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Policy and the modern food supply chain a commentary and literature review

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Publication date:
2007

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Baker, D. (2007). *Policy and the modern food supply chain: a commentary and literature review*. Frederiksberg: Fødevareøkonomisk Institut, Københavns Universitet. IFRO Working Paper, No. 15, Vol.. 2007

Policy and the modern food supply chain

A commentary and literature review

Institute of Food and Resource Economics (FOI)

Working Paper 2007/15

Policy and the modern food supply chain

A commentary and literature review

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Abstract

The modern food supply chain is assuming many roles traditionally associated with markets. This paper reviews efforts to define food supply chains and define and measure their performance from a commercial and social point of view. It proposes that little thought has been given to the role of government in food supply chains and the degree to which the existing policy environment is appropriate for the productive growth of such chains. It examines potential supply chain performance measures that might be used by policy makers, and the extent to which the appropriate information might be shared between the chain and government. It presents conclusions about necessary steps for policy development and for governments' relations with both firms and chains. Further research topics are identified.

ISBN 978-87-92087-41-6 (on-line, Policy and the modern food supply chain)

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Preface

This Working Paper addresses the rapid development of the food supply chain and the relevance of existing policy mechanisms to that changed environment. This research is conducted under the auspices of the project “Perspektiver for og Udvikling af den danske fødevarekæde (phase 2)”, commonly known as “the food chain project”. This project is funded under the Innovationslov and administered by the Directorate of Food Fisheries and Agribusiness (DFFE) of the Danish Ministry of Agriculture.

Thanks are due to Jørgen Dejgård Jensen for a review of drafts of the paper.

Division Director, Production and Technology, Mogens Lund
Institute of Food and Resource Economics
Copenhagen, December 2007

1. Introduction

1.1. Purpose of study

This study addresses issues of food industry policy in the context of modern food and agribusiness supply chains. It has three target audiences:

- Government practitioners of policy will gain some insight into the way in which the shifting nexus of food industry activity might be addressed in pursuit of policy goals;
- Researchers into policy and the economics of the food system will find a selection of literature reviewed and utilised to pose questions about current and future supply chain policies; and
- Food industry firms will improve their understanding of the purposes of policy and its possible future mechanisms in an increasingly chain-oriented commercial environment.

1.2. Background

The food system's progression toward vertical co-ordination has been variously attributed to numerous factors including available technologies (Boehlje and Sonka, 1998), transactions costs (Frank and Henderson, 1992), information exchange issues between firms (Hennessy, 1996), and the need to reflect consumer demand throughout the chain (Price, 2002; King and Pomphiu, 1996). Hughes (2002) describes the food system as “a channel to the consumer”, in which various value-addition and value-delivery mechanisms are engaged. In this setting, Maxwell and Slater (2003) identify a “new food policy” with a broadened remit, including that of addressing coordinated vertical structures and relationships. The current paper embraces “new food policy” instruments and examines issues of their design and implementation in the context of a food supply chain.

Jackson *et al.* (2006) synthesise various chain-relevant views in terms of their impact on policy and *vice-versa*. Although much contemporary policy addresses market failure and the associated roles of government towards the firm and the market, this subject has rarely been addressed in the context of supply chains. The chains are likely to generate a different pattern of market failures than do firms: in particular by solving some problems while generating others. The current paper makes one of the first attempts to identify a role of government associated with the food supply chain.

In the view of some, narrow food marketing channels are a means of exercising market power (Marsden *et al.*, 1997) as well as a consequence of it (Cotterill, 1997).¹ Others view the process as a consequence or means of specialisation, or of activities generating specific quality attributes (Meulenbergh and Viaenne, 2002). The phenomenon of a single firm dominating a channel has been dubbed “chain captaincy” by Connor (2003). Hanf and Dautzenberg (2006) identified the emergence of a chain captain (which they refer to as the “focal firm”) with some key desirable aspects of food supply chain management. Other benefits of (retail) chain captaincy have been described by Dobson *et al.* (2004), in the form of a virtuous circle/cycle of low price based on low costs, subsequent acquisition of market share, re-investment of profits into further scale, which in turn lowers costs. Much of the scale-related cost saving may be in input-sourcing, which has been the site of much recent industrial consolidation throughout Europe (Baker, 2003), and continues to occupy policy institutions.²

In a chain-dominated food economy, competition is thought to be increasingly “between chains rather than between firms” (Boehlje and Sonka, 1998). However, access to the chains has become a policy concern across contexts as diverse as access for small farmers (Dolan and Humphrey, 2000) and the demise of second-tier or local brands (Borghesani *et al.*, 1999). Within the chain, narrow channels appear to be conducive to non-competitive behaviour, such as predatory branding (Baker *et al.*, 2006). Whereas much industrial organisation-oriented work in the food industry addresses vertical integration, in fact the management tools being employed are best referred to as “vertical co-ordination” (Kaplinsky and Morris, 2000; Xu and Beamon, 2006). The current paper examines these issues in terms of a role of government and appropriate policies: for example, a co-ordination role of government in vertical relations such as quality certification may be outmoded and unproductive in some supply chains but may be a fundamental enabling factor in others.

Based on supply chain development, Moran and Ghoshal (1999) identify a shift away from markets toward quite different relationships amongst firms, stating “we live in an organisational economy, not a market economy”. This raises questions about the relevance of policy instruments that are focused on mimicking market-based efficiency. A further concern about policy is its capacity to address all stages of the chain. Hallsworth and Taylor (1996) identify close relationships between government

¹ Cotterill uses the term “food convergence” to describe narrowing in supply chains and the environment.

² See OECD (1999, 2003) for a review; and Duffy *et al.* (2003) for an investigation of the “fairness” of the retailer-supplier interface.

and firms in identifying interlocking “circuits of power”. Jackson *et al.* (2006) list policy initiatives in Britain that promoted the interests of the “commodity chain”, but specifically targeted issues of competitiveness and costs within the chain,³ and paid far less attention to stakeholder welfare, the environment and sustainability. A more acerbic treatment of chain development in Britain is presented by Lucas and Jones (an undated political treatise), which extends to criticisms of chain-related declines in farm diversification, global trade and specialisation patterns, degeneration of rural society, pollution, overuse of fossil fuels, and a disconnection between localities and the food products that they produce. Although, across a number of disciplines, much research effort is being devoted to defining and measuring food supply chain performance, there is a divergence amongst definitions of that performance. This is due not only to the usual dichotomy of views contrasting “economic” with “financial” performance, but also to the capacity of performance measures to address or take account of the interests of all members of the supply chain. The current paper provides one of the first discussions of these topics.

Most advocates of supply chain performance measurement emphasise the principle of define-quantify-benchmark-compare. They also require the key step of identifying measurable variables (“metrics”). However, within this literature has appeared a major divergence in research aims: one body of work measures the performance of firms within the supply chain; while the other measures the performance of the supply chain itself. The current study primarily addresses the latter, and the manner in which policy can monitor and enhance performance. Stewart (1995) identifies the conflict between corporate and supply chain performance as stakeholders’ asking “what’s in it for me?” when entering a supply chain. More generally, the extent to which current knowledge of food industry policy addresses incentives within, between and beyond supply chains is unclear. Government’s role in the modern supply chain has not been widely discussed, but for a variety of such roles, few have addressed the question of “what’s in it for society?”

1.3. The “Food Chain Project”

This research is conducted under the auspices of the project⁴ “Perspektiver for og Udvikling af den danske fødevarekæde (phase 2)”,⁵ commonly known as “the food chain project”. This project is funded under the Innovationslov and administered by the Di-

³ See also MAFF (1999).

⁴ Further information about the project are available from the author at db@foi.dk.

⁵ “Perspectives and outlook for the Danish food marketing chain”.

rectorate of Food Fisheries and Agribusiness (DFFE) of the Danish Ministry of Agriculture. The objectives of the project are to:

- measure changes in function, structure and commercial practice in the Danish food industry and compare and contrast these with developments in other countries;
- characterise vertical and horizontal relationships in the Danish food chain and their role in delivering optimal levels of food quality, variety and safety;
- evaluate the efficiency and competitiveness of the Danish food system at each stage of the marketing chain;
- review and evaluate instruments of Danish, EU and foreign public policy in the development of the food marketing chain; and
- communicate research results in a number of media.

1.4. Outline of report

This report has five sections. This first section has provided background to the topic and motivated the study. This essentially addresses the gap between development in, and of, the food supply chain and the role played by government in addressing food industry problems through policy. The second section focuses on the food supply chain as an entity, and section 3 relates the described components to management and performance. Section 4 questions the role of government in supply chains and examines some conventional arguments for government role in markets for their application to supply chains. Section 5 is a discussion and synthesis of the preceding sections. It returns, first, to the issue of supply chain performance, but from a social point of view and with the goal of focusing on a policy role in the food supply chain. Relevant issues for policymakers and commercial firms, and further research topics, are identified.

2. Supply Chains

2.1. Nomenclature and definition

The vertical array of firms, activities, responsibilities, relationships, structures and functions that deliver food products and services to the consumer and beyond, is generally referred to here as the “food supply chain”. It is also variously called the food commodity chain, value chain and marketing chain; as well as networks, webs, arrays and netchains. Although some well-constructed arguments identify differentiated attributes for some of these terms (e.g. Hanf and Dautzenberg, 2006; Lazzarini *et al.*, 2001), the current paper uses these expressions largely interchangeably.

Beyond nomenclature, a variety of definitions of the supply chain are in current use. Most identify an enduring vertical arrangement of firms engaged in mutually-beneficial activities that feature trust amongst firms, the pursuit of customer satisfaction, and value addition. Kaplinsky and Morris (2000) define a supply chain as “the full range of activities required to bring a product or service from conception through the different phases of production, delivery to the final consumers, and disposal after use”. Notably, (and consistently with Stewart (1995)), the procedures of new product development and introduction are included in the definition. This reinforces the dynamic nature of the food system as proposed by Wright (1996): its effectiveness must be measured in terms of its capacity and ability to serve as-yet-unknown markets with as-yet-unknown products and services.

Emphasis is often placed on three “flows” through the elements of the chain: product; information; and payment (Scramin and Batalha, 2003).⁶ Storer and Taylor (2006) generalise the third flow (payment) to include “management and control” which delineates ownership and responsibility, and hence the allocation of risk and return in the chain. Wright’s view is that innovation is also a chain function: interpreted here as another “flow”. Boon (2001), for example, reports on four case studies of innovation through vertical co-ordination between two adjacent stages of selected chains. None of these authors have identified flows of public goods and externalities from or within chains to allow comparisons with markets as delivery mechanisms.

Despite various attempts to define the supply chain as a focus of management and research, opinion is divided as to whether the supply chain is a (new) autonomous eco-

⁶ Scramin and Batalha’s (2003) paper defines the flows in a descriptive and modelling sense, then specifies them in a dynamic simulation model of a dairy catchment.

conomic entity (e.g. Gulati *et al.* (2000)) or simply a configuration of organisations recognizable to us as firms. Passiante and Ndou (2006) take the former view, treating the chain as a configuration of resources with its own capacity to generate and market value. These authors observe that, as with products, the long-term viability of such chains is dependent on their capacity to generate unique attributes that are difficult to imitate.

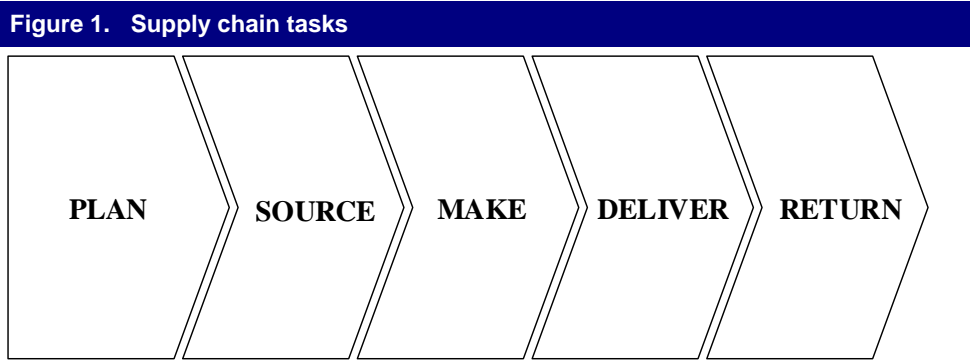
The view of the supply chain as a commercially autonomous entity has not been supported by developments in accountancy. Lalonde and Pohlen's (1996) summary of available accounting identities indicate that they (i) have limited capacity to track individual products, markets, customers and suppliers, (ii) remain focused on within-firm performance and (iii) need to be implemented using standard estimates of cost and physical quantities. Beyond costs and revenues, Folkerts (2007) advocates the valuation and inclusion of supply chain relationships as assets in firms' balance sheets. Gereffi (1999) and Kaplinsky and Morris (2000) characterise "buyer-driven", as opposed to "producer-driven" chains, the key difference being the primacy of marketing and branding in the buyer-driven chains and of a key technology in those driven by producers. Both chain attributes play roles both as barriers to entry and as attractive options for potential supply chain participants. However, no attempts have been made to value such chain attributes nor assign their values to key players.

Taking the latter view (persistence of firms) Lazzarini *et al.* (2001) observe that firms within a network operate within one or more chains, and they mobilise this as a guide to resource use within a so-called "netchain". In particular, resources that serve multiple, possibly competing (see Stewart, 1995), chains are shared and therefore have measurable value-in-use at the margin. Economic theory suggests that optimisation procedures might be brought to bear on the vertical within-chain and between-firm allocation problem, and this approach is pursued in Baker's (2007) mathematical programming model of food attribute provision. Baker contrasts valuations associated with alternative objective functions: "whole chain" (loosely, the sum total of chain participants' interests) and "single stage" (the interests of firms at just one stage). Baker identifies divergence (provision/non-provision) between the solutions as market failures. Van der Vorst (2005) identifies the "food supply chain network", and extends Stewart's reasoning about supply chains' competing for resources into a discussion of value addition by the chain. Van der Vorst observes that what happens between two firms depends not only on those two firms, but on what is happening between any number of other firms in any number of other relationships.

Public interest, as frequently portrayed in descriptions of markets, is apparently not represented in any definition of the supply chain. No known supply chain definitions attribute a role to government.

2.2. Supply chain tasks

Most descriptions of supply chain tasks use Stewart’s (1995) list, augmented by SCOR⁷ to include “return” or after-sales service (see figure 1).



Source: adapted from Stewart (1995).

The product-orientation of figure 1 avoids any mention of the chain’s wider economic role in resource allocation or social welfare. In particular, there is no assumption that markets’ role in balancing supply and demand is assumed by the chain: or perhaps it is an extension of the “planning” task.

2.3. Supply chain evolution and integration

The progression of vertical chain arrangements, through increasing levels of intensity and scope of activities, has been chronicled by several authors. The path followed by recent supply chain evolution has been characterised as a shift in emphasis “from leanness to responsiveness and dynamism”, and “from management of capacity and constraints to customer satisfaction” (Hofman, 2004). For the food industry, change

⁷ Supply Chain Operations Reference Model, operated by the Supply Chain Council, an organisation with corporate membership.

has been eloquently described by Beierlein and Miller (2000) as an evolutionary process whereby inventory, transport, purchasing and manufacturing have been progressively merged, and decisions and activities allocated amongst collaborating firms across conventional boundaries. They identify the goal of supply chain management as “to replace inventory with information”.

The primacy of information is noted by Hanf and Dautzenberg (2006), and others. They attribute the growth of strictly co-ordinated vertical linkages in the food supply chain to the increasing importance of credence attributes in the products on offer to consumers. Although Hennessy (1996) identifies vertical integration in agribusiness as a response to high costs of generating and sharing information, Kaplinsky and Morris (2000) observe a shift away from vertical integration toward “co-ordinated units, many of which are externally-owned”, or outsourcing as identified by Gunasekaran *et al.* (2001). This suggests that firms are finding new ways of dealing with information within the chain that are cheaper and/or generate more value, than when they are internalised by vertical integration. Maxwell and Slater (2003) emphasise the central role played by information generation and exchange in modern food policy: enabling so-called self-regulation and the move to outcome-driven, rather than action-driven, regulation and compliance. It is notable that none of these authors have examined the role of intellectual property, and its associated costs or restrictions imposed on information flows, on chain structure, function or performance.

Noting that information exchange is central to supply chain concepts and practice, Clark *et al.* (2001) identify seven “levels of organisational interconnectivity” associated with increasingly intense within-chain exchange of information using electronic media. They identified limits to integration, including the sensitivity of information: that concerning costs, margins and impending product introductions is not shared within the chain. Notably, Fawcett and Magnan (2001) identify the lack of information sharing as a key constraint on supply chain integration, but do not consider it an essential factor in successful integration. A further constraint identified by Clark *et al.* was the high cost of executive time required to cement relationships based on trust: particularly where there were high risks of defection by partners. Overall, Clark *et al.* propose a concave monotonic relationship between benefits generated and the intensity of firms’ interconnectivity: the marginal benefits of initial levels are high but decline with advances to successive levels.

Shen (2005) portrays “arcs of integration” that measure the form (outward and inward vis-à-vis the firm, backward and forward in the chain) and degree of co-ordination be-

tween firms. Although Shen found the degree of firms’ integration to be positively associated with their performance, the principal mechanism of benefit delivery was the reduction of uncertainty due to better demand and supply forecasting along the chain. Fawcett’s and Magnan’s (2001) survey of firms’ motivation for joining supply chains identified a focus on customer needs (mainly retailers) and a desire to reduce costs (mainly manufacturers and service suppliers). They identified “human nature” as the fundamental barrier to supply chain integration: specifically a lack of perceived need for change, and the associated organisational inertia.

Schulze *et al.* (2006) studied the factors affecting farmers’ willingness to join a particular supply chain. Echoing the findings of earlier research into incentives related to farmer participation in co-operatives (Hansen *et al.*, 2002), they found that farmers place a high value on impressions of inclusion and consultation. Schulze *et al.* measure the strength of relationships in terms of trust, satisfaction and commitment, and use principal components analysis to derive a single measure of “relationship quality”. Scramin and Batalha (2003) use a systems dynamics modelling approach to grid-search a set of possible relationships between dairy farms and dairy processors. For each possible relationship, costs and benefits are derived from specifications of key performance variables defined by all members of the chain. Decisions about entry to a specific supply chain were successfully mimicked, and were chiefly dependent on both the size of the net benefits and their allocation within the supply chain. Selected commentary on the motivation for observed increasing supply chain integration is summarised in table 1.

Table 1. Selected observations on supply chain evolution

Author: issue	Explanation
Gunasekaran <i>et al.</i> (2001): factors contributing to the emergence of supply chains	<ul style="list-style-type: none"> • change within organisations; • increased responsiveness to changed customer requirements; • increased emphasis on “leanness”; • globalisation; and • increased use of outsourcing.
Gray and Boehlje (2006): firms’ objectives in employing “more tightly-aligned supply chains”	<ul style="list-style-type: none"> • efficiency; • synergies from inter-firm pooling of resources; • responsiveness to customers; and • risk sharing
Lohman <i>et al.</i> (2004): main reasons for firms to increase co-operation with other firms in the chain.	<ul style="list-style-type: none"> • shortening of delivery times; • enhancing flexibility; and • enabling faster introduction of new products.

It is notable that much of the motivation for supply chain operation, and increased intensity of linkages between firms, is internal to the firm. Secondly, firms' stated purposes of supply chain integration (e.g. "efficiency") may be met in other ways. A third comment is that it is not clear how "flexibility" is necessarily enhanced by tightened vertical linkages to other firms.

2.4. Supply chain management

Supply chain management has been variously, and generally poorly, defined as the introduction of management principles to the integration of supply chain activities amongst chain stakeholders. Examples of definitions include:

- "the processes from the initial raw material to the ultimate consumption of the finished product linking across supplier user companies" (Lummus and Vokurka, 1999);
- "the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders" (Lambert *et al.*, 1998);
- "a network of firms interacting to deliver a product or service to the end customers" (Ellram, 1991); and
- "the collaborative effort of multiple channel members to design, implement, and manage seamless value-added processes to meet the real needs of the end customer. The development and integration of people and technological resources as well as the coordinated management of materials, information, and financial flows underlie successful supply chain integration" (Fawcett and Magnan, 2001).

Fawcett and Magnan (2001) identify a "supply chain management philosophy" which they refer to as "collaborative competition", or "competing as allied teams of companies". More generally, the purpose of supply chain management is the realisation of the strategic objectives of the chain (Hanf and Dautzenberg, 2006). Unlike the objectives of firms, however, those of chains can be derived only from collective strategies: those developed jointly by the chain stakeholders (Van der Vorst, 2005), and ignoring social concerns. In a purely commercial context, Hanf and Dautzenberg assign the implementation of strategy to a chain captain, notably as two main tasks:

- cooperation (resolving conflicts of interest that may cause motivational problems); and

- coordination (aligning the actions of firms in the absence of information about the nature of their interdependence).

Hvolby *et al.* (2001) liken supply chain management to the handling of complex systems, embodied in two approaches that are often combined. The first is the reduction of complexity. Kaplinsky and Morris (2000) offer several examples of this: operationally, firms reduce their numbers of suppliers by using key suppliers that in turn source raw material from sub-suppliers (see also le Clue, 2006); and strategically, firms identify and pursue certain “critical success factors” or thresholds of quality or performance that are easily recognisable to supply chain partners. In contrast, Shen (2005) finds complexity to be a minor motivation for supply chain management actions. In a review of case studies of manufacturers’ supply chain management, he identifies 5 “paradoxes of complexity” (see table 2).

Table 2. Shen’s paradoxes of complexity in supply chain management

Acknowledged setting	Observed behaviour
The potential gain from supply chain optimisation	Most manufacturers “act locally” (i.e. optimise within their own boundaries)
The need for consumer responsiveness	Many manufacturers are not in touch with consumers directly
Product innovation continues to accelerate,	Few manufacturers have prepared their supply chains for faster introduction of new products
Flexibility is an important goal of supply chain operations	Flexibility is being sacrificed in favour of reducing unit costs
Quality is critical	The risks of supply chain failures in quality provision continue to grow

Source: Shen (2005).

Another means of exercising co-ordination, while generally avoiding complexity, is through “power”. Kaplinsky and Morris (2000) describe the exercise of power within the chain in two forms: ensuring consequences of actions along the chain; and actively managing and co-ordinating links in the chain. The first of these supplants traditional commercial legal instruments, such as contracts. By recognising whole-chain impacts of non-performance, however, externalities generated from 1-on-1 transactions can be internalised – at least within the chain. It is clear, however, that the firm exercising the power (the chain captain) will define potential externalities in its own interests, and assign costs of internalisation in a self-interested manner.

The second of Hvolby *et al.*'s approaches is enhancing information processing capacity, perhaps embodied in investment in hardware and software as well as communication systems. Despite Rockart *et al.*'s (1996) identification of Information Technologies as a driver of vertical alignment of supply chains, Shen⁸ found widespread disappointment in IT: despite substantial investments, additional value added had not lived up to expectations. Shen suggests that IT requires accompanying systematic changes that the firms had failed to make. He does not investigate whether supply chain membership enhanced or constrained the capacity for such change. A further question is whether information, and its processing, can perform a useful role without advances in performance definition and measurement.

⁸ (2005, reporting on 25 case studies of firms in supply chains).

3. Supply chain performance

3.1. Performance

At its most basic, supply chain performance is the extent to which a set of supply chain arrangements satisfy or achieve objectives. Van der Vorst (2005) emphasises that the objectives in question must reflect the requirements of end-users and stakeholders. He then states that performance measures are meaningful only where all stages of the chain aim to realise the same, jointly-defined, objective. No candidate objective is offered. Lohman *et al.* (2004) divides firms' objectives into "operations" and "strategy", from each of which a set of goals might be derived and the supply chain's capacity to achieve them assessed. As noted above, a problem immediately emerges, in that although objectives might be clearly expressed for individual firms within a chain, this is rarely the case for an entire chain. Individual chains might operate purely to deliver a specific outcome: but this would normally be subsidiary to objectives of firms within the chain.

Beamon and Chen (2001) more clearly define the kinds of actions associated with each of operational (e.g. changing order or inventory techniques) and strategic (e.g. elimination of a stage in the chain, integration of information systems with a supply chain partner) decisions. Beamon (1999) addresses the use of strategic goals as benchmarks in performance measurement: this depends on how strategic goals are expressed within the firm and throughout the chain. Where such goals are familiar to employees they may feature in the set of variables being regularly measured and so be compatible with management that seeks to achieve these goals. On the other hand, strategic goals are often not clearly defined. An example given by Beamon is "improve product quality": pursuit of this goal spans product and services, is likely to involve several technical tasks, and relies heavily on tight relationships in the supply chain.

McDermott *et al.* (2004) examined possible divergence between chain-level and firm-level preferences for supply chain performance measures. They surveyed beef suppliers and processors to identify common or divergent requirements for supply chain performance measures that might be attributed to firm-level, as opposed to chain-level objectives. Beef producers measured supply chain performance in terms of price received, payment security and the premia offered for quality. Their trading partners (beef processors) measured it as security in terms of timing of supply, traceability and overall costs of supply. Such a divergence is all the more notable in that it is detected

for just two supply chain participants, and does not address social, environmental and sustainability issues.

Recognising such divergences, Lambert and Pohlen (2001) propose performance-based measures associated with clearly-stated functions of the chain (table 3), namely:

1. aligning processes across firms;
2. targeting the most profitable market segments; and
3. obtaining a competitive advantage through differentiated services and lower costs.

Table 3. Motivation for supply chain metrics

- The lack of measures spanning the entire supply chain
- The requirement to take a chain-wide approach
- The requirement to relate chain performance to corporate performance
- The complexity of supply chain management
- The requirement to align activities to supply chain objectives and strategy
- To extend the "line of sight" beyond the single firm
- Allocation of benefits and costs as conditions in the supply chain change
- The need to differentiate the supply chain for commercial purposes
- To encourage co-operative behaviour in the chain

Source: Lambert and Pohlen (2001).

Lambert and Pohlen note that, in the absence of good metrics, "decision-making becomes an exercise in power and/or politics". Simons *et al.* (2003) summarise a supply chain management case in the British red meat industry, where the tasks of reducing risk and uncertainty and fostering value creation had been supplanted by "power balances within the chain" and "resulting adversarial trading relationships". Supply chain tasks addressed included promotions (to reduce demand fluctuations) and production planning (similarly for supply). The authors describe a stakeholder consultation exercise, which included problem definitions and development of key information transmission mechanisms. One chain performance measure used was the proportion of lamb carcasses achieving a specified grade. This provoked several questions from the researchers: first, whether carcass grades (primarily a processor creation with historical roots) actually reflect quality as perceived by the consumer. A second question concerned measurement: it was not clear that the chain was not producing sub-grade carcasses; as the alternative was that such carcasses were entering other supply chains and continued to represent lost potential income to producers that are still chain members.

3.2. Criteria for supply chain performance

Some agreement is found in the definition of criteria for supply chain performance, at least as applied by single firms. SCOR identifies five main criteria, and these have been widely adopted in the literature:

- delivery reliability;
- responsiveness;
- flexibility;
- cost; and
- asset management efficiency.

Beamon (1998) simplifies this list to include “resources” (including financial), “output” and “flexibility”, and devotes considerable effort to define and quantify flexibility. Caplice and Sheffi (1995) favour performance criteria that are transaction-based (i.e. dealing with variable, rather than fixed, costs), and that are focused on the downstream stages (i.e. those that address the customer’s needs). Although much emphasis is placed on vertical relationships, these authors identify the danger of neglecting “horizontal” issues: if criteria are insufficiently targeted at variables at an individual stage of the chain, then problems may simply be shifted around between stages, rather than solved.

Such sets of diverse criteria reflect the multi-dimensional nature of supply chain performance. Even if chain objectives can be stated and the chains’ satisfaction of them measured, a single numeraire has not been established to rationalise performance measures. The existence of both qualitative and quantitative performance indicators is widely acknowledged, but few ideas have emerged about how to utilise them in a systematic way. Several authors have proposed balanced scorecards (e.g. Van der Vorst, 2005), but have not enlarged on how they might be designed or managed. Lohman *et al.* (2004) report on a case study of a supply chain for sports shoes, which used a balanced scorecard. These authors’ focus was on the process of developing performance measures that stakeholders will use, rather than the measures themselves. They advocate, for example, that the development process should ideally entail co-ordination of existing activities rather than design (or radical introduction) of new ones. Performance measures were assessed as % satisfaction of desirable levels (or trajectories) of variables defined into six clusters (customer service, financial performance, product flow, process improvement, employee satisfaction and environmental sustainability). A variety of weightings could be entered into a user interface resembling a car’s dashboard and control console.

Bailey and Norina (2005) adopt an alternative approach, also based on normalised measures of the satisfaction of supply chain stakeholders. In particular, expectations fully met by grain mills and traders are assigned 1 on an interval [0,1]. Other, identical, scales are used to reflect different dimensions of satisfaction. An overall satisfaction level is derived by assigning weights to the scales. Those metrics allow four insights to the performance of the chain. First, poorly-performing stages of the chain could be identified, with a focus on supply chain financial and material flows. Second, the timing of sequential performance could be identified (season-by-season, in the case of grain) and improvement or deterioration identified. Thirdly, interactions between supply chain problems with payment and with delivery could be identified to explain volumetric fluctuations in the chain over time, and the impact these have on stakeholder satisfaction. Lastly, different chains can be compared.

3.3. Performance of, and performance in, the supply chain

It is widely acknowledged that supply chain management lacks unambiguous measures of chain performance. Lee and Billington (1992) and Aramyan *et al.* (2005) both observe that the “chain information” that firms employ within supply chains is primarily internal to the firm or at best features just those firms immediately proximate in the supply chain. Firms have then focused on their “performance in a supply chain”, rather than “the performance of the supply chain”. In their study of the Dutch tomato chain, Aramyan *et al.* defined performance measures (largely following across Beamon) across 4 categories: efficiency; flexibility; responsiveness; and quality (subdivided into product and process quality) which firms then rated for importance *and* reported whether or not they measured them. The result was that firms rated as important and/or measured only those variables that affected firm performance, not chain performance.

In Taylor and Simons’ (2004) study of the UK pork supply chain, customer value at several points in the chain was identified (price, quality and taste, availability, waste, safety) by survey, and “key performance indicators” were adapted from available numbers (no new variables or metrics were developed). Five different supply chains were then evaluated. The evaluation was not for an overall score for each chain, but for the extent to which specific initiatives by/within each chain were able to contribute to improvements in the key performance indicators. Thus, the result ranked chains for their effectiveness in making changes, with results reflecting chain performance.

Van der Vorst (2000) examine a Dutch supply chain delivering chilled salads. Eight performance measures were used: 3 cost-based (inventory, processing and logistics, and wastes/price reductions) and 5 service-based (product range, number of stock-outs, utilisation of transport, freshness and delivery reliability). These span most of Aramyan's categories. Van der Vorst found that three management changes in the chain improved chain performance as measured: increased ordering and delivery frequency; reduced producers' lead times and introduction of new IT systems. As with Baker's (2007) model, that research was highly focused on financial performance within the chain, and does not address the social values that might be placed on products and processes, and used as metrics.

Jackson *et al.* (2006) motivate discussion of the performance of the food supply chain by identifying two key emotive issues in peoples' perceptions of food, namely its provenance and its authenticity. These authors present several policy and marketing initiatives that promote locally-produced food, and food products that are produced using methods that are perceived as environmentally and socially⁹ sustainable. A performance metric they describe is "Food Miles", which is essentially a measure of fossil fuel used in the production, processing, delivery, purchasing (including consumers driving to and from shops) and disposal of food products. The energy used in production and disposal of inputs and packaging is also considered. Controversy over "Food Miles" has focused more on its unexpected indications than on its validity as an indicator of resource use: notably that chains using imports from low-input exporting countries can accumulate fewer food miles than high-input local producers (Saunders *et al.*, 2006).

Following the theme of specified impacts, Life Cycle Analysis (LCA)¹⁰ maintains multi-dimensional performance measures (e.g. human health, environmental quality) that can be related to various parameters¹¹ (per area of land, volume of water, weight of product, unit of energy). From a policy perspective this allows rankings of chains across a range of potential stakeholder concerns. However, LCA has primarily been targeted at agricultural production systems in their entirety, rather than the whole chain or indeed individual chains (Foster *et al.*, 2006). Similarly, certification based on minimum levels of environmentally-related activities have been employed in designing "Good Agricultural Practice" regimes (GAPs).

⁹ In the sense of maintaining or nurturing the rural communities in which the production occurs.

¹⁰ Thanks are due to Jørgen Dejgård Jensen for this insight during a review of the paper.

¹¹ Haas *et al.* (2000) refer to these as "functional units".

Foster *et al.* (2006) carried out LCA on food supply chains in Britain, notably addressing “trolleys” (actual consumption bundles) and measuring their life cycle environmental impacts on energy use and associated global warming indicators, land use, water and eutrophication, and selected pollution measures. Their results include some reversals of conventional wisdom, such as identifying some environmental challenges associated more with organic, than with conventional, production systems; and identifying car-based shopping as a greater environmental impact than transport within the chain. They observe that many of their results are sensitive to assumptions, particularly about waste levels and methods of its disposal or recycling. The authors identify many missing elements for such an application of LCA, notably primary data with which to compare individual supply chains.

3.4. Issues of metrics

Beamon (1999) identifies four key questions associated with a performance measurement system:

1. what to measure;
2. how to integrate multiple measures into a system;
3. how often to measure;
4. how to make changes to the measurement system.

Caplice and Sheffi (1994) list eight criteria for metrics in supply chain management and performance measurement (see table 4). Essentially these reflect compatibility with management and technical tasks going on within single firms, and they probably apply less well to the chain as a whole than to firms. The final four criteria are of particular interest. The benefit/cost ratio of data collection and use (“economy” in table 3.1) and compatibility with existing data systems echo Lohman *et al.* (2004) in that changes to bring about chain performance measurement must be evolutionary rather than revolutionary. Addressing Beamon’s fourth question, the requirement for “behavioural soundness” is obviously easier to achieve within a firm than along an entire chain: indeed its application requires a positive-sum return on chain integration.

Table 4. Criteria for metrics

Criterion	Explanation
Validity	The metric accurately represents what is being measured
Robustness	The metric is comparable across users, time and location. The metric is repeatable
Usefulness	The metric is understood by the decision-maker and is capable of guiding actions
Integration	The metric includes all relevant aspects of a process of interest
Economy	Benefits of using the metric exceed the costs of collecting and processing it
Compatibility	The metric is compatible with existing information systems
Level of detail	The level of aggregation is sufficient for the user
Behavioural soundness	The incentives for strategic responses by agents is minimised

Source: Caplice and Sheffi (1994).

In contrast, Gunasekaran *et al.* (2001) elaborate supply chain performance metrics over 6 key performance topics, with much more attention to relationships across conventional boundaries of the firm (see table 5). They address many of the practical issues associated with Hofman's hierarchy, particularly supply and demand forecasting throughout the chain. In addition, "supply chain partnerships" are targeted, recognising that the relationships between firms are key to the successful operation of the chain. Gunasekaran *et al.* elaborate on measurement of "extent or depth of partnership": first, measuring the extent to which chain partners are involved in problem solving or examination of alternatives; and second, using that measure as a performance metric. Measures of "relationship quality" differ from those used by Schulze *et al.* (2006), but represent two different approaches to the same problem. Although the final topic addresses inventory (as an asset), "delivery links" also contain elements relevant to inventory in terms of how it is handled across firm boundaries. Notably inventory "scrapped", "obsolete" and "re-worked" receives consideration as recommended by Beamon.

Table 5. Selected supply chain performance metrics

Topic	Metric
Planned orders	Order lead times Path of order traverse
Supply chain partnerships	Checklist on performance of partners Extent or depth of partnership
Production level	Cost, physical productivity Range of products and services Capacity utilisation Effectiveness of scheduling Human resource productivity Inventory levels
Delivery links	Delivery-to-request date Delivery-to-commit date Order fill lead time % of goods in transit % of "faultless notes" Total distribution costs
Customer satisfaction and service	Time between customer query and information delivery Level of after-sales service relative to customer expectations Availability of spares
Supply chain finance and logistics <i>of which, inventory costs:</i>	Return on Assets and Return on Investment associated with the supply chain opportunity cost of warehousing, storage and tied-up capital and costs of work-in-progress management and insurance of stock goods in transit steps taken against risk of threat, damage, spoilage worked scrapped, re-worked or obsolete lost sales due to inadequate inventory

Source: Gunasekaran *et al.* (2001).

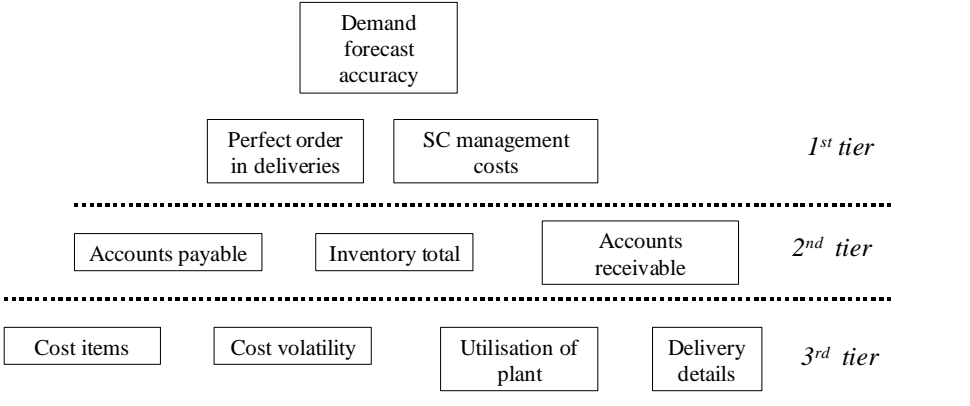
Beamon and Chen (2001) discuss the use of single performance measures, which have the advantage of simplicity. Given the difficulties in combining measures, single measures may well ignore others of equal value but which contain other information. Where a single measure involves costs, these authors emphasise the importance of addressing inventory correctly. Beamon and Chen's chief concern is that inventory features obsolescence and degradation (particularly in the food industry), which are difficult to account for in single measures (Foster *et al.*, (2006) make the same claim for multiple measures). From the point of view of the whole chain, Lambert and Pohlen (2001) further point out that inventory steadily increases in value as it moves through the supply chain, so technical improvements (such as increasing inventory turnover) have different values when brought about by different members of the chain. Particularly in the agri-food sector, costs of accumulating and managing inven-

tory also vary up and down the chain. Periera and Csillag (2004) note that Brazilian chicken meat supply chains achieved substantial improvements in handling of inventory, which was born out in increased profits to chain participants and could be measured in chain-relevant metrics. However, much of the improvement appears to have been due to vertical integration rather than co-ordination within an integrated chain.

Banamyong (2005) uses inventory-related performance metrics to examine the international supply chain that imports shrimp into the United States. She uses the length of the cash-to-cash cycle,¹² and identifies extreme divergence in supply chain performance, depending on which stage is being studied. Importers have a negative cash-to-cash measure (i.e. they sell the shrimp before paying for them), while retailers, producers and traders have quite different (but positive) values. A notable feature of that research is that chain participants’ satisfaction with the chain is not measured.

Hofman (2004) proposes a 3-tier hierarchy of supply chain performance metrics. The primacy she affords demand forecasting is supported by numerous authors in the pursuit of reducing uncertainty. Beamon and Chen (2001) provide the best description of how differing levels of variance in volumes up and down the chain (Lee *et al.*’s “bullwhip effect”) can arise from poor demand and supply forecasting. A notable feature of Hofman’s (figure 2) hierarchy is that inventory-related metrics appear in tier 2.

Figure 2. A hierarchy of supply chain metrics



¹² Accounts receivable minus inventory turnover minus accounts payable.

4. Government in the supply chain

4.1. Government's position relative to the food supply chain

The position, role and stake of government in the modern agri-food supply chain have not previously been identified. Government may be one or more of:

- a member of the supply chain;
- a provider of infrastructure;
- a provider of services; and/or
- a policeman.

Where government acts as a guardian of the public interest (de Gorter and Swinnen, 1994) it might be viewed as “exogenous to the food system” (Henson *et al.*, 1995). Another interpretation is that the government is a contributor to the social production of the food chain: essential to society's supply of public (or other) goods subject to various forms of market failure. In delivery of services outside the spectrum of the food industry, government becomes a member of the food supply chain in cases of state agencies' market participation (e.g. food provision in hospitals, schools and prisons). In government action within the food supply chain, it is unclear whether government can or should operate as a chain captain. Government that remains external to the supply chain might be perceived as the appropriate standpoint for work in compliance monitoring and enforcement (loosely described as “policing” above).

Governments may be the providers of infrastructure for the food supply chain: both “hard” (e.g. roading and communications networks) and “soft” (e.g. the legal framework for enforcement of contracts). In seeking to explain international trade flows, Hausman *et al.* (2005) noted the significant international differences in the quality and costs of logistics services, including port transit, transport and inspections. They attributed trade flows to cost amalgams made of delay times, reliability of service, complexity of procedures, and risks. The result is in agreement with Hummels (2001) who used an index of time delays and found trade flows to be related to countries' transaction procedures, measured as an index of “institutional quality”. Hausman also uses a “logistics index”, similar to Pyke's (2005) use of “total landed cost” as a compound measure of logistics and services.

Government provision of services might be motivated by arguments about under-provision due to market failure (Henson *et al.*, 1995), but might also be associated with society's trust of government, rather than firms within the supply chain, to pro-

vide services such as accurate product information to consumers (Hobbs, 2003) or market information to market participants (Hayami and Petersen, 1972). Markets' role as information providers (specifically on prices, volumes and price-quality linkages) enables government monitoring of markets for regulatory purposes, when acting as a "policeman" as above. The extent to which government can monitor these variables where they are internalised within chains is not clear.

4.2. A "government" food supply chain

Another view of government is as a parallel supply chain. Two highly-visible examples of government ownership and management of a food supply chain are emergency relief and military support operations. Davidson (2006) offers a review of supply chain management in emergency relief. She identifies three major differences between this context and the private sector. First, that the private sector's supply chains exist before the customer is served, while relief operations are created and dismantled *ad hoc*. Second, while every disaster is different, firms stay largely the same and tend to address similar sets of customers. Third, private supply chain operations are continuous, and feature feedbacks that enable the use of contemporaneously-collected information. Conversely, disasters are episodic and information from one event tends to be used in the next, rather than the current, relief operation. Davidson lists features of humanitarian organisations and their activities that create difficulties in performance measurement (Table 6). These problem areas are notable for their similarity to those applying in the private sector.

Table 6. Factors limiting performance definition and measurement in humanitarian organisations

- Lack of centrally-captured data
- Limited IT infrastructure
- Lack of funding for IT infrastructure
- Variable/chaotic environment surrounding disaster events
- External factors (often specific to localities)
- Lack of incentives for measurement due to organisations' being not-for-profit
- Potential for negative media exposure/interpretation of results
- Human resource issues
- Inappropriate organisational culture
- Conflicts between short and long term goals of a disaster response.

Source: Davidson (2006).

4.3. Social responsibility in the food supply chain

Several authors have identified firms' pursuit of "the triple bottom line" (Profit, People, Planet) as evidence of their commitment to society and environment in addition to shareholder returns. Van der Vorst (2005) observes "value now includes the triple P", and proposes that supply chains are effective vehicles for delivering it. Pierick *et al.* (2004) outline principles of corporate social responsibility, as well as processes that firms use to implement it.¹³ ASrIA. (2006) provides an overview of initiatives taken in selected supply chains in Asia, but does not outline a role for government.

Cramer (2005) reports on a survey of multinational firms that sought to impose corporate social responsibility throughout their supply chains. Firms reported that the first step in doing so was identifying the supply chain, and that this was easier for firms serving niche markets than "mainstream" markets. Subsequent steps involved formulating and imposing standards on suppliers, which was again easier in differentiated markets. Cramer also concluded that agri-food supply chains are easier to identify and standardise than industry-based ones, due to ease of tracing back to the raw material.¹⁴ Third party certification services play a significant role in Cramer's sample of firms, particularly in differentiated product delivery. However, the causality is not clear, in that differentiation may indeed be enabled by certification, rather than inviting it as an improvement in supply chain management.

Le Clue (2006) reports on risks of poor social and environmental conduct in supply chains by Asian firms. The main risks are identified as labour and environmental practices, the latter involving the exploitation of displaced farmers as a consequence of changing land use. Like Cramer, Le Clue discovered widespread use of certification services, and notably identified a government programme in China that offered financial rewards to those reporting breaches of labour laws.

4.4. Market failure

Conventionally, market failure addresses a market outcome in comparison with a projected socially-efficient outcome. The advent of the food supply chain introduces a third outcome. No theoretical construction provides guidance as to whether the supply chain outcome is necessarily a greater, or a reduced, divergence from the socially ef-

¹³ e.g. environmental assessment; stakeholder management and consultation; and issues management.

¹⁴ This statement might be debated by food industry commentators.

efficient outcome. Moreover, measures of supply chain performance are currently not targeted at social performance, so provide little guidance to policy makers. Several authors have identified market failures with the vertical array of firms involved in the supply chain. These address transactions costs, public goods and externalities.

Transactions costs that are high, or asymmetric between adjacent firms, have been identified as one such market failure (Hobbs, 1996), affecting both the firms' traded volumes and the willingness to trade in/enter the supply chain. Producer organisations have been widely proposed as a means of reducing transactions costs, perhaps in pursuit of symmetry in scale-related costs and bargaining power between chain stages (Pingali *et al.*, 2005), but such analysis has not been applied to transaction costs between stages.

The presence of public goods within the chain has been addressed in terms of generic promotions (Crespi, 2003) whereby all members benefit from such promotions but no single firm or coalition of firms at a stage has the incentive to provide such promotions. Where there exists a demand for product information, the market failure argument is usually mobilised to justify government involvement in provision and administration of food standards (Gardner, 2003). For standards, and other product differentiation mechanisms, administration of certification systems by a third party may involve government particularly in multi-purpose programmes or those targeted at consumers' peace of mind, such as traceability (e.g. British Food Standards Authority, 2002). However, government action in information provision and certification may be preferred by consumers due to mistrust of the vested interest of private firms (Hobbs, 2003), or consumers' unwillingness to pay for it (Latvala and Kola, 2000).

Clearly, many of these market failures might be corrected by vertical co-ordination, as in the case of co-ordination between farmers and powerful retailers being shown to reduce transactions costs for the small farmer and encourage entry into the chain (Reardon and Berdegué, 2002; Reardon and Swinnen, 2004). Strongly integrated supply chains would, at least in theory, internalise issues associated with promotions, information management and transactions costs. However, they may exacerbate non-market impacts on stakeholders outside the integrated chain, as described above regarding the environment, rural communities and broader issues of sustainability.

So-called "vertical externalities" also extend to imperfect competition, particularly the issues of double marginalisation that arise where two or more imperfectly competitive markets are adjacent with the chain. Vettas (2006) first concludes that, under several

conditions, double marginalisation drives the market outcome even further from the perfectly competitive outcome than does a single monopoly or monopsony stage. Second, he demonstrates that vertical integration offsets these effects, even if it involves reversion to a single monopoly or monopsony outcome. The extent to which double marginalisation may be offset by vertical co-ordination or other chain integration steps is unknown. In particular, the impact of chain captaincy on monopoly-type outcomes has not been examined.

5. Discussion and conclusions

5.1. Social performance of the food supply chain

The modern food supply chain is poorly defined, beyond its essential functions of product delivery and essential vertically co-ordinated form. It is not clear whether the chain is a collection of firms or is actually a new economic entity: value addition and asset ownership accrues to chain members, but decision-making within chains can be assigned to one agent. Balancing of supply and demand is a key function of markets and of supply chains, but takes very different forms in each. Competition between supply chains has not been compared with that between firms for its impact on cost minimisation and subsequent long run industrial adjustments. Nonetheless, supply chains are assuming the roles played by markets in resource allocation in the farming and food system. Their tasks have been described in terms of activities (“plan, source, make, deliver, return”), and extended on to embrace innovation. Supply chains’ social roles have not been identified. The definition and measurement of performance, and the policies and policy processes within which such performance might be optimised, have not been addressed.

Much commentary on supply chains and their management focuses on information. Although provision of information within the chain is promoted in pursuit of some chain outcomes (e.g. delivery of credence attributes), it is also seen by some as a constraint on chain integration. In particular, commercial secrecy prevails, which indicates that the much-vaunted “trust” element across the inter-firm boundaries in the supply chain is a scarce resource. Moreover, intellectual property held by stakeholders within chains is likely to affect information exchange. Prevailing food industry policy relies heavily on the transparency of markets, particularly their generation of observable prices, patterns of firm-level profit and investment, and clear boundaries of ownership of products and assets. The ongoing integration of the food supply chain erodes this policy-enabling database and the associated set of performance measures.

Just as markets ignore many non-traded items, so does the supply chain in terms of the environment and sustainability, community preservation and development, and other social tasks that society assigns to agriculture and the food industry. Little consideration has been given to whether these market failures are the same as, or different from, those generated by markets. Policies that seek to correct market failures, particularly by distorting markets so as to mimic socially efficient outcomes, may

have rather different effects when applied to chains. Exclusive dealing arrangements provide one example: policies designed to prevent monopoly/monopsony outcomes may undermine the tightly-integrated trading arrangements required in chains. Government inspection services in the meat sector provide another: advanced meat supply chains feature elaborate performance measures and intensive auditing at many points in the chain; duplication of these by government is unlikely to improve food safety performance but will add the costs of duplication to processing firms, who will then pass the costs on as reduced benefits throughout the chain.

One taxonomy of market failures within chains provides for problems of (i) co-ordination and (ii) co-operation (Hanf and Dautzenburg, 2006). A strong argument may be made that chain mechanisms provide better means of managing these two problems than are available from conventional markets or from vertical integration. However, a social perspective is that co-ordination and co-operation extend only to selected stakeholders, and not to society at large. Because these tasks tend to be assumed by “chain captains”, rather than any quorum of chain stakeholders, there seems little reason to believe that co-ordination and co-operation mechanisms are automatically socially optimal. Indeed, a study of “fairness” of chain transaction arrangements uncovered widespread dissatisfaction amongst chain participants (Duffy *et al.*, 2003). Weighting of social chain performance measures would then be appropriate to reflect participants’ interests, because policy is necessarily concerned with fairness.

Although chains are inclusive by design, their defining features are exclusivity in the pursuit of product differentiation and exclusion of non-performing participants and products. Substantial research attention is being paid to the plight of food industry participants (particularly small farmers) that are excluded from supply chains, but little effort has been applied to flows, particularly of product, that are excluded due to quality, scheduling or other problems. In the case presented by Simons *et al.* (2003), excellence in compliance to quality standards may have masked the fact that sub-standard product was flowing to other markets or along other chains. Although supply chains embrace the task of “return” (see above), waste product and used packaging may well exit the chain in question and impose negative externalities elsewhere. To measure the true performance of the chain, a holistic and inclusive approach is therefore needed. Notably, aggregate market indicators (averages of grades or prices achieved) will mask divergences between the chain and the residual product flows.

Just as some flows are unaccounted for, so are some stocks. Despite well-described and explained patterns (or arcs) of increasing integration and the emergence of chain-

dominated commerce, assets remain in the ownership of firms. Assets that primarily belong to chains, particularly flows and stocks of information, remain without value and so potentially subject to underprovision. Several researchers have pointed out the net-chain nature of modern food system, and the multiplicity of uses that assets at one point in the chain may have. This feature has been used in valuation of assets, but values have been shown to diverge between their value to the firm on one hand, and to the chain on the other (Baker, 2007). Moreover, firms may belong to more than one chain, each to serve a specific purpose, so that firms' assets are not attributable to single chains. Aside from social considerations, accounting valuation methods for chain assets have not yet emerged.

A major focus of supply chain management "resource" and "asset" issues is inventory. Inventory clearly increases in value as it proceeds along the supply chain, so logistics-related manipulation of inventory levels yields a different return at each point in the chain. The likely outcome is that inventory accumulates at the earliest possible point in the chain: food industry examples might include live animals left on farms and crops left standing or in farm storage. The continued presence of the products on the farms is likely to generate costs that are not compensated for in the chain: lost pasture production and/or reduced animal productivity; loss of alternative sales or storage opportunities; added risks at the farm level; and the cost of capital tied up in unsold production. A second effect is that spoilage and obsolescence (represented in livestock or weight and conditions divergence from targets) is poorly measured and compensated for in the chain. A third effect is the likely environmental externalities of degradation of soil, pasture, water, air and landscape. Lastly, the lowered value of inventory at farm level reduces incentives within the chain to provide information and preserve quality, which together are significant drivers of supply chain development.

Against this background of difficulties in agent identification, valuation and data generation, a large number of researchers have proposed supply chain performance measures for the private sector. These are primarily based on product and material delivery, system flexibility, and the return to particular resources. The overwhelming majority of such measures have targeted firms' performance in a chain setting, rather than the performance of the chain itself. A further problem is the multiplicity of possible variables of interest and the intractability of their synthesis into useable single metrics. There is agreement that satisfaction of agents' objectives is a strong basis for performance measures, and in this setting promising options are (i) balanced scorecards and (ii) indexing of objectives' satisfaction $[0,1]$ intervals with aggregation possible by assigning weights to variables. However, few metrics have been developed

that would indicate social performance of the food supply chain. “Food Miles”, “carbon footprints” and Life Cycle Analyses can embrace the entire chain and measure chain performance, but are essentially one-dimensional (associated with fossil fuel use). Such measures ignore value generated (and hence efficiency of use of the fossil fuels) and are difficult to combine with other performance indicators. More fundamentally, and as observed by Caplice and Sheffi (1994) these measures are not reflected in any chain participant’s objective set. The self-evidence of incentive-incompatibility is that governments, and not supply chains, pay for such analyses. The adoption by chains of GAP certification systems, and corporate responsibility programmes, may be a guide to suitable criteria for measures used internally.

To abstract from conflicting objectives, Davidson (2006) presents a case where objectives are simple to identify, and in which government assumes all or most supply chain functions and management: disaster relief operations. She points out that many of the difficulties of supply chain management, particularly the identification and use of metrics, are the same for government as for private firms. These entail the lack of appropriate performance criteria, lack of communication between parts of the chain, incentive-incompatibility in handling information, and poor metric definition and combination. A relevant fundamental metric would be “lives saved”, but this is rarely useful in comparing emergencies and does not address efficiency: more generally there is no counterfactual or base case upon which to base such metrics. She identifies candidates for performance measurement including delays in aid delivery and proportion of pledged aid delivered by donors. These capture the interests of the most vulnerable chain members and address payments by its most advantaged, respectively, but there is little scope for their combination. As in the private supply chain, Davidson emphasises flexibility and responsiveness as performance measures.

Chain flexibility and responsiveness (addressed in several papers by Beamon) targets magnitude of variance at several points in the chain. Social interest in this performance measure spans many issues. First, payment delays following delivery are key indicators of equity and efficiency problems. Second, socially important roles of the food supply chain such as animal disease control, responses to food contamination, and delivery to disaster-affected areas require these chain attributes. Beamon’s measures centre on capacity of a firm or chain to deliver while remaining profitable. A social orientation would require the specification of government roles and funding streams or services to support the firms in the chain.

Supply chain management has been usefully divided into “strategic” and “operational” tasks, with performance measures revealed as indicators of the extent to which objectives are met. Within the chain, strategies are difficult to discern and usually differ between agents on the chain. Establishment of government policy goals, strategies and implementation means are generally subject to rather more scrutiny, and are better publicised, than is the case for private firms. Because the “commodity chain concept” is well established in society’s expectations of the food industry and delivery system (Jackson *et al.*, 2006), the food supply chain is an appropriate focus for performance measures related to strategic policy objectives. Operational objectives for policy refer more to government actions in implementation: actions taken by government rather than by the chain.

5.2. Policy issues and responses

Focus of policy on the food supply chain requires definition of government’s relevance to specific supply chains and to the food industry in general. This will determine its objectives for the supply chain. As stated above, strategic objectives would be pursued rather than operational ones. Strategic objectives might target efficiency, equity, and the long term development of both.

Efficiency-targeting objectives for the food supply chain would, as is the case for a market-oriented food system, refer to allocative efficiency of resources based on economic values and sustainability. Chain activities that capture and promote protection or sustainable use of non-traded resources might be exempted any government intervention. Examples include chains involved in extracting resources (e.g. harvesting of forest products), production and marketing of low-fossil-fuel-intensive production, and production methods with low impact on soil, water and air quality (e.g. pastured livestock). Government roles would extend to monitoring and periodic audits, with certification and regular audits assigned to the chain or to third parties. The chain would fund such activities only if profitable by means of resource-related price premia. Access to that premium would then be rationed by access to the resource, creating a further policy problem: monopoly power. Rights of access, allocated by transferable quotas, offer one option. Such a system effectively operates in the EU as schemes for protected designation of origin (PDO), protected geographical indication (PGI) and traditional speciality guaranteed (TSG). Rationing of sustainable access to the resource is managed within each scheme. The schemes, however, contain many supply chains, so such a policy system would not refer necessarily to chains. Where PDO-type schemes were not appropriate (e.g. chains marketing low-input produc-

tion), trademark protection offers barriers to entry that are low enough to maintain competitive pressure on prices.

Power relationships in the supply chain have not yet been compared with imperfectly competitive conduct in markets in terms of distortion of socially-optimal outcomes and accumulation of excess profits by individual agents. Whereas efficient markets might be associated with many disparate and autonomous decision-makers in firms, efficient chains are frequently described in terms of chain captaincy and tasks such as co-ordination and co-operation that they perform.

Equity-targeting objectives would have a twin focus: first, on fairness within the chain; and second on the welfare and sustainability of sensitive communities. As pointed out above, fairness within the chain could not be addressed by monitoring of costs and prices because exchange between firms is subsumed into chain operation. Furthermore, most chain members face additional costs associated with value addition and product differentiation, so that available average market prices are poor indicators of profits at a given stage in the chain. True measures of fairness within the chain would target value added, and the shares accruing to each chain stage relative to (i) costs incurred; (ii) value generated; and (iii) risks endured. Alternatives to direct policing of margins include chain certification of fairness and transparency akin to that employed in first-to-third world trade schemes such as Fair Trade.¹⁵ In the presence of third-party certification of chains, the government role would revert to periodic audit.

The policy response regarding rural communities is difficult to project. Such communities' exclusion from integrated supply chains can, in theory, be countered by local marketing initiatives such as farmers' markets, "community agriculture" schemes or other short-chain options as outlined above by Lucas and Jones. Whether such options require or justify specific government interventions is debatable, but numerous regional/rural development instruments do so.¹⁶ Direct promotion of links to modern food supply chains has received much less policy attention, although these instruments target value-adding activities and marketing.

Ethical issues already receive substantial attention from interest groups and policy agencies. Animal welfare, for example, is subject to substantial regulation throughout

¹⁵ See Hayes (2006).

¹⁶ See Baker *et al.* (2007) for a discussion in the Danish context.

the chain. Rather than government policing (at each ownership change) of housing, veterinary care, transport, pre-slaughter and slaughter actions, a chain certification mechanism appears preferable. As another ethical issue, GMO certification is already common in many supply chains but operates alongside a government inspection scheme in the EU. As new ethical issues arise in the future, a certification approach allows a gradual introduction of control that might be varied in form, completeness and impact as facts emerge and/or social attitudes change.

Regulation that requires firms' compliance with high levels of investment, or high recurrent costs, has been seen as a contributing factor to food convergence. This is due to the perception that large and/or diverse firms can better afford such compliance costs than can small firms.¹⁷ Certification as a compliance measure offers the opportunity for chains, rather than firms, to negotiate with service providers. This involves firms of, potentially, all sizes and the payment form and mechanism may then suit the specific chain and product.

5.3. Commercial issues

Of primary concern to firms in supply chains, and particularly to chain captains, is the identification of social tasks required of the chain. New policy initiatives to influence chain outcomes will inevitably add costs to existing chain operations, but the more profound impact of a chain-oriented policy will be the dynamic effect of such policies on the future design and operation of chains.

Chain assets (and liabilities) currently remain within the balance sheets of chain members, rather than being owned by autonomous "chain" entities. This distorts investment incentives within the chain, due to the accumulation of risk with those owning the assets. Where policies target specific chain activities, they will inevitably address the owners of assets rather than members of a chain. This provides a destabilising influence on chains, as members may exit a chain that appears susceptible to policy-related costs, leaving the asset-owning chain member to face not only the policy-related costs, but also those associated with sub-optimal product volume and uncertainty in chain members' commitment.

Partnership with government in chain-related policy implementation will require substantial information sharing. In addition to reluctance on the part of firms to incur the

¹⁷ See Hamann and Baker (2004).

costs of generating such information, firms are unlikely to want to share potentially sensitive information with government. Indications of this are that information sharing within a chain is problematic, let alone with parties (such as government) beyond the chain. For this reason, Lohman *et al.* (2004) advocates that supply chain management systems must be adaptations of existing systems, rather than radical new sets of activities. Those authors particularly refer to the desirability of using existing information systems, rather than developing new ones. Issues of trust obviate the need to bound the government chain information requirement within that of the chain: no firm should be asked to provide chain information to government that has not already been shared with chain members.

The government as a chain participant, or as a provider of special services to chains, offers benefits to chains that are not available to firms operating in markets. Taking the example of the latter in the form of government-funded research and training programmes, serving a set of chains allows research and training to be much more focused on value addition. Chains, as the deliverers of that value, would be more amenable to providing trainees and research materials, and paying a share of costs, than are firms under current arrangements.

5.4. Further research

This study has identified the need for further research into the projected future role of government in the context of (i) the rapidly integrating food supply chain and (ii) the dominance of such chains in many countries. In particular, the position of government in, or in association with, the supply chain has not been defined.

The social performance of the modern food supply chain has not been defined. Research is necessary to identify existing definitions for the food industry and its associated markets, and evaluate their suitability for application to the modern food supply chain. Having defined performance, research is necessary to identify suitable measures of performance and practical metrics for their empirical application. Such metrics might address short-term issues of efficiency and equity, and also be extended to dynamic issues such as innovation and long term resource allocation.

Measurement of the commercial performance of the modern food supply chain is still in its early development. An issue raised by many researchers is the lack of value assigned to “chain assets”. Experience suggests that imaginative valuation mechanisms exist, for example the value of brands or trademarks associated with specific chains,

or the present discounted value of streams of value addition due to chain-specific attributes. However, further research is needed to ascertain the needs and means for such valuations, and the other implications of formal recognition of chains as a commercial entity.

A fundamental element missing from supply chain analysis is the identification of “chain objectives”, that are appropriate to be pursued by all chain members and the satisfaction of which can be measured. Separation of chain objectives from firm objectives would more clearly define the functions firms would want to assign to chains, and identification of government objectives that coincide with chain objectives would accelerate policy development.

This study has, in conclusion, identified a significant role for certification of supply chains’ activities. This has extended to policy objectives surrounding efficiency, equity, equity issues and social concerns. Research is needed to assess the application of existing schemes to an environment dominated by food supply chains, and to identify new forms of certification to replace outmoded policy practice elsewhere.

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