MEASURING PERFORMANCE OF AGRI-FOOD SUPPLY CHAINS

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ABSTRACT

During the past two decades Supply Chain Management (SCM) has become a popular topic of business discussions. SCM presents a business philosophy of improving the long-term performance of individual companies and the supply chain (SC) as a whole and, as a result, attains or sustains a company's competitive position. The practical implementation of SCM has a number of constraints. The basic problems facing SCM are difficulties in adopting a SCM philosophy, the lack of general theory, difficulties of system thinking, and the unique characteristics of agribusiness SCs.

Contemporary SCM theory is mainly descriptive and modern SCM research is predominately deductive. Research on SC performance measurement systems (PMSs) has not provided co-ordinated measurement of the bi-directional system flows (material, financial and informational). Available systems do not provide quantifiable measures for the network optimisation decision-making process.

In this study an alternative approach to SCM problem resolution was developed. The three SC flows were integrated through the evaluation of their normalised performance measurements (NPMs). The NPM system was developed based on the primary concept that the performance of each SC flow within a SC may be uniformly measured using comparable sets of characteristics. This primary concept was then used as a basis to evaluate higher levels of system performance such as two-party contractual performance and then the performance of the total SC. Special attention was paid to the strategic level of SC analysis and optimisation. The suggested methodology was used to demonstrate how performance improvement of the SC as a whole is interrelated to the performance improvement of individual companies.

Case evaluation of the proposed methodology allowed identification of the supply chain wave effect. This effect quantifies how the performance of one chain member affects the performance levels of other system participants. The application of game theory to the methodology indicated that a stable optimum SC strategy might be reached when business performances are balanced along the chain. The case study suggested that chain participants tend to move toward a stable optimum strategy over time.

This research may be used as a prescriptive tool for a range of agri-food chain studies. Extended case evaluation is required to test the robustness of the suggested methods.

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Glossary of Abbreviations and Terms

Abbreviations

ABC	-	Activity Based Costing
AV	-	Actual Value
C	-	Quality Characteristic
C&D	-	Strategic Control and Development
ECR	-	Efficient Consumer Response
EV	-	Expected Value
EVA	-	Economic Value Analysis
F	-	Financial Flow Activities
FTP	-	Normalised Performance of Financial Flow
GMO	-	Genetically Modified Organisms
I	-	Information Flow Activities
IT	-	Information Technology
M	-	Material Flow Activities
MFP	-	The Total Normalised Material Flow Performance Value
NAV	-	Normalised Acceptance Value
NDT	-	Normalised Delivery Time Acceptance Value
NDV	-	Normalised Volume Acceptance Value
NOPAT	-	Net Operating Profit After Taxes
NPC	-	The Measure of Normalised Performance of the Customer in the Chain
NPM	-	Normalised Performance Measure
NPMS	-	Normalised Performance Measurement System
NPS	-	The Measure of Normalised Performance of the Supplier in the Chain
O	-	Over-achievement
$\overline{O}$	-	Acceptable Premium Overachievement
P	-	Performance
p_1	-	The Total Normalised Value of Quality
p_2	-	The Total Normalised Value of Delivery

PMS	-	Performance Measurement System
PR	-	Productivity
SC	-	Supply Chain
SCM	-	Supply Chain Management
SCP	-	Supply Chain Participant
SCOR	-	Supply Chain Operation Reference Model
TANP	-	Total Actual Normalised Performance
TC	-	Total Customer's Contractual Normalised Performance
TDQM	-	Total Data Quality Management
TS	-	Total Supplier's Contractual Normalised Performance
U	-	Under-achievement
$\overline{U}$	-	Acceptable Discount Underachievement

Terms (introduced in this thesis)

Term	Defined on Page
Acceptable Characteristic	73
Actuality	130
Balanced Performance Value	171
Branch Level	67
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Chapter One

Introduction

In this Chapter, a number of problems encountered in Supply Chain Management (SCM) are introduced. Several of these problems which can be viewed as fundamental SCM problems are identified and discussed. Research objectives are defined in the context of the problems identified. A methodology to investigate and meet the objectives identified is proposed. The Chapter concludes with an outline of the research.

1.1. Background

SCM has grown as a discipline in response to the challenge for firms to remain competitive in the face of a complex business environment. It is in response to this complexity that contemporary business management has turned to SCM as an important co-ordinating mechanism.

As Ohmann (1957) says "business is so highly integrated and dependent on a network of other companies and industries, his (manager's) effective coordination of the elements of production is to a considerable extent in the hands of many suppliers, distributors, and subcontractors – who similarly are not in complete control of their business because of unavoidable interruptions in the flow of materials and labour" (*ibid*., p. 56).

Authors define competitiveness as the objective (Stadtler and Kilger, 2000) and motive behind the formation of supply chain arrangements (Lambert *et al.*, 1998). It is also recognised that the supply chain should be seen as the central part of competitive system analysis (Macbeth and Ferguson, 1994). Supply Chain Management (SCM) is viewed as a tool to achieve competitive advantages for all supply chain participants.

The above statements are just as true in 2004 as they were when they were first published. The work of managers today, compared with the previous century, is simpler, on one hand, and more complicated, on the other hand.

Managerial work has become simpler because technology, primarily information technology, has provided an opportunity for businesses to make products, or provide services, more quickly, more cheaply and more accurately than has previously been possible. Further, rather than wait for reports to reach their desks, managers today have real time access to a practically unlimited amount of information.

The wealth of information that makes managerial work simpler has – ironically - also made the job more complex. With an abundance of information available, managers today must be aware of what information is important and what is not important to their business. Further, they must be ready to act on that information. This situation has created the requirement that managers understand how to efficiently use the information provided so that a firm may increase its competitive ability.

The pace of technological progress has intensified the potential impact that information and technological change may have on business. It has enhanced the need for improved long-range planning and increased flexibility. In response to businesses' demand for new management approaches on how best to use new technology, SCM first appeared as a discipline in the 1980s (Copachino, 1997). SCM provides a methodology business may use to manage and co-ordinate highly dynamic and complex tasks. In applying this methodology, the main SCM principle is the requirement that businesses not only look inside their business but also co-operate with other businesses in the marketing channel. Since its initial application, managers and authors have agreed on the importance and potential benefits of SCM ideas (Copachino, 1997; Bechtel and Jayaram, 1997).

Despite its acceptance as both a competitive strategy and a co-ordinating mechanism, the nature of SCM remains elusive. It does not have a clear definition. The aim of this research was to bring some specificity to SCM by:

1. Examination of the difficulties firms encounter as they attempt to adopt a SCM philosophy;
2. An exploration of a general theory of SCM;
3. Discussion on challenges firms face when attempting to view business from a systems perspective.

In an attempt to provide insight into some possible solutions a methodology to measure performance of supply chain transactions has been created. This methodology was evaluated using case studies with the results then related to the problems detailed below.

1. 2. Problem Statement

SCM is seen as a governing element in strategy (Fuller *et al.*, 1993) and an effective and efficient way to create customer value. Despite the growing interest in SCM, there is still a lack of cohesive information that explains the SCM concept (Ganeshan *et al.*, 1999). Both practitioners and research scientists have noted a number of problems regarding SCM development over the past decade (Holmberg, 2000).

In the following sections SCM problems are discussed. The discussions describe the problems and the significance of those problems to SCM. The problems are then structured into research objectives.

1.2.1. Problem 1 - Difficulties in Adopting a SCM Philosophy

"It (philosophy) underlies various mature activities and interests whose standing is regarded as unquestionable. When these activities or interests are reflected upon, as sooner or later they are sure to be, it appears that they require the support of philosophy" (Perry, 2001).

Managers are essentially doers – as the word "executive" implies (Ohmann, 1957). Traditionally they apply managerial theories to practice in order to gain benefits for their business. With such an approach, the method by which a company receives benefits – for example increased sales, lower production costs, increased customer satisfaction - is often secondary to the reality that the benefits were actually achieved.

Cooper and Ellram (1993) compare supply chain management to a well-balanced and well-practiced relay team. Such a team is more competitive when each player knows how to be positioned for the hand-off. Relationships are the strongest between players who directly pass their businesses to each other. The runners must be ready to adjust their running style so that it fits best with other runners so that the effort of all runners results in winning a race. While the key performance indicator is the success of the track team, how the team achieves its success must not be overlooked. In a similar way, businesses that wish to increase their competitiveness must be willing to work with other businesses, and potentially adjust their business practices in order to increase the competitiveness of the chain.

For a SCM philosophy to be widely adopted by managers, the benefits a business may gain from the philosophy must be explained and demonstrated. The benefits gained must be clearly recognisable to the managers as benefits that are worth gaining. It is only after the benefits have been achieved that business can begin to more fully embrace a SCM philosophy. The growing international acceptance of SCM as a business practice may indicate that a SCM philosophy may be emerging, although that possibility has not yet been evaluated.

SCM, as both a concept and a process, is supported by a number of large corporations. The Supply Chain Council has close to 1,000 corporate members world-wide and has established international chapters in Europe, Japan, Australia/New Zealand, South

East Asia, and Southern Africa with requests for additional regional chapters pending (http://www.supply-chain.org/aboutus.asp. Accessed 20 August 2004). At the same time as Govin and Proth (2002, p. 8) say "In today's supply chains, the most powerful partner imposes the strategy of the system.... Irrespective of who dominates a supply chain, it is difficult to cite supply chains whose partners cooperate following a fair policy defined well in advance". This statement seems to indicate that SCM is a discipline imposed on system participants rather than a philosophy embraced by all chain members.

It may be difficult for medium or small businesses which supply these large corporations to understand that SCM may be as useful to them as it is to the corporation. Small and medium-sized businesses may be reluctant to adopt a SCM philosophy if a firm that dominates the supply chain has forced SCM on them. They may adopt SC operating requirements, as required by the dominating chain member, but may find it much more difficult to adjust their business philosophy to accommodate those requirements. As noted above, the benefits from adopting a SCM philosophy require both an explanation and a demonstration of specific benefits to be gained. Adoption of SCM as a business philosophy shared by all participants in a supply chain is viewed as a necessary condition for the successful implementation of system-wide initiatives. Without a business philosophy that unifies all businesses in a chain, it is believed the benefits of system-wide SC initiatives will be less than fully successful.

1.2.2. Problem 2 - The Lack of General Theory of SCM

It is recognised that SCM is an interdisciplinary subject. It adapts theories from practically all branches of management and business in addition to the fields of "logistics and transportation, marketing, operations research, organisational behaviour, transactional cost economics, purchasing and supply ...." (Stadtler and Kilger, 2000, p. 17). The scope of SCM as a discipline, in combination with many other well established disciplines, is complex.

Researchers have applied their expertise to SCM and arrived at conclusions that are valuable to business (Ganeshan *et al.,* 1998). Unfortunately, in only a limited part of the SCM research reviewed have the researchers demonstrated the inter-disciplinary cooperation inherent in SCM (Croom *et al.,* 2000). This is an ironic situation in that the cornerstone of SCM is the blending together of a wide range of business operations and procedures to achieve specific benefits.

Because of the lack of a unifying general theory of SCM, researchers from the fields of business and applied sciences, such as agribusiness, have turned to empirical descriptive case study research in what seems to be a preferred SCM research framework (Cox, 1997). Consequently, each supply chain studied, using the case study approach, is described differently. While the researchers may have provided some useful SCM information, this dependence on the descriptive case study research, may have also increased the overall confusion on the scope of SCM. A consequence of this possible confusion is the lack of a cohesive body of knowledge sufficient to provide a theoretical foundation for SCM.

As a result of the dominance of the descriptive case study methodology, the amount of information describing different supply chains is considerable. It is challenging to remain aware of new SC publications and newly published SC research. SCM research is published in a broad range of topics, for example:

- Inventory management (Chandra and Kumar, 2001);
- Supply chain coordination (Simatupang *et al.*, 2002);
- Integrated supply chain planning (Mourits and Evers, 1996);
- Sourcing relationships and strategy (Sharland, 1997);
- Supply chain design and facility location (Towill *et al.*, 1992);
- Organisation of supply chain function (Humphreys *et al.*, 1998);
- Managing product variety in supply chains (Childerhouse and Towill, 2000);
- Coordination of product and supply chain design (Redfern and Davey, 2003);
- The role of information technology in supply chain coordination (Yu *et al.*, 2001);
- Logistics, order fulfilment and distribution (Mattsson, 2003);
- Supply chain risk management (Lonsdale, 1999);
- Channel management (Barratt, 2004), and
- Performance measurement systems (Beamon, 1999).

In attempting to locate research in this complex field the first selection criterion a researcher may use is the field of their own expertise, such as operation research, management or logistics. In an effort to provide a classification of SCM research that was not discipline based, Croom *et al.* (2000) used the following framework:

Table 1.1. Classified SCM Literature According to the Methodology Oriented Criterion

	Prescriptive	Descriptive
Theoretical	6%	11%
Empirical	27%	56%

Source: Croom, S., Romano, P. and Giammakis, M. (2000) Supply Chain Management: An Analytical Framework for Critical Literature Review. *European Journal of Purchasing & Supply Management*, 6, p. 74.

The data from Table 1.1 indicates the historical emphasis researchers placed on empirical research, particularly descriptive (case study) research.

The lack of an interdisciplinary research approach may result in researchers' focusing on technical problems specific to a discipline rather than attempting to resolve problems that span a supply chain, such as determining a definition for SCM, the first step in the development of a theoretical foundation for SCM. The lack of agreement on an issue as fundamental as a definition of SCM has created problems including the incorrect use of the term SCM. For example, in "Integrated Chain Management Chicory" (Ton and van der Roest, 1996), the phrase SCM was applied to a quality assurance programme.

1.2.3. Problem 3 - Difficulties of System Thinking

Checkland (1993) defined the system concept as "a set of elements connected together, which form a whole, thus showing properties of the whole, rather than properties of its component part". Bowersox *et al.* (1985) used systems concept defining the SCM system thinking as focused on "how decisions made at a particular point in the chain affect the upstream and downstream points in the supply chain"

SCM has been described as a whole system that consists of "bi-directional dependencies of activities, actors, and resources" (Svenson, 2002). Because supply chains contain dependent activities and have bi-directional flows, it is important in SCM discussions that the whole system, rather than system components, be kept in mind. Maintaining a holistic view of SCM is difficult. These difficulties have been discussed previously: activities, actors, and resources in supply chains are constantly changing; the macro- and micro- business environment is very dynamic; and technology rapidly and continuously changes. All of these factors affect different parts of the supply chain (a part of the system) differently and potentially have impacts throughout a supply chain (entire system). The challenge, and opportunity, of systems thinking is to understand how these changes affect the entire system rather than how they affect a portion of the system.

SCM, as a managerial subject, appeared in response to practical demand (see Section 1.1). To fully satisfy this demand, it is assumed that SCM should incorporate into the description of a system structure the unique characteristics of each part of the system. Such a description would acknowledge the importance of systems thinking in a supply chain. It also would recognise the differences between the subsystems that constitute a system. Just as it is inefficient to focus on the unique characteristics of a subsystem to the exclusion of the total system, it is inefficient to view the entire system (supply chain) as homogeneous with all participants sharing similar problems and environments.

1.2.4. Problem 4 - Unique Characteristics of Agribusiness Supply Chains

SCM analysis and applications frequently focus on large manufacturing chains. Research into supply chain applications for agribusiness chains is very limited (Bailey, 2001). Because agricultural chains have characteristics that are unique and do not apply to manufacturing chains, this research considers agricultural chains as a separate discipline (Sonka and Hudson, 1989). These unique characteristics include:

- Food is vital to life
- Agricultural production is a biological process
- Agricultural production is seasonal
- The structure of agribusiness places perfectly competitive industries into the supply chain of imperfectly competitive industries.

The unique characteristics of agriculture have led to the use of the phrase 'agri-food chain' to distinguish the specific characteristics of agricultural chains from other chains. Consequently, in the context of agribusiness, the phrase 'agri-food chain management' evolved.

Despite its unique characteristics an agri-food chain, as a chain, is a sub-set of all existing chains. Because it is a sub-set of existing supply chains, agri-food chain management as a discipline shares all of the general problems encountered by all supply chains. However, the unique characteristics of agribusiness strongly influence both the structures of agri-food chains and the performance requirements of the chain. This results in a number of additional factors to be included into chain system analysis for agri-food chains. These factors include perishability, seasonality, and food safety considerations and several other factors (see Agri-food chain literature review to be discussed in Section 2.3).

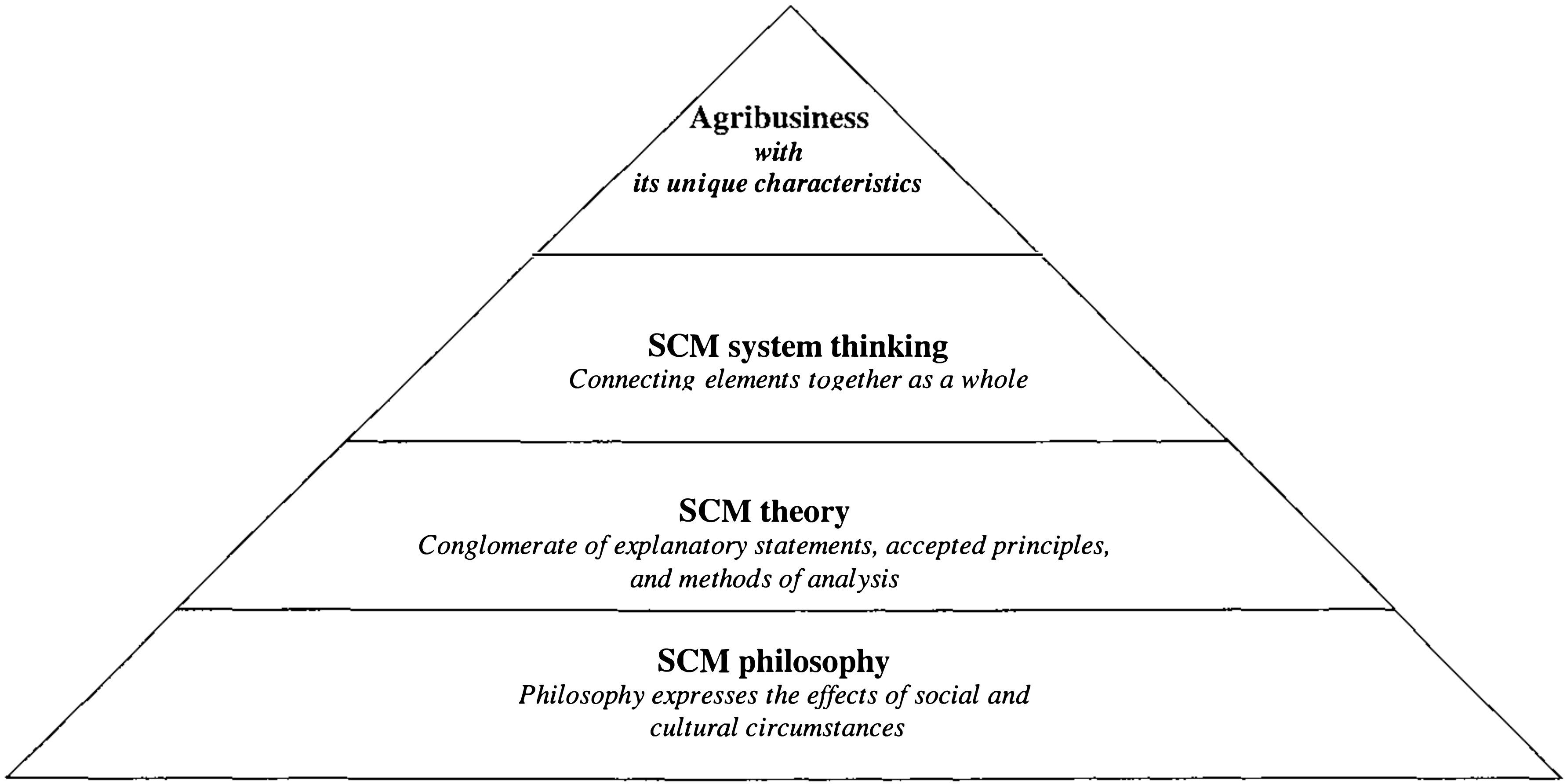
1.2.5. Classification of SCM Problems

While SCM thinking has existed for several decades, it is only recently that it has been viewed as a new cross-disciplinary subject. Evaluating SCM as a cross-disciplinary subject presents the opportunity to develop a new SCM philosophy rather than an extension of an existing discipline. This view of SCM as a philosophy has appeared in response to the high velocity of business environment and technological advances that preclude a static approach to business. It is an approach that embraces the changes that affect all, or part, of a supply chain. The philosophy has also appeared as a result of firms' needing to change their business practices in order to compete in today's global economy.

The subject of SCM is very broad and its theoretical base is continually in a process of dynamic development. SCM is constantly trying to catch up with the dynamics of the business world, with changes in other theories and operating practices, and with changes in IT.

SCM is a cross-disciplinary subject that is in constant change yet it is relied on by businesses around the world as a competitive strategy and co-ordinating methodology. As previously discussed, SCM faces several problems. Those problems are divided into four categories, as presented in Figure 1.1 below.

Figure 1. 1. Classification of Categories of SCM Problems



In Figure 1.1, the four supply chain problems previously discussed are presented as four levels in a pyramid. The lower levels of the pyramid represent general problems that may affect an entire system. As problems become more specific to a particular business, the problem classification increases to higher levels of the pyramid. Agribusiness is placed on the top of the pyramid indicating that while agri-food chains share all general SC problems, agri-food chains have unique management challenges not faced by other businesses. There are fundamental problems to be resolved in all SCs and unique problems requiring attention in the agri-food SCM. Without a consistent approach on how to solve problems presented in Figure 1.1, these problems may only increase over time.

1.3. Research Objectives

The focus of a successful supply chain is on the value the chain may create for customers (Handfield and Nichois, 1999). Although adding value is a key aspect of supply chain management, techniques to measure the value added in a supply chain are not well developed. The importance of having a consistent measurement of value increases as the number of firms in a supply chain, each adding value, increases.

A consistent and quantifiable measure of value would permit all firms in a supply chain to determine the value they, and others in the chain, add to a product as the product flows through a SC. A methodology that quantifies the value created by the members of a supply chain may also be used for strategic planning purposes to determine the impact of changes in chain activities on the value provided to the final customer.

In terms of this research, achievement of the following objectives will establish a framework to solve the SCM problems discussed above. This link is discussed in Section 1.4.

Objective 1: To create a methodology that permits chain participants to uniformly measure performance. Supply chain members' performance will be defined and measured by the businesses' ability to meet the expected value of their activities. Performance may be measured by individual firms and/or an entire supply chain at different levels of business planning (strategic, tactical and operational).

Objective 2: To create a methodology to determine if customer-directed performance in material transactions is balanced by the performance observed in up-stream financial flows. This research will introduce the definition of the "chain wave effect", the effect that takes place when the performance (high or low) of one supply chain member affects the performance balance of other chain members.

1.4. Justification

A methodology was created to measure chain performance at different stages in a supply chain. The research addresses the four problems previously discussed. Given the dynamic nature of SCM, it is difficult to find solutions that consistently resolve these problems. Nevertheless, the methodology developed provides a framework to assist in the initiation and implementation of SCM initiatives that address possible solutions to the problems.

1.4.1. Difficulties in Adopting a SCM Philosophy

SCM philosophy is based on thinking of the performance of the entire supply chain rather than of individual components, and recognition of individual player needs and goals. Each supply chain member has particular abilities and by working together to take advantage of member abilities the entire chain will benefit.

The methodology developed allows each business in a supply chain to objectively measure its performance in respect to that of other supply chain members. Measuring the performance of a business assists the business to understand if its performance in the supply chain may be improved. If the value added by the business is measured, it is also possible to determine how the value added by the business is balanced by the performances of other chain members. Finally, the methodology provides an objective measure of what a business may gain from implementation of supply chain initiatives.

The suggested methodology may be used as a measurable demonstration of the SCM philosophy. For a SCM philosophy to be widely adopted by managers, the benefits a business may gain from the philosophy must be explained and demonstrated. The benefits gained must be clearly recognisable to the managers as benefits that are worth gaining. This methodology permits measurement and explanation of the benefits that may accrue to individual businesses through adoption of a SCM philosophy.

1.4.2. The Lack of General Theory of SCM

The suggested performance measurement methodology may be used to evaluate the success of SCM strategies and to guide adjustments in strategies and business plans. In the situation of a lack of a general theory, the methodology may provide a useful empirical prescriptive tool (according to the methodology suggested by Croom *et al.*, 2000) in the development of a general SCM theory.

Further, the creation of an empirical measurement system assists researchers to change from focusing on case studies or narrow technical issues that are specific to a single discipline or a single firm. By having a measurement system that uses specific rules and guidelines, the possibility of a definition of SCM that is embraced by the profession may increase.

1.4.3. Difficulties of System Thinking

The suggested methodology may be used to demonstrate how decisions made at a particular point in the chain affect the performance of different segments and eventually the entire supply chain.

Chapter 5 contains a discussion and applications of the methodology to strategic planning and control, which is viewed as a perpetual process of measurement, and control. The methodology not only allows the demonstration of the interdependency of business performance in the chain but also gives a basis on which to control and evaluate total chain agility (Christopher and Towill, 2000).

The methodology developed underscores the view that supply chains contain dependent activities and have bi-directional flows. While the methodology permits evaluation of a single transaction between two businesses in a chain, it also permits the tracking of performance consequences throughout the chain. This is referred to as the "chain wave effect". This effect, and the measurement of the effect, emphasise that the whole system, rather than system components, must always be kept in mind. Performance measurement will assist in quantifying factors that affect different parts of the supply chain (a part of the system) and how those factors impact the supply chain (entire system).

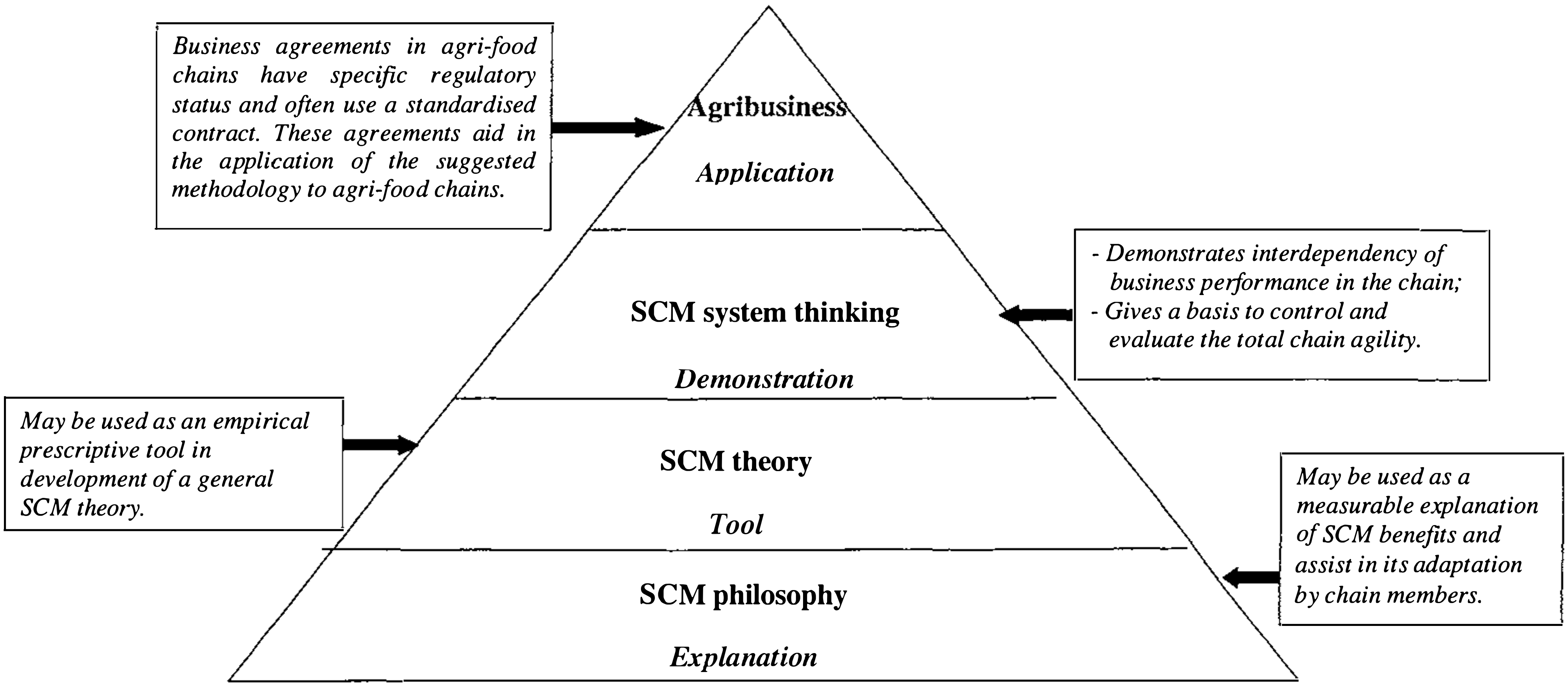
1.4.4. Unique Characteristics of Agribusiness Supply Chains

The specifics of agribusiness strongly influence the structure of the agri-food chain and the requirements of the chain's performance (Fearne *et al.*, 2001). Customer-supplier relationships are often based on contractual agreements. The customer specifies in detail quality characteristics of the product to be delivered by the supplier of agri-food products (Eswaran and Kotwal, 1985; Hayami and Otsuka, 1993; Brousseau and Glachant, 2002). Because food is vital to life, yet subject to uncontrollable biological influences, quality is always a concern - but the measurement of quality may vary depending on the condition of the food product under consideration. Quality standards that are applicable one season may be discarded the following year because of a different crop size.

Each link in the agri-food supply chain is the result of an agreement, either formal or informal, for one firm to provide goods and/or services to another chain participant in exchange for payment. Commonly, these agreements specify the obligations of the chain participants by establishing standards for quality, quantity, time and place of delivery, acceptance of goods and/or services, informational interchange, and terms of payment. Agreements in agri-food chains have specific regulatory status and often use a standardised contract. This permits direct application of the suggested methodology for agri-food chains and allows the use of agri-food case studies to evaluate different levels of the suggested methodology.

The methodology suggested in the current research may assist in solving the problems listed in Section 1.2 and classified in Figure 1.1. Justifications of this statement are mapped onto the classification pyramid from Figure 1.1, as shown in Figure 1.2 below.

Figure 1.2. Relationship of the Suggested Methodology to Classified SCM Problems



Supply chain performance measurement methods are important. This is widely discussed in the literature (See Section 2.5 for a comprehensive review of the literature on this topic). One of the main factors that define the importance of SC performance measurement is that the lack of measurements can be a barrier to implementing SCM (Bechtel and Jayaram, 1997). The SC performance measurement system provided in this research may aid in the implementation of SCM. The methodology developed also addresses problems of the SCM discipline on a number of levels – from those that affect the industry to those that affect a single business. The research has focused in providing assistance to resolve these problems.

1.5. Thesis Outline

This thesis consists of seven chapters: introduction, literature review, methodology – primary concepts, methodology – extensions, methodology applications to the strategic planning and control, case analysis and evaluation, and conclusions.

Chapter One provides a brief overview of reasons that led to the selection of the topic of this thesis. The overview is followed by the problem statement and formulation of research objectives.

Chapter Two contains the literature review. As a result of the interdisciplinary nature of SCM, the review covers the following four broad topics:

- General SCM;
- SCM in agri-food industries;
- Performance measurement systems;
- Strategic planning.

Chapter Three starts with the introduction of methodology structure. It is followed by the description of suggested methods to measure performance of a single transaction in each of three chain flows: material, financial and informational. All three measurement methods are uniformly scaled which makes it possible to extend the methodology to higher levels of system consideration and to compare the performance of different chain flows.

In Chapter Four, the methods suggested in Chapter Three are extended to the methodology of contractual performance measurement between two businesses (branch level) and network level performance measurement. A contractual agreement between two supply chain members was decomposed into the sequential transactions in each of three supply chain flows: material, financial and informational. This approach allowed the measurement of the contractual performance of two parties by measuring their transactional performance – branch level performance. The total supply network, starting from raw material and ingredient procurement and ending with the sale of the final product to customers, was presented as a network of firms. Firms in this network exchange materials, finance and information under contractual obligations between two firms. This form of the presentation of a total supply chain allows extension of the branch level performance measurement methodology to the total system.

In Chapter Five, application of the suggested performance measurement methods to strategic planning and control are introduced. Methodologies introduced in Chapters Three and Four were evaluated in a case study in Chapter Six. Information provided by a Russian Grain Company on the performance of grain contracts in 2001 - 2004 was used for the research.

Chapter Seven provides conclusions for this research. It contains a description of the results achieved and a discussion of the results. Limitations of the suggested performance measurement methods are discussed and analysed. Suggestions on further development and evaluation of methods are made. This is followed by recommendations on the application of the suggested methodology to performance measurement, system analysis and strategic planning and control in a variety of agri-food chains.

Chapter Two

Literature Review

2.1. Background

Despite the increasing popularity of the concept of SCM in both academia and the business world, the exact nature of SCM and how it may be implemented remain elusive. For example, no general definition or theoretical underpinning of the SCM concept has been developed. In addition, despite its widespread acceptance as a competitive strategy, the role of SCM in strategy development remains unclear.

A review of SCM literature was conducted in order to establish a foundation for this research in the face of the lack of a consistent and accepted view of the scope of SCM, how its performance might be measured and how it may be used in strategic planning. Without this foundation, the researcher's ability to reach research objectives discussed in Chapter 1 would be severely limited. Even if research objectives were achieved, it would not be possible to link those objectives to potential solutions to the four problems previously discussed.

Consequently, the literature review that follows is structured to:

- Provide an overview of SCM concept and the SCM definition used in this research;
- Examine the applicability of SCM to the agri-food chains;
- Define the role of SCM in strategic planning;
- Discuss different performance measurement systems for SCM.

The literature review begins with an overview of SCM schools (Section 2.2). There was no *a priori* assumption that commonly shared principles existed. The literature was reviewed to determine if commonly shared principles existed for the SCM schools and identify what those principles were. This overview of SCM schools was necessary in order to provide a basis for the selection of the SCM definition used in this research. Section 2.2 concludes with a SCM definition and a justification of the selection of that definition.

Building on Sections 2.2, Section 2.3 presents a literature overview of agri-food SCM. The specifics of agri-food chains, including the unique factors that affect their structure and performance, are discussed. Section 2.3 also discusses trends in the development of agri-food chains. Because the framework discussed in this research was applied to agri-food chains, research was needed to determine if there were characteristics unique to agri-food chains. If there were, these differences would be incorporated into the suggested framework.

While there is no agreed definition of SCM, it is agreed that SCM is a system-wide concept that focuses on strategic decisions. This relationship between SCM and strategy indicated that a literature review on strategic planning schools was appropriate (see Section 2.4). The main goal of this part of the literature review was to determine if SCM and strategic decision-making are interrelated. Further, the review of literature examined the possibility of linking research conducted in one field to another field.

The literature overview of SCM performance measurement is presented in Section 2.5. In the conclusion of the literature review (Section 2.6) the findings from the literature review are connected to the research problems formulated in Chapter 1.

2.2. Supply Chain Management Concept

2.2.1. Introduction

Supply Chain Management (SCM) became a popular discipline during the early 1990s. Numerous papers and books have since been published on this topic. The term "SCM" is widely used in both the academia and the business world. Several SCM schools have evolved and received recognition; many models and software-integrated solutions have also been developed. Despite its broad acceptance, there is no solid theoretical base for SCM. There is no unique SCM definition agreed to by people using this term. It has become a common practice to start a publication related to SCM with an overview of existing SCM definitions, followed by the offering of a new one.

As Mentzer *et al.* (2001) wrote that despite the popularity of the term Supply Chain Management, both in academia and practice, there remains considerable confusion as to its meaning.

In 1982 Oliver and Webber introduced the term "SCM". They defined SCM as occurring when an integrated systems strategy that reduces the level of vulnerability is developed and implemented. However, research into the integration and coordination of business functions was conducted much earlier than 1982. Complete taxonomic research was provided by Ganeshan *et al.* (1998) who presented the following SCM's Evolutionary Timeline that highlights a few of the many significant research papers that led to the development of SCM as a new concept. This Evolutionary Timeline defines the following research periods in SCM concept development:

Period 1. (1950s –1960s) This is the period of fundamental research in economics, operational research, business logistics and distribution channel dynamics. Alderson (1957) contributed to channel research by introducing the principle of postponement as a tool to reduce risk and transportation costs. According to this principle, the time of shipment and the location of final product processing are delayed until a customer order is received. Although postponement was principally an internal business decision, the roles of other members of a logistics channel were initially discussed. Alderson (1964) discussed "the presence of conflict and cooperation among channel members, the emphasis on long-term commitment in channel selection" (*ibid,* p. 328). Their work emphasised the importance of companies looking outside their own business operations to gain long-term partners.

In the late 50s an intensive analytical inventory management research was conducted (for example, Karlin and Scraf, 1958; Hansmann, 1959).

The first article in the field of system dynamics was published by Forrester in 1958. This was followed by his book "Industrial dynamics" (1961). The author introduced the dynamic analysis of business and applied it to the production-distribution system. He also discussed an early version of the Beer Distribution Game.

Period 2. (1960s – 1982) During this period the previous research findings were integrated and applied to distribution channels. In the late 1960s Bowersox contributed to the field of business logistics by research into integrated physical distribution. He was able to demonstrate a need for system integration into the total distribution channel. The author described the state of research in marketing, physical distribution and system analysis and stressed the importance of the quality and comprehensiveness of physical distribution research efforts (Bowersox *et al.*, 1969).

The principle of postponement was further investigated by Zinn and Bowersox in 1982. The researchers defined five types of postponement and showed that there is a cost advantage in postponing the distribution of a substantial number of products.

Heskett (1977) stated that logistics is essential to strategy for different sized businesses with different goals.

In early 1970s research was conducted in facility location. Geoffrion and Graves (1974) suggested mix-integer models for the optimal location of intermediate distribution facilities between plants and customers.

Period 3. (1982 – 1997) This period may be characterised by the strategic focus and the continued integration of research findings. Introduction of the supply chain management concept in 1982, was the beginning of the development and application of earlier findings to this concept.

Lee and Billigton (1993) used earlier findings in their research into decentralised supply chains. They noted that organisational barriers may restrict information flows and constrain the complete centralised control of material flows in a supply chain.

In 1995, Bloemhof-Ruwaard *et al.* linked SCM discipline with environmental management and demonstrated that the latter should be incorporated when analysing industrial SCs .

Gentry (1996), using empirical evidence, was able to link the concept of buyers-suppliers' partnerships to the SCM approach.

In 1997 the "bullwhip effect" was introduced. This effect describes the phenomenon when the variance of orders may be larger than that of sales, and the distortion tends to increase as one moves upstream (Lee *et al.*, 1997).

Period 4. (From the late 1990s until today) This is the period of SCM growth. The SCM concept was quickly adapted by researchers and practitioners after 1990. For example, of the 189 articles published in "*The International Journal of Logistics Management*" during 1990-2001, more than 22% of the articles were related to SCM (*The International Journal of Logistics Management*, 2001, 12(2), pp. 103-111).

"*Supply Chain Management Review*" was founded in 1997. Since its founding, it has published more than 400 articles.

The broad range of SCM research and the number of related publications have ironically created a lack of consensus about the scope of this integrative managerial discipline. The confusion has been reinforced by discussion around the term "supply chain" itself. Suggestions have been made to use other terms, such as:

- Network sourcing (Nassimbeni, 1998);
- Supply pipeline (Farmer, 1996);
- Value chain (Lee and Billington, 1993);
- Value stream (Jones *et al.*, 1997).

2.2.2. Contemporary Research on SCM

Croom *et al.* (2000) provided a comprehensive literature review on SCM in which they defined six areas related to SCM. They then classified SCM publications into one of the six areas (Table 2.1).

Table 2.1. Principal Component Bodies of Supply Chain Literature

Strategic management	*Relationships/partnerships*
- Strategic networks	- Relationships development
- Control in the supply chain	- Supplier development
- Time-based strategy	- Strategic supplier selection
- Strategic sourcing	- Vertical disintegration
- Vertical disintegration	- Partnership sourcing
- Make or buy decisions	- Supplier involvement
- Core competencies focus	- Supply/Distribution base integration
- Supply network design	- Supplier assessment (ISO)
- Strategic alliances	- Guest engineering concept
- Strategic supplier segmentation	- Design for manufacture
- World class manufacturing	- Mergers acquisitions, Joint Ventures, Strategic Alliances
- Strategic supplier selection	- Contract view, trust, commitment
- Global strategy	- Partnership performances
- Capability development	- Relationship marketing
- Strategic purchasing	

Source: Croom, S., Romano, P. and Giannakis, M. (2000) Supply Chain Management: an Analytical Framework for Critical Literature Review . *European Journal of Purchasing and Supply Management*, 6(70).

Ganeshan *et al.* (1999) classified modern SCM research. The principal categories were competitive strategy, firm-focused tactics, and operational effectiveness. The authors further classified research into subcategories (see Table 2.2).

Table 2.2. Categories of SCM Research

Subcategory	CATEGORY		
	Competitive strategy	**Firm-focused tactics**	**Operational effectiveness**
A	Objectives	Relationship development	Inventory management and control
B	Design	Integrated operations	Production, planning and scheduling
C	Competitive advantage	Transportation and distribution	Information sharing, coordination, and monitoring
D	Historical perspective	Systems	Operational tools

Adapted from: Ganeshan, R., Jack, E., Magazine, M.J., and Stephens, P.
A Taxonomic Review of Supply Chain Management Research in: Tayur, S., Ganeshan, R. and Magazine, M. (1998) (Eds.). *Quantitative Models for Supply Chain Management*, Dordrecht, the Netherlands, pp. 849-851.

Bechtel *et al.* (1997), in their article "Supply Chain Management: A Strategic Perspective", used a conceptual model to group and analyse SCM literature. In their model, the authors used the term "Supply Chain Schools of Thought" to classify publications that used different approaches to SC content and process analysis.

Table 2.3. Supply Chain Schools of Thought (According to Bechtel and Jayaram)

School	Main concept	References
The Functional Chain Awareness School	Recognises the existence of a chain of functional areas. It states that all chain members, from beginning to end, should be included, and emphasises the material flow.	Stevens (1989) Novack and Simco (1991) Cooper and Ellram (1992)
Linkage/Logistics School	This school addresses material flows through the SC. Linkage in the chain is viewed through the functional areas. The emphasis is on managing material flows to reduce system inventories.	Turner (1993)
Information School	Emphasis is placed on bi-directional informational flows.	Johannson (1994)
Integration/ Process School	Emphasis is on effectiveness in meeting customer requirements, regardless of the configuration of functional areas in the SC.	Hewitt (1994)

Adapted from: Bechtel, C. and Jayaram, J. (1997). Supply Chain Management a Strategic Perspective. *The International Journal of Logistics Management*, 8(1), p. 18.

Bechtel and Jayaram published their article in 1997. Since then, new SC concepts have been developed. Application of the above conceptual model to SCM literature published after 1997 allows defining two additional SC schools of thought (Table 2.4).

Table 2.4. Modern Supply Chain Schools of Thought

School	Main concept	References
Relationship School	SCM concept is tied to the concepts of cooperative relationships, such as partnerships, strategic alliances.	Underhill (1996) Lynch (2003)
E-commerce Schools	Emphasis is on e-commerce and e-marketing.	Poirier (2000) Berger (2001) Robertson (2002)

The Relationship School focuses on forms of inter-organisation relationships within SCs. In this School, attention is directed to risk, power and leadership issues. Global competitiveness is analysed through channel structure and reengineering of the logistics system.

E-commerce is a term that describes the growing on-line economy. E-commerce supply chain models allow the creation and maintenance of online businesses. E-commerce provides the potential for a company to significantly decrease overhead and storage costs. As a result, many companies are starting to take advantage of the cost efficiencies that may be gained from e-business. Publications on key characteristics of e-commerce transactions and their affect on chain operations and structure may be grouped into a separate conceptual approach to SC content and process analysis.

The above brief descriptions of SCM schools of thought illustrate the broad range of approaches taken by different researchers and practitioners.

The categorisation of the modern SCM research is not simple. The authors were forced to employ two-dimensional tables to present their results. The content analysis of numerous SCM publications shows contrasting themes and antecedents of the field (Croom *et al.*, 2000).

2.2.3. Overview of SCM Definitions

As a result of the broad range of opinions and the existence of several SCM schools there is a tendency to start any publication related to SCM issues with the introduction of the author's SCM definition. As a result, several literature overviews have appeared with the goal of classifying the existing points of view on the subject.

Authors have defined supply chain management as a discipline built around several points. Houlihan (1985) defines these points as:

- The supply chain identifies the complete process of providing goods and services to the final users.
- It includes all parties and logistics operations from suppliers to customers within a single system.
- The scope of the supply chain includes procurement, production and distribution operations.
- The supply chain extends across organizational boundaries.
- It is coordinated through an information system accessible to all members.
- The primary objective of the supply chain is service to customers. This must be balanced against costs and assets.
- Objectives of individual supply chain members are achieved through the performance of the chain as a whole.

Some SCM definitions are very short and straightforward:

- " SCM is an approach whereby the entire network from which suppliers through to the ultimate customers, is analysed and managed in order to achieve the "best" outcome for the whole system" (Cooper and Ellram, 1992).

- "SCM is a set of approaches utilised to efficiently integrate suppliers, manufacturer, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimise system-wide costs while satisfying service level requirements" (Simchi-Levi *et al.*, 2000) .

Some definitions attempt to include clarifications of their authors' position on the subject, and as result the definitions are extended:

- " The manfacturer and its suppliers, vendors, and customers – that is, all links in the extended enterprise – working together to provide a common product and service to the market place that the customer is willing to pay for. This multicompany group, functioning as one extended enterprise, makes optimum use of shared resources (people, process, technology, and performance measures) to achieve operating synergy. The result is a product and service that are high-quality, low-cost, and delivered quickly to the marketplace" (Kuglin, 1998).

- "Supply chain management is a continuously evolving management philosophy that seeks to identify the collective productive competencies and resources of the business functions found both within the enterprise and outside in the firm's allied business partners located along intersecting supply channels into highly competitive, customer-oriented supply system focused on developing innovative solutions and synchronizing the flow of marketplace products, services, and information to create unique, individualized sources of customer value (Ross, 1997).

2.2.3.1. Common Characteristics of Literature on SCM Definitions

Although there is no single agreed upon SCM definition, there are consistent threads through the definitions based on the following three basic characteristics:

Characteristic 1. The supply chain is an interaction of all mutually dependent firms in a marketing channel.

This interaction of firms may be defined as:

- "the overall link of firms up to final customers" (Cavinato, 1992);
- "all parties, beginning with suppliers' suppliers and ending with end-users" (Harrington, 1995);
- "pipeline chain" (Coyle *et al.*, 1996);
- "supply chain network" (Lambert *et al.*, 1998).

Characteristic 2. Channel interactions are based on an interchange of materials and information.

"The supply chain encompasses all activities associated with the flow and transformation of goods from the raw material stage (extraction) through to end users, as well as the associated information flows. Material and information flows both up and down the supply chain" (Handfield and Nichois, 1998).

Characteristic 3. SCM presents a business philosophy of improving the long-term performance of individual companies and the supply chain as a whole and, as a result, attains or sustains a company's competitive position.

"Managing the SC has become a way of improving competitiveness by reducing uncertainty and enhancing customer service" (Chandra and Kumar, 2000).

Publications that discuss a SCM definition agree that:

A) SCM is an interdisciplinary subject.

It is clear from the range of periodicals publishing articles on SCM topics, from farming journals (*New Zealand Farmer*) to international academic publications, that SCM is an interdisciplinary subject. SCM has evolved from integrated logistics, which combined various disciplines as a basis for its theory. The list of these disciplines as given by Stock (1997) include accounting, management, information sciences, economics, marketing, mathematics, philosophy, social sciences, psychology, and sociology.

B) Additional research is required.

Bechtel and Jayaram (1997) listed directions of future SCM research:

- Incorporate design and new product development into supply chain research;
- Integrate SCM across disciplines;

- Expand the role of the customer and customer information;
- Address the differences in supply chain in manufacturing versus service companies;
- Balance conceptual/theoretical research and empirical research.

The need for additional research is confirmed by Svenson (2002) who commented: "Despite the large amount of research performed in academia and management practice implemented in different industries, SCM is still in its infancy".

2.2.3.2. Summary of SCM Definitions from the Literature Review

Based on the above literature review the following conclusions were drawn:

1. As a result of the difficulties in giving a general definition for the subject of the discipline, general supply chain, there are numerous definitions of SCM with each definition presenting the author's view of the subject.
2. The majority of SCM definitions share some common characteristics.
3. Even though SCM, as a subject, has existed for more than a decade "SCM is still in its infancy" (Svenson, 2002) and additional research is required.

2.2.4. SCM Definition Used in this Research

For the purpose of the current research, the following definition of SCM, given by Svenson (2002), was used:

"SCM is a business philosophy that simultaneously should address the overall bi-directional dependencies of activities, actors, and resources on an operative, tactical, and strategic level between the point of consumption and origin in and between marketing channels in the market place".

To justify the selection of this definition, it was evaluated based on the common characteristics of other SCM characteristics 1-3 as presented in Section 2.2.3.1.

Table 2. 5. Comparison of the Selected SCM Definition With the Common Characteristics from the Literature Review

Characteristic From Section 2.2.3.1	Common Characteristics from the Literature Review (1)	Correspondent Part of the Selected Definition (2)
1	The supply chain is an interaction of all mutually dependent firms in a marketing channel.	....bi-directional dependencies of... actors
2	Channel interactions are based on the interchange of materials and information.	bi-directional dependencies of ......resources
3	SCM presents a business philosophy of improving the long-term performance of individual companies and the supply chain as a whole and, as a result, attains or sustain a company's competitive position.	SCM is a business philosophy.....

Definition 1 has the following important characteristics:

- It is general and is applicable to different industries and business structures;
- It directly defines the level of managerial decision-making that takes place in a SC: *'on an operative, tactical, and strategic level'*;
- It clearly defines the system boundaries of SCM as: *'between the point of consumption and origin in and between marketing channels'*.

2.2.5. Conclusions

The literature review presented the positions of different SCM schools. It illustrated contrasting themes and antecedents of the field. The majority of the SCM definitions appear to share common characteristics. These characteristics allowed the selection, for this research, of a SCM definition that shares most common characteristics derived from the literature review.

2.3. Agri-Food SCM

2.3.1. Background

The methods suggested in this research were illustrated and evaluated using agri-food chain case studies. A literature review that investigated the unique characteristics of the agri-food chains was conducted. This review supported the assumption that there were characteristics of agri-food SCs that made them significantly different from other SCs.

"Food is central for life....Food permeates all aspects of our culture and society" (Beer, 2001). This phrase describes the basic difference of agri-food businesses from all other enterprises. As a result, "The food consumer exists in the complicated socio-economic/environmental/political/technological' environment" *(ibid.*, p. 30).

Historically, agri-food chains were coordinated by open markets. With the development of a world economy and a global trade environment, new agri-food integrating models emerged and attracted professional attention. The characteristics of agri-food supply chain management are discussed in the literature from different perspectives. Significant attention is paid to factors affecting agri-food chain structures and performance.

2.3.2. Factors Affecting Agri-Food Chain Performance

2.3.2.1. Product Characteristics

An important role in the agri-food chain structure is played by the individual agricultural products. The following classification of agri-food SCs was suggested by Van Gaasbeek (1994, pp. 237-238):

1. The chain for fresh/or semi-processed agricultural products. The intrinsic product attributes on the consumer level are the same as those on the production level. The role of the chain is the balancing of production and consumer needs (in both quality and quantity) and a smooth and quick distribution of the products to the consumer in order to reduce quality losses.
2. The chain in processed agricultural products in the food markets. The role of the chain is enhanced with an extra value-added link in which the most substantial balancing of consumer wishes and product attributes takes place.
3. The chain of industrial commodities. In this chain the end user of agricultural product is another production chain. In these markets the chemo-physical properties of the agricultural product play the dominant role. The demand for these commodities is determined by the performance of non-agricultural chains.

The above classification stresses the different roles agri-food chains play for different agricultural products. This results in different logistical functions, chain structures and SCM issues. Agri-food SCM research is intensively focused on investigating different factors that influence chain performance. These factors are grouped and reviewed below.

2.3.2.2. Globalisation

Even though globalisation affects the whole of the world economy, there are a number of specific, food related factors. Globalisation has resulted in less restricted agri-food trade policies and led to significant changes of food chain structures (Allen, 2001). Among the changes in agri-food chain structure, increased vertical integration (Yong and Hobbs, 2002) has attracted significant research. Vertical integration in agri-food chains is constrained by the public's desire to protect small independent farms or agribusinesses. Public support puts legal barriers to contractual or vertically integrated coordination. In some cases, savings from the integration may not offset the cost of the coordinating activities (Downey, 1996).

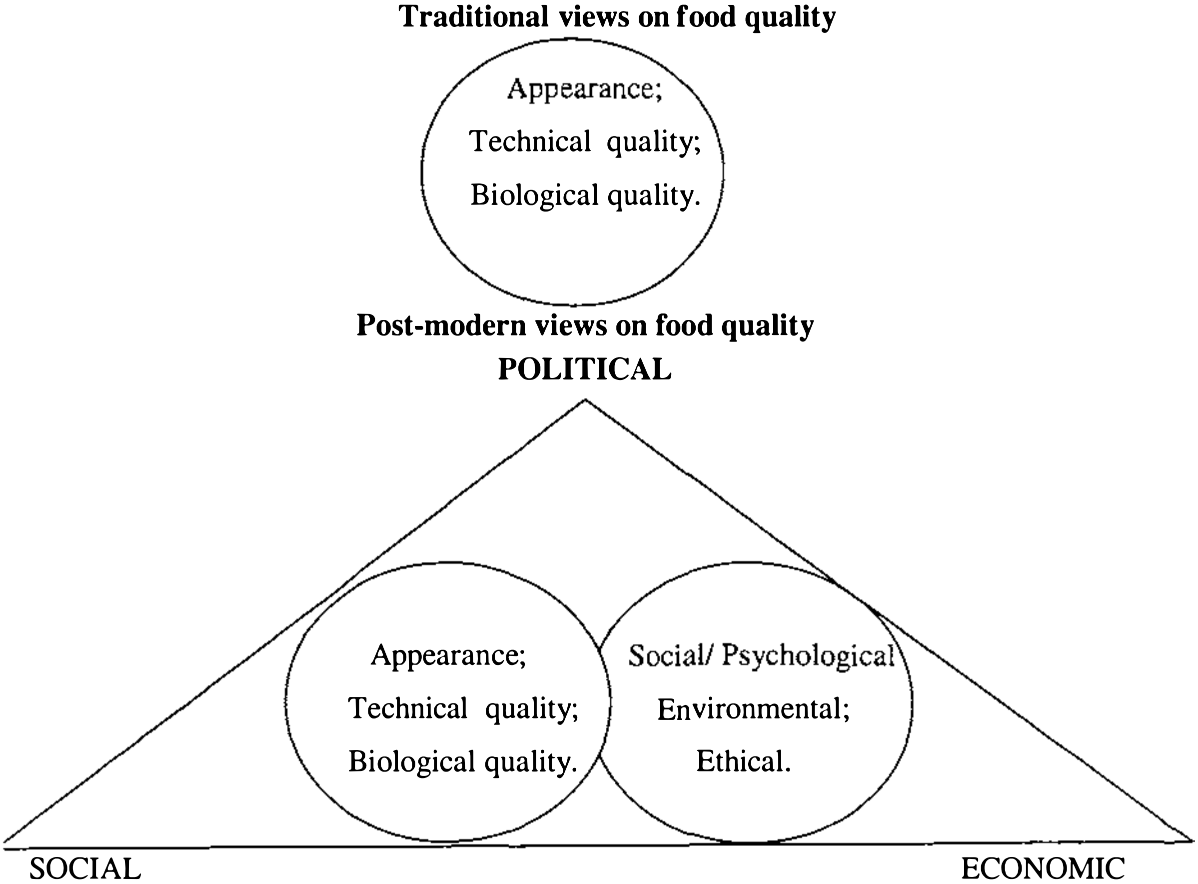
Stephens and Wright (2002) studied the effect of globalisation on major UK food retailing chains. The authors suggested that in some cases globalisation may lead to horizontal integration across competing supply chains. Such integration is possible by the universal adoption of best practice, but will be facilitated by the influence of other characteristics of firms, such as distribution in marketing strategies.

Globalisation has resulted in the decline in the number of wholesalers and other middle-chain participants (Allen, 2001). It also has increased the variety of food products available to consumers. Less restrictive trade policies are favourable for multi-national firms' operations. Global food brands have led to the introduction of the term "cyber food" or "McDonalization"– a new pseudo-food culture where the whole world ends up eating the same food (Beer, 2001).

2.3.2.3. Consumer Attitudes

Food consumers require convenience, variety, and added value. While these requirements are similar to those for many other consumer products, food quality issues are becoming predominant. Traditional views of food quality have changed, too. Beer (2001) presented these changes as follows:

Figure 2.1. The Changing View of Food Quality



Adapted from: Beer, S. A Food and Society in Eastham, J.F., Sharples, L. and Ball, S. (2001) (Ed.). *Food Supply Management: Issues for the Hospitality and Retail Sectors.* Butterworth Heinemann, Great Britain, pp. 23.

This results in increasing brand power, where consumer brand recognition leads to public trust in quality. Food safety issues and food product traceability are subjects of industrial and government legislation. This legislation puts requirements on the agri-food chain physical distribution system structure and its performance. Animal welfare issues also have became a subject of consumer concerns and affected the agri-food chains.

The US grocery industry in the early 1990s introduced the concept of Efficient Consumer Response (ECR). ECR strategy was a result of a specially formed industry project (Joint Industry Project for Efficient Consumer Response, 1994) guided by a mission statement of reducing channel costs and improving inventory control within, and between, all levels of the grocery distribution channel while simultaneously improving customer satisfaction. According to this concept the improved performance can be achieved through "a better allocation of shelf space in the retail store, fewer wasteful promotions and new product introductions and more efficient physical replenishment "(Fearne *et al.*, 2001, p. 83). The underlying concept of ECR is a "natural pull" concept. Scanned point-of-sale data are used to upgrade inventory records and trigger replenishment orders through electronic communications along the chain (Hoffman and Mehra, 2000). This concept was then successfully adapted by collaborative activities of Western European grocery chains (Kotzabt and Teller, 2003).

2.3.2.4. Government and Industrial Policies

Reduction of agricultural support programmes in many Western countries results in requirements on food chains not experienced by other chains. Often, it leads to fewer, larger and more industrialised farms (Beer, 2001). "Some government programmes influence commodity prices and farm income. Others are intended to protect the health of the consumer through the use of crop protection chemicals and affect how livestock producers handle animal waste. Tariffs and quotas impact international trade" (Erickson *et al.*, 2002, p. 10).

Along with government instituted food safety programmes and regulations there are industry specific initiatives to improve consumer confidence. One such programme, Assured British Meat (ABM), has the mission to develop and maintain standards within the red meat industry covering food safety, animal welfare and environmental protection (Source: http://www.abm.org.uk/abm, accessed 18 August, 2004). The aim of this programme is to set standards and to ensure their performance in the entire supply chain to improve consumer confidence in product safety.

Similar initiatives have led to the food traceability concept. Traceability is defined as the ability to follow and document the origin and history of a food or feed product

(*AgBiotech Bulletin*, 2003). European Union Regulation 178/2002 contains general provisions for traceability (applicable from 1 January 2005) which cover all food and feed, all food and feed business operators, without prejudice to existing legislation on specific sectors such as beef, fish, GMOs and so on.

2.3.2.5. Industrialisation

Advances in production technology such as genetic engineering, global positioning systems, preventative animal health programmes, complex and safer crop chemicals coupled with the industrialisation of farming and technology driven control over production have had a significant impact on agri-food chains (Downey, 1996).

Information technology with practically instantaneous data interchange gives an opportunity for more accurate demand-supply forecasting, order processing and is used in many agri-food supply chain programs, such as traceability. It allows an increase in agri-food chain responsiveness and flexibility. E-commerce for food products opened new niche market opportunities (Towill *et al.*, 2002).

2.3.2.6. Biological and Perishable Nature of Raw Materials

The biological nature of agricultural production affects the quantity and quality of available raw materials (Erikson, 2002). Many operations management issues related to the agri-food supply chains, such as plant location, transportation, and scheduling are related to the seasonality and perishability of agricultural production. The perishability of a product results in specific material handling requirements and regulations. The seasonality of agricultural production results in bulk volumes being produced, transported and stored for processing over a relatively short period of time. This leads to increased logistics costs, reduced flexibility and dependence on supplier performance (Erickson *et al.*, 2002).

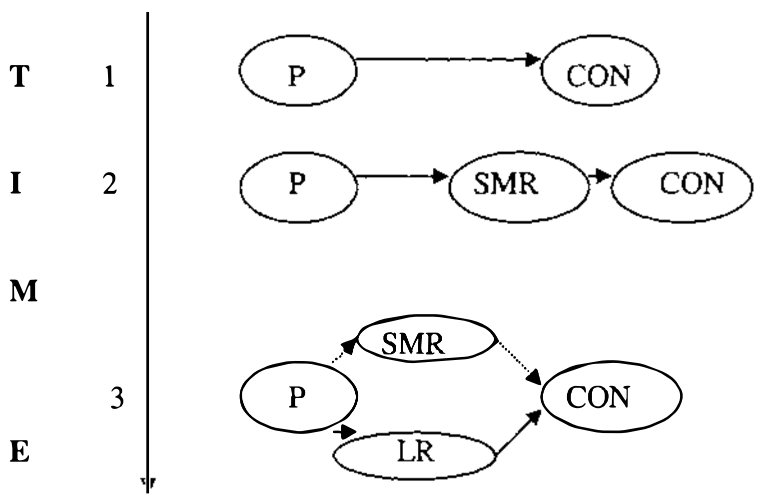
The perishable nature of agricultural production, when combined with consumer demands on year-round availability of food products, and long distances in the global marketplace, place unique requirements on the performance of agri-food chains.

2.3.2.7. Structural Changes in Agri-Food Chains

Researchers have studied changes in the agri-food chain structure. Vertical integration in agri-food chains has attracted a significant amount of attention from researchers (Barkema and Drabenstott, 1995; Fearne *et al.*, 1998; Hobbs and Young, 2000; Young and Hobbs, 2002). Horizontal integration of agri-food chains such as co-operatives, buying groups, purchasing/marketing alliances have also been intensively studied (King and Phumpiu, 1996).

The evolution of the food supply chains may be presented,as follows:

Figure 2. 2. Various Stages in the Evolution of the Supply Chain



Where: P: Producer; CON: Consumer; SMR: Small/Medium sized Retailer
LR: Large Retailer.
Adapted from: Beer, S. A Food and Society in Eastham, J.F., Sharples, L. and Ball, S. (2001) (Ed.). *Food Supply Management: Issues for the Hospitality and Retail Sectors*. Butterworth Heinemann, Great Britain, p. 25.

Figure 2.2 shows that with the industrialisation of agriculture, more intermediate steps in the agri-food chain have appeared between producers and consumers. At the same time, there is growth in farmers' markets, where farmers return to the first model in Figure 2.2. where theys sell their produce directly to customers. For example, in the USA the number of farmers' markets incresed from 1,755 in 1994 to 3,137 markets in 2002 (approximately 79%) (USDA, http://www.ams.usda.gov/farmersmarkets/ accessed 22/04/2004).

In addition to the growth in farmers' markets, there is the rise in the number of food and beverage manufacturers who have switched to the Internet and the use of the electronic Fast Moving Consumer Goods concept (eFMCG). EFMCG allows a decrease in the number of intermediaries in the consumer-directed part of the food chain (Tormey, 2000; Partos, 2001; Eurofood, 2001).

Stephens and Wright (2002) listed the following important isuues concerning the food SC evolutionary process:

1. The evolutionary process through "logistics" to "supply chain management" has been holistic in the sense that it assumes that all of the component parts of the supply chain, including physical distribution, must be treated collectively in their contribution to competitiveness.
2. The supply chain models offered are increasingly irrelevant in an environment of concentrated retail power with an increasingly complex and fragmented supply base.

2.3.2.8. Increase in Contractual Production

Between 1991 and 1997, the share of commodities produced under marketing contracts increased from 16 to 22% of the total value of U.S. production. The same trend was found in the Canadian agri-food sector (Young and Hobbs, 2002). There is also a development of contracting farming when the farmer signs an agreement to supply a food processor or retailer with a specific crop (Webster, 2001). Contractual production is usually associated with vertical integration. Contractual production reduces the producer's price risk but replaces it with relationship or contractual risk (Boehlje *et al.*, 1999).

2.3.3. Conclusions

In addition to the general SCM research topics described in Section 2.2, agri-food SCM has a set of specific research topics, such as social responsibility, the changing role of agricultural cooperatives, consumer food safety concerns, and designing systems for food quality. Significant attention in agri-food research is paid to the influence of specific agri-food factors in chain structure and performance. Agri-food chains have experienced rapid vertical and horizontal integration with an increase of contractual production. At the same time the cooperative structure of the production base may attempt to protect small independent farms or agribusinesses and put constraints on integrated coordination of SCM initiatives. All these factors increase the complexity of SCM strategic initiatives and indicate the unique nature and characteristics of agri-food chains.

2.4. Strategic Planning

2.4.1. Background

Schary and Skojott-Larsen (1995) defined the goal of SC strategy as optimisation, balancing individual objectives to achieve larger goals, in this case to meet the needs of higher corporate strategy. This quotation is indicative of the efforts to describe the main question surrounding supply chain management (SCM). What is the link between strategic planning and SCM? Strategic planning is a broad managerial discipline with a long history and several recognised and co-existing schools of thought.

A brief overview of existing strategic planning schools, combined with a description of different levels of strategic planning, will give a useful perspective and a clearer understanding of the relevance of different strategic planning schools to SCM. This is important in order to understand how value may be measured at different levels of business planning encompassing more than one business.

The concept of strategic planning, as with many other social disciplines, incorporates terminology and models from other fields, such as political science, organisation theory, military science, and business policy (Fombrum and Astley, 1983). For the purposes of this overview of the existing strategic planning schools, the researcher followed the strategic planning valuation framework suggested by Mintzberg and Lampel (1999).

A second classification of strategic planning used in the literature is produced according to planning levels: business, corporative and collective strategic planning. This framework, introduced by Peck and Juttner (2000), allows the relating of collective strategies to supply chain relationships.

The conclusions from the literature review were that collaboration and convergence of strategic management and SCM is required to achieve new strategic management approaches using SCM strategies.

2.4.2. Definitions

The word "strategy" comes from the Greek "strategos," "the art of generals."
Hax and Majluf (1996) provided a comprehensive definition of strategy:

Strategy

1. Determines and reveals the organizational purpose in terms of long-term objectives, action programs, and resource allocation priorities;
2. Selects the businesses the organization is in, or is to be in;
3. Attempts to achieve a long-term sustainable advantage in each of its businesses by responding appropriately to the opportunities and threats in the firm's environment, and the strengths and weaknesses of the organization;
4. Identifies the distinct managerial tasks at the corporate, business, and functional levels;
5. Is a coherent, unifying, and integrative pattern of decisions;
6. Defines the nature of the economic and non-economic contributions it intends to make to its stakeholders;
7. Is an expression of the strategic intent of the organization;
8. Is aimed at developing and nurturing the core competencies of the firm;
9. Is a means for investing selectively in tangible and intangible resources to develop the capabilities that assure a sustainable competitive advantage.

This definition is an attempt to cover all aspects of strategy and its role and purpose in business.

Ansoff (1965) stated that planning is required when the future state we desire involves a set of interdependent system decisions; that is a system of decisions. Mintzberg (1994) added that planning is a formalised procedure to produce an articulated result, in the form of an integrated system of decisions. The author stressed that the important components of planning are thinking about, and attempting to control, the future.

Strategic planning therefore not only is system oriented but also is oriented towards the future. It focuses on the anticipated future. It is based on the thorough analysis of foreseen or predicted trends and analysis of internal and external data. Strategic planning, according to Rowley *et al.* (1997), allows organisations to focus, because it is a process of dynamic, continuous activities of self-analysis.

2.4.3. Strategic Schools of Thought

The classification of strategic management schools given by Minzberg and Lampel (1999) is presented in Table 2.6. This classification indicates the breadth of the field of strategic planning and underscores its inter-disciplinary nature. The authors concluded that a new approach to strategic management is required. They listed the four main driving forces for such change as:

- Collaborative contacts between organisations;
- Competition and confrontation;
- Recasting the old strategic ideas;
- Sheer creativity of managers (*ibid.*, p. 29).

Today's business economic environment may be characterised by the reduction of trade barriers, increased consumer expectation, new product safety regulations, environmental concerns, recycling requirements, and increased volatility in financial/currency markets (Cohen and Huchzermeier, 1999).

Recent models of strategic planning have focused on adaptability to change, flexibility, the importance of strategic thinking, and organizational learning. 'Strategic agility' is becoming as important as strategy. It is happening because the organisation's ability to succeed "has more to do with its ability to transform itself, continuously, than whether it has the right strategy. Being strategically agile enables organisations to transform their strategy depending on the changes in their environment" (Gouillart, 1995).

Table 2.6. Dimensions of the Ten Schools of Strategy Formation (According to Mintzberg and Lampel)

School	Source	Base Discipline	Champions	Intended Messages	Realized Messages	School Category	Associated Homily	Some Shortfalls
Design	P.Selznick	None (Architecture as metaphor)	Case study teachers (especially at or from Harvard University), leadership aficionados, especially in the United States	Fit	Think (strategy making as case study)	Prescriptive	"Look before you leap"	Neither analytical, nor intuitive. Too static for the era of rapid change.
Planning	I.Ansoff	Some links to urban planning, system theory, & cybernetics	"Professional" managers, MBAs, staff experts (especially in finance), consultants, & government controllers - especially in France and the US	Formalize	Program (rather than formulate)	Prescriptive	"A stitch in time saves nine"	Neither supports real-time strategy making nor encourages creative accidents.
Positioning	Purdue University	Economics (industrial organization) & military history	As in planning school, particularly analytical staff types, consulting boutiques", & writers, especially in the US	Analyze	Calculate (rather than create or commit)	Prescriptive	"Nothing but the facts, madam"	Strategy is reduced to generic positions selected through formalized analysis of industry situations.
Entrepreneurial	J.A.Schumpeter, A.H.Cole & others in economics	None (although early writings come from economics)	Popular business press, individualists, small business people everywhere but most decidedly in Latin America & among overseas Chinese	Envision	Centralize (then hope)	Descriptive (some prescriptive)	"Take us to your leader"	Vague vision; strategies are designed manly based on the leader's intuition.

Table 2.6. Dimensions of the Ten Schools of Strategy Formation (Continued)

School	Source	Base Discipline	Champions	Intended Messages	Realized Messages	School Category	Associated Homily	Some Shortfalls
Cognitive	H.A.Simon & J.March	Psychology (cognitive)	Those with psychological bent - pessimists in one wing, optimists in the other	Cope or create	Worry (being unable to cope in either case)	Descriptive	"I'll see it when I believe it"	Too subjective approach to strategy formulation - it is just in the head of the strategist.
Learning	C.E.Lindbiom, M.Cyert, J.G.March, K.E.Weick, J.B.Quinn & C.K.Prahlad & G.Hamel	None (perhaps some peripheral links to learning theory in psychology & education). Chaos theory in mathematics.	People inclined to experimentation, ambiguity, adaptability - especially in Japan and Scandinavia	Learn	Play (rather than pursue)	Descriptive	"If at first you don't succeed, try, try again"	Strategy development process is rather chaotic, unpredictable and process-rather than result-oriented
Power	G.T.Alison (micro), J.Pfeffer & G.R.Salancik, & W.G.Astley (macro)	Political science	People who like power, politics, & conspiracy, especially in France	Promote	Hard (rather than share)	Descriptive	"Look out for number one"	Focuses mainly on the clash of self-interests of stakeholders during the process of strategy development
Culture	E.Rhenman & R.Normann in Sweden	Anthropology	People who like the social, the spiritual, the collective - especially in Scandinavia and Japan	Coalesce	Perpetuate (rather than change)	Descriptive	"An apple never falls far from the tree"	Not well suited for radical change projects.

Table 2.6. Dimensions of the Ten Schools of Strategy Formation (Continued)

Environment	M.T.Hannan & J.Freeman. Contingency theorists (eg D.S.Pugh et al)	Biology	Population ecologists, some organization theorists, splitters, & positivists in general - especially in the Anglo-Saxon countries	React	Capitulate (rather than confront)	Descriptive	"It all depended"	Severe limits to strategic choice.
Configuration	A.D.Chandler, McGill University group, R.E.Milles & C.C.Snow	History	Lumpers & integrators in general, as well as change agents. Configuration perhaps most popular in the Netherlands. Transformation most popular in the US	Integrate, transform	Lump (rather than split, adapt)	Descriptive & prescriptive	"The everything there is a season"	Polarized between two approaches favoring either radical or incremental change

1. "Strategic Management - Competitiveness and Globalization", M.A. Hint, R.D. Ireland, and R.E. Hoskisson, 2001.
2. "Strategy and the Delusion of Grand Designs", John Kay, 2003.

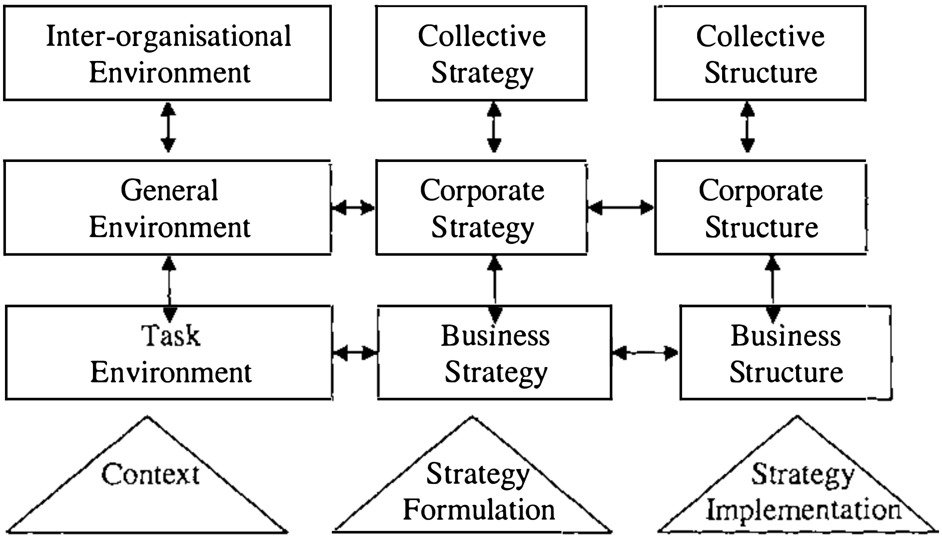
Source: Mintzberg, H. and Lampel, J. (1999) Reflecting on the Strategy Process, Sloan Management Review, Spring, pp.23-24.

2.4.4. Levels of Strategic Planning

Strategy formulation in the strategic planning schools may be classified into three levels: business strategies, corporate strategies (Hofer and Schendel, 1978), or collective strategies. Some strategic planning schools address the strategic formulation problem in the context of providing an organisation with competitive advantages over other organisations in the same market place. This type of strategy is also referred to as competitive strategy (Grant, 2002). These discussions were supplemented with corporate-level strategic planning (Ansoff, 1965), where the focus was broadened to include the set of product/market segments. Bourgeois (1980) refers to corporate strategy as the task of domain selection and business strategy as the task of domain navigation.

The dynamic nature of the business environment suggests that instead of a passive approach to the environmental impact on business strategic planning, an active approach - a shift to actions influencing this environment - is appropriate. "The critical variable of organisation – environment relations is choice, in that strategic, self-serving action assumes a degree of autonomy on the part of organisations to select beneficial courses of action and to manoeuvre independently on their own behalf" (Astley, 2001). This citation demonstrates a shift of the strategic planning domain from the corporate level to the level of collective strategies. Bresser and Harl (1986) defined collective strategy as a systemic approach by collaborating organisations for dealing with variations in their interorganisational environment. This shift is illustrated in Figure 2.3.

Figure 2.3. Levels of Organisational Strategy



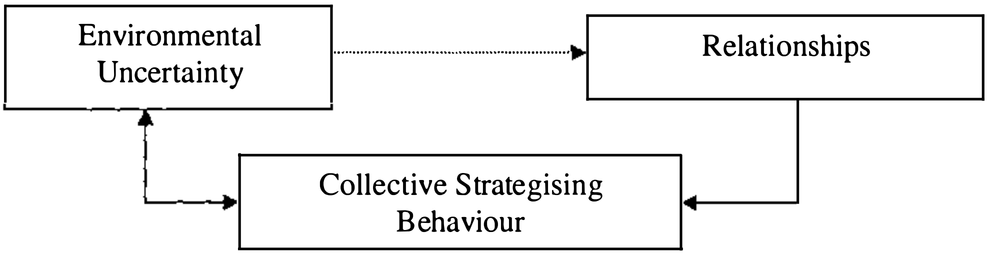
Source: Fombrun, C. and Astley, W.G. (1983) Beyond Corporate Strategy. *The Journal of Business Strategy*, 3(4), p. 48.

This view of strategic planning in which collaborating organisations are included in strategy discussions can be interpreted as an effort to blend SCM with strategic planning. This is further discussed in the next section.

2.4.5. Strategic Planning and the Supply Chain Concept

The shift of the strategic planning domain to the level of collective strategies was further investigated in the context of SC. Peck and Juttner (2000) suggested the following framework to relate collective strategies to supply chain relationships:

Figure 2.4. Strategies and Relationships in Supply Chains



Source: Peck, H. and Juttner, U. (2000) Strategy and Relationship: Defining the Interface in Supply Chain Context. *The International Journal of Logistics Management*, 11(2), p. 36.

In this model the first construct, the collective strategising behaviour in supply chains, is focused on ways in which organisations are linked. Weitz and Jap (1995) defined three models for the controlling of these relationships: power, contracts or trust. Power is a unilateral form of control where one party dominates the decision-making process (*ibid.*, 1995). A contractual relationship control mechanism includes an agreement between the parties involved on terms of relationships and mutual responsibilities. Trust is a bilateral form of control which is less formal than contracts and is an important part of strategic choice (Wicks *et al.*, 1999).

The long-term relationship approach has been seen by some authors as partnerships or alliances (Vlosky and Wilson, 1997). Global supply chains involve the creation of either partnerships or alliances (Schary and Skojott-Larsen, 1995). Ellram and Cooper (1990) defined supply chain partnerships as forward looking, taking place over the extended time period, and involving trust and associated sharing of information, risk and reward.

The models shown in Figure 2.3 and Figure 2.4 indicate the origins of supply chain collective strategic behaviour and its relationship to the different forms of supply chain relationships. In both models, an uncertain external environment is considered as a leading cause of change.

2.4.6. Supply Chain Strategies

Despite the significant attention paid by business and academia to the topic of SCM, the strategic management field has largely ignored SCM (Ketchen and Giunipero, 2004).

The strategic management research briefly discussed above permits many views of current SCM strategic discussions. This view is supported by the following classification, offered by Person (1991):

- Using the supply chain to influence competitive forces. These strategies are closely related to Porter's (1980) definition of the five forces that influence strategy (see the Positioning school in Table 2.6).
- Utilising existing resources to create new business by developing and marketing new logistics services or developing new markets. This strategy is closely related to Ansoff's (1965) propositions (see the Planning school in Table 2.6).
- Re-engineering the total logistics system to provide superior logistics service to customers. This focus is on efficiency improvement and cost leadership. This strategy is closely related to the Positioning school in Table 2.6.

2.4.7. Conclusions

Similarly to the strategic management concept, supply chain management has incorporated terminology and models from other fields.

Strategic management offers SCM a choice of different schools, methods and approaches applicable on the collective level of strategic planning (see Figure 2.3).

Supply chain management, by itself, offers strategic management system-wide analysis. SCM may be viewed as an organisation composed of participants, social structures, goals, and technology (Leavitt, 1965). Ketchen and Giunipero (2004) suggested defining such an organisation as a relatively enduring interim cooperative that uses resources from participants to accomplish shared and independent goals of its members.

SCM offers strategic planning researchers a wider level of system analysis and the ability to shift from the passive approach of reacting to environmental impacts on business strategic planning to actions that influence this environment. Recent publications stress the importance of a facilitated exchange between SCM and strategic planning and of expecting increased collaboration and convergence between the fields over time (Ketchen and Giunipero, 2004).

2.5. Performance Measurement Systems in SCM

2.5.1. Background

To determine how well, or how poorly, a system is performing, that system must be measured. Without some form of measurement system, it is not possible to evaluate the performance of a system.

Using the SCM definition set out in Section 2.2.4, the performance of SCM initiatives may be evaluated based on how well the SC achieves the operational, tactical and strategic goals of all activities, participants, and resources in the chain and the SC system as a whole. Without some form of measurement system, the performance of SCM initiatives may not be evaluated. It follows, therefore, that in order to monitor and control SC performance it is necessary to have a SCM Performance Measurement System (PMS).

A problem that arises in the context of measuring performance is that while individual firms may control their activities and resources, across a SC there is no direct ownership and control of activities and resources. Consequently, a PMS system for SCM initiatives should be able to incorporate the performance goals of each SC participant into the system-wide goals of the entire SC.

Various attempts have been made to devise measurement systems for SCM initiatives, but - as happened with the scope and definition of SCM itself - no general agreement on how to measure the performance of a SC has been reached. A discussion of this is below.

The modern approach in efforts to improve performance originated in the 1990s. This new step in performance measurement was a result of advances in information technology. During this time, it was recognised that performance improvement should be well structured, should encompass an entire organisation rather than individual operational units, and that a business should increase its knowledge of the external business environment and competitors' behaviour.

Trent and Monczka (1998) conducted research on purchasing and supply chain trends during the 1990s. According to their findings "performance improvement requirements" was one of the strategic trends in the 1990s. This emphasis led to an "increasing reliance on performance measurement" (*ibid.*, p. 7). In 1993, 26% of the companies surveyed declared they had introduced measurement systems to analyse the total cost of ownership. In 1997, more than 83% of firms surveyed used performance measurements as part of their efforts to reduce business costs (Gadde and Hakansson, 2001). The results of research conducted in 2000, during the time of increased attention to supply chain management philosophy, stressed the importance of measurement systems to both decision assessment and for continuous improvement (Monczka and Morgan, 2000).

Also during this time, it was recognised that business performance should be benchmarked against the performance of other organisations. This recognition was important in that, by benchmarking, businesses began to look outside the firm in an effort to identify areas of internal improvement, to integrate improvement plans, and to assess improvement progress (Jensen and Sage, 2000).

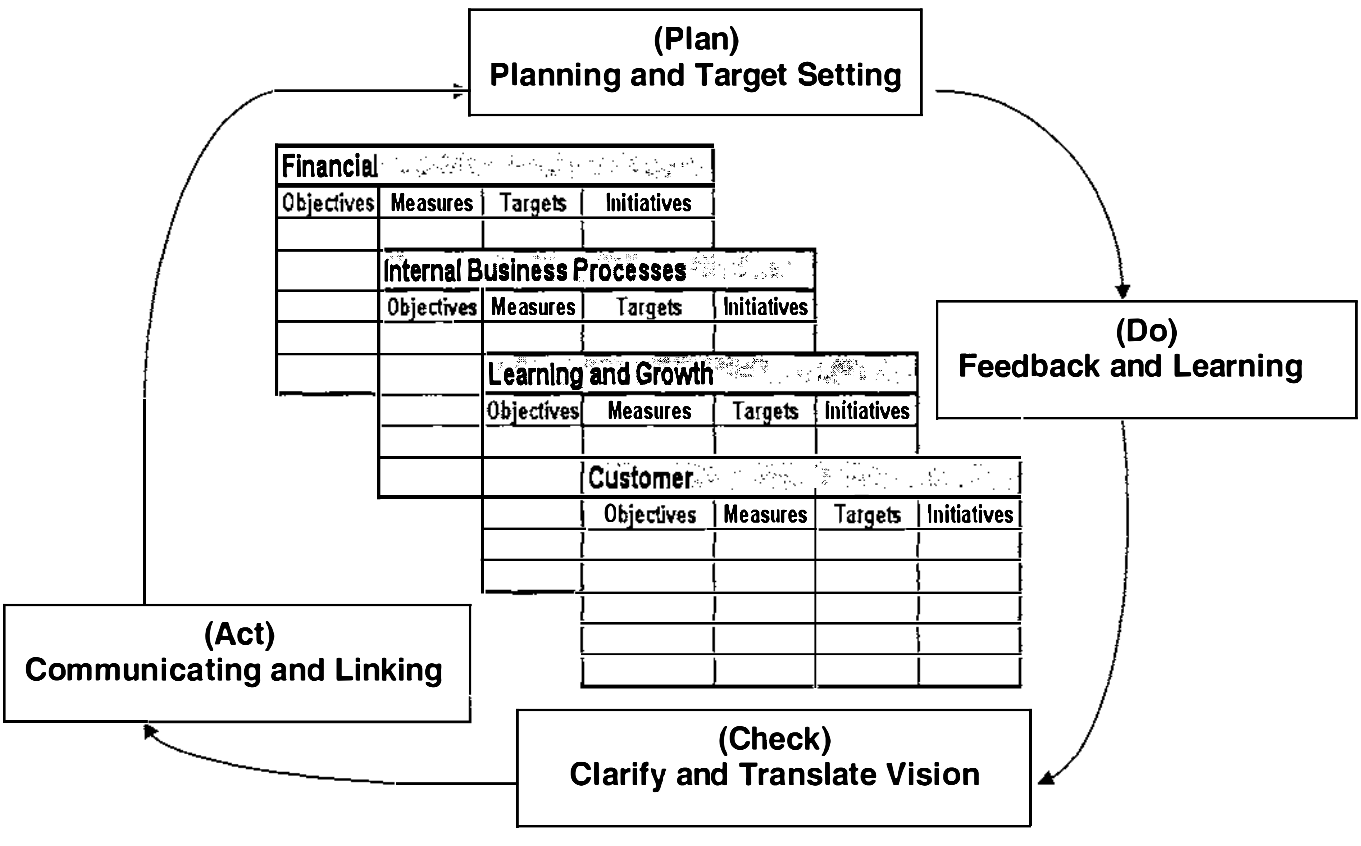
2.5.2. PMS Models

As a result of the increase in the efforts of businesses to measure their performance, numerous methods and models have been developed for the design and implementation of PMS for business. The most popular models of these PMS are briefly described below.

2.5.2.1. Balance Scorecard Model

In 1992 Kaplan and Norton offered the Balance Scorecard Model. The Balance Scorecard involves four processes: "plan-do-check-act". These processes are depicted in Figure 2.5, below.

Figure 2.5. The Four Processes to Manage Strategy in the Balance Scorecard



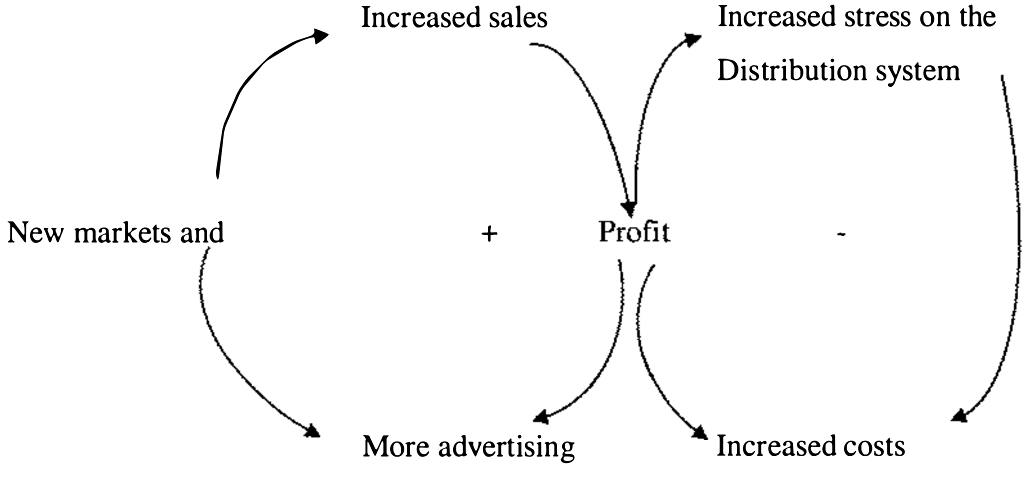
Source Sage, A. and Jensen, A.J. Systematic Measurements in Sage, A. P. and Rouse, W.B. (1998) (Eds.) *The Handbook of systems engineering and management*. John Wiley, New York, p. 559.

The main purpose of scorecards is the development of a set of strategic measures that are supported by a set of diagnostic measures. The balanced scorecard model claimed to be not only a measurement tool, but also a management system that translates strategy into objectives. This model has become very popular, with an entire industry developed around the Balanced Scorecard approach (Lapide, 2003).

As with total quality management, the Balance Scorecard Model has its critics. Neely *et al.* (1997) claimed that the Balance Scorecard Model does not include efforts to provide an answer to one of businesses' most important questions: What are the competitors doing?

Although Kaplan and Norton used a linear cause-and-effect relationship in their model, Holmberg (2000) suggested a different technique when he turned linear cause-and-effect relationships into a closed loop that resulted in increased uncertainty of the impact of linear relationships.

Figure 2.6. Circular Cause-and-Effect Relationships



Adapted from: Holmberg, S. (2000). A System Perspective of Supply Chain Measurements. *International Journal of Physical Distribution and Logistics Management*, 30(10), p. 862.

2.5.2.2. Activity Based Costing

Activity Based Costing (ABC) was created to overcome the inability of traditional accounting methods to relate financial measures to business operational performance. ABC was not designed to be a replacement for traditional accounting but rather an effort to translate accounting data into cost data that may be used for managerial decision making . "ABC data should be considered as a way to achieve insights, both strategic and operational, into organisational performance" (Cokins, 1996, p. 215).

The ABC method is based on disaggregating business activities into cost drivers in an attempt to estimate resource requirements. This method provides the information to give management a better understanding of SC productivity than do traditional accounting data.

2.5.2.3. Economic Value Analysis

Economic Value Analysis (EVA) was introduced by Stern Stewart Corporation (Stern *et al.*, 2001). EVA is a financial performance metric directly linked to the creation of shareholder value.

Stewart defined EVA (2001) as net operating profit after taxes (NOPAT) with a capital charge subtracted:

EVA = NOPAT – CAPITAL COST ⇔
EVA = NOPAT – COST OF CAPITAL x CAPITAL employed

Or equivalently, if rate or return is defined as NOPAT/CAPITAL, this turns into another formula:

EVA = (RATE OF RETURN – COST OF CAPITAL) x CAPITAL

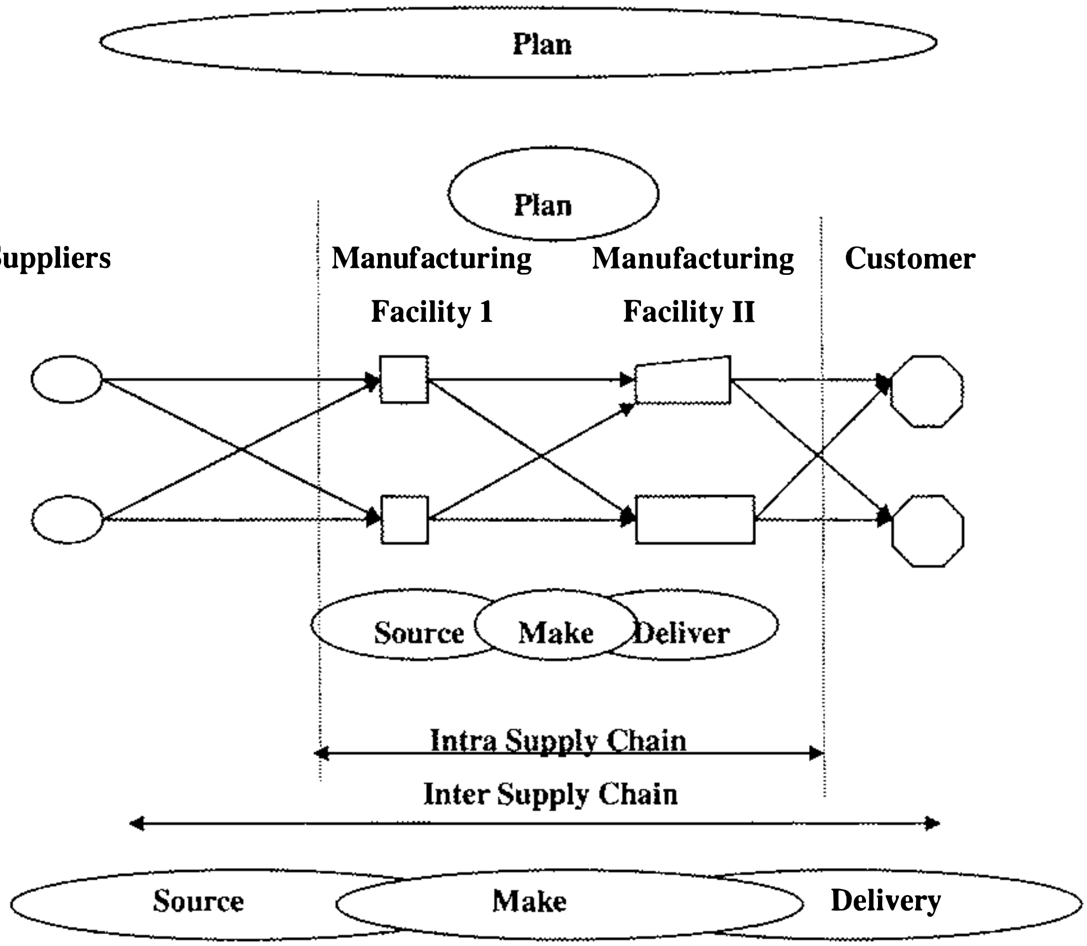
"By measuring the value added over all by costs, including the cost of capital, EVA measures, in effect, the productivity of all factors of production" (Drucker, 1995, p. 59).

EVA can be used to measure an enterprise's value-added contribution within a supply chain. EVA is useful to assess long-term shareholder value but it is less useful for measuring detailed SC performance. "It does not, by itself, tell us why a certain product or a certain service does not add value or what to do about it" (Drucker, 1995, p. 59).

2.5.2.4. Supply Chain Operation Reference Model

The Supply-Chain Council's 1996 introduction of the Supply Chain Operation Reference Model (SCOR) model has developed into one of the more successful recent PSM initiatives. The SCOR model provides guidelines for measuring a firm's overall SC performance. SCOR creates a common measurement framework by creating a common language of standardised metrics and mapping procedures for analysis. The model is organised around the four primary management processes of Plan, Source, Make, and Deliver. Figure 2.6, below, illustrates supply chain infrastructure based on the SCOR model.

Figure 2.7. The SCOR –Based Supply Chain Infrastructure



Source: Huan, S.H., Sheoran, S.K., and Wang, G. (2004) A review and Analysis of Supply Chain Operations Reference (SCOR) Model. *Supply Chain Management: An International Journal*, 9(1), p. 24.

Following the SCOR process requires high quality communication between a company, its suppliers, and its customers. This model is based on the integration of well-known concepts of process reengineering, benchmarking, and process measurement into a cross-functional relationship by:

- Capturing the "as is" state of a process and deriving the "to be" future state (reengineering);

- Quantifying the operational performance of similar companies to establish "best of class" performance (benchmarking); and,
- Characterising and describing the management processes that will result in "best of class" performance (best practice analysis).

As with other PMS, SCOR has its critics. "A frequently cited weakness of SCOR is the difficulty in implementing and executing. Closely related is a poor programmatic infrastructure." (Source: Greg Gorbach (February 17, 2004), *The ARC Advisory Group*, SupplyChainBrain.com http://www.glscs.com/news/. Accessed 7 April, 2004).

The SCOR model provides 12 performance metrics. Huan *et al.* (2004) addressed the issue of how these 12 metrics may be used to derive a quantifiable supply chain performance measure for the network optimisation decision-making process. The authors stress the importance of such a measure to reflect the dynamic nature of supply chains.

The SCOR model is not for every company and situation. A company must be willing to make fundamental changes in its business to improve the supply chain. The 'one size fits all' approach fails to recognise the differences of different industries, such as agriculture. The lowest price the author was able to find for introductory SCOR software was $25,000 USD.

2.5.3. PMS Research

As mentioned in Section 2.2.3, academics and practitioners have not reached agreement on a single definition of SCM. A similar situation has arisen for PMS. Comparing different PMS leads to lack of consistency in what constitutes a PMS. This lack of consistency may be a result of:

- Authors applying a performance measurement system using their own definition of the supply chain (Beamon, 1999) ;

- Avoiding the need to give their own SCM definition, authors focus on the measurement of a limited number of general SC characteristics (O'Donnel and Duffy, 2002);
- A lack of an interdisciplinary approach to the subject. Authors focus on the discipline of their expertise, for example, logistics or operational research. Gingenzer (2000) addresses this issue very directly: "Intellectual inbreeding can block the flow of positive metaphors from one discipline to another".
- Not connecting strategy and measurement (Eccles, 1991; Adams *et al.*, 1995)

Researchers have attempted to answer, or recognise, three key PMS questions:

1. Why is a PMS important? - Improper use of measurement tools or lack of measurements can be a barrier to implementing SCM (Bechtel, 1997).
2. What advice may be followed when selecting a PMS? What steps should be followed to implement a PMS? (Van Aken, 2002)
3. What should a PMS system do? Suggestions include:
   - "use integrated measures" (Bechtel and Jayaram, 1997);
   - "support innovative strategies" (Scapens, 1998).

Mintzberg and Lampel (1999) describe this confusion over not only the definition of PMS, but also how to use it, as a situation in which: "We are the blind people. Each of us, in trying to cope with mysteries of the beast, grabs hold on some part or other" (*ibid.*, p. 21).

Despite the lack of a consensus on several important aspects of PMS, researchers are able to agree on several common principles (Caplice and Sheffi, 1995):

- PMS should be comprehensive – it needs to capture performance in multiple dimensions (Harrington, 1991; Kaplan and Norton, 2001);

- PMS should be causally oriented – it should capture the drivers of performance. It is important to include non-financial metrics into PMS (Eccles, 1991; Kaplan and Norton, 2001);
- PMS should be vertically integrated – it should link together all levels of organizational decision-making from strategy formation to operational planning (Lynch *et al.*, 2003) ;
- PMS should be horizontally integrated – it should align business processes (Lee and Billington, 1993);
- PMS should be internally comparable – it should permit trade-offs between different dimensions of performance (Caplice and Sheffi, 1995);
- PMS should be useful – it should be understandable to its users and provide a guide for action (Caplice and Sheffi, 1995).

The above list has been further upgraded through additional research. For example, Caplice and Sheffi (1995) define eight metric evaluation criteria as validity, robustness, usefulness, integration, economy, compatibility, level of detail, and behavioural soundness.

During the last ten years, literature reviews on PMSs have become common, possibly as a result of the lack of consensus over the nature of PMS. For example, Van Hoek (1998) gives an overview of PMS literature up to the year 1997. Bourne *et al.* (2002) conducted a comprehensive overview of the literature on PMS implementation and grouped the results by:

- Organisational content;
- Process development; and
- Measurement content.

Other publications have stressed the need for additional research in PMS (Cooper and Ellram, 1997).

This research assumes the SCM philosophy has been widely embraced, if not enacted, by the business community. Market demand for ready-to-use solutions has occurred and has been met with SCM integrated approaches offered by commercial consulting firms. These approaches offer an integrated SCM solution based on different key SCM concepts and PMSs. With integrated solutions widely promoted by consulting businesses, even without a formal theory, many businesses have adopted these SCM solutions. The adaptation may be partially caused by intuitive sharing of the SCM philosophy by businesses as a way to achieve competitive advantage through close cooperation. As a result of the popularity of PMS, publications have appeared which analyse how PMSs may be used (For example, Lapide, 2003; Kennerley and Neely, 2002; Santos, 2002).

During 2000s, the discussion of how SC system dynamics affect PMS has grown. In their recent publication, Kennerley and Neely (2002) provide a list of issues that should be considered in managing the PMS to reflect the changing organisational requirements. Santos (2002) suggests using system dynamics and multi-criteria decision analysis when developing a PMS.

2.5.4. Conclusions

As is the situation with defining SCM itself, as previously discussed, there is no one school that dominates PMS. This lack of agreement has resulted in a considerable PMS body of literature, as noted above.

The researcher believes the literature reflects the situation that PMS is either too broad or too narrow and lacks an interdisciplinary perspective.

The business community has supported the SCM philosophy and has put into practice ready-to-use SC solutions. The most successful has been the SCOR model, supported by numerous Supply Chain Council members. SCOR requires process reengineering and considerable investment of time and money. Significant international corporations, such as Coca-Cola and Fonterra, support this initiative. SCOR has an opportunity to become an industrial standard, if it incorporates measures supporting supply chain optimisation decision making (Huan *et al.,* 2004).

Despite the broad acceptance of the need for PMS, a survey conducted by the Institute of Management Accounting (IMA) in 2001, reported that 31% of the survey respondents indicated they believe their PMS are less than adequate or poor in their ability to support management's objectives and initiatives. Fifteen percent of the firms surveyed considered their PMS as very good to excellent (Kellen and Wolf, 2003).

Chibba, A. and Hörte (2003) conducted a meta-analysis of 158 articles on SC performance. Only four articles discussed measures related to the front or back links of the SC, and they were mostly related to delivery or quality issues. The authors concluded that the most preferred measures were one-sided measures between suppliers or customers.

The PMS discussed above focus mainly on the performance of bi-directional material flows in a chain. The financial measures discussed, such as EVA or ABC, measure items from the internal business perspective. The researcher failed to find any references in research on the co-ordinated measurement of all three bi-directional SC flows: material, financial and informational.

2.6. Connecting of the Literature Review Findings to the Research Problems

The literature review conducted in Section 2.5 showed that existing SCM PMSs do not provide a strong base for SC optimisation decision making. This presents an obstacle for system-wide strategic planning and constrains system-wide thinking (Problem 3).

Even though many SCM definitions include the philosophic nature of this discipline (Section 2.2.3) this is made authoritative. The absence of a system-wide planning framework complicates the acceptance of a SCM philosophy by all chain members (Problem 1).

The existence of many schools for both SCM and Strategic Management, when combined with early stages of collaboration between these two disciplines (Section 2.4), increases the need for interdisciplinary research in these fields and stresses the need for a theoretical base for SCM (Problem 2).

Agri-food SCs have unique characteristics and face a number of rapid, system-wide changes. These factors have increased the use of contractual production (Section 2.3). The increasingly complex and fragmented agri-food supply base constrains the development of SCM initiatives and requires special consideration. It places agri-food supply chains into a special class of chains, which, in addition to all generic SCM problems, have a number of industry-specific challenges (Problem 4).

Chapter Three

Methodology - Primary Concepts

The aim of the suggested methodology is to measure total SC performance through the measurement of interrelated material, informational and financial flows. The methodology uses a uniform scale to measure the performance of single transactions in the above three flows. Performance measurement of separate transactions is then extended into the level of contractual performance by the integration of performance measures for all contractual transactions. The total supply chain is described as a bounded network of businesses connected by contractual agreements. The integration of performance measures for all contractual agreements in each supply network path is used for the total supply network performance analysis. The methodology is applied to the performance measurement-induced strategy model developed by Dyson and O'Brien (1998). This relates the methodology to different planning horizons such as tactics, objectives, and operational targets, and demonstrates how this method reflects the dynamics of a system.

3.1. Structure of Methodology

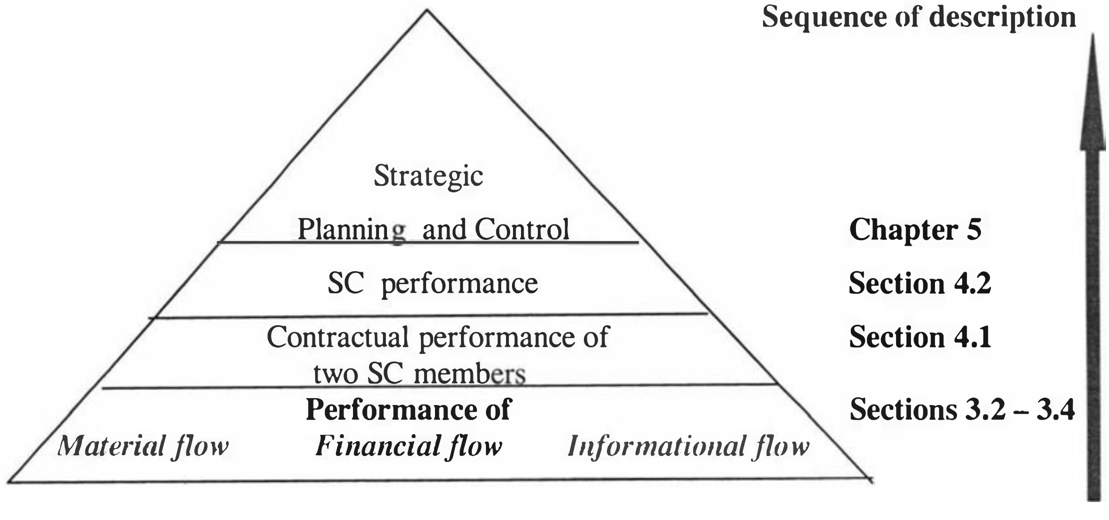
3.1.1. Introduction

The supply chain is often described through interrelated material, informational and financial flows (Ayers, 2000; Palmieri and Afrik, 1999). Supply chain management is focused on strategic system-wide decisions (Burgess, 1998). Publications have stressed the importance of measurement systems for the implementation of SCM initiatives, as well as the requirements of measures integration (Bechtel and Jayaram, 1997). There is a requirement for supply chain performance measurement methods and system models that will control inter-organisational performance and provide the basis for the strategic development process. This research methodology is described for several levels of the supply chain system discussed in Chapters 3, 4, and 5. The structure of the methodology and a brief description of its constituent parts are presented below.

3.1.2. The Structure of Methodology

The structure of methodology is presented in Figure 3.1, below.

Figure 3.1. The Structure of the Methodology



In Figure 3.1, the arrow on the right side shows the sequence in which the methodology is described in this research.

A methodology description consists of three parts. The methodology of material transaction performance measurement is described in Section 3.2. This description is followed by the description of financial performance measurement in Section 3.3. Finally in Section 3.4, the methodology of information transaction performance measurement is defined. Sections 3.2 – 3.4 introduce the methodology of uniform performance measurement of three supply chain flows at the operational level when one supply chain member initiates the transaction and another supply chain member plays the role of recipient. Sections 3.2 – 3.4 are used as a basis of performance measurement in higher system levels.

In Section 4.2 the methodology is introduced where a contractual agreement between two supply chain members is decomposed into sequential transactions for each of three supply chain flows: material, financial and informational. This approach allows measuring the contractual performance of the two supply chain members through measuring their transactional performance.

The next higher structural level for the extension of the methodology is for the total supply network level. In Section 4.3 the total supply network, starting from raw material and ingredient procurement and ending with the final product customers, is presented as a network of firms. Firms, in this network, exchange materials, finance and information under contractual obligations. This form of the total supply chain presentation allows extension of the methodology from Section 4.2 to the level of the total system.

Finally, in Chapter 5, adaptation of the performance measurement-induced strategic planning model introduced by Dyson (1998) demonstrates how the performance measurement methodology discussed in Section 4.3 may be used in the supply chain strategic planning and control process and reflects total chain system dynamics.

Each part of the methodology is briefly described below.

3.1.3. Transaction Performance Measurement

Performance of any supply chain transaction, regardless of the flow to which it belongs, is evaluated through quality, delivery and cost characteristics.

Quality and delivery are defined through their components. Components are selected using items specified in the contract. The actual value of a component is available after delivery of the content of the transaction to the recipient. The actual value is compared with the expected value (as specified in the contract). This comparison provides normalised performance measures for components (NPM). A NPM of 1 is assigned to the expected values as specified in the contract. An actual value that exceeded the customers' expectations is assigned a NPM greater than 1. An actual value that is below customers' expectations but is still acceptable is assigned a NPM less than 1. A zero NPM is assigned to the actual components' value that is not accepted by the customer because of poor performance.

3.1.3.1. Material Transaction

Material quality and delivery characteristics are measured through the weighted average of NPMs of their individual components. Total material transaction performance is calculated as an average of quality and delivery NPMs.

3.1.3.2. Financial Transaction

The amount of payments and timing of financial transactions are defined in the contract and must be synchronised with the performance of material flow. These issues are considered when defining the delivery parameters of financial transactions. A NPM of 1 is assigned to full payment made on time in accordance with the terms of payment specified in the contract. A NPM above 1 is assigned to payments produced before the date specified in the contract. Delayed payments ware assigned a NPM below 1.

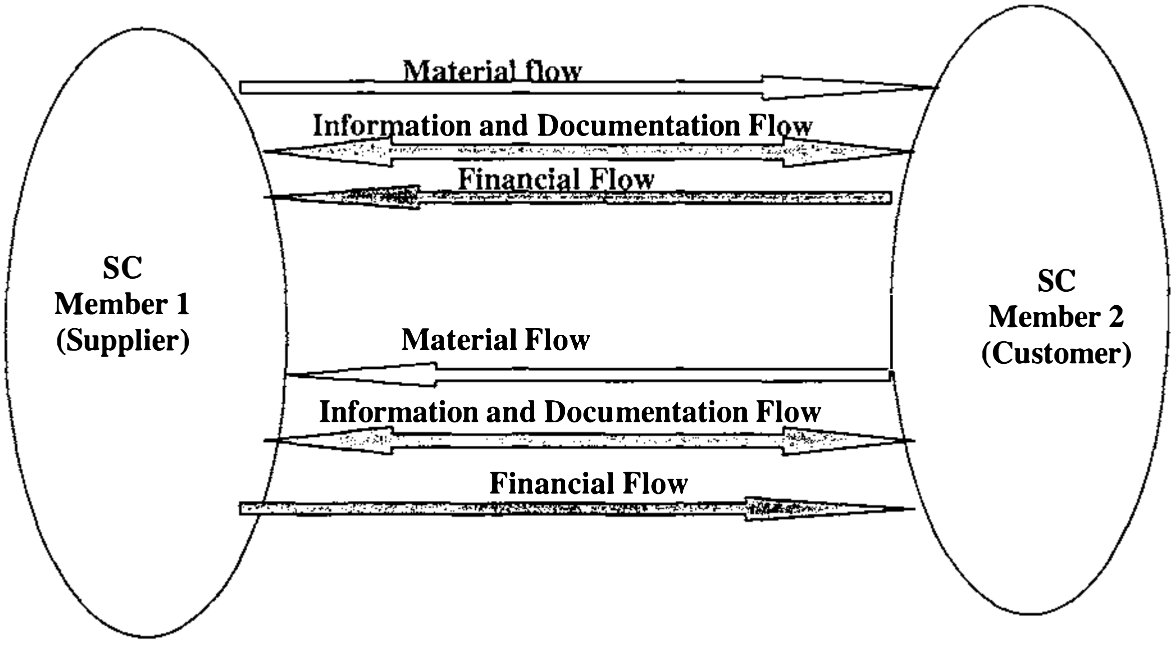
3.1.3.3. Information Transaction

Information in SCs is transferred in order to initiate activities in material and financial flows. The quality of information exchanged by two SC participants during a contractual agreement is discussed incorporating the results of data quality research. Three categories of quality are defined through a set of information characteristics (Smart, 2002). The performance of information flow is measured through its delivery time – time when information is accepted by the recipient in order to initiate SC activities.

3.1.4. Branch Level Performance Measurement

The three methodologies introduced in Sections 3.2 – 3.4 are applied to the next level of the supply chain system under consideration. This level is named "Branch Level" and is defined as the bi-directional interchange of activities and resources between two SC members. It is graphically represented in Figure 3. 2, below.

Figure 3.2. Graphical Presentation of Branch Level Interchanges.



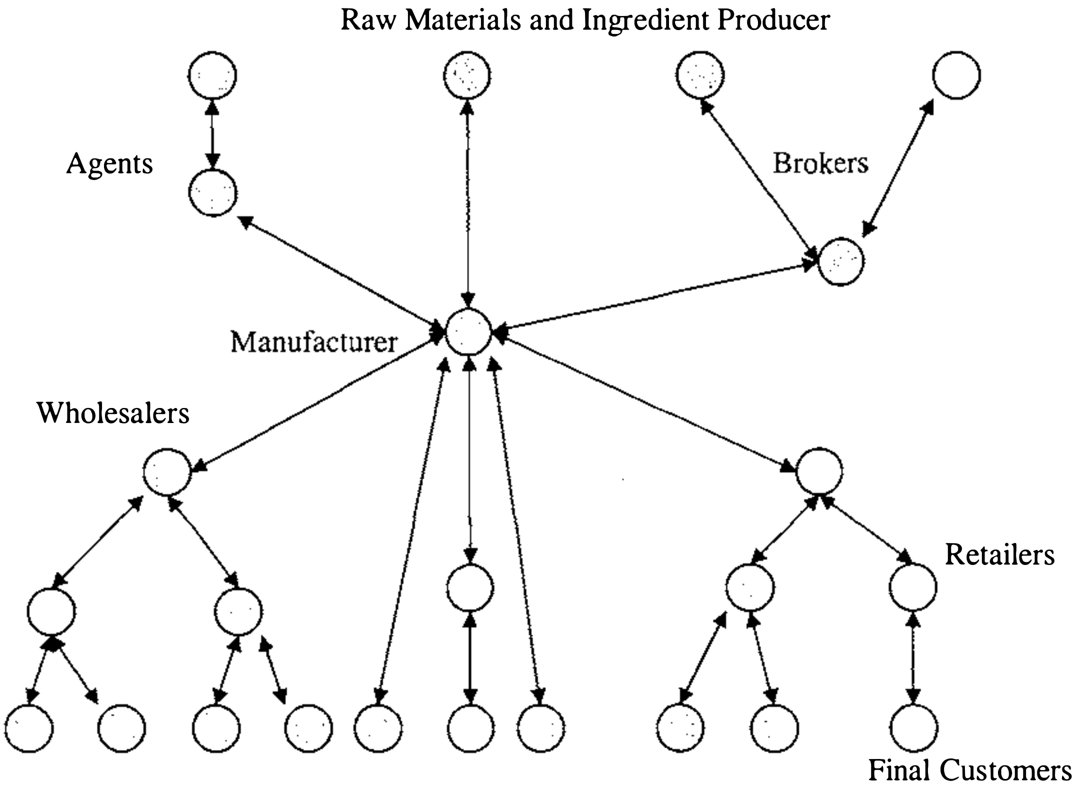
In Section 4.2, the transactional interchange between the Supplier and the Customer is represented by a network diagram (see Figure 4.1). In this diagram, activities represent the transactions in supply chain flows. The methodologies from Sections 3.2 –3.4 are applied to uniformly measure the performance of all activities. This allows introducing an extended performance measurement methodology for the Supplier's and the Customer's total performance during their contractual arrangement.

3.1.5. Network Level Performance Measurement

In Section 4.3 the Branch Level methodology is further extended to the level of the total supply chain. The total supply system is presented as a bounded network of firms starting with the raw materials and ingredient suppliers and ending with the final product customers. In this network, each node represents a supply chain member - firm. An example of the supply chain network is represented in Figure 3.3 on the next page.

Each node in the network is connected by a contractual agreement with at least one other node. Total supply chain flows are presented as a composition of branch level flows. A NPM is assigned to each path in the network. This NPM is derived from performance measures for all branches constituting the path.

Figure 3. 3. Network Supply System Presentation



Where:

○ is a firm – supply chain member

←——→ represents a contractual agreement between two supply system members.

3.1.6. Methodology Application to Strategic Planning and Control

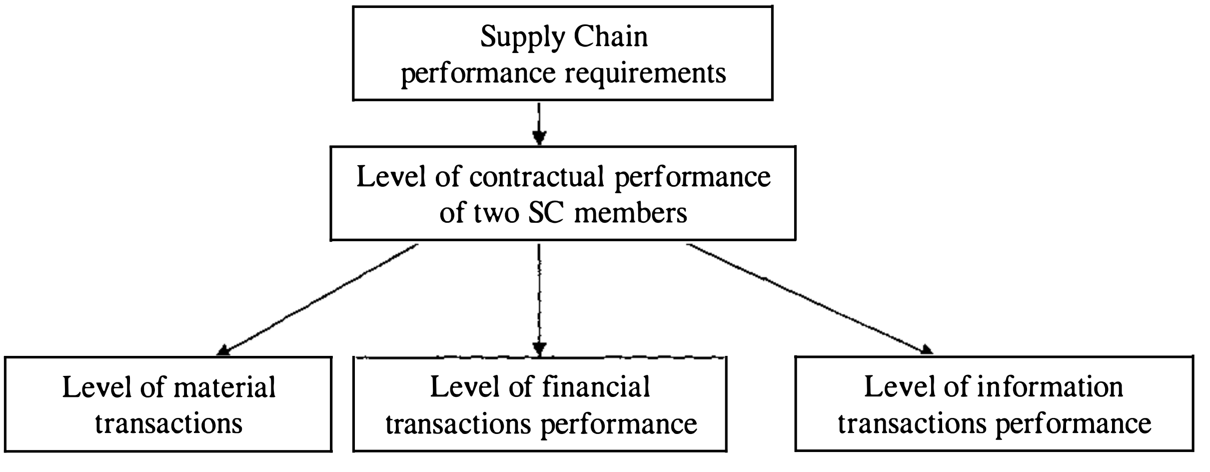
It is recognised that :

"SCM has seen companies reformulating their strategies to take into account the competitive advantages that can be gained from improvements to the supply chain" (Burgess, 1998).

It is suggested that supply chain performance measurement systems should be directly related to system strategic development and control and provide the basis for the systems' improvement. The methodologies described in Chapters 3 and 4 are applied to the performance measurement-induced strategy model developed by Dyson and O'Brien (1998). This relates the suggested performance measurement methodology to different planning horizons such as tactics, objectives, and operational targets.

The pyramidal structure of the methodology (see Figure 3.1) indicates that higher levels of a system totally incorporate methods used in the lower levels. This structure allows presenting total supply chain performance requirements in terms of the requirements imposed on the contractual performance of the two chain members. The level of contractual performance in turn may be decomposed into performance requirements for material, financial, and information transactions (see Figure 3. 4, below).

Figure 3. 4. Methodology Applications to Strategic Planning and Control



3.1.7. Conclusions

The suggested methodology has a pyramidal structure, as presented in Figure 3.1. This structure reflects the different levels of the supply chain system under consideration. The performance measurement methodology on each higher level of the system incorporates lower level methodologies. This structure allows tracking performance measures to the level of a single chain transaction. Requirements of performance system integration (Bechtel and Jayaram, 1997) are also satisfied. Application of the performance measurement-induced strategy allows relating the suggested methodology to the strategic planning and controlling process.

3.2. Material Flow Performance Measurement

This section presents the description of a methodology to measure material transaction performance. It starts with an introduction of definitions and notations, which then are used in subsequent chapters (Section 3.2.1). Examples of grain supply contracts are used for illustration and explanations. The suggested methodology is case evaluated in Section 6.1.

3.2.1. Definitions and Notations

The following definitions and notations are introduced:

The values negotiated and agreed upon in the contract between the customer and the supplier are **expected values.** When materials are delivered to the customer and inspected the **actual values** of these expected values are known. Deviations between actual values and expected values provide a basis for performance measurement.

Characteristic is a measurable or counted value that is defined in the agreement between the supplier and the customer.

Characteristic's expected value (EV) is the value of the characteristic as defined in the agreement between the supplier and the customer.

Characteristic's actual value (AV) is the characteristic's actual value as delivered to the customer.

A characteristic is "**high**" when the higher values are favourable for the customer.

For example, wheat protein content is a high characteristic. A high value of wheat protein content implies high wheat quality. Inversely, a low value of wheat protein content implies low wheat quality.

A characteristic is "**low**" when lower values are favourable for the customer.

For example, wheat moisture content is a low characteristic: a low value of wheat moisture content implies high wheat quality. Inversely, a high value of wheat moisture content implies low wheat quality.

A characteristic is **controllable** if it is accepted without penalties and/or premiums, in a range of values. This range of values includes the characteristic's expected value (EV) and is y defined through two non-negative values:

- **Over-achievement** (O) – the ranges' end-point which is favourable for the customer, and
- **Under-achievement** (U) –the ranges' end-point which is unfavourable for the customer.

Example 1 (high characteristic)

The expected value of wheat protein content negotiated and agreed upon in a contract (EV) was 14%. It was also agreed that the actual protein content in the range [13%, 14.5%] would be accepted without premiums or discounts. EV=14%, O=14.5%, and U=13%.

Example 2 (low characteristic)

The expected value of moisture content negotiated and agreed upon in a contract (EV) was 12%. It was also agreed that the actual moisture content in the range [11%, 13%] would be accepted without premiums or discounts. EV=14%, O=11%, and U=13%.

A characteristic is **acceptable** if it is controllable and the additional range is specified as acceptable with a discount or premium schedule. This range of values includes O and U and is generally defined through two non-negative values:

Acceptable premium overachievement ($\overline{O}$), and

Acceptable discount underachievement ($\overline{U}$).

Values of $\overline{O}$ and $\overline{U}$ are not included into corresponding ranges.

Example 3 (high characteristic)

In Example 1, an addition agreement was reached that delivered wheat with protein content in the range (12%, 13%) would be accepted with a discount, and wheat with protein content in the range (13.5%, 15%) would be accepted with a premium. $\overline{U}$ =12%, and $\overline{O}$=15%.

Example 4 (low characteristic)

In Example 2, an addition agreement was reached that wheat with moisture content in the range (13%, 14%) would be accepted with a discount, and wheat with moisture content in the range (10%, 11%) would be accepted with a premium. $\overline{U}$ =14%, and $\overline{O}$=10%.

For high characteristics $\overline{U}$ < U<= EV <=O < $\overline{O}$

For low characteristics $\overline{O}$ < O <= EV <=U < $\overline{U}$

Expected Acceptance

The expected acceptance value (NAV=1) is assigned to AV, which is in the range defined by O and U values.

For a high characteristic, NAV=1, when U<= AV <= O.

For a low characteristic NAV=1, when O<= AV <= U.

For wheat moisture content described in Example 2, if the actual moisture content of the delivered wheat is in the range [11%, 13%], then NAV=1.

Discount Acceptance

The discount acceptance value (0<NAV<1) is assigned to an acceptable field's actual value AV, which is outside the control range and is unfavourable to the customer, but still in the range of acceptance.

Premium Acceptance

The premium acceptance value (1<NAV<=2) is assigned to an acceptable field's actual value AV, which is outside the control range and favourable to the customer.

Non-Acceptance

A characteristic is not accepted in one of the following two cases:

Case 1.

Characteristic is controllable but not acceptable when only U and O values are defined. $\overline{O}$ and $\overline{U}$ are not defined, which means that there is no premium/discount schedule for this characteristic.

For a high characteristic, AV is not accepted when $AV < U$ or $AV > O$.
For example, the control range for wheat protein content was defined as [13%,14.5%]. If the actual wheat protein content is either below 13% or above 14.5%, the characteristic is not accepted.

For a low field, AV is not accepted when $AV<O$ or $AV>U$.
For example, the control range for wheat moisture content was defined as [11%,13%]. If the actual wheat moisture content is either below 11% or above 13%, the characteristic is not accepted.

Case 2.

A characteristic is acceptable and, for the high characteristic $AV<\overline{U}$, or for a low characteristic $AV>\overline{U}$. For example, assume the wheat protein content $\overline{U}$=12%. Any actual protein content below 12% is not accepted. Or, assume the wheat moisture content $\overline{U}$=14%. Any actual moisture content above 14% is not accepted.

Flow charts 3.2.1 and 3.2.2 summarise procedures to assign NAV for high and low characteristic, respectively.

Figure 3.5. Assignment of Normalised Acceptance Value to High Characteristic

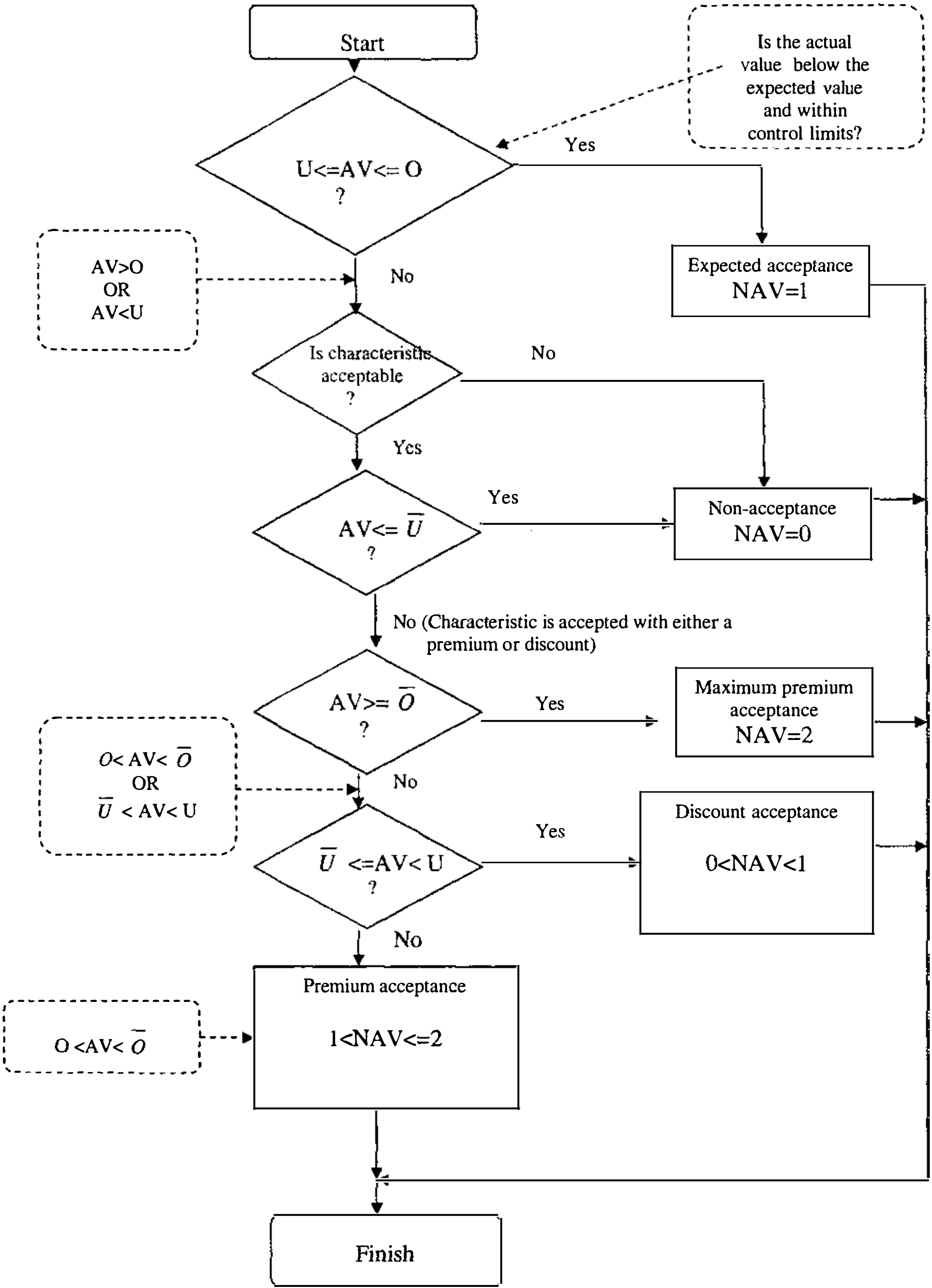
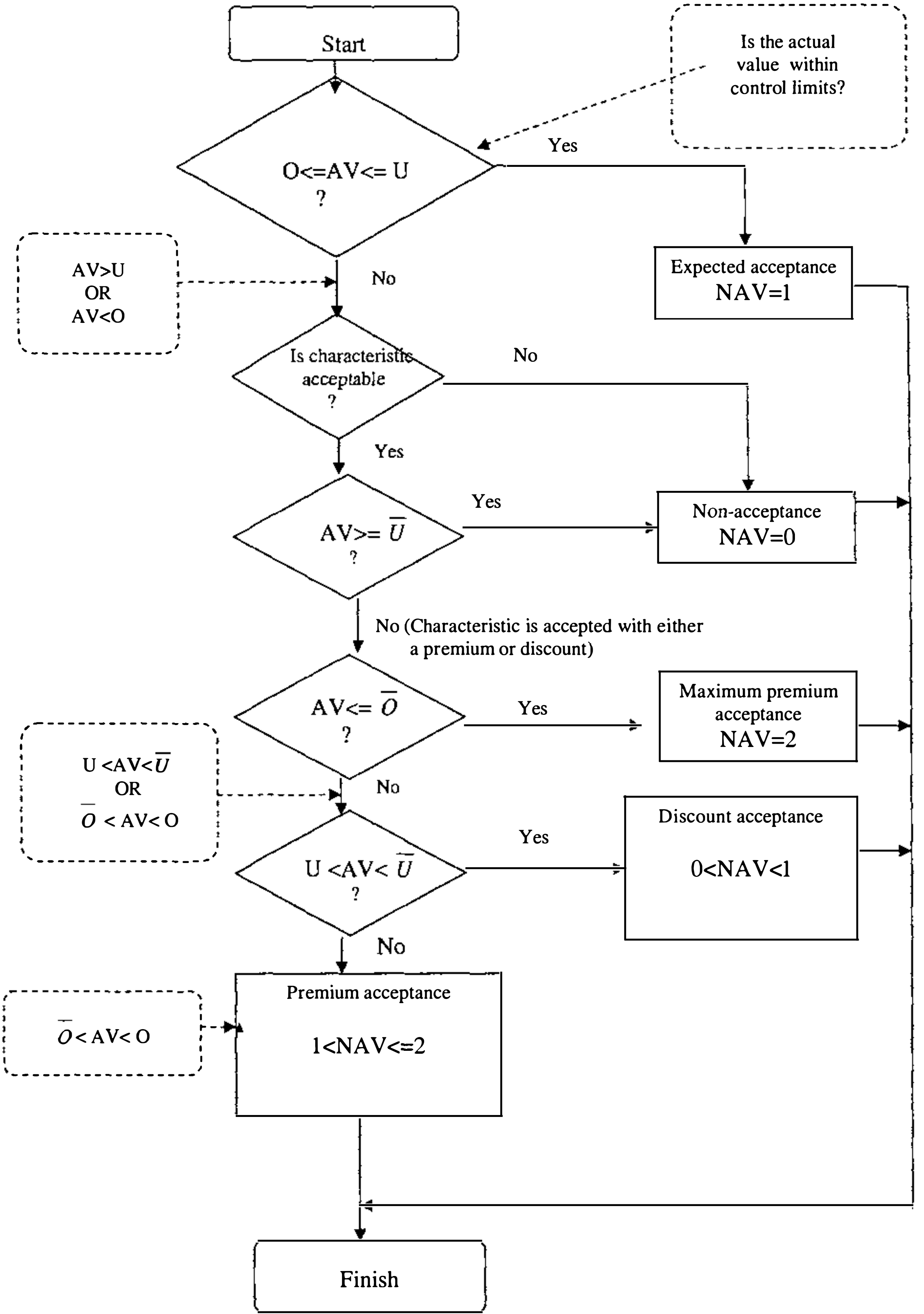


Figure 3.6. Assignment of Normalised Acceptance Value to Low Characteristic



3.2.2. The Total Normalised Value of Quality

In the contract, the quality of materials may be defined by the set of **n** characteristics that are required to satisfy customer needs:

$C_1 \ldots C_n$ (i = 1...n)

Each quality characteristic is a controllable field and may be defined as an acceptable field.

Example 5

In a hypothetical wheat supply contract, the following six quality characteristics were defined, along with control and acceptance ranges.

Table 3.1. Quality Characteristics in Hypothetical Wheat Supply Contract

Index	1	2	3	4	5	6
Quality Parameter	Protein (%)	Natural weight (gr)	Falling number	Moisture %	Foreign materials (%)	Damaged kernels (%)
Type of characteristic (Low/High)	High	High	High	Low	Low	Low
Controllable (C) or Acceptable (A)	A	A	C	A	C	A
EV	13	760	270	13	0.5	3
Overachievement O	14	770	280	12	0.5	2.5
Underachievement U	12.5	755	270	13.5	0.5	3.2
Acceptable premium overachievement $\overline{O}$	15	770	-	11	-	2.3
Acceptable discount underachievement $\overline{U}$	12	750	-	14	-	3.2

Remark: For Falling number and Foreign materials controllable quality characteristics $\overline{O}$ and $\overline{U}$ are not defined.

The product delivered to the customer has the actual values of each quality characteristic AV_i (i = 1...n) available after inspection. For example, actual wheat quality characteristics are available after laboratory analysis. The procedures described in flow charts 1 and 2 were followed to assign the normalised acceptance value for the actual value of any quality characteristic - NAV_i.

The final quality acceptance of a product depends on actual values of all quality characteristics. If all quality characteristics have normalised acceptance values of 1 then the quality of the product meets customer expectations. If at least one quality characteristic is rejected by the customer, then the quality of the product does not meet the quality level expected by the customer and it is rejected.

Some quality characteristics may be more important for the total quality acceptance than others. The total normalised quality acceptance value p_l of the product may be defined through normalised quality acceptance of its quality characteristics: p_l may be uniformly normalised as having a value of 1 when all product quality characteristics meet the customer's expectations, and consequently have normalised acceptance values of 1.

If product is rejected because of poor quality of some characteristics then p_l may be uniformly normalised as having value of 0. The total normalised quality acceptance p_l may be assigned values below 1 when the total quality of the product, as a result of lower than expected quality of some characteristics, is below the customer's expectations. If the total quality of the product, as a result of the higher than expected quality of some characteristics, is above the customer's expectations, then the total normalised quality acceptance p_l may be assigned values above 1. This may be summarised as follows:

- $p_l = 1$, expected total quality. $NAV_i = 1$ for all $(i = 1 \ldots n)$
- $p_l = 0$, as a result of poor quality product is rejected. $NAV_i = 0$ for some characteristics
- $0 < p_l < 1$ acceptance with discount. For some i $0 < NAV_i < 1$
- $1 < p_l <= 2$ acceptance with premiums. For some i $NAV_i > 1$.

With a variety of agri-food products and their quality characteristics it is difficult to cover all possible cases and demonstrate how p_l may be defined through values of its quality characteristics. In Section 6.1 cases are presented where the total normalised quality acceptance p_l was derived for quality acceptance of three commodities: grain, raw milk, and beef.

3.2.3. The Total Normalised Value of Delivery

Delivery is defined in terms of the volume ordered by the customer and its delivery time. Both volume and delivery time, in terms of definitions introduced in Section 3.2.1, are controllable characteristics and may also be defined as acceptable characteristics.

3.2.3.1. The Normalised Acceptance Value of Volume

Using the terminology introduced in Section 3.2.1, volume is a high characteristic.

Example 6

The volume of wheat agreed upon in the contract was 100 MT (EV). The customer agreed to accept any volume in the range of 98 – 100 MT without premiums or discounts. Volumes in the range (90,98) are accepted with a discount. Volumes above 100 MT are accepted but the premium schedule is not applicable.

In terms of Section 3.2.1: EV=100, U=98, O=100, $\overline{U} = 90$, $\overline{O}$ value is defined as a practically unachievable large number, for example 10^{10}.

Notation NDV was used for normalised volume acceptance value. After delivery the actual volume of product is known (AV). The actual volume of product delivered to the customer meets his/her expectations when it is within the acceptance range (in terms of definitions introduced in Section 3.2.1 U <= AV<= O). In this case, the normalised volume acceptance value is 1 (NDV=1).

If AV< $\overline{U}$ then volume is below the lowest acceptable value and the consignment is rejected. In this case, the normalised volume acceptance value is 0 (NDV=0).

.

Discount and Premium Volume Acceptance

The discount normalised acceptance value may be assigned to the actual volume AV, which is outside the range of expected volumes and is unfavourable to the customer, but is still in the range of acceptance ($\overline{U}$ <= AV < U).

The premium normalised acceptance value may be assigned to the actual volume AV, which is more than the largest expected volume and is favourable to the customer. In this situation the customer agrees to consider this situation as a premium suppliers' performance (different from the situation described in Example 5).

In both cases NDV is suggested to be measured as a proportion of actual volume (AV) to the expected volume (EV): AV/EV.

Example 7

A) 95 MT (AV) were actually delivered instead of expected 100 MT (EV).

NDV = 95/100=0.95

B) The customer agreed to accept and to consider volumes larger than 100 MT (EV) up to 150 MT as a premium supplier's performance. 120 MT (AV) were actually delivered.

NDV = 120/100=1.2

3.2.3.2. The Normalised Acceptance Value of Delivery Time

Using the terminology introduced in Section 3.2.1, delivery time is a lower characteristic. Faster deliveries are favourable for the customer, and delayed deliveries are unfavourable.

Example 8

The expected delivery time agreed upon in the contract was 13 January. The customer agreed to accept delivery between 12 January and 14 January without premiums or penalties. Delivery between 14 January and 16 January was accepted with penalties, although the delivery was late. Any delivery after January 16 was not accepted.

Delivery earlier than 12 January was accepted with a premium.
The following values were assigned to control and acceptance ranges, as defined in Section 3.2.1: EV=13/01/03, O=12/01/03, U=14/01/03, $\overline{U} = 16/01/03$, $\overline{O} = 8/01/03$.

Notation NDT was used for normalised delivery time acceptance value. After delivery takes place the actual time is known (AV). If actual delivery time is within the acceptance range (in terms of definitions introduced in Section 3.2.1 O < AV< U) then NDT=1. In Example 8 if actual delivery took place between January 12 and January 14 then NDT=1.

If delayed then NDT=0. In Example 8 if materials are delivered to the customer after January 16, they are not accepted and NDT=0.

Discount and Premium Delivery Time Acceptance

The discount normalised acceptance value may be assigned to the actual delivery time AV, which is later than expected time and is unfavourable to the customer, but is still in the range of acceptance (U < AV <= $\overline{U}$).

NDT in this case is suggested to be measured as:

$$\frac{\overline{U} - AV}{\overline{U} - U}$$

Example 9
Using data from Example 8 and actual delivery time of January 15:
NDT=(16-15)/(16-14) 1=0.5
$\overline{U} - U$ gives the number of delayed delivery days which the customer agrees to accept with discounted performance.
$\overline{U} - AV$ gives the actual number of days the delivery was delayed.
Proportion of actual delay to the maximum acceptable delay gives the relative measure which is suggested to be used as a normalised delivery time performance value.

The premium normalised acceptance value may be assigned to the earlier than expected actual delivery time AV $\overline{O}$ <= AV <= O. In this situation the customer agrees to consider earlier delivery as premium suppliers.

NDT in this case is suggested to be measured as:

$$\frac{O - AV}{O - \overline{O}} + 1$$

Example 10

Using data from Example 8 and actual delivery time of January 11:
NDT=(12-11)/(12-8) +1=1.25
$O - \overline{O}$ gives the number of earlier delivery days which the customer agrees to accept with discounted performance (4 days).
$O - AV$ gives the actual number of days the delivery was made before the earliest expected time (1 day).
Proportion $\frac{O - AV}{O - \overline{O}}$ gives a relative measure of how "early" delivery was made.
This relative measure is added to 1 (expected performance) to receive higher than 1 relative measurement which indicates higher than expected level of performance.

The total normalised delivery acceptance value p_2 =0 if at least one characteristic is not accepted (has a zero value).
Non-zero p_2 values are defined in two steps.

Step 1.
The weighted sum of normalised values NDV and NDT is calculated:
$W_V \times NDV + W_T \times NDT$

where :
W_V is the weight of the volume characteristic ;
W_T is the weight of the time characteristic, and
$W_V + W_T = 1$

Step 2.

NDT=NDV=1 for the expected volume of the product and the expected delivery time. Consequently, the total expected normalised delivery acceptance value p_2 equals 1.

If the weighted sum from Step 1 is more than 1 but one of NDV or NDT values is below 1 then p_2 is assigned value of 1. This reflects the situation when even though premium performance of one delivery characteristic overweighed discounted performance of another delivery characteristic, the total delivery performance should not be considered above the expected level.

Comparison of the p_2 value with 1 gives an indication of total delivery acceptance with respect to the expected delivery value.

Example 11

Volume and time values from Examples 7 and 9 are used. 95 MT were actually delivered on January 11.

NDV=95/100=0.95
NDT=(12-11)/(12-8)+1=1.25

Equal weights were assigned to volume and delivery time acceptance: W_T=0.5 and W_v=0.5. Weighted sum is calculated as:

(0.95+1.25)/2=1.1

Weighted sum value is above 1 but NDV is below 1 (0.95). Therefore p_2=1 reflecting the balance between positive effect of earlier than expected delivery with the negative effect of smaller than expected volume of materials.

3.2.4. The Total Normalised Material Flow Performance Value

The total normalised material flow performance measure (MFP) is defined through the total normalised acceptance values of quality (p_1) (Section 3.2.2) and delivery (p_2) (Section 3.2.3).

$p_1 * p_2$ measures the customer's acceptance or rejection of the material. If either p_1 or p_2 has a zero value, it indicates that materials were not accepted and, therefore, the value of the performance is zero (MFP =0).

Similarly to the method used for defining non-zero p_2 values (Section 3.2.3), non-zero MFP values are defined in two steps.

Step 1.

The weighted sum of normalised values p_1 and p_2 is calculated:

$W_Q \times p_1 + W_D \times p_2$

where :

W_Q is the weight of the total normalised quality acceptance ;

W_D is the weight of the total normalised delivery acceptance, and

$W_Q + W_D = 1$

Step 2.

$p_1 = p_2 = 1$ if the expected volume of the right product (expected quality) was delivered to the customer at the right time (expected delivery time).

Consequently, the total normalised material flow performance value MFP =1.

If the weighted sum from Step 1 is more than 1 but one of p_1 or p_2 values is below 1 then MFP is assigned the value of 1. Even though the premium quality overweighed the discounted delivery or the premium delivery overweighed the discounted quality, the total situation should not be considered as a total premium – exceeding the customer expectations performance.

3.2.5. Conclusions

This Chapter described the methodology for measuring material transaction performance. The performance measurement was defined through comparing actual product quality characteristics, actual delivered volume and actual delivery time with the values defined in the contractual agreement (expected values). The performance measures introduced were normalised with a value of 1 representing the expected performance level. Deviations of the normalised performance measures from 1 indicated the level of underachievement (values below 1) or overachievement (values above 1) expected in the contract. Suggested methods are further discussed and case-evaluated in Section 6.1.

3.3. Financial Flow Performance Measurement

This chapter describes normalised performance measurement for financial flow. The amount of actual payment (AP) that the customer should produce depends on quality and delivery of materials. The contractual agreement defines the expected time for customer payments. Performance measurement of financial flow is normalised using techniques similar to the normalisation produced for material flow.

3.3.1. Normalised Financial Flow Performance Measurement

In general, a customer may be required to make several payments: 1....j to the supplier.
Notation T_i represents the date when the customer pays the sum AP_i to the supplier for material under consideration, where i=1...j.

The normalised performance of a financial flow (FTP) is calculated as:

$$FTP = \frac{\sum_{i=1}^{j} AP_i \times (1+r)^{(ET_i - T_i)}}{\sum_{i=1}^{j} AP_i} \qquad \text{(Formula A)}$$

where:
ET_i - expected payment date and r is the discounting factor.

Example 12

a) If the contract stipulates one payment of $10,000 to be made by January 12, and the actual payment was made on this date, then ET=T→ $(1+r)^{(ET-T)}=1$, and FTP=1.

b) If the payment was delayed, and was made on January 15 instead of January 12 ,
$(1+r)^{(ET-T)}=(1+r)^{-3}$

c) If the payment was made earlier than expected, and was made on January 10 instead of January 12,

$$(1+r)^{(ET-T)}=(1+r)^{2}$$

Possible options to select an r-value are discussed in Section 3.3.2, below.

Example 13

Assume that an annual discount rate was selected at 6.78% per annum, then
r= 0.0678/365=0.00018575.
For the situation described in example 1a, the FTP is calculated as:

$$\frac{10{,}000\times(1+0.00018575)^{-3}}{10{,}000}=0.99944295$$

For the situation described in example 1b, the FTP is calculated as:

$$\frac{10{,}000\times(1+0.00018575)^{2}}{10{,}000}=1.00037154$$

If several payments are required from the customer, then Formula A yields a value of 1 when all payments are produced at the expected times, or some prepayments compensate for delayed payments. For example,

Table 3.2. The Normalised Performance of a Financial Flow Calculation with Several Payments

i	AP_i	ET_i	T_i	$(1+r)^{(ET_i-T_i)}$	$AP_i(1+r)^{(ET_i-T_i)}$
1	$ 10,000	10-Jan	12-Jan	0.9999628504	$ 9,999.63
2	$ 20,000	15-Jan	14-Jan	1.0000185753	$20,000.37
3	$ 30,000	20-Jan	20-Jan	1.0	$30,000.00
Total	$ 60,000				$60,000.00

According to Formula A, FTP=1.

Formula A yields the FTP value > 1 when some prepayments are made, and
The FTP value < 1 if there are payment delays.

3.3.2. Selection of Discounting Factor *r*

Selection of discounting factor *r* requires careful consideration. *r* calculations may be based on the buyer's cost of capital. The topic of cost of capital evaluation is a large topic of discussion by itself, offering different models, such as the Capital Asset Pricing Model (CAPM) (Pratt, 2002); the Weighted Average Cost of Capital (WACC) (Davey and Vos, 1997); the Market-Derived Capital Pricing Model (MCPM) (McNulty, *et al.*, 2002); Dueling Models (Fink, 2003) and other models. As a result, selection of the method of *r* calculations using cost of capital is not discussed in detail in this research. The assumption is made by the researcher that the discounted factor r value may be calculated and agreed upon between the seller and the buyer, similarly to how it is done with contractual agreements used in the case evaluation (Chapter 6.1).

3.4. Information Flow Performance Measurement

3.4.1. Introduction

One of the key components of logistics and a supply chain (SC) is the bi-directional flow of information for all chain participants. Bowersox (1996) underlined the importance of this flow: "Information is a major factor for enhancing logistics competitiveness"(*ibid.*, p. 220). At the same time there are no publications available on how to measure performance of SC information flows.

Performance of information flow is measured through the delivery time for related material or financial transactions using methodologies described Sections 3.2 and 3.3.

Information is accepted or rejected according to its quality. It is recognised that the economic impact of poor quality information is significant (Strong *et al.*, 1997). Information and data quality are topics of intensive literature discussions. The social and economic impact of poor-quality data is well recognised (*ibid.*, pp. 103-104). It is agreed that many corporate initiatives are dependent on data quality and, as a result, data quality should be considered for those initiatives (Wang and Strong, 1996). Suggestions have been made to consider data quality as a unique source of competitive advantage (Redman, 1995). At the same time, "a significant amount of the literature on quality management – specifically quality in technical communication – is normative, focusing on how to implement standards, tools and procedures" (Smart, 2002, p. 134).

There are no publications on applying the results of data quality research to SC management. However, authors have applied the total quality management principles to data quality management:

- The quality concept of "fitness for use", that emphasises a consumer viewpoint on quality, has been used in data quality management (DQM) (Wang and Strong, 1996).

- The Deming cycle for quality enhancement (Deming, 1986) was adapted to information in the development of the total data quality management (TDQM) cycle (Wang *et al.*, 2001).

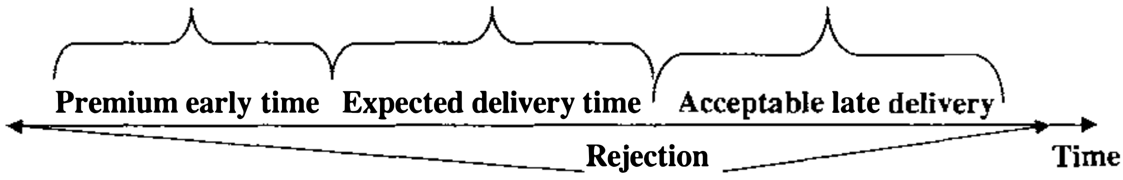
The performance of information flow is measured through its delivery time – time when information is accepted by the recipient in order to initiate SC activities. Information flow delivery time is related to the delivery time of material or financial flows. This permits use of methodologies described in Sections 3.2 and 3.3.

The quality of information exchanged by two SC participants during a contractual agreement is discussed incorporating the results of data quality research. In this discussion a customer-focused approach to quality, defined as "fitness for use by consumers" (Deming, 1986) is related to information acceptability. Different levels of customer satisfaction are defined through a set of dimensions of information quality (Smart, 2002).

3.4.2. Normalised Information Delivery Time Acceptance Value

Information flow is related to SC material and financial flows. A SC message is defined as the transfer of information related to material and financial SC flows. SC messages are transferred in order to initiate activities in material and financial flows. The normalised performance measurement of financial and material flows includes time of delivery evaluation (see Sections 3.2 -3.3). In this evaluation the actual delivery time for financial and material activities was compared with acceptable premium overachievement (earlier than expected delivery time), acceptable discount underachievement (later than expected delivery time), and the interval of expected delivery time (see Figure 3.7 below).

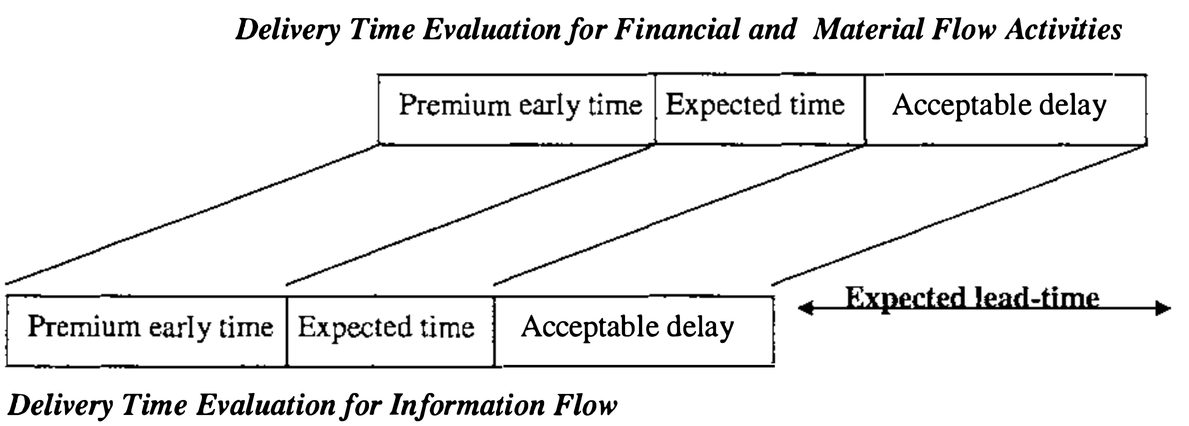
Figure 3.7. Evaluation of the Actual Delivery Time for Financial and Material Flow Activities



Some financial and material flow activities may be initiated only after the related information is received and accepted. The assumption is made that these activities may be initiated at the moment when the related information is accepted by the recipient.

Each activity has an expected lead-time, defined as the time from the moment when an activity is initiated until its results are delivered to the recipient with planned use of resources. By subtracting the activity's expected lead-time from times defined for the proceeding financial or material flow activity time intervals may be obtained which are similar to those presented in Figure 3.7:

Figure 3.8. Evaluation of the Actual Delivery Time for Information Flow

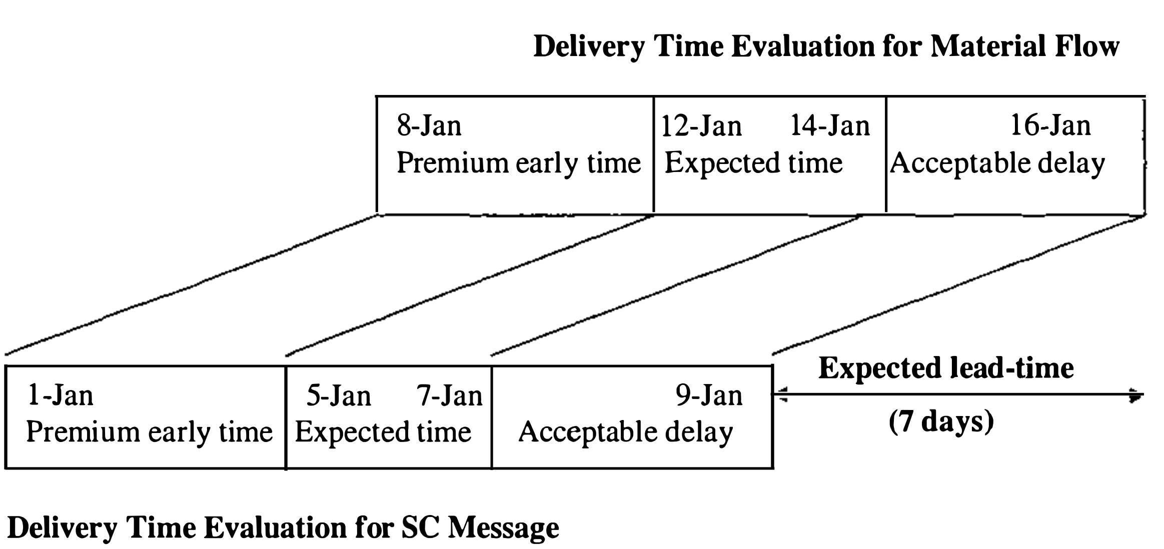


A SC message normalised delivery performance measure may be derived using techniques similar to the normalised delivery performance measurement of related material or financial flows (Section 3.2.3 for material flow and Section 3.3.1 for financial flow).

Example 16

Example 8 (Section 3.2.3.2) presented values for material flow delivery times.
Activities related to consolidation of the required volume of production and transporting it to the customer had the expected time of seven days. These activities were initiated by the supplier when the message confirming availability of train carts was received. Data are presented in Figure 3.9, below:

Figure 3.9. Example of SC Message Delivery Times



In Figure 3.9 delivery times for material flow were obtained from Example 8 in Section 3.2.3.2. The expected lead-time of 7 days was subtracted from each of the four times defined in the material flow delivery time evaluation (8-Jan, 12-Jan, 14-Jan, and 16-Jan). The resulting four values defined times required for delivery time evaluation for the related message.

For example, if the SC message was accepted on January, 4 then its normalised delivery performance is calculated using Example 12 B) from Sections 3.2.3.2 (January, 4 + 7 days lead-time= January, 11):
(12-11)/(12-8)+1=1.25

3.4.3. Quality of Information

Quality of information plays an important part in the acceptance of a SC message by the recipient. The *quality of information* has been defined as "fitness for use by information consumers" (Wang and Strong, 1996, p. 6). SC messages contain expected and/or actual data related to material and financial flows. The person receiving these data (the customer) uses them to initiate related activities. In order to initiate related activities, the customer expects the data to be relevant to the above two flows, to be easy to use and easy to understand.

3.4.3.1. Quality Characteristics of a SC Message

The information quality dimensions suggested by Kano (1984) are used to define the quality characteristics of a SC message.

Table 3.3. Three Dimensions [Categories] of Information Quality Characteristics

Dimension [Category]	Definition
Essential (or must-be) quality	Information content: characteristics that are required to initiate related activities.
Convenient quality	Quality characteristics that lead to the expected level of customer satisfaction when present and low levels of satisfaction when not present.
Attractive quality	Quality characteristics that go beyond customers' expectations.

Example 17

The following informational interchange was contained in the grain supply contract, used for the Case evaluation in Chapter 6: "The Supplier has an obligation to inform, at his/her cost, the Customer about product dispatch not later than the next day after the day of dispatch through fax. Information should include the date of dispatch, quantity of the dispatch production, and numbers of carts". The suppliers' notification was used by the Customer to initiate several post- dispatch activities such as tracking the movement of carts, arrangement of storage and payment. Contract information quality characteristics were described as follows:

Table 3.4. Description of Information Quality Category

Quality Category	Information Characteristics
Essential Quality	Includes Contract number and name of railway station of departure. Cart numbers are confirmed after an entry into the railway computer tracking system. For each cart the weight of product is given.
Convenient quality	Text should be easily read. Information is organised in a structured way without redundancy.
Attractive quality	Does not contain excessive text. Good grammar, text is well tabulated. Uses different fonts / features to emphasise fields important to the customer.

In Table 3.4 each quality category is described through the set of characteristics.

3.4.3.2. Essential Quality Characteristics

Following Table 3.4, essential quality characteristics should be presented to achieve expected levels of customer satisfaction. Those characteristics define informational "fit for use". Only when all essential quality characteristics are presented may the message be used to initiate related activities, and, as a result, be accepted.

For example, in the grain supply contract described in Example 17, the customer expected information to allow him/her to undertake business actions. These actions included entering all information listed as essential quality characteristics in Table 3.4 into a computer tracking system.

3.4.3.3. Convenient Quality Characteristics

Convenient quality characteristics define the amount of time and effort the customer should spend to retrieve essential information. All convenient quality characteristics should be presented to achieve the expected level of customer satisfaction. If the convenient quality characteristic is not present, it results in a lower than expected level of customer satisfaction because retrieving the information takes more time and effort than expected. If all convenient quality characteristics are missing then the customer rejects the message.

For example, for the grain supply contract message the customer expected the text to be easily read and that information would be organised in a structured way without redundancy. If the message contents redundancy it slows down retrieving of essential information and decreases the level of customer satisfaction. If, in addition, the customer has difficulties in reading the message, the message is rejected.

3.4.3.4. Attractive Quality Characteristics

According to the definition in Table 3.3, attractive quality characteristics go beyond customers' expectations. The presence of attractive quality characteristics is not required to achieve the expected level of customer satisfaction. When present, they assist in saving time and effort, and, as a result, give a higher than expected level of customer satisfaction.

For example, for the grain supply contract under discussion, if the text is well tabulated and emphasises fields important to the customer, then it allows retrieving information with less time and effort than expected by the customer.

The description of the three information quality categories in respect of different levels of customer satisfaction may be summarised as follows:

a) The expected level of customer satisfaction is achieved when all essential and convenient quality characteristics are present, but none of the attractive characteristics;
b) Customer satisfaction is above the expected level (high satisfaction) when all essential and convenient quality characteristics and at least one attractive quality characteristic are present;
c) Customer satisfaction is below the expected level (low satisfaction) when all essential quality characteristics are present, with at least one convenient quality characteristic missing (not all convenient characteristics);
d) The customer does not accept (rejects) a message when at least one essential quality characteristic is missing or all essential quality characteristics are available, but all convenient quality characteristics are missing.

The level of customer satisfaction is related to the time when information is accepted by the customer to initiate related activities. Information is accepted by the customer in cases a)-c), listed above.

The expected level of customer satisfaction assumes that related activities may be initiated with the expected use of time and/or other resources. A high level of customer satisfaction potentially allows the customer to reduce lead-time (see Figure 3.8). A low level of customer satisfaction requires use of more than expected time and/or other resources and may increase lead-time.

Information is rejected by the customer as a result of its low quality in case d).

In this situation SC messages must be re-sent until accepted by the customer. This process may cause significant delays that affect a related activity's delivery time.

3.4.4. Conclusion

Although it is recognised that bi-directional information flow is a part of a SC, there are no publications available on how to measure its performance.

In this Chapter, the performance of information flow was measured through its normalised delivery time when information is accepted by the customer and related SC activities may be initiated. The amount of time required is a function of the quality of information.

The quality of information plays an increasingly important part in the coordination of supply chain activities (Mitch, 2001). This Chapter suggested methods to evaluate quality of information.

Knowledge of the customer's expected level of information quality allows the supplier to achieve high information quality. As a result, the customer avoids unexpected use of resources and may initiate subsequent activities earlier than expected.

The normalised quantification of information flow performance measurement establishes a base for supply chain information flow analysis, control and optimisation. It also allows comparison of information flow performance measures with performance measures of two other SC flows: material and financial.

The method of information quality evaluation suggested in this Chapter is case evaluated in Section 6.3.

Chapter Four

Methodology Extensions

4.1. Introduction

In the methodologies described in Chapter 3 performance measures for three SC flows (material, financial, and informational) were uniformly scaled to allow their composition.

In Section 4.2 methodologies from Chapter 3 are extended to the level of customer-supplier contractual performance. Normalised measurement of a contractual party's performance is described. Attention is paid to the balance of supplier's and customer's contractual performance. The conclusion is drawn that unbalanced performance might affect other parts of the chain or/and the long-term relationship between two parties. The suggested methodology is Case evaluated in Section 6.4.

In Section 4.3, a traditional food industry supply chain is presented as a network where each node denotes a supply chain participant and branches represent contractual agreements. The total normalised performance measures calculated using the methodology from Section 4.2, for both suppliers and customers, are assigned to each branch of a supply network. The name 'set' is used for a sequence of business transactions leading from the raw materials and ingredient suppliers to the final consumer. Two total normalised performance sums are calculated for each set in the supply chain network: one sum for the suppliers' performance, another sum for the customers' performance. These sums allow ranking of the sets in accordance with the highest total supplier, customer and overall set performance. Sets with lower total normalised performance measures have margins of potential performance improvement in comparison with the highest total performance in the chain. The methodology confirms that in selected food industry networks, the manufacturer plays a central role because its performance directly affects overall chain performance. The suggested methodology is Case evaluated in Section 6.5.

4.2. Branch Level Performance Measurement

4.2.1. Supplier – Customer Contractual Transactions

Supplier–customer operations, during contractual transactions, may be described through activities performed in material, information and financial flows.

Supplier–customer contractual performance may be presented as a diagram with three colours representing the branches. Each colour is assigned to each flow: material, informational and financial.

The diagram represents the synchronisation of the above flows.
A uniquely defined index may be assigned to each branch of the diagram.
Each index may define:

- The party (supplier or customer) whom the index identifies;
- The flow with which it identifies (material, informational or financial), and
- The sequential order number for the relevant flow.

Each node in the diagram represents a key stage in the contract.
By key stages, the researcher means the completion of the party's actions. Actions should be completely defined in the contract in terms of mutual obligations and responsibilities, and the time frame for actions to be accomplished. Actions should be accomplished before any subsequent action takes place. For example, before the shipment of goods takes place, relevant information must be exchanged between the parties.

The following example is used to illustrate the proposed methodology.
A contract was signed between the supplier and the customer that defined the following seven key stages (events):

1 The contract is signed by both parties. Contractual activities are initiated by both parties.
2 The information required for the supplier to arrange the dispatch of goods, and for the customer to arrange the goods' receipt, is exchanged. The customer then produces prepayment for the goods.
3 Pre-shipment informational interchange is accomplished. The dispatch of goods may be initiated.
4 Goods are delivered to the customer and all accompanying informational interchange is accomplished.
5 The delivered goods are inspected to determine if they meet with the contractual requirements.
6 Both parties, according to the results of event 5, fulfil their material and financial obligations with the support of informational interchange.
7. The information interchange required for the contract's closure is accomplished.

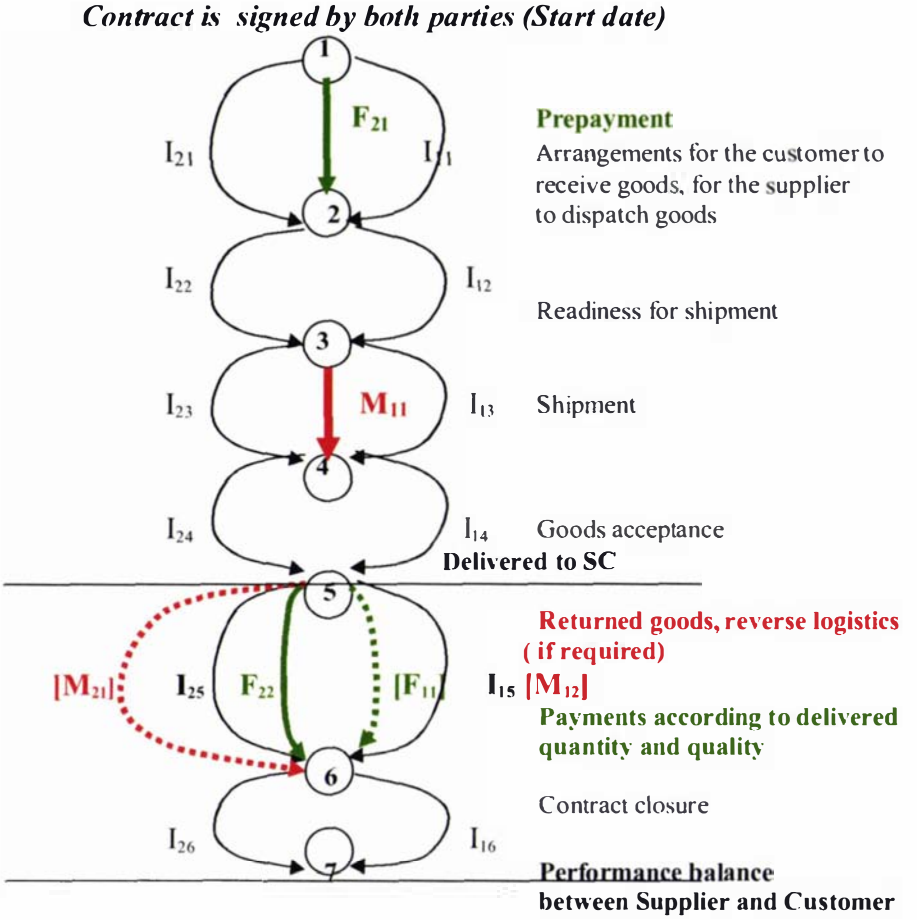
These stages may be presented by the following Figure 4.1 where:

- The supplier is assigned index 1, and the customer is assigned index 2;
- Capital letter **M** is used for activities in the material flow; capital letter **I** is used for activities in the information flow; capital letter **F** is used for activities in the financial flow.

Material flow
Information flow
Financial flow

Dashed lines show activities that may be not required, such as returned goods and/or additional customer payments. The direction of arrows for the activities is used to show the sequence of activities rather than the direction of flows.

Figure 4.1. Example of Customer-Supplier Activities Under Contractual Agreement



where:

I_{11}, ... I_{16} – information sent by the Supplier to the Customer;

I_{21}, ... I_{26} – information sent by the Customer to the Supplier;

F_{21} - prepayment made by the Customer;

M_{11} - product delivery from the Supplier to the Customer;

M_{21} - returned goods and/or reverse logistics performed by the Customer (if required);

M_{22} - returned goods and/or reverse logistics performed by the Supplier (if required);

F_{21} - funds returned by the Supplier to the Customer (if required);

F_{22} - additional payments made by the Customer to the Supplier (if required);

In the above diagram two events have a special level of importance. The name "***critical events***" will be used for these two nodes.

Event 5 is defined as the event that takes place when goods are accepted by the customer. After this event, the goods are available to subsequent chain members for further value-added transformation and movement through the supply chain in the direction of final consumers. In this process, the customer becomes the supplier to the next customer and/or consumers along the chain. Therefore customer's and supplier's performances in activities leading to event 5 have a direct impact on subsequent chain segments. If a delay occurs in event 5 it may potentially affect overall chain performance.

Event 7 is the second critical event. It defines the end of the contractual transaction when all required activities are accomplished. This is the final event node in the diagram above. Performance at this node consists of performance evaluated at event 5 plus performance in all additional activities (in the example $[M_{21}]$, $[M_{12}]$, , $[F_{22}]$, $[F_{11}]$, $I_{15}, I_{16}, I_{25}, I_{26}$). In this event node, the performance of how parties carried out their contractual obligations and responsibilities may be evaluated.

For each event to happen, the set of activities in different flows must be accomplished. For example, event 2 happens when all three activities, I_{11}, I_{21}, and F_{21} are accomplished.

4.2.2. Branch Level Normalised Performance Measurement

Methodologies introduced in Chapter 3 allow the measurement of the performance in each flow: material, financial and informational. These methodologies use a consistent normalised measurement scale. The normalised performance measure of one represents the expected performance specified in the contract. Normalised performance measures below 1 indicate a lower than expected performance. Normalised performance measures above 1 correspond to a higher than expected performance.

The notation **NPM** is used for normalised performance measures. In node 5 (see Diagram 4.1.1) goods are available to the customer and normalised performance measures $NPM(M_{11})$, $NPM(I_{11})$, NPM (I_{12}), NPM (I_{13}), NPM (I_{14}), for the customer's performance, and normalised performance measures NPM(F_{21}), NPM(I_{21}), NPM(I_{22}), NPM(I_{23}), NPM (I_{24}), for the supplier's performance, may be calculated by applying correspondent methodologies from Chapter 3.

The measure of normalised performance of the supplier in the chain (**NPS_1**) is defined through the composition of normalised performance measures of the supplier's activities in each flow, from event 1 through event 5 (In the example: $M_{11}, I_{11} - I_{14}$). This may be calculated as an average of five normalised performance measures:

$$\mathbf{NPS_1} = \frac{NPM(M_{11}) + NPM(I_{11}) + NPM(I_{12}) + NPM(I_{13}) + NPM(I_{14})}{5}$$

The measure of normalised customer's performance (**NPC_1**) is defined through the composition of normalised performance measures of the customer's activities in each flow, from event 1 through event 5 (In the example: $F_{21}, I_{21} - I_{24}$).

$$\mathbf{NPC_1} = \frac{NPM(F_{21}) + NPM(I_{21}) + NPM(I_{22}) + NPM(I_{23}) + NPM(I_{24})}{5}$$

The values **NPS_1** and **NPC_1** may be balanced if **$NPS_1 = NPC_1$**, or unbalanced if **$NPS_1 \neq NPC_1$**.

The term *"marginal normalised performance"* (**ΔNP_1**) is used for the difference of **$NPS_1 - NPC_1$**.

If **NPS_1** and **NPC_1** are balanced then **ΔNP_1**=0.

If **NPS_1** > **NPC_1** (**ΔNP_1** >0), then the average normalised performance provided by the supplier to the chain exceeds the average of the customer's normalised performance.

If **NPS_1** < **NPC_1** (**ΔNP_1** <0), then the average normalised performance provided by the supplier to the chain is below the average customer's normalised performance.

There are nine possible combinations of **NPS_1** and **NPC_1** values. They are presented in Table 4.1.1, below.

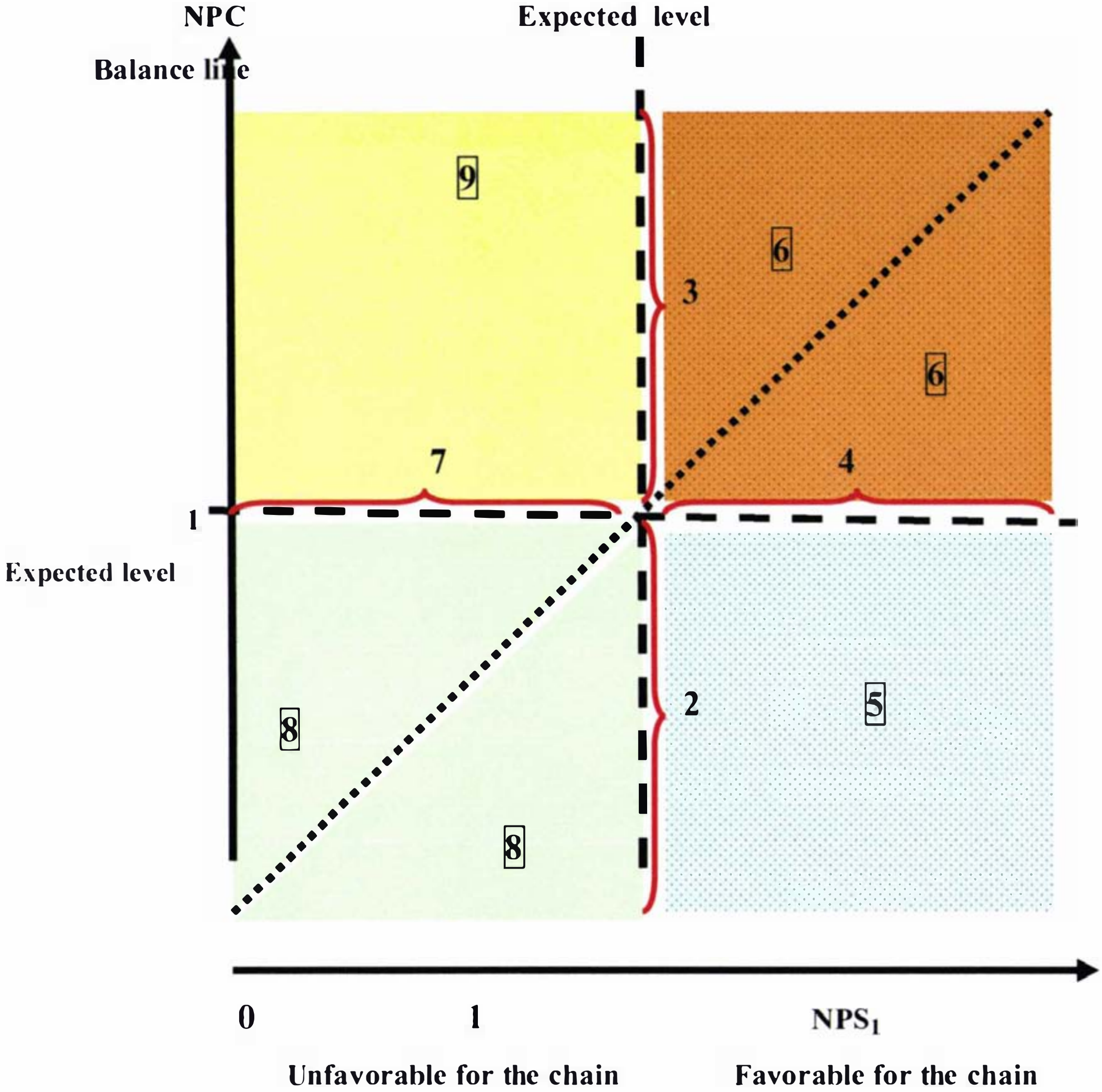
Table 4.1. Customer and Supplier Normalised Performance Values

№	Level of supplier's performance	NPS_1	NPC_1	Comments	(ΔNP_1)
1	Expected level	1	1	Expected performance	0
2		1	<1	The customer performed below the expected level	>0
3		1	>1	The customer performed above the expected level	<0
4	Performance above the expected level	>1	1	The supplier performed above the expected level	>0
5		>1	<1	The customer performed below, and the supplier performed above the expected level	>0
6		>1	>1	Both parties performed above the expected level	May have any value
7	Performance below the expected level	<1	1	The supplier performed below the expected level	<0
8		<1	<1	Both performed below – clarification is required.	May have any value
9		<1	>1	The supplier performed below, and the customer performed above the expected level	<0

In the above Table 4.1, three groups of performance are presented. Each group represents a different level of supplier's performance, which may potentially affect the rest of the supply chain.

Nine different combinations of supplier-customer performance are presented graphically in Figure 4.2, below.

Figure 4.2. Graphical Presentation of Supplier-Customer Contractual Performance



In Chart 4.2 two axes are used for different values of the supplier's and customer's normalised performance measures. The bold dotted lines indicate expected NPMs of 1. The intersection of these two lines corresponds to situation number 1, from Table 4.1. The four squared areas in the chart are colored differently. The line plotted through points (0,0) and (1,1) represents utilities with equal (balanced) values. Four outcomes from Table 4.1 (2, 3, 4 and 7) are represented by intervals. Four areas represent other situations (5, 6, 8, and 9).

Two of the nine situations listed in Table 4.1 deserve particular attention. In situation 6 (the orange area in Chart 4.1) the performance of both the supplier and the customer exceeded the expected level. This situation presents useful data for performance benchmarking. In situation 8 (green area in Chart 4.1) both the supplier and the customer performed below the expected level. The low level of performance of one party may be a result of the low level of performance of another party in earlier chain activities. Detailed analysis of all NPM values is required to determine which party initiated low performance to avoid similar situations in the future. There is a chance that the customer initiated the low performance, indicating that the low NPM value of the customer's performance may potentially affect the rest of the chain.

Similarly to the example above, analysis may be conducted for all activities up to event node 7 (see Diagram 4.1). The total normalised performance provided by the supplier under the contract (**NPS_2**) is defined through the average of NPM values in each flow from event 1 through event 7 (in the example activities: M_{11}, I_{11} – I_{16}, [M_{12}], [F_{12}]). The total customer's normalised performance under the contract (**NPC_2**) is defined through the average of NPM values of customer activities in each flow from event 1 through event 7 (in the example: F_{21}, F_{22}, I_{21} – I_{26}, [M_{21}]).

We use the term normalised performance balance (ΔNP_2) for the difference **$NPS_2 - NPC_2$**. Customer's and supplier's normalised performance values are balanced when **NPS_2 = NPC_2** ($\Delta NP_2 = 0$). The customer's and supplier's normalised performance values are balanced **NPS_2 = NPC_2** ($\Delta NP_2 \neq 0$). An imbalance of the above two values may potentially lead to dissatisfaction of the parties in business relationships. It may happen that one of the parties provided high normalised performance value to compensate of the low level of performance of another party. These are situations 2 and 5 from Table 4.1, when the supplier provided the expected normalised performance to the rest of the chain and the customer's normalised performance was below the expected value. Situations 7 and 8 present the higher than expected customers' normalised performance, which was not balanced by poor customer's performance. This potentially affected the rest of the chain.

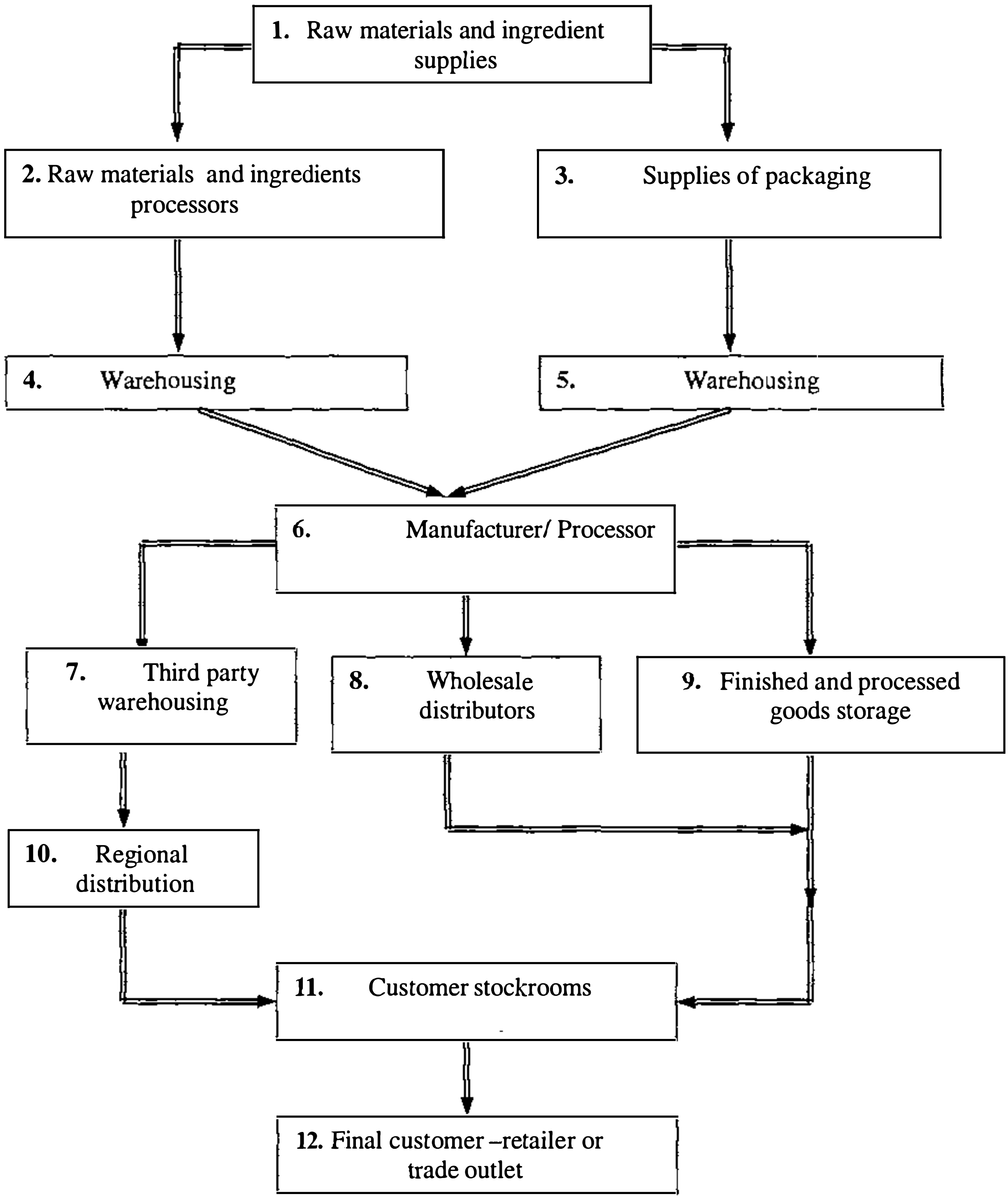
4.3. Network Level Normalised Performance Measurement

In Section 4.2 a method to measure supplier – customer contractual performance (branch level) was introduced. Uniformly scaled performance measures for three supply chain flows (material, financial, and informational) were combined to measure total contractual performance. A traditional food industry supply chain may be presented as a network where each node denotes a supply chain participant and branches represent contractual agreements. Using methodology from Section 4.2, two normalised performance measures may be assigned to each branch: the supplier's normalised performance measure and the customer's normalised performance measure. The set of activities that provide the maximum total normalised performance measure may be used for comparative analysis for all other sets sequences of chain members. The same method allows defining the set of supply chain activities that provides the highest total customers' normalised performance measure. Sets in which both the suppliers' and the customers' total normalised performance measures are above the expected total value may be used for purposes of supply chain benchmarking and optimisation.

4.3.1. Measurement of the Total Supply Chain Performance

The structure of any particular supply chain is strongly related to the nature of the product delivered to the final customer. It also depends on numerous other factors, such as the economic, political and business environment. The number of factors that affect the structure of agri-food chains is relatively high when compared to industrial chains (see Section 2.3). To introduce a method to measure total supply chain performance, the researcher used the structure of a traditional food industry chain suggested by Barford (2001). This structure is presented in Figure 4.3, below.

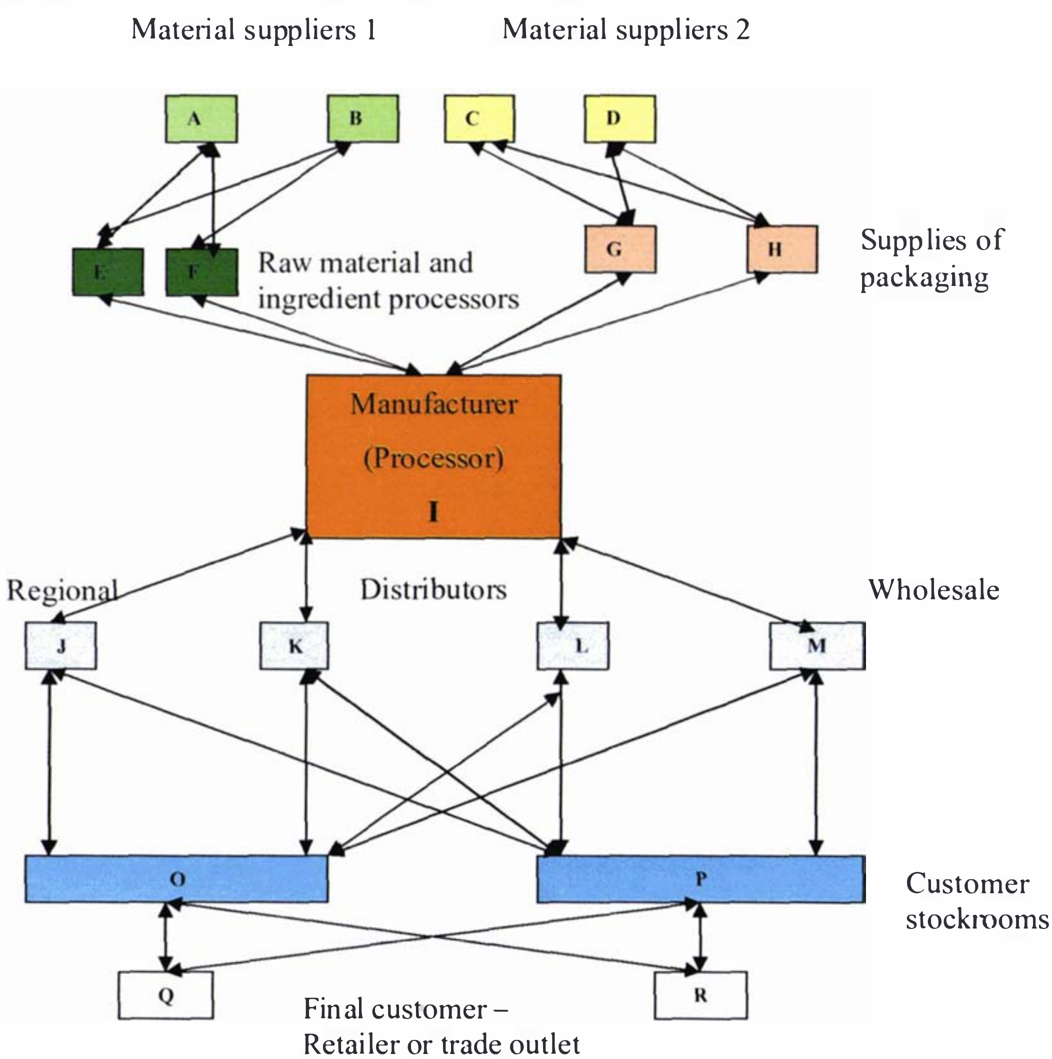
Figure 4.3. A Traditional Food Industry Supply Chain



Source: Bamford, C., 2001. Current practice: inter-firm relationships in the food and drink supply chain. In *Food Supply Chain Management: Issues for the Hospitality and Retail Sector*. Ed. By Eadtham, J. F., Sharples, L. and S. D. Ball, 2001, Butterworth Heinemann, Chapter 5, pp. 90 – 110.

The structure of the traditional food industry chain, adapted to the example of a food industry network, is presented in Figure 4.4, below. Supply chain participants are presented as nodes in Figure 4.4 marked by letters A-R. Each bi-directional arrow in Figure 4.4 represents a business transaction. For the purpose of simplicity, eight groups of businesses from the twelve presented in Figure 4.3 were used in Figure 4.4. Each group consists of two businesses (four for distributors), which perform similar activities and, potentially, may substitute each other. Businesses that perform the similar activities are coloured alike.

Figure 4.4. Example of a Food Industry Supply Network



A food product is delivered to the final customer (Q or R) by the sequence of supply activities. These activities are represented by branches in Figure 4.4, from Material suppliers 1 and 2 (nodes A- D) to Final customers (nodes Q and R).

In the above example these activities are:

- Materials for ingredient processing (Material suppliers 1 in Figure 4.4);
- Ingredients for food product manufacturing;
- Materials for packaging (Material suppliers 2 in Figure 4.4);
- Packaging products for food product manufacturing;
- Food product for further distribution either by regional distributors or wholesalers;
- Food product from either regional distributors or wholesalers to customer stockroom, and
- Food product from the customer stockroom to the final customer.

For the food product to reach the final customer, each of the above activities has to be performed. This is performed by a set of activities performed by one business from the seven groups (one and only one differently coloured node in Figure 4.4).

For example, the set of activities delivering food product to the final customer Q may be:

A – E; E- I; C-G; G-I; I-J; J-O; O-Q

In Figure 4.2.2 there are 2^8 (256) different sets of activities that may deliver a food product to each of the final customers Q, or R.

Two normalised performance measures were assigned to each branch. Each branch represents a business transaction:

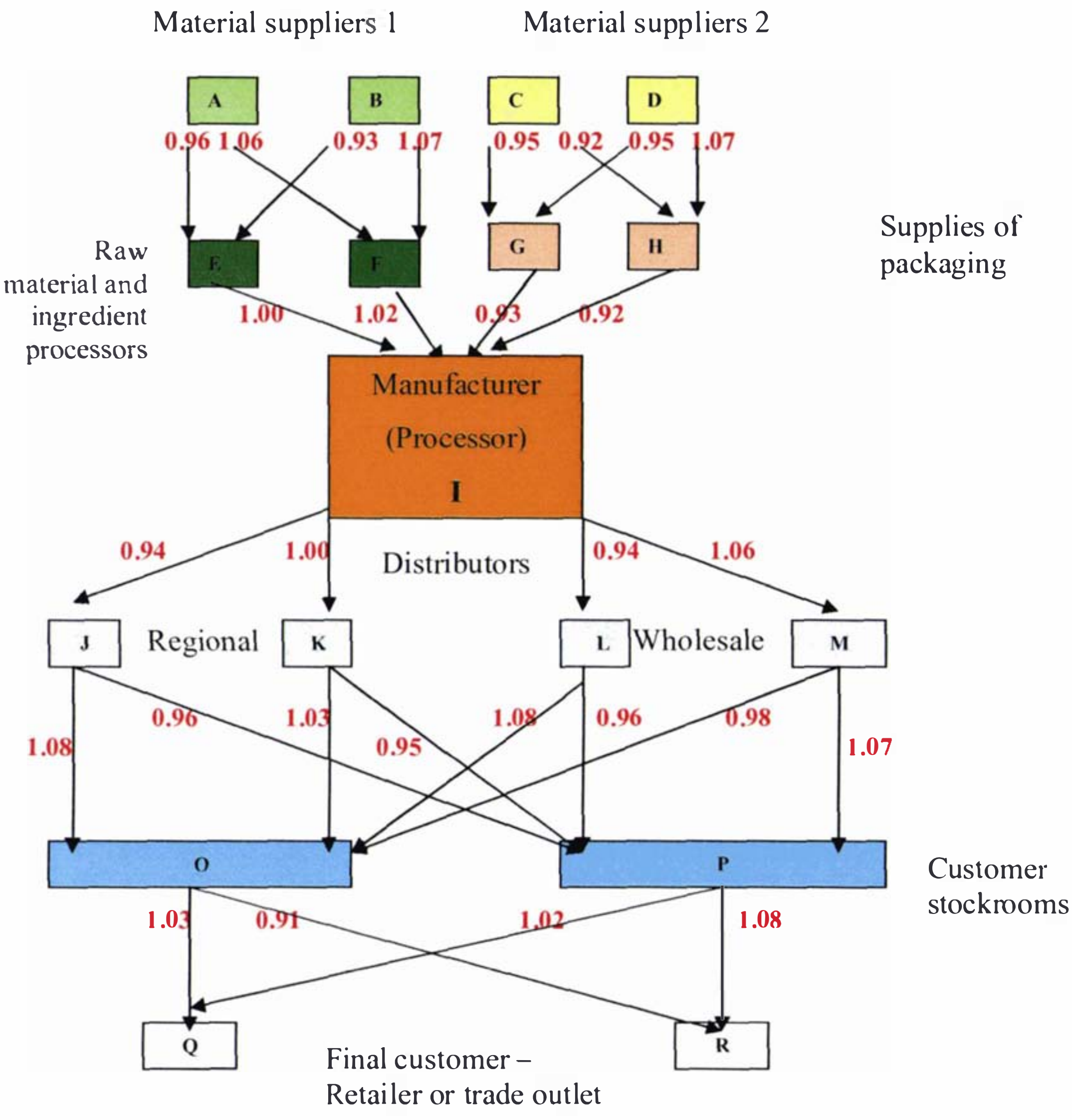
- The normalised performance measure of the suppliers' performance (except for the final nodes), and
- The normalised performance measure of the customers' performance (except for the starting nodes).

The total of the normalised suppliers' performance measures may be used to measure performance of a set of activities supplying food product to the final customer. Normalised performance measures, as defined in Chapter 3, increase in value as performance measures increase. The set of activities that provide the largest total normalised performance measure may be used for comparative analysis for other sets – sequences of chain members.

Example 18

To replicate measuring a food industry network, random numbers in the range [0.9, 1.1] were generated and assigned as normalised supplier performance measures for the example in Figure 4.4. Normalised performance measures were generated and are represented by the numbers in Figure 4.5. They are placed next to the arrows leading from the Material suppliers 1 and 2 to the Final customers.

Figure 4.5. Example of Suppliers' Normalised Performance Measures in a Food Industry Supply Network



In the above example, the highest total normalised performance measure is achieved by the set of activities: B-F; F-I; D-H; H-I; I-M; M-P for both final customers Q and R. For customer Q the highest total normalised performance measure is 7.23, and for customer R this value is 7.29.

All other sets of activities have lower total normalised performance measures. For example, the total normalised performance measure for the set of activities A-E; E-I; C-G; G-I; I-K; K-P; P-R is 6.87 which is for 0.42 below maximum value.

All sets of activities in the supply network under discussion may be subdivided into two groups:

Suppliers Group 1. Sets with total normalised performance measure not less than the total expected normalised performance measure are placed in Group 1. For each activity the expected normalised performance measure is 1. The total expected normalised performance measure in the supply network presented in Figure 4.4 for each set is 7. In the example presented in Figure 4.5 there are 74 sets in Group 1.

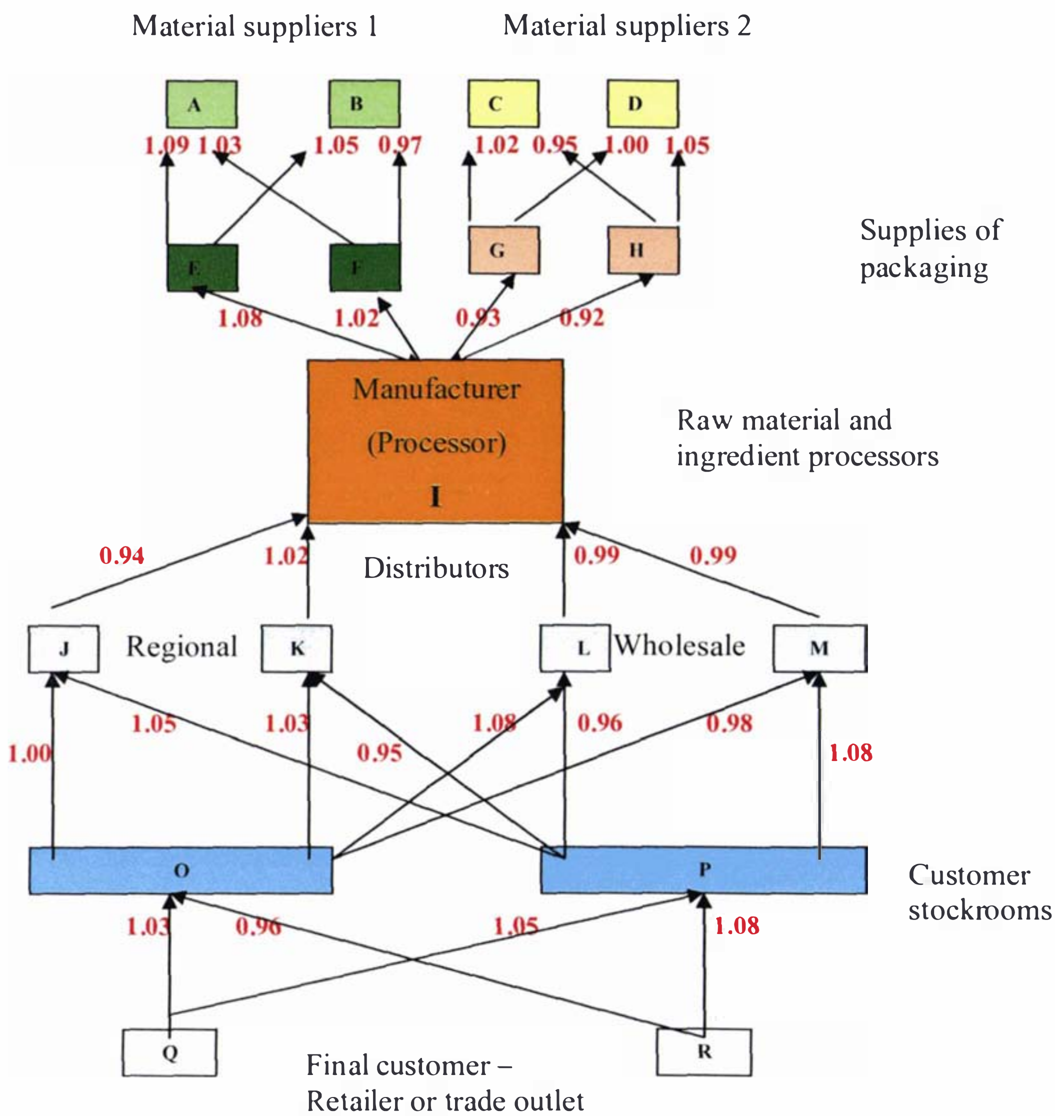
Suppliers Group 2. Sets with the total normalised performance measure less than the total expected normalised performance measure are placed in Group 2. These sets have a total utility less than the number of branches (business transactions) in the path. In the supply network presented in Figure 4.4, paths in group 2 have a total utility below 5. In the example presented in Figure 4.5 there are 182 sets in Group 2 1.

An approach similar to the above may be used to group sets in the supply network according to the customers' normalised performance measurement. In this case, an evaluation is produced for reverse flows in the supply network: from the final customer to the raw material and/or ingredient producers.

Example 19

Another set of random numbers in the range [0.9, 1.1] was generated and assigned as normalised customer performance measures in the example from Figure 4.2. Normalised performance measures were generated and are presented by the numbers in Figure 4.6. They are placed next to the arrows leading from the Final customers to the Material suppliers 1 and 2.

Figure 4. 6. Example of Customers' Normalised Performance Measures in a Food Industry Supply Chain



In the above example the highest total normalised performance measure of 7.29 is achieved by the set of activities: A –E; E-I; D- H; H-I; I- M; M- P; P- R (see Table 4.3).

Similar to the suppliers' performance evaluation, all sets of activities in this case may be subdivided into two groups according to the customers' total performance:

Customer Group 1 with the total normalised performance measure >= 7. In the example in Figure 4.6, there are 177 sets in Group 1.

Customer Group 2 with the total normalised performance measure < 7. In the example in Figure 4.6, there are 79 sets in Group 2 1.

For the purposes of supply chain analysis, it is important to identify different levels of both the suppliers' and the customers' performance in each network path.

Each set of activities in the supply network, as discussed above, has two total performance measurements assigned to it: the customers' total performance measurement and the suppliers' total performance measurement. Total performance measurement, as defined above, may have one of two states:

- A value below the total expected performance measurement, or
- A value not less than the total expected performance measurement.

Combining the suppliers' and the customers' performance gives four different combinations that may be used to group the sets of supply chain activities:

Table 4.2. Groups of Sets of Activities in Supply Network

Sets of activities defining customers' total expected performance measurement	**Sets of activities defining suppliers' total expected performance measurement**	
	Total performance measurement >= Total expected performance measurement	Total performance measurement < Total expected performance measurement
Total performance measurement >= Total expected performance measurement	**1** **Expected or higher than the expected level of chain performance**	**2** **Low level of suppliers' performance**
Total performance measurement < Total expected performance measurement	**3** **Low level of customers' performance**	**4** **Low level of both suppliers' and customers' performance**

Sets of activities in Group 1 represent business transactions which meet or exceed the expected or the higher than expected level of performance. A situation when the suppliers' and customers' total performance measurement is equal to 1 is a particular case in Group 1 when both parties performed as expected. Business transactions from Group 1 may be used as a base to benchmark all supply network businesses.

The sets of activities in Groups 2 and 3 represent business transactions where the high performance in network flows, in one direction, is unbalanced by the low level of performance in the opposite network flows.

The sets of activities in Group 4 represent the case when both the suppliers' and customers' total performance measurements are below the expected value (a low level of performance).

A lower than expected performance value for a business in a particular path may be the result of the "chain wave effect" introduced and discussed in Section 6.5.

In Examples 18 and 19, above, the numbers of sets of activities in these groups are:

Group 1(Expected or higher than expected level of chain performance)	51;
Group 2 (Low level of suppliers' performance)	126;
Group 3 (Low level of customers' performance)	23;
Group 4 (Low level of both suppliers' and customers' performance)	56.

Business transactions from Group 1 may be used as a base to benchmark all supply network businesses.

The total normalised suppliers' and customers' performances for Group 1 are summarised in Table 4.3. Five sets have a balance of total values of 7, 7.02, 7.04, 7.05, and 7.12 for both suppliers and customers. Twenty two sets have the total normalised customers' performance above the total normalised suppliers' performance (above the diagonal in Table 4.3). The remaining 51-5-22=24 sets have the total normalised suppliers' performance above the total normalised customers' performance (below the diagonal in Table 4.3).

Table 4.3. Total Normalised Suppliers' and Customers' Performances (Group 1).

Suppliers	Customers																														Suppliers
	7.00	7.01	7.02	7.03	7.04	7.05	7.06	7.07	7.08	7.09	7.10	7.11	7.12	7.13	7.14	7.15	7.16	7.17	7.18	7.19	7.20	7.21	7.22	7.23	7.24	7.25	7.26	7.27	7.28	7.29	
7.00	1					1						1													1						7.00
7.01				1					1		1									1			1								7.01
7.02			1		1		1		1						1							1		1							7.02
7.03	2		1																												7.03
7.04					1																										7.04
7.05						1				1																1					7.05
7.06				1																								1			7.06
7.07					1																		1								7.07
7.08																															7.08
7.09																															7.09
7.10								1																			1				7.10
7.11		1									1		1																		7.11
7.12					1		1						1																		7.12
7.13							1	1			1															1					7.13
7.14		1	1		1																										7.14
7.15																															7.15
7.16																														1	7.16
7.17														1	1																7.17
7.18								1		1																					7.18
7.19																															7.19
7.20																															7.20
7.21																															7.21
7.22															1																7.22
7.23									1																						7.23
7.24																															7.24
7.25																															7.25
7.26																															7.26
7.27																															7.27
7.28																		1													7.28
7.29												1																			7.29
	7.00	7.01	7.02	7.03	7.04	7.05	7.06	7.07	7.08	7.09	7.10	7.11	7.12	7.13	7.14	7.15	7.16	7.17	7.18	7.19	7.20	7.21	7.22	7.23	7.24	7.25	7.26	7.27	7.28	7.29	

Customer's total normalised performance >
Supplier's total normalised performance
Supplier's total normalised performance >
Customer's total normalised performance

Further analysis of the sets in Group 1 sets, which represent the highest total normalised performance measures for suppliers and customers, follows. In the simulated example, the top five total normalised suppliers' performance measures are:

Table 4.4. The Top Five Total Normalised Suppliers' Performance Measures (Simulated Example)

Total normalised suppliers' performance	Correspondent total normalised customers' performance	Sum of total normalised performances	Rank
7.29	7.11	14.40	1
7.23	7.08	14.31	3
7.22	7.14	14.36	2
7.18	7.09	14.27	4
7.18	7.07	14.25	5

In Table 4.4, the total normalised suppliers' and customers' performance measures were added and the results were compared. The top five cases were ranked, with the highest total normalised suppliers' performance measure first. For example, even though the total normalised suppliers' performance measure of 7.23 (case 2) is one percent above 7.22 (case 3), the corresponding total normalised customers' performance in case 2 is 6 per cent below of the customers' performance in case 3.

Similar analysis was produced for the top five total normalised customers' performance measures:

Table 4.5. The Top Five Total Normalised Customers' Performance Measures (Simulated example)

No	Total normalised customers' performance	Correspondent total normalised customers' performance	Sum of total normalised performances	Rank
1	7.29	7.16	14.45	1
2	7.27	7.06	14.33	4
3	7.26	7.10	14.36	3
4	7.25	7.13	14.38	2
5	7.25	7.05	14.30	5

The resulting top five total normalised performances of both suppliers and customers are:

Table 4.6. Activities in The Top Five Total Normalised Customers' Performance Measures (Simulated example)

No	Activities	Sum of total normalised performances	Total normalised suppliers' performance	Correspondent total normalised customers' performance
1	A-E; E-I; D-H; H-I; I-M; M-P; P-R	14.45	7.16	7.29*
2	B-F; F-I; D-H; H-I; I-M; M-P; P-R	14.40	7.29**	7.11
3	B-E; E-I; D-H; H-I; I-M; M-P; P-R	14.38	7.13	7.25
4	A-E; E-I; D-H; H-I; I-M; M-P; P- Q	14.36	7.10	7.26
5	A-F; F-I; D- H; H-I; I-M; M-P; P-Q	14.36	7.22	7.14

*The highest customers' performance

**The highest suppliers' performance

All five sets from Table 4.6 include the transactions:

D-H, and I-M, M-P.

Results of the analysis presented in Tables 4.4 –4.6 may be used to select sets, activities and business transactions for setting best performance indicators. For example, business transactions D-H, and I-M, M-P may be selected as the performance benchmark.

The diagram in Figure 4.3 indicates that all sets include the manufacturer (node I). Therefore, the food manufacturer plays a special role in this supply network. Any set may alternatively be defined as a composition of two sets:

- The set that starts with the raw material and ingredient supplier and ends with the manufacturer;
- The set that starts with the manufacturer and ends with the final consumer;
- The central role of the manufacturer in the traditional food industry chain underscores its responsibilities for overall chain performance.

This decomposition is consistent with the different nature of material flows in different parts of the agri-food supply network. The main part of the material flow is directed from raw material and ingredient supplies to the manufacturer and deals with either commodities or industrial food products. The structure of this part of the supply network is highly related to the type of raw materials used.

The main part of the material flow directed from the manufacturer to the final consumer deals with processed agri-food products. The structure of this part of the supply network, either totally or partially, may be similar to those of a wide range of agri-food products.

Chapter Five

Applications to Strategic Planning and Control

The performance measurement induced strategy model, suggested by Dyson and O'Brien (1998), is discussed in the context of the SCM discipline and the suggested performance measurement methodology. Particular attention is paid to the supply chain management mission statement.

The model of the strategic development of an organisation, developed by Dyson and O'Brien (1998), is used to demonstrate the location of a research performance measurement system in the total strategic development process. Beer (1981) introduced measures of achievement that are used to link together performance measures with different planning levels. Measures of achievement are discussed and related to the strategic development process in the supply chain system context. This allows demonstrating how the suggested performance measurement methodology may be used in the supply chain strategic planning and controlling process.

5.1. Introduction

There are several existing strategic management schools. Analysis and classification of the existing strategic management schools were presented in Section 2.4. Strategic planning is viewed as a process:

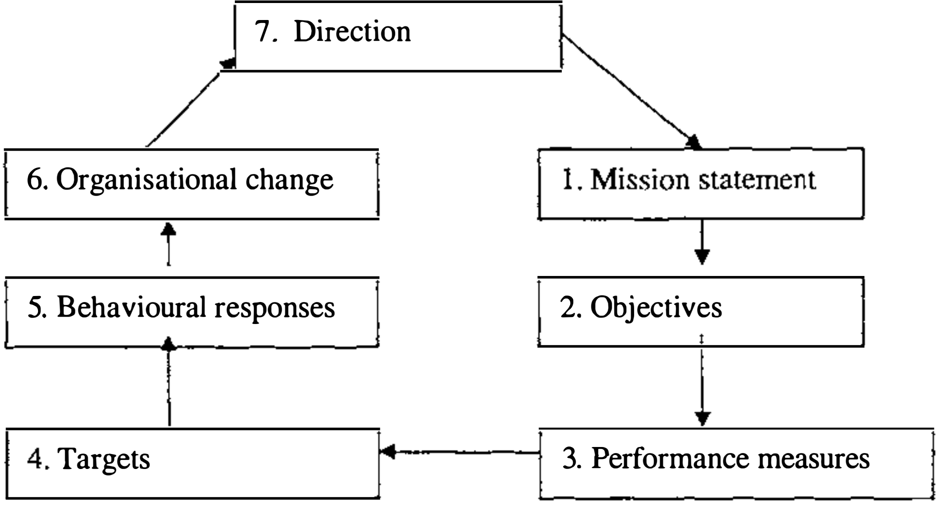
- " of transformation – change from the one dynamic state to another" (Miles, 2003);
- " both logical and incremental. Logical instrumentalism honours and utilizes the global analyses inherent in the formal strategy formulation model" (Quinn, 1980).

The literature presents many different strategic process models (Porte , 1980; Newman, 1982; Hill, 1992). The majority of available models include the same basic strategic management definition, such as mission statement, objectives and goals, and targets. In the research suggested by Dyson and O'Brien (1998), Dyson's (2000) performance measurement induced models were adapted for supply chain systems.

5.2. Relationship between Performance Measures and the Strategic Planning Process

Dyson and O'Brien (1998), and Dyson (2000) showed the relationship between performance measures and the strategic planning process. They recognised that any organisation has a complex set of goals designed to achieve a desired direction of organisational development. This relationship of organisational goals to the strategic direction of a company is presented in Figure 5.1, below.

Figure 5.1. Performance Measurement Induced Strategy



Source: Dyson, R. G.(2000), Strategy, Performance and Operational Research. *Journal of the Operational Research Society*, 51, p. 7.

5.2.1. Mission Statement

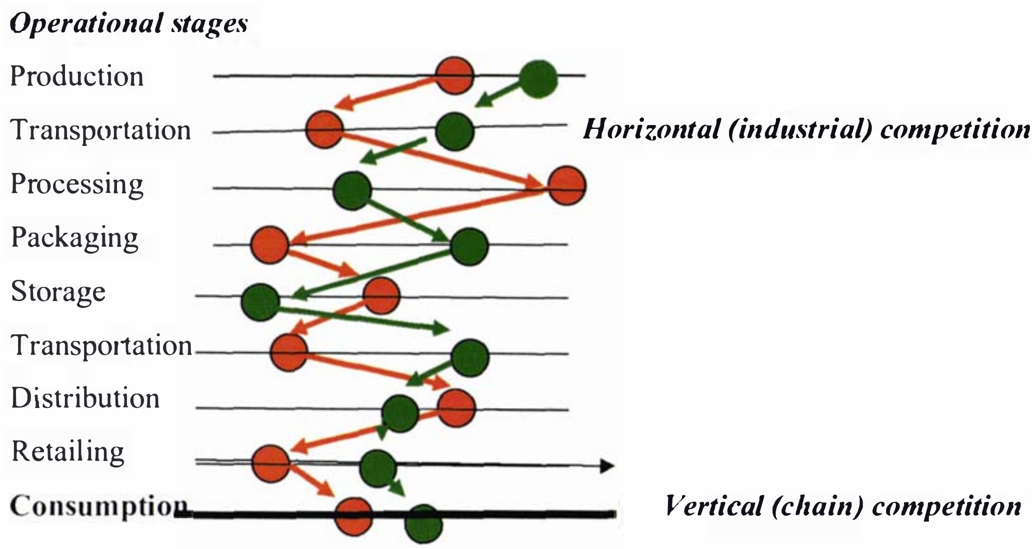
A mission statement is a general statement of the overriding purpose of an organisation (Johnson and Scholes, 2001). The supply chain philosophy views the achievement of competitive advantage for each individual company as being managed through improving the performance of the system as a whole and, conversely, improving the performance of the individual companies, as the way to achieve competitive advantage for the total system. Just as there must be agreement within an organisation about its strategic direction, there must also be agreement among supply chain members as to the strategic direction of the entire chain. Agreement allows defining a SCM mission statement, as:

To achieve a competitive advantage for supply chain members.

Each individual company in a supply chain adds value to a final consumer product. Consumers pay for the total value of that product. A product's total value is the sum of all values added to the product by each member of the supply chain. Competition between different final consumer products (see the bottom line in Figure 5.2, below) may be viewed as competition between different total value offerings created by different supply chains - the green and oranges chains in Figure 5.2, below. Each company in a supply chain participates in this competition as a part of the total supply chain through the value that the company adds to the final consumer product. This competition may be defined as vertical supply chain competition. The name "vertical" is used to stress the fact that companies that participate in this competition are vertically integrated with different and competing supply chains.

Individual companies operate in different industry environments and are subject to horizontal (industrial) competition. This principle is graphically presented in Figure 5.2, below.

Figure 5.2. Vertical (Chain) and Horizontal (Industrial) Levels of Competition



In the context of vertical competition, enterprises depend on not only adjacent activities but on total chain effectiveness. This is because the final consumer product provides a source of financial flow for all members of the chain. The final consumer product is the output of chain members. The more efficient is any company, the less it may potentially price its products, and, as a result, the higher is its competitive position in the market place (horizontal competition). Strong horizontal competitive positions of SC members allow increased value of the final consumer product. That results in a stronger competitive position for the entire SC (vertical competition).

5.2.2. Objectives

Business objectives are the strategic goals of the organization (Web definition by accuracybook.com/glossary.htm). A goal, in general, is the answer to the question: "What do we want to achieve"? Business objectives do not necessarily have a numerical form, but "are specific outcomes that are to be achieved" (Johnson and Scholes, p. 241).

The SCM definition given by Kuglin (1998) helps to relate a SCM mission statement with the firm's objectives:

" The manfacturer and its suppliers, vendors, and customers – that is, all links in the extended enterprise – working together to provide a common product and service to the market place that the customer is willing to pay for. This multicompany group, functioning as one extended enterprise, makes optimum use of shared resources (people, process, technology, and performance measures) to achieve operating synergy. The result is a product and service that is high-quality, low-cost, and delivered quickly to the marketplace".

The conclusion may be drawn that SCM considers high-quality, low-cost, and fast delivery to the marketplace as a way to attain a competitive position for all supply chain members.

5.2.3. Targets

Targets usually have numerical forms that define the desired level of achievement for specific objectives. The last phrase of the above SCM definition defines operational parameters that have to be quantified: quality, cost and delivery. All of these parameters are incorporated into the suggested methodology (see Chapter 3) in the form of actual normalised performance measurement. Therefore, targets may be defined and achieved not only through meeting internal operational targets but through the level of actual performance that is to be accomplished by all sets in the SC network.

5.2.4. Performance Measures

Performance measurement systems, as baselines to assess the success of an organisation and the level of achievement of established objectives, have been used throughout history (Kennerly and Neely, 2002). With the continued increase of business attention to SCM topics, the interest in the question "how to measure SC performance" has also increased.

Lapide (2003) states that SC performance measures must be closely aligned with both the strategic corporate objectives and the performance objectives of SC partners.

In the context of strategic SCM tasks, performance measures should then provide an indication of how each individual company, and the whole supply chain, performs. Performance measures and targets typically support these objectives (Dyson and O'Brien, 1998). Applications of the performance measurement methodology suggested in this research (Chapters 3 and 4) to SCM strategic planning and control are discussed in detail in Section 5.3, below.

5.2.5. Behavioural Response and Organisational Change

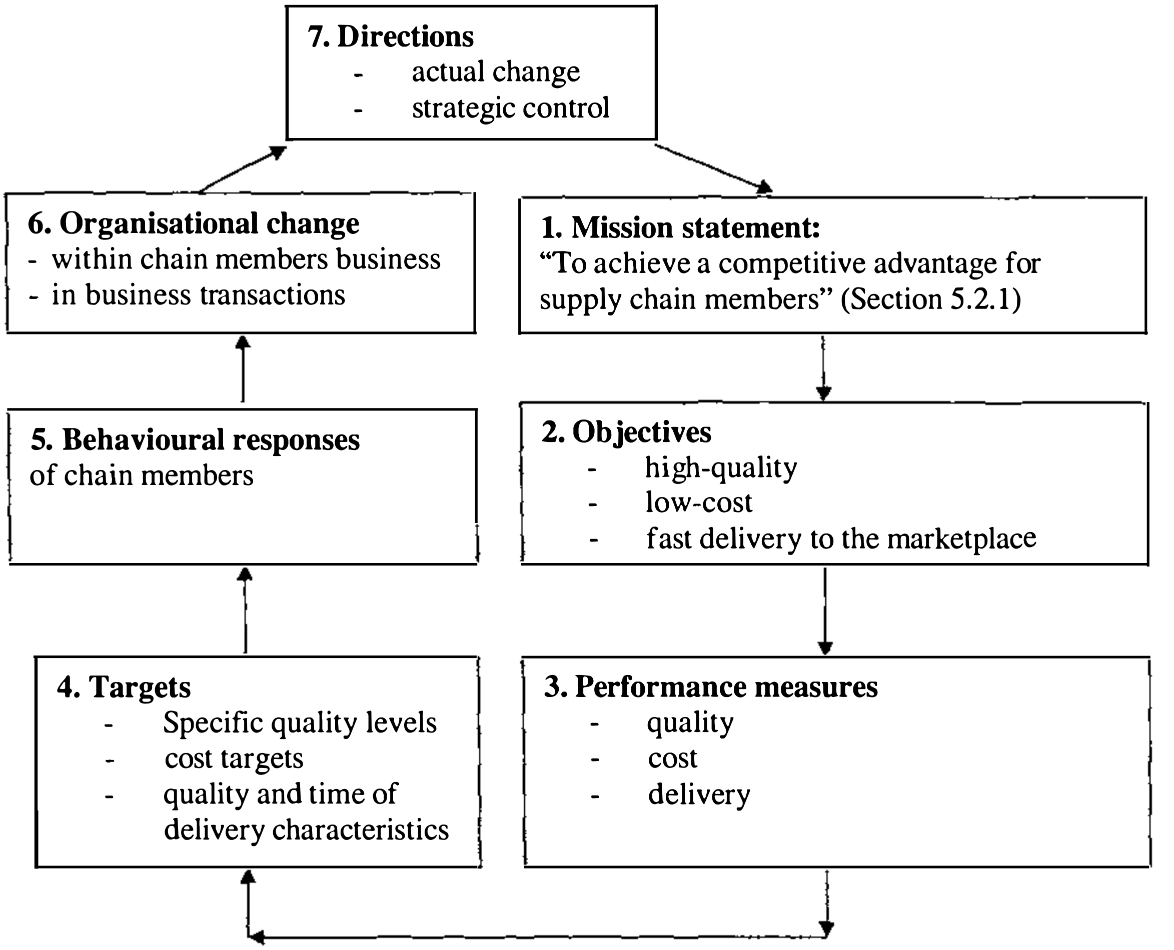
Targets defined in terms of performance measurement systems force an organisation to respond. This leads to organisational change defined by Dyson and O'Brien (1998) as "a performance measurement induced strategy". In the context of the supply chain, response and change are induced on the whole chain and each chain member by performance measurement systems. As Kaplan and Norton (1998) indicate "It is only when word statements are translated into measures that everyone understands clearly what the vision and strategy are about".

5.2. 6. Directions

Real changes in organisational performance may be seen in the direction taken by an organisation. A performance measurement system should monitor actual changes and monitor if the actual changes are consistent with the firm's pre-defined mission statement, objective and targets. These issues were considered by Beer (1981) who discussed "measures of achievement", defined through the measures of actuality, capability and potentiality.

The performance measurement induced strategy model (Figure 5.1), suggested by Dyson and O'Brien (1998), was discussed above (Sections 5.2.1 -5.2.5) in the context of SCM discipline and the suggested performance measurement methodology. The results of this discussion resulted in the model presented in Figure 5.3, below.

Figure 5.3 SCM Performance Measurement Induced Strategy

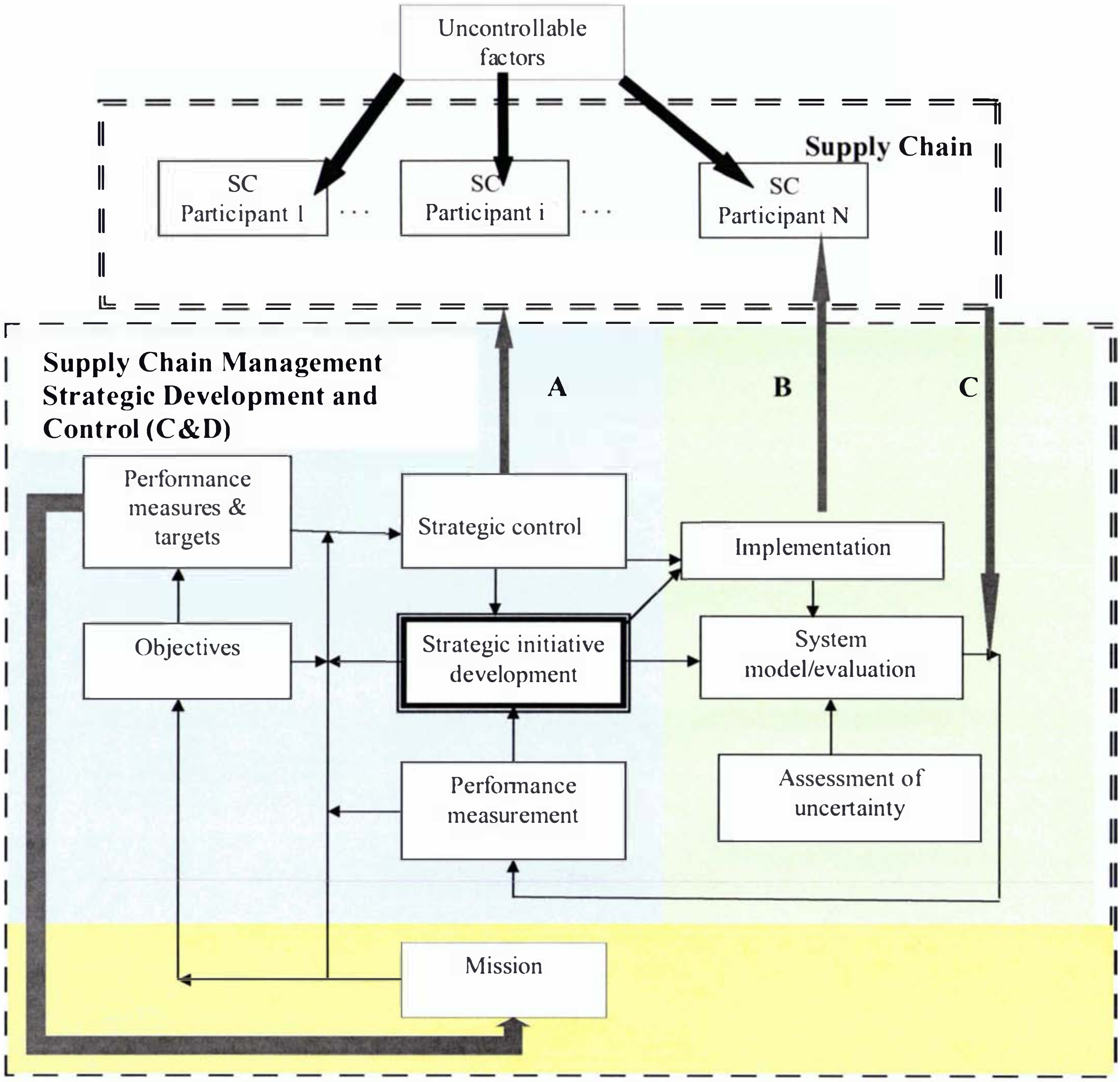


5.3. Strategic Development Process

The model of the strategic development of an organisation, developed by Dyson and O'Brien (1998), was used as a basis for supply chain strategic development and control framework, presented in Figure 5.4, below. Figure 5.4 consists of two main parts. The top part contains all business entities included into the supply chain where *N* is the number of supply chain participants (SCP_1, ... SCP_N). Each business entity is affected by uncontrollable factors. The bottom part of Figure 4 represents a supply chain management strategic development and control framework (C&D). Two parts of Figure 5.4 are interrelated through arrows A, B, and C. The C&D framework establishes control procedures for all SC participants (arrow A). Implementation plans are communicated to the SC through arrow B.

The SC system feedback on performance is represented in Figure 5.4 by arrow C. The blue colour in Figure 5.4 is used for the C&D process sub-models covered in this research.

Figure 5.4 A Strategic Development Process



Source: Adapted from Dyson, R. G., and O'Brien, F. A., Ed. (1998), *Strategic Development : Methods and Models*, Chichester, England ; New York : John Wiley, p. 7)

5.4. Suggested Methodology as a Part of the C&D Process

The supply chain C&D process, as presented in Figure 5.4, consists of three main parts:

- Mission (yellow colour);
- Modelling and implementation (green colour), and
- Performance measurement control and upgrade (blue colour).

These parts are interrelated. Each part plays a significant role in the overall C&D process. This Section demonstrates how the performance measurement system suggested in Chapters 3-4 is related to the performance measurement and control part of the C&D process (blue colour in Figure 5.4).

5.4.1. Measures of Achievement

Beer (1981) introduced measures for three levels of organisational achievement:

- **Actuality**: measurement of actual current performance, with existing resources, under existing constraints. In the context of this research, actuality is presented as total actual normalised performances measured for all sets of activities in the existing chain structure (see Section 4.2) – $TANP_1......TANP_n$ (where n – is the number of sets in the chain).

- **Capability:** measurement of what could be done with existing resources, under existing constraints, if performance was to be improved. Capability, in terms of the performance measurement system introduced, is the best network actual performance defined by the set of activities with the highest sum of total performances – $TANP_{max}=max(TANP_1......TANP_n)$.

- **Potentiality:** measurement of what could be achieved by developing resources and removing constraints. For the SC, this means network reorganisation resulting in an increase of the highest sum of total normalised performances $\overline{TANP}_{max}$.

Beer (1981) introduced several performance measures, listed below, and discussed them in the SCM context.

Productivity= Actuality/Capability

Productivity provides a measure for each set of activities of its actual performance in relationship to the best network practice. For the performance measurement system introduced, n Productivity values are calculated (where n – is the number of sets in the chain):

$PR_1=TANP_1 / TANP_{max}$

......

$PR_n=TANP_n / TANP_{max}$

Productivity equals 1 for the set of activities with the highest sum of total performances of $TANP_{max}$ and is below 1 for all other sets of activities. For example, for the set of activities with TANP=14.36 with $TANP_{max}$ = 14.45, productivity is 14.36 /14.45=0.99.

Another measure of achievement is Latency, calculated as:

Latency= Capability/Potentiality

Potentiality, as defined above, may be viewed as a target value for the set of activities with the highest total normalised performance of $TANP_{max}$. For example, for $TANP_{max}$ =14.45 with Potentiality $\overline{TANP}_{max}$ =15, the Latency of the total network at 14.45/15=0.96. It shows that by developing resources and removing constraints the best network performance targeted may be improved by 4 per cent.

Beer (1981) introduced the following definition of performance:

Performance= Actuality/Potentiality

For the set of activities with the highest sum of normalised performances of $TANP_{max}$, Performance equals Latency of 0.99, from above. For the set of activities with the total normalised performance of 14.36, Performance equals 14.36/15=0.957. This means that by developing resources and removing constraints, the set's performance is targeted to be improved by 4.3 percent.

By substituting formulas for Productivity and Latency into the Performance formula, another form of Performance formula may be derived:

$$\textbf{Performance} = \text{Actuality/Potentiality} = \frac{\text{Productivity*Capability}}{\text{Capability/Latency}} = \textbf{Productivity* Latency}$$

For a network with n sets of activities, performance values are:

$P_1 = PR_1 * Latency$

......

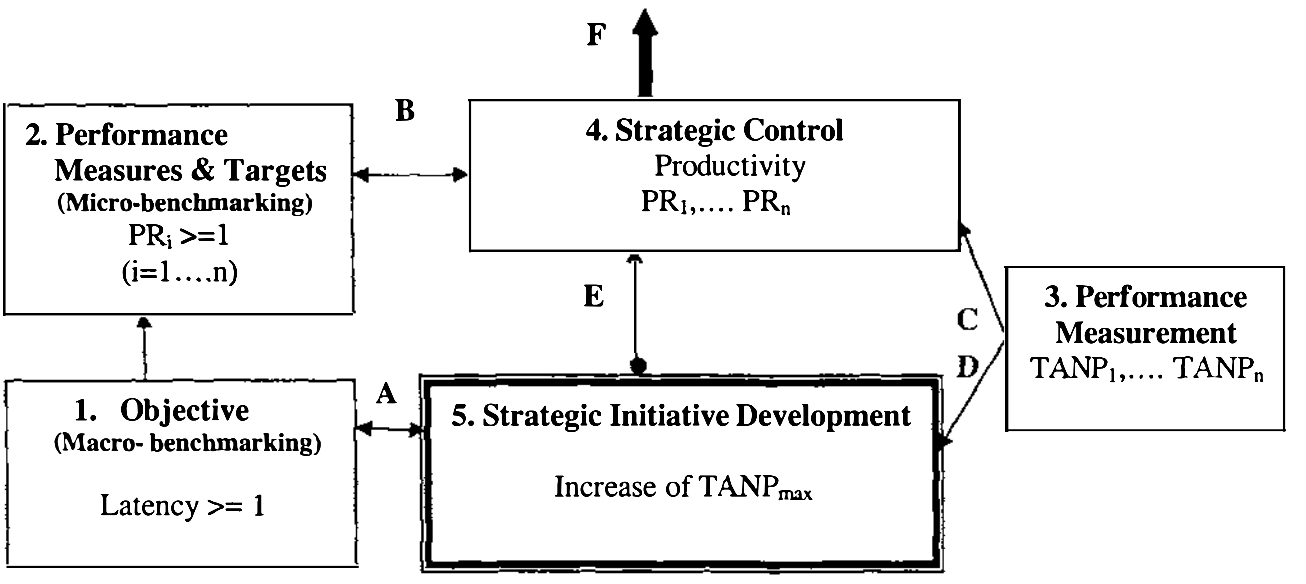
$P_n = PR_n * Latency$

The above formula defines performance in terms of achievements in two different planning horizons. Productivity, as discussed above, presents relative measures of actual performance. Latency defines the level of desired improvement for best network performance and requires development of resources and the removal of constraints.

5.4.2. Measures of Achievement as a Part of a Strategic Development Process

The relationship between measures of achievement and the strategic development model (Section 5.3) is presented in Figure 5.5, below, taken from Figure 5.4.

Figure 5.5 Measures of Achievement as a Part of the Strategic Development Process



Objective

In Section 5.2.2 it was indicated that SCM considers high-quality, low-cost, and fast delivery to the marketplace as a means to attain a competitive position for supply chain members. In terms of the proposed performance measurement system, this suggests high actual normalised values. Latency, as defined in Section 5.4.1, quantifies the level of improvement needed to attain the best network performance. This may be achieved by developing resources and removing constraints. A Latency value of 1 means that by developing resources and removing constraints, the best network performance level has reached the pre-defined target level (see definition of Latency in Section 5.4.1) which is referred to as macro-benchmarking. The macro-benchmark is obtained from the Strategic Initiative Development sub-model (see arrow A in Figure 5.5).

Performance Measures and Targets

In Section 5.2.3, targets were defined as the level of actual performance to be achieved by all sets in the SC network. This level may be defined through a set's Productivity (PR), which, according to the definition given in Section 5.4.1, measures the actual performance (TANP) in relationship to the best network practice ($TANP_{max}$) for each set of activities. By setting the target of productivity as not less than one for all network sets, the requirement is placed on all network sets' actual performance to reach and exceed the best in network performance. This becomes the micro-level benchmark. The micro-level benchmark is defined by the Strategic Control sub-model as a target value for all network sets (see arrow B in Figure 5.5).

Performance Measurement

The Performance Measurement sub-model includes all procedures to collect actual performance data from all network members. These data may then be used in the proposed performance measurement procedures to calculate the actual total values for all network sets' performance, which, as defined in Section 5.4.1, gives values of Actuality ($TANP_1$......$TANP_n$). Values of Actuality for network sets are transferred to the Strategic Initiative Development sub-model (see arrow C in Figure 5.5) and to the Strategic Control sub-model (see arrow D in Figure 5.5).

Strategic Control

In the Strategic Control sub-model, values of Productivity (PR1,.... PRn) are analysed to define required system actions (if any) and are communicated to supply chain members (see arrow F in Figure 5.5). A Productivity value of above 1 indicates that a new $TANP_{max}$ was found. The higher $TANP_{max}$ value indicates that it may be possible to upgrade the Capability value. The final decision on a Capability value upgrade is produced by the Strategic Initiative Development sub-model discussed below. Any change in the Capability value is transferred to the Performance Measures & Targets sub-model. The increase of the value of Capability will cause a corresponding increase of the Latency value (see definition of Latency in Section 5.4.1). All previous values of Performance ($TANP_{1,....}$ $TANP_n$) remain unchanged. An increase in the Latency value causes a proportional decrease in all previously calculated Productivity values (PR_1,...PR_n). This is illustrated by the example in Table 5.1, below.

Table 5.1. Effect of Capability Increase on Measures of Achievement

Measures of Achievement		Set 1 with $TANP_1=TANP^0_{max}$	Set 2 with $TANP_2< TANP_{max}$ vs. Set 1	Set 3 with $TANP=TANP^1_{max} > TANP^0_{max}$	Set 2 vs. Set 3
		1	2	3	4
1	Actuality	14.450	14.360	14.600	14.360
2	Capability	14.450	1.450	14.600	14.600
3	Potentiality	15.000	15.000	15.000	15.000
4	Productivity	1.000	0.994	1.000	0.984
5	Latency	0.963	0.963	0.973	0.973
6	Performance	0.963	0.957	0.973	0.957

In Table 5.1, columns 1 and 2 contain the values used in the examples in Section 5.4.1. Identification of a new $TANP^1_{max}$, value of 14.6, results in an increase of Latency from 0.963 to 0.973 (14.6/15) and in a decrease of Productivity for set 2 from 0.994 to 0.984.

Selection of the new $TANP_{max}$ value establishes a new, higher, micro-level target and stipulates an increase in previous requirements on network sets' performance by decreasing their previous Productivity measures. At the same time, increased Latency indicates the step to reach the objective of Latency>=1.

Strategic Initiative Development

A Strategic Initiative Development sub-model, as presented in Figure 5.5, is focused on an increase of the Capability value with the goal of Capability equalling Potentiality. The Strategic Initiative Development sub-model includes in-depth supply network system analysis that seeks a more effective use of system resources. Figure 5.4 represents the Strategic Development Model where the above sub-model is interrelated with the System Model and Evaluation block.

The Strategic Initiative Development sub-model is interrelated with the Strategic Control sub-model (see arrow E in Figure 5.5). This relationship allows each set of activities to be evaluated in terms of system Capability. This interface also allows the selection of a new Capability value. A Productivity value above 1, for some network sets, may be caused by favourable external factors or exploitation of internal resources which give a short-term increase in the Productivity value. These situations are filtered by the Strategic Initiative Development sub-model in the procedure of Capability value upgrading. This procedure upgrades the Capability value on the basis of pre-planned Productivity increases that resulted from actions undertaken on utilisation of chain resources and the removal of constraints.

The relationships between the measures of achievement in the strategic development process are presented in Figure 5.6, below.

Figure 5.6. The Relationships between Measures of Achievement in the Strategic Development Process

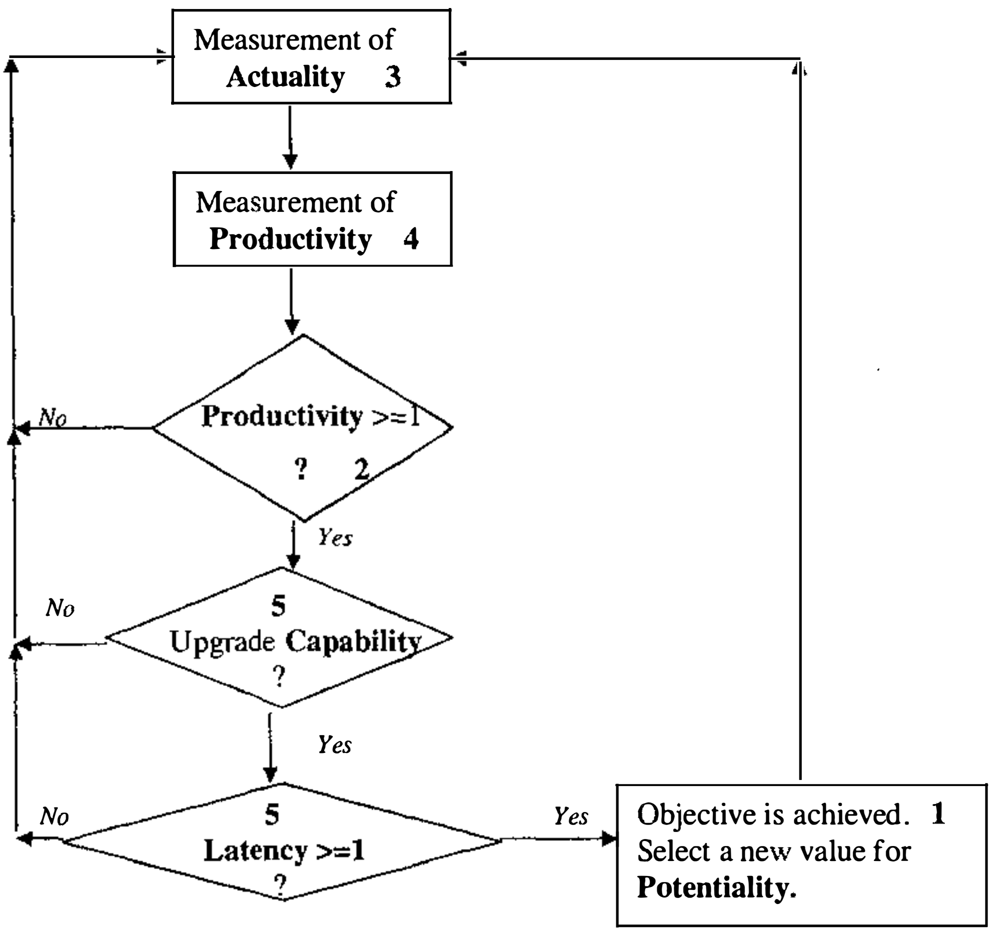


Figure 5.6 presents the perpetual measurement process. Numbers in each block show the order number of the sub-model from Figure 5.5 which performs a corresponding operation or is responsible for the corresponding decision. All blocks in Figure 5.6 were discussed above except for one - when Latency>=1. In this situation the objective to make Potentiality equal to Capability is achieved. This represents the situation when the best supply chain performance has reached the pre-established benchmarked level of performance. This means that benchmarked levels increased to stimulate further system development. A new, higher value of Potentiality must be selected as a new system performance benchmark. This indicates that the system had reached a new qualitative stage in its development.

5.5. Conclusions

Supply chain management "encompasses the firm's activities at many levels, from the strategic level through the tactical to the operational level" (Simchi-Levi *et al.*, 2000). The performance measurement system used in this Chapter was introduced in Chapters 3 and 4. Adaptation of performance measurement induced strategic planning models (Dyson and O'Brien, 1998; Dyson, 2000) and measures of achievement suggested by Beer (1981) allowed for demonstrating how the suggested performance measurement methodology may be used in the supply chain strategic planning and control process. Application of the suggested methodology allows for controlling the dynamic states in supply chain development when the level of system capability achieves its pre-defined potential.

Chapter Six
Case Analysis and Evaluation

In this Chapter methods suggested in Chapters 3-4 are applied to agri-food cases and results are analysed and evaluated. The following Table 6.1 describes the structure of this Chapter.

Table 6.1. Levels of the Suggested Methodology vs. Case Analysis

Methodology		Case analysis	
Chapter / Section	**Content**	**Chapter / Section**	**Content**
3.2	Material flow performance measurement	6.1.1.	Russian wheat grain supply
		6.1.2	New Zealand fresh milk Demerit points
		6.1.3	New Zealand beef auction prices
3.3	Financial flow performance measurement	6.2	Russian grain trade contracts
3.4	Information flow performance measurement	6.3	Consumer evaluation of e-commerce information
4	Measurement of Supplier – Customer Contractual Performance	6.4	Russian grain trade contracts
5	Network Level Performance Measurement	6.5	Russian grain trade contracts

6.1. Material Flow Performance Measurement Case Analysis and Evaluation

In Section 3.2 the methodology was suggested for SC material flow performance (MFP) measurement using the normalised MFP value. MFP was defined as a weighted sum of quality and delivery normalised acceptance values. The normalised quality acceptance value was defined in Section 3.2 as a function of the normalised acceptance values of all quality characteristics when the quality is acceptable. Delivery was defined in terms of the volume ordered by the customer and its delivery time. The normalised delivery acceptance value was defined as the weighted sum of volume and delivery time normalised values.

In Section 3.2 the example of the wheat grain supply was used to illustrate the methodology and also to evaluate its applicability. The author worked with three Russian grain trading companies for four years. Information on material flow and financial transactions provided by these companies was used for evaluation of methodology extensions (Sections 6.1.1 and 6.2).

In Section 6.1.1 the total normalised quality acceptance value p_l is defined for the Russian wheat supply. This method was discussed and agreed upon with the three grain trading companies as adequately representing their practices.

For the additional case analysis and evaluation data concerning two agri-food products were selected: Demerit points used by Fonterra and published New Zealand beef prices. Selection of these two agricultural commodities was made based on their importance for the New Zealand economy; the large volumes of supply; defined quality characteristics; quality characteristics discount schedules, and availability of secondary information.

This Section 6.1 evaluates information available on material flow performance for the selected agri-food products. It also studies applicability of the methodology suggested in Section 3.2 to these different products.

6.1.1. Russian Wheat Grain Supply

Table 3.1 from Section 3.2 presented quality characteristics in wheat supply contracts. In this table six quality parameters were listed: protein, natural weight, falling number, and moisture content, foreign materials, and damaged kernels.

Each characteristic was defined in Table 3.1 using terminology introduced in Section 3.2 as controllable or acceptable, low or high. In accordance with these definitions either two values are specified in the customer-supplier agreement (controllable characteristics) or four values (acceptable quality characteristics).

This method was suggested to assign normalised acceptance value (NAV) for acceptable characteristic, the actual value of which was outside control limits but was accepted with discount. The discount acceptance value (0<NAV<1) was assigned to acceptable field's actual value AV, which was outside the control range in the unfavourable to the customer direction but still in the range of acceptance.

For high characteristics (protein, natural weight) NAV was measured as: $\frac{U - AV}{U - \overline{U}}$

For low characteristics (moisture, damaged kernels) NAV was measured as: $\frac{\overline{U} - AV}{\overline{U} - U}$

Example 20 (high characteristic)

For a wheat protein content

U=13%, $\overline{U}$ =12%, AV=12.5%, $NAV = \frac{13 - 12.5}{13 - 12} = 0.5$

Example 21 (low characteristic)

For a wheat moisture content

U=13%, $\overline{U}$ =14%, AV=13.75%.

$$NAV = \frac{14 - 13.75}{14 - 13} = 0.25$$

The premium acceptance value (1<NAV<=2) was assigned to acceptable field's actual value AV, which is outside the control range in the favourable to the customer direction.

For high characteristic – (protein, natural weight) NAV is measured as: $\frac{AV - O}{\overline{O} - O} + 1$

For low characteristic - (moisture, damaged kernels) NAV is measured as: $\frac{O - AV}{O - \overline{O}} + 1$

Example 22 (high characteristic)

For a wheat protein content

O=14.5%, $\overline{O}$=15%, AV=14.7%, $NAV = \frac{14.7-14.5}{15-14.5}+1=1.4$

Example 23 (low characteristic)

For a wheat moisture content

O=11%, $\overline{O}$=10%, AV=10.8%, $NAV = \frac{11-10.8}{11-10}+1=1.2$

Special case.

When AV>$\overline{O}$ (for high characteristic) or AV>$\overline{O}$ (for low characteristic) NAV is assigned the maximum value of 2.

For example, for wheat protein content $\overline{O}$=15% and AV=15.5% NAV=2.

for wheat moisture content $\overline{O}$=10% and AV=9% NAV=2.

The above NAV definitions combined with definitions from Section 3.2 are presented in Figure 6.1 and Figure 6.2.

Figure 6. 1. NAV for Acceptable High Wheat Quality Characteristic

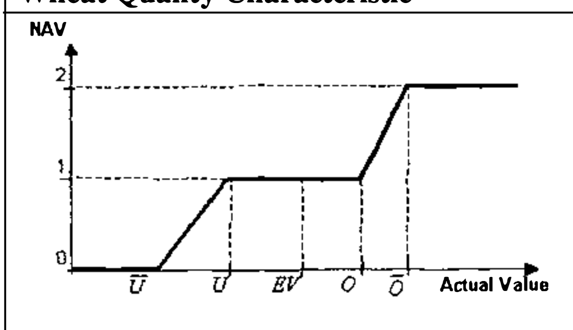
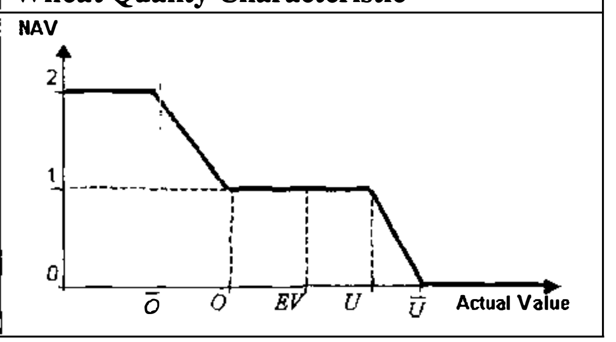


Figure 6. 2. NAV for Acceptable Low Wheat Quality Characteristic



The total normalised quality acceptance value p_l was defined as an average of normalised acceptance values of all eight wheat quality characteristics when the quality is acceptable. p_l =0 if at least one quality characteristic is not accepted (has a normalised acceptance value).

$$p_1 = \begin{cases} 0 & \text{if } \prod_{n}^{i=1} NAV_i = 0 \\ \dfrac{\sum_{i=1}^{8} NAV_i}{6} & \text{if } \prod_{i=1}^{n} NAV_i \neq 0 \end{cases}$$

This definition satisfies the requirement imposed on p_1 values in Section 3.2.2.

- $p_1 = 1$, expected total quality. $NAV_i = 1$ for all ($i = 1\ldots n$)
- $p_1 = 0$, as a result of poor quality product is rejected. $NAV_i = 0$ for some characteristics
- $0 < p_1 < 1$ acceptance with discount. For some i $0 < NAV_i < 1$
- $1 < p_1 <= 2$ acceptance with premiums. For some i $NAV_i > 1$.

The above definition was used to uniformly convert the data of the laboratory wheat analysis into p_1 values.

6.1.2. New Zealand Fresh Milk

Global Dairy Company Limited (Fonterra) quality standards for fresh milk supply are used to evaluate the applicability of the material transactions performance measurement methodology proposed in Section 3.2. Quality standards for fresh milk supply are precisely defined and published in the "*Supplying Shareholder Handbook*" available at: (http://www.fonterra.com/pdfs/supp_share.pdf). This document contains raw milk quality test standards for the 2003/2004 seasons (see Table 6. 2 on the next page).
According to the "*Supplying Shareholder Handbook*" (page 5):
"The Company operates a demerit points scheme under which demerit points are incurred by a Supplying Shareholder for quality defects detected during the course of a month".

Table 6.2. Raw Milk Quality Test Standards for 2003/2004 Seasons

Supplying Shareholder Handbook" available at: http://www.fonterra.com/pdfs/supp_share.pdf (Accessed 8 February /2004).

TEST	MINIMUM FREQUENCY	STANDARD	DEMERIT POINTS	NOTES
1. Bactoscan	3 per month	APC EQUIVALENT A+ Less than 10,000/ml A 10,000 -19,999/ml B 20,000 -49,999/ml C 50,000 - 99,999/ml D 100,000-199,999/ml E 200,000 - 499,999/ml F 500,000/ml and over	 0 0 0 1 2 3 5	'BACTO ALERT' will show on DRS where a B category result is obtained, C,D,E and F results may be further checked on Blood Plates
2. Thermoduric Plate Count	1 per month (3 per month Oct - March inclusive)	Less than 1,500/ml 1,500-4,999/ml 5,000 -14,999/ml 15,000/ml and over	0 1 2 3	"THERM ALERT' will show on DRS for counts 500 – 1,499/ml inclusive. "THERM EARLY WARNING" for counts > 1,000/ml at 48 hours
3. Coliform Plate Count	1 per month	Less than 1,000/ml 1,000-1,999/ml 2,000/ml and over and over	0 2 3	"COLI ALERT" will show on the DRS for counts 300 – 999/ml inclusive Note that for the 2002/2003 Season the acceptable coliform plate count will reduce to 500/ml
4. Organoleptic Assessment (Senses)	as required	as per MAP standards	0 1 3	
5. Cress Taint	as required		5	
6. Sediment	As required	as per MAP standards	0 3	
7. Colostrum	As required	1.35% or less over 1.35%	0 3	
8. Inhibitory Substances	3 per month	Less than 0.003 IU/ml 0.003<0.006 IU/ml 0.006 < 0.03 IU/ml 0.03 IU/ml or greater (with auditable system a positive unnotified result is reduced by 5 demerit points)	0 13 20 25	If notified: Less than 0.003 IU/ml - no demerits 0.003 IU/ml or greater - 5 demerits F or any non-notified positive result, supply is on daily testing for 6 months. There is a charge for this testing of $300
9. Freezing Point	Daily computer scan on Composition results	Freezing Point: - 0.513 °C or lower Freezing Point: - 0.512 °C or higher	0 1	Where Combi Foss monitoring for EW shows persistent problems Freezing Point check on a Cryoscope is initiated
10. Somatic Cell Count	Per consignment	GM 0 - 399,999/ml GM 400,000 - 499,999/ml GM 500,000 - 599,999/ml GM 600,000/ml and over	0 5 11 14	Demerits applied on the basis of Geometric Mean of all results in a period. (Days 1-10, 11-20, 21 -31) SCC demerit points not subject to scaling or merit point reduction
11. Collection Temperature	Per consignment (advisory up to 31 January 2002)	0 hour 18.0°C 1 hour 14.0°C 2 hour10.0°C 3 hour 7.0°C 1 or 2 non conformances in a month 3 or 4 non conformances in a month 5 or 6 non conformances in a month 7 or more non conformances in a month	 0 1 2 4	Time is from end of milking. End of milking is defined as: 7.30 am for morning and 6.00 pm for evening Demerit points take effect from 1 February 2002. Temperature demerit points not subject to scaling or merit point reduction
12. DDE	As required	Above 0.2 mg DDE/kg Milkfat, penalties applied June to September inclusive Above 0.5 mg DDE/kg Milkfat, penalties applied October to May inclusive	$1.20/mg DDE	All new supply properties must have weighed average soil level of 0.2 mg/kg or less for DDT and its metabolites Collection ceased for any Milk level greater than 1.0 mg DDE/kg Milkfat.

Table 6.3. Converting Monthly Demerits to Milk Payments

Adjusted Demerits	Deduction %	Adjusted Demerits	Deduction %	Adjusted Demerits	Deduction %
1	0	41	13	81	26.7
2	0	42	13.3	82	27
3	0	43	13.7	83	27.4
4	0.3	44	14	84	27.7
5	0.7	45	14.4	85	28
6	1	46	14.7	86	28.4
7	1.4	47	15	87	28.7
8	1.7	48	15.4	88	29.1
9	2.1	49	15.7	89	29.4
10	2.4	50	16.1	90	29.7
11	2.7	51	16.4	91	30.1
12	3.1	52	16.8	92	30.4
13	3.4	53	17.1	93	30.8
14	3.8	54	17.4	94	31.1
15	4.1	55	17.8	95	31.5
16	4.4	56	18.1	96	31.8
17	4.8	57	18.5	97	32.1
18	5.1	58	18.8	98	32.5
19	5.5	59	19.1	99	32.8
20	5.8	60	19.5	100	33.2
21	6.2	61	19.8	101	33.5
22	6.5	62	20.2	102	33.8
23	6.8	63	20.5	103	34.2
24	7.2	64	20.9	104	34.5
25	7.5	65	21.2	105	34.9
26	7.9	66	21.5	106	35.2
27	8.2	67	21.9	107	35.6
28	8.5	68	22.2	108	35.9
29	8.9	69	22.6	109	36.2
30	9.2	70	22.9	110	36.6
31	9.6	71	23.2	111	36.9
32	9.9	72	23.6	112	37.3
33	10.3	73	23.9	113	37.6
34	10.6	74	24.3	114	37.9
35	10.9	75	24.6	115	38.3
36	11.3	76	25	116	38.6
37	11.6	77	25.3	117	39
38	12	78	25.6	118	39.3
39	12.3	79	26	119	39.7
40	12.6	80	26.3	120	40

Source: http://www.fonterra.com/pdfs/supp_share.pdf accessed 8 February 2004.

In Table 6.3 monthly demerits are converted to milk payments. In this table an increment of one demerit point corresponds to an increment of either 0.3 or 0.4 per cent. For example, 23 demerits correspond to deduction of 6.8%; 24 demerits – to 7.2% deduction (0.4% increment), and 25 demerits correspond to 7.5 % deduction (0.3% increment).

According to Table 6.2 there are a maximum of 12 milk quality parameters that may be tested in each milk delivery. Each quality characteristic has several measurable levels, which correspond to demerit points.

Fonterra is responsible for raw milk pick ups, therefore the delivery performance was assumed to be on the expected level and was assigned the normalised performance value of 1 (see Section 3.2).

In terms of definitions given in Section 3.2 normalised acceptance value for each raw milk quality parameter listed in Table 6.2 (NAV) may be calculated as:

NAV= 1- Deduction % from Table 6.3 for Demerits assigned to quality characteristic / 100

For example, if the somatic cell count in delivered raw milk is in the range 400,000 - 499,999/ml then according to Table 6.2 five Demerits are assigned, which from Table 6.3 corresponds to a deduction of 0.07 percent.

$NAV_{10} = 1 - 0.07/100 = 0.9993$

where index 10 is a number of somatic cell count quality characteristic from Table 6.2.

Fonterra evaluates the quality of raw milk delivered by its suppliers through the total Demerits which is the sum of Demerits assigned to different quality parameters.

Therefore, the total normalised quality performance p_1, as defined in Section 3.2, may be defined as:

$p_1 =$ 1- (Deduction value from Table 6.3 for Total Demerits) / 100

Fonterra uses the total normalised quality performance measure p_1 to adjust farmers' payoff. Fonterra, being a leading world exporter of dairy products, does not use premium schedules - assuming the high level of performance of each supplier – shareholder.

The conclusion may be drawn that Fonterra uses quality evaluation methods that may be transferred into normalised total quality performance measures, as suggested in Section 3.2.

6.1.3. New Zealand Beef

Information about beef prices was collected for 25 weeks (02/08/03 – 24/01/03) (see Table 6.4). Weekend *New Zealand Dominion Post* Farm Schedules (with reference to Agri-Fax) were used as the source of secondary data. In the published schedule, it was mentioned that "the North Island price range column is based on operating prices of four companies". Because information on the operational prices of these four companies was not available to the researcher, the decision was made to use published New Zealand South Island gross average steer prices for this case evaluation. Information about South Island steer prices was collected for 25 weeks (02/08/03 – 24/01/03) (see Table 6.4).

The assumption is made that open market prices based on quality characteristics: carcass weight and fat class (P2, T2, and F2) for steer beef, subjectively reflect the relative importance of each of these two quality factors in the customers' price determination. Because prices are spot prices, delivery performance is assumed not to have any influence on beef market prices.

Table 6.4. New Zealand Beef Prices (02/08/03 – 24/01/03)

	Weight Range	Week/ date									
		1	2	3	4	5	6	7	8	9	10
		2/08/2003	9/08/2003	16/08/2003	23/08/2003	30/08/2003	6/09/2003	13/09/2003	20/09/2003	27/09/2003	4/10/2003
P2 Steer	221-245	263	265	265	265	265	273	285	278	278	278
	246-270	273	269	269	269	269	277	287	280	280	280
	271-295	276	276	276	276	276	284	297	290	290	290
	296-320	279	276	276	276	276	284	298	291	291	291
	321-345	278	276	276	276	276	284	297	290	290	290
	346+	278	274	274	274	274	282	291	284	284	284
T2 Steer Discount		-16	-16	-16	-16	-16	-16	-16	-16	-16	-16
F2 Steer Discount		-81	-77	-77	-77	-77	-77	-80	-80	-80	-80

	Weight Range	Week/ date									
		11	12	13	14	15	16	17	18	19	20
		11/10/2003	18/10/2003	27/10/2003	3/11/2003	10/11/2003	15/11/2003	22/11/2003	1/12/2003	8/12/2003	15/12/2003
P2 Steer	221-245	288	291	291	291	291	291	286	281	271	256
	246-270	298	294	294	294	294	296	297	296	291	281
	271-295	300	304	304	304	304	304	299	299	294	284
	296-320	303	307	307	307	307	307	302	302	296	287
	321-345	303	301	302	302	302	302	302	302	297	287
	346+	303	296	296	296	296	301	301	301	296	286
T2 Steer Discount		-15	-17	-17	-17	-17	-17	-15	-15	-15	-15
F2 Steer Discount		-83	-88	-88	-88	-88	-88	-85	-85	-85	-85

	Weight Range	Week/ date				
		21	22	23	24	25
		20/12/2003	29/12/2003	3/01/2004	17/01/2004	24/01/2004
P2 Steer	221-245	252	252	252	252	252
	246-270	277	277	277	277	277
	271-295	279	279	279	279	279
	296-320	282	282	282	282	282
	321-345	282	282	282	282	282
	346+	281	281	281	281	281
T2 Steer Discount		-15	-15	-15	-15	-15
F2 Steer Discount		-85	-85	-85	-85	-85

The hypothesis was: historical steer prices reflect beef quality parameters (carcass weights and fat classes), and it is possible to identify normalised acceptance values for them (NAV_1 and NAV_2, respectively) as well as the total normalised beef quality acceptance value (p_1) in accordance with the definitions given in Section 3.2.

Remark: Rejection of the product as a result of unacceptable low quality was not considered because listed prices were given only for the steer beef that was accepted.

To evaluate the validity of the above hypotheses, calculations described in the following *Steps 1-8* were performed.

Step 1. Historical P2 fat class prices were normalised: prices for the given date were added together and the proportion of each given price to the total values was calculated.

For example, from Table 6.4 the total P2 prices for 2/08/2003 was 1,647.
Price for the weight range 221-245 kg (263) was converted to the proportion 263/1,647= 0.1597.

Step 2. The relative score of each weight range was calculated as an average of 25 weekly proportions from Step 1. The following results were obtained:

Table 6.5. Relative P2 Beef Prices Scores Derived from Historical Prices

Weight Range	Relative Price Score
221-245	0.1591
246-270	0.1653
271-295	**0.1687**
296-320	0.1699
321-345	0.1692
346+	0.1677
Total	1.0000

Step 3. Scores from Table 6.5 were then normalised as proportions from 271-295 weight range score of 0.1687. Results are presented in Table 6.6 (Column 3) below. Assumption (1) was made that fluctuations in the P2 auction prices for 271-295 kg weight group,

defined as a **basic price,** reflect market supply/demand relationships, and that normalised proportions from Table 6.6 may be used as normalised weight range acceptance values (NAV_1).

Table 6.6. Normalised Beef Carcass Weight Acceptance Values (NAV_1)

Weight Range	Relative Price Score	Normalised Acceptance Value (NAV_1)
1	2	3
221-245	0.1589	0.9430
246-270	0.1655	0.9822
271-295	**0.1685**	**1.0000**
296-320	0.1698	1.0077
321-345	0.1693	1.0047
346+	0.1680	0.9970

Basic prices and NAV_1 from Table 6.6 were used to estimate the total weekly P2 beef price. Estimated prices then were compared with historical prices and an absolute average error of 2.6 was obtained. This average absolute error is an approximately 1% from the 271-295 kg weight group auction price. This error measure is low enough to prove the validity of Assumption (1).

Step 4. According to Table 6.4, T2 and F2 fat class prices are defined as discounted P2 prices. The P2 fat class was assigned a normalised quality acceptance value NAV_2 of 1.

Historical data were used to calculate a proportion of 271-295 kg weight range prices of T2 and F2 fat classes to the P2 price. For example, from Table 6.4 the price for the 271-295 kg weight range P2 fat class on 2/08/2003 was 276 c/kg, and the discount for the T2 class was 16 c; the proportion was:

(276-16)/276=0.9420

A similar proportion for the F2 fat class was calculated as:

(276-81)/276=0.7065

Step 5. Proportions defined in Step 5 were calculated for each of the 25 historical weekly prices from Table 6.4. Average values then were calculated as 0.9453 for the T2 class, and 0.7127 for the F2 class.

Step 6. Assumption (2) was made that the above values may be used as normalised acceptance values of beef fat classes (NAV_2).

Discounts for T2 and F2 fat classes were calculated for each week as:
Basic price*(1 - 0.9453) for T2 fat class, and
Basic price*(1-0.7127) for F2 fat class.

These values were compared with actual historical discounts from Table 6.4. Average absolute errors values were: 0.40 for the T2 fat class, and 2.7 for the F2 class. These errors represent 2.53 and 3.28 per cent from average discounts for these two fat classes, respectively. These error measures are low enough to prove the validity of Assumption (2).

Step 7. Assumption (3) was made that the market price may be estimated as:

$$P^* NAV_1 - P^*(1-NAV_2)$$

where P is a basic price; NAV_1 is from Table 6.6 (Step 3), and NAV_2 from Step 6.
The P2 fat class NAV_2 is 1 according to Step 5.

Estimated prices were compared with actual historical prices and average percentage absolute errors were calculated:

0.94% for P2 fat class,
1.1% for T2 fat class, and
1.2% for F2 fat class.

These errors are low enough to prove the accuracy of suggested price estimates.

Step 8 (Conclusions). The original hypothesis was that it is possible to identify normalised acceptance values for beef quality parameters (NAV_1 and NAV_2, respectively) as well as the total normalised beef quality acceptance value (p_1) in accordance with the definitions given in Section 3.2.

The total normalised quality acceptance value p_1 (see Section 3.2) may be defined as a proportion of estimated weekly prices (see Step 7) to the basic price P:

$$p_1 = \frac{P * NAV_1 - P * (1 - NAV_2)}{P} = (NAV_1 + NAV_2) - 1$$

The above definition of the total normalised beef quality acceptance value p_1 is consistent with suggestions made in Section 3.2. For the basic price ($NAV_1 = NAV_2 = 1$) and $p_1 = 1$.

NAV_1 – normalised carcass weight acceptance values were defined using historical data (Steps 1-3) and were summarised in Table 6.6.

NAV_2 – normalised fat class acceptance values were defined using historical data (Steps 4-6) as:

1 – for P2 fat class;

0.9453 - for T2 fat class, and

0.7127 - for F2 fat class.

In Step 7 suggested normalised values were used to estimate beef prices and to compare estimated values with historical prices. The highest average percentage absolute error was 1.2%.

This proves the validity of the original hypothesis. The method introduced in Steps 1-7 of this case study showed a relationship between steer beef quality characteristics (carcass weight and fat class) and the customers' price determination on the open market.

6.1.4. Conclusions

A price for an agricultural product is a summation of a number of factors, among which are quality and delivery terms. It is well recognised that a higher quality product normally receives a higher price, while a lower quality product receives a lower price. Certain quality factors may be met exactly, in which case the expected value and the actual value are the same. When these values differ, then the price may vary in accordance with an agreed schedule of premiums and discounts.

Another factor that may, or may not, have premiums or discounts associated with it is the terms of delivery of a product. Items delivered ahead of the expected time may incur storage expenses while a product delivered after the expected time may cause a business to be late in meeting its obligations. Items delivered as expected neither add to, nor reduce, the value of the delivered product. This means how well a supply chain member meets the agreed to delivery terms may affect the value of other products in the supply chain, in addition to the value of the delivered product.

While different products have different quality and delivery standards, price is used as a measure of how well the supply chain performs, regardless of the product. The concept that despite different performance measures of different agricultural chains, it is nevertheless possible to have a single measure of the performance of those chains was evaluated in this Chapter.

Three agricultural products –grain, milk and beef – were studied. The relationship between the total normalised quality acceptance of these products and normalised acceptance of their quality characteristics was demonstrated.

6.2. Case Analysis of Financial Flow Performance Measurement

Financial flow performance measurement is evaluated using data provided by three Russian companies. The researcher received verbal permission to use these data with the companies being kept anonymous. All data were organised in tabular form and are presented in Table 6.8 on the next two pages.

Financial data for 2003 Consignee's payments to the Company (see Table 6.7) are used for case evaluation of the normalised performance measurement methods suggested in Section 3.3.

Table 6.7. Financial Data for 2003 Transactions (Payee - Consignee)

Due date (ET_i)	Value (roubles)	Date of actual payment (T_i)	Value paid (roubles)
13/11/2003	1,065,750.00	20/11/2003	213,150.00
19/11/2003	850,468.50	26/11/2003	866,932.50
20/11/2003	213,150.00	5/12/20003	2,141,863.50
24/11/2003	645,513.75		
26/11/2003	221,418.75		
3/12/2003	225,645.00		
Total	3,221,946.00		3,221,946.00

It may be seen from Table 6.7 that the Consignee paid the total amount in fewer than expected payments. There were delays in payments produced by the Consignee.

Table 6.8. Financial Data for 2001-2004 Transactions

Year	Payee	Due on date (ETi)	Value (roubles)	Date of actual payment (Ti)	Value paid (roubles)
2001	*Company*	4/09/2001	435,455.00	26/09/2001	2,171,498.00
		5/09/2001	1,029,178.00	5/10/2001	2,171,498.00
		7/09/2001	444,284.00	15/10/2001	1,000,000.00
		8/09/2001	706,865.00	2/11/2001	1,040,807.00
		12/09/2001	135,160.00		
		15/09/2001	582,823.00		
		16/09/2001	541,790.56		
		16/09/2001	30,568.44		
		17/09/2001	588,055.00		
		18/09/2001	1,003,781.00		
		19/09/2001	885,843.00		
		Total	***6,383,803.00***		***6,383,803.00***
	Consignee	4/09/2001	449,437.50	11/10/2001	1,000,000.00
		5/09/2001	1,062,225.00	26/10/2001	3,000,000.00
		7/09/2001	458,550.00	31/10/2001	2,588,787.50
		9/09/2001	729,562.50		
		12/09/2001	139,500.00		
		15/09/2001	601,537.50		
		16/09/2001	590,737.50		
		17/09/2001	606,937.50		
		18/09/2001	1,036,012.50		
		19/09/2001	914,287.50		
		Total	***6,588,787.50***		***6,588,787.50***
2002	*Company*	16/01/2002	2,052,330.00	16/01/2002	2,052,330.00
		15/02/2002	175,060.00	15/02/2002	175,060.00
		Total	***2,227,390.00***		***2,227,390.00***
	Consignee	16/04/2002	530,840.00	19/04/2002	530,840.00
		21/04/2002	413,770.00	6/05/2002	413770
		30/04/2002	1,567,450.00	7/05/2002	862155
		4/05/2002	432,055.00	8/05/2002	705295
				13/05/2002	432055
		Total	***2,944,115.00***		***2,944,115.00***

Table 6.8. Financial Data for 2001-2004 Transactions (Continued)

Year	Payee	Due on date (ETi)	Value (roubles)	Date of actual payment (Ti)	Value paid (roubles)
2003	*Company*	15/10/2003	356,500.00	20/10/2003	672,000.00
		23/10/2003	672,002.50	24/10/2003	451,244.00
		24/10/2003	672,002.50	29/10/2003	268,801.00
		28/10/2003	155,077.50	5/11/2003	356,500.00
		1/11/2003	270,227.00	12/11/2003	411,080.15
		3/11/2003	121,994.30	19/11/2003	525,000.00
		4/11/2003	31,015.50	20/11/2004	440,881.65
		6/11/2003	411,080.15		
		9/11/2003	88,625.90		
		10/11/2003	140,309.49		
		11/11/2003	31,309.61		
		18/11/2003	141,468.11		
		19/11/2003	33,894.24		
		Total	***3,125,506.80***		***3,125,506.80***
	Consignee	13/11/2003	1,065,750.00	20/11/2003	213,150.00
		19/11/2003	850,468.50	26/11/2003	866,932.50
		20/11/2003	213,150.00	5/12/20003	2,141,863.50
		24/11/2003	645,513.75		
		26/11/2003	221,418.75		
		3/12/2003	225,645.00		
		Total	***3,221,946.00***		***3,221,946.00***
2004	*Company*	10/01/2004	1,107,069.75	13/01/2004	1,107,100.00
		21/01/2004	195,365.25	30/01/2003	180,000.00
				26/02/2004	15,335.00
		Total	***1,302,435.00***		***1,302,435.00***
	Consignee	29/01/2004	1,365,660.00	29/01/2004	1,365,660.00
		Total	***1,365,660.00***		***1,365,660.00***

To quantify the Consignee's normalised performance, each actual payment is allocated to the expected payments (see Table 6.9 below). For example, 1,065,750.00 roubles were expected to be paid on 13/11/2003. The Consignee produced the first partial payment of 213,150.00 on 20/11/2003. The remaining 852,600.00 roubles were paid on 26/11/2003.

Table 6.9. Allocation of Consignee Payments for 2003 Transactions

Expected performance			Actual performance		
Due on date (ETi)	Value (roubles)	Subtotal	Date of actual payment (Ti)	Value paid (roubles)	Subtotal
13/11/2003	213,150		20/11/2003	213,150.00	*213,150.00*
13/11/2003	852,600.00	*1,065,750.00*	26/11/2003	852,600.00	
19/11/2003	14,332.50		26/11/2003	14,332.50	*866,932.50*
19/11/2003	836,136.00	*850,468.50*	5/12/20003	836,136.00	
20/11/2003	213,150.00	*213,150.00*	5/12/20003	213,150.00	
24/11/2003	645,513.75	*645,513.75*	5/12/20003	645,513.75	
26/11/2003	221,418.75	*221,418.75*	5/12/20003	221,418.75	
3/12/2003	225,645.00	*225,645.00*	5/12/20003	225,645.00	*2,141,863.50*
Total	3,221,946.00			3,221,946.00	

The above allocation allows using Formula A from Section 3.3. According to the agreement between the Company and the Consignee the discounting factor *r* (see Section 3.3) had a value of 0.1% for each banking day of payments delay. A banking day is defined as an operating day of the payees' bank (weekends and public holidays are excluded). Results are presented in Table 6.10 below.

Table 6.10. Normalised Performance of the Consignee in 2003 Transactions

	Actual payment AP_i	Expected payment date – Actual payment date ET_i-T_i	$AP_i \times (1+r)^{(ET_i - T_i)}$
	213,150	-7	211,663.90
	852,600	-13	841,593.40
	14,332.50	-7	14,232.57
	836,136	-16	822,870.86
	213,150.00	-15	209,978.18
	645,513.75	-11	638,455.52
	221,418.75	-9	219,435.91
	225,645.00	-2	225,194.39
Total	**3,221,946**		**3,183,424.73**

In Table 6.10 the difference between expected payment date and the actual payment date is calculated in numbers of banking days. Normalised performance of the Consignee are calculated as 3,183,424.73 / 3,221,946 = **0.9880.**

Similarly to foregoing, calculations are produced for all 2001-2004 financial transactions, both for the Consignee's payments to the Company, and the Company's'payments to the Agent (8 normalised values in total). Results are presented in Table 6.11 on pages 157 - 160.

Data from Table 6.11 are used to calculate normalised performance in the 2001-2004 financial transactions.

Table 6.12. Normalised Financial Performances for 2001-2004 Transactions

Year	Payee	Total Actual Payment	Total Discounted Payment $AP_i \times (1+r)^{(ET_i - T_i)}$	Normalised Financial Performance $4 \div 3$
1	2	3	4	5
2001	Company	6,383,803.00	6,268,220.48	**0.9819**
	Consignee	6,588,787.50	6,332,190.53	**0.9611**
2002	Company	2,227,390.00	2,227,390.00	**1.0000**
	Consignee	2,944,115.00	2,940,009.74	**0.9986**
2003	Company	3,125,506.80	3,109,059.81	**0.9947**
	Consignee	3,221,946.00	3,183,424.73	**0.9880**
2004	Company	1,302,435.00	1,296,981.49	**0.9958**
	Consignee	1,365,660.00	1,365,660.00	**1.0000**

Normalised financial performance measures from column 5 are used in Sections 6.4 - 6.5 for the case analysis of branch and network levels of the suggested normalised performance measurement methods.

Six normalised financial performance measures from Table 6.12 are below 1, which reflects lower than expected level of performance (delayed payments).

Table 6.11. Financial Performances for 2001-2004 Transactions

Year	Payee	Expected performance			Actual performance			Eti - Ti	$AP_i \times (1+r)^{(ET_i-T_i)}$
		Due on date (ETi)	Value (roubles)	Subtotal	Date of actual payment (Ti)	Value paid (roubles) APi	Subtotal		r=0.001
	Company	4/09/2001	435,455.00	*435,455.00*	26/09/2001	435,455.00		-15	428,975.13
		5/09/2001	1,029,178.00	*1,029,178.00*	26/09/2001	1,029,178.00		-14	1,014,877.00
		7/09/2001	444,284.00	*444,284.00*	26/09/2001	444,284.00		-12	438,987.09
		8/09/2001	262,581.00		26/09/2001	262,581.00	*2,171,498.00*	-11	259,709.86
		8/09/2001	444,284.00	*706,865.00*	5/10/2001	444,284.00		-19	435,926.43
		12/09/2001	135,160.00	*135,160.00*	5/10/2001	135,160.00		-16	133,015.71
		15/09/2001	582,823.00	*582,823.00*	5/10/2001	582,823.00		-12	575,874.37
		16/09/2001	541,790.56	*541,790.56*	5/10/2001	541,790.56		-11	535,866.46
		16/09/2001	30,568.44	*30,568.44*	5/10/2001	30,568.44		-11	30,234.20
		17/09/2001	436,872.00		5/10/2001	436,872.00	*2,171,498.00*	-10	432,527.21
		17/09/2001	151,183.00	*588,055.00*	15/10/2001	151,183.00		-21	148,042.81
		18/09/2001	848,817.00		15/10/2001	848,817.00	*1,000,000.00*	-20	832,017.61
			154,964.00	*1,003,781.00*	2/11/2001	154,964.00		-37	149,337.87
		19/09/2001	885,843.00		2/11/2001	885,843.00	*1,040,807.00*	-38	852,828.71
2001			**6,383,803.00**			**6,383,803.00**			**6,268,220.48**
	Consignee	4/09/2001	449,437.50	*449,437.50*	11/10/2001	449,437.50		-34	434,420.86
		5/09/2001	550,562.50		11/10/2001	550,562.50	*1,000,000.00*	-33	532,699.23
			511,662.50	*1,062,225.00*	26/10/2001	511,662.50		-48	487,694.51
		7/09/2001	458,550.00	*458,550.00*	26/10/2001	458,550.00		-46	437,944.56
		9/09/2001	729,562.50	*729,562.50*	26/10/2001	729,562.50		-45	697,475.60
		12/09/2001	139,500.00	*139,500.00*	26/10/2001	139,500.00		-41	133,898.91
		15/09/2001	601,537.50	*601,537.50*	26/10/2001	601,537.50		-38	579,118.93
		16/09/2001	559,187.50		26/10/2001	559,187.50	*3,000,000.00*	-37	538,885.61
			31,550.00	*590,737.50*	31/10/2001	31,550.00		-41	30,283.23
		17/09/2001	606,937.50	*606,937.50*	31/10/2001	606,937.50		-40	583,150.80
		18/09/2001	1,036,012.50	*1,036,012.50*	31/10/2001	1,036,012.50		-39	996,405.17
		19/09/2001	914,287.50	*914,287.50*	31/10/2001	914,287.50	*2,588,787.50*	-38	880,213.12
			6,588,787.50			**6,588,787.50**			**6,332,190.53**

Table 6.11. Financial Performances for 2001-2004 Transactions (Continued)

Year	Payee	Expected performance			Actual performance			Eti - Ti	$AP_i \times (1+r)^{(ET_i-T_i)}$
		Due on date (ETi)	Value (roubles)	Subtotal	Date of actual payment (Ti)	Value paid (roubles) APi	Subtotal		r=0.001
2002	*Company*	16/01/2002	2,052,330.00	*2,052,330.00*	16/01/2002	2,052,330.00	*2,052,330.00*	0	2,052,330.00
		15/02/2002	175,060.00	*175,060.00*	15/02/2002	175,060.00	*175,060.00*	0	175,060.00
		2,227,390.00			**2,227,390.00**				**2,227,390.00**
	Consignee	16/04/2002	530,840.00	*530,840.00*	19/04/2002	530,840.00	*530,840.00*	-2	530,607.38
		21/04/2002	413,770.00	*413,770.00*	6/05/2002	413,770.00	*413,770.00*	-11	412,773.73
		30/04/2002	862,155.00		7/05/2002	862,155.00	*862,155.00*	-6	861,022.08
			705,295.00	*1,567,450.00*	8/05/2002	705,295.00	*705,295.00*	-7	704,213.85
		4/05/2002	432,055.00	*432,055.00*	13/05/2002	432,055.00	*432,055.00*	-7	431,392.70
		2,944,115.00			**2,944,115.00**				**2,940,009.74**

Table 6.11. Financial Performances for 2001-2004 Transactions (Continued)

Year	Payee	Expected performance			Actual performance			Eti - Ti	$AP_i \times (1+r)^{(ET_i-T_i)}$
		Due on date (ETi)	Value (roubles)	Subtotal	Date of actual payment (Ti)	Value paid (roubles) APi	Subtotal		r=0.001
2003	Company	15/10/2003	356,500.00	*356,500.00*	20/10/2003	356,500.00		-5	354,722.84
		23/10/2003	315,500.50			315,500.50	*672,000.50*	2	316,131.82
			356,502.00	*672,002.50*	24/10/2003	356,502.00		-1	356,145.85
		24/10/2003	94,742.00			94,742.00	*451,244.00*	0	94,742.00
			268,801.00		29/10/2003	268,801.00	*268,801.00*	-3	267,996.21
			308,459.50	*672,002.50*	5/11/2003	308,459.50		-9	305,697.19
		28/10/2003	48,040.50			48,040.50	*356,500.00*	-6	47,753.26
			107,037.00	*155,077.50*	12/11/2003	107,037.00		-11	105,866.63
		1/11/2003	270,227.00	*270,227.00*		270,227.00		-9	267,807.07
		3/11/2003	33,816.15			33,816.15	*411,080.15*	-7	33,580.38
			88,178.15	*121,994.30*	19/11/2003	88,178.15		-12	87,126.86
		4/11/2003	31,015.50	*31,015.50*		31,015.50		-11	30,676.37
		6/11/2003	405,806.35			405,806.35	*525,000.00*	-9	402,172.29
			5,273.80	*411,080.15*	20/11/2004	5,273.80		-10	5,221.35
		9/11/2003	88,625.90	*88,625.90*		88,625.90		-8	87,920.07
		10/11/2003	140,309.49	*140,309.49*		140,309.49		-7	139,331.24
		11/11/2003	31,309.61	*31,309.61*		31,309.61		-6	31,122.41
		18/11/2003	141,468.11	*141,468.11*		141,468.11		-2	141,185.60
		19/11/2003	33,894.24	*33,894.24*		33,894.24	*440,881.15*	-1	33,860.38
			3,125,506.80			**3,125,506.80**			**3,109,059.81**
	Consignee	13/11/2003	213,150		20/11/2003	213,150.00	*213,150.00*	-7	211,663.90
		13/11/2003	852,600.00	*1,065,750.00*	26/11/2003	852,600.00		-13	841,593.40
		19/11/2003	14,332.50		26/11/2003	14,332.50	*866,932.50*	-7	14,232.57
		19/11/2003	836,136.00	*850,468.50*	5/12/20003	836,136.00		-16	822,870.86
		20/11/2003	213,150.00	*213,150.00*	5/12/20003	213,150.00		-15	209,978.18
		24/11/2003	645,513.75	*645,513.75*	5/12/20003	645,513.75		-11	638,455.52
		26/11/2003	221,418.75	*221,418.75*	5/12/20003	221,418.75		-9	219,435.91
		3/12/2003	225,645.00	*225,645.00*	5/12/20003	225,645.00	*2,141,863.50*	-2	225,194.39
		Total	**3,221,946.00**			**3,221,946.00**			**3,183,424.73**

Table 6.11. Financial Performances for 2001-2004 Transactions (Continued)

Year	Payee	Expected performance			Actual performance			Eti - Ti	$AP_i \times (1+r)^{(ET_i - T_i)}$
		Due on date (ETi)	Value (roubles)	Subtotal	Date of actual payment (Ti)	Value paid (roubles) APi	Subtotal		r=0.001
2004	*Company*	10/01/2004	1,107,069.75	*1,107,069.75*	13/01/2004	1,107,069.75		-3	1,103,755.17
		21/01/2004	30.25		13/01/2004	30.25	*1,107,100.00*	6	30.43
		21/01/2004	180,000.00		30/01/2003	180,000.00	*180,000.00*	-9	178,388.07
		21/01/2004	15,335	*195,365.25*	26/02/2004	15,335.00	*15,335.00*	-35	14,807.82
			1,302,435.00			**1,302,435.00**			**1,296,981.49**
	Consignee	29/01/2004	1,365,660.00	*1,365,660.00*	29/01/2004	1,365,660.00	*1,365,660.00*	0	
			1,365,660.00			**1,365,660.00**			**1,365,660.00**

6.3. Information Quality Measurement Case Evaluation

The methodology introduced in Section 3.4 suggested measuring information flow normalised performance through its delivery time defined as the time when information is accepted by the recipient to initiate SC activities. The researcher failed to obtain any business data for this method's Case evaluation. None of the businesses approached were keeping data required for Case evaluation on the time when information was received and accepted.

In Section 3.4 the influence of information quality on SC performance was stressed. The results of data quality research combined with a customer-focused approach to quality were related to information flow performance. Different levels of customer satisfaction were defined through a set of dimensions of information quality (Smart, 2002). The following Case Study is used to evaluate the information quality assessment suggested in Section 3.4.

6.3.1. Case Description

Participants were asked to evaluate quality characteristics of information contained in three New Zealand Web-sites:

Web-site 1: http://www.deer-velvet.co.nz (Deer Velvet New Zealand Ltd.) ;
Web-site 2: http://www.southerncrossvelvet.com (Southern Cross Velvet);
Web-site 3: http://www.gammanz.com/gnp/velvet.htm (Gamma Natural Products Ltd).

The above three Web-sites were selected from the list of suppliers provided in the New Zealand Deer Velvet Web-site (http://www.velvet.org.nz/). Selection criteria were:

- Comparable range of human health velvet products;
- High quality of Web-design;
- More than two years of existence.

Participants were asked to fill in shaded areas in the table (see Table 6.13 below) by evaluating information quality characteristics as "High", "Medium" or "Low" and to optionally fill in the column headed "Comments". Finally, participants were asked to name the best Web-sites from the three offered according to the quality of information required for their purchasing decision making.

Three information quality categories (dimension) defined in Table 3.3 (Section 3.4): essential (or must-be) quality, convenient quality, and attractive quality were defined through the information quality characteristics suggested by Smart (2002). The essential information quality category included task orientation, accuracy, and completeness. The convenient information quality category was described through clarity, concreteness, and style. The attractive information quality category consisted of three characteristics: organisation, retrievability, and visual effectiveness. Short descriptions were provided for each information quality characteristic.

The suggested questionnaire required at least half an hour of participant's free time, access to the Internet, a basic knowledge of information management, and no prior knowledge of either the three companies selected or of the velvet products offered by them. These criteria resulted in the limited number of people surveyed, and affected the way in which participants were selected. Participants were selected among Massey former and current students and staff members who were willing to help the researcher. In total, 16 participants filled in Table 6. 13. Summarised results are presented in Table 6.14.

Table 6.13. Case Evaluation of Information Quality Characteristics

Quality Characteristics	**Description**	**Comments**	Deer Velvet New Zealand Ltd.	Southern Cross Velvet	Gamma Natural Products Ltd.
		Easy to use			
Task orientation	Helps the user complete tasks related to their work by using the information				
Accuracy	Contains no mistakes or errors; truthful and factual				
Completeness	Includes all essential parts (but only these parts)				
		Easy to understand			
Clarity	Contains no ambiguity or obscurity				
Concreteness	Contains no abstractions; includes appropriate examples, scenarios, and metaphors				
Style	Uses correct and appropriate writing conventions and word choice				
		Easy to find			
Organisation	Organizes material coherently in a way that makes sense to the user				
Retrievability	Presents information in a way that lets users find information quickly and easily				
Visual Effectiveness	Uses layout, illustrations, colour, type, icons, and other graphical devices to enhance meaning and attractiveness				

Table 6.14. Summarised Questionnaire Results

Quality Group	Quality Characteristic	PARTICIPANT															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Web-site 1															
Essential	Task orientation	1.0	1.0	0.5	1.0	1.0	0.5	0.5	0.5	0.0	1.0	1.0	0.5	0.5	0.5	0.0	0.5
	Accuracy	1.0	0.5	1.0		0.5	1.0	0.5	0.5	0.5	0.5	1.0	0.0	0.0	0.5	0.5	0.5
	Completeness	1.0	1.0	1.0	1.0	0.5	0.0	0.0	0.5	1.0	0.5	0.5	0.0	0.5	0.5	0.0	0.0
Convenient	Clarity	1.0	1.0	1.0		1.0	0.0	0.5	0.0	0.0	1.0	1.0	0.5	0.0	1.0	0.5	0.5
	Concretness	0.0	1.0	1.0	1.0	1.0	0.0	0.5	0.5	0.0	1.0	1.0	1.0	0.0	0.5	0.0	0.5
	Style	0.0	1.0	0.5	1.0	1.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.5	0.5	0.5
Attractive	Organisation	1.0	1.0	0.5	0.5	0.0	0.0	0.5	0.0	0.5	1.0	1.0	0.5	0.5	1.0	0.0	0.0
	Retrievability	0.5	1.0	1.0	0.5	1.0	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	0.5	1.0
	Visual Effectiveness	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.5	0.0	0.5	0.5	1.0	0.5	0.0	0.0	0.0
		Web-site 2															
Essential	Task orientation	0.5	0.5	1.0	1.0	1.0	0.5	1.0	0.0	0.5	1.0	1.0	0.5	0.5	1.0	1.0	1.0
	Accuracy	0.5	1.0	0.5		0.5	1.0	1.0	0.0	0.0	0.5	1.0	0.5	1.0	1.0	0.5	1.0
	Completeness	1.0	0.5	0.5	1.0	1.0	0.5	0.5	0.0	0.5	0.5	1.0	0.5	0.5	1.0	1.0	0.5
Convenient	Clarity	1.0	1.0	0.5		0.5	0.5	0.5	0.0	0.5	0.0	1.0	0.5	0.5	1.0	1.0	0.5
	Concretness	1.0	1.0	1.0	1.0	0.5	1.0	0.5	0.0	0.5	1.0	0.5	0.5	0.5	1.0	1.0	1.0
	Style	1.0	0.5	1.0	1.0	0.5	1.0	1.0	0.5	0.5	0.0	0.5	0.5	0.5	1.0	1.0	1.0
Attractive	Organisation	1.0	0.5	1.0	0.5	0.5	0.5	0.5	0.0	0.5	0.5	1.0	0.5	0.5	1.0	0.5	0.5
	Retrievability	1.0	1.0	0.5	0.5	0.5	0.5	1.0	0.0	1.0	0.5	1.0	0.5	0.5	1.0	1.0	1.0
	Visual Effectiveness	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.0	0.5	0.5	0.5	0.5	0.5	1.0	0.5	1.0
		Web-site 3															
Essential	Task orientation	0.0	0.5	0.5	1.0	1.0	1.0	0.5	0.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0
	Accuracy	0.0	0.5	0.0		0.5	1.0	1.0	0.5	1.0	0.5	1.0	1.0	0.5	1.0	1.0	1.0
	Completeness	0.0	0.0	0.0	0.5	0.5	1.0	0.5	0.0	0.5	0.5	1.0	1.0	1.0	1.0	0.5	1.0
Convenient	Clarity	0.0	1.0	0.5		0.5	1.0	0.5	0.0	0.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
	Concretness	0.5	0.5	0.5	1.0	0.5	1.0	1.0	0.5	0.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0
	Style	0.5	0.0	1.0	1.0	0.5	1.0	1.0	0.5	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Attractive	Organisation	0.0	0.0	0.5	0.5	0.5	1.0	0.0	0.0	0.5	1.0	1.0	1.0	1.0	1.0	0.5	1.0
	Retrievability	0.0	0.5	1.0	0.5	0.5	1.0	0.5	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Visual Effectiveness	0.5	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 6.15. Average Values for Information Quality Groups

Quality Group	PARTICIPANT															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Web-site 1																
Essential	1.00	0.83	0.83	1.00	0.67	0.50	0.33	0.50	0.50	0.67	0.83	0.17	0.33	0.50	0.17	0.33
Convenient	0.33	1.00	0.83	1.00	1.00	0.00	0.50	0.33	0.17	0.83	0.83	0.67	0.00	0.67	0.33	0.50
Attractive	0.50	0.67	0.67	0.50	0.33	0.17	0.33	0.33	0.33	0.83	0.83	0.83	0.67	0.67	0.17	0.33
Total	1.83	2.50	2.33	2.50	2.00	0.67	1.16	1.16	1.00	2.33	2.50	1.67	1.00	1.84	0.67	1.16
Web-site 2																
Essential	0.67	0.67	0.67	1.00	0.83	0.67	0.83	0.00	0.33	0.67	1.00	0.50	0.67	1.00	0.83	0.83
Convenient	1.00	0.83	0.83	1.00	0.50	0.83	0.67	0.17	0.50	0.33	0.67	0.50	0.50	1.00	1.00	0.83
Attractive	1.00	0.83	0.83	0.67	0.67	0.50	0.67	0.00	0.67	0.50	0.83	0.50	0.50	1.00	0.67	0.83
Total	2.67	2.38	2.33	2.67	2.00	2.00	2.17	0.17	1.50	1.50	2.50	1.50	1.67	3.00	2.50	2.50
Web-site 3																
Essential	0.00	0.33	0.17	0.75	0.67	1.00	0.67	0.17	0.83	0.67	1.00	1.00	0.83	0.83	0.83	1.00
Convenient	0.33	0.50	0.67	1.00	0.50	1.00	0.83	0.33	0.00	1.00	1.00	1.00	0.83	0.83	1.00	1.00
Attractive	0.17	0.50	0.67	0.67	0.67	1.00	0.50	0.33	0.50	1.00	1.00	1.00	1.00	1.00	0.83	1.00
Total	0.50	1.33	1.51	2.42	1.84	3.00	2.00	0.83	1.33	2.67	3.00	3.00	2.66	2.66	2.66	3.00

6.3.2. Results Analysis

Tables 6.13 filled in by each participant were processed as follows:

- "High", "Medium" or "Low" measures were substituted by numbers 1, 0.5, and 0, respectively. Summarised results are presented in Table 6.14 on page 164.
- Characteristics were grouped according to Table 3.4 (see Section 3.4).
- For each group an average value of information characteristic evaluation was calculated. Average values are given in Table 6.15 on page 165.

In Tables 6.14 and 6.15 those selected as the best Web-sites are defined through the shaded areas.

Results showed that participants named as the best different Web-pages:

- 7 participants named Gamma Natural Products Ltd. (Web-site 3);
- 5 participants named Southern Cross Velvet (Web-site 2), and
- 4 participants selected Deer Velvet New Zealand Ltd. (Web-site 1).

This approximately equal distribution of customer selection explains the two year existence of Web-based sales of these companies in competition with 45 companies listed in the New Zealand Deer Velvet Web-site.

Results from Table 6.15 show that all participants named as the best Web-sites those with the largest average information quality measurement.

In two cases from 16, the highest average evaluation was assigned to two Web-sites:

Web-site	Information quality group	Participants			
		3		5	
		Average	Total av.	Average	Total av.
1	**Essential** **Convenient** **Attractive**	0.83 0.83 0.67	**2.33**	0.67 1.00 0.33	**2.00**
2	**Essential** **Convenient** **Attractive**	0.67 0.83 0.83	2.33	0.83 0.50 0.67	2.00
3	**Essential** **Convenient** **Attractive**	0.17 0.67 0.67	1.50	0.67 0.50 0.67	1.83

In these two cases both participants named as the best the site where the sum of an average essential and convenient quality measures was higher:

Web-site	Information quality group	Participants			
		1		3	
		Average	Essential + Convenient	Average	Essential +Convenient
1	**Essential** **Convenient** **Attractive**	0.83 0.83 0.67	**1.66**	0.67 1.00 0.33	**1.67**
2	**Essential** **Convenient** **Attractive**	0.67 0.83 0.83	1.5	0.83 0.50 0.67	1.33

Results also showed that the one selected as the best Web-site had the highest average convenient quality, which may be explained by the customer-focused nature of the Case study. One of the often mentioned B2C e-commerce benefits is its convenience to customers (Strauss *et al.* ,2003; Chesher ,2003; Blattberg and Deoghton ,1991).

Case evaluation using the methodology suggested in Section 3.4 for measuring information quality showed a relationship between participants' assessment of different groups of information quality characteristics and their total evaluation of information.

Additional case evaluation is required to gain more empirical knowledge of this relationship. The designing and conducting of such case studies are not well investigated and present significant challenges.

The conclusion may be drawn that the present case evaluation did not prove the validity of the suggested methods. However, it did not show that they are not valid either. Additional extensive research is required to prove one of these two hypotheses.

6.4. Case Evaluation: Measurement of Supplier – Customer Contractual Performance

In this Section, the proposed methodology is evaluated using data provided by three Russian companies for grain transactions. Uniformly scaled performance measures for material and financial flows are calculated and compared. The balanced performance value is defined as the firm's incoming performance value minus outgoing performance value. It is demonstrated that if one of the contractual parties performs below the expected value of 1, it places another party in a disadvantaged position that requires unexpected use of resources.

6.4.1. Case Study Description

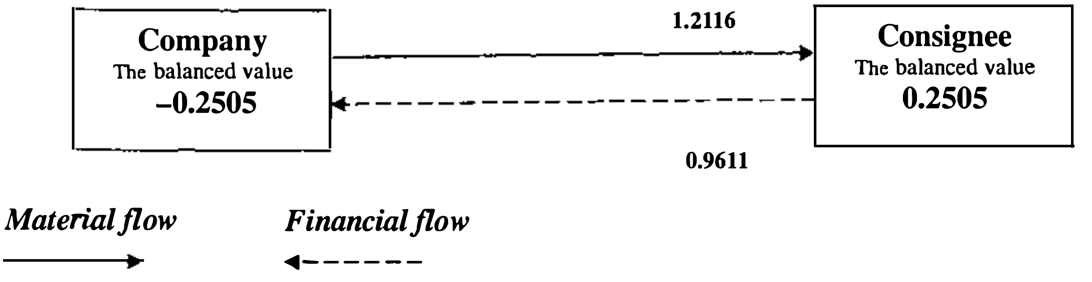
Two grain companies selected for the case evaluation have business relationships which started in 2000. These companies agreed to provide the researcher with full information on their transactions for 2001-2004 contracts. The transactions involved the supply of food grain to a Saint-Petersburg milling factory (Consignee). The milling factory is the largest in North-West Russia and requires a constant supply of high grain volumes. Because of the difficulties experienced by the Russian agricultural sector over the last decade, the milling factory outsourced some of its grain purchasing activities to The Grain Company (Company).

6.4.2. Evaluation of Actual Values in the Case Studies

6.4.2.1. 2001 Year Transactions

Normalised performance measures for material and financial flows were calculated using methodologies described in Chapter 3. Results are summarised in Figure 6.3, below.

Figure 6.3. Actual Normalised Performance for 2001 Transactions



The Company provided higher than expected material flow performance as a result of the high level of delivery performance. At the same time, the Consignee delayed payments which resulted in lower than expected financial flow performance.

For each party, the balanced performance value was calculated. The **balanced performance value** is defined as the sum of all incoming performance values minus all outgoing performance values for each party.
The balanced performance values were:

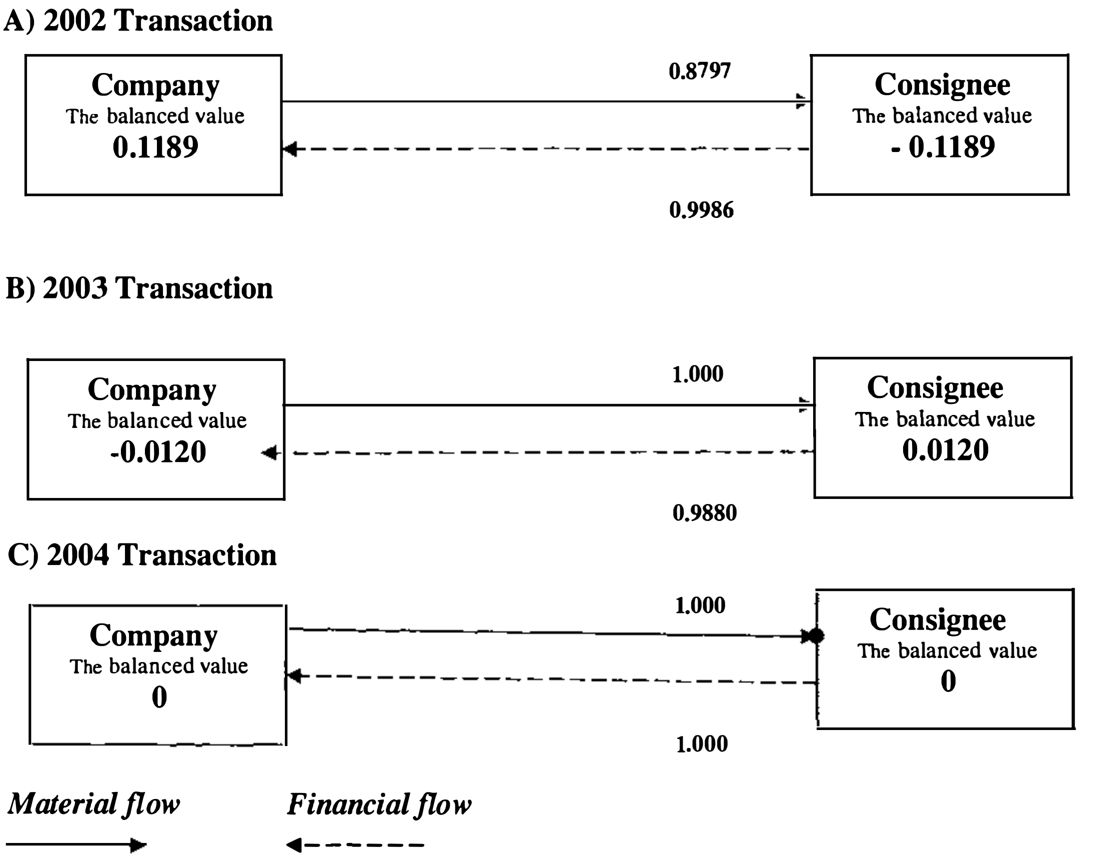
for the Consignee 1.2116-0.9611=0.2505
for the Company 0.8050-1.211= -0.2505

The positive balanced performance value obtained by the Consignee was a result of the higher than expected incoming material flow performance and lower than the expected outgoing financial flow performance. This positive value was passed as a negative balanced performance value to the Company. This value indicated that the material flow performance was not balanced by the financial flow performance. In other words, the participants did not perform the transaction equally well.

6.4.2.2. 2002-2004 Year Transactions

Similar to the 2001 Contract, normalised performance measures for material and financial flows were calculated using data provided for the 2002-2004 transaction. The results are summarised in Figure 6.4, below.

Figure 6.4. Actual Normalised Performance Values of Material and Financial Flows for 2002-2004 Transactions



In the 2002 transaction the Company performed below the expected value (0.8797) by partially delaying delivery of grain. Even though the Consignee's financial performance had a value of 0.9986, which is below the expected value of 1, it appeared to be higher. This resulted in the positive balanced performance value for the Company, and, consequently in the negative value for the Consignee.

Similarly to the 2001 transaction, in the 2003 transaction the Consignee obtained the positive balanced performance value of 0.0120 by performing lower than expected in financial flow. This was transferred into the negative balance performance value of -0.0120 for the Company.

In 2004 transactions both companies performed according to expected values. Both normalised performances had a value of 1 and the balanced values had a value of 0.

In the situation where one of the contractual parties performed below the expected value of 1, another party is placed in a disadvantaged position. That requires unexpected usage of resources. For example, in the 2001 and 2003 transactions, delayed Consignee's payments caused financial difficulties for the Company that resulted in additional costs. In the 2002 transaction, the Company's low performance caused unplanned rescheduling of the Consignee's production plans that resulted in an increase of production costs.

In general, a negative balanced performance value may occur when both parties perform above the expected level at a different rate. For example, if in the 2001 transaction the Consignee had provided the financial flow performance of 1 (expected level), then its balanced performance value would be 0.2166, leaving the Company with the negative balance of -0.2166. This negative value did not lead to unplanned use of resources or/and additional costs. The negative value indicated the amount the Company's performance exceeded the performance of the Consignee.

The conclusion may therefore be derived that a normalised performance measurement system allows the uniform comparison of contractual performance. Balanced performance values have the same absolute value for both parties. The sign of the balanced performance value indicates the party in the relatively disadvantaged position. If the negative balanced performance value resulted from lower than expected performance of the other party, this disadvantage results in unexpected use of resources, as happened in 2001 and 2003 with the Company and in 2002 with the Consignee.

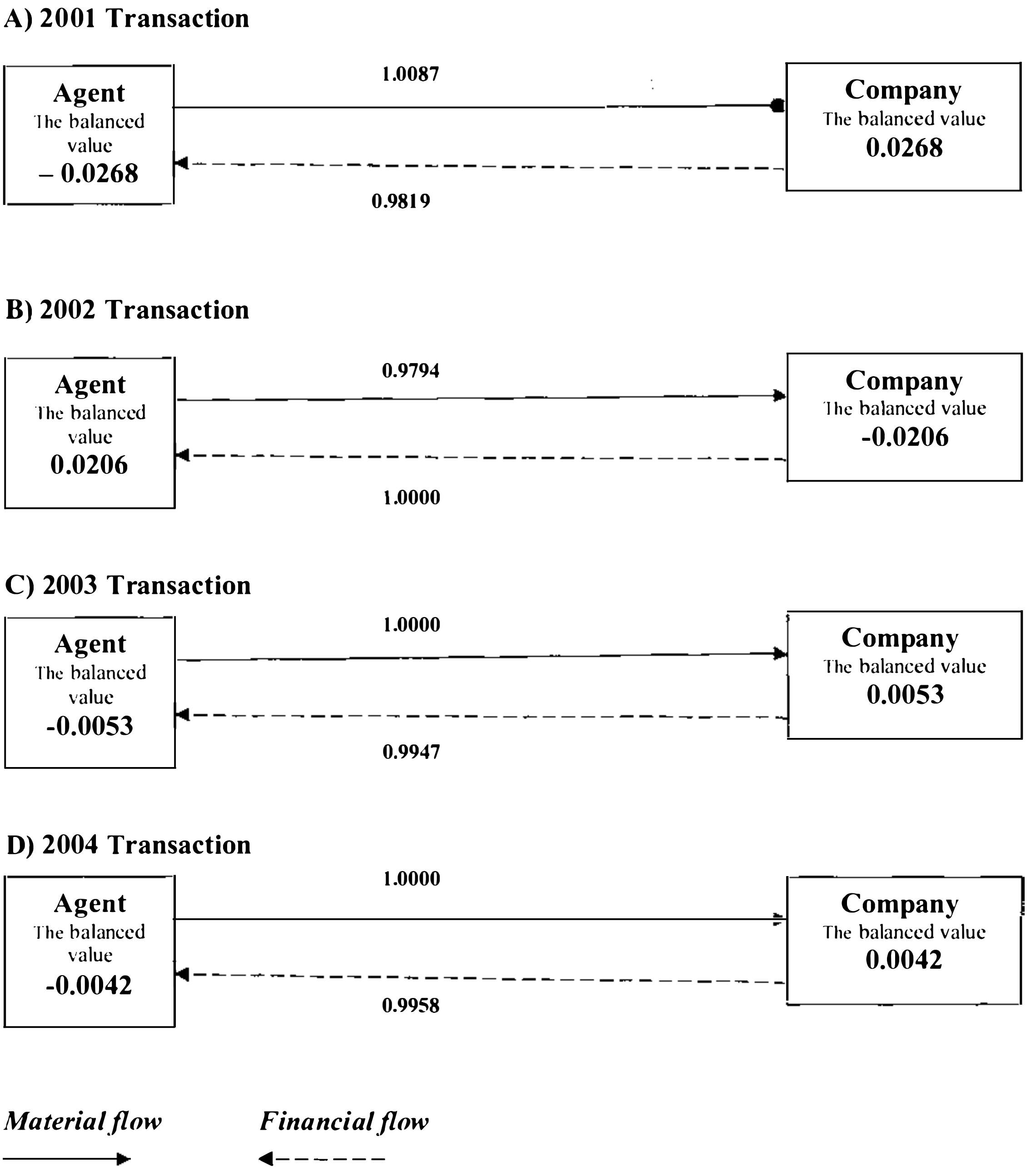
6.5. Case Evaluation: Measurement of Network Performance

In this Section, the methodology suggested in Chapter 4 is evaluated using data provided by three Russian companies for their grain transactions in 2001-2004. Two companies were introduced in Section 6.4: the Gain Company (Company) and the Saint-Petersburg milling factory (Consignee). The Grain Company established agreements with several regional agents. The Agent's functions were to consolidate the required volumes of grain, with the specified quality characteristics, in different grain producing regions and to ship the grain to the Consignee – the milling factory in Saint-Petersburg. Business relationships with one of regional agents (Agent) continued for four years. This allowed the researcher to obtain information on contractual performance between the Company and the Agent during this period in addition to the contractual performance between the Company and the Consignee.

6.5.1. Contractual Performance between the Agent and the Company

Normalised performance measures for material flows between the Agent and the Company were calculated using the methodology described in Chapter 4. Normalised performance measures for financial flows between the Agent and the Company were calculated in Section 6.2 (see Table 6.12). These values, along with the balanced performance values, are presented in Figure 6.5, below:

Figure 6.5. Normalised Performance Measures for Agent and Company Transactions



The above normalised performance measures were combined with the normalised performance measures for transaction between the Company and the Consignee (see Section 6.4). Results are presented and discussed below in Section 6.5.2.2.

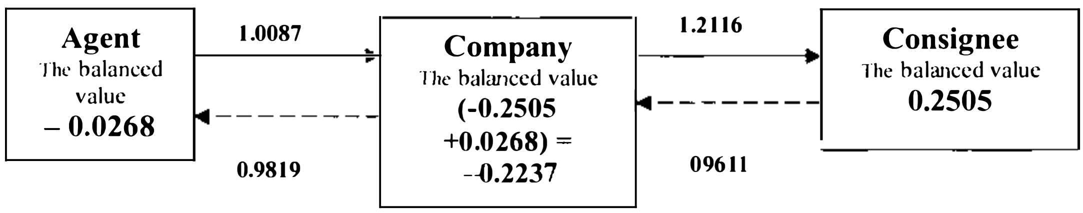
6.5.2. Network Contractual Performance

Normalised performances for 2001-2004 transactions were combined for all three companies. For the Company the total balanced performance value was calculated by adding the balanced performance value of its transactions with the Consignee (see Section 6.4) to the balanced performance values of the Company's contractual performance with the Agent.

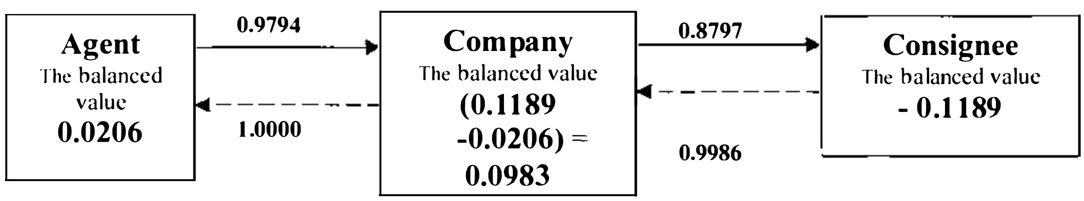
Results are presented in Figure 6.6, below:

Figure 6.6. Network Normalised Performance Measures for 2001-2004 Transactions

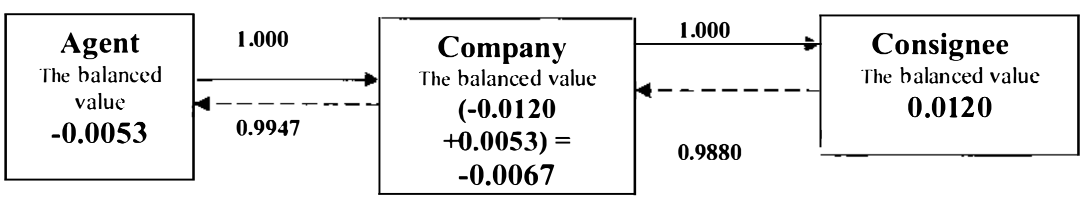
A) 2001 Transactions



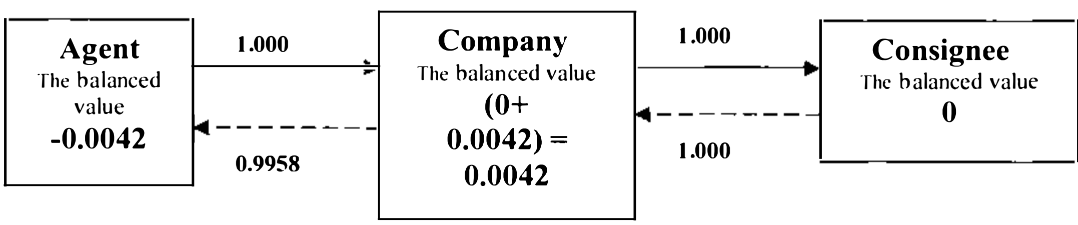
B) 2002 Transactions



C) 2003 Transactions



D) 2004 Transactions



As discussed in Section 4.2 (Network Level Performance Measurement) normalised performances were summarised for material and financial flows. Results are presented in Table 6.16, below:

Table 6.16. Case Study: Total Normalised Supplier's and Customer's Performance Measures

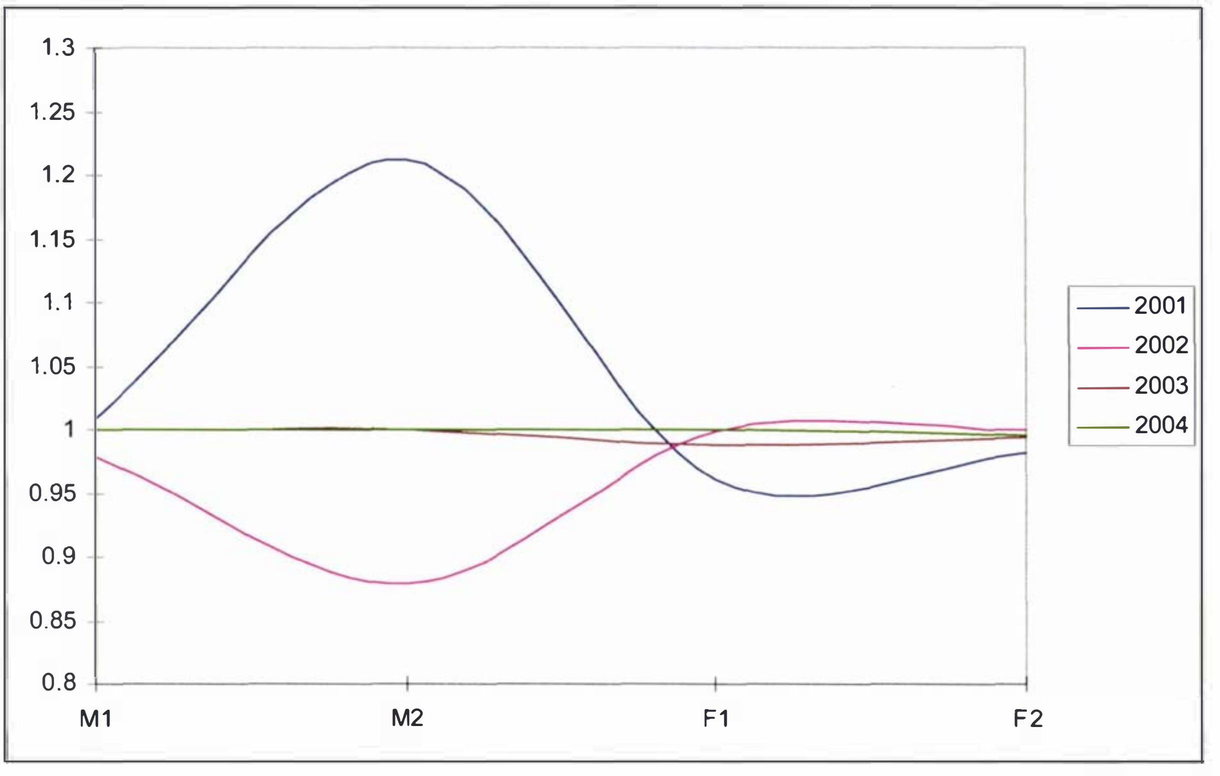
Year	Sum of total normalised performances	Total normalised supplier's performance	Correspondent total normalised customer's performance
2001	4.1633	2.2203	1.943
2002	3.8577	1.8591	1.9986
2003	3.9827	2.0000	1.9827
2004	3.9958	2.0000	1.9958

Table 6.16 indicates that in three of four transactions, the total supplier's performance was equal to, or above the total normalised expected value (2). In all four transactions the total customer's performance was below the total normalised expected value.

6.5.3. Case Study Results Analysis. Supply Chain Wave Effect.

The term "**supply chain wave effect**" (the wave effect) is used when the low performance of one supply chain member affects the balance of performance value for one or more chain members. The wave effect is similar to the bullwhip effect (Lee, *et al.*, 1993). However, the wave effect is related to the balance of performance values in the chain rather than to amplifications of orders occurring within the chain. This effect for 2001 and 2004 transactions is demonstrated in Figure 6.7, below:

Figure 6.7. Supply Chain Wave Effect



M1 – normalised performance value for material flow between the Agent and the Company;

M2 – normalised performance value for material flow between the Company and the Consignee;

F1 – normalised performance value for financial flow between the Consignee and the Company;

F2 – normalised performance value for financial flow between the Company and the Agent.

In Figure 6.7 normalised performance values were presented in time sequential order of the activities performed.

The party that initiates the wave effect may be identified from normalised performance values determined for branches in the chain. The first step in this process is to locate a transaction that initiated a performance below the expected value of 1. In the 2001 transaction, the initiating party was the Consignee (financial flow performance of 0.9611). For the 2002 transaction, the Agent played this negative wave effect role (material flow performance of 0.9794).

The wave effect may be amplified or reinforced along the chain, if the immediate predecessor in the chain provides a value below the incoming value, as happened with the Company during the

2002 transaction. The incoming value for the Company was 0.9794, and the Company provided a lower value of 0.8797 to the Consignee.

The wave effect may be reduced by a positive contribution. For example, the wave effect in the 2001 transaction caused by the Consignee's payment delays was partially weakened by the Company when it transformed the incoming financial flow performance value of 0.9611 into the higher outgoing performance value of 0.9819. The wave effect in the 2002 transaction was partially weakened by the Consignee when it transformed the value of 0.8797 into the higher value of 0.9986. The wave effect was totally eliminated by the Company in 2002, when it transformed the incoming value of 0.9986 into an outgoing value of 1.000.

When the wave effect occurs in the chain it creates a positive balance of performance for the party that initiated it. For example, in the 2003 transaction, the Consignee, who initiated the wave effect, created the positive performance balance of 0.012 which created its comparative gain at the expense of the other contractual party – the Company. It was discussed in Section 6.4 how the Consignee's positive balanced performance value is transferred to the Company's negative balanced performance value of -0.012. The negative balanced performance indicates the Company's comparative gain.

6.5.4. Conclusions

Although the three enterprises which participated in the Case study have long-term business relationships, in all four transactions described above, they did not reach a balance of performance.

Application of the methodology suggested in Chapters 3 and 4 demonstrated, using the Case Study, the supply chain wave effect. This effect takes place when the low performance of one supply chain member affects the balance of values of other chain members. A methodology was described that, when applied to all enterprises involved in a transaction, identifies the party that initiates the wave effect, and parties that reinforce or weaken this effect. It was also shown that the party that provides a value less than 1 to the immediately preceding party may be affected by the lower performance of the preceding supply chain members and, by the use of their resources, weaken the wave effect.

The Case study showed that over time the scale of the wave effect weakened. In 2001 transactions the wave effect was presented by the big scale of performance curve (blue line in Figure 6.7). This scale had lower magnitude for 2002 transactions, and significantly decreased in 2003-2004. This decrease may be explained by the desire of the three enterprises to maintain a long-term business relationship which assumes that the performance of all parties involved will not fall below the expected level.

The Case study demonstrated that material flow performance, except for the 2002 transaction, was at expected or above expected levels, which is consistent with the literature on supply chain customer focus (Hines, 2003). At the same time, from 8 financial flow measures, only two were at the expected level. This indicates that the existing business relationships did not support SCM principles of shared risks and rewards (Lambert *et al.*, 1996).

Chapter Seven
Results and Conclusions

7.1. Introduction

In this Chapter discussions are provided on how the research objectives formulated in Chapter 1 were reached. In Sections 7.2 and 7.3 research results relevant to the research objectives are analysed and conclusions are drawn.

In Section 7.3.4 discussions on how results of this research may assist in solving fundamental SCM problems (Chapter 1) are presented.

7.2. Achievement of the First Research Objective

The first objective of this research was defined in Chapter 1, as:

"This research will create a methodology that permits chain participants to uniformly measure performance. Supply chain members' performance will be defined and measured by the businesses' ability to meet the expected value of its activities. Performance may be measured by individual firms and/or an entire supply chain at different levels of business planning (strategic, tactical and operational)".

These objectives were reached in Chapters 3 -5 where a methodology for normalised SC performance measurement was described and illustrated with examples. The suggested methodology incorporated bi-directional material, financial, and information chain flows. Interrelation and interdependence of the above SC flows require a mechanism to measure the performance of these flows. A normalisation process for performance measures was conducted to provide such a mechanism. The most commonly used performance SC characteristics (Ross, 1998) were incorporated into the suggested methodology: quality, delivery, price, lead-times, and quantity received.

The primary concepts of the suggested methodology were introduced in Chapter 3. Theses concepts focused on the normalised performance measurement of transactions in SC flows when materials, payments, and information are sent by one SC member to another SC member. The suggested primary concepts use a similar measurement scale, where the value of actual performance relates to the expected (planned) level of performance. Normalised performance values below one and above one uniformly indicate lower or higher than expected (planned) levels of performance, respectively. The same measurement scales allowed performance composition and comparison for different SC flows. For example, use of the same scale permits a comparison of financial transaction performance with material flow transaction performance. As a result, it was possible to use primary performance measurement concepts in the evaluation of the contractual performance of two SC members (Section 4.2).

Contractual performance was presented as sequential interrelated transactions of the three bi-directional SC flows. The literature on SC performance measurement methods focuses mainly on supplier's performance (References). The proposed research methodology allows the symmetrical evaluation of the performance of both contractual parties. Symmetrical evaluation means that the customer's contractual performance is evaluated as well as the supplier's performance. If the customer performs poorly in providing the supplier with accurate and timely information and timely and full payment, it will be reflected by the normalised performance measurement system, as well as by the supplier's performance. This measurement approach assumed the expected (planned) performances of both contractual parties to be balanced against each other. The parties should reach an agreement in terms of the quality, delivery, price, lead-times, and quantity of the planned SC transactions.

The suggested normalised symmetrical performance measurement approach may be extended to the performance evaluation of any number of connected SC members. For example, evaluation of the first tier supplier, supplier and manufacturer was demonstrated in the Case Study in Section 6.5. The number of SC members connected by contractual agreements may be increased according to the boundaries of the required system analysis. A general methodology for network performance measurement was introduced in Section 4.3. An example of a typical agri-food chain was used in this Section to illustrate the main methodological concepts.

A key aspect of a SC measurement system is how it is related to the strategic planning and control process (Bechtel and Jayaram, 1997). The proposed SC performance measurement process adapted the performance-induced strategic model (Dyson, 2000). In Chapter 5 this model was discussed in terms of the normalised performance measurement system suggested in Chapters 3-4. This model allowed defining the main components of the SC strategic planning and control process - such as mission statement, objectives and targets - using different levels of the performance measurement system proposed in this research. It was possible to demonstrate the applicability of this research methodology when the performance-induced strategic planning and the development model (Dyson and O'Brien, 1998) were combined.

7.3. Achievement of the Second Research Objective

The second research objective was formulated in Chapter 1, as:

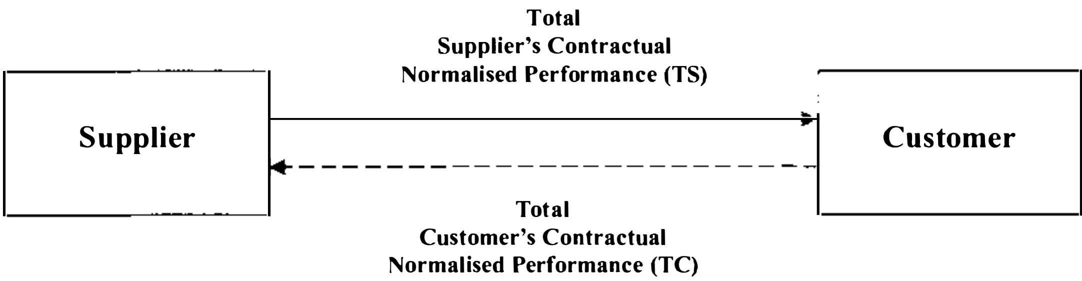
"This research will create a methodology to determine if customer-directed performance in material transactions is balanced by the performance observed in up-stream financial flows. This research will introduce the definition of "chain wave effect"- the effect that takes places when the low performance of one supply chain member affects the performance balance of other chain members".

This objective was met and discussed in the Case evaluation conducted in Chapter 6

7.3.1. Balanced Normalised Performance

Four years of data were used to evaluate the normalised supplier-customer contractual performance measurement (see Section 6.4) that was suggested in Section 4.2. In this Case evaluation, the normalised performances of the contractual parties were balanced against each other. The resulting balanced performance value was defined as the difference between one firm's total normalised performance value and the total normalised performance value of the other contractual participant.

Figure 7.1. Normalised Performance Balance for Contractual Parties



In Figure 7.1, the balanced performance value for the Supplier was calculated as the difference between the Total Supplier's Contractual Normalised Performance (TS) and the Total Customer's Contractual Normalised Performance (TC), that is TS - TC. The Customer's balanced performance value was calculated as TC-TS. It may be noted that the sum of the Supplier's and the Customer's normalised performance values is equal to zero. If one of the balanced performance values is negative, then the other one will be positive with the same absolute value. A negative balanced performance value, for either the supplier or the customer, indicates that the party experienced an opportunity loss caused by the other party's performing at a lower level. An opportunity loss is defined as the loss of the opportunity to obtain a higher performance level from the other contractual party.

In balanced transactions there are no lost opportunities because each participant is performing at the same level.

The improved performance by one party is demonstrated by an increased normalised contractual performance value. If that improved value is compared with the unchanged normalised performance of the other party in the contract, a decrease of the first party's balanced performance results. For example, suppose initially that both parties performed at the expected level. This results in equal balance of performance results - TC=TS=1. If, however, TC=1.02, with TS unchanged at 1.00, then the balanced customer's performance measure will be 1.00-1.02= -0.02. The value -.02 indicates that the Customer experienced the opportunity loss of .02 as a result of the relatively lower level of the Supplier's performance, even though the Supplier performed at the expected level. In this situation, the improved performance of the Customer was not matched by a similar increase in the performance of the Supplier.

As a result, the Customer had an opportunity loss that represented the magnitude of the mismatched levels of performance. The Supplier, however, experienced an opportunity gain of .02. Such an opportunity gain indicates the Customer provided benefits to the Supplier that were not reciprocated by the Supplier.

This situation may be represented as a Two-Person Zero-Sum Game with a payoff matrix, as presented in Table 7.1, below.

Table 7.1. Contractual Balanced Payoff Matrix

Supplier's normalised performance	Customer's normalised performance					Row min
	1	**1.01**	**1.02**	**1.03**	**1.04**	
1	0	0.01	0.02	0.03	0.04	0
1.01	-0.01	0	0.01	0.02	0.03	-0.01
1.02	-0.02	-0.01	0	0.01	0.02	-0.02
1.03	-0.03	-0.02	-0.01	0	0.01	-0.03
1.04	-0.04	-0.03	-0.02	-0.01	0	-0.04
Column max	0	0.01	0.02	0.03	0.04	

In Table 7.1, the payoff matrix rows represent different levels of a Supplier's normalised performance. The columns represent different levels of a Customer's normalised performance. Values for normalised performances were arbitrarily assigned from 1 (expected normalised performance) with increments of 0.01. In Table 7.1, if the Supplier's normalised performance value is 1, and the Customer's normalised performance value is 1.01, the Customer experiences an opportunity loss of 0.01 because its level of performance exceeds that of the Supplier. The Supplier receives an opportunity gain of .01.

For further discussion, the Supplier's performance is analysed first. The Supplier's normalised performance value is defined in the rows in Table 7.1 with the Customer's normalised performance values defined in the columns. For the Customer not to experience an opportunity loss, the optimum strategy is to select the column with the lowest possible performance. Selecting higher performance strategies increases the possibility of opportunity loss for the Customer, while lower performance strategies reduce the possibility of opportunity loss. For example, if the Supplier's normalised performance value is 1.01, then to minimise the possibility of opportunity loss, the

Customer will provide a normalised performance measure of 1. In this situation, the Supplier will experience an opportunity loss of 0.01 while the Customer will experience an opportunity gain of .01.

Table 7.1 presents the Contractual payoff matrix. The saddle point, Max(row min) = Min (column max)=0 is achieved when both the Supplier and the Customer provide equal and the lowest (expected) normalised performance values. The saddle point is defined in game theory as an equilibrium point in which neither player can benefit from a unilateral change in strategy (Winston, 1994). The conclusion may be made that if both the Supplier and the Customer are interested in long-term relationships, the saddle point in the two-person zero-sum game presented in Table 7.1 provides the optimum business strategy.

Suppose the Supplier decides to improve its performance, with the new Supplier's normalised performance value goal established at 1.01. The Supplier is unable to change the performance of the Customer, so no changes are made in the Customer's normalised performance values. The new payoff matrix is in Table 7.2, below:

Table 7.2. Contractual Balanced Payoff Matrix with Increased Supplier Normalised Performance

Supplier's normalised performance	Customer's normalised performance					Row min
	1	**1.01**	**1.02**	**1.03**	**1.04**	
1.01	-0.01	0	0.01	0.02	0.03	**-0.01**
1.02	-0.02	-0.01	0	0.01	0.02	**-0.02**
1.03	-0.03	-0.02	-0.01	0	0.01	**-0.03**
1.04	-0.04	-0.03	-0.02	-0.01	0	**-0.04**
1.05	-0.05	-0.04	-0.03	-0.02	-0.1	**-0.05**
Column max	**-0.01**	**0**	**0.01**	**0.02**	**0.03**	

Table 7.2, similarly to Table 7.1, presents the payoff matrix with the saddle point. Max(row min) = Min (column max)=-0.01 is achieved when both the Supplier and the Customer provide equal and lowest (expected) normalised performance values. This saddle point provides equilibrium and defines the optimum strategies for both parties.

At this equilibrium point, however, the Supplier experiences a balanced normalised performance opportunity loss of 0.01. This opportunity loss results from the fact that the level of the Customer's normalised performance does not balance the improved performance by the Supplier.

The same conclusion may be derived for the improvement of the Customer's normalised performance, if it is not balanced by the Supplier's normalised performance.

With the drive for continuous SC improvement there is a drive to increase normalised performance. From the above examples, it may be seen that the saddle point - which provides the equilibrium for these improved service levels and the optimum strategies for both parties - always lies on the diagonal of the payoff matrix, as presented in Tables 7.1 and 7.2. The optimum strategy that does not cause opportunity loss for either of the two parties is the strategy wherein the normalised performance values are balanced – the balanced performance value in the payoff matrix has zero value. The matrix of the balanced normalised performance values has zero values on its diagonal when both the Supplier's and the Customer's normalised performance values, represented by rows and columns in the payoff matrix, have the same values, as presented in Table 7.1.

In terms of the long-term contractual performance of two parties, this analysis indicates that if requirements on normalised performance improvement are imposed on one of the contractual parties, for this party not to experience any opportunity loss and to ensure a long-term stable business relationship, the same level of normalised performance improvement should be provided by the other party.

In the payoff matrix presented in Table 7.3 below, normalised performance values from the Case Study (see Section 6.4) were used as both the Agent's and the Company's strategies.

Table 7.3. Payoff Matrix (Agent and Company)

Agent's Normalised Performance	Company's Normalised Performance					
	0.9794	0.9819	0.9947	0.9958	1	1.0087
0.9794	0	0.0025	0.0153	0.0164	**0.0206**	0.0293
0.9819	-0.0025	0	0.0128	0.0139	0.0181	0.0268
0.9947	-0.0153	-0.0128	0	0.0011	0.0053	0.014
0.9958	-0.0164	-0.0139	-0.0011	0	0.0042	0.0129
1	-0.0206	-0.0181	**-0.0053**	**-0.0042**	**0**	0.0087
1.0087	-0.0293	**-0.0268**	-0.014	-0.0129	-0.0087	0

Transaction 1 Transaction 3 Transaction 4 Transaction 2

Table 7.3 shows the decrease of absolute values of balanced normalised performances from 0.0268 in 2001 to 0.0042 in 2004. The four transactions described in the Case Study showed that the normalised performance of the two enterprises moved in the direction of the zero diagonal. The zero diagonal, as discussed above, presents the equilibrium state and optimum strategies for both parties. The shift of the transactional balanced normalised performance values in Table 7.3 was also in the direction of increased normalised performance values for both parties (right-hand low level of the payoff matrix).

The same trend may be seen for the Company's and the Consignee's balanced normalised performance values (see Chapter 6.5), presented in Table 7.4, below.

Table 7.4. Payoff Matrix (Company and Consignee)

Company's Normalised Performance	Consignee's Normalised Performance					
	0.8797	0.9611	0.9880	0.9986	1	1.2116
0.8797	0	0.0814	0.1083	**0.1189**	0.1203	0.3319
0.9611	-0.0814	0	0.0269	0.0375	0.0389	0.2505
0.9880	-0.1083	-0.0269	0	0.0106	**0.012**	0.2236
0.9986	-0.1189	-0.0375	-0.0106	0	0.0014	0.213
1	-0.1203	-0.0389	-0.012	-0.0014	**0**	0.2116
1.2116	-0.3319	**-0.2505**	-0.2236	-0.213	-0.2116	0

Transaction 1 Transaction 2 Transaction 3 Transaction 4

Table 7.4 shows the decrease of absolute values of balanced normalised performances from 0.3319 in 2001 to 0 in 2004. The four transactions described in the Case Study showed the shift of normalised performance values in the direction of the zero diagonal, reached during the last 2004 transaction.

The Case study evaluation indicated that with a long-term business relationship, the two companies tended to move in the direction of increased and balanced normalised performance values.

7.3.2. Supply Chain Wave Effect

Information provided by the Russian grain firms was evaluated on the level of chain connectivity of three firms over a four-year period of time. Case evaluation, discussed in Section 6.5, allowed detection of the chain wave effect. This effect takes place when the low performance of one supply chain member affects the balance of value of other chain members. Methods were described to identify the party that initiates the wave effect, and the parties that reinforce or weaken this effect. It was also demonstrated that unexpected use of resources is required for SC members affected by the wave effect to weaken its influence on the remaining part of the chain.

It is believed that the three enterprises involved into the Case study were interested in maintaining their long-term business relationships. This interest may explain their mutual co-ordinating efforts that resulted in the scale of the wave effect's weakening over time. The weakening of the wave effect may also be explained using game theory, as has been demonstrated for two-party transactions. It was demonstrated in the previous Section that in a contractual relationship between two parties, an optimum strategy is achieved, over time, when both normalised performance values are balanced. This principle, when applied to each participant in the chain, leads to the balanced normalised performance in each branch of the network. This results in a weakening of the chain effect.

7.4. SCM Problems Resolution

In Section 1.2 several fundamental SCM problems were identified and related to the research objectives. In the following Sections 7.3.1 – 7.3.2 additional analysis is produced of how the suggested NPMS may assist in resolving SCM problems.

7.4.1. Problem 1 - Difficulties in Adopting a SCM Philosophy

In the justification for this research (Section 1.4), it was stated that the normalised SC PMS "*may be used as a measurable explanation of SCM benefits and assist in its adaptation by chain members*".

Discussions in Sections 7.2.1 and 7.2.2 may be used in the clarification of SC problems, as defined in Chapter 1.

The requirement for normalised performance to be balanced for a successful long-term business relationship, as discussed in Section 7.2, may be used in the illustration of a SCM mission statement, as was defined in Section 5.2.1: "achieving a competitive advantage for supply chain members".

The customer-focused SCM approach (Childerhouse and Towill, 2000) imposes a requirement for constantly improving the normalised performance of businesses that provide products to the final consumer.

Using the analysis conducted in Chapter 7 for two contractual parties, a long-term business relationship requires the same level of normalised performance improvement for the next relationship along the SC. This is illustrated in Figure 7.2, below.

The proposed PMS includes a limited number of operational parameters. It suggests similar principles of performance evaluation for all SC members, regardless of their internal differences, such as size, type of ownership, and so on. A symmetrical approach of the suggested PMS, where both the Supplier's and the Customer's performance are evaluated using the same scale, may assist in achieving a more open business relationship between SC members and the adoption of SCM by all chain members.

7.4.2. Problem 2. The Lack of General Theory of SCM

In justification for this research (Section 1.4) it was stated that the normalised SC PMS " *may be used as an empirical prescriptive tool in the development of a general SCM theory*".

An overview of main SCM schools was presented in Tables 2. 3 and 2.4 (Chapter 2). In Table 7.5, below, the main concepts for each SCM school are subdivided into two columns.

The main similarities between school concepts and the proposed PMS are listed in column 3. The main differences between school concepts and the proposed PMS are listed in column 4.

7.5. Existing SCM Schools vs. NPMS.

№	School	Main similarities with the suggested PMS	Main differences from the suggested PMS
1	2	3	4
1	**The Functional Chain Awareness School**	Recognition of the existence of a chain of functional areas. All chain members, from beginning to end, should be included.	School emphasis on material flow. PMS considers three SC bi-directional flows, not only material flow.
2	**Linkage/Logistics School**	Linkage is viewed through the functional areas.	Addresses material flows through the SC. The emphasis is on managing material flows to reduce system inventories. PMS considers three SC bi-directional flows between at least two chain participants.
3	**Information School**	Bi-directional informational flows are considered.	Emphasis is placed on bi-directional informational flows. PMS considers three SC bi-directional flows, of which information flow was one element.
4	**Integration/ Process School**	Emphasis is on effectiveness in meeting customer requirements.	No consideration of the configuration of functional areas in the SC. Functional areas are considered and measured. PMS considers three SC bi-directional flows, not only material flow.
5	**Relationship School**	Concepts of cooperative relationships.	Focus on different forms, such as partnerships, strategic alliances. PMS may be used as a planning and control tool in cooperative relationship.
6	**E-commerce Schools**	Emphasis is on e-commerce and e-marketing.	One type of chain structure with a relatively small number of participants. PMS is case evaluated for traditional agri-food chains. It may be used for e-commerce performance measurement.

From the above Table 7.5 it may be concluded that the main contribution the proposed NPMS brings to the existing SCM concepts is the consideration and integration of material, financial, and informational bi-directional flows (Schools 1-4 in Table 7.4).

As a prescriptive tool that is incorporated into existing schools and used for evaluation, the suggested PMS may assist in the development of general SCM theory.

7.4.3. Problem 3. Difficulties of System Thinking

In justification for this research (Section 1.3) it was stated that the normalised SC PMS "*demonstrates interdependency of business performance in the chain, and gives a basis on which to control and evaluate total chain agility*".

In this research, the SC was presented through a set of businesses starting with the original raw material and ingredient suppliers and ending with the consumers. The connectivity of such a system is provided through bi-directional material, financial and information flows. A Case evaluation of the suggested PMS (Chapter 6) and the requirement for balanced total normalised performance, provided in Sections 7.2.1 - 7.2.2, showed how the performance of a particular chain member affects the upstream and downstream performance of the supply chain.

Applications of the suggested NPMS for the SC strategic planning and control were discussed in Chapter 6.

7.4.4. Problem 4. Unique Characteristics of Agribusiness Supply Chains

In the justification for this research (Section 1.4), it was stated that " *Business agreements in agri-food chains have specific regulatory status and often use a standardised contract. These agreements aid in the application of the suggested methodology to agri-food chains*".

There are international organisations which provide agri-food businesses with standard contract terms. For example, GAFTA (The Grain And Feed Trade Association) has 80 standard forms of trade contracts. Different forms of contracts reflect different grains and feeds, countries of origin and modes of transportation. One of these standard forms, number 78, was used between the parties evaluated in the Case study (Chapter 6).

Agri-food chains have specific regulatory status. Specific regulations on agri-food chains' performance were introduced recently to meet emerging international requirements, such as the USA Public Health Security and Bioterrorism Preparedness and Response Act of 2002. This regulatory status places unique, often internationally standardised, requirements on agri-food chain performance.

A uniformed performance measurement system, based on a standardised contractual agreement between chain members, that is adapted to regulatory requirements, may assist in agri-food chain management and governmental monitoring of its performance.

7.5. Limitations of Study

This study suggested approaching the main SCM problems, formulated in Chapter 1, through the introduction of NPMS. This measurement system uniformly evaluates the SC through measuring the bi-directional performance of chain members in three areas – material flows, information flows and financial flows.

It is well recognised that the field of SCM is vast, as there is difficulty in reaching agreement on a definition that encompasses all of SCM is testament. In addition to its scope, the interdisciplinary nature of SCM has resulted in a number of different views on the nature of SCM and, as a result, many different schools of thought.

This study presented an approach to SCM system analysis that is an alternative to other analytical approaches. The search for this alternative approach was defined by the researcher's desire to combine experience in applied mathematics with agribusiness management experience in a search of SCM problem resolution.

As with any alternative approach to an intensively discussed topic, this research is a subject to the critical evaluation. The researcher was able to present several concepts developed in this research to international audiences.

The researcher faced difficulties in finding data for the case evaluation of the suggested methodology. For this research, case evaluation required the willingness of several companies to open their records on material and financial flow performance and information flows. The most challenging aspect of data collection was obtaining information on financial performance. Three Russian grain companies, with whom the researcher had previously worked, supported the request for co-operation. These companies agreed to provide the data required for Case evaluation of the proposed NPMS.

While the research could not have been successfully conducted without the information supplied by the three grain companies, information from supply chains that involved more than three companies or information from supply chains in other industries would have permitted a more comprehensive testing of the methodology set out in this research. The most significant limitation on the research was the limited data available for the case study.

Another limitation was the fact that the information flow normalised performance measurement methodology proposed in Chapter 3.4 was not completely case evaluated. The three grain companies that provided data did not keep records on their informational transactions. In fact, it is believed it is not common for businesses to track information flows. This research presented the potential benefits associated with firms' monitoring information flows more closely. Because the firms involved in the research did not keep records, an alternative assessment of information flows, one part of the NPMS evaluation methodology, was required. The information quality evaluation (Section 6.3) was limited by the selection criterion of its participants that included at least 30 minutes of the participant's free time, access to the Internet, and a basic knowledge of information management.

Evaluation of the proposed methodology was focused primarily on the grain trade. While the international grain markets are considerable, reaching 109.2 million metric tonnes in 2002/2003, the applicability of the methodology to other industries is unknown. As mentioned above, information from other supply chains, particularly from other industries, would have enhanced the robustness of this research.

7. 6. Suggestions for Further Research

The suggested NPMS requires further case evaluation including a supply chain that consists of more than three businesses. In addition, data collected over a longer period of time may be used to calculate how firms adjust their relationships over time, taking into considerations changes in their balanced performance scores. Information from longer supply chains would also permit further analysis of the SC wave effect phenomenon introduced in this research. Additional research is also required to measure the performance of information flows, with a particular emphasis on the measurement of SC information quality.

The proposed NPMS focused on performance of SC businesses. The customer focus of SC activities was incorporated only at the strategic level in Chapter 5). The inclusion of the quantitative characteristics of final customers into the suggested PMS is also recommended for further investigation.

The popular Supply Chain Operation Reference Model (SCOR), as mentioned in Section 2.5.2.4, establishes a general measurement framework by creating a common language of standardised metrics and mapping procedures for analysis. The main shortcoming of this model is that it does not provide quantifiable SC performance measures. Additional research may be conducted on how SCOR metrics may be incorporated into the suggested NPMS methodology for the network optimisation decision-making process. The interface between the SCOR model and the suggested NPMS may benefit both models.

7.7. Conclusion

The key tenet in the development of SCM theory centres on the flow of materials, finance and information to connect raw material and ingredient producers with final consumers. Contemporary SCM theory is mainly descriptive and modern SCM research is predominately deductive. These approaches are a result of attempts to systematise and analyse broad business experience in different types of supply chains. The economic complexity of chain processes, when combined with social factors, makes it difficult to create a single unique quantitative model that adequately describes all available supply chain systems. The development of SCM theory assumes an emphasis on the investigation of the main idea behind this subject - the integration of SC flows (Semenenko, 2003).

The suggested research presents an alternative approach to the subject of SCM. Three SC flows were integrated through the evaluation of their NPMS. This research developed a NPMS based on a primary concept - the performance of each SC flow within a SC may be uniformly measured using similar sets of characteristics. This primary concept was then used in higher levels of system performance: in the evaluation of two-party contractual performance and then the performance of the total supply chain. The researcher paid special attention to the strategic level of system analysis for optimisation of the decision-making process (Chapter 5).

Evaluation of the proposed methodology (Chapter 5) permitted the quantification of chain interdependency through the measurement of the chain's performance characteristics. The application of game theory to the NPMS (Section 7.3.1) indicated that a stable optimum strategy might be reached when business performances are balanced along the chain. The Case Study suggested that chain participants might tend to move toward a stable optimum strategy over time.

These conclusions were used to illustrate, using quantified measures, how total chain performance is related to the performance of each particular chain member. The competitiveness of businesses in the chain was explained using the proposed NPMS in terms of total chain competitiveness. The NPMS also was able to quantify the wave chain effect, where the poor performance of one chain participant affects the performance of other chain participants. Further, the NMPS was able to identify that firms may move to cushion the impact of poor performance by one chain member on others in the chain.

This research may be used as a prescriptive tool for a range of agri-food chain studies. Extended case evaluation is required to test the robustness of the suggested methods. Possible further research areas were listed in Section 7.3.

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Appendix 1. Example of the Contract Between the Company and the Agent (Russian version)

ДОГОВОР № 09/08-01

Санкт-Петербург "09" августа 2001 года

ООО "Санкт-Петербургская Зерновая Кампания", в лице директора Петушкова К.М., действующего на основании Устава, именуемое в дальнейшем "Покупатель», с одной стороны, и ООО « Консультант Пресс », в лице генерального директора Быковского Д.Ю., действующего на основании Устава, именуемое в дальнейшем " Поставщик ", с другой стороны, заключили настоящий договор о нижеследующем:

1. ПРЕДМЕТ ДОГОВОРА.

1.1. Поставщик обязуется поставить, а Покупатель принять и оплатить продукцию - рожь продовольственная класса А

1.2. Единица измерения - метрическая тонна.

2. КАЧЕСТВО И КОЛИЧЕСТВО.

2.1.Количество поставляемой продукции - 3 000 (три тысячи) тн.(ориентировочно).

2.2.Качество продукции:

- в соответствии с требованиями ГОСТ 16990-88;
- число падений не менее 170 с

2.3. Каждая партия отгруженной продукции должна сопровождаться сертификатом качества ГХИ, карантинным сертификатом и сертификатом соответствия с протоколом радиационного контроля

3. СТОИМОСТЬ ПРОДУКЦИИ.

3.1. Стоимость одной тонны продукции, включая НДС 10%, составляет 2 180 (две тысячи сто восемьдесят) рублей на условиях франко-вагон станция назначения (ст. Санкт-Петербург-товарный Московский Октябрьской ж/д).

3.2. Общая стоимость продукции составляет 6 540 000 (шесть миллионов пятьсот сорок тысяч) рублей. НДС 10% в том числе 594 545,45 рублей

4. УСЛОВИЯ ПОСТАВКИ.

4.1 Поставка продукции осуществляется равномерными партиями ж/д транспортом в специальных вагонах типа "Хоппер" по отгрузочным реквизитам Покупателя.

4.2. О произведенной отгрузке Поставщик (или по его указанию Грузоотправитель) обязан не позднее дня, следующего за днем отгрузки , за свой счет сообщить Покупателю (или по его указанию Грузополучателю) по телеграфу, факсу и т.д. Информация должна включать дату отгрузки, количество отгруженной продукции, номера вагонов.

5. РАСЧЁТЫ ЗА ПОСТАВКУ.

5.1. Покупатель производит оплату за продукцию на основании счетов- фактур Поставщика в соответствии с фактически принятым весом, на основании приемного Акта Грузополучателя течение 5-ти банковских дней с даты приемного Акта.

Appendix 1 (Continued)

6. СРОКИ ИСПОЛНЕНИЯ ОБЯЗАТЕЛЬСТВ ПО ДОГОВОРУ.

6.1 Весь объем продукции должен быть отгружен не позднее «15» сентября 2001 года.
6.2. Датой отгрузки продукции считается дата на штемпелях ж/д накладной станции отправления.
6.3. Датой поставки продукции считается дата на штемпелях ж/д накладной станции назначения.

7. ОТВЕТСТВЕННОСТЬ СТОРОН.

7.1. В случае несоблюдения сроков оплаты или отгрузки продукции на виновную сторону начисляется пеня в размере 0,1 % от стоимости неоплаченной (неотгруженной) продукции за каждый день просрочки.

8. ФОРС-МАЖОР.

8.1 Если возникнут обстоятельства, препятствующие выполнению сторонами их обязательств по настоящему договору полностью или частично, такие, как пожар, природные бедствия, блокада, запреты правительства и другие обстоятельства, не зависящие от сторон, время выполнения обязательств должно быть продлено на период, равный периоду действия таких обстоятельств. В данном случае, сторона, для которой сложилась невозможность выполнения обязательств, должна проинформировать другую сторону о начале и завершении вышеуказанных обстоятельств, препятствующих выполнению её обязательств, не позднее чем через три дня после их начала(прекращения).
8.2. К форс-мажорным обстоятельствам не относятся различного рода запреты местных органов власти и других организаций, т.к. они должны быть известны Поставщику до момента подписания Договора.
8.3. Ни одна из сторон не будет нести ответственность за полное или частичное невыполнение своих обязательств, если они будут являться следствием форс-мажорных обстоятельств.

9. СРОК ДЕЙСТВИЯ ДОГОВОРА И АРБИТРАЖ.

9.1. Все споры по настоящему Договору разрешаются в Арбитражном суде Санкт-Петербурга.
9.2. Договор вступает в силу с момента его подписания и действует до выполнения сторонами своих обязательств, но не позднее "15" октября 2001 года.

10. ДОПОЛНИТЕЛЬНЫЕ УСЛОВИЯ.

10.1. Настоящий Договор составлен в двух экземплярах , обладающих равной юридической силой. Все приложения и дополнения к настоящему Договору являются его неотъемлемыми частями и действительны только в том случае, если они совершены в письменной форме и подписаны полномочными представителями обеих сторон.
10.2. В случае несоответствия качества поставляемой продукции условиям договора, подтверждённого удостоверением качества, вся партия некачественной продукции подлежит уценке по согласованию сторон.
10.3. Приемка продукции по количеству осуществляется на основании веса, указанного в приемном Акте грузополучателя.
10.4.Расторжение договора, прекращение его действия или пролонгация производятся по письменному согласованию сторон.

Appendix 1 (Continued)

10.5.Стороны согласны на подписание договора и дополнительных соглашений к нему с использованием факсимильной связи
10.6.Взаимоотношения сторон, не предусмотренные настоящим договором, регулируются действующим законодательством РФ

11. ЮРИДИЧЕСКИЕ АДРЕСА СТОРОН.

ПОКУПАТЕЛЬ:
ООО "Санкт-Петербургская Зерновая Кампания"
Юридический адрес:
199155, г. Санкт-Петербург,
ул. Железноводская, д. 17/5
Почтовый адрес:
198207, Санкт-Петербург, Ленинский пр., д. 115, офис 97
ИНН 7801176009
Код по ОКОНХ: 81200, 71100
Код по ОКПО: 56189848
Р/сч: 40702810100020003595
в филиале "Санкт-Петербургский" ОАО "Альфа-Банк"
к/сч: 30101810600000000786
ГУ ЦБ РФ по Санкт-Петербургу
БИК 044030786

ПОСТАВЩИК:
ООО «Консультант Пресс»
Юридический адрес:
113054, г. Москва, Зацепа 28,
Почтовый адрес:
121002, г.Москва, Староконюшенный пер., дом 5/14-2
ИНН 7705220907
Код по ОКОНХ: 81200
Код по ОКПО: 46441809
Р/с 40702810600000000225 в банке «Кредит Свисс Ферст Бостон АО» г. Москва
К/сч 30101810800000000236
БИК 044525236

ПОКУПАТЕЛЬ

__________ К.М. Петушков

ПОСТАВЩИК

___________ Д.Ю Быковский

Appendix 2. Example of the Contract between the Company and the Agent (English version)

This appendix contains the translation of the contract signed between the Company and the Agent. According to the author's agreement with these companies confidential information has been omitted from this translation.

AGREEMENT № 09/08-01

Saint-Petersburg 09 August 2002

Saint-Petersburg Grain Company represented by the Director <Name> acting on the basis of the Company's regulations, referred to below as "The Buyer" from one side, and <Agent> represented by the General Director <Name> acting on the basis of the Company's regulations, referred to below as "The Supplier" from the other side, entered into the following agreement:

1. SUBJECT OF THE AGREEMENT

1.1. The Supplier takes an obligation to supply, and the Buyer takes an obligation to receive and pay for the following production:

- Food rye class A;

1.2.Unit of measurement – metric tonne.

2. QUALITY AND QUANTITY

2.1. Quantity of the supplied product: 3 000 (three thousand) tn (approximately).

- fodder barley – 1000 tonnes (approximately);

2.2. Quality of the production:

- in accordance with the GOST 16990-88;
- falling number not less than 170 s.

2.3. Each dispatched production lot has to be accompanied by a quality GHI certificate, quarantine certificate and with a certificate of compliance with radioactivity control protocol.

Appendix 2 (Continued)

3. PRICE OF PRODUCTION

3.1. The price of one tonne of production including VAT on the basis of Franco - rail cart station of destination (Saint-Petersburg Moscovskij Tovarnyj Octtjabrskaya railway) is 2 180 (two thousand one hundred and eighty) rubles for one tonne.
3.2. The total price of production is 6 540 00 (six millions five hundred forty thousand) rubles, including VIA 10% of 594 545.45 rubles.

4. SUPPLY REQUIREMENTS

4.1. Supply is produced in even lots by railway transport in the special "Hopper" type rail carts in accordance with the Buyer's requirements.
4.2. The Supplier (or in accordance with the Supplier's instruction a Consignor) has an obligation to inform the Buyer of his/her cost (or in accordance with the Buyer's instruction a Consignee) about the produced dispatch not later than the next day after the day of dispatch through telegraph, fax, etc. Information should include the date of dispatch, quantity of the dispatch production, and numbers of carts.

5. PAYMENTS FOR SUPPLY

5.1. The Buyer produces payments for production based on the Supplier's invoices in accordance with the actually received weight based on the Consignees' Acts during 5 bank days from the date of the Receiving Act.

6. FULFILMENT TIME.

6.1. The total volume of production has to be dispatched not later than 15 September 2001.
6.2. The date of dispatch is the date on the stamp on the railway receipt issued at the railway station of product dispatch.
6.2. The date of supply is the date on the stamp on the railway receipt issued at the railway station of the final destination.

Appendix 2 (Continued)

7. RESPONSIBILITIES OF PARTIES

7.1. If any party does not meet his/her obligations on payment or dispatch of production, then this party pays a penalty of 0.1% of the value of unpaid (not dispatched) production for each day of delay.

8. FORCE MAJEURE

8.1. If circumstances occur that would prevent parties from fully or partially fulfilling their obligations in accordance with the present Agreement, such as fire, natural disasters, blockade, government restrictions and other circumstances not under the control of the parties, then the fulfilment time has to be extended for a period of time equal to the duration of the above circumstances. In this case, the party that is not able to fulfil its obligations must inform the other party at the beginning and completion of the above circumstances no later than three days after these circumstances have occurred (or finished).

8.2. Different restrictions of local regulatory bodies as well as other organisations are not viewed as Force Majeure circumstances because they should be known to the Supplier before the date the present Agreement was signed.

8.3. No party will bear responsibility for full or partial non-fulfilment of its obligations if it was caused by Force Majeure circumstances.

9. PERIOD OF ACTION AND ARBITRAGE

9.1. All disagreements between parties shall be resolved in the Saint-Petersburg and Leningrad Region Arbitrage Court.

9.2. The present Agreement is valid from the date it is signed by both parties until the mutual obligations are fulfilled but not later that 15 October of the year 2002.

Appendix 2 (Continued)

10. ADDITIONAL CONDITIONS

10.1. The present Agreement is prepared in two copies. Each copy has the same legal status. All appendices and additions to the present Agreement are irrevocable parts of this Agreement and are valid only if they are performed in a written form and are signed by the legal representatives from both parties.

10.2. If the quality of supplied production is not in accordance with requirements of the present Agreement then the total volume of the low quality production is discounted in accordance with the mutual agreement of parties.

10.3. Production is accepted by weight in accordance with Consignees' Receiving Act.

10.4. Consolation of the present Agreement, discontinuation of its action or its prolongation are performed by the written agreement of both parties.

10.5. Parties agree to sign this Agreement and any additional agreements through facsimile intercommunication.

10.6. Interrelationships between parties that are not stipulated by the present Agreement are regulated by Russian Federation laws currently in force.

10. LEGAL ADDRESSES

THE BUYER	**THE SUPPLIER**
THE BUYER	**THE SUPPLIER**
________________ <Name>	________________ <Name>
Signed and stamped	

Appendix 3. Example of the Contract Between the Company and the Consignee (Russian version)

ДОГОВОР ПОСТАВКИ № 213/2001

Санкт-Петербург "09" августа 2001 г.

ООО " Санкт-Петербургская Зерновая Компания", именуемое в дальнейшем "Поставщик", в лице директора Петушкова К.М., действующего на основании Устава, и ***ОАО МК "Невская мельница",*** именуемое в дальнейшем "Покупатель", в лице генерального директора Косачева И.Н., действующего на основании Устава, заключили настоящий договор о нижеследующем:

1. ***Предмет договора***

1.1 Поставщик обязуется поставить, а Покупатель принять и оплатить **рожь продовольственную в количестве 4000 (четыре тысячи) тонн** ± 1,5% по цене не превышающей - **2250,00 (две тысячи двести пятьдесят)** рублей с учетом НДС и стоимости доставки до ст. "Санкт-Петербург - Московский" Октябрьской железной дороги за одну тонну в период с 09. 08.2001г по 09.09.2001г. **Поставка из регионов России .**

2. ***Качество и приемка продукции***

2.1 Продукция должна соответствовать следующим требованиям:
ГОСТ 16990-88, класс, первый, второй (группа А)

влажность, не более -14.0%
сорная примесь, не более - 2,0%
зерновая примесь, не более - 4,0%
зараженность не допускается.

число падения- 141 сек.
класс-первый, второй
натура, не ниже- 745 гр/литр

2.2 Продукция должна соответствовать ГОСТу и Сан ПИН № 2.3.2.560-96.

2.3 Приемка продукции по качеству и количеству производится на складе Покупателя.

3.Порядок отгрузки

3.1 Отгрузка производится железнодорожным транспортом.
Отгрузка каждой партии оформляется отдельным счетом-фактурой с указанием отправителя, станции отправления, поставщика, покупателя, номера договора, в счет которого поставляется зерно, а также количество отгруженного зерна с указанием номеров ж.д. накладных и его стоимости. При заполнении счетов-фактур провозная плата должна быть выделена отдельной строкой с начислением НДС 20%.

Кроме того, если лицо, производящее отгрузку продукции, не совпадает с лицом, осуществляющим поставку, последнее должно предоставить соответствующие документы от грузоотправителя, свидетельствующие о праве Поставщика распоряжаться данной продукцией.

В противном случае поставленное зерно не будет зачтено в счет договора.

3.3. К сопроводительным документам должны быть обязательно приложены следующие сертификаты:

1. Сертификат качества ГХИ;
2. Сертификат соответствия ГОСТу РФ (с оригинальной печатью отправителя);
3. Фитосанитарный (карантинный) сертификат.

В случае отсутствия данных сертификатов, суммы, затраченные Покупателем, на их оформление, будут удержаны из сумм, подлежащих перечислению за зерно.

4. **Порядок расчетов**

4.1 Оплата продукции производится путем перечисления денежных средств на расчетный счет Поставщика в течение **трех банковских дней**, с момента поступления груза на элеватор Покупателя по адресу: Санкт-Петербург, пр. Обуховской обороны, д.7. (датой поступления груза считается дата, указанная в графе железнодорожной накладной «оформление выдачи груза») при условии предоставления правильно оформленного счет

Appendix 3 (Continued)

фактуры с подписью генерального директора и главного бухгалтера, а также документов, указанных в п/п. 3.2., за фактически поставленное количество зерна.

4.1 Окончательные расчеты производятся после представления счетов, проведения сверки расчетов.

5. Ответственность сторон

5.1 За несвоевременную поставку или недопоставку оплаченной полностью или частично продукции Поставщик уплачивает Покупателю штраф в размере 1 % за каждый день просрочки поставки от суммы предоплаты.

5.2 За поставку некачественной продукции Поставщик уплачивает Покупателю штраф в размере 20% стоимости некачественной продукции.

5.3 Ущерб, причиненный недостачей, возмещается Поставщиком.

6. Прочие условия

6.1 При поступлении импортного зерна, подлежащего таможенному оформлению, кроме документов указанных в п. 3.3 должны предоставляться также документы, указанные в приложении № нет настоящему договору.

6.2 Все документы должны быть предоставлены Покупателю не позднее, чем через 12 часов после поступления вагонов с зерном на ст. Санкт-Петербург – Товарный - Московский.

6.3 В противном случае все штрафы, пени, неустойки, возникшие из-за несвоевременного предоставления перечисленных документов, будут взысканы с поставщика либо удержаны из сумм, подлежащих к оплате за зерно.

7. Заключительные положения

7.1 Положения, не оговоренные в настоящем договоре, регулируются в соответствии с действующим законодательством России и Положением о поставках ПТН.

7.2 Споры, связанные с заключением, расторжением и выполнением договора, не урегулированные сторонами, подлежат рассмотрению в арбитражном суде Санкт-Петербурга и Ленинградской области.

7.3 Досудебное урегулирование возникших споров и разногласий необязательно.

7.4 Покупатель имеет право в одностороннем порядке расторгнуть договор, уведомив об этом Поставщика за 15 дней.

8.Юридические адреса и реквизиты

Россия, 193019, Санкт-Петербург,	Россия 198207 г. Санкт-Петербург
пр. Обуховской Обороны, 7	Ленинский пр., д.115, офис 97
тел (812) 567-34-34; факс 567-36-35	телефон /факс (812) 153-79-01; 153-05-16
Р/С 40702881085510011 3808	**Р/С 40702810100020003595**
Северо -Западный банк Сбербанка РФ	банк филиал « Санкт-Петербургский»
г. Санкт-Петербурга Фрунзенское ОСБ № 2006/0567	ОАО « Альфа- Банк» г. Санкт-Петербург
К/С 30101810500000000653	**К/С 30101810600000000786**
БИК 044030653, ИНН 7811037526	**БИК 044030786, ИНН 7801176009**
ОКОНХ 19211, ОКПО 00933401	**КПП 780101001**

Отгрузочные реквизиты: код 3481 ОАО МК "Невская мельница", ст. Санкт-Петербург – Товарный - Московский Окт. ж.д. код 031808

ПОКУПАТЕЛЬ	ПОСТАВЩИК
Генеральный директор	Директор
ОАО МК "Невская мельница"	ООО " Санкт-Петербургская Зерновая Кампания «
И.Н. Косачёв	**Петушков К.М.**

Appendix 4. Example of the Contract Between the Company and the Consignee (English version)

This appendix contains the translation of the contract signed between the Company and the Agent. According to the author's agreement with these companies confidential information has been omitted in this translation.

SUPPLY CONTRACT № 213/2001

Saint-Petersburg 09 August 2001

Saint-Petersburg Grain Company represented by the Director <Name> acting on the basis of the Company's regulations, referred to below as "The Supplier" from one side, and <Consignee> represented by the General Director <Name> acting on the basis of the Company's regulations, referred to below as "The Buyer" from the other side, entered into the following contract:

10. SUBJECT OF THE CONTRACT

1.1. The Supplier takes an obligation to supply, and the Buyer takes an obligation to receive and pay for food ray in quantity of 4000 (four thousand) tonnes ±1.5% with a price not more than 2250.00 (two thousand two hundred fifty) rubbles for one tonne including VAT and cost of delivery to station "Saint-Petersburg-Moscow" Octyabrskaya railway during the period from 09.08.2001 until 09.09.2001. Supply from Russian regions.

11. QUALITY AND PPRODUCTION ACCEPTANCE

2.1. Quality of the supplied production has to be in accordance with the following requirements:

GOST 16990-88, the first and the second classes (group A)

Moisture not more than – 14.0%	Falling number- 141 sec
Foreign materials not more than – 2.0(%)	Class – the first, the second
Other grains not more than – 4.0%	Natural weight not less than - 745 gr/l

Appendix 4 (Continued)

Contamination is not allowed.

2.2. Production has to be in accordance with the GOST and San PIN №2.3.2.560-96.

2.3. Production is accepted on the basis of quality and quantity at the Buyer's warehouse.

3. SUPPLY REQUIREMENTS

3.1. Supply is produced by railway transport.

Dispatch of each production lot has to be documented by a separate invoice indicating a consignor, a dispatch railway station, a buyer, the contract number the production is supplied under, as well as the quantity of dispatched grain with numbers of railway bills and its value. When filling in invoices a transportation charge has to be marked up in a separate line with the addition of VAT of 20%.

In addition, if a consignor is a different person from the supplier, the Supplier has to provide corresponding documents from the consignor verifying the right of the Supplier to deal with the defined production or the supplied grain will not be taken into account in the present Contract.

3.2. The following certificates are required to be attached to accompanying documents:

- GHI quality certificate;
- A certificate of compliance with GOST RF (with the original consignor's stamp);
- Phytosanitary (quarantine) certificate.

If the above certificates are not available, all Buyers' expenses on their registration will be deducted from the sum to be paid for the grain.

4. SETTLINGS

4.1. Payment for the production is produced by money transferred to the Supplier's account during three banking days from the date when the cargo was received at the Buyer's elevator: Saint-Petersburg, pr. Obuhovskoj oborony, 7 (the date of arrival is the date on the railway receipt in the section "registration of goods dispatch") under the condition that a correctly performed invoice for the supplied grain signed by the General Director and the Head Accountant is provided and also all documents mentioned in section 3.2.

Appendix 4 (Continued)

4.2. The final settlements are produced after all invoices are provided and the joint checking of calculations is performed.

5. RESPONSIBILITIES OF PARTIES

5.1. For delayed supply or supply of lower volume of fully or partially prepaid production the Supplier pays to the Buyer a penalty of 1% for each day of supply delay from the value of prepayment.
5.2. If low quality production is supplied then the Supplier pays the Buyer a penalty if 20% from the value of the low quality production.
5.3. Damage caused by product shortage is compensated by the Supplier.

6. OTHER CONDITIONS

6.1. If imported grain is supplied which requires Customs procedures in addition to documents mentioned in Section 3.3. and also documents mentioned in Appendix №<no> have to be provided.
6.2. All documents have to be provided to the Buyer not later than 12 hours after carts with grain arrive at the Saint-Petersburg – Cargo- Moscovskij station.
6.3. Otherwise all penalties, penni, and forfeits which occurred as a result of the delay will be charged from the Supplier or deducted from sums to be paid for the grain.

7. FINAL STATEMENTS

7.1. Standings not discussed in the present Contract are regulated in accordance with the acting Russian law and the Provision on deliveries PTN.
7.2. All disagreements correlated with conducting, consolation, and performance of the Contract, not resolved by parties should be resolved in the Saint-Petersburg and Leningrad Region Arbitrage Court.
7.3. A regulation of raising arguments before the Court is not required.
The Buyer has the right to unilaterally cancel the Contract if the Supplier is informed within 15 days of cancellation.

Appendix 4 (Continued)

8. LEGAL ADDRESSES.

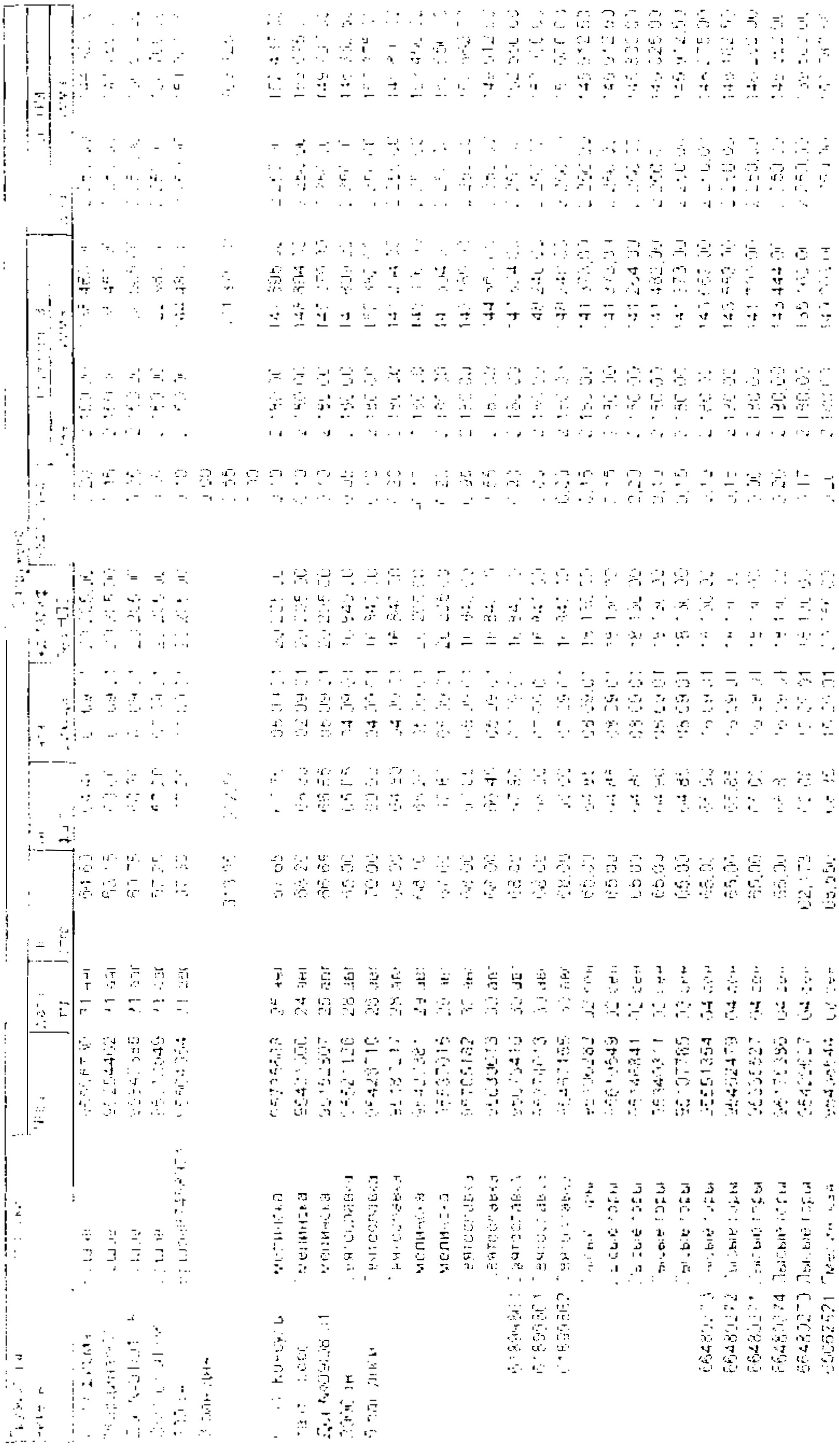
THE BUYER **THE SUPPLIER**

THE BUYER **THE SUPPLIER**

________________ <Name> ________________ <Name>

Signed and stamped

Appendix 5. Example of Material Flow Records Provided by the Company for Case Evaluation



Appendix 6. Example of Financial Records Provided by the Company for Case Evaluation

Карточка счета 60

Контрагенты: Консультант-Персс

за 2001 г.

Дата	Документ	Операции	Дебет		Кредит		Текущее сальдо
			Счет	Сумма	Счет	Сумма	
Сальдо на 01.01.01							
11.09.01	Поступление товаров 000003	Поступление товаров Поступили товары Рожь продовольственная Основной склад Консультант-Персс сч-ф KPS01014 11/09/01 Кол-во	41.1		60.1	1,331,484.55 671.850	К 1,331,484.55
11.09.01	Поступление товаров 000003	Поступление товаров Выделен НДС Кон ультант-Персс сч-ф KPS01014 11/09/01 Консультант-Персс сч-ф KPS01014 11/09/01	19.6		60.1	133,148.45	К 1,464,633.00
14.09.01	Поступление товаров 000004	Поступление товаров Поступили товары Рожь продовольственная Основной склад Консультант-Персс сч-ф KPS01014/1 14/09/01 Кол-во	41.1		60.1	642,604.55 324 250	К 2,107 237.55
14.09.01	Поступление товаров 000004	Поступление товаров Выделен НДС Консультант-Персс сч-ф KPS01014/1 14/09/01 Консультант-Персс сч-ф KPS01014/1 14/09/01	19.6		60.1	64,260.45	К 2,171 498.00
19.09.01	Поступление товаров 000005	Поступление товаров Поступили товары Рожь продовольственная Основной склад Консультант-Персс сч-ф KPS01014/2 19/09/01 Кол-во	41.1		60.1	3,829,368.18 1932 250	К 6,000,8 18
19.09.01	Поступление товаров 000005	Поступление товаров Выделен НДС Консультант-Персс сч-ф KPS01014/2 19/09/01 Консультант-Персс сч-ф KPS01014/2 19/09/01	19.6		60.1	382,938.82	К 6,383,803.00
26.09.01	Выписка 000097	Движения по р/с за рожь продовольственную Консультант-Персс сч-ф KPS01014/1 14/09/01 РСХ Банк	60.1	706,865.00	51		К 5,676,938.00
26.09.01	Выписка 000097	Движения по р/с за рожь продовольственную Консультант-Персс сч-ф KPS01014 11/09/01 РСХ Банк	60.1	1,464,633.00	51		К 4,212,305.00
28.09.01	Выписка 000100	Движения по р/с закрыт счет возврат РСХ Банк Консультант-Персс сч-ф KPS01014 11/09/01	51		60.1	1,464,633.00	К 5,676,938.00
28.09.01	Выписка 000100	Движения по р/с закрыт счет возврат РСХ Банк Консультант-Персс сч-ф KPS01014/1 14/09/01	51		60.1	706 865.00	К 6 383,803.00
05.10.01	Выписка 000106	Движения по р/с за рожь Консультант-Персс сч-ф KPS01014 11/09/01 РСХ Банк	60.1	1,464,63300	51		К 4,919,170.00
05.10.01	Выписка 000106	Движения по р/с за рожь Консультант-Персс сч-ф KPS01014/1 14/09/01 РСХ Банк	60.1	706,865.00	51		К 4 212,305.00
15.10.01	Выписка 000110	Движения по р/с Оплата за товар по сч-ф № Консультант-Персс сч-ф KPS01014/2 19/09/01 РСХ Банк	60.1	1.000,000.00	51		К 3.212,305.00
02.11.01	Выписка 000129	Движения по р/с за пшеницу Консультант-Персс сч-ф KPS01014/2 19/09/01 РСХ Банк	60.1	2,000,000.00	51		К 1,212,305.00
06.11.01	Выписка 000138	Движения по р/с за товар Консультант-Персс сч-ф KPS01014/2 19/09/01 РСХ Банк	60.1	1,212,305.00	51		
Обороты за период				8,555,301 00		8,555 301 00	
Сальдо на 31 12 01							