, 348*(17), 1625-1638.

Centers for Disease Control (CDC). (2005a). Available online: http://www.cdc.gov/ncidod/eid/vol5no5/mead.htm.

Centers for Disease Control (CDC). (2005b). Available online: http://www.cdc.gov/ncidod/dvrd/vcjd/factsheet_nvcjd.htm.

Centers for Disease Control (CDC). (2005c). Available online: http://www.cdc.gov/PDF/Facts_About_Obesity_in_the_United_States.pdf.

Connolly, C. (2003). Health costs of obesity near those of smoking. *Washington Post,* May 14, p. A9.

Economic Report to the President. (2003). Available online: http://www.gpoaccess.gov/eop/ (Accessed 2005 Data from 2003).

Food and Drug Administration (FDA). (2002). *Consumer,* March –April, p. 8.

Food and Drug Administration (FDA). (2005). Available online: http://www.fda.gov/oc/bioterrorism/bioact.html; http://www.cfsan.fda.gov/~dms/fsbtac25.html.

Golan, E.H., Ralston, K., Frenzen, P., & Vogel, S. (2000). The costs, benefits and distributional consequences of improvements in food safety: The case of HACCP. In Laurian J. Unnevehr (Ed.), *Economics of HACCP: Costs and Benefits.* St. Paul, MN: Eagan Press.

Hooker, N. (2002). Stock market reaction to food recalls: A GARCH application. *Applied Economics Letters, 9,* 979-987.

Knowler, C. W., Barret-Connor, E., Fowler, S.E., Hamman, R., Lachin, J.M., Walker, E.A., & Nathan, D.M. (February 2002). Reduction in the incidence of Type 2 Diabetes with lifestyle intervention or Metformin. *The New England Journal of Medicine, 346*(6), 393-403.

Lakhani, H. (2000). Benefit-Cost Analysis of Reducing Salmonella Enteritidis: Regulating Shell Egg Refrigeration. In Laurian J. Unnevehr (Ed.), *Economics of HACCP: Costs and Benefits, Chapter 8*. St. Paul, MN: Eagan Press.

Nord, M. (2002). Household food security in the United States. *ERS Information*, November. Available online: http://ers.usda.gov/publications/fanrr29/.

Ollinger, M., & Mueller, V. (2003). Managing for safer food: The economics of sanitation and process controls in meat and poultry plants. Washington, DC: USDA, ERS Agricultural Economics Report No. 817.

Ropeik, D., & Gray, G. (2002). *Risk.* Boston: Houghton Mifflin Co., pp. 98-100.

Shiptsova, R., Thomsen, M.R., & Goodwin, H.L. (2002). Producer welfare changes from meat and poultry recalls. *Journal of Food Distribution Research, 33*(2), 25-33.

Thomsen, M.R., & McKenzie, A.M. (2001). Market incentives for safe foods: An examination of shareholder losses from meat and poultry recalls. *American Journal of Agricultural Economics, 83*(3), 526-637.

Townsend, M.S., Peerson, J., Love, B., Achterberg, C., & Murphy, S.P. (2001). Food insecurity is positively related to overweight women. *Journal of Nutrition*, *131,* 2880-2884.

United States Department of Agriculture – Economic Research Service (USDA-ERS). (2003). Foodborne illness cost calculator. Available online: www.ers.usda.gov/data/foodborneillness.

Wolf, A.M. (1998). Impact of obesity on healthcare delivery costs. *American Journal of Managed Care*, *4*(3), Sup., 141-148.

Jean Kinsey is Professor, Applied Economics Department, and Co-Director, The Food Industry Center, University of Minnesota, St. Paul, Minnesota.

CHOICES
The magazine of food, farm, and resource issues
4th Quarter 2005 • 20(4)
A publication of the American Agricultural Economics Association

Transitioning from Transaction-Based Markets to Alliance-Based Supply Chains: Implications for Firms

by Thomas L. Sporleder, Constance Cullman Jackson, and Dennis Bolling

Rapid technological innovation, such as biotechnology and information technology, is part of food industry dynamics and complicates individual firm strategy. As these technologies become more important, managers of firms in the global food system wrestle with defining their optimal strategies. Also, judging supply chain performance from a public policy perspective becomes more arduous. Managers must decide over time on their firm's research and development (R&D) initiatives, the firm's core competencies and boundaries, and the firm's relationships to upstream suppliers and downstream customers. How can we better understand these dynamics and the implications for participants within those supply chains?

Rapid advances in biotechnology generate the opportunity for genetically engineered customized production of plant and animal products that possess distinct traits targeted to specialized end-use markets. Pharming is a good example of this.[1] Promising scientific processes provide the foundation for an increasing stock of intellectual property in the form of genetically engineered plant and animal material that is patented, trademarked, protected as trade secrets, or otherwise insulated from imitation. Genetic engineering enhances the stock of intellectual property (IP). IP, in turn, invites and empowers food and agribusiness firms to create strategies to differentiate their products. In general IP, flowing from product or process innovation, provides a foundation for a novel basis for rivalry relative to a firm's competitors (Bontis, 2002). Managers continually pursue strategies which they believe may result in sustainable competitive advantage for their firm relative to rivals (Porter, 1985).

Like biotechnology, rapid advances in information technology are inviting enhanced supply chain coordination. For example, online B2B (business-to-business) marketplaces connect consumer-goods manufacturers, suppliers, and retailers in networks for the purpose of minimizing costs. GlobalNetXchange recently announced a merger with rival WorldWide Retail Exchange in an effort to facilitate all member firms of the merged exchange to better control supply chain inventory and reduce supply chain cost (*Chicago Sun-Times*, 2005).

The longer-term foundation of rivalry in the global food system is shifting. Encouraged by the rapid development of IP, the foundation of rivalry within the global food system is shifting away from tangible assets toward intangible assets (Boehlje, 1999). The consequences of this evolution are pervasive and fundamentally change the character of relationships among firms within the global food system. In particular, when the basis for rivalry is centered on intangible assets, *value-creating vertical networks are spawned in response* (Sporleder & Moss, 2002).

This article discusses the consequences of the changes that are evolving in food supply chains. The basic notion is that the basis for rivalry is shifting in the interdependent

1. *The two major markets that dominate biotechnology applications are human health and food. Recent trends in biotechnology suggest that the traditional lines between food and medicine will blur. The future medicine cabinet may contain compounds harvested from bioengineered pharmaceutical plants. These plants have been altered by recombinant DNA technology (genetic engineering) to contain genes capable of 'manufacturing' a biologic or drug compound. These compounds are then harvested and make their way into applications in human medicine or veterinary health applications. Hence, 'pharming' is the use of genetically engineered plants or livestock to produce medically useful products.*

"farm gate to plate" food industries. The discussion focuses on vertical network coordination or alliance-based supply chains as one specialized response to this new basis for rivalry. How these responses result in transitioning away from transaction-based markets is discussed, particularly for commodity markets. Value capture has enhanced the need for supply chain participants to correctly identify the target market space.[2] The authors argue that food supply chains have unique characteristics based on the nature of vertical dependencies found within chains.

Vertical Network Alliances

Strategic alliances are intermediate between open spot markets and complete vertical integration (Sporleder, 1992). Vertical alliances coagulate among upstream and downstream firms in an effort to form networks that are synergistic and add value beyond what an individual firm may be able to achieve (Lazzarini, Chaddad, & Cook, 2001). The networks are formed to create competitive advantage by investing in and controlling relation specific assets, knowledge sharing routines, complementary resources and/or capabilities, and effective governance within the vertical network (Dyer & Singh, 1998; Sporleder, 1994; Sporleder & Peterson, 2003; Teece, 2000).

A more sophisticated understanding of how exchange relationships develop revolves around intellectual property that *induces firms to structure exchange relations vertically within the food chain* in a manner that maximizes transaction value. In essence, vertical network alliances form (often based on IP) around an objective of *maximizing value added* within the vertical supply chain.

For example, Suiza Foods, through their Morningstar Foods division, formed a strategic alliance with Hershey to create supply chain value. Hershey is responsible for contributing enhanced flavor technologies while Morningstar is responsible for contributing enhanced packaging technologies (*Wall Street Journal,* 2000). Sparling and Cook (1998) analyze an international strategic alliance involving Casa Ley with Sun World International. This strategic alliance, based on IP leveraging, was aimed at enhanced shelf-life vine-ripe tomatoes and other fresh products.

The foundation adopted here for the transition to alliance-based supply chains is that firms in vertical networks can increase value creation by *increasing* dependence on a small number of suppliers (limiting suppliers to one or a few) and thereby deepening incentives of suppliers to share knowledge and engage in R&D. Firms in alliance-based supply chains may make performance-enhancing investments of benefit to their downstream customers and the overall supply chain (Sporleder & Peterson, 2003).

Supply Chains and Vertical Networks

Networks are defined as a mode of organization that is used by managers or entrepreneurs to position their firm at a competitive advantage over rival firms. This arrangement is viewed as a long-term, purposeful arrangement that allows each firm to operate as a distinct firm, yet participate in a vertically-allied network. A formal definition of an alliance-based supply chain is useful. Such a supply chain consists of *firms that participate in a vertically-linked organizational network and share a strategic vision centered on the objective of creating value within the network.* Member firms remain independent, but trust one another and may more readily share proprietary information. Of course, a network may be only a portion of a supply chain.

Alliance-based supply chains imply the ability to differentiate products and to quickly respond to market changes compared to traditional transaction-based supply chains. Alliance-based supply chains can identify targeted markets and *create* value for products and services. This is a huge leap from the typical focus in transaction-based supply chains to *creating* value. Value creation is accomplished by forming alliances that leverage intellectual property to match unique product characteristics and information technology with under-served markets.

Supply Chains as a Basis for Rivalry

One of the challenges that occur for managers and entrepreneurs within the global food system is to adjust managerial perceptions concerning the identification of rivals. Perceptions may change with or without technology adoption.

Retail grocery stores in the United States illustrate the evolution in the perception of rivals over time. The now outdated managerial perception was that retail grocery stores competed against similar stores in the same industry. The perception of rivalry has now evolved to include not only the traditional competitors but also quick service food establishments, such as McDonalds and Burger King. This expanded percep-

2. *Value capture often is defined as the managerial strategy to enhance value of the firm's product or service and/or reduce costs without sacrificing quality.*

tion of rivals is multi-industry in scope. This evolution in rivalry has resulted in retail grocery store managers perceiving their market to include selling meals, not solely the traditional role of selling ingredients for meals. One obvious consequence of this evolution has become more delicatessens and ready-to-eat products offered in grocery stores.

As supply chains transition from transaction-based to alliance-based, it becomes even more difficult to assess one's rival. A rival's tangible assets are relatively easy to identify and assess. As rival firms' holdings become increasingly concentrated in intangible assets, the capabilities and capacities of rivals become more uncertain and even ascertaining the industries that may produce future rivals becomes more elusive. For example, traditional food processors such as Kellogg did not anticipate consumer preference shifts to on-the-go breakfast foods, and new rivals developed from firms in industries outside the mainstream ready-to-eat breakfast cereal manufacturers.

The transition from transaction-based supply chains to alliance-based supply chains changes many "drivers" or factors that managers must consider. The traditional basis of rivalry, compared to a new and evolving basis for rivalry, is outlined in Table 1. An important aspect of the new basis for rivalry is the existence of an alliance-based supply chain centered on soft assets (e.g., IP) rather than hard assets (e.g., plant and equipment). A major purpose of the alliance-based network becomes the commercialization of the technology, typically focused on target markets that are relatively low volume and/or represent specialized end-use.[3] Trust becomes more pronounced within alliance-based supply chains (Sporleder, 1994). For example, trust is especially critical in the early stages of a cooperative interfirm alliance.

The generic items summarized in Table 1 offer some indication of the challenges to, and the evolution of, managerial perceptions presented within alliance-based supply chains. The first six items of the table are associated with *internal management* of the firm. The next four items are factors associated with the *competitive environment* in which the firm operates. The last two items of the table are factors associated with *strategic planning and outcomes*. Not all items may pertain to a specific situation.

Recent improvements in our ability to transmit information have forged new partnership and alliance opportunities among firms around the globe. Now an agribusiness firm may form an alliance of a block of growers in the United States, a pharmaceutical firm in Europe, and a manufacturer in India to produce a highly specialized product based on biotechnology intellectual property. The use of genetically engineered plants to harvest medicinal compounds, such as corn to produce monoclonal antibodies, is just emerging. In this example, it is no longer clear whether a firm's rivals are growers, a research company or a processor or even within the agribusiness sector. Complicating the issue is that the firm, via its alliances, is now international with multinational assets.

As the public strives to assess the performance of these new alliances, non-traditional measurement techniques are required. Assessing the performance of IP-driven relationships is more difficult, compared to physical asset-driven relationships, because of the tacit knowledge involved.[4] Tacit knowledge (knowledge that people carry in their minds that is, therefore, difficult to access and difficult to codify) often is a factor in understanding the value proposition of relationships and the value of knowledge firms possess within the chain (Sporleder & Moss, 2002). Some new performance measurements will surely rely on improved definition, valuation, and understanding of intangibles (Lev, 2001).

Market Space Defined by Dependency and Differentiation

Considering commodities and food products in a market space defined by the degree of differentiation and the nature of dependency within supply chains adds to our understanding of why various exchange arrangements are frequent in some supply chains, but not in others. The extent of differentiation, of course, typically increases in markets closer to the final consumer level.

Another factor inherent to agricultural commodities and food products, in a comparative sense, is perishability. Perishability partially determines the inherent nature of economic dependency within supply chains. For less-perishable commodities, storage can be a primary means of vertical coordination in the supply chain. Buffer stocks are held by firms in upstream and downstream markets in an effort to mitigate risk and generally deal with unexpected

3. *Additional consequences of the shift from commodities to differentiated products and some market structure issues are addressed by Rausser, Scotchmer, and Simon (1999).*

4. *See Tirole (1988) for a standard treatment of the role of market forces and industry structure on the performance within markets and industries.*

Table 1. Economic drivers for managers of firms in the transition from transaction-based to alliance-based supply chains.

Driver	Traditional Basis of Rivalry	New Basis of Rivalry
Firm Assets	Tangible (hard)	Intangible (soft)
Firm Mission	Manufacture/assemble	Create/add value; focus on "trait" demand
Tactics	Build/acquire key manufacturing facilities	Quickly out-source and partner with other firms; share proprietary information
Key Objective	Achieve scale economies	Create value, excel in low-volume target niche markets, customize products
Human Resources	Reward individuals	Utilize empowered teams
Quality/safety	Fix quality problems as they occur	Hazard Analysis Critical Control Point (HACCP); adopt identity preservation and traceback technologies
Product/service Aspects of Rivalry	Based on cost	Based on traits and product differentiation; vertical traceability or "identity preservation" is an important component of the vertical network
Perception of Rivals	Other firms in the same industry	Other vertical networks competing in the same market space
Farm Gate	Agricultural producer sells undifferentiated commodity which is commingled with other production at the first handler level, identity of producer or production protocols not preserved downstream	Agricultural producer harvests biotechnologically-modified and patented "value added" items provided under contract to first handler
Number and Turnover of Suppliers	Several competitive suppliers, turnover expected; price sensitive relationships	Limit suppliers to a few, turnover not expected or at least more stable; relationship relatively less sensitive to price
Strategic Planning	Secret strategic planning, no vertical sharing of proprietary information	Share strategies within a network; adopt vertical system goals; off-load some R&D to upstream suppliers where possible
Managerial Success Criterion	Maximize shareholder value	Maximize shareholder value partially through maximizing supply chain value creation

events. Vertically dependent firms at successive stages in the supply chain are referred to as sequentially dependent because buffer stocks play a major role in risk mitigation and coordination. The portions of a supply chain that rely on buffer stocks for risk mitigation typically also rely on transaction-based open markets.

In commodity markets characterized by perishable commodities, reciprocal dependency is the relationship among vertically allied firms in the marketing channel. Buffer stocks are not feasible. One consequence of this is that the coordination problem is more severe and alternative exchange mechanisms emerge beyond simple spot market transactions, such as contracting, joint ventures, and various forms of strategic partnering. In short, these alternative exchange mechanisms are examples of interfirm alliances. These alternatives are attempts to enhance coordination and, in part, "substitute" for the economic role that buffer stocks play in the sequentially dependent channels. The relative relationship among some selected commodities and food products can be easily portrayed in the market space defined by the intersection of differentiation intensity and sequential-reciprocal dependency (Figure 1).

Along the vertical axis, the fungibility of items decreases from the bottom of the axis to the top. Thus, items such as soybean oil are more fungible than pharmaceutical corn. In general, the space above the horizontal requires relatively increased investment, often predominantly in intangibles. Moving from left to right of the vertical represents declining potential for buffer stocks and the increasing reliance on exchange arrangements that tend to replace cash markets, such as contracting and strategic alliances.

Table 2. Selected exchange mechanisms that are typical within the dependency and differentiation categorization.

Nature of Dependency	Amount of Differentiation	
	Generic	Differentiated
Sequential	• Buffer stocks • Cash market transactions	• Strategic partnering • Joint venture • Long-term contracts
Reciprocal	• Seasonal contracts	• Specification buying under contract • Just-in-time deliveries • Ownership integration

The "dependency/differentiation" space may be used to understand the

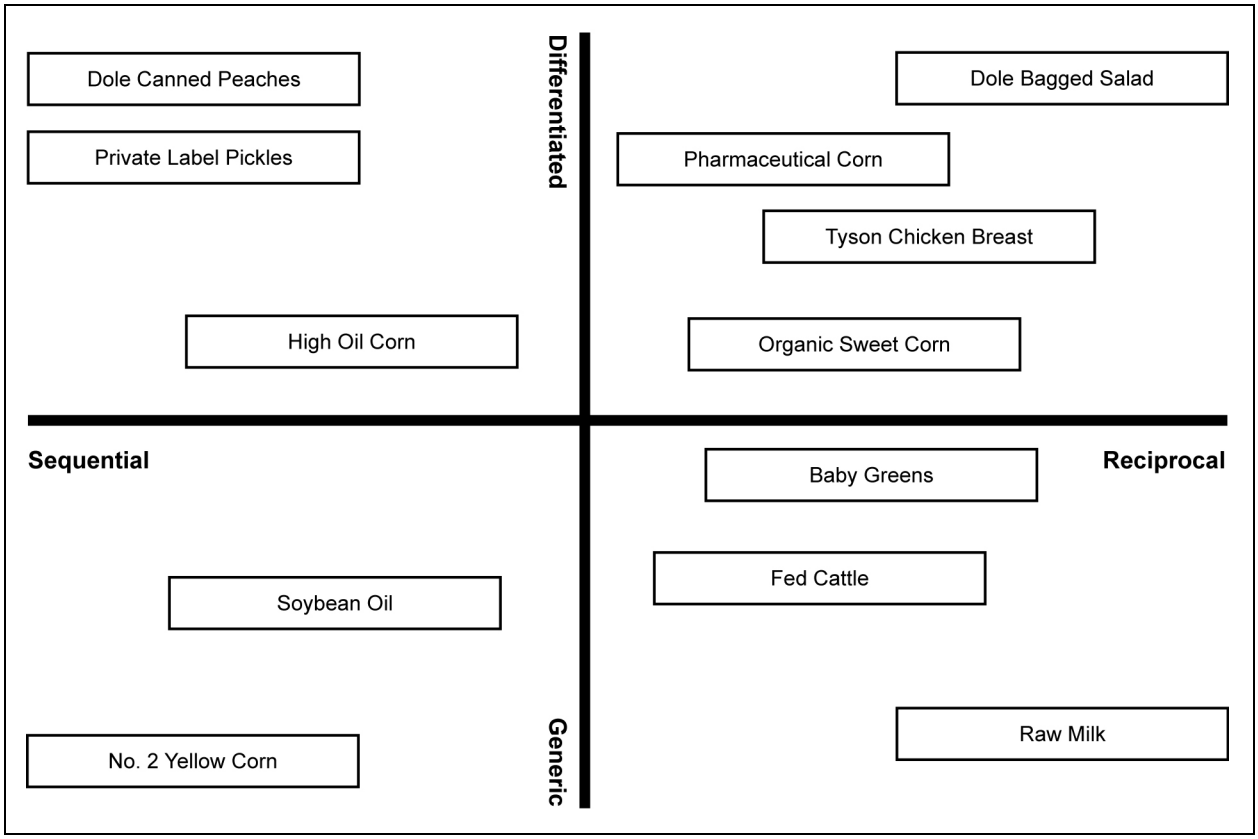


Figure 1. Selected examples of items in the dependency and differentiation space.

major thrusts within value creating alliance-based supply chains (Table 2). The distinction of sequential and reciprocal dependency and the extent of product differentiation are factors useful for better understanding the type of exchange mechanism that is appropriate for a particular combination of dependency and differentiation. The relative importance of alternative exchange mechanisms is provided within the cells of Table 2. The dynamics of how firms participate in supply chains that drift from transaction-based to alliance-based may generally be characterized as movement away from either cell of the 'reciprocal' row of Table 2 to either of the cells of the 'sequential' row.

Conclusions

The basis of rivalry within the global food system is shifting over time toward alliance-based supply chains where intangibles serve as a foundation for spawning closer coordination in an effort to create value. Firms may participate in an alliance-based supply chain network for the purpose of creating competitive advantage through investing in and controlling relation specific assets, knowledge sharing routines, complementary resources, and/or capabilities. The key element is that intellectual property *induces firms to structure exchange relations vertically within the food chain* in a manner that maximizes transaction value. In essence, transaction-based supply chains develop around an objective of *maximizing value creation* within the chain.

The basis for rivalry is shifting and these shifts present challenges for managerial perceptions. Factors associated with internal management of the firm, the competitive environment in which the firm operates, and strategic planning and outcomes all must be revised when firms join an alliance-based supply chain. Firms may adopt new definitions of their rivals and look beyond traditional sectors to identify collaborators and competitors, while new means of assessing firm performance may become necessary.

The degree of differentiation and the nature of dependency within supply chains enhances our understanding of the incentives for alliance formation. The transition to alliance-based supply chains creates challenges in how firms assess their relative position within industry and requires novel approaches to understanding both competitors and collaborators. Participation in alliance-based supply chains demands managerial flexibility and nimbleness, yet offers virtually unlimited opportuni-

ties to leverage assets. Firm assets concentrated in intangibles, in tandem with novel alliance formation, offers exciting potential for value creation within the global food system.

For More Information

Boehlje, M.D. (1999). Structural changes in the agricultural industries: How do we measure, analyze, and understand them? *American Journal of Agricultural Economics, 81,* 1028-1041.

Bontis, N. (2002). Managing organizational knowledge by diagnosing intellectual capital. In C. W. Choo and N. Bontis (Eds.). *The strategic management of intellectual capital and organizational knowledge* (pp. 621-642). New York: Oxford University Press.

GlobalNetXchange moving headquarters to Chicago. (April 27, 2005), *Chicago Sun-Times*.

Dyer, J.H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review, 23*, 660-679.

GlobalNetXxchange web site: https://www.gnx.com/reg/index.jsp.

Lazzarini, S.G., Chaddad, F.R., & Cook, M.L. (2001). Integrating supply chain and network analysis: The study of netchains. *Journal on Chain and Network Science, 1,* 7-22.

Lev, B. (2001). *Intangibles: Management, measurement, and reporting.* Washington, DC: Brookings Institution Press.

Porter, M.E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York: The Free Press.

Rausser, G., Scotchmer, S., & Simon, L. (1999). *Intellectual property and market structure in agriculture*. Rome, Italy, The International Consortium on Agricultural Biotechnology Research (ICABR).

Sparling, D., & Cook, R. (1998). Strategic alliances and joint ventures under NAFTA: Concepts and evidence. *Policy Harmonization, Convergence, and Compatibility*, A. Loyns (ed.), Friesen Printers: Winnipeg, Manitoba, pp. 68-94.

Sporleder, T.L. (1994). Assessing vertical strategic alliances by agribusiness. *Canadian Journal of Agricultural Economics, 42,* 533-540.

Sporleder, T.L. (1992). Managerial economics of vertically coordinated agricultural firms. *American Journal of Agricultural Economics, 74*, 1226-1231.

Sporleder, T.L., & Peterson, H.C. (2003). Intellectual capital, learning, and knowledge management in agrifood supply chains. *Journal on Chain and Network Science, 3*, 75-80.

Sporleder, T.L., & Moss, L.E. (2002). Knowledge management in the global food system: Network embeddedness and social capital. *American Journal of Agricultural Economics, 84*(5), 1345-1352.

Teece, D.J. (2000). *Managing intellectual capital: Organizational, strategic, and policy dimensions.* New York: The Oxford University Press.

Tirole, Jean. (1988). *The theory of industrial organization.* Cambridge, MA: The MIT Press.

Wall Street Journal. (2000). Suiza food group: Unit will develop products in an alliance with Hershey, August 30, p. 1.

Thomas L. Sporleder is Professor, AED Economics Department, The Ohio State University, Constance Cullman Jackson is Vice President of Agricultural Ecology, Ohio Farm Bureau Federation, and Dennis Bolling is President and CEO, United Producers, Inc., respectively, Columbus, OH.

CHOICES
The magazine of food, farm, and resource issues
4th Quarter 2005 • 20(4)
A publication of the American Agricultural Economics Association

Risk Sharing and Transactions Costs in Producer-Processor Supply Chains

by Allan W. Gray and Michael D. Boehlje

Introduction

Several forces are converging to encourage the agricultural industry to form more tightly aligned supply chains. Efficiency, synergies, inter-firm pooling of resources, customer responsiveness, and risk sharing are the four key objectives that firms seek to improve by forming such chains (Besanko, Dranove, & Shanley, 2000). Efficiencies are often gained by more accurately sharing information between parties in the chain. For example, a pork processor may be able to manage the flow schedule of hogs through the slaughter plant by contracting or even owning the production stage of the pork chain. And complementary inter-firm synergies resulting from, for example, alliances between research and development (R&D) and manufacturing firms and downstream distribution and marketing firms can also be captured with effective supply chains.

Responsiveness to consumer demand is another reason for developing supply chains. Products that can be differentiated at various stages of the food chain allow for the potential to meet the demands of certain segments of the market. Retailers as well as processors argue that their supply chains allow them to respond to an ever changing set of consumer preferences more quickly than they could with traditional open-market transactions.

In addition to efficiency, inter-firm synergy, and responsiveness, supply chain participants often express a desire to manage risks as a reason for forming supply chains. The risks may be input/output price risk, quantity/quality risks, and/or safety/health risks. The recent interest in food safety and traceability are often cited as reasons for forming tighter vertical alliances. Agricultural producers often state that reductions in price and volume variability are key influencers in their decision to join a supply chain (Hennessey & Lawrence, 1999; Rhoades, 1995).

Supply chains have been a dominant focus of both academic research and business strategy in the food and agribusiness industries for the past decade. Much discussion, analysis, and experimentation with various forms of vertical alignment using governance structures such as strategic alliances, joint ventures, contracts, and vertical integration has occurred. Much of the recent debate and discussion, as well as the controversy concerning the development of these arrangements has focused on the production sector, and in particular, the linkages between producers and processors.

The effectiveness and long-term viability of a supply chain is determined in no small part by how well the coordination governance structure manages the sharing of the risks and rewards of the supply chain among its participants. The different types of risks encountered in alternative supply chain business structures, the incidence of risk on the part of individual supply chain partners and the sharing of risk and reward among supply chain participants has important implications for who will be the most likely participants in a supply chain, as well as the benefits the various players will receive.

Risk Sharing and Costs of Vertical Alignment

The research on supply chain risk/reward sharing in agriculture has often been focused on producer impacts. As noted, producers are often seeking avoidance of risk in these arrangements. However, governance structures such as contracting that lead to risk avoidance also result in lower returns on average. Governance structures that reduce risks for producers can lead to misalignment of incentives resulting in shirking behavior (moral hazard) if not monitored carefully. For example, producers on fixed payment contracts may be more inclined to deliver lighter weight hogs to the slaughter facility than the processor desires. In addition, governance structures that reduce

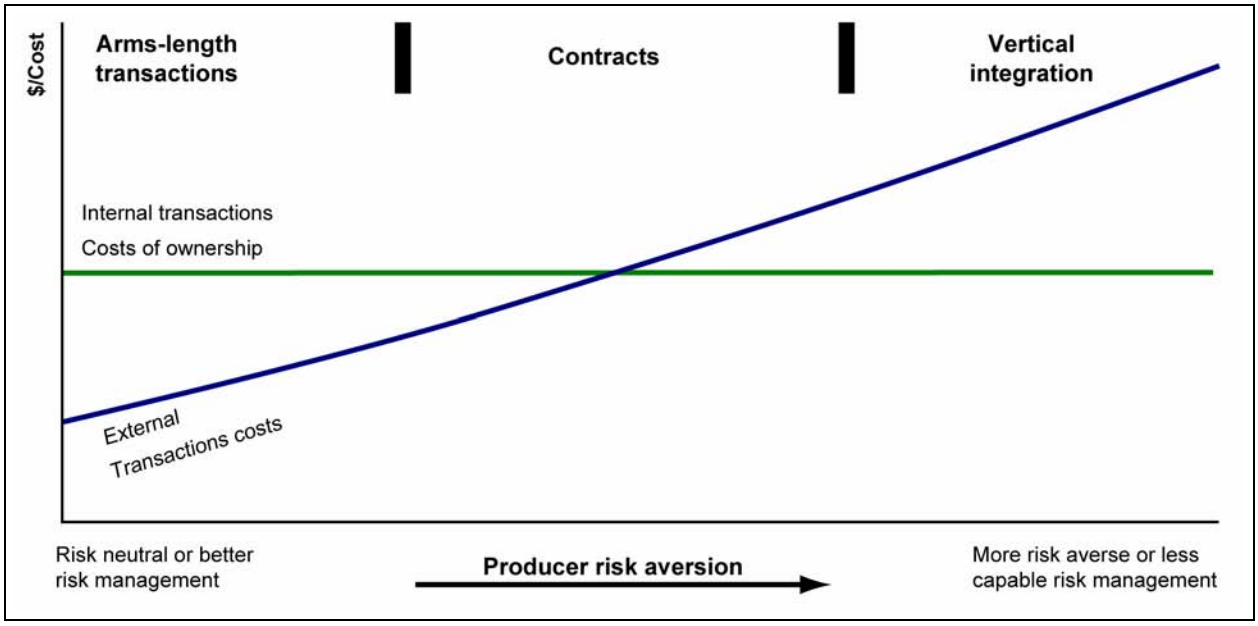


Figure 1. Conceptual framework for external transactions costs of risk sharing versus the internal transactions costs of vertical ownership.

risks for producers can attract producers that are relatively more risk averse (adverse selection). This risk averse nature often manifests itself in less aggressive adoption of new technologies and business practices – behaviors that do not enable a value chain to reap full benefits of efficiency and productivity improvements over time. Thus, channel partners that absorb more risk in their agreement with producers generally expect and receive higher returns to compensate for the higher risk and/or risk mitigation costs.

For some firms, the risk sharing transactions cost of monitoring channel partners exceeds the willingness of the marketplace to compensate them. In these cases, the firm may choose to acquire the chain (vertically integrate), thereby avoiding the transactions costs associated with moral hazard and adverse selection. These firms have decided that the internal transactions costs associated with owning both stages of the chain (agency costs, influence costs, increased production risks, employee risks, etc.) are less than the external transactions costs (moral hazard, adverse selection, and risk premia). Smithfield Foods and Tyson Foods offer examples where vertical ownership has been the preferred choice in an industry where other governance structures continue to be employed. These two firms, with their international brand identity and diverse product bases, may be in a position where the transactions costs of open-market, contract, or joint venture agreements exceed their internal transactions costs of owning the chain.

Figure 1 depicts the conceptual framework of external transactions costs of risk sharing in comparison to internal transactions costs of ownership. The vertical axis measures the total cost of the transactions of products, services, information, and compensation between stages of the chain. The horizontal axis represents the risk aversion and/or ability to manage risk for producers from whom the processor may choose to acquire products. The processor is assumed to have a lower relative risk aversion than producers. Thus, as channel captain, if the processor wants to source products from more risk averse producers, they must design vertical arrangements to either take on more of the risk, or compensate the risk averse producers more for accepting the same share of the risk.

Two separate lines are displayed in Figure 1. The external transactions costs line reflects the additional risk-sharing cost borne by the processor when the exchange is between the processor and producers in a vertical arrangement. This line increases at an increasing rate as producer risk aversion increases. Increasing external transactions costs reflect the additional costs that must be borne by the processor in the form of either increased risk taking or increased compensation to the more risk averse producer for taking on more risk.

The internal transactions costs line reflects the cost of ownership to a processor that owns both stages of the chain where separate firms are

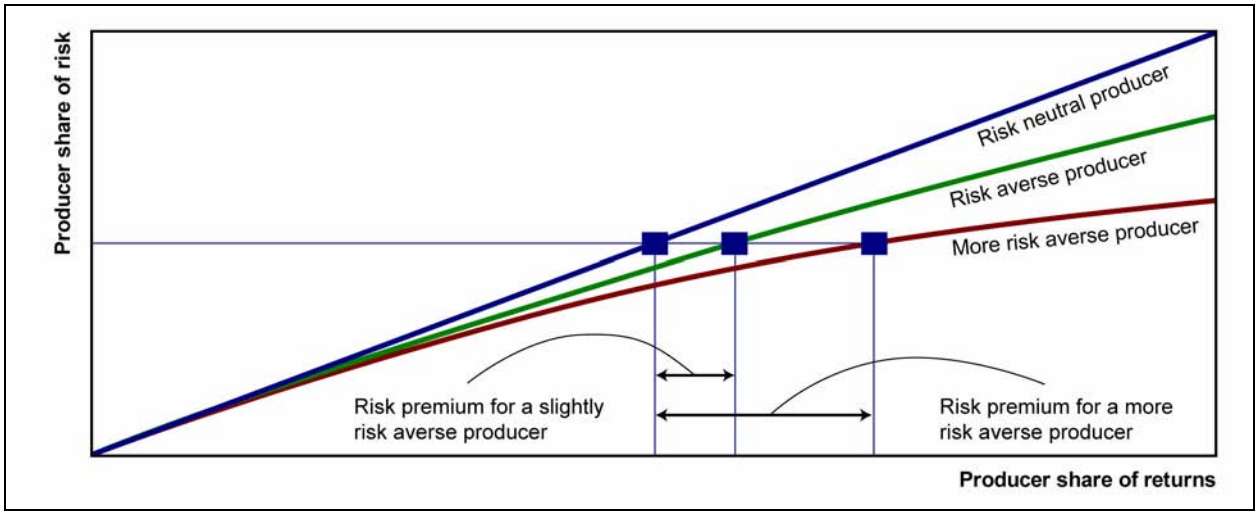


Figure 2. Risk/reward sharing between the processor and producers at various risk aversion levels.

replaced with employees. Internal transactions costs of ownership are initially assumed to be higher than external transactions costs. That is, we assume that the efficiencies of an open-market transaction in the absence of risk aversion by the producer result in lower transactions costs than vertical ownership.

As producer risk aversion increases, the internal transactions costs of ownership do not change -- only the risk sharing transactions costs of a market-based exchange increase. There is a point where the additional transactions costs of risk sharing cause the transactions costs of the market exchange to exceed the internal transactions costs of ownership.

The delineations across the top of the figure illustrate the different governance structures likely to be employed. When producers have 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). There is a point along the producers' risk aversion/management scale where the risk sharing transactions cost of the market exchange are higher than the internal transactions costs of owning the chain. It is at or just beyond this point where ownership of the channel (vertical integration) becomes an option because the transactions costs of risk sharing exceed the internal transactions costs of ownership. Producers at this level of risk aversion would likely choose to become a grower for a vertically integrated firm, receiving a flat fee for their services much like an employee of the company.

Research in supply chains in other industries shows that eventually external transactions costs decline below the internal transactions costs of chain ownership as firms become more accustomed to working together and better equipped to handle the risks in the exchange between segments of the chain (a learning supply chain as described by Sporleder & Peterson, 2003). If the goal is to reduce external transactions costs, then firms will favor partners that are less risk averse or better able to manage risk. As such, contracts and similar vertical arrangements would likely accrue to larger producers. However, for processors willing to absorb more risk, the preferred partner may be more risk averse producers in very tightly linked production contracts, where producer risks are transferred to the processor but rewards to the producer are lower. The framework presented here ignores any concept of market power among channel participants, and yet illustrates a logical economic reason for more tightly aligned vertical arrangements and industry consolidation to occur even in the absence of market power.

Risk Premiums and Contract Production

A common governance structure that more explicitly shares risks and rewards between supply chain partners is the contract. Figure 2 illustrates the nature of the risk premium required to entice more risk averse producers into contract arrangements that share more risk. The horizontal

axis is the proportion of returns shared by producers in a vertical arrangement with a processor. The vertical axis is the risk shared by the producer. There are three lines in the graph, each representing different levels of producer risk aversion. If the producer and the processor were both risk neutral, then the sharing of risk and reward would be illustrated by the 45 degree line. If the risk-neutral processor wishes to maintain this same level of risk sharing, but must do so with more risk averse producers, the processor will have to give a greater share of the rewards to the producer — a risk premium required by the producer. And the greater the producer's risk aversion, the more sizeable the risk premium becomes. To minimize this risk premium payment, the processor would prefer to contract with producers who are less risk averse or have more capacity to manage or absorb risk; this motivation again favors larger producers.

Contracts frequently spell out portions of both "fixed" payments and incentive payments from buyers to suppliers based on performance variables. The balance of fixed versus incentive payments depends, ultimately, on the relative risk aversion/management capability of the partners in the chain. If a processor seeks a governance structure that allows the risks to be shared between the parties, then they will seek a governance structure with more incentive payments. To entice risk averse producers to accept more incentive payments (share more of the risk), the fixed payment would have to be greater than for less risk averse producers (this is reflected in Figure 2 as the risk premium).[1] The risk sharing transactions cost of governance structures with more incentive payments will be less if the producers are relatively less risk averse or relatively more capable of managing risk. This again suggests that agribusinesses seeking production partners in a contract-coordinated supply chain that will share the risks and rewards will tend to favor larger producers with the ability to spread risk and/or producers that are less risk averse. For processors that are more willing and/or able to manage risk, a fixed payment contract may be the preferred arrangement to attract risk averse producers that are willing to take less return for lower risk.

Implications for Producer Financial Performance

The transfer of risk and the accompanying reward from supplier (producer) to buyer (processor) suggests that suppliers will likely be less profitable under a vertically aligned governance structure compared to the traditional open-market governance structure that has dominated agriculture. And in fact most studies support this argument when profitability is measured by traditional metrics such as profit per unit of production or return on assets (ROA). But vertical arrangements that share business risk and rewards allow producers to access more debt capital if the business risk is reduced through contracting or similar business arrangements.

Analysis of pork contracting illustrates the financial implications of using more debt in the capital structure of the contract production farm compared to an independent grower. Contract swine growers can in fact finance their operations with debt comprising a large portion of their capital structure (Lins, 1997; Roberts et al., 1997). Table 1 illustrates the implications of different capital structures for different business arrangements on the return on equity (ROE). Note that with no debt, independent business arrangements generate a higher ROE (and ROA since they are equal when no debt is used) than the typical contract business arrangements analyzed. As debt becomes a larger proportion of the capital structure of the business, the ROE increases for all business arrangements. But the independent grower who does not manage operating risk will likely not be able to use as much debt as part of his/her capital structure as the contract grower. Comparing the ROE of the independent grower at 40% debt (23.5%) with that of contract growers at 80% debt (23.1% and 27.6%), it is apparent that vertically aligned systems that transfer risk to the buyer (processor) have equal or superior financial performance. By accessing more external financing these firms also have increased capacity to expand their business.

Increased access to debt capital allows vertically aligned producers to generate competitive financial performance, grow at a more rapid pace, and adopt new technologies more quickly than those not vertically aligned — further separating these producers from those with less access to vertical markets and debt capital. This outcome may, again, lead to a more rapid consolidation as well as vertical coordination of the industry as has been witnessed in poultry, pork, and potato industries.

Risk of Vertical Alignment

The development of more tightly aligned supply chains creates new

1. *The discussion here is based on incentive contract literature and more explicitly from the discussion of the "Second-Best" Contract by Besanko, Dranove, and Shanley (2000).*

Table 1. Financial performance of various pork production business arrangements (mean return on equity, %).

	FINANCIAL STRUCTURE		
Pork Production Business Arrangement	**0% Debt**	**40% Debt**	**80% Debt**
Independent Farrow-to-Finish	17.0	23.5	56.5
Efficiency and Marketing Incentive Finishing Contract	10.4	12.5	23.1
Death Loss Incentive Only Finishing Contract	11.3	14.0	27.6

Source: Boehlje and Ray (1999)

and less easily quantifiable risks for the participants in the supply chain. For example, one of the supply chain risks faced by both suppliers and buyers is contractual or relationship risks. A grower may have a contract that guarantees a price for his/her products, and enticements to invest in specific assets, but what happens if the processor goes bankrupt? What happens to the contract (availability or terms) and the capital investments made by the produer next year if the processor finds other suppliers in other areas who can satisfy their needs at a lower price? This risk is not unlike that of losing a critical supplier or a lender, but losing access to the product market has typically not been a significant risk for producers in commodity-based agriculture.

The adoption of more tightly aligned supply chains in agriculture is likely to compound the risk and uncertainty related to the effectiveness of markets in providing accurate messages to consumers and suppliers in the food chain concerning prices, quantities, and qualities of products and attributes. With the formation of more tightly aligned food supply chains, it can be argued that messaging is much more precise, timely, and generally more accurate for participants in the chain than might be provided by market forms of coordination. But, what about the risk faced by those who are not part of the tightly aligned supply chain – are not qualified suppliers? Is there more volatility in the prices they receive because of thin markets? Do they have access to a market or are they closed out because only qualified suppliers can participate? Because of the thinness of these markets, are they not only subject to more volatility, but also more potential for manipulation? Do the prices and other information conveyed by these thin markets provide accurate messages to consumers and suppliers concerning quantities, qualities, cost, and value?

Conclusions

Tightly aligned supply chains are forming at a rapid pace in the agricultural section. Traditional transactions costs are a critical determinant of the appropriate governance structure for these supply chains. However, risk considerations and the risk aversion/sharing characteristics of the players are also important. The search for reduced risk sharing transactions cost leads to the formation of supply chains among participants that are more willing to share risks as well as rewards. More specifically, 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. At the same time, the transformation of the industry to more tightly aligned supply chains will introduce new strategic risks which will require additional analysis and skills to manage and/or mitigate those risks.

For More Information

Besanko, D., Dranove, D., & Shanley, M. (2000). *Economics of Strategy.* New York: John Wiley & Sons, Inc.

Boehlje, M., & Ray, J. (1999). Contract vs. Independent Pork Production: Does Financing Matter? *Agricultural Finance Review*, 31-42.

Hennessey, D., & Lawrence, J. (Spring/Summer 1999). Contractual relations, control, and quality in the hog sector. *Review of Agricultural Economics, 21*(1), 52-67.

Lins, D.A. (October 1997). *Financing pork producers: Challenges and opportunities.* Paper presented at the 1997 National Pork Lending Conference, Minneapolis, MN.

Rhoades, V.J. (1995). The industrialization of hog production. *Review of Agricultural Economics, 17*(1), 107-118.

Roberts, B., Barry, P., Boehlje, M., & Baker, T. (Summer 1997). Financing capacitities of independent versus contract hog production. *Journal of Agricultural Lending,* 8-14.

Sporleder, T.L., & Peterson, H.C. (2003). Intellectual capital, learning and knowledge management in agrifood supply chains. *Journal on Chain and Network Science, 3*, 75-80.

Allan W. Gray (gray@purdue.edu) is Associate Professor and Michael D. Boehlje is Professor, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana.

CHOICES
The magazine of food, farm, and resource issues
4th Quarter 2005 • 20(4)
A publication of the American Agricultural Economics Association

Logistics, Inventory Control, and Supply Chain Management

by Frank Dooley

Many argue that the focus point (and perhaps the linchpin) of successful supply chain management is inventories and inventory control. So how do food and agribusiness companies manage their inventories? What factors drive inventory costs? When might it make sense to keep larger inventories? Why were food companies quicker to pursue inventory reduction strategies than agribusiness firms?

In 1992, some food manufacturers and grocers formed Efficient Consumer Response to shift their focus from controlling logistical costs to examining supply chains (King & Phumpiu, 1996). Customer service also became a key competitive differentiation point for companies focused on value creation for end consumers. In such an environment, firms hold inventory for two main reasons, to reduce costs and to improve customer service. The motivation for each differs as firms balance the problem of having too much inventory (which can lead to high costs) versus having too little inventory (which can lead to lost sales).

A common perception and experience is that supply chain management leads to cost savings, largely through reductions in inventory. Inventory costs have fallen by about 60% since 1982, while transportation costs have fallen by 20% (Wilson, 2004). Such cost savings have led many to pursue inventory-reduction strategies in the supply chain. To develop the most effective logistical strategy, a firm must understand the nature of product demand, inventory costs, and supply chain capabilities.

Firms use one of three general approaches to manage inventory. First, most retailers use an inventory control approach, monitoring inventory levels by item. Second, manufacturers are typically more concerned with production scheduling and use flow management to manage inventories. Third, a number of firms (for the most part those processing raw materials or in extractive industries) do not actively manage inventory.

Many agribusiness firms do not actively manage inventory. This does not mean that they ignore inventory. Rather, they hold large inventories because any potential savings from inventory reductions are far outweighed by the inventory-induced reductions in production, procurement, or transportation costs. Often economies of size cause long productions runs which lead to inventory accumulation. Simultaneously, seasonality leads to inventory buildups of key inputs like seed as well as outputs like corn. Economies in procurement such as forward buying in the food industry and quantity discounts increase inventories. Similarly, unit trains and other forms of bulk shipping discounts contribute to inventory buildups.

Yet, such firms must be alert to changing conditions that may require more exact inventory management. One example would be if crops are marketed as small lots of value-added grain instead of commodities. Production proliferation in the seed industry may be another instance. Finally, whether due to food safety concerns, GMOs, food labeling, or the growth of organic food markets, identity preservation requires more precise inventory control.

The Importance of Demand

Inventory management is influenced by the nature of demand, including whether demand is derived or independent. A derived demand arises from the production of another product. For example, when John Deere knows its demand for a tractor, it can simply compute the demands for the parts, materials, and components needed to produce that tractor. Manufacturers of all sizes use such calculations which are part of flow management to manage inventories, schedule deliveries for inputs, and manage capacity. Flow management software has evolved from Materials Requirements Planning (or MRP) in the 1960s to the much more complex Enterprise Resource Planning (or ERP) of the 1990s. A flow management system is set in

motion by the demand for end products.

Independent demand arises from demand for an end product. End products are found throughout a supply chain. Wheat is an end product for a grain elevator, as is flour for a miller or cereal for a grocer. By definition, an independent demand is uncertain, meaning that extra units or safety stock must be carried to guard against stockouts. Managing this uncertainty is the key to reducing inventory levels and meeting customer expectations. Supply chain coordination can decrease the uncertainty of intermediate product demand, thereby reducing inventory costs.

Customer Service and Inventory

The availability of inventory provides customer service. The Item Fill Rate (IFR) measures how often a particular product (often called a stock keeping unit or SKU) is available. A common metric of customer service, IFR is expressed as the percentage of time that a customer can obtain the item they seek. A firm may set its customer service order policy at 95%, seeking to fill 95% of the orders for an item from inventory.

However, life is a bit more complicated. A customer might not obtain what they seek for several reasons. The seller may have run out of a product due to an inaccurate forecast. Or the supplier may have shipped an incorrect package size or flavor. Products in inventory may be unfit for sale because of damage or an expired shelf life. Finally, a seller may not have the capability to accurately track inventory in their stores or distribution centers.

To avoid shortfalls or stockouts, firms carry extra inventory known as safety stock. As more customer service is provided, a firm can expect sales to increase (Figure 1). However, as a firm tries to provide perfect customer service, logistical costs increase exponentially. Also, if a firm holds too much inventory, it can lead to low inventory turnover and hide operational problems. For example, carrying too much stock means that you might not discover that your supplier is frequently late with delivery times.

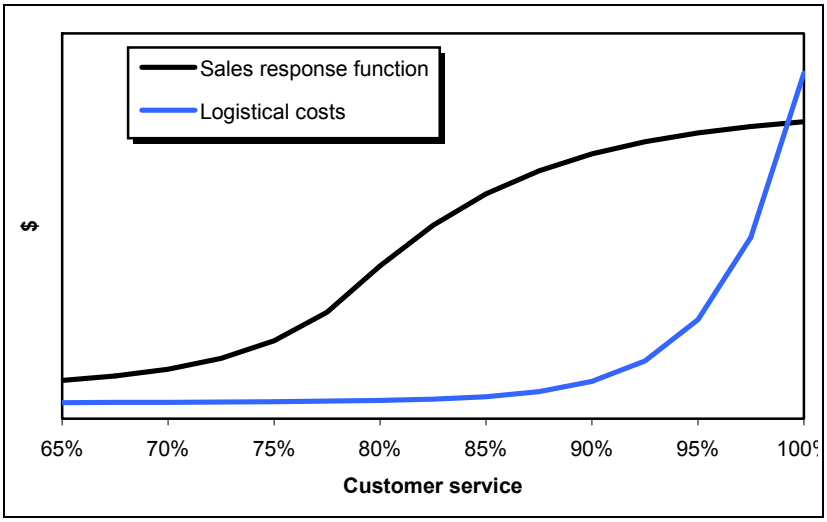


Figure 1. Incremental sales and logistical costs.

The Product Life Cycle, Demand Uncertainty, and Inventory

The structure of independent demand and logistical requirements vary by stage in the product life cycle (introduction, growth, maturity, and decline). During introduction, logistics must support the business plan for product launch, while preparing to handle potential rapid growth by quickly expanding distribution. At market maturity, the logistical emphasis shifts to become cost driven. In the decline stage, cash management, inventory control, and abandonment timing become critical. Over-abundance of products in the late maturity or decline stage will eventually result in obsolete products. The obvious difficulty is predicting how long each stage will last and how abruptly sales will fall in the decline stage.

The life cycle strategy typically involves getting to profitability quickly recuperating startup costs, then sustaining high profits for as long as possible, and finally acting decisively for products in decline to minimize losses. Understanding this life cycle can help managers select logistical tactics, inventory levels and supply chain designs. The ultimate goal for companies should be to have just enough inventory to satisfy consumer demand.

Another life cycle attribute is that demand uncertainty shifts as we progress through time. Product managers face substantial uncertainty during the introduction and growth stages, relative stability during maturity, and increasing uncertainty in decline. This uncertainty drives forecasting accuracy and the level of safety stock required to meet customer service expectations.

The coefficient of variation (CV) measures the stability of a product's demand, comparing the variability in demand to the size of the average demand (Figure 2). High demand

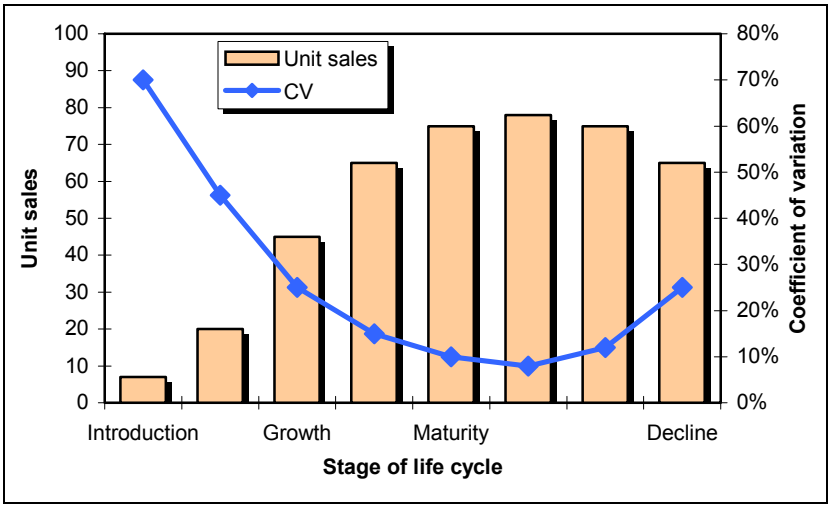


Figure 2. Product life cycle and uncertainty.

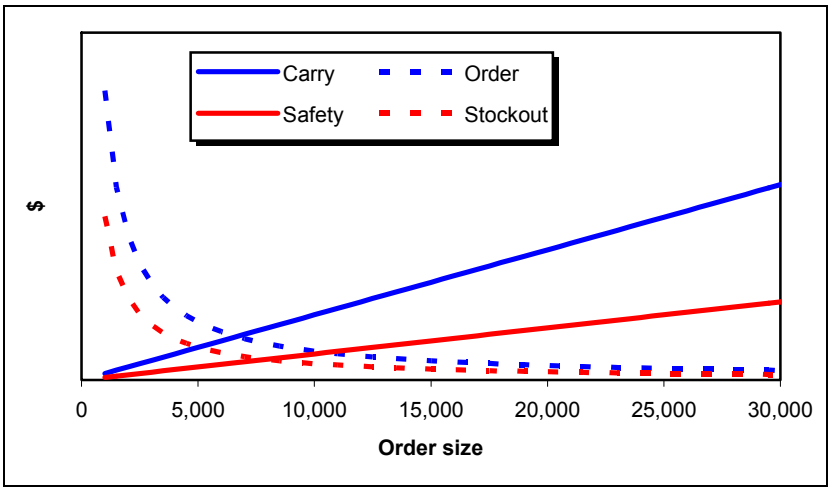


Figure 3. Inventory costs by order size.

variability in the introductory stage means it is difficult, if not impossible, to forecast demand. Thus, high levels of inventory must be held to meet even minimal customer service levels. In contrast, lower variability during maturity means that demand forecasts are quite accurate. However, inventory levels may still be large because they are based on larger sales volumes.

In addition to the vagaries associated with product life cycle stage, two other sources of uncertainty also drive the level of inventory. First, demand can vary from day to day, week to week, or seasonally. Second, there may be variability in lead time, or the time from when an order is placed until delivery is made.

Forecasting demand used to be more exact because products stayed in the mature product life cycle phase for a long time. Today many companies find it far more difficult to forecast sales because of product proliferation. Product line extensions result in more products that cannibalize sales and shorten the life cycle. Thus, more sales are coming from products in the erratic earlier stages of life, as opposed to sales from products in the mature stage of the life cycle.

Inventory Costs

Different models are used to manage inventory for products that are continually available (like milk) or products available for limited time (like seed). The Economic Order Quantity (EOQ) model determines the least cost level of inventory to carry, as well as costs. News Vendor models are used for products only available for a single period.

EOQ and News Vendor models have proved useful for managing inventory for many years, analyzing tradeoffs among major cost components. These models are robust and easy to customize to particular industries. Their approach to costing is similar reflecting levels of inventory, as well as shipping costs or quantity discounts.

Inventory costs fall into three classes: 1) carrying costs of regular inventory and safety stock; 2) ordering or setup costs; and 3) stockout costs. Inventory control systems balance the cost of carrying inventory against the costs associated with ordering or shortfalls (Figure 3).

First, carrying cost (or a cost to hold inventory) is comprised of capital costs, service costs, storage costs, and risk costs. A carrying cost involves the opportunity cost for holding inventory. If the firm did not have money tied up in inventory, it could either use the savings to make investments in other assets or pay down debt. Thus, a firm should first determine what it would do with any savings from a reduction in inventory. If the dollars are used to buy capital equipment, an appropriate opportunity cost is the firm's hurdle rate or its "required rate of return." If the dollars are used to pay down debt, the interest rate on the loan should be used to value the inven-

tory. The other three aspects of carrying cost are non-capital costs.

The service costs are often masked in a firm's fixed costs. A firm should determine how much of its insurance and tax expense is associated with inventory. This is especially important in states that have an inventory tax. A firm has cash outlays for warehouses and materials handling equipment, either owning or leasing space from a distributor. In either case, the firm should determine how much is spent on space. Inventory risk reflects characteristics of the product. Some items are more prone to be stolen, others are more likely to be damaged, yet others may become obsolete before a sale is made. In any case, risk means that if too much inventory is held, a certain proportion of the inventory will be unavailable for production or sale.

To determine the cost of carrying inventory, one needs to know the average quantity of inventory, an inventory carrying cost (as a percent of product cost), and the average cost per unit of inventory. If a firm plans to use inventory reductions to fund other capital assets, inventory carrying cost might be 30% (25% for an opportunity cost and 5% for the service, space, and risk costs). If the firm plans to use the savings to reduce debt, the appropriate rate might be 12% (7% for the interest rate and 5% for the other costs). Regardless of the carrying cost rate being used, as a firm holds more inventory, carrying cost increases (Figure 3).

Firms carry extra inventory to guard against uncertain events. Known as safety stock, the purpose of this inventory is to provide protection against stockouts. Safety stock is costed just like regular inventory, it is an interest rate times the level of safety stock. The level of safety stock required to guard against a stockout depends upon the customer service level, the standard deviation of demand of the product, and lead time. Let's explain in greater detail.

Assume that it takes 10 days from the time an order is placed until a shipment arrives and that on an average 20 cases are sold each day. Thus, over the 10 days that we are waiting for the delivery (our lead time), we expect to sell 200 cases. If we trusted our forecast, supplier, and trucking company, we would simply hold 200 cases for the 10 days. But we realize that forecasts are inaccurate, some suppliers are unreliable, and shipping times vary. If less is sold than expected during the 10 days or if the shipment arrives early, we will still have inventory on the 10^{th} day and no customer service problems are encountered. However, if sales are above expectations during the 10 days or deliveries are late, we might run out (or stockout) of product.

Managing the uncertainty surrounding safety stock is the key to reducing inventory levels. But in today's competitive environment, it is difficult to lower safety stock requirements for two reasons. First, some buyers (especially large retailers) are requiring higher customer service levels, which raise safety stock levels. Second, the product mix for many firms includes more new products with the corresponding greater demand variability. Thus, most firms seeking to reduce safety stock can only do so by focusing on aggressively cutting lead times.

The second cost to consider is ordering costs. Ordering costs include a cost for transmitting the order, receiving the product and placing it into storage, inbound transportation, and processing the invoice. Recent advancements in information technology have lowered this cost by a factor of six for many industries. A manufacturer uses the cost of a production setup instead of an ordering cost.

Finally, stockout costs involve lost sales when no inventory is on hand. Such costs fall as inventory (and customer service) levels increase. The relationship between stockout costs and inventory depends upon the accuracy of the demand forecast and the ability of the firm to recognize and react to a change in demand. Stockout costs depend on how a customer reacts to a stockout, the frequency of stockouts, and the availability of substitute products. Stockout costs can be very high if a lack of substitute products means that a customer will switch suppliers. In contrast, if buyers simply substitute a different product, stockout costs may be inconsequential.

In practice, many firms do not assess stockout costs because different divisions of a firm cannot reach agreement on what is the cost of running out. Marketing may desire a very high stockout cost to force a penalty cost on running out. Operations or finance may resist this as it leads to inventory buildups.

Service level goals can differ by the value placed on stockouts and indirectly carrying costs. A high stockout valuation will result in higher inventories and higher service levels. One way to evaluate an inventory management policy is to choose a service level target. From this target, the inventory policy will determine the inventory requirements and associated costs of providing that level of service. A higher service level implies that more inventory will be held as safety stock. The tradeoff decision occurs at the point where the cost of carrying extra safety stock balances the stockout cost.

Closing Thoughts

Inventory levels are affected by customer service expectations, demand uncertainty, and the flexibility of the supply chain. For products with relatively certain demand and a long product life, it should be relatively easy to maintain desirable customer service standards even as inventories are reduced. However, for products characterized by erratic demand, a short life cycle, or product proliferation, a more responsive supply chain and larger buffer inventories may be needed to meet a desired customer service level.

Consumers are demanding more customer service from firms throughout the supply chain. Firms with high customer service levels may gain a competitive advantage over those that do not have the supply chain capabilities in place or the ability to manage them. Firms who understand their demand recognize stockout costs and carry appropriate levels of inventory are ultimately better able to effectively manage inventory and provide the desired service level to customers. As industrialization affects agribusiness and agriculture in general, the importance of customer service and competitiveness will become critical for firms and supply chains.

For More Information

Ballou, R. (2004). *Business logistics/ supply chain management, 5th ed.* Upper Saddle River, NJ: Prentice Hall.

Fisher, M. (1997). What is the right supply chain for your product? *Harvard Business Review,* Mar/ Apr., pp. 105-116.

Institute for Supply Management. Available online: http:// www.napm.org/.

King, R., & Phumpiu, P. (1996). Reengineering the food supply chain: The ECR initiative in the grocery industry. *American Journal of Agricultural Economics*, *78,* 1181-1186.

Wilson, R. (2004). *15th Annual State of Logistics Report.* Council of Supply Chain Management Professionals. Available online: http:/ /www.cscmp.org/.

Frank Dooley (dooleyf@purdue.edu) is Professor, Department of Agricultural Economics and the e-Enterprise Center at Discovery Park, Purdue University, West Lafayette, Indiana.