

Demand for Quality Drives Changes in Food Supply Chains

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Production and marketing of a differentiated product, in response to consumer demand, requires adjustments in the traditional food supply chain to preserve the product's identity and provide quality assurance to consumers.

High-value food products have unique characteristics that differentiate them from other food products. These characteristics may be related to sensory attributes, nutritional content, health claims, food safety guarantees, origin, production and processing practices, and/or convenience. High-value foods—which include semiprocessed, processed, and other packaged food products—have long been an important part of agricultural trade in local, regional, and interregional markets. For example, the ancient Greeks traded olive oil and wine throughout the Mediterranean Basin, and trade in spices and seasonings was the basis for early commercial and cultural linkages between Europe and East Asia. High-value foods constitute a major share of total agricultural trade in the contemporary world economy. That share has increased significantly in recent years—from 31 percent in 1975 to 69 percent in 2000 for the United States, and globally from 73 to 87 percent over the same period (FAO, 2002).

Suppliers of high-value food—farmers, manufacturers, or retailers—face challenges in creating and preserving the unique characteristics of their products and conveying information about those characteristics to consumers. Often, suppliers must rely on numerous members of the food supply chain, such as farmers, for raw products and key services required for production, and they must work through downstream market intermediaries, such as processors and distributors, as their products move to consumers. This configuration of food chain members complicates information sharing and the coordination of activities, product monitoring and quality assurance, and the provision of incentives to supply chain members to ensure equitable and efficient allocation of costs and returns. It also makes it more difficult to convey information about product attributes, especially the increasing number of attributes that cannot be observed or independently verified before or after purchase and consumption (known as credence goods). The diverse solutions developed to address these problems are helping to shape the evolving global food market, influencing patterns of production, distribution of revenues and costs, product innovation, product availability, and economic development.

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The problems faced by food suppliers are not new, but recent research on supply chain design and management puts them in a new light. Writing about quality assurance in food supply chains, Venturini and King (2002, p. 58) define a supply chain as “... a linked set of value creating activities encompassing product design, input procurement, primary production and processing, marketing, distribution, and service.” Supply chain thinking encourages a systemwide view of the chain—focusing as much on the linkages between technologically separable segments as on the management of processes within those segments. This perspective is valuable for chain participants as they plan supply chain designs and make management decisions to further the growth of and benefits from expanding markets in high-value food.

Key Elements of High-Value Food Supply Chains

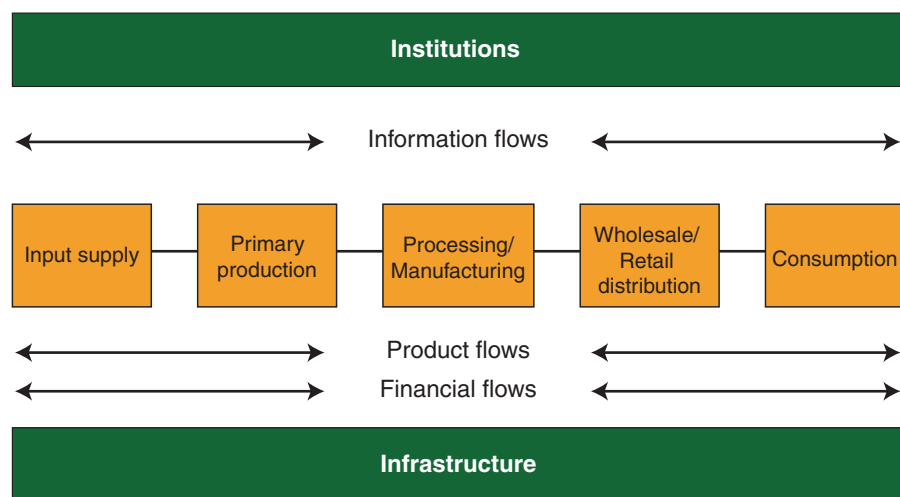
Supply chains for high-value foods are complex and product specific. The generic supply chain represented in figure 2-1 is highly simplified, but it captures key features that are useful for describing and comparing supply chains for different products.

This chain has five technologically separable processes: input supply, primary production, processing/manufacturing, wholesale/retail distribution, and consumption. Of course, not all five segments are relevant for every supply chain, and in many cases these processes can be further divided into separable subprocesses. The configuration of ownership and control over supply chain segments is one important dimension of supply chain design. Coordination between two processes is often simpler when both are controlled by the same firm or when the relationship between distinct firms is governed by long-term contracts.

There are three major types of flows through the supply chain: product, financial, and information. The first, physical product flows, are unidirectional.

Figure 2-1

Key elements of a high-value food supply chain



Source: King and Venturini.

tional in most cases, starting with input supply and ending with consumption. In some chains, return flows of defective products and backhauls of shipping containers can also be significant. Financial resources flows tend to move in the opposite direction of product flows, with payments going to upstream suppliers as products move downstream toward consumers. In some cases, however, suppliers who retain ownership of their products as they move through the supply chain may pay fees to downstream firms for production, processing, or distribution services. Information flows move in both directions throughout the supply chain. From any point in the chain, suppliers convey information about product attributes and availability to downstream customers, while receiving information about product demand, product inventories in downstream segments, and consumer reactions to product attributes.

Supply chains operate in a broad environment that is characterized by infrastructure and institutions. Infrastructure includes transportation and telecommunication systems, multipurpose technologies for packaging and product preservation, third-party providers of logistics and information system services, organizations, such as universities, that create and transfer knowledge, and mass media that reach consumers with advertising messages. Markets and exchanges are also an important component of supply chain infrastructure. Internet-based business-to-business exchanges are transforming trading practices in segments of food supply chains that are far removed from the transactions supported by traditional commodity exchanges.

Supply chain institutions dictate the “rules of the game,” circumscribing the allowable actions of supply chain participants. These institutions may be established through international organizations, national or local governments, or nongovernmental organizations, such as trade associations. They establish laws and regulations that govern commercial practices, food safety and product quality, trade, labor practices, and intellectual property. They also establish industry standards associated with supply chain features ranging from product packaging and contract provisions to electronic data interchange and funds transfer.

Infrastructure quality and institutions can have far-reaching impacts on supply chain design for high-value products, and cross-country differences can significantly affect supply chain configuration and the geographical scope of product distribution. For example, suppliers of branded food products may choose not to enter markets where infrastructure to support advertising is lacking and legal institutions that protect brand trademarks are weak.

Finally, there are many possible dimensions for assessing the performance of high-value food supply chains. However, the following are of critical importance to both supply chain participants and society:

- Systemwide efficiency of resource use
- Equitable distribution of costs and returns
- Food safety and quality
- Adaptability and innovation

The supply chain design process focuses on the configuration of technologically separable processes and the linkages between them; flows of products, financial resources, and information; and investments in infrastructure and institutions. It is iterative and often contentious, but the ultimate aim is to make progress in these four dimensions.

Influence of Locus of Value Creation on Supply Chain Design

Value can be created in any segment of a high-value food supply chain. For example, many food products are distinguished by their place of origin or by unique sensory attributes associated with production practices. Similarly, branded food and beverage products, a growing component of the world market in high-value foods, usually derive their value from processing, packaging, and marketing activities based in the processing/manufacturing segment of the supply chain. Restaurants operating in the wholesale/retail distribution segment of the chain are the primary creators of value in fast food supply chains. Input suppliers are the primary source of value in supply chains for new products with unique nutrition or health attributes based on genetic characteristics of food product ingredients. Therefore, as illustrated by the following four examples of high-value food supply chains, the locus of value creation often determines the supply chain design.²

Value Created in Primary Production: Label Rouge Poultry Example³

The French Label Rouge system is a national food quality assurance program for products of artisanal farming with a well-defined geographical origin. Label Rouge poultry products have been available since 1965, and they currently account for a significant share of the poultry purchased by French households. They are recognized for their taste, appearance, safety and wholesomeness, and the environmentally friendly practices used in producing them. As such, the primary production segment of the supply chain is especially critical in creating high value.

Label Rouge poultry products are produced by *filière*, farmer-centered supply chains comprising genetics development organizations, hatcheries, feed mills, farms, and slaughter/processing facilities. Close cooperation and information sharing across the input supply, primary production, and processing/manufacturing segments of the supply chain is coordinated through procedures and processes established in a *cahier des charges*, a document that must be approved by a national agency. Compliance with the *cahier des charges* is monitored by third-party certification. Noncompliant products, identified at any point in the system, are either destroyed or marketed without the Label Rouge designation, thereby sacrificing a price premium 50 to 150 percent above the price for similar non-Label Rouge poultry products (Westgren, 1994, p. 572; 1999, p. 1109). *Filière* participants are responsible for their losses resulting from noncompliance.

Cahier des charges provisions differ across supply chains, and these differences provide the basis for product branding at the retail level. Label Rouge poultry is packaged and labeled before it leaves the processing

² These brief supply chain descriptions are based on longer descriptions presented by Venturini and King (2002, pp. 60-71).

³ This description is based on material presented by Westgren (1994, 1999) and by Sylvander (1996).

plant. The branding protects product identity as the products enter the distribution/retailing segment of the supply chain with other packaged fresh poultry products.

The Label Rouge poultry supply chain is noteworthy for the degree of cooperation it achieves among input suppliers, farmers, and processors. To a large extent, this is made possible by the institutional foundations provided by the laws establishing the Label Rouge program and by the strong organizational infrastructure that has developed around the program. The program produces a high-value product demanded by consumers, while returning added profits to farmers.

Value Created In Processing/Manufacturing Segment: Wheaties Example⁴

Wheaties breakfast cereal has been produced and marketed by General Mills since 1921. Wheaties is a revered brand, with a loyal customer base built on a simple but appealing product design, decades of consistent quality control, and advertising centered around sports themes. The cost of the ingredients in a box of Wheaties is only a fraction of the price General Mills receives from wholesalers and retailers. This cereal is a classic example of a high-value product that derives most of its value from the processing/manufacturing segment of the supply chain.

Until recently, General Mills procured wheat for Wheaties in traditional commodity markets. However, given recent research revealing superior taste, appearance, and processing attributes of cereal flakes made from particular wheat varieties, General Mills has decided to use select wheat varieties in producing Wheaties. Working through a small line of corporately owned grain elevators in Idaho to control the supply of seed and to collect and store the harvest, General Mills has established a supply chain that ensures a supply of identity-preserved wheat to its manufacturing plants. The wheat is grown under contract with growers in the area, who are paid a small premium—ranging from 5 cents to 25 cents per bushel—for using approved production practices and for keeping the wheat segregated from other varieties. Through its grain elevators, General Mills monitors crop production practices, tests for varietal integrity, and implements grain storage and handling practices designed to minimize risks of contamination or co-mingling. These measures help minimize quality assurance costs elsewhere in the chain. Ownership of the grain elevators also makes it easier for General Mills to coordinate the logistics of shipping wheat to its cereal manufacturing plants and the liquidation of excess supplies through sales in regular commodity markets. The changes in procurement practices have not affected manufacturing processes for Wheaties. Like Label Rouge poultry, cereal leaves the manufacturing plant packaged, which enables it to move easily through wholesale and retail distribution systems.

Value Created in Retailer-Led Supply Chain: Marks & Spencer Beef Example⁵

Food retailers in the United Kingdom (UK) have been leaders in the development of high-quality private label products that shift brand identity from

⁴ This description is based on presentations by and conversations with Ronald D. Olson, Vice President Grain Operations, General Mills.

⁵ This description is based primarily on material presented by Fearn, 1998.

the food manufacturer to the retailer. This shift has partly resulted from implementation of the 1990 Food Safety Act, which requires retailers to take primary responsibility for ensuring the safety of the food products received from their suppliers. The Act forced retailers to focus more on the upstream segments of the supply chain and led to the development of farm quality assurance schemes that set standards for product traceability, animal feeding, animal health and welfare, and product transport and handling (Fearne, 1998, p. 220). Subsequently, the outbreak of Bovine Spongiform Encephalopathy (BSE) in the UK has made quality assurance in food even more important to British consumers.

The supply chain for beef products sold by Marks & Spencer exemplifies a retailer-led supply chain. Marks & Spencer procures beef exclusively through Scotsbeef, a family-owned slaughter and processing firm that buys all its beef from Marks & Spencer-approved Scottish producers. In this way, Marks & Spencer clearly defines its suppliers back through the primary production segments of the supply chain and establishes linkages with them to facilitate coordination and two-way information flows. Marks & Spencer maintains a database with information on all its producers and conducts regular taste tests that are used to provide feedback to individual farmers (Fearne, 1998, pp. 222-223). This system promotes learning throughout the supply chain and is mutually beneficial, since it improves both farm-level performance and product quality.

Value Created in Input Supply Segment: LoSatSoy™ Oil Example⁶

In recent years, seed companies have placed increased emphasis on developing varieties with traits well suited for special end uses. For example, Iowa State University developed the low palmitic-acid soybean using traditional breeding methods. Pioneer Hi-Bred International commercialized the variety under a license agreement. LoSatSoy™ cooking oil produced with low palmitic-acid soybeans has a level of saturated fat comparable to that in canola oil (Iowa State University Office of Biotechnology, 1997). LoSatSoy™ oil sells for a premium retail price relative to standard soybean oil. This high-value food product derives its value primarily from activities at the input supply end of the supply chain.

The DuPont Company, which owns Pioneer Hi-Bred, faces two difficult challenges in commercializing low-saturate soybeans. First, these soybeans have added value only if varietal integrity is maintained during farm production and as the product moves from the farm to the manufacturer. Second, while DuPont operates at the input supply end of the supply chain, the added value for the low-saturate soybeans is not realized until the cooking oil produced from the soybeans is sold to end-users. Both identity preservation and value capture are difficult when ownership changes hands several times as a product moves through the supply chain. Working through Pioneer Hi-Bred and two other subsidiaries—Optimum Quality Grains, L.L.C. (OQG) and Protein Technologies International (PTI)—DuPont has developed an innovative supply chain to address these challenges.

⁶ This description is based on an unpublished case study by Robert King. Information for that case was collected from the Web sites of Optimum Quality Grains, L.L.C. (now DuPont Specialty Grain, <http://www.oscar.dupontsg.com>) and Protein Technologies International (<http://www.protein.com>) and from personal communication with Robert E. Kennedy at Optimum Quality Grain.

OQG coordinates seed production and distribution, farm production, assembly, and transportation through an Internet-based contracting system called OSCAR™. This system enables farmers to identify nearby grain elevators offering contracts for identity-preserved products. Low-saturate soybean seeds are sold only to farmers who have contracted through this system. The contracts stipulate production practices that ensure varietal integrity and require farmers to deliver all their production to the contracting elevator. In return, farmers receive a premium of 25 cents over the local price for commodity soybeans. Contracting elevators, not OQG, purchase the low-saturate soybeans from the farmers. OQG reimburses the elevators for the identity preservation premium paid to farmers, pays the elevators a small fee for segregating the low-saturate soybeans during storage, and directs elevators to ship the identity preserved soybeans to crushing plants when needed.

PTI coordinates soybean processing and distribution to retail channels and works with retailers to promote demand for LoSatSoy™ oil. PTI contracts with crushing and refining plants to ensure the product's identity throughout processing. PTI never actually owns the soybeans or the oil derived from them. Rather, it pays small quantity-based premiums to crushers and refiners and then charges a royalty fee to refiners for each unit of LoSatSoy™ oil sold.

The LoSatSoy™ oil supply chain brings many independent segments together in a well-integrated identity-preserved system that promotes efficiency and responsiveness to consumer demand. As such, it may be a model for other high-value food products that derive their value from genetic attributes. DuPont has developed a system that converts intellectual property into a tangible product with value to consumers. DuPont captures a large share of the added value in the chain by paying downstream chain participants for identity preservation while never actually taking title to the low-saturate soybeans or the products derived from them.

In the four examples, it is apparent that successful production and marketing of high-value products requires coordination between the different segments of the supply chain. The degree and types of coordination and integration among the different segments may vary based on the locus of value generation. When value is generated in the primary production process, coordination is required among input suppliers, farmers, and primary processors. When value is added at the processing segment, coordination is required between suppliers of raw material and processors. In the case of General Mills' Wheaties, coordination is further facilitated by General Mills' ownership of elevators in the wheat-producing areas. When value creation is driven by the retail sector, a high degree of coordination is required among farmers, processors, and retailers. Finally, when value is created in the input supply segment and product identity must be preserved along different levels of the supply chain, coordination is required among many different players, including producers of the input (seed), farmers, grain elevators, crushing and processing plants, and retailers.

Fundamental Principles Behind a Successful Supply Chain

Contemporary studies of supply chains have focused on the concept of “lean thinking.” In *The Machine That Changed the World*, Womack, Jones, and Roos (1991) describe the development of lean production methods by Toyota Motor Company and the impacts of those methods on the global automobile industry. In their followup book, *Lean Thinking*, Womack and Jones (1996, pp. 15-99) identify five fundamental principles for lean enterprises and show how they have been applied by firms in a range of industries and locations. Even though these principles are based on the experiences of nonagricultural firms, they are reflected in the four examples in this section and in supply chain designs for other successful high-value foods.

- **Specify value**—Firms need to understand the value their product offers to end-users, staying focused on the customers’ points of view rather than their own. Supply chains for Label Rouge poultry, Wheaties, and Marks & Spencer beef all focus on delivering products that consumers appreciate and demand. Despite possessing attributes that are important to consumers, LoSatSoy™ oil has been less successful than the other three products. Input suppliers are far removed from consumers, and conveying value to consumers is generally difficult for makers of biotech products.
- **Identify the value stream**—The value stream is the entire set of activities required to deliver the product and the value embodied in it to the ultimate customer. It includes product design and development, the information tasks associated with order processing and scheduling, and the physical transformation in form, space, and time associated with manufacturing and distribution. Firms must fully understand the entire value stream, including those activities performed by other firms. This kind of learning is especially evident in the supply chains for Label Rouge poultry, Marks & Spencer beef, and LoSatSoy™ oil.
- **Ensure continuous flow**—Firms need to make the value stream flow continuously rather than in batches. Traditional manufacturing systems were characterized by long production runs and large inventories of intermediate and finished goods, which served as buffers for responding to demand shocks. Flow is difficult to achieve in agriculture, where production is seasonal and requires weeks, months, or years. Even though primary production in the Label Rouge poultry and Marks & Spencer beef chains is in batches, the involvement of many producers who coordinate their production makes it possible to achieve a steady flow in the processing/manufacturing segment of the chain. Grain storage serves the same purpose in the Wheaties and LoSatSoy™ chains.
- **Govern production through pull**—Quite simply, this principle implies that production of a product should not begin until requested by a customer. Pull eliminates the need for large price swings and inventory buildups but is difficult to fully achieve in food supply chains due to the fundamental nature of agricultural production. In both the Wheaties and LoSatSoy™ supply chains, however, the principle of pull governs movements from storage to processing and manufacturing plants. Also, in the four chains, improved information flows help transmit demand signals

more quickly to the input supply and primary production segments than would be the case in less integrated chains.

- **Strive for perfection**—Firms should strive for continuous, incremental improvement in their products and processes. They should configure the value stream to minimize defects at each stage to reduce the need for costly reworking and replacement of defective items. Once again, all four supply chains described in this chapter include quality assurance processes that reduce product contamination. The Wheaties and LoSatSoy™ supply chains achieve this primarily through monitoring and testing. On the other hand, information sharing and the threat of being excluded from the chain for noncompliance with quality standards are key quality assurance tools in the Label Rouge poultry and Marks & Spencer beef chains.

The idea of transparency is also critical for understanding Womack and Jones' view of the lean enterprise. In almost all cases, the supply chain encompasses several firms, and many of the most difficult challenges in implementing lean thinking involve eliminating negative externalities firms impose on each other and fostering positive externalities. This requires openness among firms along the supply chain regarding costs, prices, and processes, and some commitment by all to ensuring each firm receives an adequate return on investment (Womack and Jones, 1996, pp. 276-278). The high degree of information sharing in the four chains described here helps promote transparency. Nevertheless, complete transparency is an ideal that is difficult to achieve. It is crucial to recognize that noncooperative strategic behavior continues to be prevalent, even with the focus on efficiency and collaboration associated with the shift toward the lean enterprise.

Evolving Linkages Shape Food Supply Chain

The problem of supply chain design is one of configuring a set of discrete activities and processes into an integrated system that creates value and delivers it to customers. Physical processes are often product specific, though there is usually some degree of choice regarding technology, scale, and location. Linkages between processes are more generic, and linkages developed for one chain can often be adapted for use in others. Mechanisms for linking and coordinating processes can be grouped into three broad categories: standards, markets, and organizational coordination mechanisms.

Standards

Standards have long been recognized as a tool for linking discrete processes in the food system. The publicly defined grain grades established under the 1916 Grain Standards Act lower transaction costs and are an institutional foundation for the decentralized grain marketing system in the United States (Hill, 1998). Even as the system moves away from standard commodities to more specialized products, public grades and the standard measures that define them continue to be important (Chambers and King, 2002). Standards can also be established by trade associations or by individual firms. For example, the Universal Product Code (UPC) identification number system is

the product of an industry-sponsored organization. This system revolutionized operations at the retail end of the supply chain, not only in the checkout lane but also in the backroom, where inventory management and product ordering are key concerns (Walsh, 1993).

At least three types of standards are likely to play a role in the design of supply chains for high-value foods.

- **Primary production practice standards** often serve as a basis for value creation in food supply chains. These standards may simply specify a variety or a time when a production cycle will be initiated, as in the Wheaties and LoSatSoy™ supply chains; or they may be more complex and far-reaching, as in the Label Rouge poultry and Marks & Spencer beef chains.
- **Packaging and logistics standards** aid the configuration of new supply chains. “Packaging” used in a very broad sense refers to any technology that preserves the integrity of a product as it moves through the supply chain. At the distribution/retail end, standards have been developed for reusable pallets and containers used to transport food products from manufacturers to distributors and retailers. These standardized tools make it possible to move large numbers of distinct products from many points of origin to many destinations in an efficient manner. As the overall volume and diversity of identity-preserved products increases, incentives emerge to develop new packaging and logistics standards for the upstream segments of food supply chains. For example, greater use of containers to move food products from farms to processors and manufacturers adds flexibility in transport. This facilitates identity preservation and quality assurance in general purpose logistics systems that may be able to approach the efficiency of current bulk transportation systems.
- **Data transfer standards** shape supply chain design. Building on the UPC standards developed in the 1970s and 1980s, food manufacturers, wholesalers, and retailers developed and implemented electronic data interchange (EDI) standards in the 1990s. More recently, the pace of development has increased for Internet business-to-business systems. These systems rely on more generic standards and tools, requiring less upfront investment by trading partners. They are well suited for data transfer between small firms and for situations where low volumes of data are transferred infrequently.

Standards development greatly influences systemwide efficiency and quality assurance. New standards alter the level of transparency and the intensity of competition, thereby impacting the distribution of returns within a supply chain. Standards can also affect innovation by making it easier for new firms to develop the management systems and business practices needed to enter a supply chain segment or establish a supply chain for a new product. Narrowly defined standards, however, may make it difficult to introduce radically new systems and processes.

Markets

Markets are efficient mechanisms for coordinating resource allocation decisions and product flows among firms when externalities, public goods, and

access to information are not important factors and when there is adequate competition among both buyers and sellers. The emergence of greater product diversity at the primary production end of the food system is creating many new opportunities for market formation. At the same time, the rapid development of electronic commerce is lowering the cost of establishing new markets.

The electronic commerce system for production contracts in the LoSat-Soy™ supply chain helps producers identify delivery points for low-saturate soybeans and provides information on contract terms and price premiums. DuPont also uses the same system for other crops, making it easier for elevators and other downstream firms to identify and contact potential farmer suppliers. The system provides farmers an opportunity to compare delivery point locations, contract provisions, and price premiums for a range of crops.

Though the development of electronic commerce has slowed recently in segments closely linked with primary agricultural production, progress continues in developing electronic exchanges that link manufacturers, wholesalers, and retailers. These new markets are having profound effects on the structure of business-to-business linkages and the role of intermediaries. The impacts are likely to extend back upstream to the primary production and input supply segments of food supply chains (Wheatley, Buhr, and DiPietre, 2001). Future developments will continue to be driven by advances in information technology and by economic research on theories of bidding and auction market design (McAfee and McMillan, 1987), helping to clarify the efficiency and distributional impacts of alternative market mechanisms.

New markets can lower systemwide costs and alter the distribution of returns among chain participants. The presence of markets spanning across several supply chains should help foster adaptation and innovation if the control of competing supply chains is not highly concentrated. For example, several distinct supply chains compete for supplies of identity preserved grain in the United States. It is important to consider interchain markets in the institutional design process. Inter-chain markets can inject competitive forces and are more likely than markets operating within a single chain to be the focus for public sector regulation and intervention.

Organizational Coordination Mechanisms

Organizational coordination mechanisms used in supply chain design include business practices that may be established through nonprice/quantity provisions in contracts or through informal interfirm relationships. They also include new organizational forms, such as third-party certification agencies helping guarantee product quality and joint ventures and alliances that coordinate investment, operations, and gain-sharing among otherwise independent trading partners.

Information sharing, decision transfer, and decision partnership are three generic business practices for coordinating resource allocation and product flows across firm boundaries. Each helps reduce information asymmetries,

facilitating trading partners to recognize and reduce the effects of externalities they impose on each other. For example, vendor-managed inventory practices between food manufacturers and distributors use information sharing and decision transfer to realize efficiency gains. A wholesaler or self-distributing retailer regularly sends product movement data to a manufacturer, which allows the manufacturer to make decisions regarding replenishment flows, subject to restrictions on minimum and maximum inventories at the distribution center. This enables the manufacturer to lower costs by smoothing production and rationalizing logistics, with cost savings being shared by the two parties. Higher degrees of interdependence and information sharing are evident in retailer-led supply chains, such as in the case of Marks & Spencer beef.

Category management practices at the retail end of the food system illustrate the value of decision sharing. Manufacturers, brokers, wholesalers, and retailers form teams to make joint decisions about product assortment, shelf-space allocation, pricing, and promotions. Often, these teams are based on informal ties rather than on contractual agreements. When successful, category management reduces costs and increases product flows for all parties.

New organizational forms also facilitate coordination. Third-party certification agencies can play a role in high-value food supply chains when defining attributes are linked to production practices, as they are in the case of organic products. In such cases, a group of firms in one segment of a supply chain, a vertical alliance of trading partners, or a government body may establish and use an independent certification agency for quality assurance. For example, in the Label Rouge case, a third-party certification agency monitors compliance with *cahier des charges*. Generally, the certification process involves a combination of baseline and periodic followup inspections, strict record-keeping procedures, and unannounced audits. This process can be costly, but in some settings it is more efficient and effective than direct monitoring and laboratory testing.

Vertical joint ventures and alliances are also organizational tools for supply chain design. A joint venture may make it possible for independent trading partners to establish a service that draws on the unique competence of each firm and broadly benefits the entire supply chain. More broad-based alliances between trading partners—for example, an alliance between a cooperative, with members that can source a wide range of identity-preserved raw ingredients, and a food manufacturer requiring ingredients for a diverse product line—may be the basis for efficiency gains across a number of more narrowly defined high-value product supply chains.

Looking Ahead

The future evolution of high-value food supply chains will be primarily driven by creative ideas and strategic choices of individuals and firms responding to new market opportunities. In general, competitive forces at the local, national, and international levels can be expected to push this evolutionary process toward increased efficiency and higher quality products. However, some economists voice concern that concentration of owner-

ship and control will skew the distribution of costs and returns and impede innovation in some segments of the food system.

Public sector organizations will help shape the evolution of high-value food supply chains. Perhaps the most important influences will be through public investment in infrastructure and public establishment of institutions. In developing countries, especially, infrastructure and institutions will be a major factor determining both the ability of suppliers to offer their food products in world markets and the opportunities consumers will have to enjoy efficiency gains of new technology and product development. In developed countries, infrastructure and institutions will have important impacts on product diversity, competition, competitiveness, and innovation.

The world food system is undergoing fundamental changes due to technological change, population growth, economic development, and globalization. The emergence of more highly integrated supply chains for high-value foods, increasingly demanded by consumers across all income levels, is an important part of the overall pattern of change. Sound knowledge of supply chain design principles and thoughtful evaluation of design alternatives will help promote change that fosters economic growth, food safety and security, and innovation.

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