ISSUES AND TRENDS IN THE FRESH PRODUCE AGRI-FOOD SUPPLY CHAIN MANAGEMENT

Antonio C. Caputo, caputo@ing.univaq.it
Pacifico M. Pelagagge, pelmar@ing.univaq.it
Department of Mechanical, Energy and Management Engineering, University of L'Aquila, Italy

Abstract. *Supply chains for fresh produce are generally fragmented, with poorly coordinated planning and little communication between growers, processors and retailers. They are affected by product perishability and unpredictable variability in quality and volumes, while there is a strong unbalance in the bargaining power of the various stages. Their evolution trend aims at a progressive consolidation of the distribution channels which try to rationalize their supply lines and develop stronger and more efficient links with fewer, larger professional growers of the highest quality produce, thus putting more pressure on the upstream stages of the chain. Therefore, an efficient supply chain is essential to ensure profitability and the service level asked by customers. In this paper a review of agricultural fresh produce supply chains is carried out, based on an extensive literature review, in order to discuss the main relevant issues, identify criticalities, present possibile solutions and state future research needs.*

Keywords*: Fresh produce, agricultural produce, supply chain, agri-food, review*

1. INTRODUCTION

The agricultural fresh produce supply chain (AFPSC) is characterized by peculiar criticalities. While AFPSCs enjoy an effective opportunity of vertical integration, they suffer also from a marked variability in the demand and the availability of raw materials, making planning and coordination difficult. Even the yield of single transformation processes and the quality of the final product is influenced by the stochastic produce characteristics.

Furthermore, the extremely short processing and transportation times allowed by the rapidly deteriorating produces require very strong coordination among the AFPSC actors (Gigler et al., 2002, Van der Vorst et al., 1998). This also leads to a necessity for intensive data exchange among AFPSC participants, in that at any stage of the chain the product quality can be adversely influenced either intentionally or not, making complete product traceability required. Such requirements have to be satisfied at minimum cost owing to the competitive pressure in global markets and the high mark up levels applied through the distribution channels which significantly increase the prices paid by final customers. Consequently, there is a strong need for improving the effectiveness and competitiveness of fresh AFPSCs in order to reach the goals of certified quality and service level requested by international regulations and final customers. Otherwise, a rapid competitivity loss will occur eventually leading to exclusion from the market of those not conforming.

The competitivity of AFPSCs, therefore, relies heavily on the ability of the participants to set up effective coordination, to develop a thorough integration of the processes and to create a strong partnership (Ziggers and Trienekens, 1999). However, significant Supply Chain (SC) performance improvement opportunities also arise from the adoption of proper SC planning and management criteria. This is a prerequisite in order to perform in an efficient manner the forecasting and planning, supply, transformation, transportation, distribution and quality control adopting proper accounting methods for cost control, and suitable procedures for product safety and traceability. Nevertheless, these tasks may be strongly supported even by the innovative tools made available by Information and Communication Technology (ICT) (Schiefer, 2004). Relevant ICT tools span from automatic labeling systems, to bar code readers, point of sales data gathering equipments, radio-frequency identification systems, enterprise resource planning tools etc., which enable acquisition, management, and distribution of huge quantities of data in real time. The role of ITC tools as enablers of AFPSCs is widely acknowledged (Heezen and Baets, 1996; Howard et al., 1996; Kinsley, 2000; Krieger and Schiefer, 2003; Salin, 1998; Studman, 2001), while the emerging role of E-business operations in the fresh produce sector, although negatively affected by product perishability issues, has been also recognized (Fernandes and White, 2000; Montealegre et al., 2004).

In this paper a review of AFPSCs is carried out in order to discuss the main relevant issues, identify criticalities, present possible solutions and state future research needs. At first the main criticalities of this kind of supply chain are examined, then the available analysis tools and models are reviewed and, finally, the possible improvement options are listed as a reference for both researchers and managers of AFPSCs.

2. CHARACTERISTICS AND CRITICALITIES OF THE AGRICULTURAL FRESH PRODUCE SUPPLY CHAIN

Supply chain management is intended as the set of activities, management decisions and techniques aimed at integrating in an effective manner suppliers, producers or manufacturers and the transportation and distribution network

in order that goods are produced and distributed in the exact quantities required and made available in the right places at the right time, so that the desired service level is met at the minimum total system cost. The SC literature is immense and many design and analysis criteria have been developed (Beamon, 1998). However, there is general agreement that a strategic fit among SC capabilities and product/market characteristics should be achieved (Fisher, 1997). A proper measurement of SC performances (Beamon, 1999; Salama and Towill, 2005; Simatupang and Sridharan, 2005) is then critical to effectively rationalize and reengineer the SC (Hoole, 2005; Stanley and Wisner, 2001; Trienekens and Volby, 2001; van der Vorst and Beulens, 2002).

A food supply chain is a network of food-related business enterprises through which food products move from production to consumption, including pre-production and post-consumption activities. Typical links in this supply chain are producers (growers, farmers), processors, distributors, wholesalers, retailers and consumers. Traditional food supply chains can handle both undifferentiated (commodity) and "value added" food products. Value added products are products that are converted from raw products through processes that give the resulting product an "incremental value" in the market place, owing either to a higher price the customer is willing to pay or an expanded market, and which differentiate from similar products based on specific attributes such as geographic location, environmental stewardship, food safety or functionality (from nutraceutical foods, to bioagriculture products, to precooked meals).

The distinctive features of AFPSCs have been discussed in general by a number of authors (Bell et al., 1997; Cadilhon et al., 2003; Henson et al., 1995; Hingley and Lindgreen, 2002; Lummus, 2004; McKinnon, 1996; Prussia and Werner, 2000; Rosini, 2005; Sexton et al., 2005; Van Roekel at al., 2002), while country-specific studies are also available for example from Thailand, New Zealand and Europe (Kritchanchai, 2004; Hughes, 1996; Maurer, 2000; Scotzko and Hinson, 2000; Wilson, 1996 a,b). A few authors also discussed the success factors of effective supply chains basing on empirical studies (Grant, 1995; Grimsdell, 1996; Fearne and Hughes, 1999). Other authors, instead, provided valuable insights and suggestions to improve AFPSCs performances focusing on reducing uncertainty (Van der Vorst et al., 1998), improving customers' response and category management (King and Phumpiu, 1996, O'Keefe and Fearne, 2002), as well as increasing participants coordination (Aghazadeh, 2004; Hobbs and Young, 2000; Duffy, 2005; Hughes and Merton, 1996). In particular the issue of collaboration, relationship management and partnership building has been the object of extensive empirical research (Barratt, 2004; Batt, 2003; Fearne and Dedman, 1999; Hingley, 2001 and 2005; Hobbs and Young, 2000; Hogarth-Scott and Parkinson, 1993; Loader, 1997; Rademakers and McKnight, 1998; Wang and Benaroch, 2004; White, 2000; Zanquetto-Filho et al., 2003).

Although the structure of the AFPSC may be rather simple, and the product structure generally is much simpler than that of industrial products counterparts, nevertheless, a number of distinctive features characterize the AFPSC making it quite difficult to manage. The most relevant characteristics are listed in the following.

2.1. Product-Related Criticalities

Main product-related problems of AFPSCs respect the SCs of other industrial products may be resumed as follows.

- Strong randomness in the quality and amount of the raw materials (owing to biologic cycles, seasonality and weather conditions). This makes difficult the planning of supply and transformation activities. Agricultural produces are often supplied by many small growers which make them available in time moments not coordinated, and with quantity and quality levels hardly predictable. Even the yield of the transformation process and the quality of the end product is influenced in random manner by the characteristics of the fresh produce.
- Random variability in the consumer demand.
- Variation of the product quality with time and storage conditions (i.e. temperature) leading to gradual perishability and quality loss (Bogataj et al., 2005; Kopec, 2003). This causes handling and storage difficulties and asks for a fast crossing of the SC to avoid excessive product deterioration.
- Necessity of a quality and sanitary control during SC crossing and complete traceability of the product (ECR Europe, 2004) so that the consumer can know all relevant information about the transformations the produce has undergone (place of origin, growing modality, pesticide treatments and so on).
- The markets are largely oversupplied, which means that the supply chain efficiency is essential if growing and farming are to remain profitable.
- High price volatility. Furthermore, the seasonal nature of many products may make the price higher when the quality is lower.
- Treating products which traditionally have a low level of innovation, are often undifferentiated and sold in bulk. There is limited possibility of adopting branding policies to obtain competitive advantage on the marketplace.

2.2. Organizational Criticalities

From an organizational standpoint AFPSCs are characterized by the strong presence of small and medium-sized enterprises and growers/farmers. Therefore, AFPSCs are traditionally highly fragmented. This implies the impossibility of enforcing a strong control level, which has to be compensated with greater collaboration. However, this is difficult in practice because there is no central coordinating unit and there is a low level of information sharing. In the past this

kind of fragmentation from the one side caused many inefficiencies of the supply chain, and from the other side prevented from applying the sophisticated but effective SC management techniques largely utilized in other productive sectors.

Business relationships within the supply chain are often framed in win-lose terms, with resulting levels of inter-organizational mistrust. Relationship are constructed as competitive, even adversarial, whereby each company seeks to buy as cheaply and sell as expensively as possible.

Farmers/growers are treated as interchangeable and exploitable input suppliers, often operating in restricted markets under short-term contracts where risks are usually born by producers.

Benefits and profits from the sale of the final food products are unevenly distributed across the supply chain, with food processors and marketers usually receiving a disproportionately higher share.

Operations are increasingly located and coordinated on a national or international scale, with food production, processing and marketing sited according to short-term economic gains for those parties who dominate the chain.

Moreover, the supply chain is highly unbalanced as a predominant role of the distributors with a stronger bargaining power is witnessed while the raw produces supply base is strongly fragmented, suffers from an excess production capacity and has a low contracting power. Furthermore there are virtually no entrance barriers in the growers/farmers arena because branding policies are difficult or impossible to apply and products are easily replicable.

Another issue contributing to the inefficient SC control is the difficulty of costs allocation along the chain. In fact, modern cost accounting methods, such as Activity Based Costing are not utilized. This prevents from knowing the actual cost incurred by each actor for the performed activities, while an accurate cost monitoring could enable instead the search for more economically efficient solutions according to changing scenarios in terms of raw material availability and customers demand.

Therefore, in the initial steps of the chain there is also a need for introduction of formal accounting methods to daily record the relevant coltural data and events, the performed services (mechanical maintenance, workforce etc.) and treatments (ploughing, fertilizing, antiparasitary treatments etc.) pertaining to each produce in order to enable an allocation to the specific cost centers.

3. AVAILABLE MANAGEMENT TOOLS AND MODELS

Despite the above managerial difficulties in planning and controlling the AFPSC, in this field one observes a rather strong lack of suitable operational management tools and practices, respect to what happens in other industrial sectors.

The literature makes available some studies on the managerial aspects of AFPSC but those are rather qualitative. Otherwise a greater attention is focused on the activities of the distribution and retail network, while the managerial problems of producers and transformers are neglected. In order to carry out an audit and diagnosis of the potential/criticalities of the SC, only general purpose qualitative managerial models are available, while there are very scarce quantitative engineering models to analyse the performances of the SC and to assess the effects of different management policies or new organizational criteria.

The commercially available SC management (SCM) information systems are essentially aimed at data management (acquisition, processing, storage / retrieval, and exchange) and at the integration with other information systems of the various logistic functions such as Enterprise Resource Planning, thus giving visibility to the process, enabling traceability, and making available data useful for managerial decision making, but not for analysis, simulation, and redesign of the SC (Aksoy and Derbez, 2003).

Furthermore, SCM information systems are costly, are developed for the requirements of large enterprises instead of small and medium sized enterprises and are more oriented to the needs of B2B applications in large distribution and the consumer goods sectors instead of the horticultural supply chains. Moreover, the SCM models integrated in the enterprise information systems, even when utilizing optimisation methods, are intrinsically deterministic in nature, thus neglecting stochastical events typical of the AFPSC.

A strong lack is thus observed of quantitative models and tools aimed specifically at assessing and analysing the performances of the whole AFPSC considering all the related peculiarities.

From the point of view of the theorical modelling, many quantitative models for decision making of the single SC participant are available (i.e. for transportation or inventory management), but there are very few studies about modelling the overall dynamics of AFPSCs.

Again, the problem is often examined from the perspective of the distribution system or the retailer/consumer rather than from that of the producer or transformer. Often, the available models are based on unrealistic hypotheses or are excessively complex for a practical industrial utilization.

In the fresh produce industry forecasting is not adopted as extensively as in other consumer goods sectors owing to the fragmentation in many small business units, the lower electronic data coverage and the intrinsic difficulty in accounting for a greater number of stochastic variables. Standard forecasting methods that are designed to cope with seasonal demand (Box et al., 1994) often are no longer applicable in practice. In fact due to growing assortments and shorter product life cycles, demand data may show too high variation or may be insufficient to construct reliable forecast models at the individual item level (Adebanjo and Mann, 2000). Therefore, alternative forecasting methods that

are based on using demand information from a higher aggregation level and on combining forecasts have been suggested (Bunn and Vassilopoulos, 1999; Dekker et al., 2004). However, there is a wide agreement on the need of more collaborative forecasting among supply chain participants (Helms et al., 2000).

In the last decade there has been and increasing effort in developing and applying planning models in different instances of the food industry. Mathematical programming planning models have been proposed for example in the field of production aggregate planning and scheduling (Arbib et al., 1999; Tadei et al., 1995), capacity allocation (Feng and Xiao, 2006) or the integration of production planning with inventory management (Goyal and Gunasekaran, 1995, Sana et al, 2004). Less attention has been received instead by operations management issues even if some tactical decision models have been proposed for example for distribution centers for vegetables and fruits (Broekmeulen, 1998), fruit packaging plants (Blanco et al., 2005) or fruit SC planning (Masini et al., 2003). Possible integration of make-to-order and make-to-stock policies has been also investigated (Soman et al., 2004; Van Donk, 2001), as well as efficient distribution issues (Iijima et al., 1996; Tarantilis and Kiranoudis, 2001).

However, the field which has received far more attention of researchers has been that of perishable goods inventory management decisions. Earlier research has been reviewed by Nahmias (Nahmias, 1982) and Rafat (Rafat, 1991). More recent inventory models have been proposed as variation of traditional economic order quantity and periodic review models (Chiu, 1995a and b; Dye and Ouyang, 2005; Williams and Patuwo, 1999) also including backordering (Luop, 1998) as well as optimal inventory control policies (Adachi et al., 1999; Hariga, 1977; Hwang and Hahn, 2000; Gurnani and Tang, 1999; Nahmias and Pierskalla, 1973), while non traditional techniques such as fuzzy logic have been also proposed (Katagiri and Ishii, 2002). Several authors also compared the performances of alternative approaches (Aghazadeh, 2001; Tekin et al., 2001). Significant attention also received the issue of optimal pricing policies for perishable commodities (Abad, 2003; Anjos et al., 2005; Arcelus et al., 2003; Chatwin, 2000; Chun, 2003; Zhao and Zheng, 2000). Finally the importance of sourcing decision in multivendor contexts have been also addressed (Agrawal et al., 2002; Bhattacharjee and Ramesh, 2000; Stanley and Wisner, 2001).

There is general agreement that simulation can help in design and optimization of any supply chain even if simulating a supply chain, which includes a number of separate business units, is far more difficult than simulating a single facility or manufacturing system. This explains why simulation has been only recently introduced in this field. Supply chain simulation started by adopting the industrial dynamics approach of Forrester (Forrester, 1961) through the works of Towill (Towill, 1991 and 1995; Towill et al., 1992). However, in recent times computer based discrete-events stochastic simulation approaches have been also developed (Banks et al., 2002; Jain et al., 2001a and b; Jain 2004; Joines et al., 2002; Rossetti and Chan, 2003; Schunk and Plott, 2000) and a number of SC oriented software tools are available (Bagchi et al., 1998; Barnett and Miller, 2000; Ding and Hans, 2004; Hieta, 1998, Liu et al., 2004; Padmos et al., 1999; Phelps et al., 2001; Williams and Gunal, 2003). However, such models and software tools are often general purpose or aimed at different industrial sectors (mainly manufacturing enterprises), and therefore unable to explicitly model the fundamental phenomena of the fresh produces supply chain such as progressive perishability, or specific AFPSC management logics which adopt performances indicators integrating logistic costs, service level and produce quality.

Simulation models specific for food supply chains have been also developed but do not necessarily solve the above cited problems. Some authors utilize traditional mathematical models to analyze the SC behaviour (Sarker et al., 2000; van der Vorst, 2000; Van der Vorst et al., 2000) while other authors adopt the system dynamics approach (Georgiadis et al., 2005; Minegishi and Thiel, 2000; Sachan et al. 2005). On the contrary, simulation tools focusing on quality variation during SC crossing according to the evolution of temperature levels and storage conditions are available but are aimed at evaluating shelf life and inventory management policies from the retailed perspective and are not directly utilizable for planning the activities of the entire SC (Aggarwal et al., 2003a,b; Aggarwal et al., 2004 a,b; Prussia, 2000). Some produce quality simulation models are also available as instructional games (Aggarwal et al., 2004c; Hofstede et al., 2002; Prussia et al., 2001). However, a discrete event simulation tool for APFSC including quality changes simulation and quality-based performance measures has been only recently developed (van der Vorst et al., 2005).

This means that a capacity of analyzing the time dynamic of the AFPSC intended as a decision support tool enabling to comprehend and quantify the complex cause and effect interactions among the fundamental aspects of inventory management, production planning and transportation policies and the manner in which those influence the costs, service level and customer satisfaction, in this industrial sector is still lacking.

Few are the available information systems expressly aimed at studying and optimizing the interactions and coordination among the partners of AFPSCs. Therefore, an evolution is required to shift from current commercial systems simply enabling a global visibility of information (i.e. tracking and tracing) towards systems implementing also planning and integration functions. This would enable decision makers to perform what-if analyses and simulations of the behavior of the SC in order to reengineer the business processes exploring different managerial criteria in many scenarios.

4. IMPROVEMENT OPTIONS

From the above discussion it follows that in the short term the competitive factors of AFPSCs are the service level, the price and the response time, while in the long term the search of a greater vertical integration with a stronger coordination and aggregation of the actors is required. Participants shall share the objectives and utilize new business models adopting a collaborative strategy instead of an antagonist one. A further critical issue shall be innovation through the development of value added products such as nutraceutical foods, ready meals (i.e. ready to eat salads), new product varieties with better organolectic properties and improved stability, new selling formats etc. There are six fundamental requirements for an efficient AFPSC according to Grimsdell (Grimsdell, 1996), namely the scale of operation, strategic alliances, production flexibility, continuity of supply, quality control, communications. Furthermore, as happens in any supply chain, the capability of effective forecasting and reducing the causes of variability is critical. Fearne and Hughes (1999) also state that critical success factors are: strategic orientation, organizational structure and business culture to meet customer needs, ability to exploit market information, ability to measure and control the full costs of servicing customer requirements, ability to innovate.

Therefore the main opportunities to enhance competitiveness and efficiency of AFPSCs may be summarized as follows.

- To make each link of the chain as much as a "strategic partner" as possible, i.e. a business that significantly adds value to the food product or the supply chain performance. Within the chain the strategic partners shall have rights and responsibilities related to value chain information sharing, risk-taking, governance and decision making.
- Transition from a traditional food supply chain to a food "value chain" (i.e a vertical coordination through alliances with strategic partners), in which business relationship among the strategic partners within the chain are framed in win-win terms, and are constructed on collaborative principles that feature high levels of inter-organizational trust. This means moving towards vertical co-ordination instead of vertical integration.
- Growers/farmers shall become as much as possible producers of differentiated products, and should determine effective strategies for product differentiation, branding and promotion of regional identity.
- Product innovation should be pursued in order to satisfy the rising customer needs in terms of variety, quality, service level, price, and value added products. This shall make fresh produce exit from the traditional commodities trading market and drive towards a culture of innovation and value creation already typical of fast-moving consumer goods.
- Collaboratively exchange sales data and information in order to make more reliable forecasts and integrate production planning operations. In this way promotions, seasonal effects, price responses and other characteristics of consumer demand can be better evaluated and an improved coordination between demand and supply can occur thus stimulating sales and achieving more consistent volumes and quality.
- Commitment to the welfare of all strategic partners in the chain, including fair profit margins, fair wages, and business agreements of appropriate duration, through participatory governance structures.
- Development and defence of regionally-meaningful identities and brands enabling farmers/growers to maintain ownership and control of brand identities on food products throughout the supply chain.
- To develop food quality control systems that address weather, seasonality, multiple production sites and quality preserving distribution mechanisms.
- To develop advanced record keeping, accounting and cost control methods enabling the true cost structures to be understood and used to monitor and improve chain performances. Accordingly, determine appropriate strategies for product pricing.
- More fully exploiting promotions and merchandising, which tends to be retailer-led in fresh produce but supplier-led in fast moving consumer goods.
- Networking between growers/farmers, surpassing their competitive attitude, in order to form large enough groups capable of supplying significant and consistent volumes of high-quality, differentiated food products with stable pricing. This enables to counter the higher buying power in the procurement of fresh produce exercised by retailers and wholesalers, who strengthen their competitive position through mergers and acquisitions.
- To implement efficient consumer response (ECR) and category management (CM) criteria to exploit the opportunities arising from a more discerning customer in a cosmopolitan marketplace.
- To adopt supply chain management techniques to streamline the distribution system by eliminating non value-adding transaction costs, and implement information technology and systems to get whole electronic integration of the participants capable of serving the needs of large scale buyers and prevent being phased out of the large grocery retailing channels.
- To acquire adequate capitalization and competent management. Access adequate technical, research, and development support. Both enable, in fact, to invest in product innovation and process capacity able to deliver it.

- To create meaningful standards and consistent certification and traceability mechanisms across the chain. If this can be demonstrated professionally, then the links in the supply chain are strengthened.
- In parallel to traditional distribution channels, to develop business-to-consumer food marketing choices (i.e. online food shopping) at least in niche markets such as gourmet foods and specialty regional products, and develop e-commerce platforms tailored to the fresh produce sector.

In summary, the fresh produce market is characterized by a fragmented supply base with excess capacity and oversupply of raw material with a substantially static demand of traditional fresh fruit and vegetables, but a growing demand of innovative products. In the commodity portion of the market, regarding raw produces, the competition is price-driven with low margins. One sees an extremely weak bargaining position of the pre-packers respect retailers which results in a short term perspective focusing on service levels and meeting the current needs of multiple retailers in an adversarial confrontation between participating businesses. In the value-added portion of the market share instead, which is value-driven and has high margins, the growth is steady, but requires a long term perspective on investments and innovation, collaborative business partnership, and focus on the future needs and wants of consumers with innovative vision and market intelligence. In both cases, although with different goals and requirements, supply chain efficiency is a critical success factor because the supply line will become more streamlined, with fewer players competing in an increasingly aggressive market. This also implies from the academic research point of view, the need for developing new tools to effectively model and manage the supply chain in order to capture its dynamic interactions and to use this knowledge for informed decision making.

Resorting to new integrated quantitative models of the SC, managers could examine the system behavior in the actual variability conditions according to realistic scenarios, in order to evaluate costs and performances resulting from the adopted management policies, in order to define better management criteria able to give more competitivity to the SC. Managers could therefore assess the benefits from a collaborative approach to SC management instead of limiting to merely manage transactions between the immediately preceding or following stages of the SC. The industrial experience in other sectors teaches, in fact, that significant performance improvements can be obtained adopting modern SC management criteria. Among the most relevant benefits to be reaped there are the better demand forecasting accuracy, which is critical to line up the supply and production plans to customers demand, the reduction of inventories, the increase of return on investments and return on sales, the increase of customer service level, the transportation cost reduction, the reduction of quality related costs, a shortening of lead times and a quicker response, a reduction of stockouts.

5. CONCLUSIONS

In this paper, basing on an extensive literature review, the main issues concerning the management of supply chains in the agricultural fresh produce sector have been examined. At first the criticalities of this kind of supply chains resulting from either the products characteristics and the organizational structure and relationships among the participants have been discussed, highlighting their impact on supply chain management. Then an analysis of the availability of adequate quantitative models to support decision making has been performed in the realms of forecasting, production planning and control as well as inventory management, also discussing the emerging role of supply chain simulation as an effective tool. Limitations of the existing models and approaches have been pointed out as well in order to suggest further research. Finally, a set of possible improvement options and related managerial implications to make more efficient and effective the fresh produce supply chain are given considering the undergoing structural changes and market evolutions. The review, by attempting to present an overall comprehensive framework of fresh produces supply chain management issues, shall be useful to both industrial practitioners, and researchers in order to better focus their efforts on further research and innovative managerial practices in this competitive sector.

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