CHAPTER 1

QUANTIFYING THE AGRI-FOOD SUPPLY CHAIN

Overview and new research directions

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Abstract. The Frontis workshop 'Quantifying the agri-food supply chain' aimed at discussing the possibilities and limitations of quantifying performance, risks and investments in the agri-food chain and at bringing people from international institutes together. Their contributions are organized around five key issues in the agri-food chain: concepts of measuring performance; empirical research in measuring costs, benefits and risk; modelling; value of information; and governance and performance.

Papers with a wide variety of approaches from different economic disciplines have been demonstrated to be useful in analysing the supply chain. However, understanding the complex system of agri-food chains requires more investments in retrieving empirical data for testing propositions and developing appropriate models. The identified research gaps and discussion points were shared among an international forum of researchers. International cooperation among researchers will enhance progress in this research field. The workshop was highly valued in this respect.

Keywords: agribusiness; food production chains; performance measurements; risk and uncertainty; chain governance

INTRODUCTION

The chapters in this volume were first presented at a Frontis workshop on 'Quantifying the agrifood supply chain', held at Wageningen, The Netherlands, 22-24 October 2004. The overall purpose of this workshop was to discuss the possibilities and limitations of quantifying performance, risks and investments in the agri-food chain and to bring people from international institutes together. Agri-food chains entered a new era in which customer orientation and social responsibility are the main driving forces. Globalization of supply chains complicates the chain governance. In order to develop a research agenda that meets the challenges facing industry and policymakers, invited experts from around the world convened to review the state of the art.

The papers in this volume were written on invitation and are organized around five key issues in the agri-food chain:

1. Concepts of measuring performance.

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2. Empirical research in measuring costs, benefits and risk.
3. Modelling.
4. Value of information.
5. Governance and performance.

In the following overview we provide the highlights of each key issue and important insights obtained from the presentations and discussions. In the conclusions we define research areas for future work.

MEASURING PERFORMANCE IN AGRI-FOOD CHAINS

At firm level a large number of performance indicators are available; see for instance the balanced scorecard of Kaplan and Norton (1992). Performance indicators at chain level are still being developed. First of all, performance indicators on chain level have to deal with the governance structure of the chain. The objectives of chain partners are not necessarily in line with optimal performance of the total chain. Secondly, the relevance of information differs on each level, even if the information is of high importance for the overall chain performance. Thirdly, the strategic value of some of the information inhibits a free exchange between chain partners.

Many researchers and practitioners are working on the enhancement of supply-chain collaboration in order to improve performance of the individual supply-chain members and supply-chain performance as a whole. The first group of papers provides an overview of approaches of chain performance measures.

Van der Vorst presents a framework for the development of innovative food supply-chain networks and discusses the implications for performance measurement systems. Performance measurement fulfils a crucial role in the development of supply chains and networks as it can direct the design and management of the chain towards the required performance. It is the key instrument to discuss and evaluate the effectiveness of (potential) chain partnerships. He defines supply chains and supply-chain management. Furthermore, he distinguishes Key Performance Indicators (KPIs) on chain, organization and process level. Lack of transparency and cooperation are the main bottlenecks in measuring chain performances. Many indicators focused on local operational use and are lacking standard definitions. He also points out that academics are interested in bringing definitions, adaptation and validation under one heading. This conflicts in many cases with the managers' view that providing useful information quickly is a good enough measure.

Principles for accounting in supply chains are the topic of Bremmers's paper. The availability of (normative) accounting standards is a prerequisite for effective and efficient accounting in supply chains. He proposes three accounting standards for cooperative supply chains:

- Reciprocity in information access: those that deliver information to the system should be able to retrieve an equivalent amount.
- Equivalent cash flows: provision of assets (supply-chain investments) should be matched with an equivalent amount of assets (cash flows) in return.

- Matching risks and returns: the bigger the opportunities for individual firms, the bigger the contribution should be in risk sharing and risk management.

These three rules of reciprocity cause a transparent supply-chain policy and performance measurement. Transparency will replace (or at least will have to supplement) *trust* as a measure for relational quality. These three standards are not meant to be exhaustive; other standards should still be developed. Moreover, he argues that technological innovation, such as electronic chain-wide reporting, is beneficial for transparency, decision making and control in/of supply chains, and will reduce the administrative costs of (supply-chain) accounting systems at the same time.

The topic of Bunte's paper is evaluating market power based on welfare theory. Social welfare – or alternatively supply-chain performance – depends on two elements: (1) efficiency and (2) equity. Efficiency is concerned with the creation of value-added; equity is concerned with the division of value-added over the respective stakeholders. Efficiency and equity are not necessarily compatible. Efficient solutions may be very 'inequitable'. Maximizing value-added is not necessarily beneficial for all stakeholders concerned! First he addresses the question whether price changes at the farm level are fully and instantaneously transmitted into changes at the consumer level. He observes a general pattern of price asymmetry to the disadvantage of farmers and consumers. In general, price symmetry and price levelling are as prevalent as price asymmetry is. Secondly, he questions whether there have been changes in the price risk distribution in post-war agri-food supply chains. A shift in price risk from farmers to marketing organizations in the Dutch ware-potato supply chain has been observed. He finds limited evidence for the abuse of market power in European food processing and retail trade.

In the paper of Aramyan et al. performance indicators in agri-food chains are reviewed. The performance indicators range from highly qualitative indicators like customer satisfaction to quantitative indicators such as return on investments. Lacking consensus on what determines the performance of supply chains complicates the selection of one measurement system. Their literature review shows that many attempts have been made to develop a measurement system; however none have been successfully incorporated in practice. They suggest a performance measurement framework based on efficiency, flexibility, responsiveness and food quality.

The papers and discussion focused on one of the fundamental issues of chain performance: how are the objectives of chain and individual actor related? It is obvious that each stakeholder has his own objectives and his own performance measures. But it was also recognized that the performance of the chain as a whole is more than the sum of the performances of each individual chain member. That means that just one indicator will be insufficient for measuring chain performance, and the choice for performance indicators depends on the scope of performance measurement. Human capital, in particular the position of employees, is mentioned as a neglected item. Education, wages, productivity and job satisfaction could be performance measures in this case. Further research efforts are needed to connect

theory and practice, but also to connect managerial opportunities with academic efforts to measure and improve chain performance. The issue of 'Who is the chain leader?' was also discussed. It is argued that in the end the supply-chain performance indicator should be directly related to the value-added for the final consumer. Also the position of retailers, their concentration and their influence on consumer prices as well as the distribution of the added value among the chain partners are important topics for further research.

SHARING COSTS, BENEFITS AND RISK IN AGRI-FOOD CHAINS

Integrated supply chains and networks, as a distinction from loosely related up- or downstream firms, offer opportunities for creating additional added value. High customer satisfaction and confidence in the purchase can be achieved by labelling or, at a higher level, branding. Labelling requires supply chains with a shared strategic focus and more chain coordination. Cooperation in chains enables traceability systems, which can reduce cost in the event of food safety problems and can improve verification of quality and credence values of food. Furthermore, the competitive positions of chains can be improved by using the competitive position of individual firms in the chain. In this section three papers based on empirical research are presented.

The growth of Minimum Quality Standards in the sector of fresh agricultural produce is a recent occurrence closely related to the food and food-safety crises of recent years. While the public authorities were creating new control and health-monitoring procedures, tightening regulatory production standards and enhancing regulations related to official marks of quality, some retailers were adopting new segmentation strategies for demand of a chain brand. Retailers are seeking to reassure consumers by creating their own quality labels and by communicating about the additional guarantees afforded to consumers by these quality labels. Giraud-Héraud and Soler discuss the impact on the performance of retailers and producers. The benefit of product differentiation through the implementation of a chain brand is higher for the retailer when the minimum quality level is low. The more the public authorities raise the minimum quality level the more difficult it becomes for retailers to implement a differentiation strategy. High levels of minimum quality standards make it impossible to establish a chain brand or private label. An increasing level of professionalism in the chain enables high standards, which decreases the possibilities of differentiation strategies.

Hobbs explores the economic functions of traceability, examining the extent to which traceability can bolster liability incentives for firms to practice due diligence. The extent to which consumers value traceability per se, versus verifiable quality assurances delivered through traceability, is evaluated empirically using survey and experimental auction data. The empirical analysis shows that consumers were willing to pay non-trivial amounts for a traceability assurance. For consumers, traceability has the highest value when bundled with additional quality assurances.

Ingenbleek uses the evolving logic in marketing to examine the problem of sharing financial rewards in agricultural supply chains. Building on resource-

advantage theory it is suggested that the potential reward that firms may derive from participating in a supply chain depends on the competitive position of the chain as a whole and on the competitive position of the individual firm within the chain. To understand what its contribution to the chain is worth, the firm should be able to quantify relative customer value. Inappropriate assessments lead to a disability of the firm to take financial rewards in exchange for its contribution to the chain. To ensure that chain members remain motivated to invest in the chain and to provide them with sufficient financial resources to do so, it is in the common interest of all chain members that each of them is rewarded for its contribution to the competitive position of the chain.

The discussion focused on aspects of the retailers' strategy to create Premium Private Labels (PPL). Two main motivations for creating PPL are:

- Creating market power. Retailers experience severe price competition. Creating PPL enables higher profits, and also a higher market share can be one of the benefits. Furthermore, a wide range of PPL products enables economies of scale in advertising.
- Securing food safety. The General Food Law is a driver for food quality and safety standards. Some retailers apply additional requirements, thus creating a PPL. By coordinating the chain, retailers gain more influence on the production process and reduces the risk of insufficient food quality. Higher customer loyalty should outweigh higher chain costs due to food safety guarantees.

Despite clear conceptual approaches research on empirical verification needs to be strengthened.

Another issue discussed is the position of the supply base. A share in the higher profits, as showed by Giraud-Héraud and Soler, is not obvious. Retailers can buy their product from local producers but also from producers in low-cost countries. The value-added of producers participating in a PPL should be recognizable and therefore their produce should be differentiated from the bulk. A more traditional approach is creating countervailing power, e.g., by establishing a producers' cooperative. This cooperative can differentiate their produce and aim at different markets and at different countries.

MODELLING AGRI-FOOD CHAINS

The advantages of cooperation in agri-food supply chains and establishing consumer values by adding tangible and intangible assets to products can be argued from theoretical viewpoints. Modelling these advantages and assessing risks and robustness of chain cooperation provide information for decision making on chain cooperation. The papers in this session provide insight into the advantage of robustness modelling and the potential impact on chain profit by quality improvements and promotion activities.

Kleijnen[1] presented an approach of designing 'robust' as opposed to 'optimal' supply chains. The reason for such a robust approach lies in the stochastic nature of production and economic environments. Inherent risks and uncertainties prevailing in business environments may lead to sub-optimality of solutions in situations

where, for example, key modelled parameters of the 'optimal' design differ from their real-life counterparts. As opposite, it is argued that robust solutions provide acceptable performance even when the number of possible scenarios is large. The variety of scenarios in this 'robust' framework is taken care of by assigning probability distributions to each scenario. The concept of robust supply chains is based on the ideas of Genichi Taguchi, a Japanese engineer who applied this approach to design Toyota cars. Kleijnen combined the approach of Taguchi with stochastic Monte Carlo simulation to incorporate the uncertainty into an analysis that provides robust solutions.

Schepers and Van Kooten present a quantitative model for the analysis of the optimal timing of selling commodities in agri-food retail chains. The key proposition of this paper is that larger gains for stakeholders in the chain can be achieved when fresh produce is sold at a riper stage. Inevitable high product losses and higher marketing costs will be outweighed by increased consumers' purchases of riper products. The model is dynamic and is based on three knowledge domains: consumer science, quality management and chain science. Applying the model shows how such actions as promotions and positioning of products influence the profits of stakeholders in the mango retail chain as well as the effects on cost-sharing agreements.

The discussion concerning the design of robust chains aimed at the question: "What are the specific robust issues facing developing optimal design of an agri-food supply chain?". It was agreed that these issues are largely determined by inherent characteristics pertaining to agricultural production and food distribution. The most important of these characteristics include the biological character of agricultural production, its close relation to nature and, hence, dependence on weather and other uncontrollable (and stochastic) natural forces, the perishability of products, and environmental concerns. A recent increase in public and scientific interest on 'tracking and tracing' issues in the supply chain, animal welfare and food safety concerns suggests these as important points to be taken into account when developing robust agri-food chains. Further research should therefore focus on incorporating the above issues in robust design of agri-food chains. The foreseeable challenge for those involved in this field of research may come from the difficulty of measuring important factors, such as food safety concerns, as well as notorious difficulties in getting (quantitative) data.

The discussion on the model presented by Schepers and Van Kooten centred on the possibilities for extending the model to deal with a lot of different agents, including producers, wholesalers, retailers and other stakeholders that are actually present in the chain. It was also stressed that any model should take into account the bargaining powers of the agents in the chain. The argument is that if a producer of, e.g., exotic fruits wishes to supply its products at a different ripeness stage than required by the retailer, the latter might switch to other suppliers whose produce conform to required specifications. Given that retail chains currently possess large bargaining power, efforts should be exercised to convince retailers that changes in the selling pattern proposed in the model may also benefit them.

THE VALUE OF INFORMATION IN AGRI-FOOD CHAINS

According to the US Department of Commerce, information technology has been one of the key drivers for economic growth in the USA: information technology was attributable for one third of real economic growth. In the 20th century mankind made a transition from an economy based on natural resources to one based on design and organization (Contractor and Lorange 2002). Due to this transition, the costs of carrying out exchanges between firms, whether in a market place or in a vertically integrated firm, increased. Growing diversity of knowledge sources, accelerating technical change, growing importance of outsourcing and hence a growing importance of vertical coordination are examples of the importance information and alliances play in a chain. In this section three papers are presented on management information infrastructure, on recalls in the dairy sector and on knowledge management in alliances.

Schiefer addresses the establishment and management of information infrastructures in chains. Tracking, tracing and quality-assurance systems in agriculture and the food sector are a prerequisite to support the guarantee of food safety and the focus on consumers' quality needs. The paper discusses the need for new information layers that utilize enterprise information but focused on the communication between chains for quality assurance towards the consumer and for improvements in risk management.

The General Food Law, which was implemented on 1 January 2005, emphasizes 'adequate traceability' and 'recalls whenever necessary'. The paper of Meuwissen et al. quantifies the costs of recall of consumption milk, and aspects for supporting due diligence are identified and prioritized. In counterattacking liability claims due diligence is central. Even when a company shows to be the cause of contamination, due diligence can demonstrate non-accountability and, hence, eligibility for insurance payments. Total recall costs are simulated using a Monte Carlo simulation model. Important parameters in the model are batch size and the point along the supply chain where contaminated products are identified. Analyses show that farmers are currently at a disadvantage in demonstrating due diligence compared to other participants of the chain.

Sporleder defines and analyses the concept of a strategic alliance as one specialized collaborative agreement among vertically allied firms in the supply chain. Intellectual property may serve as a base for *maximizing value-added* within a strategic alliance. Knowledge management provides novel insight into the foundations of a strategic alliance. The potential of a strategic alliance creating a real option for managers is examined along with the characteristics of networks that are organized around constant learning. The role of management is critical when evaluating strategic alliances. They need to be aware of what types of resources, tangible and intangible, are dedicated to the strategic alliance. Performance evaluation of alliances based on a certain-to-fuzzy continuum of inputs and outputs is suggested.

Concerning information management the discussion focused on the question what type of information is needed. In an empirical research for processed

vegetables the end user, in this case the consumer, defines the needed information. In cases of liability it is important to know who is blamed according to the end user. The question is not only who is guilty but who has to repair the insufficient food quality. The performance of multilevel networks and chains can be measured by a balanced scorecard. Strategies concerning the financial, production, information and trust performance should be evaluated.

SUPPLY-CHAIN ORGANIZATION AND CHAIN PERFORMANCE

Markets are becoming increasingly global in scope, technologies are changing rapidly and the life cycles of products are ever-shortening. These changes in the external environment are incentives for cooperative activities between firms. Porter and Fuller (1986) mention the following benefits from cooperation:

- To achieve economies of scale and learning together with a partner.
- To get access to the benefits of other firms' assets: technology, market access, means of production, special skills.
- To reduce risk by sharing investments, including R&D.
- To speed up in reaching the market.

The papers in this section provide an overview of theoretical approaches of supply-chain organization and cooperation as well as empirical findings.

Wysocki et al. present the PWH (Peterson, Wysocki and Harsh) model, which focuses on vertical-coordination strategies of firms in agri-food chains. The model assesses the main decision points for strategy-making processes by firms with respect to vertical coordination. They analyse the chain on three phenomena: the firm's strategy to participate in the supply chain, the chain governance structure, and the application of industrial organization and institutional economic theory. In their overview they discuss the advantages of the various forms that agri-food chains may take: channel-master, chain-web and chain-organism model. They conclude that understanding agri-food chains requires a multidisciplinary approach, such as the PWH, learning supply-chain governance structure model.

The importance of chain transparency (e.g. market information symmetry) for developing corporate social responsibility (CSR) is emphasized by De Vlieger. The relationships between the social responsibilities of firms and chain organization are founded on the 'credence' characteristics of social responsibility. These credence characteristics make market information necessary to ensure market information is symmetric at every stage of the production chain. The incorporation of transparency on CSR into a chain is possible in a product-oriented or in a company-oriented way. De Vlieger supports his preference for the latter strategy with a company-oriented model in which the consequences of CSR for a chain are identified. The dynamic model addresses the opportunities for developing CSR by integrating it with quality-assurance systems, which are based on the same rules ('requirements').

Bijman presents a model for studying governance structure choice, applied to changes in governance structures in the Dutch fresh-produce industry. This industry has gone through substantial restructuring in recent years. Asset specificity has increased, mainly due to the introduction of brands and the establishment of

specialized packaging stations. Measurement problems have increased due to specific quality attributes, product innovation and quality guarantees. As a solution, producers have vertically integrated by taking over or setting up downstream wholesale companies. Coordination problems have increased due to the shift from pooled to sequential interdependence. As a solution, coordination mechanisms have shifted from standardization to direct supervision. The latter has been materialized by giving the management of marketing cooperatives more authority

Relationships between key partnership characteristics and performance are discussed by Duffy and Fearne. In an empirical study they investigate how the development of more collaborative relationships between UK retailers and fresh-produce suppliers affect the financial performance of suppliers in such relationships. The results provide support for the theory that partnerships can help a firm to improve its performance. The results also show that commitment and trust and relational norms have the greatest predictive ability in the multiple-regression analysis, followed by functional conflict resolution and involvement in decisions and planning.

The discussion concentrated on concerns about variables that should be included in the different models. Although it was agreed that the PWH model reflects the important factors for adjusting or changing the strategy of a company, some variables seem to be interrelated. An example is the relationship between customer satisfaction and profit. In general, when the customer is satisfied the profits are higher. The CSR model shows a rather complex picture at first instance. Some variables have names that are difficult to understand. Could the content of the variable 'Chemistry' be the same as social capital? It seems that they have the same content because they are dealing with past experiences of a company in a chain; for example, the way of trading, communication and so on. The influence of norms/standards on the type of governance structure has been questioned. It should be noticed that norms (values) vary across different nations. This gives an extra notion to collaboration in international food supply chains. In designing governance structure a trade-off has to be made between norms, authority and price mechanisms. The discussion also explored the issue of transparency. Will these models achieve more transparency in international food supply chains? Are members willing to give more insight into their business processes and are they willing to give (sensitive) information for more transparency in chains? And how will the quality of the transparency variables be guaranteed? The papers and discussion made it clear that the theories give the concepts, but that each chain has to deal with these issues separately as a part of the chain cooperation. Next, the practical value of the models was discussed. In the PWH model a path is made to achieve the appropriate strategy for a company or a chain. Is it possible to use this model for optimizing the strategy and could this strategy be placed on the continuum for the different forms of learning supply chains? Does the cooperative model only give a situation of steady state or is the model also able to take care of dynamism in the business environment or, in other words, can the model determine the best structure for the chain of tomorrow?

CONCLUSIONS

The emerging field of quantifying the agri-food supply chain is demonstrated by the chapters in this volume. First, a wide variety of approaches from different economic disciplines are useful in analysing the supply chain. The approaches tackle questions to get optimal, efficient or robust solutions of chain performance, structure, organization or chain strategy. Concepts, cases and empirical findings of these approaches in agri-food supply chains have been demonstrated. Second, understanding the complex systems of agri-food chains requires more investments in retrieving empirical data for testing propositions and developing appropriate models. The experiences from past research can be and should be further explored. This will result in opportunities and support managerial decisions. Third, the contributions show that on an international level large interest exists in the issue of supply chains and in the importance of the agri-food chain. The identified research gaps and discussion points are shared among an international forum of researchers. International cooperation among researchers will enhance progress in this research field. The workshop was highly valued in this respect.

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NOTES

[1.] This presentation is not included in this volume.

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