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Nottingham University Business School

Analysing the role of information exchange for demand forecasting in collaborative supply chains

by

Usha Ramanathan, MSc., BEd., MBA

Thesis submitted to Nottingham University Business School for the degree of

DOCTOR OF PHILOSOPHY

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Abstract

It is now widely recognized that supply chains, not individual organisations, are responsible for the success or failure of businesses. This has necessitated close coordination among supply chain partners. In the past few decades, in an attempt to improve the overall efficiency of the supply chain, many companies have engaged in collaboration with other supply chain members. Consequently, several supply chain management initiatives such as Vendor Managed Inventory, Efficient Consumer Response, Continuous Replenishment and Accurate Response have been proposed in the literature to improve the flow of materials as well as information among supply chain partners. In this line, Collaborative Planning Forecasting and Replenishment (CPFR) is a relatively new initiative that combines the intelligence of multiple trading partners in planning and fulfilment of customer demand by linking sales and marketing best practices. The role of CPFR has been widely studied in the US retail industry, but it has not been researched much in the UK and also in Asian countries. Hence, this research focuses on the adoption of CPFR in the UK and India.

Levels of collaboration and information sharing differ to a great extent across the supply chains based on the needs of individual businesses. Accordingly, the importance of CPFR varies in different supply chains. The study reported in this research explores the operations of CPFR and highlights the corresponding benefits in different firms using case studies of Indian (4 cases) and British (2 cases) companies operating in Make-To-Stock (MTS) and Make-To-Order (MTO) environments. In this research, information exchange among collaborating partners is analysed with a focus on its role in demand forecasting and timely replenishment.

In order to identify potential benefits of CPFR, this research has adopted a four stage approach. In the first stage, interviews with top and middle managers in the case

companies helped to develop a clear understanding of the collaborative arrangements in each company. In stage two, a conceptual model called the Reference Demand Model (RDM) was developed. RDM is a specific model representing the dependency of demand projection on information from different supply chain members involved in supply chain processes. When fully developed, the RDM will serve as a decision tool for the companies involved in collaboration to decide on the level of collaboration and the type of information exchange in order to improve supply chain planning and forecasting.

Further, to explore how demand information collected through RDM can help improve forecasts accuracy, a quantitative approach is employed in the next two stages. Therefore, stages 3 and 4 were studied only for the cases with detailed sales data. In stage 3, structural equation models were developed to establish the underlying relationships among demand factors that were identified using RDM. In stage 4, regression forecast models of sales were developed using the demand factors identified through RDM. The forecast models showed an improved accuracy and thus this research suggested the case company (Soft Drink Co.) to use the demand information (identified from RDM) in the demand forecasts.

The results strongly support CPFR in a MTS environment with promotional sales, and exchanging the detailed sales information from downstream to upstream supply chain members may improve the accuracy of demand forecasts. Information exchange is also required to ensure timely replenishment for MTS products. However, in a MTO environment, there is less need for collaboration with downstream supply chain partners for the purpose of short term demand forecasting.

Publications based on this research

Journal article

Usha Ramanathan and Luc Muyldermans, 2010, ‘Identifying demand factors for promotional planning and forecasting: A case of a Soft Drink Company in the UK’, International Journal of Production Economics. doi:10.1016/j.ijpe.2010.07.007

Conference presentations

Ramanathan, U.; Muyldermans, L.; MacCarthy, B., 2009, "Improving forecasting accuracy of sales promotions through Reference Demand Model and Multiple Linear Regression analysis", in POMS 2009, 20th Annual Conference of the Production and Operations Management Society, Orlando, Florida, May.

Ramanathan, U.; Muyldermans, L.; MacCarthy, B., 2008, "Forecasting Promotional Sales Using Linear Regression Models", in INFORMS Annual Meeting, Washington DC, 12-15 October.

Ramanathan, U.; Muyldermans, L., 2007, "Supply Chain Collaboration: A Review and Scope for Future Research", in the proceedings of the Logistics Research Network Annual Conference, LRN2007, September (Full paper presented).

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I dedicate this research to my parents, especially to my father, Sankaralingam, who was always interested in my higher education. I am sure my research will earn my mother, Krishnaveni, the highest pride in her life.

Table of Contents

Abstract 2
Publications based on this research 4
Acknowledgements 5
Chapter 1 Introduction 12
  1.1 Background of supply chain management 13
  1.2 What is supply chain collaboration? 14
  1.3 Purposes and strategies of supply chain collaboration 16
  1.4 Research focus 18
  1.5 Research approach 19
  1.6 Structure of the thesis 20
Chapter 2 Literature Review 22
  2.1 Introduction 22
  2.2 Supply chain collaboration 22
    2.2.1 A brief history of the evolution of SCM practices 24
    2.2.2 CPFR framework 27
  2.3 Impacts of supply chain collaboration: Models and case studies 32
  2.4 Establishing supply chain collaboration 39
    2.4.1 Levels of collaboration 40
    2.4.2 The role of information exchange 41
  2.5 Forecasting promotional sales 46
  2.6 Gaps in the literature 50
  2.7 Summary 52
Chapter 3 Research questions and Research Methodology 53
  3.1 Introduction 53
  3.2 Main Research Question 53
  3.3 Research design 57
  3.4 Research Methods 58
  3.5 Case study 60
  3.6 Conceptual model development 62
  3.7 Structural equation models (SEM) 63
  3.8 Multiple linear regression models 65
  3.9 Summary 66
Chapter 4 Case studies - UK 67
  4.1 Introduction 67
  4.2 RDM for Study 1 - Soft Drink Manufacturing Company (Soft Drink Co.) 67
    4.2.1 Company profile 67
    4.2.2 Product portfolio and promotion mechanisms 68
    4.2.3 Planning cycle at Soft Drink Co 71
    4.2.4 Supply chain collaboration at Soft Drink Co. 73
    4.2.5 The current forecasting method employed by Soft Drink Co. 74
    4.2.6 Some complexities 75
  4.3 Study -2 Wholesale customer of Soft Drink Co 76
    4.3.1 Company profile 76
    4.3.2 Relationship between Soft Drink Co. and Wholesale Co. 77
    4.3.3 Relationship of Wholesale Co. with their customers 79
    4.3.4 Inventory management and forecasting at Wholesale Co. 80

4.3.5 Potential improvements in forecasting and inventory management 82
4.3.6 Enhancing Wholesale Co. – Soft Drink Co. collaborative arrangement .. 86
Chapter 5 Case studies – India 88
5.1 Introduction 88
5.2 Study 3 –Textile manufacturing company 88
5.2.1 Company profile 88
5.2.2 Business strategy of Textile Co. 89
5.2.3 Capabilities 91
5.2.4 Supply chain collaboration at Textile Co. 96
5.2.5 Planning cycle at Textile Co. 98
5.2.6 Value of information in planning and forecasting at Textile Co. 102
5.2.7 Purpose of collaborative forecasting in Textile Co. 105
5.2.8 Some complexities 107
5.3 Study 4 – Crude-oil refiners and distributors 108
5.3.1 Company Profile 108
5.3.2 Collaborative arrangement 110
5.4 Summary 112
Chapter 6 Conceptual model development 114
6.1 Introduction 114
6.2 Development of Reference Demand Model (RDM) 114
6.2.1 Purpose of RDM 115
6.2.2 Role of information exchange in developing RDM 115
6.2.3 Step1 of RDM - Information on demand factors 117
6.2.4 Step 2 of RDM - Attributes of the information 120
6.2.5 Step 3 of RDM - Evaluation and interpretation of information 127
6.3 RDM for Textile Co. 130
6.3.1 Analysis of RDM –Textile Co. 133
6.4 What is RDM for collaborating companies? 135
6.5 Summary 136
Chapter 7 Cross Case analysis - Qualitative study 137
7.1 Introduction 137
7.2 Role of the case companies in the supply chain 137
7.3 Cross-case comparison 139
7.4 Role of RDM in case companies 144
7.5 Supply chain collaboration in the case companies 147
7.5.1 Current practice and suggestions 147
7.5.2 New perspective of SC collaboration 148
7.6 Summary 150
Chapter 8 Data Description 151
8.1 Introduction 151
8.2 Data collection methodology 151
8.3 Scales used to represent quantitative data 157
8.4 Descriptive analysis of sample data 163
8.5 Summary 165
Chapter 9 Structural equation modelling 166
9.1 Introduction 166
9.2 Conceptual demand-factor model and hypotheses development 167
9.2.1 The influence of promotional strategies on sales volume 168
9.2.2 Influence of non-promotional demand factors on sales 169
9.3 Data 173
9.4 Model constructs 176

9.5 Stage 2: Model construction and testing 180
9.6 Structural equation model for 2ltr pet bottles 185
9.7 Analysis of the model for 2ltr pet bottles 185
9.8 Structural equation model for 6packs-330ml cans 187
9.9 Structural equation model for 500ml pet bottles 190
9.10 Discussion 193
9.11 Summary 194
Chapter 10 Multiple Linear Regression Forecast Models 195
10.1 Introduction 195
10.2 Promotional sales factors 195
10.2.1 Rules for developing MLRM 196
10.3 Development of Multiple Linear Regression Models 198
10.4 The MLRM for Retailer R1 199
10.5 MLRMs explained 206
10.6 Advantage of using Multiple Linear Regression Models 209
10.7 MLRM for Retailer R2 212
10.8 Forecasting sales uplift 218
10.9 Discussion of MLRMs 222
10.10 Summary 227
Chapter 11 Discussions and conclusions 228
11.1 Introduction 228
11.2 Discussions of case studies and conceptual model 228
11.2.1 Discussion of Quantitative Models 229
11.3 Contribution to knowledge 231
11.4 Scope for future research 233
References 236
Appendix-I Case study-5 250
Appendix-II Case study-6 262
Appendix–III Interview Questions 268

Table of figures

Figure 1-1 Traditional versus Modern supply chain 14
Figure 1-2 Supply chain strategies 17
Figure 1-3 Position of the case companies in the supply chain 19
Figure 2-1 CPFR Process Model 29
Figure 2-2 Sales forecast and dispatch forecast 30
Figure 2-3 Different levels of collaboration 40
Figure 3-1 Research plan 59
Figure 3-2 An example of a measurement model 64
Figure 4-1 Effect of promotions on sales 71
Figure 4-2 Planning cycle at Soft Drink Co. 72
Figure 4-3 Various levels of relationships in Soft Drink Co. 78
Figure 4-4 End customer demand and orders of Wholesale Co. 81
Figure 4-5 Inventory level at Wholesale Co. 82
Figure 4-6 Demand forecast of Soft drinks at Wholesale Co. 83
Figure 4-7 (R, Q) model 85
Figure 4-8 Evolution of inventory at Medway warehouse 87
Figure 5-1 Business strategies of Textile Co. 90
Figure 5-2 Importance of forecasting in Textile Co. 95
Figure 5-3 Current supply chain collaboration of Textile Co. 98
Figure 5-4 Sales at Textile Co 100
Figure 5-5 Planning cycle at Textile Co. 101
Figure 5-6 Information exchange in Textile Co supply chain 105
Figure 5-7 Forecasting at Textile Co. 106
Figure 5-8 Application of supply chain information and forecasts 107
Figure 5-9 Products of Crude-Oil Co. 109
Figure 5-10 Supply chain of Crude-oil Co.– Information flow and material flow 112
Figure 7-1 Main role of case companies studied 138
Figure 8-1 Percentage of types of promotions offered by four retailers 155
Figure 8-2 Example of average sales during promotions at R2 for 2ltr bottles 156
Figure 8-3 Example of average sales during promotions at R4 for 2ltr 158
Figure 9-1 Conceptual demand-factor model 167
Figure 9-2 Measurement model 183
Figure 9-3 Model - 1 183
Figure 9-4 Model - 2 184
Figure 9-5 Complete structural equation model of demand -2ltr pet bottles 184
Figure 9-6 Structural model of 330ml cans 189
Figure 9-7 Structural equation model of 500ml pet bottles 192
Figure 10-1 Example 1- Regression and forecast (Orange drink 500ml) 201
Figure 10-2 Example 2 - Regression and forecast (6-pack of 330ml cans) 202
Figure 10-3 Extent of explanation of linear models 206
Figure 10-4 Comparison of traditional and regression forecasts 209

Table of tables

Table 2-1 Purpose of supply chain relationships 23

Table 2-2 Some existing models in collaborative supply chain from the literature 35

Table 2-3 Literature overview of some case studies and reviews on CPFR........ 37

Table 2-4 Literature on information sharing........ 44

Table 2-5 Some models on promotional forecasting 48

Table 2-6 Gaps in the literature 51

Table 3-1 Research study plan........ 57

Table 3-2 Research approach........ 60

Table 3-3 Details of case company interviews 61

Table 4-1 Components of promotional calendar 69

Table 4-2 MAPE of seasonal forecasting at Wholesale Co. 84

Table 4-3 Inventory at Medway warehouse 86

Table 6-1 Step1 of RDM - List of information on demand factors 119

Table 6-2 Step 2 of RDM - Attributes of information........ 124

Table 6-3 RDM of Soft Drink Co 126

Table 6-4 Analysis of RDM of Soft Drink Co........ 129

Table 6-5 RDM of Textile Co........ 132

Table 6-6 Analysis of RDM of Textile Co. 134

Table 7-1 Basic designs for case studies 138

Table 7-2 Case study details 141

Table 7-3 Suggested techniques 146

Table 7-4 Supply chain collaboration strategy 149

Table 8-1 Number of promotions at retail stores’ for leading products 153

Table 8-2 Scales used in the data analysis........ 162

Table 8-3 Promotional and non-promotional sales........ 164

Table 9-1 Descriptive statistics of first order observed variables........ 175

Table 9-2 Exploratory factor analysis for 2ltr pet bottles........ 177

Table 9-3 Results of confirmatory factor analysis (Factor loading) -2ltr pet bottles ... 178

Table 9-4 Description of model fit indices 179

Table 9-5 Model summary of structural equation models – Fit indices 182

Table 9-6 Testing of structural model for different data sets of 2ltr pet bottles 185

Table 9-7 Exploratory factor analysis for 330ml cans........ 188

Table 9-8 Results of confirmatory factor analysis (Factor loading) - 330ml cans 188

Table 9-9 Exploratory factor analysis for 500ml bottles 190
Table 9-10 Results of confirmatory factor analysis (Factor loading) 500ml bottles 191
Table 9-11: Significant demand factors 194
Table 10-1 Examples of output 198
Table 10-2 Summary output - Example 1 200
Table 10-3 Summary output - Example 2 203
Table 10-4 R^2 value in regression analysis 205
Table 10-5 Average MAPE during regression period and forecast period – R1 207
Table 10-6 Comparison of regression and traditional forecasts for R1 (year 2007) 211
Table 10-7 Average MAPE during regression period and forecast period – R2 213
Table 10-8 Comparison of regression and traditional forecasts for R2 (year 2007) 215
Table 10-9 MAPE during regression period and forecast period – Retailer 3 216
Table 10-10 MAPE during assessment period and forecast period – Retailer 4 217
Table 10-11 Comparison of MAPEs in three forecasts – Retailer R1 219
Table 10-12 Comparison of MAPEs in three forecasts – Retailer R2 220
Table 10-13 Summary of results 222
Table 10-14 Promotional sales uplift in R1 and R2 and MAPE 225

Chapter 1 Introduction

Supply chain collaboration was regarded as a major research topic in the late 1990s within the area of supply chain management. Firms interested in improving either cost effectiveness or overall supply chain performance tend to collaborate with other supply chain players (McIvor et al., 2003; McCarthy and Golicic, 2002; Matchette and Seikel, 2004). In general, businesses with similar objectives work closer together in order to achieve the desired excellence in common supply chain processes such as planning, forecasting, production and replenishment. However, the extent and intensity of collaboration vary greatly based on individual business objectives, which in turn define the level of supply chain collaboration (Larsen et al., 2003, ECR Europe, 2002).

At all the levels of supply chain collaboration, information exchange is considered an integral part of bridging all the members in the collaborative arrangement. While exchange of point of sales information and inventory records are widely encouraged within the supply chain (Gavirneni et al., 1999; Raghunathan, 1999), the role of other information such as promotional plans, forecasts and production levels are not much discussed in the literature. The importance of transparent information exchange in the supply chain is not explained in such a way to persuade many supply chain members to be a part of collaboration (Barratt and Oliveira, 2001; Ryu et al., 2009). The main focus of this research study stems from this aspect of supply chain collaboration. Consequently, this research attempts to identify the role of information exchange in supply chain collaboration in six different companies. After that, this research will further analyse the potential benefits of collaboration in these companies. In this attempt, the research goals and specific research questions are developed further in Chapters two and three.

To understand the basic idea behind this research, it is important to know the background of supply chain management and collaboration. For this reason, the following sections outline an overview of the developments in supply chain management over the past two decades with reference to practitioners' and researchers' viewpoints. The general purposes and strategies of supply chain collaboration are explained further. Also, this chapter briefly outlines the research focus, contributions and research approach. This chapter also summarises the structure of the thesis.

1.1 Background of supply chain management

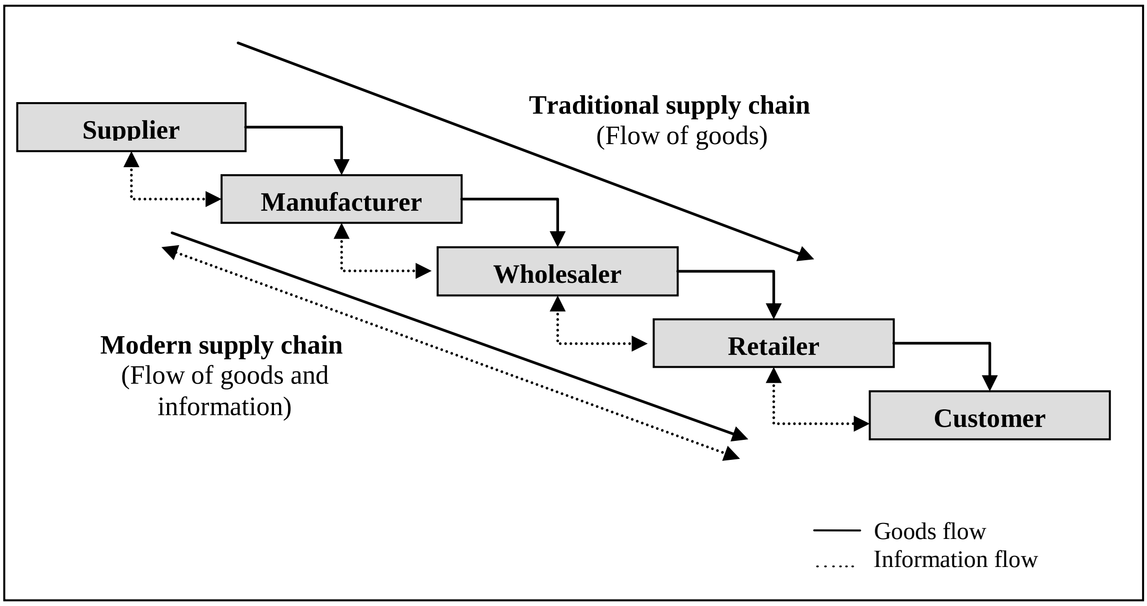
Generally, supply chain management refers to the organisation and management of all activities of a supply chain from suppliers through manufacturers, wholesaler, retailers and customers. In other words,

Supply chain management is the management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole (Christopher, 1998).

Normally, suppliers are referred to as upstream members and customers are referred to as downstream members in the supply chain (Chen and Paulraj, 2004). Traditionally, the supply chain was designed with more focus on the movement of materials rather than information flow (see Figure 1-1). Due to ever increasing competition in the business world, the supply chain also has taken a twist from its traditional way of functioning. This has resulted in a modern supply chain in which the integration of material flow and information flow is a key aspect.

Although the supply chain has taken different forms, such as agile and lean supply chains, over the past two decades, the core idea of the supply chain has always been customer focused. Customer driven inventory management (pull strategy) has replaced the traditional way of pushing inventory from upstream to downstream i.e. from supplier to customer (Simchi-Levi et al., 2003a, pp-17). Similarly, the traditional way of forecasting product demand independently by individual members is slowly being replaced by collaborative forecasting arrangements (Aviv, 2007). Collaborative forecasting involves exchanging information from different supply chain members so that the demand for the final product (and hence the demand for components to be supplied by different members) can be predicted more accurately (Aviv, 2007). Although some recent supply chains include reverse flow of goods such as product returns (Dowlatshahi, 2000; Daugherty et al., 2001), this research concentrates on the forward supply chain with one-way material flow and two-way information flow as shown in Figure 1-1.

Figure 1-1 Traditional versus Modern supply chain


Traditional supply chain
(Flow of goods)
Supplier
Manufacturer
Wholesaler
Retailer
Customer
Modern supply chain
(Flow of goods and information)
Goods flow
Information flow

1.2 What is supply chain collaboration?

A supply chain (SC) comprises suppliers, manufacturers, wholesalers, retailers and customers (Christopher, 1998). All or some of these supply chain members can coordinate their processes (namely planning, forecasting, production, and replenishment) to make the supply chain more effective in terms of cost, revenue generation and timely replenishment (SCC, 2001). When this supply chain coordination formally continues to accommodate dynamic changes in various supply chain processes, it will evolve into a collaborative supply chain. A collaborative supply chain encourages exchange of relevant information to improve the accuracy of demand forecasts.

However, today's competitive and unpredictable business world makes demand forecasting a complicated task. In many supply chains, order variability increases from downstream to upstream and can result in excess inventory and huge obsolescence throughout the supply chain (Lee et al., 1997; Lee and Padmanabhan, 1997; Lee and Whang, 1999). To avoid such problems, information exchange and collaboration in SCs are encouraged in the literature. Fisher et al. (1994) have conducted a case study of Sports Obermeyer (manufacturer of fashion skiwear) and found that the real success of a product was dependent on the customers' response to the product. They have also found that the exchange of point of sales data from downstream members helped the upstream members to understand demand patterns, which in turn assisted the future planning, production and replenishments. However, Toktay et al. (2000) have observed that the information exchange was possible only when the two supply chain members expected mutual benefits from the partnership.

To reap maximum benefit from collaboration, each member of the supply chain may need to make different levels of infrastructural investment. Companies do collaborate for new product design and launch; but this aspect is beyond the scope of this research. This research will identify the role of information exchange and the potential benefits for companies that are involved in supply chain collaboration, for the purpose of forecasting and replenishment.

1.3 Purposes and strategies of supply chain collaboration

Businesses have been collaborating for several decades in many different forms for various purposes (Horvath, 2001; Barratt, 2004; Danese, 2007). Some of the purposes of collaboration are - improve overall business performance, reduce cost, increase profit and improve forecast accuracy (McCarthy and Golicic, 2002; McIvor et al., 2003; Matchette and Seikel, 2004). Lucrative benefits of collaboration encourage many supply chain members to initiate the process of collaboration. This is reflected in recent supply chains having information exchange among supply chain members as one of the core processes in a formal or less formal collaboration (Chang et al., 2007). Generally in the SC literature, the purpose of supply chain collaboration is related to the company's business goals, objectives and business strategies. This research aims to identify benefits of such collaboration in various supply chains. In this effort different companies, Make-To-Order (MTO) and Make-To-Stock (MTS), are studied for their collaborative arrangement with their downstream partners.

In an attempt to identify the right supply chain for various products, Fisher (1997) has classified products under two main categories, namely functional products and innovative products, depending on their demand pattern. In general, functional products, such as groceries and food products, show less demand uncertainty while innovative products, such as music players and mobile phones, show high demand uncertainty. Subsequently Lee (2002) has presented a framework that matched supply chain strategies with demand and supply uncertainties of both functional and innovative products (see Figure 1-2). Lee's framework is the starting point of this research. According to his framework, functional products with low supply uncertainty need to have supply chain strategies aiming at the highest cost efficiency. However, the same functional products with high supply uncertainty need to have risk-hedging supply chain with inventory pooling and resource sharing. Innovative products with low supply uncertainty need to have responsive supply chains (responsive to customer demand) and innovative products with high supply uncertainty need to have agile supply chains with the combined strengths of ‘hedged’ and ‘responsive’ supply chains.

Figure 1-2 Supply chain strategies

Demand Uncertainty

Supply Uncertainty		Low (Functional products)	High (Innovative products)
	Low (Stable process)	Efficient supply chains	Responsive supply chains
	High (Evolving process)	Risk-hedging supply chains	Agile supply chains

Source: Lee (2002)

Each supply chain mentioned in Lee’s framework has different characteristics and hence necessitates a different supply chain coordination mechanism. For example, to achieve Lee’s ‘efficient supply chain’, with low demand uncertainty and low supply uncertainty, a simple transactional level of collaboration between suppliers and buyers may be sufficient. However, to achieve Lee’s ‘agile supply chain’, with high demand uncertainty and high supply uncertainty, a close level of collaboration among different supply chain members may be needed.

Lee (2002) and Fisher (1997) have defined functional products as those with stable demand patterns. However, their demand need not be quite stable in the presence of sales promotions. In recent years, sales promotions at retail outlets have become a common practice, especially in the UK. These sales promotions increase normal sales of functional products and hence the functional products will also have uncertain demand during the period of promotional sales. In such cases, the promotional sales of functional products will not follow a stable demand pattern as defined in Lee (2002) and Fisher (1997). To execute sales promotions, an active participation from all supply chain partners is highly critical. Aviv (2007) has highlighted that Collaborative Planning Forecasting and Replenishment (CPFR) may be a good option to improve the agility in supply chain. This is mainly because the CPFR framework encourages transparent information exchange as one of the key elements of collaboration. This particular aspect of CPFR is considered further in this research to identify the role of information exchange in planning, forecasting and replenishment processes at various companies.

1.4 Research focus

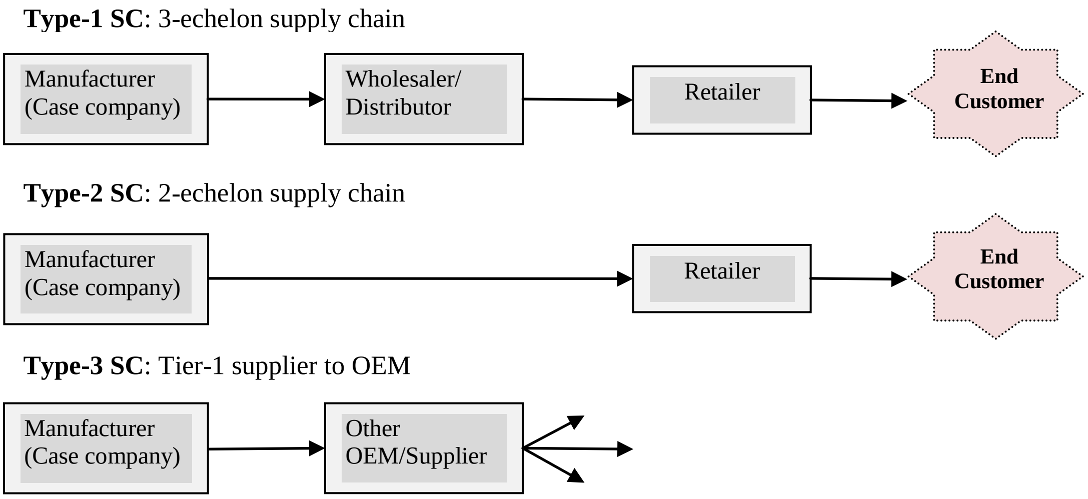
The main focus of this research will be on the analysis of collaborative arrangements and related information exchange, specifically for supply chain collaboration initiatives such as CPFR. Originally CPFR emphasised infrastructure of information technology (IT) as part of collaborative planning and forecasting. However, IT infrastructure is not the main aspect of this research. This research will focus on the collaboration among supply chain members aiming to improve demand forecasting through information exchange. Demand patterns of products and their respective information requirement for CPFR will be analysed through a conceptual model called the “Reference Demand Model” in case companies. This will assist managers in drawing conclusions on the need for collaboration in various businesses.

While considering the benefits of CPFR, this exploratory research is also focusing on the underlying factors that have significant impact on the demand. This research is exploratory in the sense that it considers larger sets of demand factors, systematically identified through case studies. The influence of information factors in different processes of the supply chain is discussed with evidence from the literature and case studies.

1.5 Research approach

This research employs both quantitative and qualitative approaches. Initially the case study approach, which is a qualitative approach, is used to understand the extent of collaborative arrangements between manufacturers and downstream supply chain members. Case studies are conducted in different companies namely, a soft drink manufacturer, a wholesaler of soft drink products, a textile material manufacturer, a packaging material manufacturer, an electrical equipment manufacturer, and a crude oil refiner and distributor. All these case companies practice supply chain collaboration with their downstream customers. The position of these companies in the supply chain is classified as type-1; type-2 and type-3 (see Figure 1-3).

Figure 1-3 Position of the case companies in the supply chain


Type-1 SC: 3-echelon supply chain
Manufacturer (Case company)
Wholesaler/ Distributor
Retailer
End Customer
Type-2 SC: 2-echelon supply chain
Manufacturer (Case company)
Retailer
End Customer
Type-3 SC: Tier-1 supplier to OEM
Manufacturer (Case company)
Other OEM/Supplier

Type-1 companies have 3-echelon supply chains involving a manufacturer dealing with wholesalers and retailers. Type-2 companies have 2-echelon supply chains involving a manufacturer dealing with retailers. Type-3 companies are manufacturers/suppliers of raw materials either to original equipment manufacturers (OEM) or to other suppliers.

In the case studies, attention was paid to understand the role of information exchange at various tiers of the supply chain. This information was then used to create a conceptual ‘Reference Demand Model’ (RDM), presenting the factors and events on which the final product demand was based. In this attempt, some steps to identify the need for improving the RDM were also suggested. This approach has helped to identify the potential benefits of information exchange in supply chain collaboration, which is the main focus of this research.

For one of the case companies, Soft Drink Co, detailed quantitative sales data was available. Hence, more sophisticated quantitative modelling methods such as structural equation modelling and multiple regression analysis have been employed to understand the underlying demand structure. While structural equations were developed to establish the general structure of demand, regression models were developed to forecast demand. Knowledge gained through the RDM and other quantitative models will assist managers in decision making on future collaborative information exchange.

1.6 Structure of the thesis

The thesis is structured as follows. Chapter two starts with a literature review to facilitate appropriate direction for this research and to identify the research goals. Based on these goals, research questions are formulated and explained along with an appropriate research methodology in Chapter three. Chapter four reports the case studies from British companies and Chapter five reports the case studies from Indian companies. Chapter six explains the development of the conceptual Reference Demand Model (RDM) and illustrates its importance in the case study companies. Chapter seven discusses the cross-case analyses of all of the cases studied in chapters four and five. Chapters eight to ten provide a quantitative perspective to the RDM framework developed in Chapter six. The quantitative approach is applied to only one case study company - a Soft Drink Manufacturer that has supply chain collaboration with major retailers and wholesalers. Data description is detailed in Chapter eight. Structural equation models are developed in Chapter nine. These models assist in grouping products based on their characteristics of demand. Chapter ten uses multivariate linear regression analysis models for analysing demand data. Chapter eleven summarises the contribution of this research. This final chapter also includes some ideas for future research.

Chapter 2 Literature Review

2.1 Introduction

Perceived and expected benefits of supply chain collaboration (SCC) have prompted supply chain (SC) partners to develop sophisticated ways of exchanging information for better management of supply chain processes (namely planning, forecasting, production and replenishment). Improved accuracy of forecast of product/component demand has been recognised as a key benefit of such collaboration (Ireland and Crum, 2005). Better forecasting is said to reduce the problem of the so called bullwhip effect, which refers to an amplification of demand variability, resulting in excess inventory in all levels of the supply chain (Lee and Padmanabhan, 1997). The information needed to forecast demand varies depending on the nature of product (e.g., functional or innovative), on the position of the partner in the supply chain (e.g., a retailer or a manufacturer or a supplier of raw material/components) and also on business objectives (e.g., businesses with promotional sales need to collaborate for promotional planning). This chapter deals with the literature on supply chain collaboration with special emphasis on the Collaborative Planning Forecasting and Replenishment (CPFR) framework to understand the structure and the role of information exchange. Studies on promotional sales forecasting are also discussed. Important gaps in the literature are identified and discussed at the end of this chapter.

2.2 Supply chain collaboration

Although the literature on supply chain management (SCM) is rich with several research ideas, concepts, models and case studies, the concept of collaboration has only really evolved over the past two decades. But, several companies or businesses have been collaborating for several decades in many different forms for various purposes

(Horvath, 2001; Barratt, 2004; Danese, 2006, 2007). In the past three decades several academics have researched the purposes behind various types of SC relationships.

Table 2-1 reports the purpose of various SC relationships into three main headings: production planning, information sharing and forecasting, and replenishment. Companies that collaborate for production planning may need to have cross functional activities and clear power sharing agreement to better align their production processes (Akkermans et al., 1999; Beamon, 1999). Companies that collaborate for information sharing and forecasting may need to accept organisational changes, both internal and external to the company, to improve their performance (Barratt and Oliveira, 2001; Forme et al., 2007). This will help the SC partners in joint decision making. Companies that collaborate for timely replenishment need to be good in logistical performances (Simchi-Levi and Zhao, 2005; Chen and Paulraj, 2004).

Table 2-1 Purpose of supply chain relationships

Purpose	Essential elements	Authors
Production planning	Cross functional activities	Akkermans et al. (1999); SCC (2001) - SCOR model
	SCC leadership and power sharing	Kim and Oh (2005); Aviv (2007); Simatupang and Sridharan (2004a,b)
	Process alignment	Beamon (1999); Lambert and Pohlen (2001); Dong and Chen, (2005); Emmet and Crocker (2006)
Information sharing and forecasting	Managing changes (external & internal)	Barratt and Oliveira (2001); Angerhofer and Angelides (2006); Forme et al. (2007)
	Joint decision making	McCarthy and Golicic (2002); Forslund and Jonsson (2007); Raghunathan, (2001); Chang et al., (2007)
Replenish-ment	Logistics performance	Ettl et al. (2000) ; Cachon (2001); Chen and Paulraj (2004); Simchi-Levi and Zhao (2005); Aviv (2007)

Most of these studies have discussed the purpose of the SC relationship, but in isolation from the effort of SC information sharing. These details have not been clearly indicated in these studies. Some supply chain practices such as Vendor Managed Inventory (VMI) and Collaborative Planning Forecasting and Replenishment (CPFR) use demand information in supply chain processes. The next section continues with a brief history of the evolution of these supply chain management practices. Supply chain collaboration, with particular interest to the CPFR framework, is discussed in detail in later sections.

2.2.1 A brief history of the evolution of SCM practices

Several practices such as Vendor Managed Inventory (VMI), Efficient Consumer Response (ECR), Continuous Replenishment (CR) and Accurate response (AR) have been suggested to improve material and information flows in supply chains. (Barratt and Oliveira, 2001)

VMI developed in mid 1980s when Wal-Mart and Procter & Gamble jointly decided to implement the initiative as a pilot project. After the successful implementation, VMI was subsequently adopted by many other leading companies such as Nestle and Tesco, Boeing and Alcoa (Micheau, 2005). VMI is one of the most popular partnering initiatives for encouraging collaboration and information sharing among trading partners. In VMI, vendor decides on the appropriate inventory level of each of agreed product, and the appropriate inventory policy to maintain these levels, whereas the retailers provide access to real-time inventory information (Sari, 2008).

In VMI, communication technology has become essential to help vendors in order to access retailers' inventory status. Waller et al (1999) stated that the success of VMI implementation depends on computer platforms, communications technology, and product identification and tracking systems which should be in place at both the retailers and suppliers. They also pointed out that the software systems are the most important, due to the fact that they help to determine replenishment quantities and timing, safety stock levels, transportation routing and inter facility trans-shipments. Advanced Technologies such as EDI (Electronic Data Interchange) are an enabler. However, Holmström (1998) showed that VMI could be enabled via fax, emails and spreadsheets.

VMI is expected to help retailers gain competitive advantage by improving product availability and service level as well as decreasing inventory monitoring and ordering cost (Sari, 2008). Increased information flow in VMI can help making fast decisions and reducing the bullwhip effect (Disney and Towill, 2003). In addition, it may result in better utilization of manufacturing capacity and better synchronization of replenishment process (Waller et al 1999).

Even though many benefits have been identified, there are also many challenges. For instance, Sari (2008) showed that Sparton Stores, a grocery chain, shut down its VMI effort in about one year due to VMI vendors' inability to deal with product promotions. Similarly Kmart cut a substantial amount of VMI contracts because Kmart was not satisfied with the forecasting ability of VMI vendors. A major obstacle of VMI initiative was ineffective usage of retail level information. Since retailers are closer to the marketplace, they may have better knowledge about customer behaviours, products and marketplace (Sari, 2008). However, in early VMI programs, this unique knowledge of the retailers was not included into inventory decisions. This is because in a typical VMI program, retailers were excluded from the demand forecasting process.

Continuous replenishment (CR), introduced in the late 1980s, is a result of some improvements over VMI. It involves replenishing inventory continuously in smaller batches. CR uses point of sale (POS) data for replenishment. During its initial stages, CR was considered a success by the companies that applied it. For example, initially, the company 'Campbell Soup' could reduce supply chain costs by adopting CR

(Cachon and Fisher, 1997; Fisher, 1997). However, the benefits of CR did not prove to be sustainable owing to a lack of coordination between suppliers and buyers in sharing the cost information (Fisher, 1997). Also CR was not successful in avoiding excess inventory in the pipeline at Procter & Gamble (Barratt and Oliveira, 2001).

In an effort to achieve better supply chain collaboration, an integration of VMI and CR was attempted by some companies. Companies also harnessed the advances in information technology in the form of Electronic Data Interchange (EDI) to make point of sale data available to supply chain partners. These three developments, VMI, CR and EDI, have been successfully employed by some companies (such as P&G) under the name of ECR to reduce the information distortion in supply chains and also to reduce lead time (Andraski, 1994).

In all of the above supply chain practices, the impact of inaccurate forecasts on its performance was not considered as a major issue. Later in 1997, Sports Obermeyer, a leading sports company has adopted a new approach called ‘Accurate Response’ (AR) (Fisher et al., 1997). Using this approach the company has suggested observing its customer demand to make accurate forecasts and to incorporate this customer demand information in their own production plans and production plans of suppliers. The attractive feature of AR is the use of early market signals to predict demand of highly unpredictable items (Fisher et al., 1997). The use of AR improved supply chain flexibility, reduced production costs and reduced production lead times of Sports Obermeyer, but was not considered effective in the case of high supply uncertainty.

With the arrival of the internet, new and hitherto unexpected channels for sharing information have become available to supply chain members. Given the increasing complexities of information in supply chains, and given the increasing sophistication in information technology and the use of the internet, a new supply chain management tool has emerged in the last few years for supply chain collaboration. This new tool is the so called Collaborative Planning, Forecasting and Replenishment (CPFR) framework. This framework exploits computer networking, information technology and other internet based technologies. Some researchers see CPFR as a second generation ECR (Seifert, 2003) to help companies to rapidly respond to consumer demand (Sherman, 1998).

2.2.2 CPFR framework

CPFR was introduced as a pilot project between Wal-Mart and Warner-Lambert in the mid-nineties, aiming to be highly responsive to consumer demand. According to the Voluntary Inter-industry Commerce Standards Association (VICS) (2004), CPFR can be perceived as a new collaborative business framework that could combine the intelligence of multiple trading partners in the planning and fulfilment of customer demand by linking sales and marketing best practices. Due to its flexible and adaptive nature, the companies practicing CPFR reaped early successes in the US retail industry; but it is still in its infancy in Europe (Seifert, 2003).

The CPFR Process Model (VICS, 2002; Ireland and Crum, 2005 and Seifert, 2003) involves nine steps, grouped under three stages called planning, forecasting and replenishment (see Figure 2-1 for CPFR process model). In stage one, the collaborative arrangement is formally agreed by supply chain members. In stage two, forecasts from individual supply chain members along with sales information are exchanged to arrive at a single demand forecast figure. In the final stage, products are replenished based on the demand forecast. All these three stages are explained below.

Stage I: Planning the collaboration

Collaborative planning aims at improving the visibility between upstream and downstream partners. Implementing CPFR needs to begin with understanding of CPFR practices at all levels. Conflicting areas such as resource sharing and allocation need to be resolved before initialising CPFR (VICS, 2002; Ireland and Crum, 2005). At this stage of collaborative planning, five important questions need to be answered by all the partners intending to initiate collaboration:

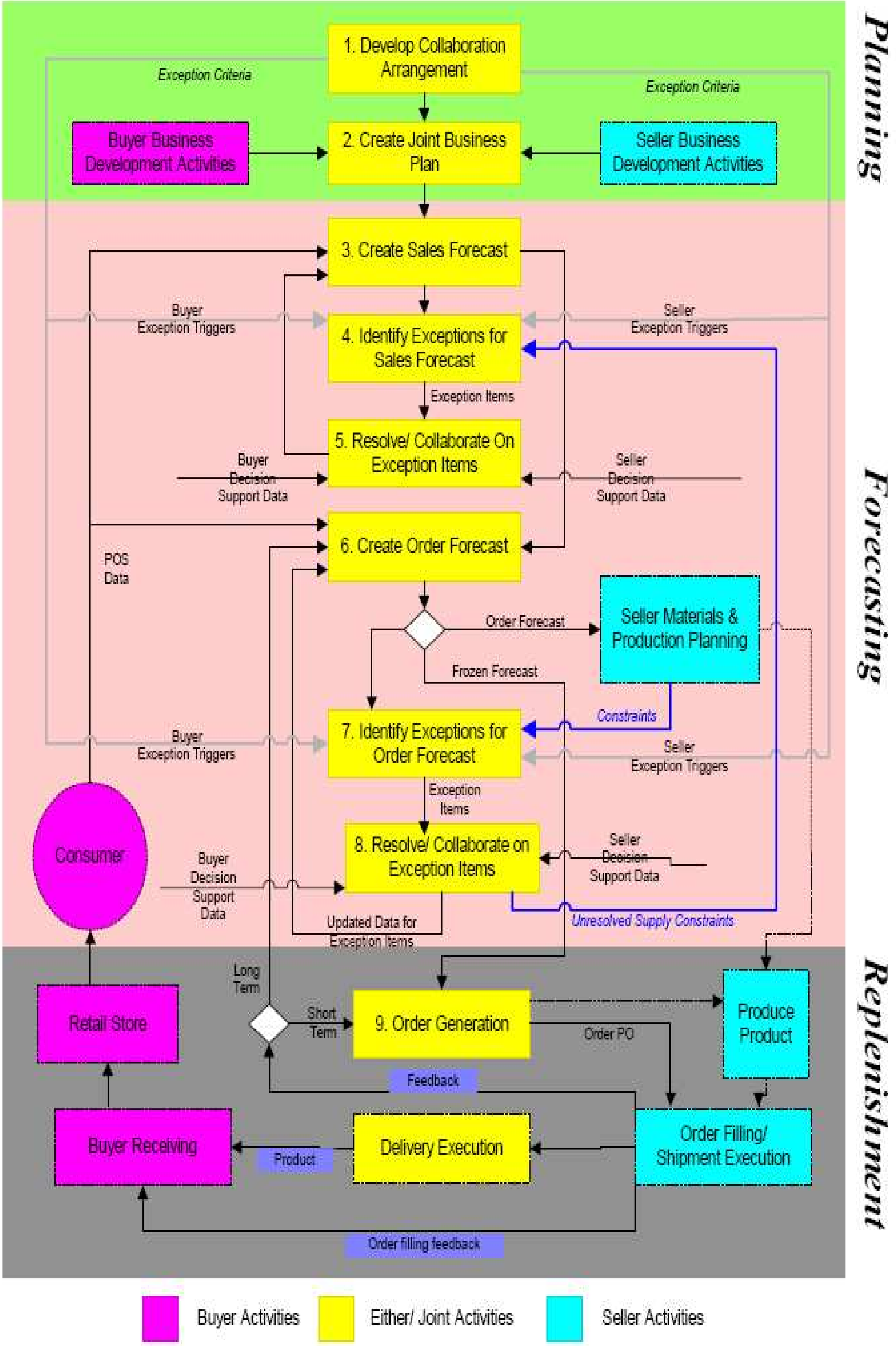
- Who are the collaborating partners?
- What is the role and task of each player?
- What is the incentive for each player in the supply chain collaboration?
- What types of resources need to be shared?
- How and what type of information will be shared?

In CPFR, the planning stage comprises the development of the collaboration arrangement and the creation of joint business plans (Steps 1- 2).

Step 1 - Develop collaboration arrangement: CPFR mission statement, goals and objectives are formed in this stage. Identification of core competencies, resource and information sharing, and role of each player are discussed in detail to avoid disagreements. Front-end agreement is created and updated time to time to reflect any new developments.

Step 2 - Create joint business plans: This stage comprises of definition of product category roles, objects, tactics etc. The development of joint business plans facilitates the communication and coordination across various levels of supply chain.

Figure 2-1 CPFR Process Model

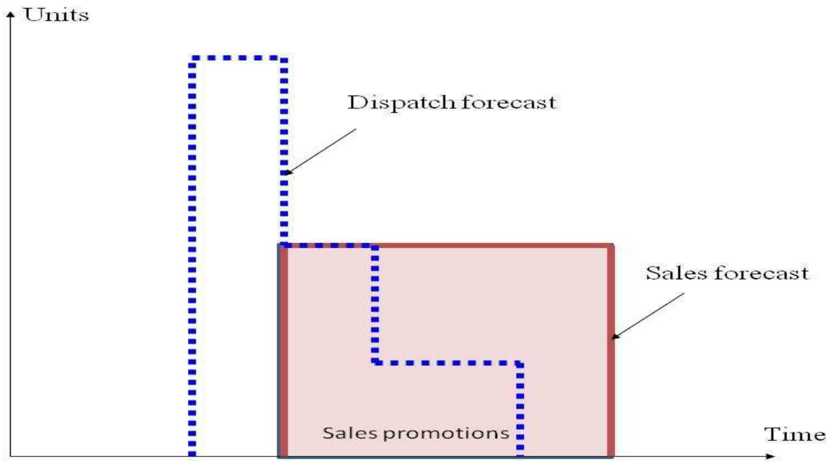

Planning
Forecasting
Replenishment
1. Develop Collaboration Arrangement
Exception Criteria
Exception Criteria
Buyer Business Development Activities
2. Create Joint Business Plan
Seller Business Development Activities
3. Create Sales Forecast
Buyer Exception Triggers
Seller Exception Triggers
4. Identify Exceptions for Sales Forecast
Exception Items
5. Resolve/ Collaborate On Exception Items
Buyer Decision Support Data
Seller Decision Support Data
6. Create Order Forecast
POS Data
Order Forecast
Seller Materials & Production Planning
Frozen Forecast
Constraints
7. Identify Exceptions for Order Forecast
Buyer Exception Triggers
Seller Exception Triggers
Exception Items
Consumer
8. Resolve/ Collaborate on Exception Items
Buyer Decision Support Data
Seller Decision Support Data
Unresolved Supply Constraints
Updated Data for Exception Items
Long Term
Short Term
Retail Store
9. Order Generation
Order PO
Produce Product
Feedback
Buyer Receiving
Product
Delivery Execution
Order Filling/ Shipment Execution
Order filling feedback
Buyer Activities
Either/ Joint Activities
Seller Activities

Source: VICS (2002)

Stage II: Forecasting

This stage includes creating sales and order forecast, identifying exceptions for sales and orders forecast and resolving exception items (VICS, 2002). Sales forecasts are made based on the historic sales that assist production planning. Order forecasts (or dispatch forecasts) are based on sales forecasts but possibly adjusted for existing inventory, and time-phased (to account for distribution lead times) to ensure timely replenishment (see Figure 2-2). Initially, internal forecasts are developed by all supply chain partners independently, based on the information available to them. Internal forecasts by each supply chain partners are reconciled to produce a Collaborative Forecasting (CF). CF is 'advanced demand information' based on the forecasts figures from the other partners (Aviv, 2007).

Figure 2-2 Sales forecast and dispatch forecast



Proper use of available information can assist achieving improved forecast accuracy. Answering the following questions will help to better understand the process of CF.

- What information or data is needed to forecast demand?
- What are the factors that influence demand?

- How frequently will the data be exchanged and how?
- What technology will be used to exchange the data?
- How will CF be calculated?
- How is the CF figure incorporated into production planning?

VICS (2002) created steps 3 - 8 in the CPFR process model to explain the collaborative forecasting.

Step 3 - Create sales (demand) forecast: Sales forecasts are made on the basis of historical POS data and other information on planned events such as promotions.

Step 4 - Identify exceptions for sales forecast: Exceptions to the sales forecast such as seasonal and trend values are identified in the data.

Step 5 - Resolve/collaborate on exception items: Once the exceptions to sales forecast are identified, clarification is made to create a new sales forecast through mutual communication.

Step 6 - Create order forecast: POS data is linked to the individual inventory strategy to help generate specific order forecast. Short term forecasts and long term forecasts are used to generate actual order and overall planning respectively.

Step 7 - Identify exceptions for order forecast: In this step, exceptions to the collaboratively determined acceptance of the order forecast are identified.

Step 8 - Resolve/collaborate on exception items: Exceptions are resolved through communicating with the partners and new forecast is created incorporating exceptions.

It was identified that the effective information sharing (Raghunathan, 2001) and joint decision making by all supply chain members would increase the reliability of the order generation and avoid bullwhip effect (Lee et al., 1997; Lee and Padmanabhan, 1997). Also by sharing inventory status companies can ensure timely replenishments (Gavirneni et al., 1999).

Stage III: Replenishment

In the CPFR process model (see Figure 2-1), demand forecasts by individual supply chain members are aggregated to generate orders, which in turn are used to make decisions on replenishment.

Step 9 - Order generation: Based on the order forecast, order generation is handled either by manufacturer or retailer depending on their competence in the process, access to appropriate technology and the availability of resources. Through joint planning and decision making, the understanding of the replenishment process is becoming clearer (Barratt and Oliveira, 2001); which is considered as one of the positive features of collaboration.

These nine steps of CPFR framework are combined to form the CPFR business process model, which has been adopted by companies such as Wal-Mart, Sara Lee Corporation, Motorola, Hewlett-Packard Corporation, Gillette, Procter & Gamble, IBM etc. It is important to note that all steps of CPFR need not be performed by all supply chain players.

2.3 Impacts of supply chain collaboration: Models and case studies

The CPFR business process model is based on the experiences of practitioners and their business strategies (Ireland and Crum, 2005; Fliedner, 2003). However, increasing need to better align supply with demand has prompted academics and practitioners to suggest improvements to the CPFR framework and to suggest new approaches of SC collaboration (Chung and Leung, 2005; Corsten and Felde, 2005). Chung and Leung (2005) have suggested inclusion of market information in the CPFR processes to improve responsiveness of the supply chain and also to incorporate 'engineering change con*trol'* in the business process. This process of engineering change control is aimed to integrate knowledge of different supply chain players. Chang et al. (2007) have proposed 'an augmented CPFR model' to include market data in forecasting to improve its accuracy and to reduce the bullwhip effect. Humphreys et al. (2001) have ascertained that supplier collaboration and level of trust have positive impact on innovation and success of the supply chain. In SC collaborations, the performance of suppliers can be improved through knowledge transfer programs (Modi and Mabert, 2007). The conceptual model developed by Corsten and Felde (2005) has related impact of trust, dependence and supplier collaboration on innovation, purchase cost reduction and financial performance. Some models have related internal and external collaboration with logistical service performance in order to maximise the benefits of supply chain collaboration (Cooper et al., 1997; Stank et al., 2001; Cooke, 2002; Caridi et al., 2005).

Almost all conceptual frameworks have been designed to explain the organisational and functional aspects of the supply chain collaboration whereas mathematical or simulation models have focused more on the performance evaluation in the way of identifying the quantifiable benefits. This also helps to identify the areas for improvement. Collaborative forecasting has been described in the literature to improve forecast accuracy (McCarthy and Golicic, 2002; Aviv, 2007). Information sharing plays an important role to improve forecast accuracy. This is evident from mathematical models developed by Lee et al. (2000) and Raghunathan (2001). Simulation models of Kim and Oh (2005) and Angerhofer and Angelides (2006) have drawn attention to performance evaluation of supply chain collaboration to identify the areas that need improvement. Table 2-2 covers the literature on models of CPFR.

VICS (2002) claims that CPFR will help to save cost and gain competitive advantage. Several case studies have been reported in the literature that examined the impact of collaboration. Some of the studies are tabulated in Table 2-2. Tangible and intangible benefits of collaboration are evident through a specific case study on West Marine (see www.vics.org). Wal-Mart's initiative of constructing purchase patterns on the profiles of customers has helped to increase visibility of demand throughout the value chain (Mclvor et al., 2003). The importance of information exchange and demand forecast based on the sales data have helped Sport Obermeyer to improve forecast accuracy amidst demand uncertainty (Fisher et al., 1994). In general, most of the CPFR cases reported improved inventory levels and forecast accuracy. This is evident from the cases of Burlington Northern Santa Fe (BNSF) and P&G. However, poor forecast capability of some players in the European grocery sector have made collaborative forecasting complicated (Smaros, 2007). Many case studies listed in Table 2-2 and Table 2-3 are anecdotal in nature; hence deriving any generalisation based on these studies is difficult.

Table 2-2 Some existing models in collaborative supply chain from the literature

Author	Type of model	Purpose and findings
Conceptual models		
Chung and Leung (2005)	An improvement to CPFR model	Purpose: To be responsive to market changes. Key insight: Inclusion of ‘Engineering change management’ increases the responsiveness to market changes.
Simatupang and Sridharan (2004a) Simatupang and Sridharan (2004b)	Collaborative performance system Empirical evidence for performance of supply chain collaboration	Purpose: Measure the current status of the performance of supply chain collaboration and to systematically improve the identified gaps. Key insight: Collaborative enablers are directly linked with collaborative performance metrics. Four types of collaboration identified: Efficient, underrating, prospective and synergistic.
Stank et al. (2001)	Model related internal and external collaboration with logistical service performance	Key insights: To achieve logistical effectiveness, firms should promote collaboration across internal processes. Collaboration with external supply chain partners along with internal support will improve logistical services.
McCarthy and Golicic (2002)	Collaborative forecasting	Increased revenues and earnings are possible with collaborative supply chain.
Lambert and Pohlen (2001)		Developed a framework with following seven steps: supply chain mapping, identifying value addition process, identifying the effect of relationship on profitability, realign supply chain processes accordingly, measure individual performance, compare value with supply chain objectives, replicate steps at each link in the supply chain
Caridi et al. (2005)	Multi agent model to optimise benefits of supply chain collaboration	Insight: Mutli-agent system can be used to automate and optimise supply chain collaboration.
Singh and Power (2009)	Structural Equation Model	Insight: Firm performance will increase if both supplier and customer are involved in collaborative relationship.
Simulation models		
Angerhofer and Angelides (2006)	Performance measurement	Model helps to identify the areas need improvement by measuring the performance of the supply chain
Kim and Oh (2005)	Performance measurement	Purpose: To check the impact of structure of decision making process in the collaborative supply chain performance

Author	Type of model	Purpose and findings
		Key insight: Collaborative (balanced) decision-making in the supply chain creates more value in the system level.
Fu and Piplani (2004)	Evaluation of supply-side collaboration	Key insight: Supply-side collaboration can improve the distributor's performance.
Chang et al. (2007)	Simulation model to verify forecast accuracy	Purpose: To test A-CPFR (Augmented CPFR) on forecasting accuracy and reduction of the bullwhip effect. Key insight: A-CPFR, with application of service provider, will have access to market information and hence can improve forecast accuracy and achieve considerable reduction of inventory.
Optimisation and other models		
Aviv (2001)	Mathematical model for forecasting	Purpose: Finding the usefulness of collaborative forecasting in supply chain by quantifying the inventory and service performance of supply chain Key insight: Products with shorter lead time have more benefit from supply chain collaboration.
Aviv (2007)	Mathematical model for forecasting	Purpose: Study the potential benefits of collaborative forecasting in a decentralized supply chain Key insight: Dominance or power of partnership, agility of the supply chain and internal service rate affect the benefits of collaborative forecasting.
Aviv (2002)	Mathematical model for joint forecasting and replenishment	Key insight: Auto-regressive demand process can decrease the demand uncertainty in VMI and CFAR (Collaborative Forecasting and Replenishment) programmes.
Chen and Chen, (2005)	Mathematical model for joint replenishment	Purpose: To develop four decision making models to determine optimal inventory replenishment and production policies in a supply chain considering three-level inventory system in a two echelon supply chain; Model also includes major and minor set-up cost for manufacturers, and major transportation and minor processing cost for the retailer.
Raghunathan, (2001); Lee et al. (2000)	Mathematical model	Inventory reduction and cost reduction can be achieved with efficient use of information sharing (Lee et al, 2000) and there is no need to invest in inter-organizational systems for information sharing if order history is available (Raghunathan, 2001).
Mishra and Shah (2009)	Structural equation model	New product development will benefit from collaborative effort of supplier and customer, and cross functional involvement.

Table 2-3 Literature overview of some case studies and reviews on CPFR

Author	Name of industry adopted CPFR	Purpose to adopt CPFR/Collaborative forecasting	Modification/ improvement to the original CPFR framework	Benefit or impacts	Barriers of implementation	How was it resolved?	Collaboration (supplier/ manufacturer/ retailer)	Technology and forecasting
Ireland and Crum (2005); Parks (2001)	Wal-Mart-Retailer	Reduce bullwhip effect and improve SC performance.	Initiated development of CPFR framework along with VICS Association	Improved product availability and reduced price, reduced inventory	Less accuracy in forecasting	Using technology and frequent information sharing	Supplier - Retailer	Initially used Electronic Data Interchange then developed a private information exchange called Retail Link
Steermann (2003)	Sears-Michelin	Improve inventory disparity	Included evaluation and assessment in each stage	Inventory level cut by 25 %	Less information visibility	Using technology and frequent information sharing	Producer-Retailer	GNX(GlobalNetXchange) with Manugistics
Smith (2006)	West Marine Inc-Consumer goods retailer	Accelerate business performance by adopting appropriate technology and cross-functional support	Added performance improvement steps	Increased forecasting accuracy	Need to change core culture	Supplier training programme	Retailer-suppliers	JDA/E3 forecasting systems
Wise and Fagan (2001)	Burlington Northern and Santa Fe (BNSF)-Coal manufacturer	Improve resource planning	----	Improved coal movement between manufacturer (supplier) and customer	Information sharing	Web based collaborative forecasting tool	Supplier-buyer	Web-based collaborative Coal Forecasting tool
Schachtman (2000); Ireland and Crum (2005)	Procter & Gamble - manufacturer	Improve forecast accuracy, reduce inventory, reduce operating expenses	Pilot test was successful	Improved cycle time, reduced out of stock problem	Internal forecasting system	Using Syncra collaboration tool	Manufacturer-Retailer	Syncra Ct trading collaboration tool
Cadilhon and Fearne (2005)	Metro Cash & carry - grocery wholesaler	Not formal CPFR, but engage in collaboration, joint planning and information sharing to optimise forecasting and product replenishment	----	Trust based relationship	Information sharing	Using frequent communication through simple mode like phone/fax	Wholesaler (supplier)-retailer	Tele-communication

Author	Name of industry adopted CPFR	Purpose to adopt CPFR/Collaborative forecasting	Modification/ improvement to the original CPFR framework	Benefit or impacts	Barriers of implementation	How was it resolved?	Collaboration (supplier/ manufacturer/ retailer)	Technology and forecasting
Chung and Leung (2005)	Copper clad laminate industry	Reduction of -- inventory, stock-outs, obsolescent scrap, running cost; improvement in - accuracy of sales and order forecast, response to engineering change	CPFR process was modified with engineering change control	Increased sales with reduced cost. Improved supply chain performance and profitability	Lack of point of sale data. Frequent changes in product design	Engineering change control was introduced in CPFR process	Manufacturer-end user	For the pilot project: sales forecast using MRP program developed by EDP programmers and Data exchange using Excel spread sheet.
Smaros (2007)	European grocery sector	Observation of the challenges of implementing collaborative forecasting in the European grocery sector	----	Findings: Technology in collaboration is not a key obstacle. Retailers and manufacturers have different forecasting and collaboration needs	Findings: 1. Retailers' limited forecasting capability is a key obstacle. 2. Lack of integration and long production interval are barriers to collaborate	-----	----	----

2.4 Establishing supply chain collaboration

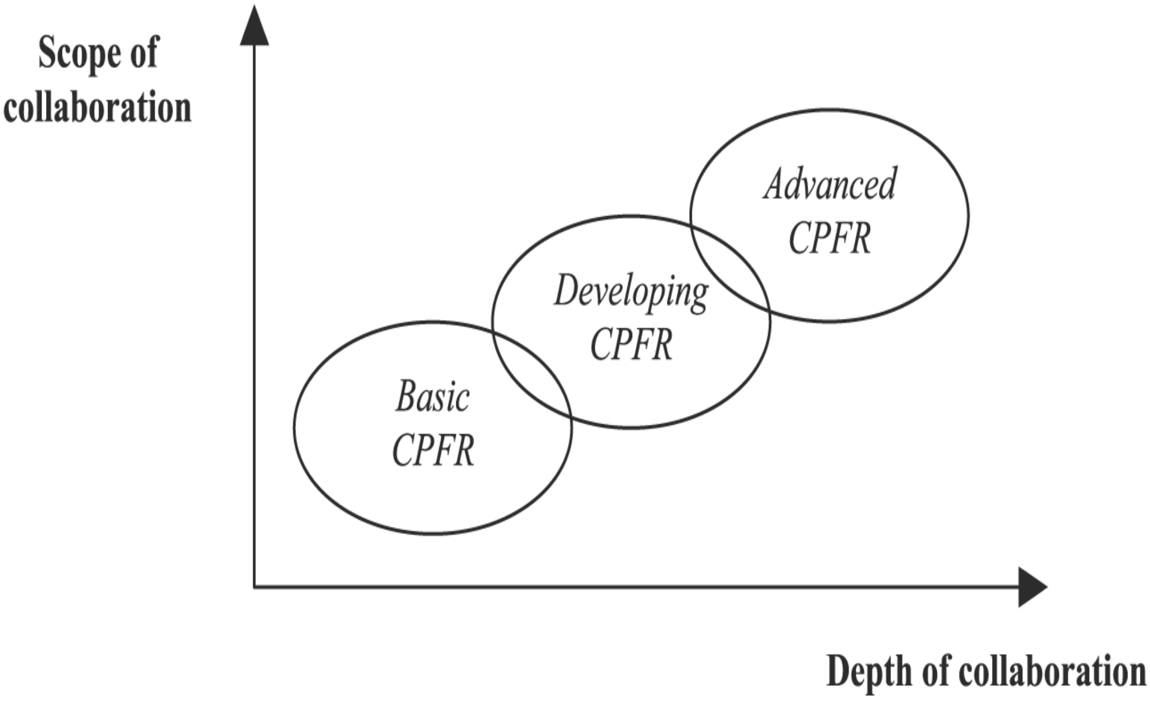
Although supply chain management incorporates several collaborative practices such as VMI, ECR and CR, not all businesses have found it simple and easy to control the partnerships among supply chain players (Seifert, 2003). Recently, CPFR has become popular among the members of a supply chain to enhance collaboration because of its nature of transparent information sharing. Following the success in the retailing sector in the US, CPFR is slowly becoming popular in the other parts of the world in retailing and manufacturing sectors (Seifert, 2003). For example, Wal-Mart's (US retail giant) great success in implementing CPFR encouraged manufacturing companies such as Procter & Gamble, Hewlett-Packard Co. and West Marine Products Inc. to engage into CPFR.

Importantly, the combined effort by all the players is vital to the success of the collaboration. Initiatives in establishing collaboration among supply chain partners can be seen as more viable to suppliers than buyers (Chen et al., 2007) or equal to both suppliers and buyers if equal involvement is revealed in collaboration (Kim and Oh, 2005). From a case study of a telecommunication company Kim and Oh (2005) have found that by sharing the decision-making process and by having equal involvement in collaboration, both suppliers and buyers can maximise their profit. Chen et al. (2007) carried out a simulation study, in which they compared buyer-driven CPFR with supplier-driven CPFR. The authors claimed that the supplier-driven approach will be more appropriate compared with the buyer-driven approach. In summary, to reap maximum benefit of collaboration, each collaborating partner may need to exchange information with other SC partners, irrespective of who initiates collaboration. However, the levels of collaboration (Larsen et al., 2003; Danese 2007) and information exchange are dependent on the nature of the business. Specific details representing the type of information to be exchanged at various levels of collaboration can make collaborative processes simpler and unambiguous.

2.4.1 Levels of collaboration

In the literature on collaborative supply chains, CPFR is classified under three levels such as basic CPFR, developing CPFR and advanced CPFR (Larsen et al., 2003; ECR Europe (2002). The basic CPFR is a simple transactional relationship among supply chain partners. At this level, sales orders and inventory data will be exchanged (see Figure 2-3). In developing CPFR, demand, order planning, promotional and production data will be exchanged. In the highest level, advanced CPFR, supply chain partners will have transparent information sharing. A similar classification of collaboration was used by Danese (2007).

Figure 2-3 Different levels of collaboration



Source: Larsen et al. (2003)

Danese (2007) has conducted a detailed case study on seven European companies. Three levels of collaboration - communication, limited collaboration and full collaboration - were identified. This classification is almost similar to (Larsen et al., 2003) but has included a number of interacting units. Danese (2006; 2007) has demonstrated that a company practicing advanced CPFR would have a high number of interacting units. The collaboration limited to basic communication for replenishments may result in reduced cost. But to achieve a more responsive supply chain a closer collaborative network may be essential. In practice, there may be more than three levels of collaboration than explained in the literature. Identifying the different levels of collaboration and benefits attached to each level is important to decide on the ideal level of supply chain collaboration. This research aims to classify the extent of collaboration in relation to the supply chain environment (MTS versus MTO) and the difficulty to make accurate forecasts.

2.4.2 The role of information exchange

In this research, information exchange refers to exchange of point of sales information and inventory status from downstream to upstream members, and all other information that may impact on sales (for example - promotional sales) exchanged among upstream and downstream members for the purpose of organisational planning (both long range and short range planning), forecasting, production and replenishment.

The literature articles on supply chain information exchange focuses mainly on two areas. One is production and replenishment, and the other is forecasting and planning. Either cost reduction or inventory control is the primary motive of these supply chain collaborations (Chen, 1998; Cachon and Fisher, 2000; Kulp et al., 2004). This section considers articles dealing with supply chain collaboration and information exchange for the purpose of improved forecast accuracy and timely replenishment.

In contrast to traditional supply chain practices, today's supply chain management is more transparent to supply chain operators. Healthy collaborative arrangements among supply chain partners proved to be a successful integral part of many world-class businesses such as Wal-Mart, Sara Lee, Nabisco etc (Lee, 2002). Following the greatly successful adoption of CPFR in the US, many companies around the globe have experimented with collaborative partnerships in their supply chain (Seifert, 2003). Transparent information sharing in supply chain collaboration hopes to reduce uncertainty and avoid excess inventory (Holweg et al., 2005; Chen et al., 2000).

Initially at the inception of CPFR, understanding of the collaboration process and the framework to collaborate were considered the two basic requirements for a collaborative supply chain (Barratt and Oliveira, 2001). In a later stage, information sharing was recognised as one of the key elements for the success of the collaboration (Seifert, 2003). Li and Wang (2007) have asserted that the benefit of information sharing is dependent on two factors: one is content and another is proper use of information (Lee and Whang, 1999, 2001; Lee et al., 2000; Raghunathan, 2001). Distorted information and inefficient use of available data will lead to excess inventory in each level of the supply chain. Hence, it may be important for the companies under collaboration to decide on what information to exchange in order to reduce cost or inventory, to create more accurate demand forecasts, to make production flexible, and to achieve timely replenishments.

Sharing of demand information with upstream members can help reducing the manufactures' supply chain cost (Raghunathan, 1999). Knowledge of demand information also reduces the inventory cost of both supplier and customer (Gavirneni, et al., 1999, Lee, et al., 2000; Graves, 1999). Sharing demand information along with current inventory status facilitates achieving reductions in inventory cost (Chen 1998; Cachon and Fisher, 2000).

Depending upon the forecasting capabilities (technology and manpower) of the parties involved, the benefit of information sharing will also range from basic inventory reduction to higher profit earning. The manufacturer could reduce the variance in demand forecast if readily available historical order data is being used capably (Raghunathan, 2001).

POS data and market-data-sharing are found influential in achieving forecast accuracy in Chang et al. (2007)'s 'augmented CPFR' model. A more detailed discussion on the value of information sharing in supply chains is given in Li et al. (2005). Sanders and Premus (2005) have attempted to model the relationship between firm IT capability, collaboration and performance. However, the authors have not discussed information sharing and forecasting in detail.

Most of the above discussed literature lists the benefits of exchanging information either of point of sale data or inventory data but not any other information. Recognising the type of information to be shared among supply chain members to build-in more visibility is a big challenge in achieving collaboration (Barratt and Oliveira, 2001). Ryu et al. (2009) have presented a simulation study on the evaluation of supply chain information sharing. They have compared the value of exchanging short term forecasts and long term forecasts among SC players. Under high demand variability, long term forecasts performed better than short term forecasts. Under low demand variability, short term forecasts performed better than long term forecasts. Using store level SKU data, Ali et al. (2009) have found that simple time series forecasting will be appropriate for normal sales without promotions. They have suggested using advanced techniques for sophisticated input to improve forecast accuracy of promotional sales. See Table 2-4 for more literature on information sharing.

Table 2-4 Literature on information sharing

Authors	Information sharing	Purpose
Bourland et al. (1996)	Inventory	Minimising inventory cost
Cachon and Fisher (1997)	Historical data (no need to invest)	Decision on technology investment
Chen (1998)	Demand and inventory	Minimising total inventory cost
Gavireneni et al. (1999)	POS and Inventory	Minimising inventory cost
Cachon and Fisher (2000)	Demand and inventory	Minimising inventory cost throughout whole supply chain
Lee et al.(2000)	Demand information	Minimising inventory cost
Raghunathan (2001)	Order history (no need to invest)	Decision on technology investment
Kulp et al. (2004)	Demand information (Asymmetric)	Improve supplier benefit
Byrne and Heavey (2006)	Inventory, sales, order status, sales forecast, production/ delivery schedule	Total supply chain cost saving
Chang et al.(2007)	POS & market data	Improve responsiveness to demand fluctuations
Ketzenberg (2009)	Demand, recovery yield, capacity utilisation	Capacity utilisation showed more value than any other information in a capacitated closed loop supply chain.
Ryu et al. (2009)	Demand information	Study changes in inventory level and service level
Ali et al. (2009)	SKU-store level data	Forecast promotions

While most of the articles support sharing of POS data for reduction of cost or inventory, a very recent paper by Nakano (2009) has claimed that internal forecasting (with-in the firm) but not external collaborative forecasting (with other supply chain players) had significant impact on logistics and production performance. He has used survey data from the Japanese manufacturing sector to develop a structural equation model. However, his results have identified a positive relationship between internal forecasting and planning, and external (upstream/downstream) collaborative forecasting.

Information exchange among supply chain partners has been viewed as a tool of performance improvement in the supply chain (Cachon and Fisher, 2000; Byrne and Heavey, 2006; Lee et al., 2000). In this line, a special issue of the Management Science journal in 2004 on ‘marketing and operations management interfaces and coordination’ has debated various issues in the fields of operations management and marketing having sales information as a main focus. In this special issue, Kulp et al. (2004) have related different forms of information and knowledge integration to evaluate the supply chain performance. Steckel et al. (2004) have questioned the importance of point of sale information (POS). The authors have argued that the POS information may distract decision making particularly if product demand is highly fluctuating. However, Aviv (2001; 2007) has supported sharing sales information and local forecasting between retailers and manufactures. Through mathematical models the author has confirmed that collaborative forecasting (CF) could improve the forecast accuracy of products with short lead times. In another study Aviv (2007) has also confirmed that CF could improve the overall performance of SC by about four percent. However, depending on other factors, such as explanatory power of the supply chain partners, the supply side agility, and the internal service rate, the performance improvement will differ (Aviv, 2007).

The quality of the information exchanged among the supply chain partners is another important factor that decides the performance. The overall supply chain performance has been shown to be higher with high quality information from supply chain partners (Forsuland and Jonsson, 2007; Zhao et al., 2002). But, obtaining high quality information in the supply chain requires a high level of cooperation and trust among various players (Barratt and Oliveria, 2001; Fliedner, 2003). Good inter-organisational communication among various supply chain players is therefore necessary (Paulraj et al., 2008). This inter-organisational communication is vital especially during sales promotions.

In recent years, many retail outlets offer promotional sales in collaboration with manufacturers (Ailawadi et al., 2009). This initiates more collaborative action among various supply chain players. Knowing the demand information (POS information) and inventory levels at the retail outlets may help the supplier to replenish on time (Gavirneni, 1999; Cachon and Fisher, 2000). It has always been accepted that good forecasting will avoid stock outs and excess inventory. But, achieving good forecast accuracy in the presence of promotions is not an easy task because the buying behaviour of customers can be influenced by various factors (Sun, 2005).

This research will demonstrate the significant impact of collaborative forecasting in improving the accuracy of promotional sales by having demand information from other downstream supply chain partners.

2.5 Forecasting promotional sales

As stated earlier many journal articles in the area of Operations Management have focused on various supply chain processes and information exchange in supply chains. But not many of these articles have discussed the relationship between demand and its influencing factors to a great extent. This is evident from the recent review papers on supply chain coordination (Arshinder et al., 2008; Bahinipati et al., 2009). Raju (1995) has attempted to relate sales demand with promotional factors. In his theoretical model he has incorporated various types of promotions such as sales price discount with advertisement, on-shelf discount without advertisement and coupon discount. The effect of promotions on consumers’ buying behaviour and consumption patterns are an interesting topic of research in the area of marketing and retailing (Sun, 2005; Chandon and Wansink, 2002; Wansink, 1996). With respect to the supply chain operations, every piece of information on customers’ demand and their preferences are important to plan and forecast. Accurate demand forecasts are important to avoid lost sales or excess inventory.

Forecasting is one of the most important topics in the field of supply chain management. Generally, short term forecasts are used for production scheduling and inventory control and long term forecasts are used for market planning (Wacker and Sprague, 1998; Sanders and Ritzman, 1995). In the past three decades several quantitative and qualitative forecasting techniques have been proposed in the literature. Quantitative forecasting techniques include multivariate regressions, exponential smoothing, the Holt-Winter model, the Box-Jenkins model, and many other time series models. Qualitative forecasting techniques include sales force composites, customer surveys, jury of executive opinion, the Delphi method and judgemental forecasting.

The 1980s literature on forecasting supported judgemental forecasts more than any single forecast based on mathematical/statistical techniques (e.g. Mentzer and Cox, 1984; Sparkes and McHugh, 1984, and Dalrymple, 1987). Later, combination forecasts based on two or more techniques were supported. These procedures resulted in higher levels of forecast accuracy than many other forecasts methods (Winkler and Makridakis, 1983; White and Dattero 1992; Clemen, 1989; Sanders and Ritzman, 1990). It has been well understood by many practitioners and academics that a mathematical tool alone is often insufficient to improve forecast accuracy, but additional information and knowledge from different supply chain partners is required to reach reliable forecasts (Makridakis et al., 1998; Ireland and Crum, 2005). A recent study by Onkal et al. (2008) stressed the importance of judgemental information to adjust forecasts. Some review articles discussed general issues related to forecasting techniques (Clemen, 1989; Mentzer and Cox, 1984; Fildes et al., 2008).

Though the forecasting literature is vast and wealthy, to the best of my knowledge promotional forecasting techniques have been reported in the literature only in the past two decades. A recent review article of Fildes et al. (2008) discussed in detail the literature on forecasting in the area of operational research. The authors have considered both qualitative and quantitative approaches. This review paper has pointed that there were few articles on promotional forecasting, mostly published in the marketing literature. This article refers to very few 'event forecasting models' such as PromoCast™ and CHAN4CAST (see Table 2-5).

Table 2-5 Some models on promotional forecasting

Authors	Forecasting model	Dependent variable (Sales forecast)	Independent variables
Divakar et al. (2005)	CHAN4CAST Regression Model	Group of products (pack size and category) - soft drinks and water	Display, advertisements
Cooper et al. (1999)	PromoCast™ Regression Model	Individual products - detergents, food products etc.	67 variables used - region, price, seasons, special days and temperature
Rinne and Geurts (1988)	Regression Model	Forecast of 3 individual functional products included to forecast total profit	Price, advertise medium, size of advertisement, type of promotion and day of the week
Dube (2004)	Econometric Model	Bundle of products (cereals, soups, soft drinks)	Family size, time of buying, time of consumption, location, loyalty and advertisements, quality of product

Sales promotions are normally attached with a price discount (Raju, 1995; Sun, 2005). These promotions can improve normal sales alone or in conjunction with other factors for example holidays, temperature and display locations (Cooper et al., 1999). However it is important to recognise the impact of these factors individually on sales to measure the effectiveness of promotion. The effectiveness of promotions is normally reflected in an increase in the volume of sales during the period of promotion (Divakar et al., 2005). Forecasting the promotional sales is a complicated task requiring a variety of information from different supply chain partners. The promotional sales forecaster also needs a good knowledge of the local market such as the behaviour of consumers and their buying habits (Dube, 2004).

Some articles have proposed regression forecasting models with multiple independent variables (Cooper et al., 1999 and Divakar et al., 2005). Cooper et al. (1999) have developed a forecast model called PromoCast™ which was specific to a particular company. This model included 1.3 million promotional events of a retailer grocery chain and 67 independent variables. The forecasts of new products were not included. In an attempt to forecast the effect of promotional sales, Cooper et al. (1999) identified that the display location of items in the store has a positive impact on sales. In addition longer duration of promotions with major displays had mixed effects on sales especially for slow moving items.

Several attempts have been made to estimate the effect of promotions and price discount on sales using store level data (Abraham and Lodish, 1987; Blatteberg and Levin, 1987; Naik et al., 2005) and market level data (Dube, 2004; Christen et al., 1997). However, these articles have not suggested any method of forecasting to predict promotional sales. But, these effects of promotions have been considered by other researchers to relate demand factors with different attributes of sales (Dube, 2004 and Sun, 2005). Dube (2004) has tried to predict the consumers' purchase behaviour of bundles of products, such as cereals, soups, soft drinks etc., using the quality of the product. In Dube's econometric model, consumers' purchase pattern has been related to the time of buying and the time of consumption. The author has used several variables including price, location, loyalty and advertisements. Sun (2005) has related the customers' behaviour with different types of promotions. McIntyre et al. (1993) have attached demand factors with judgemental indexing. Rinne and Geurts (1988) have developed a forecast model with five variables namely price, advertise medium, size of advertisement, type of promotion and day of the week. The authors have related the forecast model with an evaluation of the profit of three products. The model with more profit has been considered the best performing model.

Divakar et al. (2005) have developed a model called CHAN4CAST for a packaged goods (food products) company with multiple products. CHAN4CAST, a sales forecasting decision support model, incorporated a variety of variables such as trend, promotional variables, seasonality, holidays and temperature. The authors have suggested judgemental intervention for new products and trading day's adjustments. In the model, the authors considered channel level data combining a variety of products. Divakar et al. (2005) concentrated more on forecasting rather than identifying the underlying demand variables and their relationship to sales. Despite the previous research on promotional forecasting methods, there is still a lack of a structured methodology which can guide and direct practitioners (Fildes and Goodwin, 2007).

2.6 Gaps in the literature

The literature on information exchange has focused more on exchanging specific piece of information but has not clearly linked the level of information exchange and collaboration to the supply chain environment (see Table 2-6). This indeed has raised a critical question on the extent of the benefits of collaboration and information sharing.

Table 2-6 Gaps in the literature

Main theme of supply chain collaboration and Authors	Gaps	Possible research approach
Different levels and degrees of collaboration are possible (Larsen et al, 2003; Danese, 2007). Barratt and Oliveira (2001) identified the gap of lack of mention of functions/ departments involved in the CPFR. Collaboration adopted in many industries like clothing, retailing, manufacturing etc. (Smith, 2006; Steermann, 2003; Rowat, 2006; Samaddar and Kadiyala, 2006; Simatupang and Sridharan, 2004a,b)	What is the role of information exchange in different collaborative supply chains?	• Analyse and study the CPFR arrangement in different sectors • Identify the role of information in the supply chain processes. **Approach:** • Conducting case studies
Supply chain performance improved through collaborative forecasting (Ireland and Crum, 2005; McCarthy and Golicic, 2002)	What procedure or tool can be used to identify the pieces of information to be exchanged and/or decide on the level of collaboration between different SC members?	• Develop a tool/technique to evaluate whether CPFR or other SC collaborations are beneficial **Approach:** • Developing RDM • Suggesting levels of collaboration
CPFR case studies in the literature claim to have achieved improved forecast accuracy, but are unclear about what specific forecasting techniques were used? CPFR is a framework but is not clear on what techniques or tools to be used to make forecasts	What techniques can be used to gain more insight into the structure of demand and/or make better forecasts?	• Use factors identified through RDM to improve and automate forecasting **Approach:** • Analysing the sales through structural equation models (SEMs) to generalise the demand patterns • Using multiple linear regression models to forecast demand

Therefore, ascertaining a mapping between information, collaboration arrangement and supply chain environment is not possible from the literature. This identified gap in the literature led me to form an idea of identifying the role of information exchange in collaborative supply chains. The goals of this research can be briefly stated as follows:

Goal 1: Understanding the role of information exchange in collaborative supply chains

Goal 2: Identifying critical factors influencing demand. This will result in the development of a 'Reference Demand Model'

Goal 3: Analyse the factors underlying the demand through SEM

Goal 4: Forecast the demand using multiple regression models based on the variables identified through RDM and SEM

Goal 5: Aligning supply chain collaboration with reference to product demand variability

An attempt is made to explore these five goals through appropriate case studies, which is explained further in the next chapter.

2.7 Summary

This chapter explained the literature on supply chain management and supply chain collaboration, especially the CPFR framework. This chapter also discussed specific models and case studies on supply chain collaboration. A review of SC collaboration was included from the literature. The role of information exchange in the supply chain was discussed with reference to its impact on supply chain performance. Forecasting sales promotions was discussed from both the operations and the marketing literature. Finally, the goals of this research and the gaps identified from the literature were stated. The knowledge gained from the literature on supply chain collaboration and the identified gaps will be further developed into research questions in the next chapter.

Chapter 3 Research questions and Research Methodology

3.1 Introduction

In this research, information exchange among supply chain partners is considered for understanding its role in different supply chain processes such as forecasting and replenishment. While considering information exchange for the purpose of forecasting, it is important to be aware of the underlying factors that may explain the demand and the relationship between these factors. This idea forms the foundation to deal with the gaps identified in the literature and also to formulate the research questions. Four different but inter-related research methods are suggested to bridge the gaps. In this process, research questions are developed and countered with the help of established tools such as conceptual models, multivariate regression models and structural equation models. A brief description of each of these techniques is further given in this chapter.

3.2 Main Research Question

Generally CPFR, either fully or partly, is adopted by companies to accomplish their business goals. As mentioned in the literature review (Chapter 2), businesses can achieve several benefits by collaborating with other supply chain partners (Chung and Leung 2005; Simatupang and Sridharan, 2004 a,b). But, the specific role of supply chain information and its impact on production planning or forecasting are not clearly stated in the literature. In order to fill this gap, this research focuses on understanding the collaborative arrangements in different industries and the need of information exchange for better forecasting and planning. Accordingly the main research question can be formulated as follows:

What is the role of information exchange in collaborative supply chains for demand forecasting?

The main research question will be answered in four steps.

This research begins by defining the nature of the collaboration and the subsequent information exchange in supply chain processes in a form of a process map (Handfield and Melnyk, 1998). In this process, four sub-questions are formulated:

Question 1: What types of collaborative arrangement exist between manufacturers and buyers, and what type of information is being exchanged to facilitate CPFR?

This first question is based on the observation from the literature that the collaborative arrangement between manufacturers and retailers was inadequately addressed. The reported benefits of supply chain collaboration are of wide range and include inventory reduction, cost reduction or reduction of lead time. However, there was no mention of what type of collaborative arrangement and SC information exchange helped to achieve specific supply chain benefits. For example, from the literature it is difficult to understand the role of information exchange in forecasting the sales promotions.

Some researchers attempted to relate information exchange with supply chain benefits such as inventory control and cost reductions (Lee et al., 2000; Raghunathan, 2001; Aviv, 2007). But those articles did not explain in detail when and how this data was exchanged and what the significance of this data in different supply chain processes was. Hence, it is vital to understand the impact of supply chain collaboration and information exchange in practice. This will help to comprehend the actual collaborative arrangement and the role of information exchange for production planning, forecasting and replenishment. The case study approach will be employed to answer this question.

Question 2: What techniques can be used to decide on the level of information exchange in CPFR?

The second question considers the information exchange among suppliers and buyers involved in supply chain collaboration. Two different viewpoints have been raised in the literature (Lee et al., 2000; Raghunathan, 2001; Nakano, 2009). One is that POS data helps forecasting and another is that POS data confuses the forecasters. As given in the literature review in Section 2.4, Raghunathan (2001) criticised the investment on technology for exchange of POS data, provided historical data was used for forecasting. In most of the companies, POS data is not used for their forecasts. In many cases only the historical sales data is been used for forecasting. However, POS data may be required to monitor performance of sales against the forecasts during the promotional sales events. The inventory data may also be required to decide on replenishment plans. Likewise several partners of the supply chain may require a variety of SC information specific to their business.

Hence, by answering the proposed research question, it is possible to identify the different factors and signals that explain the demand. This will benefit the companies, particularly involved in sales promotions, to implement various promotional mechanisms in line with the identified factors underlying the demand. Based on the inputs from the case studies, a conceptual model called ‘Reference Demand Model’ is developed to answer this question.

Question 3: How are the different demand factors related to sales?

Question 3 reflects the fact that forecasters and/or decision makers need to understand the underlying relationship of factors with sales. This will assist them in understanding the importance of information exchange. While information exchange among supply chain members involves both technology and people, the technology attracts some additional investment. Hence, investment in technology has been questioned by many researchers in the aspect of its contribution to profit (Raghunathan, 2001; Smaros, 2007). This research is trying to identify the relationship among various demand factors and their impact on sales. Though this research does not suggest anything on technology investments, the research findings may assist management decisions for future collaborative arrangement. This research question is answered by constructing ‘structural equal models’ to identify the underlying structure of demand factors.

Question 4: Can the identified demand factors from RDM help to improve forecast accuracy?

Question 4 relates to the core idea in previous research that collaborative forecasting may improve accuracy, especially when the lead time is shorter (Aviv, 2002). This research relates the previous findings with the actual practice of supply chain collaboration through case studies. The quality and value of information exchange have been widely discussed in the context of organisational resistance for collaboration (Paulraj et al., 2008; Samros, 2007). Some analytical models have been developed to see the impact of information exchange by assuming stable demand (Gavirneni et al., 1999; Aviv, 2007). But, in practice, the demand is not always stable, especially during promotions. Hence, answering the question 4 will be ideal for decision making on the level of collaboration. This question 4 is answered by developing multivariate regression forecast models.

By answering questions 1 to 4, the main research question will be answered. The research conducted for answering these questions will also suggest an ideal collaborative arrangement for all the case companies studied.

3.3 Research design

To study the above research propositions six different case studies have been conducted. Some of the products of these six case companies are easy to forecast while the others are difficult to forecast. From the cases studied, it has been identified that the products are of two main types – Manufacture-to-Order (MTO) and Manufacture-to-Stock (MTS). Hence, this research analyses the cases in two main dimensions, namely type of products (MTO and MTS) and demand variability (easy to forecast and difficult to forecast) (see Table 3-1).

Table 3-1 Research study plan

		Type of forecasts	
		Easy to Forecast	**Difficult to forecast**
Type of environments	**MTS**	**Study 2** Soft drink wholesaler Case study **Study 4** Crude oil refiners and distributors Case study	**Study 1** Soft drink manufacturer Case study and quantitative analysis **Study 3** Fashion textile material manufacture Case study
	MTO	**Study 5** Packaging material manufacturer Case study **Study 6** Flame-proof electrical equipment manufacturer Case study	---

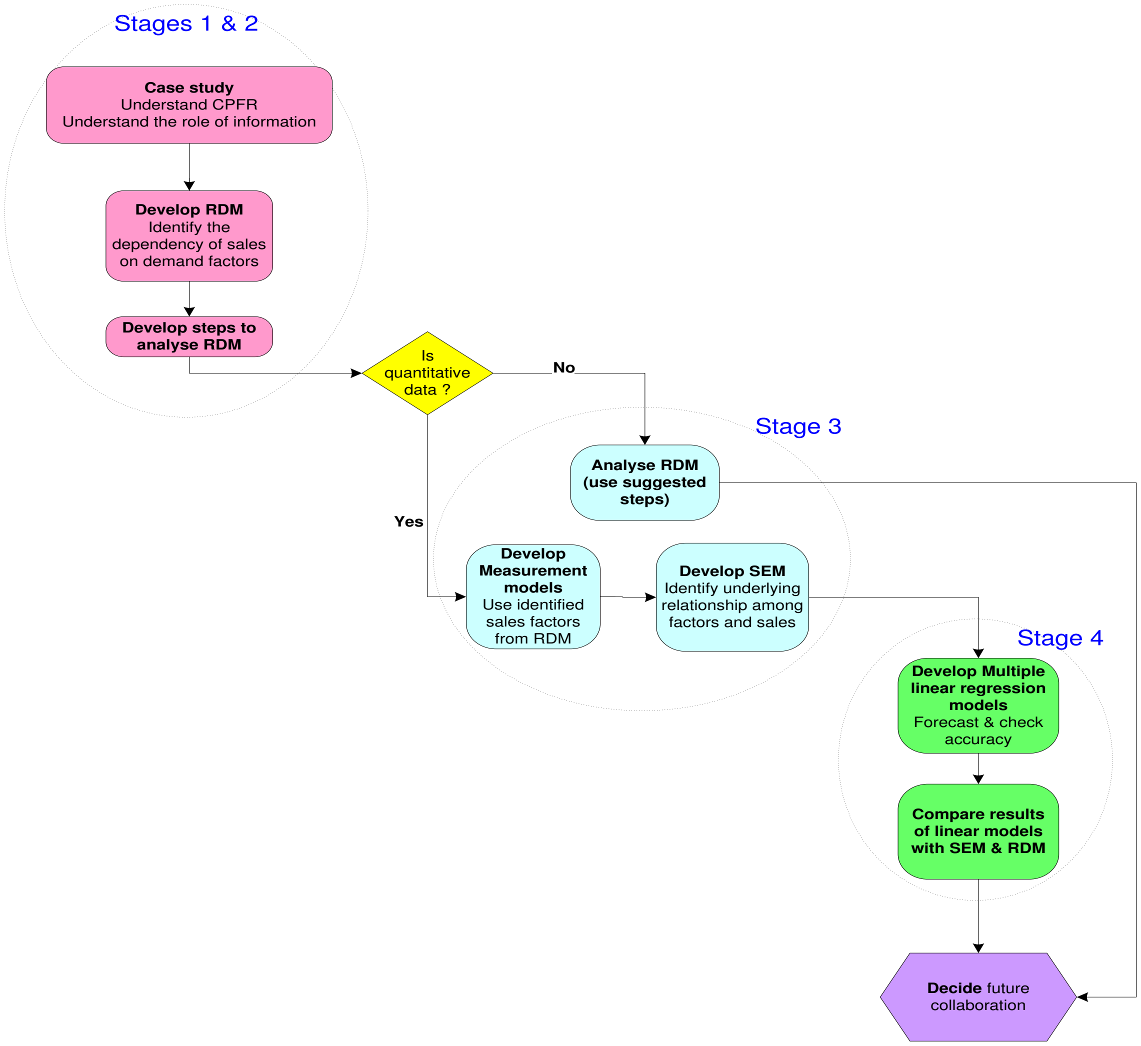
Research Question 1 and Question 2 were addressed through case studies that help to better understand the current collaboration arrangement and exchange of information in the case companies. A conceptual model called ‘Reference Demand Model’ (RDM) is developed to represent the dependency of demand projection on information from SC members. Question 3, about the relationship of underlying demand factors, is answered partly through RDM. Further to the development of RDM, demand factors and actual sales are linked through the structural equation modelling technique. Structural equation models validate the dependency of demand on the factors identified in the RDM and also explore the relationships among underlying factors with the demand. This answers Question three. The significant factors identified through the RDM are further used in forecast models to answer Question four.

3.4 Research Methods

This research explores suitable collaborative arrangements for the case study companies in order to gain advantage of CPFR. The companies under study are of two types; of the first type are companies with established collaborative practices and hence they maintain a detailed database on sales, inventory and other related information. The second are companies which have been involved in business partnership and information exchange to support their business but have no readily available database. All the case companies are classified under two categories - Manufacture to Stock (MTS) and Manufacture to Order (MTO).

The research process involves four stages (see Figure 3-1). In the first stage, the case study approach is used to identify the CPFR arrangement in the case companies. Based on the case studies and interviews, a RDM is developed in the second stage for two case companies revealing the dependency of demand projection on the information signals.

Figure 3-1 Research plan


Stages 1 & 2
Case study
Understand CPFR
Understand the role of information
Develop RDM
Identify the dependency of sales on demand factors
Develop steps to analyse RDM
Is quantitative data ?
No
Yes
Stage 3
Analyse RDM (use suggested steps)
Develop Measurement models
Use identified sales factors from RDM
Develop SEM
Identify underlying relationship among factors and sales
Stage 4
Develop Multiple linear regression models
Forecast & check accuracy
Compare results of linear models with SEM & RDM
Decide future collaboration

In the third stage, further research is carried out for the company that provided sales data with details such as promotional events, festival dates, discount prices etc. The factors identified in the RDM are used to develop and test measurement model. This measurement model aims to examine the impact of demand factors on sales. This is done through the structural equation modeling (SEM) technique. The resulting demand factors of SEM are used in the fourth stage of the analysis. In this final stage, sales forecasting is carried out using multiple regression forecasting models. These four stages in the methodology - case study, conceptual model development, structural equation modeling and multiple regression analysis are discussed further in this chapter.

As diversity in the selection of cases is instrumental to theory building (Eisenhardt, 1989), the case studies were conducted in different companies. The companies selected for the purpose of this research are listed in Table 3-2.

Table 3-2 Research approach

	Case study company	MTO/ MTS	Type of SC	Related Research questions	Research approach
Study 1	Soft drink manufacturer - retailer	MTS	Type-2	Q1,Q2,Q3 and Q4	Case study, Reference demand model, Structural equation model and Regression models
Study 2	Soft drink manufacturer - wholesaler	MTS	Type-1	Q1 and Q2	Case study
Study 3	Fashion textile material manufacturer	MTS MTO	Type-2	Q1 and Q2	Case study Reference Demand Model
Study 4	Crude oil refiners and distributors	MTS	Type-1, Type-2	Q1 and Q2	Case study
Study 5	Packaging material manufacturer	MTO	Type-3	Q1 and Q2	Case study
Study 6	Flame-proof electrical equipment manufacturer	MTO	Type-3	Q1 and Q2	Case study

All of these case studies have been conducted to understand the current collaboration practices. The names of the companies are not disclosed as part of a confidentiality agreement. A brief description of each of the cases studied is given in this section.

3.5 Case study

The case study approach has been widely adopted to answer the research questions when an exploratory in-depth understanding is needed (Voss et al., 2002). Company visits (field visits) and observational studies on supply chain collaboration practices have been part of the case studies in this research. Questions one and two are more related to the structure of the collaborative arrangement of the case companies and hence detailed case study with intensive semi-structured interviews have been conducted for this purpose of the research. The interviews have been recorded, using digital voice recorder, and used for the case analysis and writing-up of this thesis.

The interviews with case companies have been conducted in different periods of time with top and middle managers. A list of the main contacts, the period of interviews, the number of personal and telephonic interviews is shown in Table 3-3.

Table 3-3 Details of case company interviews

Company	Main Contact	Period	No. of (face-to-face) interviews	No. of telephone interviews	Total hours	Availability of sales information
Soft Drink Co. **(Study- 1&2)**	Forecast analyst Logistics Manager Planning Manager Customer Demand Analyst	2007-2009	11	2	24	Complete (Study-1) Partly (Study-2)
Textile Co. **(Study-3)**	Secretary to MD* Planning Manager	2007-2009	6	5	12	Partly
Crude-Oil Co. **(Study-4)**	Distribution Manager Logistics Manager	2007-2008	3	1	6	Not available
Packaging Co. **(Study-5)**	Managing Director Planning Manager Demand Analyst	2007-2009	6	3	12	Partly
EEM Co. **(Study-6)**	Operations Manager Distribution Manager	2007-2008	3	0	5	Not available
				Total hours of interview	**59**	

*people at different positions were interviewed

Soft Drink Co. has provided detailed sales data and a promotional calendar for 2005-2007. Textile Co. has provided details on company partnership and sales volume but no detailed sales data. Packaging Co. has provided detailed sales data for one year, but it was not very useful for this research. The other two companies Crude-Oil Co. and EEM Co. agreed to have interviews but did not provide any sales details. Further details of the case studies are given in Chapters four and five, and also in Appendices I and II.

3.6 Conceptual model development

Aviv (2007) developed a stylised reference model (mathematical model) to improve production planning of manufacturers by integrating demand information from other supply chain members. He mentioned the name reference demand model to specify the dependency of the demand process on supply chain information. Based on this idea, this research has developed a conceptual model called a ‘Reference Demand Model’ (RDM). RDM is a specific model representing the dependency of demand projection on information from various supply chain members involved in the supply chain processes such as planning, forecasting, production and replenishment.

In general, business processes greatly rely on demand forecasts, which in turn enable all supply chain members to plan, produce, and replenish in good time. Thus, accuracy in demand forecast is considered as one of the most important criteria for the success of supply chain processes. However, achieving good forecast accuracy is not a standalone process in the supply chain. Information from various supply chain players is important to develop collaborative forecasting. In this research, the supply chain information exchanged between supplier and buyers has been collected. Various attributes of information such as action-ability, reliability and source of information have also been recorded to verify the importance of information in the process of forecasting and planning. Based on the attributes of information, RDM attempts to find the actual importance of information at various supply chain processes at different times. Further details on development of RDM are given in Chapter 6.

3.7 Structural equation models (SEM)

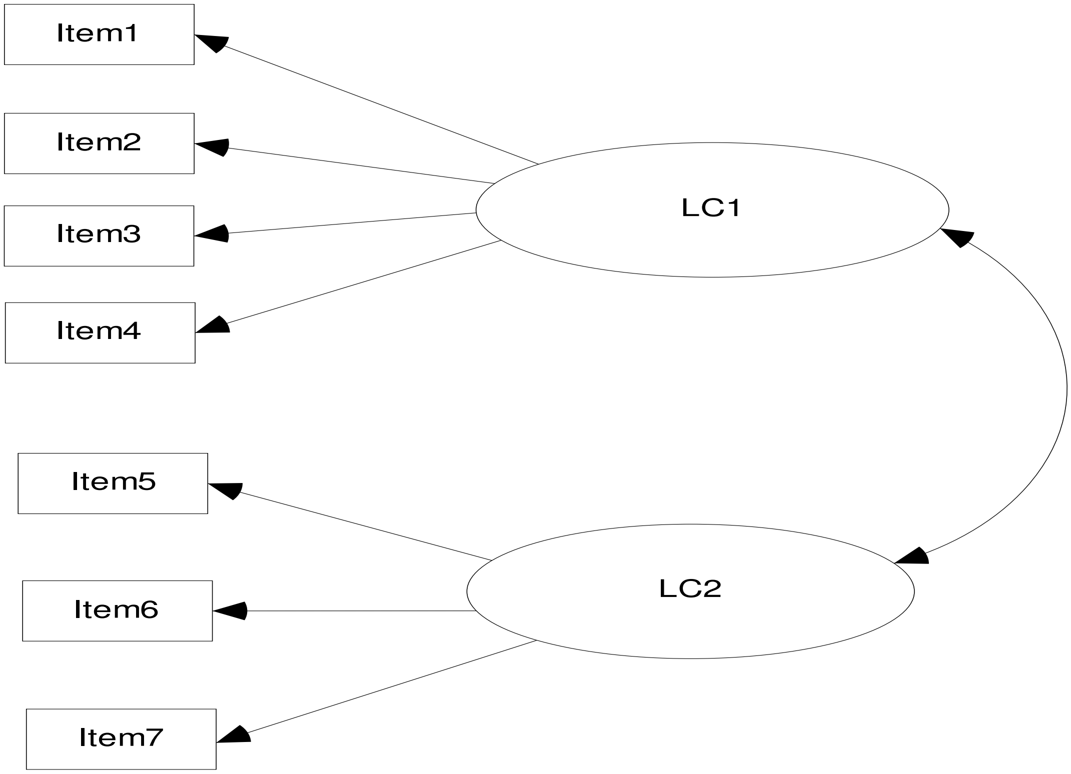
Structural equation modelling (SEM) is a quantitative multivariate analysis technique solving simultaneous linear regression models. It is used for establishing and testing the causal relationship among various research constructs. SEM is normally used for two purposes: testing the construct validity of factors and testing the theoretical relationships among a set of constructs measured using multiple observed variables (Hair et al., 2009).

To form SEM one needs to have a strong theoretical grounding such as a well established/argued hypothesis. However SEM is rarely used for exploratory study. In the area of supply chain collaboration, not many studies have discussed the relationships between information and demand. Although, SEM is a new approach in the fields of operations and forecasting, some researchers have used this technique to find relationships among different groups (suppliers and buyers) or departments (marketing and operations) in analysing a firm’s performance (Mishra and Shah, 2009; Kim, 2009). In this research SEM is used for exploring the underlying structure of various demand factors identified through RDM (Ramanathan and Muyldermans, 2010).

In general, SEM uses a two-step approach. In the first step, confirmatory factor analysis is conducted to test the appropriateness of the measured variables for each factor under study (Anderson and Gerbing, 1988). In the second step, relationships among factors are tested using structural equation models. Both these steps together unveil the dependency, direct effect and indirect effect of each factor on the other as well as on the final endogenous variable (sales). In this research, the actual sales figures have been used as the endogenous variable and the identified demand factors (from RDM) as measured variables. The resulting final structural models of this research could be used as a decision tool for planners and forecasters.

In SEM, before developing a complete structural equation, normally measurement model(s) are developed. The measurement model (i.e., structural model under examination) deals with the relationships between measured variables and latent constructs (Mishra and Shah, 2009). A simple example of a measurement model is given in Figure 3-2.

Figure 3-2 An example of a measurement model



In this example, there are two latent constructs (or factors) LC1 and LC2. LC1 is represented through four variables (items 1 to 4) and LC2 is measured through three variables (items 5 to 7). Both these constructs are connected by covariance relationship (correlated). The validity of this model is normally tested through suggested SEM fit indices. This measurement model will be further used to establish a structural equation model based on the research hypotheses already developed in this research.

3.8 Multiple linear regression models

Multiple regression analysis is a popular statistical technique to analyse the relationship between a single dependent variable and several independent variables. The regression equation can also be used as a modelling tool to express impacts of various factors influencing the dependent variable. In simple words, total sales can be expressed as a function of different demand factors such as promotions and other effects. For example, total sales 'Y' can be represented as follows: $Y = a_0 + a_1 x_1 + a_2 x_2 + ... + a_n x_n + e_i$ where $a_0, a_1, a_2, ...a_n$ are coefficients, e_i is an error term and $x_1, x_2, x_3, ..., x_n$ are explanatory variables. These explanatory variables are factors influencing the product demand (sales). Regression analysis with more explanatory variables is known as multivariate regression analysis.

While the case study interviews (discussed in Chapter 4) help to identify various factors influencing the demand, the regression method will be used to analyse the dependency of real sales data on those factors. Multiple regression analysis will be conducted with the sales data of the Soft drink Company in Chapter 10.

3.9 Summary

In this chapter, the research questions were discussed in detail with relevance to the identified gaps in the literature. This was followed by an outline of the research design and research approach to answer the research questions. Four different research methods were proposed – case study, conceptual model development, structural equation modelling and multiple regression analysis. An introduction to each case was also outlined with a note to its future role in the thesis. A brief description was given for each of the methods in this research. The next chapter will describe case studies from the UK.

Chapter 4 Case studies - UK

4.1 Introduction

In the process of developing RDM, the importance of collaboration and information exchange has been identified through two case studies from the UK. The first study is about a Soft Drink Manufacturing Company. The CPFR arrangement between Soft Drink Co. and its retailers is explained in detail especially for promotional sales. The second case study is about a Wholesaler of chilled and frozen products, who is one of the main customers of Soft Drink Co. This case describes the relationship maintained by the wholesaler with its retailers and one of the main suppliers - Soft Drink Co.

4.2 RDM for Study 1 - Soft Drink Manufacturing Company (Soft Drink Co.)

4.2.1 Company profile

Soft Drink Co., a soft drink manufacturing company is one of the oldest companies in the United Kingdom. Since its launch in 1900, Soft Drink Co. has been successful by introducing more and more consumer preferred products. Soft Drink Co. has always been trying to dominate the soft drink market through its aggressive promotions and introduction of new products along with the other business strategies such as health concerns, environment commitment and corporate social responsibility. The company has been maintaining healthy partnerships will their customers (say retailers).

The products of Soft Drink Co. are classified as Fast Moving Consumer Goods (FMCG). Hence, Soft Drink Co. maintains a low inventory level, typically less than two weeks. The company distributes about 240 million cases of soft drinks a year in the UK. Their product portfolio consists of 43 % of large pet bottles (2ltr and 1.5ltr), 24 % of 330 ml cans and multi-packs, and 33 % of other small packs (pet bottles and 150ml cans etc). This study is conducted at the office in Nottingham (Customer Logistics), which looks after the 400 largest customers (including main grocery retailers, wholesale customers, national retail outlets and main brewers). The company manages demand for their largest customers, such as Tesco, Sainsbury's, Morrisons, Asda and Somerfield, through the three stages of CPFR.

Soft Drink Co. strongly feels that their relationship with retailers will help in reducing unnecessary waste such as excess inventory and stock-outs. In the past five years, the company has been engaged in information sharing and collaborative forecasting with retailers, aimed to improve forecast accuracy, inventory management and reduce cost.

4.2.2 Product portfolio and promotion mechanisms

The company produces a variety of carbonated and non-carbonated drinks. Due to increasing awareness on health, Soft Drink Co has introduced nearly 20-25 new varieties of health drinks and fruit juices in the past 3 years. Each product line has a variety of different drinks to choose from e.g., with sugar, without sugar (diet, light and zero), and flavours like orange, lemon, pineapple, etc.

Unlike in other European countries, the sale of soft drinks in the UK is heavily dependent on various promotional mechanisms that are run in retail outlets. In the past five years, Soft Drink Co. has been engaged in CPFR with retailers for promotional planning and forecasting. Soft Drink Co. encourages information sharing and collaborative forecasting with their retailers in a view to improving forecast accuracy, inventory management and to reduce costs. As a first step towards establishing collaboration, the company is being engaged in a ‘front-end-agreement’ with retailers as suggested in stage one of CPFR (VICS, 2002). At this stage, Soft Drink Co discusses their promotional plans with other retailers and comes up with a promotional calendar specific to each retailer. Each promotional calendar clearly represents the products on promotion, periods of promotion, types of promotion, price discounts, promotional displays and other promotional features. Please see Table 4-1 for details on components of promotional calendar.

Table 4-1 Components of promotional calendar

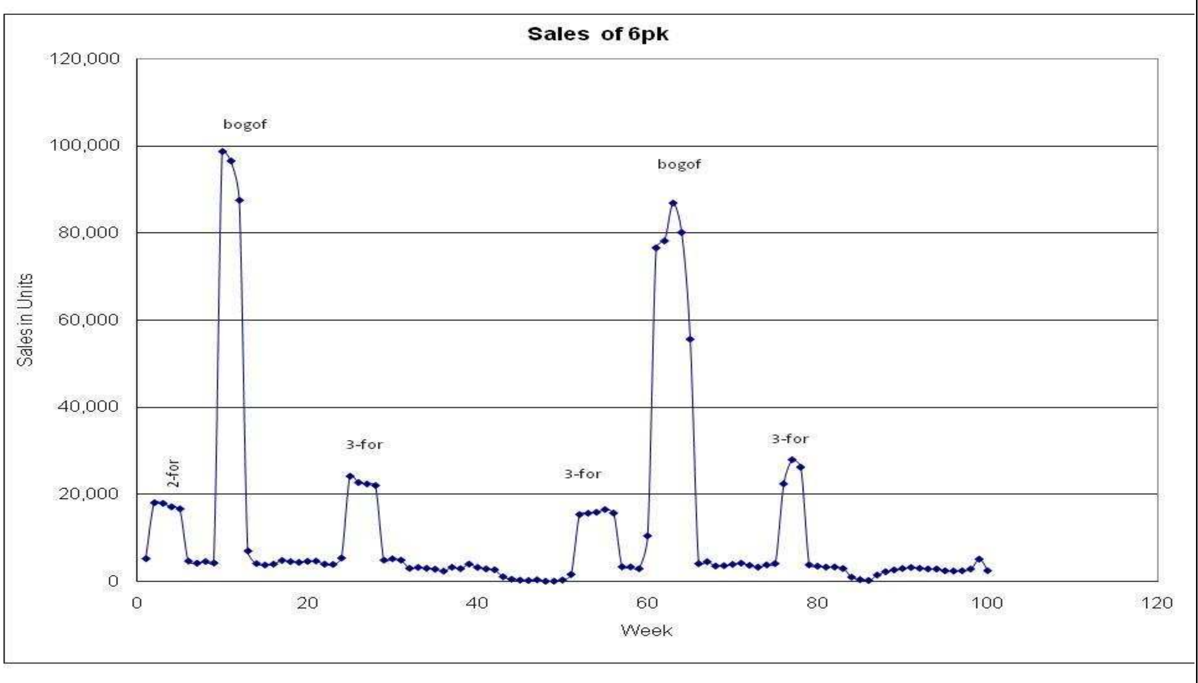
Products on promotion	2ltr/500ml/ 6-packs of 330ml cans/others
Period of promotion	4 weeks; starts on 01/01/2007 and ends on 28/01/2007
Types of promotion	2-for £3/ 3-for £4/half price/bogof/ save 50p/others
Price discount	26%/ 30%/ 50%/others
Display	Gondola end/ plinth/end aisle/ side aisle
Feature	Sports logo &/ advertisements on TV, radio, magazine, etc.

The company generally offers promotions on similar products at the same time. For example, if a promotion is planned for a 2ltr Cherry drink, this will also be offered to a 2ltr Strawberry drink. However, it is quite unusual to offer promotions for the same products of different packs (for example a 2l Cherry drink and a 500ml Cherry drink). Normally sales promotions of two major selling product types do not run at the same time. Soft Drink Co. avoids conflicts in the promotional calendar for different retailers. For example if Tesco runs a promotion in the first week of January for a ‘product x’, the same product will normally not be on promotion at Asda during the same period.

The period of promotion is normally represented by fixing the starting week and the number of promotional weeks. Normally, the company offers promotions for 2 to 5 times a year. Each of the promotions typically lasts for 3-6 weeks. The types of promotion differ widely across various retailers. This includes buy-one-get-one-free (bogof), buy-2-get-2-free, half-price, 2-for £x, 3-for £x, save £x, and other new promotions. Each of these types of promotions can be converted into a discount of the normal sales price. Normally, promotions such as bogof and half price will involve higher price discounts and attract more sales. The display of promotional items also has a great impact on promotional sales. Items on promotions can be displayed at gondola end, end aisle, side aisle, plinth, stack, etc. Gondola end is located at the end of the aisle with a prominent display sign board. Among these locations gondola end is a very attractive in-store location for product display that captures maximum attention from customers. The promotional features also represent in-store sales advertisements such as sign boards, sports features with a product logo etc., and media advertisements outside the stores such as those on the radio, television and magazines.

All the above elements of promotions generally result in an increase over the normal sales. The extent of increase is captured using a measure called 'sales uplift' defined as the percentage of sales over and above the normal sales. Figure 4-1 shows the effect of promotions on retailers' sales in a time series data of the past 2 years for a specific product of 6-packs 330ml cans. While the promotional sales above 80000 units resulted from bogof promotions with a gondola display, the sales between 17000 and 40000 units resulted from 3-for and 2-for type promotions. From figure 4-1 it is clear that promotional events can have a very big impact on the sales volume, and that automatic replenishment systems (e.g. based on reorder point/order quantity) cannot deal with these huge demand fluctuations.

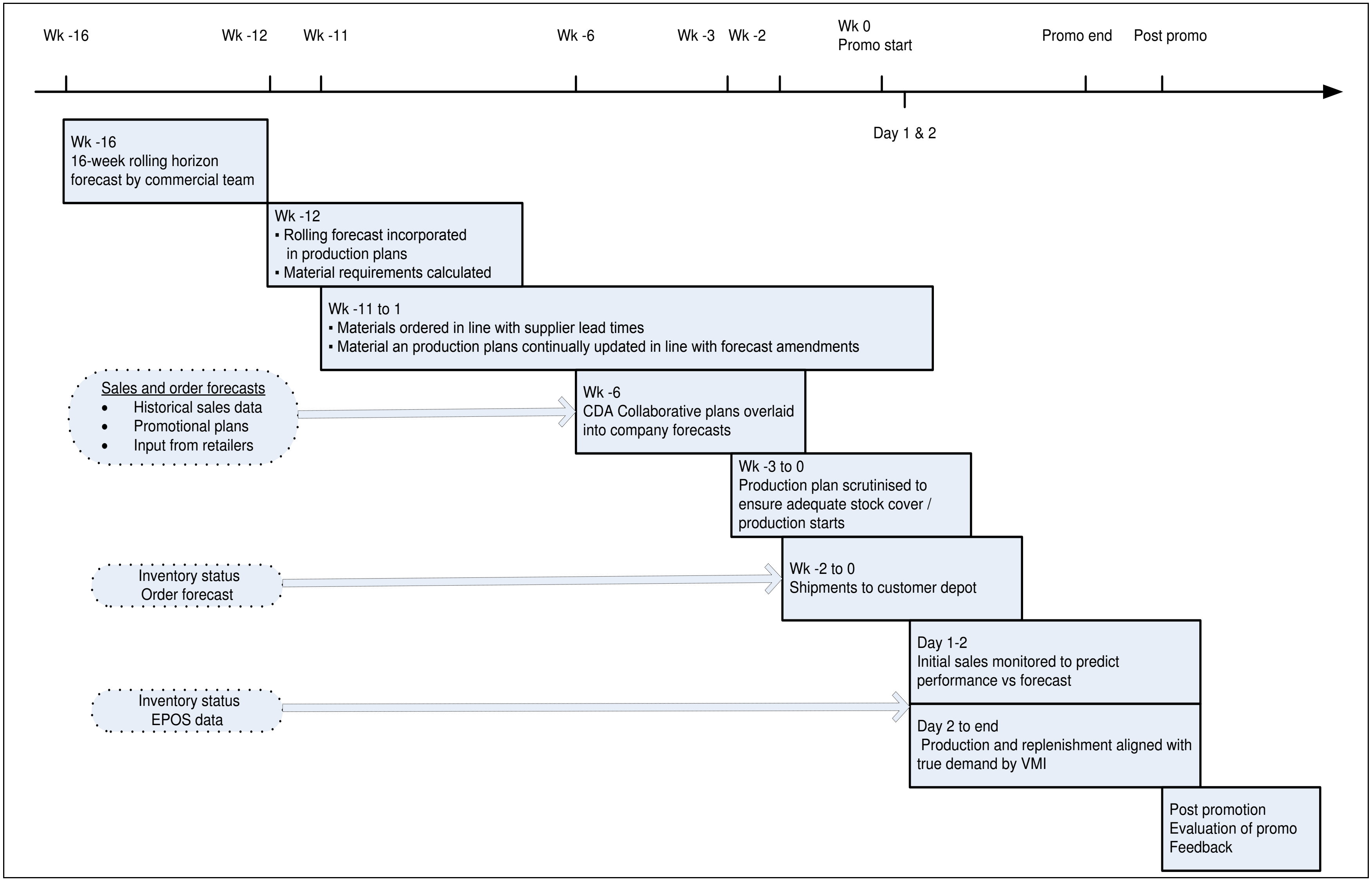
Figure 4-1 Effect of promotions on sales



4.2.3 Planning cycle at Soft Drink Co

As a large proportion of Soft Drink Co.'s sales are dependent on promotions, the promotional calendar plays an important role in their production planning, forecasting and replenishment. Based on the promotional calendar, the company starts its production planning and forecasting well in advance, as early as 16 weeks before promotions. Approximately 11 weeks in advance, the company starts their material requirement planning (MRP). Planning and forecasting continues until final replenishment. Customer demand analysts (CDA) involved in the collaborative forecasting at week 6 agree upon a single forecast figure. This forecast includes forecast of demand and agreeing on a dispatch schedule. This ensures timely delivery during promotional sales. See Figure 4-2.

Figure 4-2 Planning cycle at Soft Drink Co.


Wk -16
Wk -12
Wk -11
Wk -6
Wk -3
Wk -2
Wk 0
Promo start
Promo end
Post promo
Day 1 & 2
Wk -16
16-week rolling horizon forecast by commercial team
Wk -12
▪ Rolling forecast incorporated in production plans
▪ Material requirements calculated
Wk -11 to 1
▪ Materials ordered in line with supplier lead times
▪ Material an production plans continually updated in line with forecast amendments
Sales and order forecasts
• Historical sales data
• Promotional plans
• Input from retailers
Wk -6
CDA Collaborative plans overlaid into company forecasts
Wk -3 to 0
Production plan scrutinised to ensure adequate stock cover / production starts
Inventory status
Order forecast
Wk -2 to 0
Shipments to customer depot
Day 1-2
Initial sales monitored to predict performance vs forecast
Inventory status
EPOS data
Day 2 to end
Production and replenishment aligned with true demand by VMI
Post promotion
Evaluation of promo
Feedback

Soft Drink Co. practices Vendor Managed Inventory (VMI) for replenishment. Inventory is monitored continuously by Soft Drink Co.'s representatives at the retailers' distribution centre. Though the company's initial forecast starts with historical sales data to draft production and material purchase plans, the collaborative forecast figure is then finalised only on confirmation from retailers six weeks prior to the planned promotion. This is further explained through Figure 4-2. Feedback on promotions is collected to make the next stage of forecasting and replenishment process more effective.

4.2.4 Supply chain collaboration at Soft Drink Co.

Under normal conditions, the promotional mechanism is quite straight forward as Soft Drink Co. first proposes its promotional calendar to retailers. Replenishment is also planned jointly to ensure on time delivery[1]. Retailers react to Soft Drink Co.'s plan by suggesting changes to the promotional calendar and generally promotional plans are agreed by consensus. The mutually agreed promotional plans come into effect in stores at the planned period. In order to ensure smooth running of these planned promotions at the retailers' outlet, Soft Drink Co has established collaborative arrangement with their retailers.

This enables the company to get point-of-sales (POS) data regularly. Electronic point-of-sales data (EPOS) is available to Soft Drink Co. through an intranet service provided by retailers and other third-party web service providers. However, all the retailers do not use the common electronic data interface; some use exclusive techniques similar to Wal-Mart's 'retail link', while others use NetWare.

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[1] But very rarely, retailers run promotions independently without consulting Soft Drink Co.

Soft Drink Co. monitors EPOS closely during promotion and uses this information to adjust its replenishment strategy. As Soft Drink Co. takes the responsibility of maintaining the inventory level, the retailers are assured of timely replenishment. If the actual demand exceeds predicted sales, EPOS information will trigger the Soft Drink Co. trading team to react quickly if needed, by rerouting or deploying inventory from other production or distribution plants.

4.2.5 The current forecasting method employed by Soft Drink Co.

The current forecasting method of Soft Drink Co. is based on historical sales data and the promotional calendar. Forecast analysts of Soft Drink Co. calculate forecasts manually for each product on promotion. Initially, customer demand analysts make their forecasts by looking at a similar promotion from historic sales data and adjusting it based upon input from the retailers. If the promotional mechanism (i.e., the type of promotion) is similar to previous year's promotions, a sales forecast will be made by averaging previous sales. Based on the sales forecast, an order forecast (or dispatch forecast) is generated to replenish goods on time in the retailers' main distribution centre (see Figure 2-2). These forecasts may be updated at the time of the promotion based on actual EPOS data, in case the sales exceed the forecast.

The present forecasting procedure adopted by Soft Drink Co. is simple but time consuming. For example, there is no structured way of forecasting to deal with changes in the type of promotion or display. These complications not only affect forecast accuracy but also increases the time needed to generate forecasts. Soft Drink Co. claims that their forecast accuracy of promotional sales is about 80%. Although the company has well established collaboration with customers, they face a few complexities while executing promotions, which are explained further.

4.2.6 Some complexities

While enjoying increased sales during the promotional period, Soft Drink Co is concerned about the aftermath effect of promotional sales. As soon as the end of Soft Drink Co.'s promotion, if the retailer plans to run another promotion by other beverage company, its impact on sales of Soft Drink Co. products seems to be quite high. The company is constantly checking the customer buying patterns, using EPOS data, for any changes to adjust its production process.

Sometimes, Soft Drink Co. has not been informed about in-store promotions run by retailers. These promotions are being decided solely by the retailer aiming to improve their overall sales. For example, if a promotional deal is agreed to sell 2 bottles for £1.5 for the period of three weeks and the retailer changes the deal at the end of third week at some of their outlets, the sales uplift will be higher than anticipated. Unfortunately, on some occasions Soft Drink Co. has not been informed of such changes. Consistent monitoring of promotional sales from day one, either by visiting stores running promotions or following advertisement from public data, is indeed helpful for Soft Drink Co. to check the compliance with promotional plans. At times, very short notice on in-store promotions makes Soft Drink Co. work hard to avoid stock-outs in retail outlets. EPOS data helps customer demand analysts to monitor sales and react quickly to any sudden changes.

Normally, retailers do not intend to deviate from their original deals with their suppliers. At the same time, to compete with their business competitors, it is essential for retailers to keep the retail price in line with others. This necessitates Soft Drink Co to work closer to the market and hence try to get market information through third party information providers. Another problem faced by Soft Drink Co. is that an increase in sales of one of its products may result in a decrease in sales of another item (which is referred as cannibalisation). Although these problems are not regular, careful consideration is essential to avoid future complexities. Our research aims to identify demand factors through a Reference Demand Model. The RDM was constructed through a series of interviews with CDA and forecasters of Soft Drink Co. and will be explained in Chapter 6.

4.3 Study -2 Wholesale customer of Soft Drink Co.

4.3.1 Company profile

Wholesale Co. is the UK's leading independent and national wholesaler of soft drinks, tobacco, confectionery, chilled & frozen goods, and grocery & convenience goods. This company manages nearly 6300 stock keeping units with approximate value of 67 million GBP at any time. The company has 15 depots[2] or warehouses across the country. Most of these warehouses are working independently of each other. However, some of the warehouses are cooperating with each other especially for slow moving products. Here, slow moving products refer to the products with irregular demand or consistently low demand. Usually these slow moving products are stored at one warehouse and transported to the other warehouse on demand, which avoids excess inventory. Among all products sold through Wholesale Co., the soft drinks are one of the major selling products.

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[2] Medway, Coventry, Fareham and Haydock are the 4 major warehouses.

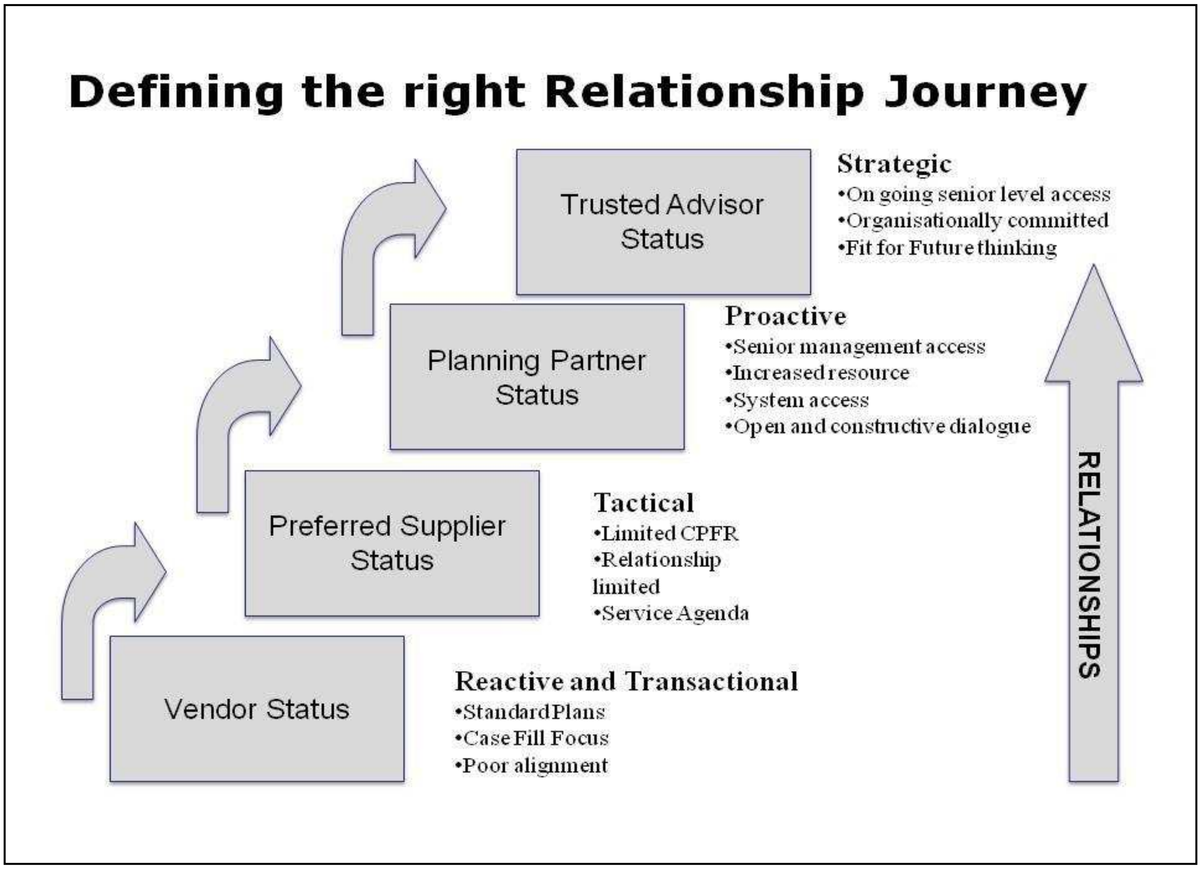
Wholesale Co. has a good business relationship with one of the leading soft drink manufacturers.

Wholesale Co. is one of the most valuable wholesale customers of Soft Drink Co. Every year Wholesale Co. sells around 8 million cases of soft drinks products with a value of about 35 million GBP. Most of these products are either 500ml pet bottles or 330ml cans. However a small portion of the business is devoted to selling 2ltr pet bottles. The company aims to maintain about five days of stock of soft drink products at all times. Recently, stock of Soft Drink Co. products at Wholesale Co. has increased to 6.9 million pounds in July 2009 compared to 2.4 million pounds in June 2009. Consequently, this has increased the service rate of Wholesale Co. to 98%.

4.3.2 Relationship between Soft Drink Co. and Wholesale Co.

Both Soft Drink Co. and Wholesale Co. value all of their customers and attempt to serve them to the highest possible level. Currently Soft Drink Co. maintains 4 different levels of relationships with their customers namely vendor, preferred supplier, planning partner, trusted advisor (see Figure 4-3). The ‘vendor status’ is the basic transactional level relationship between Soft Drink Co. and customers. In the vendor status, Soft Drink Co. simply reacts to demand; the customers ordering pattern does not follow any standard pattern. This level of collaboration encourages sharing of basic standard plans of replenishment among the suppliers and the buyers. Customers' of Soft Drink Co. in this level of collaboration place irregular orders (volume and timing).

Figure 4-3 Various levels of relationships in Soft Drink Co.


Defining the right Relationship Journey
Trusted Advisor Status
Strategic
•On going senior level access
•Organisationally committed
•Fit for Future thinking
Planning Partner Status
Proactive
•Senior management access
•Increased resource
•System access
•Open and constructive dialogue
Preferred Supplier Status
Tactical
•Limited CPFR
•Relationship limited
•Service Agenda
Vendor Status
Reactive and Transactional
•Standard Plans
•Case Fill Focus
•Poor alignment
RELATIONSHIPS

(Source: Soft Drink Co., 2009)

The next level of relationship is called 'preferred supplier'. This is of a more tactical nature. This level also accommodates CPFR to a limited extent. Service to the end customer is regarded as highly important and hence a common service agenda is created. The next higher level of relationship is 'planning partner', which is a more proactive type of relationship with transparent access to sales information. In the planning partner status, Soft Drink Co. and their customers interact at senior managerial level with access to systems. In this level transparent communication is possible and hence it is more transparent compared to the other two levels. The highest level of relationship is called 'trusted advisor', which involves the customers in business plans of Soft Drink Co. In this level both Soft Drink Co. and customers plan replenishment orders, promotional sales and new product introductions.

Soft Drink Co. considers Wholesale Co. as one of their preferred customers (Figure 4-3 - level 2 from bottom), and encourages repeat and more consistent orders from Wholesale Co. Soft Drink Co. offers cost incentives on orders of the same product in full truck loads (26 pallets). These orders can be shipped from the same production plant, and hence the replenishment lead time could be reduced by one day.

Soft Drink Co. has also streamlined the ordering system in such a way to ensure timely replenishment. Accordingly, Soft Drink Co.'s electronic online ordering system is available to Wholesale Co. every day from 6:00 am until 6.00 pm. All the orders placed before 12:00 noon of each day are replenished to Wholesale Co. depots anytime after the end of day 2. However Wholesale Co. accepts delivery from Soft Drink Co. for only limited hours in a day from 8:00 am until 5:00 pm, which puts more pressure on Soft Drink Co. and may increase the lead time to 3 days. Currently, this complication is being considered by both companies and will be resolved in the near future, as both are interested in having a higher level of collaborative relationship.

4.3.3 Relationship of Wholesale Co. with their customers

Wholesale Co. has a wide range of customers from big national chain customers such as Tesco convenient stores to small local shops and independent stores. Wholesale Co. maintains a close and healthy relationship with all these customers. Since January 2000, the company has been in collaboration with YP Electronics for a brand new Windows based 'Epos solution Sinqua'. This new system assists retailers so that they can benefit from a full product file and pre-installed system, so that orders can be placed electronically to Wholesale Co. Wholesale Co. encourages their customers to use Sinqua. Wholesale Co. values their customers' participation in profit earning and timely replenishment. Wholesale Co. published the followed message in their website.

> By responding to accurate trading records, retailers will be able to control stock more professionally, save valuable management time, and offer your customers exactly the right range of goods at the right time. Valuable margin is maintained at the point of sale and orders can be compiled in seconds. Retailers can identify shrinkage, pinpoint best sellers, reduce stock outs and analyse promotions, making informed decisions on what they know rather than what they think they know (Company website accessed on 22 July 2009).

Currently Wholesale Co. maintains 1-2 days lead time for local shops and independent customers; however it takes 1-3 days to replenish retail customers. To reduce Wholesale Co.'s inventory at the warehouses, Whole Co. has put some pressure on Soft Drink Co. to reduce the lead time.

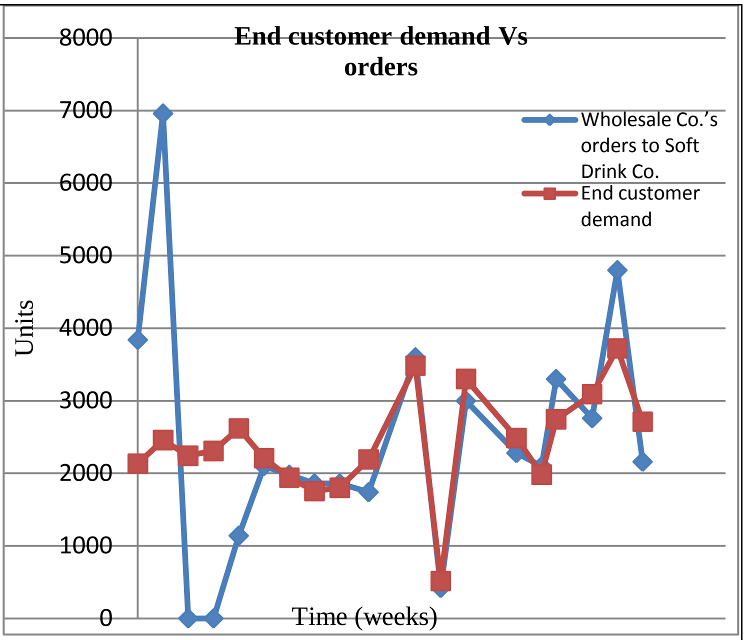
4.3.4 Inventory management and forecasting at Wholesale Co.

Wholesale Co. and Soft Drink Co. have only been working together for the past two years, and their information systems have not been integrated to a great extent as yet. Currently, Wholesale Co. has no standard procedures for forecasting and inventory management, and at the same time end customer demand is not visible to Soft Drink Co. This results in Wholesale Co. placing irregular replenishment orders at Soft Drink Co., and missing out the benefits of full truck load orders.

Figure 4-4 shows the end customer demand and Wholesale Co.'s orders to Soft Drink Co. over time (January- June 2009) for one of the warehouses (Medway) for a 500ml drink.

Figure 4-4 End customer demand and orders of Wholesale Co.

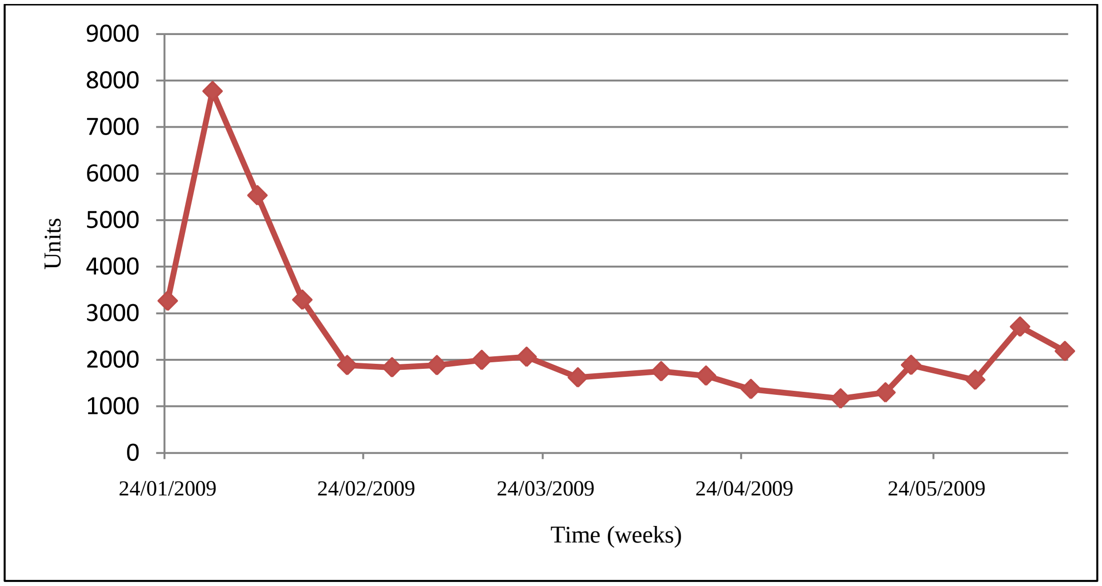
500ml - Medway warehouse		
Date	**Wholesale Co.'s orders to Soft Drink Co.**	**End customer demand**
24/01/2009	3840	2132
31/01/2009	6960	2457
07/02/2009	0	2242
14/02/2009	0	2308
21/02/2009	1140	2619
8/02/2009	2100	2209
07/03/2009	1980	1938
14/03/2009	1860	1754
21/03/2009	1860	1801
29/03/2009	1740	2191
11/04/2009	3600	3482
18/04/2009	420	514
25/04/2009	3000	3300
09/05/2009	2280	2485
16/05/2009	2100	1982
20/05/2009	3300	2744
30/05/2009	2760	3091
06/06/2009	4800	3722
13/06/2009	2160	2710



From Figure 4-4, it is clear that the orders placed on Wholesale Co. by its end customers are less variable as compared to the replenishment orders placed by Wholesale Co. to Soft Drink Co. (especially at the beginning of the year). This is a clear illustration of the bullwhip effect. In addition, end customer demand is rather smooth (apart from an Easter effect). This indicates that simple or standard forecasting approaches should work well to predict demand. Also, a full truck load comprises 1560 cases. In order to exploit the price discounts offered by Soft Drink Co., it may be better to replenish in multiples of 1560.

Figure 4-5 shows the evolution of inventory over time of the 500ml drink at the Medway warehouse. The average inventory level was 2458 cases, whereas the average weekly end customer demand was 2404 cases. Thus the Medway warehouse holds about one week of demand in stock of this drink.

Figure 4-5 Inventory level at Wholesale Co.



4.3.5 Potential improvements in forecasting and inventory management

Because the end customer demand was rather smooth, we proposed and tested a simple forecasting approach in which we first calculate the average weekly demand and then adjust by multiplying with a seasonal coefficient. This approach is known as seasonal decomposition. We applied the approach on 6 months of data, and defined two seasons only: season one comprises the first 3 months while season two is based on the next 3 months. In addition, we also defined Easter seasonal coefficients to deal with the Easter seasonal coefficients to deal with the Easter effect. (It should be clear that the same principle can be applied if more data were available. For example, if the demand in Summer and Autumn seasons are significantly different from those in Winter and Spring, then four seasons needs to be defined). More details of the approach can be found in (Singh, 2009[3]).

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[3] Copy of Singh (2009) will be available from the Nottingham University Business School on request

Figure 4-6 Demand forecast of Soft drinks at Wholesale Co.

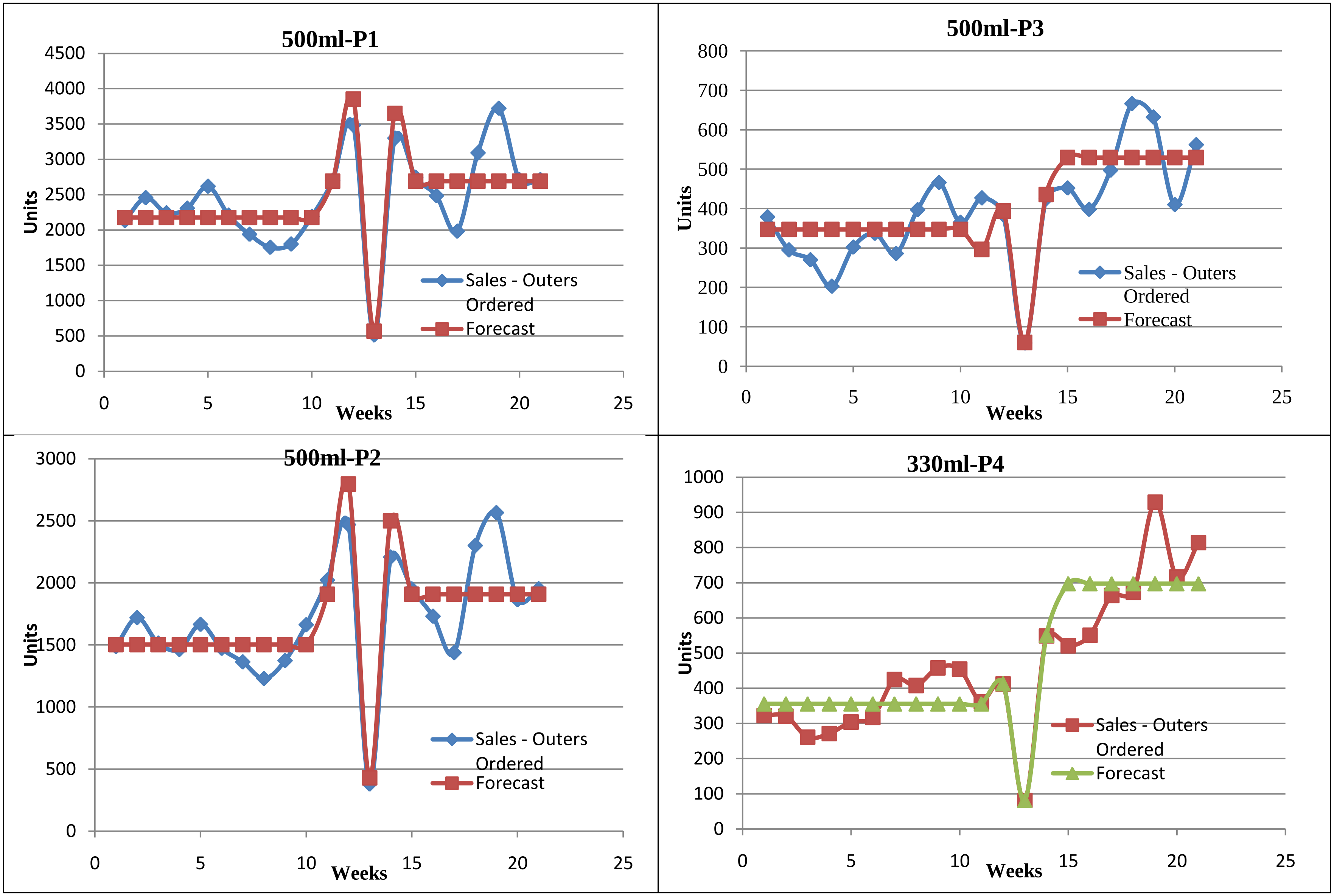


Figure 4-6 illustrates the forecasts and demand profiles for a number of products. We evaluated the forecast accuracy by calculating the mean absolute percentage error (MAPE). Table 4-2 reports the MAPE results for different 500ml and 330ml products at three different deports. The average MAPE ranges between 12.83% and 16.54%. Hence, it can be concluded that the approach works very well.

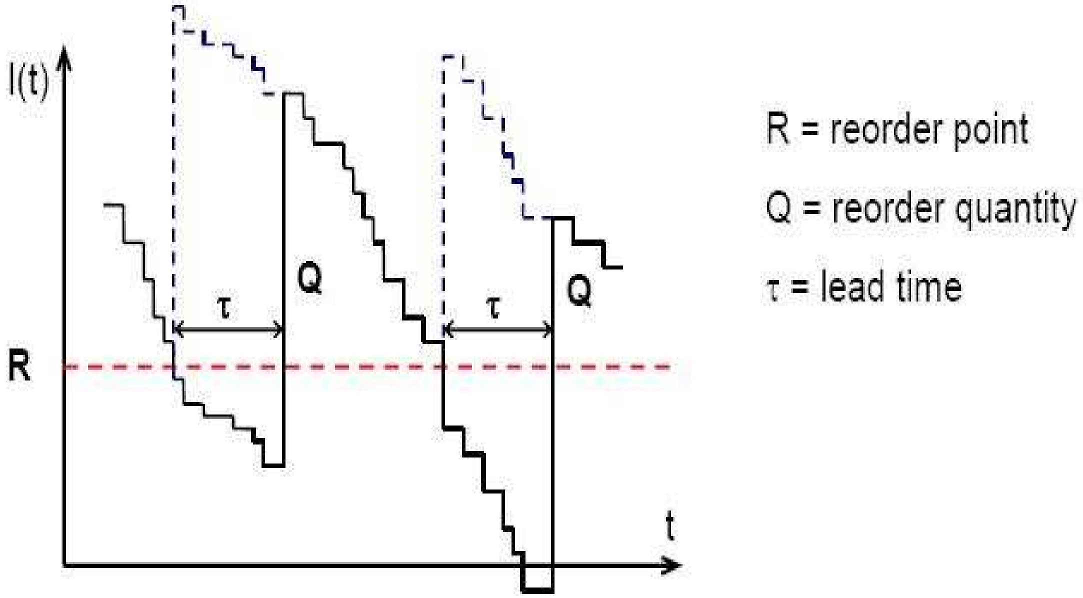
Table 4-2 MAPE of seasonal forecasting at Wholesale Co.

	MAPE		
	Medway Depot	**Coventry Depot**	**Fareham Depot**
500ml products			
500ml-P1	10.42	12.82	9.94
500ml-P2	11.58	13.17	11.38
500ml-P3	17.83	12.34	19.39
500ml-P4	19.39	12.53	21.36
500ml-P5	17.44	13.92	18.88
500ml-P6	17.23	13.59	18.6
500ml-P7	17.21	19.72	16.25
Average MAPE	**15.87**	**14.01**	**16.54**
330 ml products			
330ml-P1	15.31	11.86	13.33
330ml-P2	11.36	9.29	11.65
330ml-P3	17.97	16.16	20.7
330ml-P4	14.5	14.02	15.21
Average MAPE	**14.79**	**12.83**	**15.22**

In terms of inventory management, we suggested (and tested) simple (R,Q) or reorder point (R)-order quantity (Q) models (Nahmias, 2009). The key principle is to place a replenishment order of size Q whenever the inventory position drops below the reorder point R. The idea is illustrated in Figure 4-7.

We used the EOQ (Economic order quantity) model to calculate Q, but then adjusted the value to multiples of full truck loads. This approach works well for fast moving products. For slower moving items, rounding the EOQ to a full truck load would result in too high inventory levels. Hence, we proposed a joint replenishment model. This involves monitoring different products simultaneously and placing replenishment orders for these products at exactly the same times, and in such a way that the total order quantity equals a full truck load. The order quantities for the different products are proportional to their respective demand rates and can be calculated by solving a set of linear equations. Full details of the approach can be found in Singh (2009).

Figure 4-7 (R, Q) model



The reorder point was calculated for a target service level (SL) or fill rate of 99.5% and 99.8%. Here, fill rate refers to the effectiveness at meeting customers' demands. A manual simulation in MS Excel was carried out to evaluate the technique.

Table 4-3 Inventory at Medway warehouse

500ml Medway warehouse							
	Q		R		Constant (k)		
Order cost K	Season1	Season2	Season1	Season 2	Season1	Season2	
Order cost 10 to 50	1560	1560	1600	2240	1.4	1.66	SL=99.5%
	1560	1560	1680	2380	1.78	2.02	SL=99.8%
Order cost 51 to 100	3120	3120	1550	2150	1.06	1.35	SL=99.5%
	3120	3120	1620	2280	1.5	1.75	SL=99.8%
	Target service level	Service level achieved (simulated)		SOH (simulated)	SOH (Actual)	Inventory reduction	
Order cost 10 to 50	99.5	96.1		1390	2458	43.45%	
	99.8	98.5		1488	2458	39.46%	
Order cost 51 to 100	99.5	97.23		2009	2458	18.27%	
	99.8	98.5		2088	2458	15.05%	

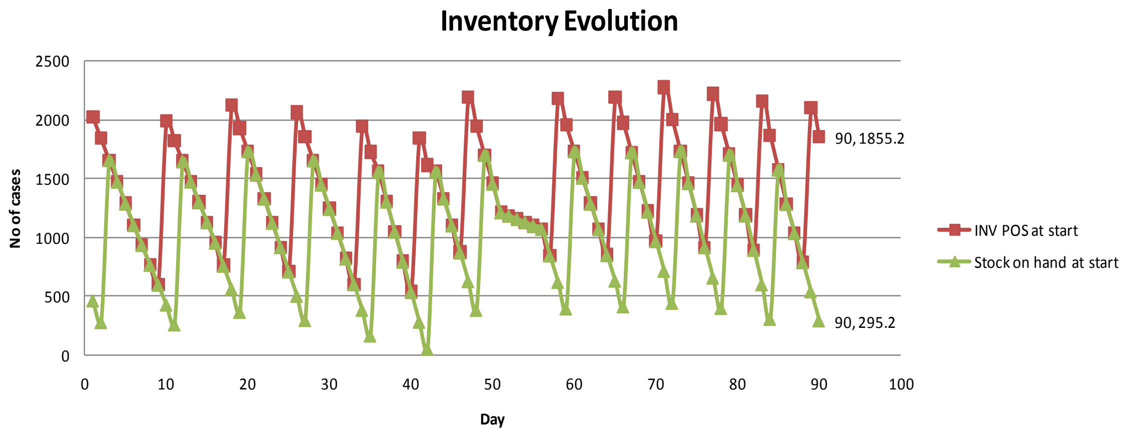
Table 4-3 shows the input parameters for one of the simulations for a 500ml drink at Medway warehouse. The first part of the table shows the different values for R and Q for different order costs, seasons and service levels. The second part of the table shows the target service level, the achieved service level in the simulation, the average stock on hand (SOH) in the simulation and the actual stock on hand. The last column shows the percentage reduction in average inventory level by comparing simulation and actual stock on hand. The simulation results indicate that inventory levels can be reduced (sometimes significantly) without compromising the service levels and at the same time earning benefits from quantity discounts. These results were confirmed for a variety of products. Figure 4-8 shows the simulation results for a 330ml drink at Medway and the evolution of inventory over time.

4.3.6 Enhancing Wholesale Co. – Soft Drink Co. collaborative arrangement

Both Soft Drink Co. and Wholesale Co. are interested in improving their performance and enhancing their collaborative arrangement. Since end customer demand at Wholesale Co. is

Figure 4-8 Evolution of inventory at Medway warehouse

330ml-Medway warehouse										
	Q		R		Constant (k)					
Order cost K	**Season**		**Season**		**Season**		**Service level achieved (simulated)**	**SOH (simulated)**	**SOH (Actual)**	**Inventory reduction**
	S 1	S 2	S 1	S 2	S 1	S 2				
Order cost 10 to 100	1560	1560	720	940	1.06	1.35	99.5	935	1618	42.21%
	1560	1560	765	1015	1.49	1.75	99.8	976	1618	39.68%



rather easy to forecast, there is no need for a detailed RDM. However, since Soft Drink Co. has better forecasting and inventory management capabilities, it may be beneficial to engage in a VMI arrangement. It is then important for Wholesale Co. to make end customer demand visible (avoiding the bullwhip effect) and for Soft Drink Co. to use appropriate forecasting and inventory management techniques (e.g. seasonal decomposition, (R,Q) models, joint replenishment for slower moving items). Soft Drink Co. would benefit from more regular, consistent full truck load orders (which can be shipped from the same production plant). Wholesale Co. would benefit from reduced inventory levels and at the same time earning cost benefits due to quantity discounts, while maintaining high service levels. The next chapter will describe two case studies of Indian companies who operate globally.

Chapter 5 Case studies – India

5.1 Introduction

Chapter four has introduced two cases in the UK companies. This chapter presents three case studies from Indian companies operating globally. One more case of an Indian company is discussed in Appendix-I. The third case study is about a Textile Manufacturing Company. This company, Textile Co. maintains three different levels of collaboration with its retail customers. The case underlines the importance of supply chain collaboration in expanding future business. The fourth case study involves a Crude oil company that maintains well established relationships with downstream SC partners to make timely replenishments. The fifth case study, given in Appendix-I involves a packaging material manufacturing company. Packaging Co. maintains a basic collaboration with their customers to understand the customers' demand and business plans. The sixth case study, given in Appendix-II, is from a Fire-proof electrical equipment manufacturer, who deals with different SC operators globally. These four cases illustrate different levels of collaboration with downstream partners. Each of the companies requires various supply chain information from other supply chain partners. This chapter discusses in detail each of these cases and their existing supply chain collaborations.

5.2 Study 3 –Textile manufacturing company

5.2.1 Company profile

Textile Co. is a leading textile manufacturing and exporting firm in India. It is one of India's largest producers of home furnishing fabric. The company exports their products to many other countries across the globe. Customers of the company include Deco Design in

Germany; Bravo Fabrics, Barston, Jo-Ann stores and Wal-Mart in USA; Prestigious in the UK; Southcity, Al Kilani in the UAE. The company's annual sales turnover in the year 2007 was approximately Indian Rupees 500 Crores which is equivalent to 120 million US Dollars[*]. Textile Co.'s production site is situated in Tarapur near Mumbai, India. The company employs 3500 personnel in its production process.

It is well known that India and other developing Asian countries have cheap labour that can bring down the cost of production. However, Textile Co. is also aware of the need for maintaining product quality to remain competitive in the international textile industry. As the Indian Government is committed to encouraging quality exports, Textile Co. regularly receives incentives from the Government for its export business. For instance, the local government awarded 10-12% of foreign currency earned through Textile Co. back to the company. In addition, the company also received prestigious awards from the Government under five different categories of excellence in export performance.

5.2.2 Business strategy of Textile Co.

The business strategy of Textile Co emphasises meeting customers' expectations and exploring new customers through international trade fairs. Textile Co.'s relationship with their customers' is based on the quality of their product and timely delivery. The company's basic guiding philosophy is "to be the best through the pursuit of Excellence in Performance and Quality".

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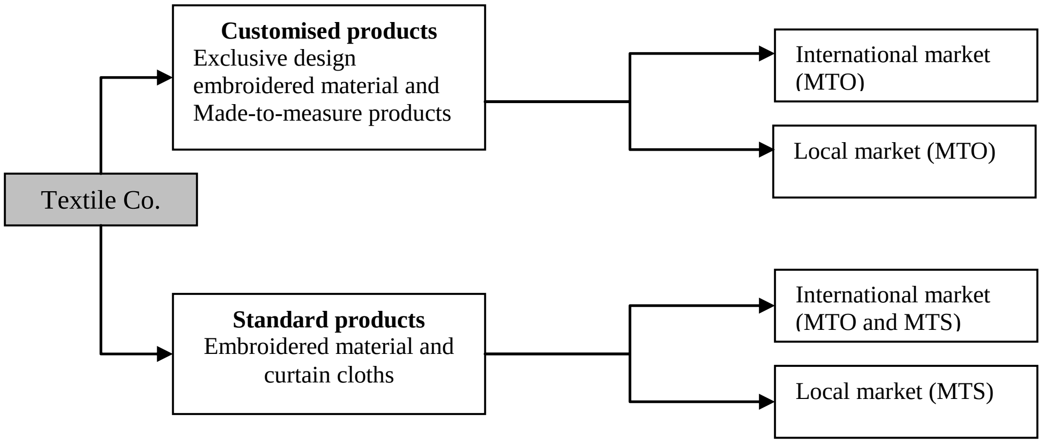
[*] (1 USD ≈ 41.6 Indian Rupees in December 2007)

Manufacturing textile materials for international exports is the primary objective of Textile Co., though the company also caters for local needs. It produces customised and standard textile materials (see Figure 5-1). Customised products are embroidered dress materials with exclusive design, and made-to-measure finished cushions, pillows and curtains. Standard products are embroidered material with multiple repeated designs and curtain materials. The company generally follows a make-to-order (MTO) strategy for its exports and local business for customised products. Standard products follow a make-to-stock (MTS) strategy with very limited stock that minimises inventory and obsolescence cost. We categorise the company as a MTS company since nearly 60 percent of the company's business follows a MTS strategy.

Figure 5-1 Business strategies of Textile Co.


Customised products
Exclusive design embroidered material and Made-to-measure products
International market (MTO)
Local market (MTO)
Textile Co.
Standard products
Embroidered material and curtain cloths
International market (MTO and MTS)
Local market (MTS)

Textile Co. aims to align its products to support the business strategies of its customers. For instance, whenever the retail giant Wal-Mart employs product differentiation as its competitive strategy, Textile Co. has produced exclusively designed fabrics that would be sold only to Wal-Mart. This flexibility fetches them repeat orders and plays a dominant role in building long term partnerships.

In order to retain customers, the company collects feedback on the quality and design of the products. Usually it is done through a series of exhibitions and trade shows around the world especially in the major business capitals in Europe or USA. For instance, the company has taken part in the trade fair festival ‘Heimtextil’ held in Frankfurt, Germany during 9-12 January 2008. Forthcoming trade fair events in Italy and Turkey are believed to give exposure to the international market and also to innovative ideas in new product introduction based on various cultures.

The company benefits from these trade fairs by exhibiting their products to many business customers. These trade shows are attended by manufacturers from all sectors of the textile industry such as machineries including spinning, nonwovens, weaving, knitting, dyeing and finishing, garment making, testing, software as well as dyestuffs and chemicals (Source: http://www.biztradeshows.com/trade-events/heimtextil-frankfurt.html as on 19 December 2007). Textile Co. utilises this opportunity to expand its business in different parts of the world.

5.2.3 Capabilities

The capability of a manufacturing company in building successful collaborations with its partners can be divided into production, communication, logistics, and planning and forecasting. These capabilities are discussed separately in this section in the context of Textile Co.

5.2.3.1 **Production capabilities**

An examination of the past records of the company revealed that it has made substantial investment in production technologies in the last five years. Since the company has a 24 hours production policy, it views investments in appropriate technology as critical. New production technologies have been introduced regularly with 10% of the old machines replaced annually.

In addition to production capabilities, the company also recognises the need for efficient planning, and scheduling of its operations. On average, the company accepts a daily order of 25 thousand meters for specialised and regular products, which is approximately its full capacity. Successful completion of this order is highly dependent upon proper and efficient capacity utilisation of its production facilities. To add to the complexity, the company has a variety of machinery with differing production rates and qualities. For example, the company has three machines namely Saurer, Tajima and Gigliotti that run 24 hours per day. The production rates are 1000, 100 and 500-1000 meters per day respectively. Tajima is a multi-head embroider machine that produces fabrics of the highest quality compared to the other two machines. Selling price and demand for the product from Tajima machines are very high. Based on the capability of the machines, jobs are allocated (scheduling) to them in accordance with the received orders. For long term customers, Textile Co. uses historical orders to forecast their demand. These forecasts are also used as input for production planning and scheduling.

5.2.3.2 **Communication and logistics capabilities**

Efficient communication capability is vital for the businesses operating globally. The production lead time, which is the period from the day of receiving the order until the product reaches the customer, varies from six to eight weeks for normal orders and about four weeks for urgent orders. In order to facilitate production planning and scheduling given this tight time frame, Textile Co. has invested in the appropriate communication infrastructure that would give maximum flexibility. For example, all employees in the sales and planning division are provided with the latest Personal Digital Assistants (PDA) such as BlackBerry communication system (a Wireless handheld device that provides access to email, corporate data, phone, web, and organiser features). They use Skype to communicate with customers in the UK and USA, and Kiwi for Switzerland and Germany. This helps to schedule or re-schedule production. Nearly ten percent of the total profit of the company is claimed to be spent on technology improvement and employees training every year. The company spent around ten million Indian rupees to have SAP in place. The company is using SAP ERP software and SAP CRM software for enterprise resource planning, production planning and scheduling, forecasting and customer relationship management.

Communication facilities with upstream supply chain members generally relies more on long term relationships than on technologies. Most of the suppliers of raw materials are located in close proximity and are usually contacted through telephone and fax. Based on the information on production lead time and customer orders, the ERP software automatically generates inventory status reports that are used by the company to place raw material orders. The company never experiences a shortage of raw material thanks to their long term relationship with the suppliers.

However, Textile Co.'s performance in using appropriate third party logistics provider (3PL) has not been found to be satisfactory in the past few years. In estimation of production time, Textile Co. arranges a 3PL to deliver finished products to their customers in Europe or USA. The company has experienced a higher transportation time through local 3PLs, which becomes crucial especially when the production is delayed. In those cases, Textile Co. has used their customers' preferred logistics service at higher cost to secure fast delivery. This problem is expected to be avoided through more efficient communication with the 3PLs.

5.2.3.3 **Planning and forecasting capabilities**

Planning plays a major role in supply chain processes such as production and replenishment. As an increasing number of orders impose tighter production capacity constraints on Textile Co., the company keeps its production plans ready at least three months in advance. The company also requests a minimum number of orders from their clients to schedule and allocate jobs to different production units. Although production takes 4 to 6 weeks, the company proclaim their total lead time (time span between order and delivery/replenishment) to be 8 weeks for irregular orders.

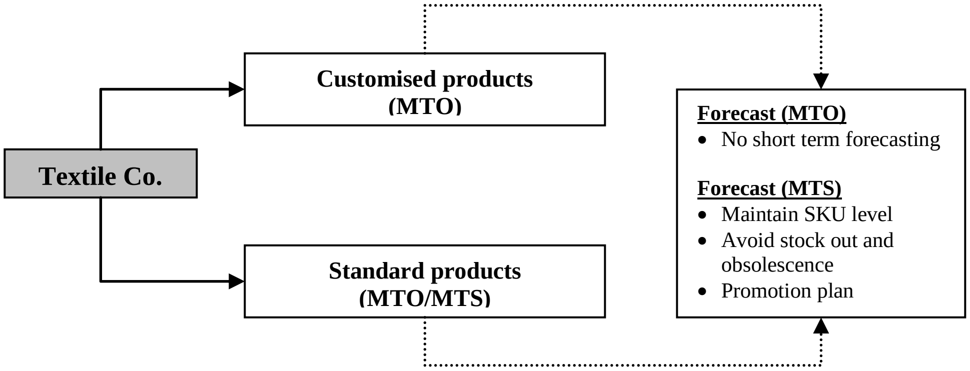
Whilst, Textile Co. independently delineates their production and material resource planning, the company encourages their customers to get involved in promotional sales planning. Textile Co strongly supports sales promotions as it is essential for improving sales of newer products. In addition, sales promotions for established products are believed to retain customers and hence create long term relationship with buyers.

Once the promotional plans are finalised, the forecasting of promotional sales is collectively done with the cooperation of all downstream members (buyers), who are involved in promotions. Production planning and material procurement planning of Textile Co. are dependent on forecast figures. A draft job schedule is also planned in advance helping Textile Co. to decide on job outsourcing depending on the availability of production capacity. Here it is worth noting that all of the machines do not make similar products and hence job scheduling becomes more and more essential for uninterrupted production and replenishment. For example, if promotional sales are scheduled at the same time period for two different market leaders (competitors), the company needs to produce exclusive products for both of the companies at the same period. This requires more sophisticated machines which are obviously out of reach of the normal capacity and hence some of the jobs need to be outsourced. These managerial decisions are very much dependent on forecasting.

For MTO products Textile Co. does not need to make short term demand forecasts. Customers' orders are entered into the MRP system. The MRP engine then generates purchase and production orders.

The company has been engaged in collaborative forecasting for several years. Textile Co. is using sales forecasts in its production planning and replenishment for MTS products (see Figure 5-2). In order to improve forecast accuracy, the first and foremost step is supply chain collaboration with downstream and upstream supply chain members. The current collaborative arrangements of the company with the other supply chain partners are described in the next section.

Figure 5-2 Importance of forecasting in Textile Co.


Customised products (MTO)
Textile Co.
Standard products (MTO/MTS)
Forecast (MTO)
No short term forecasting
Forecast (MTS)
Maintain SKU level
Avoid stock out and obsolescence
Promotion plan

5.2.4 Supply chain collaboration at Textile Co.

5.2.4.1 Supply side partnership

Textile Co uses only yarn and dye as their primary raw materials. As mentioned earlier, suppliers are located in close proximity and hence obtaining these materials on-time, before actual production, is not a difficult task for the company. Yarn is supplied by Indorama, Reliance and Wellspun. Dye is purchased from mixed sources. Japanese and European manufacturers supply major machinery to the company. The supplier selection is mainly based on the quality of raw material and their prompt delivery.

Textile Co enjoys several benefits due to long term relationships with its suppliers. The supply of raw material is guaranteed at the production site of Textile Co. almost all of the time. Reliability on the supply side enables Textile Co to maintain hassle free production. Good relationships with suppliers are found to be essential at the time of unexpected bulk orders from retailers and also at the time of promotional sales. The suppliers' contribution in improving the quality of the products is through suggestions on the use of raw material. At times, suppliers also give guidance on the variety of raw materials available in the market that are suitable to particular production. Any change to the existing government policy on use of raw material is usually notified to the manufacturer through the supplier. In return for such benefits from suppliers, Textile Co. prefers to have formal agreements with their suppliers for a definite period of time. These guaranteed orders from Textile Co. are motivating suppliers to be involved in collaboration. Textile Co. also encourages the suppliers' collaboration for improved quality and reduced cost.

5.2.4.2 **Partnership with customers**

While collaboration with suppliers is simple and straightforward, Textile Co. carefully plans the collaborative arrangement with its downstream supply chain partners. As the company’s business is mainly supported by regular repeat orders, promotions and seasonal sales, establishing a comfortable long term partnership is sensed highly essential.

Sales promotions are usually planned for improving sales of existing products and new products. Promotions can be initiated by retailers or by manufacturers. In either case, a close coordination between manufacturers and retailers is important. Some regular customers of Textile Co. e.g. Jo-Ann stores predict sales of new products through initial promotions. Textile Co supports these promotions by supplying sample material at a subsidised cost. Such samples are one of the strong business strategies of Textile Co. in establishing relationship with their customers. Orders from customers are directly proportional to the sales of sample materials. Information on promotional plans is regularly exchanged between Textile Co. and customers. Other types of promotions, based on local festive seasons are communicated to Textile Co. through their customers. This supports the company’s decision making at the time of a new product launch.

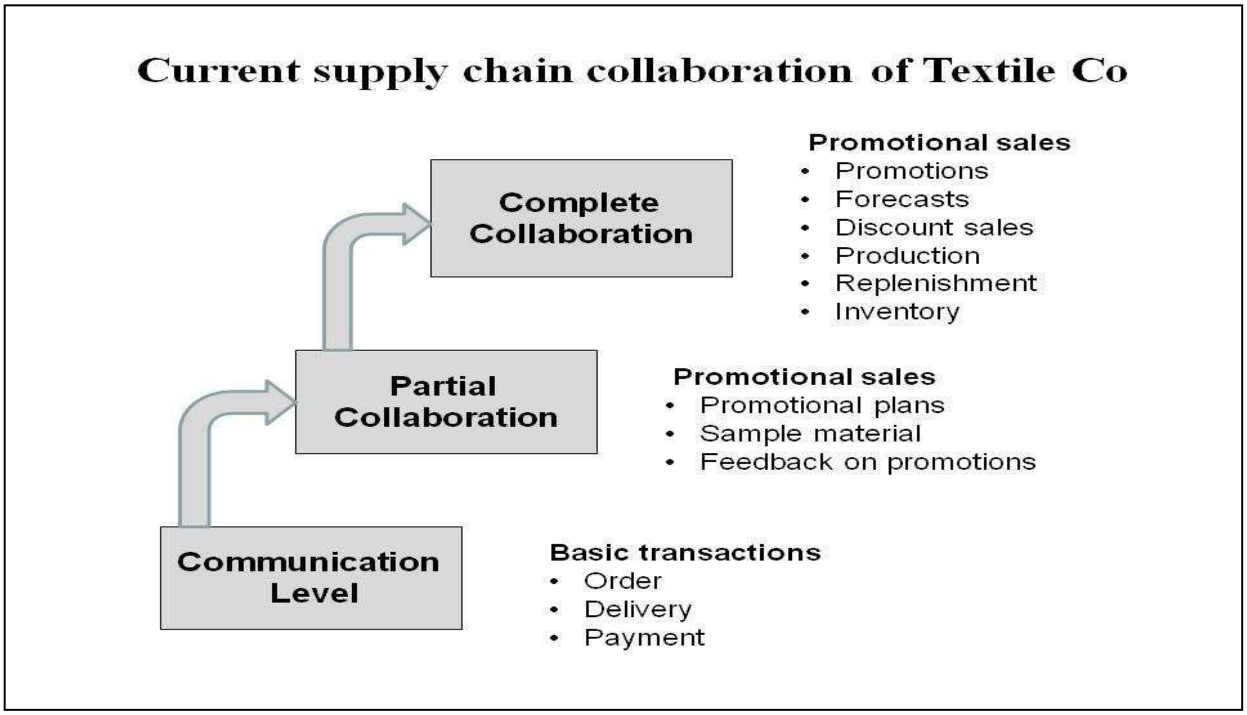
The company maintains three levels of collaboration with their downstream partners. The first involves a minimum level communication for orders and replenishments. This is usually for new or relatively new customers and also for those who are not dealing with regular business orders. The second level of collaboration is for customers involved in promotions but not having ‘minimum order’ policy agreements. In the highest level of collaboration, Textile Co. and collaborating partners exchange information, promotion plans, and maintain agreed level of minimum orders. See Figure 5-3 for the as-is collaborative arrangement of Textile Co. with their downstream customers.

Although Textile Co. maintains various levels of collaboration, it plans its promotional sales with all customers participating in promotional sales. Accordingly, the planning cycle at Textile Co. spans a whole year and will be discussed in the next section.

5.2.5 Planning cycle at Textile Co.

Promotional planning is highly valued at Textile Co for production and resource planning. Promotions are mainly of two types. The first type of promotion is a price reduction at the time of new product launch, while the other promotions are for established products. During the product launch Textile Co. initiates promotions with support from the buyers and runs the promotion for two months. Once the product is successful in the market, the buyer decides on their interest of having further sale of that particular product.

Figure 5-3 Current supply chain collaboration of Textile Co.



Current supply chain collaboration of Textile Co
Complete Collaboration
Promotional sales
• Promotions
• Forecasts
• Discount sales
• Production
• Replenishment
• Inventory
Partial Collaboration
Promotional sales
• Promotional plans
• Sample material
• Feedback on promotions
Communication Level
Basic transactions
• Order
• Delivery
• Payment

This decision leads to ‘Exclusive right for product design to the buyer’. Exclusive right is an assurance of repeat orders from clients throughout the year. At the same time, an exclusive right policy keeps the company working around the clock to make a variety of products with more designs to attract many customers, as some of the products designs (with exclusive rights) cannot be marketed anywhere other than by the agreed customers. Duplication of the design is absolutely not possible and hence Textile Co. retains an innovative design team as an integral part of the workforce.

For new products, promotional plans are started three months after their launch, but it is formally confirmed after obtaining a better understanding of the buyers’ interest by monitoring initial sales. Both the company and the buyers collaboratively make their promotion plans in the middle of the fourth month. The Company calls this period the ‘warm-up-period’. Forecasting and planning in advance (about six months) helps the company to replenish goods on time and run promotions without great deal of difficulty. But unexpected over sale of products creates complexity as the production needs 2 to 4 weeks time depending on the inventory of partly finished products. Here, it is worth mentioning that the products are undergoing almost the same processing steps. Customisation such as embroidery and other designs are postponed until the final stage and require sophisticated machines. The sales of the embroidered materials are high during the promotions (see Figure 5-4).

Figure 5-4 Sales at Textile Co

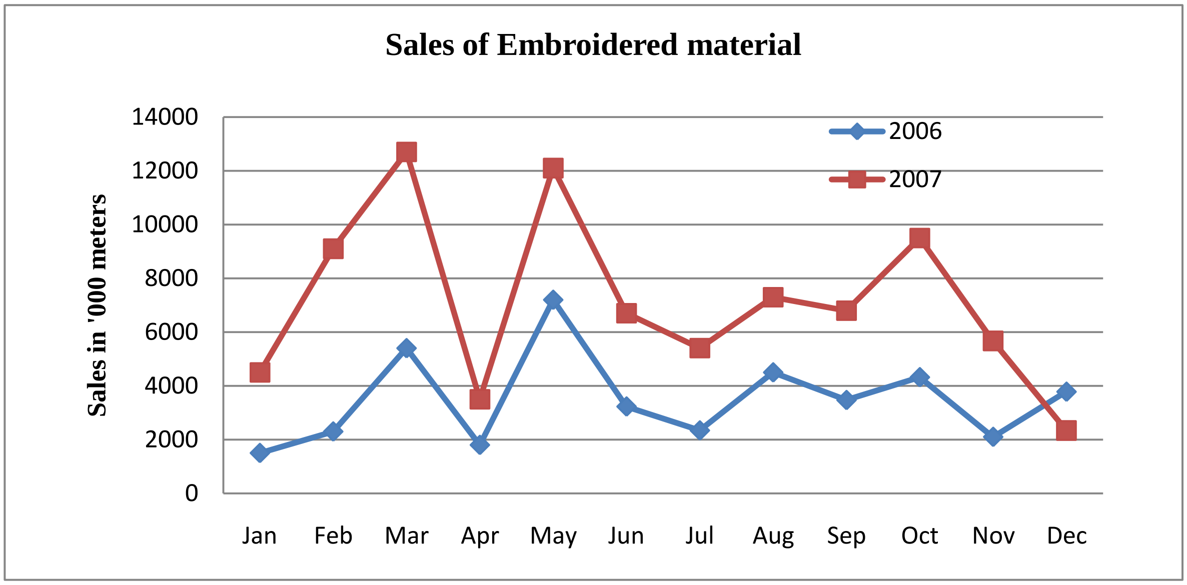
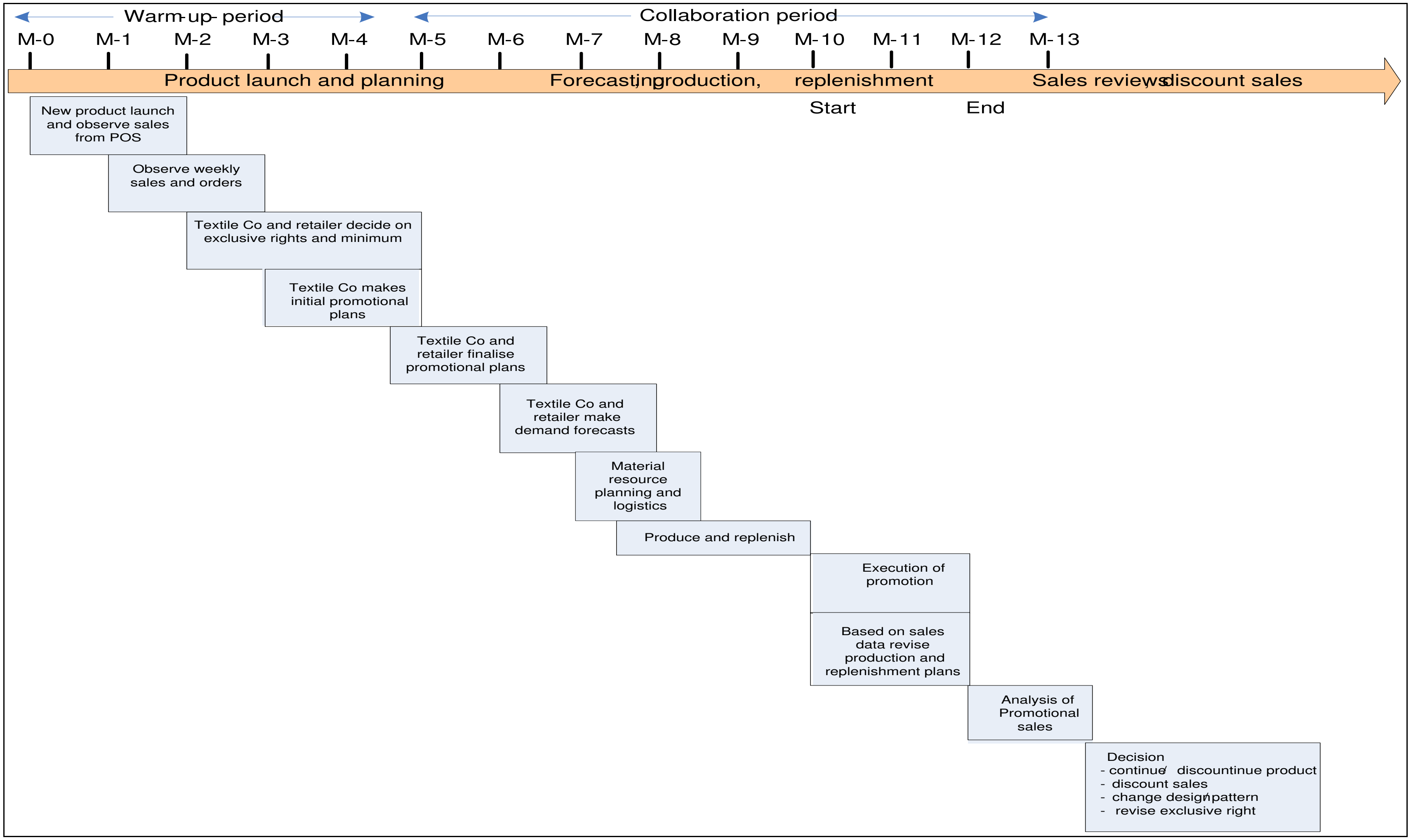


Figure 5-5 represents the planning cycle at Textile Co. The company monitors the initial sales for the first two weeks. If the sales are above their initial forecast then the company tries to replenish as much as possible in the fourth week of promotion. Final sales reviews by both the parties assist them in deciding on future promotional/discount sales. The frequency of sales promotions for each product ranges from two to a maximum of eight times a year. As mentioned before, each of these promotions runs for about two months.

Textile Co.'s planning cycle includes the company's CPFR plan for the first five months after the launch of a new product. For established products, the warm-up period (first four and half months after the product launch) is not required and sales promotions can start once the deal between Textile Co. and retailer is finalised. During promotional sales, the sales information from downstream supply chain members assists the company to quickly act upon the demand.The value of information exchange in Textile Co.'s supply chain is discussed in the next section.

Figure 5-5 Planning cycle at Textile Co.


Warm-up period
Collaboration period
M-0
M-1
M-2
M-3
M-4
M-5
M-6
M-7
M-8
M-9
M-10
M-11
M-12
M-13
Product launch and planning
Forecasting, production, replenishment
Sales reviews, discount sales
Start
End
New product launch and observe sales from POS
Observe weekly sales and orders
Textile Co and retailer decide on exclusive rights and minimum
Textile Co makes initial promotional plans
Textile Co and retailer finalise promotional plans
Textile Co and retailer make demand forecasts
Material resource planning and logistics
Produce and replenish
Execution of promotion
Based on sales data revise production and replenishment plans
Analysis of Promotional sales
Decision
- continue/ discountinue product
- discount sales
- change design/pattern
- revise exclusive right

5.2.6 Value of information in planning and forecasting at Textile Co.

5.2.6.1 General information

It is obvious from our study that the production in Textile Co is heavily dependent on initial forecasts. Although all the production is based on forecasts, some of the customised products get their final touch towards the end of production cycle only. In the production cycle prior to the promotion (see M-7 and M-8 in Figure 5-5). Textile Co. can also include some changes, like colour or design, based on the current sales at retail stores. This is indeed highly essential as the sales of textile materials are affected by seasonality, economic factors and market trends.

In the context of sales, seasonality is one of the main factors affecting the sale of textile products. Usually demand for cotton material is higher in summer and lower in winter. Textile Co. can generate this seasonal information from its own records for its long term customers. This information is also found valuable for new customers. Seasonality is a main concern for standard products but not for customised products.

Economic downturn usually gets reflected in the sales of textile materials. To avoid inventory cost and to get rid of overstocks, discounts are offered by retailers to sell slow moving products. Information on discounts from retailers will alert manufacturers to any shortcoming in the design of the product and the need to sell the product at a lower price. But information on discounted sales is not readily available to Textile Co. The company persuade their customers to convey discounts offered at their store in detail. This information assists them in planning.

The demand pattern of a product can be analysed through the sales data. Sales data can give a comprehensive picture of a prevailing market trend. But the trend is not always stable due to external factors such as inflation of the local currency and natural calamities. Sometimes, customer order information acts as a baseline to trace the demand pattern. Governmental policies of the local markets, such as prohibited types of dye or yarn, are known through the customers. Another vital piece of information in predicting demand is competitor information. The company is collecting this data through third party (3P) information providers and trade fairs.

5.2.6.2 **Product specific and customer specific information**

Based on the type of product, the information need for demand forecasting varies. To make accurate forecasts for standard products, Textile Co talks to many supply chain partners and needs to know the sales information and local forecast from each client. Customised products follow a different demand pattern and predicting demand is more difficult. In this case, forecasting requires some additional information such as customers’ satisfaction and feedback on the product. As the number of customers is limited for the customised products, it is possible for Textile Co to involve all of them in the forecasting process. Textile Co contacts those customers on weekly basis to track details.

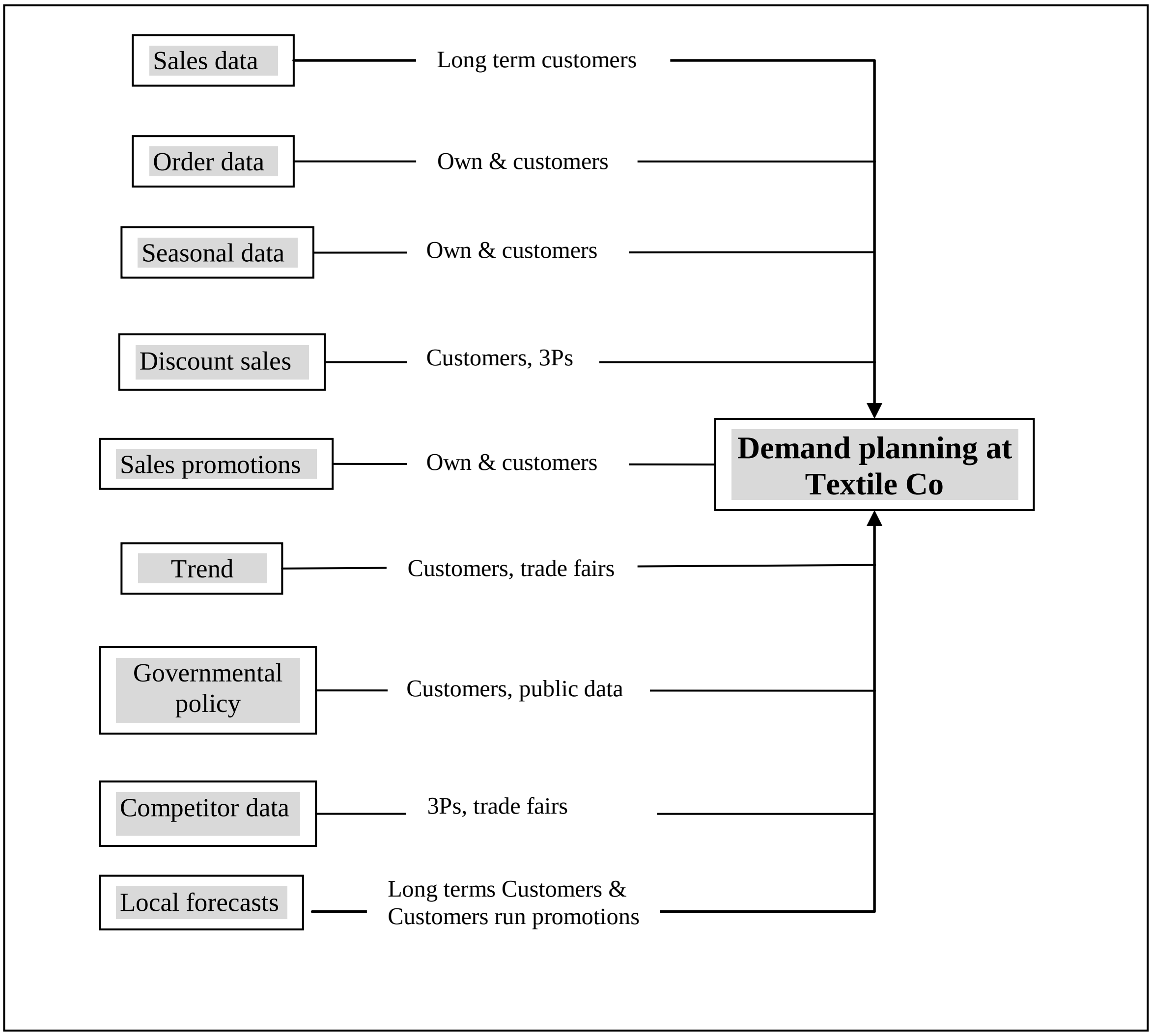
Customers with regular repeat orders create a close partnership with Textile Co and the company maintains a record of orders. In this case, Textile Co. can easily trace orders and demand patterns of their product. In practice, communication between the customers and Textile Co. is on weekly basis. The company achieves a better forecast accuracy in the case of regular repeat orders. Textile Co. faces more uncertainty in the case of irregular orders. Several attempts to communicate with those customers failed in the past due to lack of co-operation from the customers.

5.2.6.3 **Sales information and local forecast**

Sales promotions are aimed to increase the sales of a specific new or existing product in the targeted market. Although the cost involved in a Textile Co induced promotion is quite high (as Textile Co gives a free samples to some of the customers), the company is still interested in promotions as this could help establishing future deals with customers.

Textile Co. receives the total weekly or fortnightly sales figures from their long term customers and more detailed daily sales data during promotional events. For well established customers, records of historical information on orders, sales, discounts etc. are maintained by Textile Co., which helps them to identify demand patterns. Sales forecast are collected by Textile Co. from their customers, these are called local forecasts. Only customers under long term relationship send their own local forecasts to Textile Co. In addition to these local forecasts, all the above mentioned information is also used to create Textile Co.'s demand planning and forecasts (see Figure 5-6).

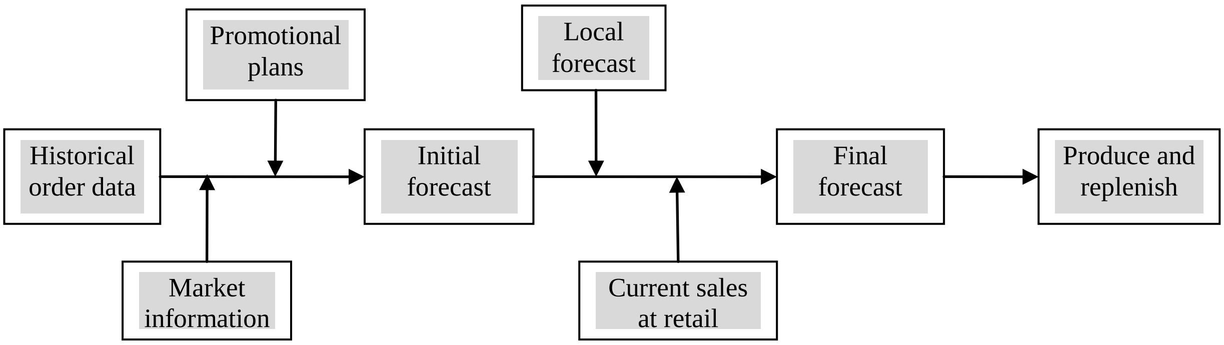
Figure 5-6 Information exchange in Textile Co supply chain


Sales data
Long term customers
Order data
Own & customers
Seasonal data
Own & customers
Discount sales
Customers, 3Ps
Sales promotions
Own & customers
Demand planning at Textile Co
Trend
Customers, trade fairs
Governmental policy
Customers, public data
Competitor data
3Ps, trade fairs
Local forecasts
Long terms Customers & Customers run promotions

5.2.7 Purpose of collaborative forecasting in Textile Co.

Textile Co. makes its initial demand forecasts based on historical order data and then incorporates other inputs such as market information and promotional plans, from other supply chain partners and 3P information providers (see Figure 5-6). Here the market information refers to trend and competitor information of the local market. Figure 5-7 reports the process of forecasting at Textile Co. The promotional plans of retailers are updated by the company before making the initial forecasts. This initial forecast is then updated with the local forecasts of retailers. Before making the final forecasts, Textile Co. observes the sales at the retailers' outlet. This helps the company to understand current customer preferences. The final forecasts are used by Textile Co. for productions (see Figure 5-7). Textile Co claims that their forecast accuracy of the promotional sales is about 75%.

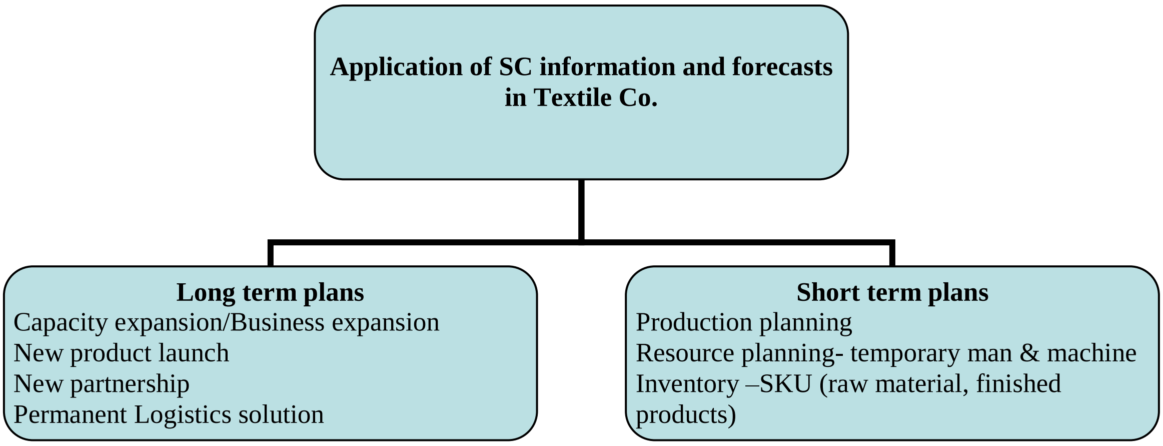
Figure 5-7 Forecasting at Textile Co.


Promotional plans
Local forecast
Historical order data
Initial forecast
Final forecast
Produce and replenish
Market information
Current sales at retail

Decision makers at Textile Co prepare long term expansion plans and short term production plans based on the final forecasts, which are combinations of all the information as specified in Figure 5-6. Textile Co. aims to improve their business by the way of repeat orders from customers. The capacity expansion plans are continually reviewed with the sales figures. To obtain repeat orders the company is also concentrating on on-time delivery.

Fast delivery or replenishment at Textile Co. is found to have a direct relationship with repeat orders from the customers. Hence, Textile Co. tries to achieve a lower lead time and a fast replenishment by expanding the production capacity. Return on investment has not declined in the past. Hence, Textile Co.'s interest in making accurate forecasts in their make to stock business seems convincing. Figure 5-8 summarises the purpose of information exchange and forecasts at Textile Co.

Figure 5-8 Application of supply chain information and forecasts


Application of SC information and forecasts in Textile Co.
Long term plans
Capacity expansion/Business expansion
New product launch
New partnership
Permanent Logistics solution
Short term plans
Production planning
Resource planning- temporary man & machine
Inventory –SKU (raw material, finished products)

Textile Co. uses quite a large number of observations from various supply chain partners and 3P information providers for forecasting their product demand. The idea of using information from various sources has led to the construction of a reference demand model (see Section 6.3). Though Textile Co. enjoys the benefits of having supply chain collaboration with some long term customers, it also faces some complexities in establishing collaborations with other customers. This is further explained in the next sub-section.

5.2.8 Some complexities

Currently the company maintains complete collaboration with partners who place repeat orders. Based on the value of orders, the collaboration level is maintained. But, repeat orders for standard products are less profitable compared to repeat orders of customised products with exclusive right. Hence, Textile Co. tries to increase the number of customers with exclusive rights. In this effort, the company invests a large amount of money for initial sales promotions. On the success of these promotions, Textile Co. establishes long term collaborations with these customers. At this point the company depends on information from customers to predict sales demand. Otherwise, the company concentrates on regular sales and a few promotions as agreed upon earlier with their partners. In this case, the customer exchanges only promotional sales details and Textile Co. uses order data for their regular forecast. To survive the competition and to retain their position in the market, Textile Co. spends a large amount of money on marketing such as trade fairs. Although this is beneficial to the company in attracting many new customers, the global economic slowdown makes further deals difficult.

It is a big challenge and possibly a too costly strategy for the company to maintain a long term partnership with all the customers. A Reference Demand Model can help the company to trace the right information path and to decide on the right level of collaboration with different customers. This is further explained in Chapter 6.

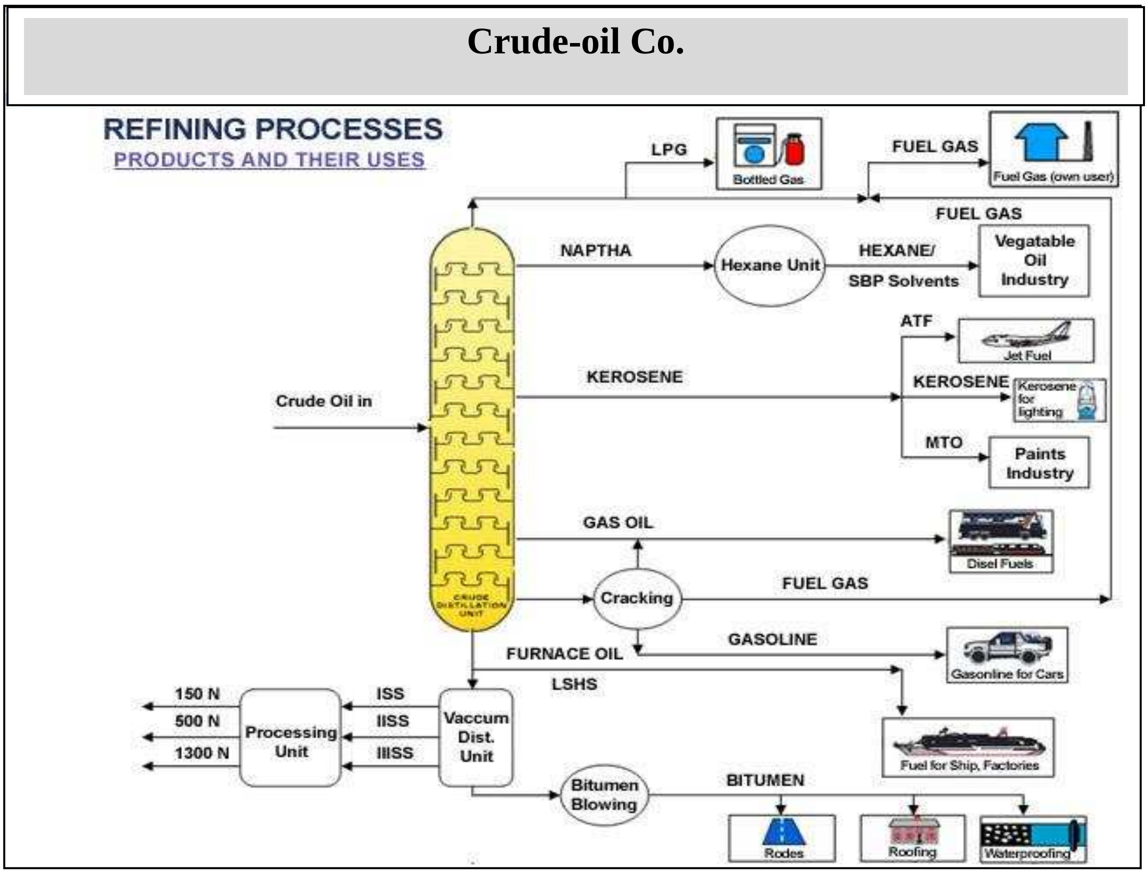
5.3 Study 4 – Crude-oil refiners and distributors

5.3.1 Company Profile

Crude-oil Co. is a fortune 500 company with an annual turnover of over 740,440 millions Indian rupees. It has nearly twenty percent of the refining & market share in India. It is one of the leading crude oil refiners and distributors catering for the local demand in the Indian market. Crude-oil Co. has two refinery plants, one in Mumbai and another in Vaisakh, India. The current capacity of the refinery is 6.5 million metric tons per annum in each of these plants. The main administrative offices are operating from four metropolitan cities and it has 85 regional offices facilitated by a supply & distribution infrastructure comprising Terminals, Aviation Service Stations, Bottling Plants, and Inland Relay Depots & Retail Outlets.

Crude-oil Co. is also producing lubricant oils. With a capacity of 335,000 metric Tons of lubricant oil refinery, the company accounts for over 40% of the country’s total lubricant oil production. Crude-Oil Co. has retail outlets all over the country. The case study was conducted at Crude-oil Co. distribution centre, Chennai, on the southern coast of India. Its primary and only supplier is CPCL. Crude-oil Co. is one of the four main distributors for the products namely Gasoline, High Speed Diesel, Superior Kerosene Oil, Furnace Oil, Light Diesel Oil, and Aviation Turbine Fuel (see Figure 5-9).

Figure 5-9 Products of Crude-Oil Co.


Crude-oil Co.
REFINING PROCESSES
PRODUCTS AND THEIR USES
LPG
Bottled Gas
FUEL GAS
Fuel Gas (own user)
FUEL GAS
NAPTHA
Hexane Unit
HEXANE/
SBP Solvents
Vegatable Oil Industry
ATF
Jet Fuel
KEROSENE
KEROSENE
Kerosene for lighting
MTO
Paints Industry
Crude Oil in
GAS OIL
Disel Fuels
CRUDE DISTILLATION UNIT
Cracking
FUEL GAS
GASOLINE
Gasonline for Cars
FURNACE OIL
LSHS
Fuel for Ship, Factories
150 N
500 N
1300 N
Processing Unit
ISS
IISS
IIISS
Vaccum Dist. Unit
Bitumen Blowing
BITUMEN
Rodes
Roofing
Waterproofing

Source: Crude-oil Co.

In some parts of the country, the distribution of crude oil is managed directly by the company (through pipelines and trucks) and in other parts the company distributes its products through other operators. The company has three different roles in the supply chain such as direct distributor, supplier to distributor and supplier to wholesaler. Down-stream customers of Crude-oil Co. are mostly tier 2 and tier 1 supplier in the supply chain. These clients are distributors to many other private and public customers.

As the number of motor vehicles is increasing every year, the demand for petroleum products also follows an increasing trend. Meanwhile, projecting product demand becomes mandatory for all of the supply chain partners to be viable in the market.

5.3.2 Collaborative arrangement

Crude-oil Co. is striving to establish and maintain a friendly relationship with its supplier and downstream customers. Crude-oil Co. has a permanent office space in their supplier CPCL's working area. Transparent and quick information exchange between Crude-oil Co. and its supplier assists to have responsive and flexible supply chain. This collaborative arrangement helps Crude-oil Co. to co-ordinate the distribution and avoids any problems in replenishment. Some of the retail outlets are directly connected with the Crude-oil distribution plants through pipelines. The lower inventory level at the retail outlet will prompt an indication to the main distribution plant. Due to this technological advancement, it is easy for Crude-oil Co. to check retailer's inventory and plan replenishment accordingly.

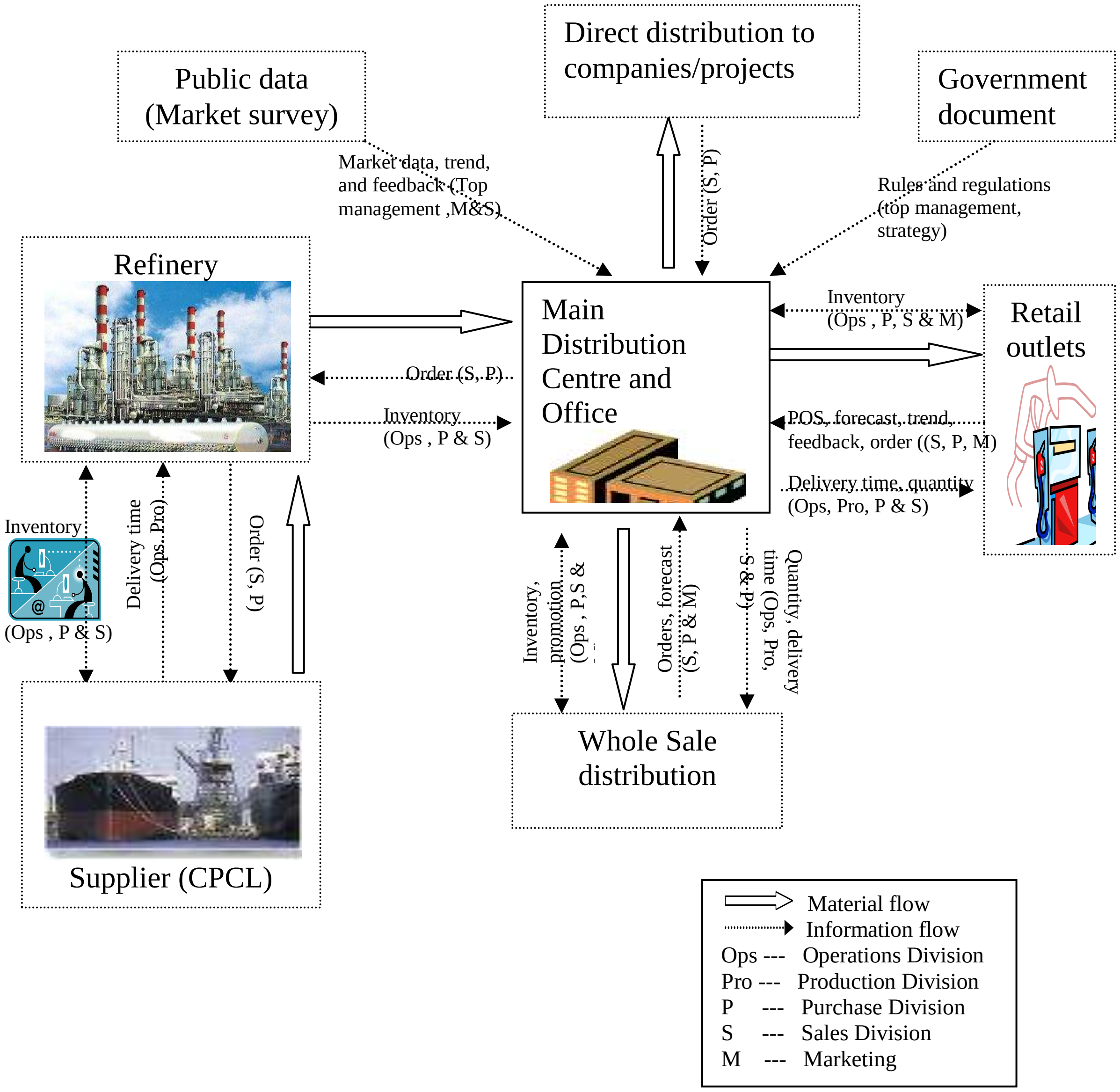
Nearly twenty percent of the retailer outlets automatically provide information to Crude-oil Co. This makes demand forecast easier and facilitates timely replenishment. The retailers who are involved in supply chain collaboration are connected by an automated inventory tracking system which makes them aware of other retailers' inventory levels. Crude-oil Co. is committed to making timely replenishment for the clients involved in collaboration. The company practices vendor managed inventory (VMI) for timely replenishments. For example, if the inventory tracking system indicates a low inventory level at retail-A then Crude-oil Co. will try to replenish at retail A either by sending a truck or by inventory pooling. If retailer A and retailer B are connected by pipeline, any shortage of crude-oil at retail-A will be compensated by excess inventory at retailer B (this is called inventory pooling). The pipeline connection between the two or more retailers makes replenishment easier for Crude-oil Co. The collaborative arrangement among different retailers and Crude-oil Co. avoids stock-outs and also reduces inventory. A strategy of inventory pooling by Crude-oil Co. facilitates to maintain sustainable distribution in many of the branches by balancing inventory between high demand outlets and low demand outlets.

A pilot study with Crude-oil Co. helped to observe the role of suppliers and down-stream customers in the supply chain. Unlike other case studies, the local Government is also playing a main role in Crude-oil Co.'s supply chain. The sales price of crude oil is fixed by the local Government. At the same time, the local Government decides the maximum number of automobiles (cars and bikes, trucks etc.) in every state of the country. This limitation controls the demand fluctuation of crude oil.

Though crude-oil is a rare commodity in India, the demand for crude-oil in recent years has increased considerably. However, Crude-oil Co. depends heavily on a single supplier and hence the company maintains a high level of collaboration with its supplier to ensure timely replenishment. With respect to downstream customers, such as wholesalers and retailers, the company has established a well structured collaboration to know inventory levels, this helps with timely replenishment (see Figure 5-10). Various divisions of Crude-oil Co. such as marketing, operations, production, sales, and purchase are involved in collaboration with down-stream and up-stream customers.

From Figure 5-10, it can be seen that the supply chain information of the company is mainly focusing on the orders from the clients and timely replenishment at the distribution outlets. The company has not much benefited from the information its suppliers pass on but needs the support of suppliers to assure timely replenishment to down-stream customers. The tight supply constraint is making the planning team of the company concentrate more on avoiding stock-outs than forecasting future demand.

Figure 5-10 Supply chain of Crude-oil Co.– Information flow and material flow


Direct distribution to companies/projects
Public data (Market survey)
Government document
Market data, trend, and feedback (Top management ,M&S)
Order (S, P)
Rules and regulations (top management, strategy)
Refinery
Main Distribution Centre and Office
Inventory (Ops , P, S & M)
Retail outlets
Order (S, P)
Inventory (Ops , P & S)
POS, forecast, trend, feedback, order ((S, P, M)
Delivery time, quantity (Ops, Pro, P & S)
Inventory
(Ops , P & S)
Delivery time (Ops, Pro)
Order (S, P)
Inventory, promotion (Ops , P,S &
Orders, forecast (S, P & M)
Quantity, delivery time (Ops, Pro, S & P)
Whole Sale distribution
Supplier (CPCL)
Material flow
Information flow
Ops --- Operations Division
Pro --- Production Division
P --- Purchase Division
S --- Sales Division
M --- Marketing

5.4 Summary

Chapters four and five explained the current (as-is) scenario of supply chain collaboration in five different case companies. In Chapter 4, the supply chain collaboration of Soft Drink Co. with down-stream retailers and wholesalers was illustrated separately in two different cases. In Chapter 5, the supply chain collaboration of Textile Co. with their retail partners was described in detail. Then a simple supply chain collaboration of Crude-oil Co. with their customers were explained. Two more cases, Packaging Co. and EEM Co., are explained in Appendix-I for better understanding of the information flow and its role in the supply chain. In all of these cases, the supply chain information exchange was illustrating its impact on various processes of supply chain specific to planning, forecasting, production and replenishment. The individual Reference Demand Models will be developed and analysed for Soft Drink Co. and Textile Co. in the next chapter to evaluate the importance of SC information.

Chapter 6 Conceptual model development

6.1 Introduction

Exploration of the literature on supply chain collaboration and subsequent formulation of the research questions guided to the development of a conceptual model called a 'Reference Demand Model' (RDM). The construction of RDM is done in three steps. In the first step, information on demand factors are listed and grouped under relevant categories. In step two, various attributes of the demand information are explained. In step three, each demand factor is analysed according to the different attributes explained in the step 2. The RDM will be illustrated for the cases of Soft Drink Co. and Textile Co. Interpretations of RDM of case companies are made based on the analysis to decide on the inclusion of the information in the supply chain processes. This chapter starts by explaining the purpose of developing RDM. To facilitate the understanding of RDM development and the role of SC information in RDM development, the key ideas are explained with the example of Soft Drink Co.

6.2 Development of Reference Demand Model (RDM)

A Reference Demand Model (RDM) is a model representing the dependency of demand projection on information from different supply chain members (Aviv, 2007). The RDM can be highly qualitative or quantitative depending on the information available. This research develops a RDM in the form of a qualitative conceptual framework. Before developing the proposed RDM, it is important to make its purpose and its role in collaborative planning clear.

6.2.1 Purpose of RDM

The development of RDM aims to be an important tool to identify any discrepancy in actual sales and forecasted sales. RDM also aims to assist managers in one or more of the following:

- To plan and design information sharing among different SC members
- To improve the demand forecast accuracy by identifying relevant explanatory demand factors
- To improve production and material planning
- To improve on-time replenishment
- To identify areas where the forecasting process can be improved
- To decide on the future role of information in SC processes
- To align supply chain planning and information sharing
- To decide on the level of collaboration

Developing the RDM aims to assist managers in business sectors by the way of having a standardised procedure for planning and forecasting. This will also enable managers to decide on the right level of information sharing. Sharing of demand information and local forecasts among SC members improves mutual understanding of the different SC members' on SC processes and constraints.

6.2.2 Role of information exchange in developing RDM

In general, business processes greatly rely on products' demand forecast; this in turn enables all SC members to plan, produce, and replenish in good time. Thus, accuracy in demand forecast is considered as one of the important criteria for the success of supply chain processes. To improve forecast accuracy, SC members need to exchange sales related information (Lee et al., 2000). However, the information needed for demand projection varies broadly and depends on the products life cycle stage and promotional sales. In some cases, supply uncertainty may also have an impact on product demand (Lee, 2002). For example, supply uncertainty of rare metals such as palladium and titanium may indirectly influence the demand of original equipment in aerospace manufacturing companies. Generally, the demand of these products is predicted based on historical demand information (Raghunathan, 2001). In certain circumstances, like promotions, other information such as stock level and point of sale data will be considered during replenishment. This will help reduce inventory costs (Lee et al., 2000). In practice, the demand forecast of a product may also incorporate various other aspects of information which are not usually looked into carefully.

- Who observes the market signal?
- Who is the owner of the information (i.e., responsibility)?
- What are the types of data available?
- When is the information available?
- How is this observed sales information being exchanged to other supply chain members (technology)?
- How fast this information is exchanged (quickness of obtaining data)?
- Is the available data actionable (to act upon the current supply chain)?
- How accurate is the information?
- How important is this information?
- Is this information currently used in forecasting?

By looking at the above questions, a structured plan can be developed to identify the supply chain information and its importance for planning and forecasting. Subsequently, this plan will help managers to trace the information and its source(s). Then by evaluating the information, managers can interpret the results to decide on whether to include the information in the decision making or not. In order to evaluate certain information, it is important to take account of several aspects regarding the demand signals. This idea of a systematic approach to identifying and collecting relevant SC information is captured through RDM. To understand the development of RDM, the ideas are applied to Soft Drink Co. Information collected through a series of interviews with the case companies has helped to identify the factors influencing demand and also to identify data requirement for demand forecasting. The three steps in developing RDM are explained further.

6.2.3 Step1 of RDM - Information on demand factors

Various pieces of information from downstream partners may be essential to improve performance of various SC processes, such as forecasting and replenishment (Gavirneni et al., 1999; Lee et al., 2000; Aviv, 2002).

It is widely agreed that the changing trend in the consumer market impose more challenges to manufacturers (Sun, 2005). Hence, the right price for the products has always been a great dispute in a competitive market. In order to improve performance and to earn profit, companies need to have good planning and higher level of accuracy in demand forecasts. This necessitates the SC planners to consider as much information as possible in planning and forecasting.

The literature on supply chain management reveals that predicting demand for functional products is usually easier compared to forecasting demand for innovative products (Lee, 2002). But in recent years, the changing habits of consumers have posed more of challenges to forecasting teams irrespective of the type of products produced. Sales promotions may have a great influence on buying patterns and complicate the forecasting process. Less complicated seasonal sales are also no longer easily predictable due to external forces such as inflation or changing market trends (Fisher et al., 1994; 1997).

From the literature review, it was identified that inventory and POS were common pieces of information shared among SC collaborative partners (see Table 2-4 for literature on information sharing). This concept of information sharing helps to form a first step in developing RDM. In this step, detailed list of information shared among SC members is collected and grouped. Step 1 is illustrated through the following example.

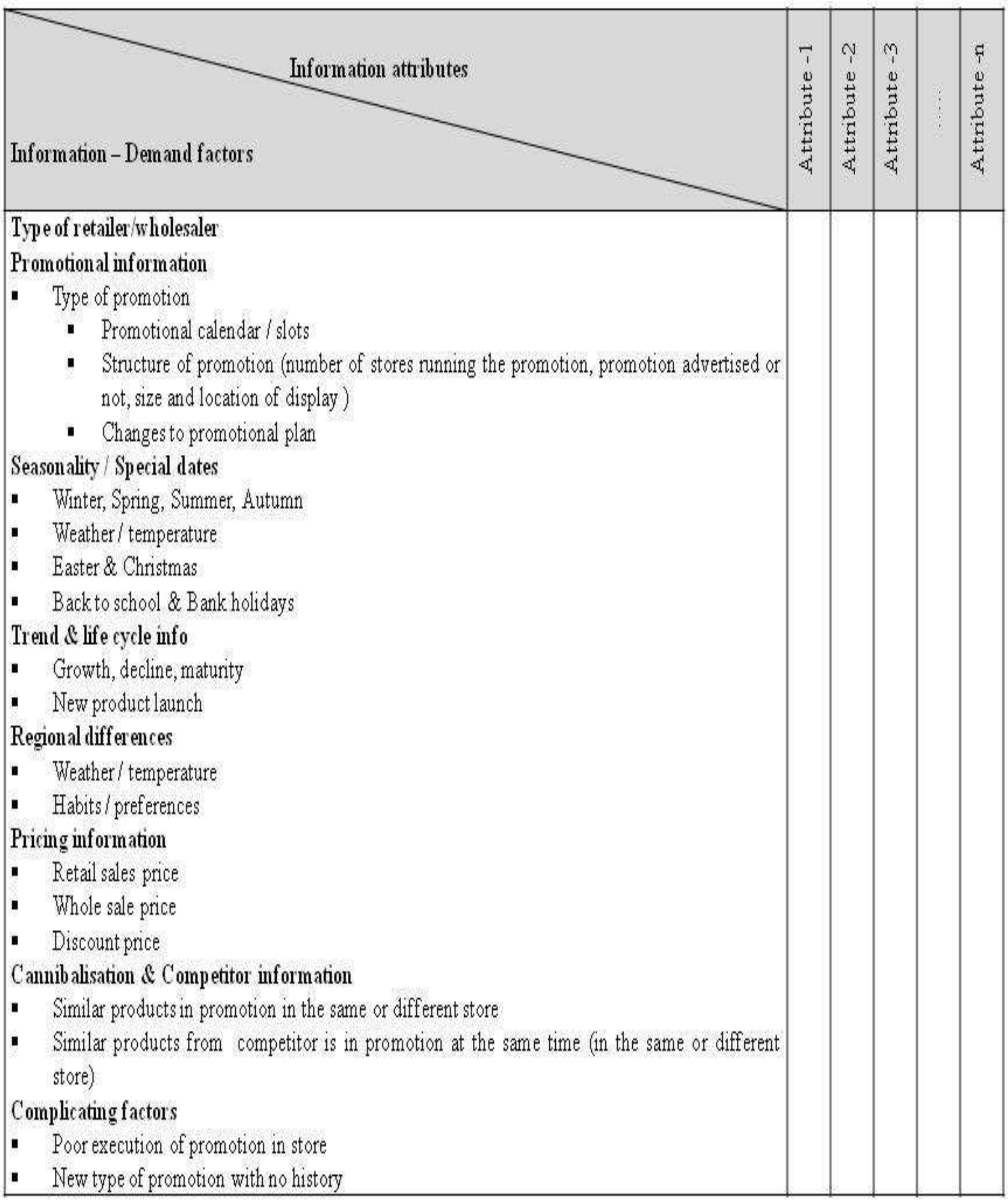
Step 1 - Example from Soft Drink Co

Apart from the basic demand factors (identified from the literature) namely promotions, pricing, seasonal and trend components (Cooper et al., 1999), there are also some other factors identified through case study analysis of Soft Drink Co. namely - regional factors, competition and cannibalisation. See Table 6-1 for a list of information on demand factors identified from Soft Drink Co.

The information related to promotional sales is grouped under 'Promotional information'. The information related to seasons and holidays is grouped under seasonality/special dates. The information related to products life cycle and trends is mentioned separately. The regional factors are more related to culture and habit of a local community. Buying behaviour is partially related to the local temperature. Therefore, the regional factors and temperature are grouped together under the name 'Regional differences'.

In general for all the products, pricing is one of the important factors of sales. Similar products from competitors with low prices may affect the sale of the products of Soft Drink Co. Hence, pricing is considered as a very important factor by Soft Drink Co. For soft drink products, cannibalisation – an increase in sales of one of its products that results in a decrease in sales of another item – is a more specific factor that affects demand. Other complicating factors specific to the sales promotions of Soft Drink Co are identified as poor execution of promotions by the stores and demand forecasts of new products. In Step 1 demand information has been listed under relevant groups (see Table 6-1).

Table 6-1 Step1 of RDM - List of information on demand factors



Information attributes Information – Demand factors	Attribute -1	Attribute -2	Attribute -3	.....	Attribute -n
Type of retailer/wholesaler					
Promotional information					
▪ Type of promotion					
▪ Promotional calendar / slots					
▪ Structure of promotion (number of stores running the promotion, promotion advertised or not, size and location of display)					
▪ Changes to promotional plan					
Seasonality / Special dates					
▪ Winter, Spring, Summer, Autumn					
▪ Weather / temperature					
▪ Easter & Christmas					
▪ Back to school & Bank holidays					
Trend & life cycle info					
▪ Growth, decline, maturity					
▪ New product launch					
Regional differences					
▪ Weather / temperature					
▪ Habits / preferences					
Pricing information					
▪ Retail sales price					
▪ Whole sale price					
▪ Discount price					
Cannibalisation & Competitor information					
▪ Similar products in promotion in the same or different store					
▪ Similar products from competitor is in promotion at the same time (in the same or different store)					
Complicating factors					
▪ Poor execution of promotion in store					
▪ New type of promotion with no history					

Step 2 of developing RDM is explained further.

6.2.4 Step 2 of RDM - Attributes of the information

Step 2 of developing RDM includes various attributes of the information that have been identified from the literature and case studies.

The cost and benefit of obtaining and using information act as a base line to SC information exchange (Sari, 2008). The cost involved in information exchange is measured either in terms of investment on technology and/or amount spent on obtaining information. The benefit of information exchange is represented through good forecast accuracy. The impacts of information exchange can also be measured through improved inventory, production and replenishment (Gavireneni et al., 1999). This research concentrates on the forecast accuracy as the main benefit of SC collaboration. Although accuracy of information is obligatory in reduction of forecast error, it is highly subjective to the explanatory power of the partner involved in the process of information exchange and also the accuracy of the information at the time of predicting demand forecast (Aviv, 2007).

It is also important to mention that the ability of observing market changes and the descriptive nature of the observer can alter the quality or accuracy of the information used for demand forecast (Aviv, 2002). For example a sudden change in temperature may increase the sale of beverages but will not help to alter the production plan at very short notice. But correct inventory deployment in the supply chain will assist in smooth replenishment. Hence, action-ability of the information obtained is partially related to the agility and responsiveness of the supply chain. This study considers six major attributes of information namely–source, cost availability, reliability, action-ability and importance of information. These attributes act as evaluation criteria of demand factors (see Table 6-2).

Source of information

The source of information indicates the parties involved in information exchange. In particular, the source can help to identify who observes/owns the data and/or where this information is available. The source can be ‘own’, ‘supplier’, ‘manufacturer’ or ‘retailer’. In some cases the source can also be a third party information provider or public data source.

Availability of information

Availability indicates the status of accessibility of information with a specific time scale such as always, intermediate, short term, sometimes, after and before the promotional event. The time scale is dependent on the length of the planning cycle and the duration of special events/sales promotions in the case company. This can be referred to in terms of ‘always available’ or ‘never’.

Reliability/Accuracy of information

The ability of observing market changes and descriptive nature of the observer can alter the reliability of the information used for demand forecast (Aviv, 2002). Hence, it is obligatory to know the accuracy of information being used in ones’ forecast. This attribute can be mentioned as correct or incorrect, complete or incomplete and firm or provisional.

Action-ability of information

Action-ability refers to the extent to which the available information can be used in forecasting, production and replenishment. Action-ability represents the capability of using the available information in the SC. All SC information is not always actionable. Some will be actionable most of the times and some may be less actionable, or not at all.

Importance of information

Importance of information in supply chain processes conveys the need for information exchange among supply chain members. Each demand factor and its respective information signals can be weighed for its importance in order to make the decision process easier. Scales for mentioning importance of information can be important, not important, very important, and extremely important. In some cases it is also possible that the importance is not known to the SC decision maker.

Cost of information

The cost of information represents the actual cost of obtaining information from other SC members. This will include initial investment on technology or people and operating cost.

The general scales used for availability, reliability, action-ability and importance of information are different for each cases studied.

Other information attributes, such as capability of using the information and current use of information, can also be added to the above list of attributes. For example, quick transfer of sales information (such as EPOS data) may have a positive impact on the planning and hence improve responsiveness of supply chain to demand fluctuations (Bourland et al., 1996; Chang et al., 2007, Cachon and Fisher, 2000) rather than just using historical data. However, the use of technology can alter the speed of the data transfer and hence the responsiveness of the supply chain will differ. If all information available is used effectively in order to respond quickly to the changes, the benefit to the supply chain will be in the form of, for example: forecast accuracy, inventory reduction, cost reduction etc (Cachon and Fisher, 2000; Bourland et al., 1996).

Generally, the capability can be of two sub-categories - technical and managerial. Here, technical refers to IT support to handle huge amounts of data, and managerial refers to the ability to incorporate the information in planning, production and replenishment. In general, the managerial capability is linked to judgmental forecasts. Although, measuring the capability is not the focus of this research, the same can be evident through performance, such as forecast accuracy, of the supply chain. In this research, the current 'use of information' is considered further in the case study analysis; but is not included in evaluation of RDM. Table 6-2 represents the SC information on demand factors and its corresponding attributes. The above mentioned attributes of information will be made clear through the example of Soft Drink Co.

Step 2 of RDM - Example from Soft Drink Co

Source - For the case company, the main source of information is either Soft Drink Co. or retailers. Sometimes, third party or publicly available information is also used for forecasting.

Availability – Some information is always available, other pieces of information reveal 6 weeks before the promotional event (W- 6), whereas still other pieces of information are confirmed just prior to the event (W-2, W-1).

Reliability/Accuracy - The information exchange between manufacturers and retailers are made electronically and hence sales data is correct at most of the times, while the other data is correct to a certain extent. In the case of Soft Drink Co, the scales used for reliability are 'correct' (High/Low/Medium) and 'not correct'.

Table 6-2 Step 2 of RDM - Attributes of information

Information attributes **Information – Demand factors**	**Observer/ Source of information** -Case company -Retailer -Other party	**When is the info available?** -Always -Long term (6-16 wks in advance) -Intermediate term (1-6 wks in advance) -Short term (Less than 1 week in advance) -After the event -Never	**Reliability and accuracy of information** - Correct/not correct - Complete or incomplete - Provisional/Firm	**Action-ability (responsiveness to information)** - Not actionable - Actionable (Please specify who in the supply chain can act on this information	**Importance of factor?** 1 - Not Important 2 - Somewhat important 3 - Important 4 - Very important 5 - Extremely important 6 - Difficult to say	**Is this factor currently used in forecasts?** - Yes, always - Yes, sometimes - No, never	**Cost of obtaining info?** - extra cost involved (high or low) - no extra cost
Type of retailer/wholesaler **Promotional information** ▪ Type of promotion ▪ Promotional calendar / slots ▪ Structure of promotion (number of stores running the promotion, promotion advertised or not, size and location of display) ▪ Changes to promotional plan **Seasonality / Special dates** ▪ Winter, Spring, Summer, Autumn ▪ Weather / temperature ▪ Easter & Christmas ▪ Back to school & Bank holidays **Trend & life cycle info** ▪ Growth, decline, maturity ▪ New product launch **Regional differences** ▪ Weather / temperature ▪ Habits / preferences **Pricing information** ▪ Retail sales price ▪ Whole sale price ▪ Discount price **Cannibalisation & Competitor information** ▪ Similar products in promotion in the same or different store ▪ Similar products from competitor is in promotion at the same time (in the same or different store) **Complicating factors** ▪ Poor execution of promotion in store ▪ New type of promotion with no history							

Action-ability - Action-ability of information varies widely across different information. For example, early information on any changes to the structure of promotion is useful until 6 weeks before promotions. However, it is more difficult to act upon the information after this period of time. In case of Soft Drink Co, the scales used for action-ability are - always, actionable, somewhat actionable, limited, and not actionable.

Importance - Except for competitor's information and information on cannibalisation, almost all the other information is considered important by the forecasters. In case of Soft Drink Co, the scales used for importance of information are not important, somewhat important, important, very important, extremely important, and difficult to say.

Cost - The Company does not incur extra cost to obtain information. This is because the company is involved in collaboration and information exchange with retail giants who maintain well established information network.

Table 6-3 represents both SC information and its attributes related to Soft Drink Co. Each demand factor is evaluated according to the different attributes. The RDM will be analysed in Step 3.

Table 6-3 RDM of Soft Drink Co

Information attributes → **↓Demand factors & information signals**	**Source**	**Availability**	**Reliability/ Accuracy**	**Action-ability**	**Importance**
Promotional information					
- Promotional slots(timing)	SDC + Retailer (calendar)	Intermediate (Week-6)	High	Actionable	Extremely important
- Type of promotion	SDC + Retailer (calendar)	Intermediate (Week-6)	High	Actionable	Extremely important
- Structure of promotion	SDC + Retailer (calendar)	Short term (Week-2)	Medium	Actionable	Very important
- Changes to planned promotion	Retailer	Short term (Week-1)	Known when communicated	Sometimes	Very important
- Effectiveness of promotion					
- during promotion	Retailer (EPOS)	During event	High	Sometimes	Very important
- after promotion	SDC + Retailer (Sales history)	After event	High	Not actionable	Very important
- % redemption rate	Retailer (Sales history)	After event (not all retailers)	High	Not actionable	Somewhat important
Pricing information Retail sales price (as a surrogate for type of promotion)	Retailer	Always	High	Actionable	Extremely important
Seasonality/Special dates					
- Winter, Spring, Summer, Autumn	Public Calendar	Always	Correct	Actionable	Important
- Weather/Temperature	Short term - local weather news;	Short term (Week-1)	Correct	Sometimes	Somewhat important
	Long term - historical data	Always	Correct	Actionable	Somewhat important
- Easter / Christmas	Public calendar	Always	Correct	Actionable	Extremely important
- Back to School/ Bank holidays	Public calendar	Always	Correct	Actionable	Important
Trend and product life cycle information					
- Growth/decline	SDC(demand history)	Always	Correct	Actionable	Very Important
- New/established products	SDC (demand history)	Always	Correct	Actionable	Very Important
Cannibalisation & Competitor information					
- SDC products in promotion in the same or different store	SDC	Most of the time	Correct	Sometimes	Somewhat important
- SDC and competitor products in promotion at the same time (in same or different store)	Retailer	Not always	Correct	Not actionable	Somewhat important
Complicating factors					
- Poor execution of promotion in store	Retailer + SDC	During event	Low	Limited	Very important
- New type of promotion with no history	Retailer + SDC	Intermediate	Low	Limited	Important
- Unplanned in-store promotion	Retailer	After event	Low	Not actionable	Important
- Regional difference (Habits/preferences)	Retailer/other party	Sometimes from regional deals	Requires further analysis – data is not available	Not actionable	Important

*SDC - Soft Drink Co

6.2.5 Step 3 of RDM - Evaluation and interpretation of information

The availability and value of supply chain information are dependent on the relationship with other SC partners and type of businesses (Fisher et al., 1994; Fisher 1997). Different kinds of information are useful during forecasting, production planning and replenishment. For example, historical sales data and promotional calendars are used for sales forecasting whereas POS data and inventory status are required at the time of replenishment. The company needs to obtain the information from downstream supply chain members or from other reliable sources. But not all SC members are usually engaged in information exchange and collaboration. Hence, obtaining all the required information is not always possible. If the company is not able to obtain the information it requires, then it may need to manage with whatever information available. A RDM may help to decide on what information to collect from different supply chain partners and/or use in the forecasting/replenishment processes. In addition, a RDM may help to identify those areas where the information exchange can be improved (e.g. based on the reliability/correctness rating).

Some demand factors may not be relevant in certain environments, for example a factor like temperature is a more important for soft drink products than for other products like electrical bulbs or crude oil. Here, the same demand information (temperature) is valued differently.

Step 3 of RDM - Example from Soft Drink Co

Table 6-4 reports the detailed evaluation of SC information of Soft Drink Co. This lists important demand factors affecting the sales of soft drinks at promotional and non-promotion periods. The last column of the table shows the evaluation of SC information. This evaluation has two aspects – one is the usefulness of information in forecasting and the second is the need for further improvement in the quality of the data.

From Table 6-4, it is clear that Soft Drink Co. can make use of all of the SC information from downstream members except for unplanned in-store promotions. Some retailers plan in-store promotions (like roll-back promotions in Asda) independently. Since these are not normally communicated in advance, Soft Drink Co. cannot plan accordingly, which may result in stock-outs at retail outlets.

According to the analysis, most of the promotional information is rather reliable and accurate (except the structure of promotion). In some occasions, the retailers change the structure of promotion; but this information is not communicated until the promotion is executed. For example, if 2-for promotion is changed to bogof promotion, then the sales uplift will be very high, and it may be difficult for Soft Drink Co. to replenish on time. Currently, the company is not considering the redemption rate of a promotion in its forecasting. (The redemption rate is the percentage of sales transactions that is exclusively based on the promotional deal. For example, if a 6-pack of 330ml cans is on bogof, but a customer buys only one six pack, then this sales transaction reduces the redemption rate). But, inclusion of this information may improve the forecasts.

Pricing information, seasonality and trend information are evaluated as ‘can be used’. Currently, Soft Drink Co. is not using temperature or local weather in its forecasting. In this research, temperature and trend information are used in the multiple linear regression models in Chapter ten.

Table 6-4 Analysis of RDM of Soft Drink Co

Information attributes → ↓Demand factors & information signals	Source	Availability	Reliability/ Accuracy	Action-ability	Importance	Evaluation	
						Useful/ not	Need to check
Promotional information							
• Promotional slots(timing)	SDC + Retailer (calendar)	Intermediate (Week-6)	High	Actionable	Extremely important	✓	---
• Type of promotion	SDC + Retailer (calendar)	Intermediate (Week-6)	High	Actionable	Extremely important	✓	---
• Structure of promotion	SDC + Retailer (calendar)	Short term (Week -2)	Medium	Actionable	Very important	✓	Reliability
• Changes to planned promotion	Retailer	Short term (Week-1)	High (if communicated)	Sometimes	Very important	✓	Availability
• Effectiveness of promotion							
- during promotion	Retailer (EPOS)	During event	High	Sometimes	Very important	✓	---
- after promotion	SDC+Retailer (Sales history)	After event	High	Not Actionable	Very important	✓	Action-ability
- % redemption rate	Retailer (Sales history)	After event (not all retailers)	High	Not Actionable	Somewhat important	✓	Action-ability
Pricing information							
Retail sales price (as a surrogate for type of promotion)	Retailer	Always	High	Actionable	Extremely important	✓	---
Seasonality/Special dates							
• Winter, Spring, Summer, Autumn	Public Calendar	Always	Correct	Actionable	Important	✓	---
• Weather/Temperature	Short term - local weather;	Short term (Week-1)	Correct	Sometimes	Somewhat important	✓	Importance
	Long term - historical data	Always	Correct	Actionable	Somewhat important		
• Easter / Christmas	Public calendar	Always	Correct	Actionable	Extremely important	✓	---
• Back to School/ Bank holidays	Public calendar	Always	Correct	Actionable	Important	✓	---
Trend and product life cycle information							
• Growth/decline	SDC (demand history)	Always	Correct	Actionable	Very Important	✓	---
• New/established products	SDC (demand history)	Always	Correct	Actionable	Very Important	✓	---
Cannibalisation & Competitors' information							
• SDC products in promotion in the same or different store	SDC	Mostly	Correct	Sometimes	Somewhat important	✓	Availability
• SDC and competitor products in promotion at the same time (in same or different store)	Retailer	Not always	Correct	Not actionable	Somewhat important	✓	Availability
Complicating factors							
• Poor execution of promotion in store	Retailer + SDC	During event	Low	Limited	Very important	✓	Accuracy, action-ability
• New type of promotion with no history	Retailer + SDC	Intermediate	Low	Limited	Important	✓	Action-ability
• Unplanned in-store promotion	Retailer	After event	Low	Not actionable	Important	✗	Improve collaboration
• Regional difference (Habits/local preferences)	Retailer/other party	Sometimes from regional deals	Requires further analysis - data is not available	Not actionable	Important	?	Availability, action-ability

*SDC - Soft Drink Co.

Cannibalisation and competitors' information if available can be used in planning. Based on its importance, Soft Drink Co. may consider using this information in decision making. Some of the complicating factors such as poor execution of promotion and new type of promotion are difficult to be considered in the forecasting. Poor execution of a promotion will be known only after the promotional event, but it may distort the demand profile. A peak in the sales profile may be much lower in case the promotion was not executed properly in the stores or in case stock-outs occurred. Regular monitoring of promotions at retail stores may help Soft Drink Co. to improve the performance. In case of new types of promotion, the company can consider similar promotions from the past. Comparing similar past sales event can help to improve forecasts. Currently, Soft Drink Co. has not considered local customers' habits of consuming soft drinks. Inclusion of this information may also help improving SC performance.

6.3 RDM for Textile Co.

As explained earlier, the development of RDM involves three steps. In step 1, the SC information related to Textile Co. is collected and listed under the relevant groups. Then in step 2 each demand factor is evaluated against a number of demand attributes. The information specific to Textile Co. collected in steps 1 and 2 forms a RDM. The RDM of Textile Co. is shown in Table 6-5. This RDM lists all the factors that may explain the demand together with an indication of the role of each partner in information exchange, the accuracy of information, the action-ability of the information, the cost involved, the reliability and the importance of the information.

The main source of information is either the customer or Textile Co. But for some other pieces of information such as trend and discount sales, Textile Co. depends on third party information providers, trade fairs and public data. SC information related to promotional events is available to the company approximately three months in advance. The scale that is used for availability is ‘month in advance’, ‘sometimes’ and ‘always’. Reliability of information is marked as low, medium and high. Action-ability of the information is marked as ‘actionable’ and ‘sometimes actionable’. Scales used for importance of information are ‘important’ and ‘extremely important’. Normally, Textile Co. does not incur extra cost to obtain basic information but does incur extra cost to obtain some other information from 3Ps and trade fairs. Please see Table 6-5 for RDM of Textile Co.

Table 6-5 RDM of Textile Co.

Information attributes → ↓Demand factors & information signals	**Source**	**Availability (in months)**	**Reliability/ Accuracy**	**Action-ability**	**Importance**	**Cost**
Type of Customers	Wholesaler Retailer					
Promotional information						
• Duration of promotion	Customer	3 - 4 M	Medium	Actionable	Ext. important	No cost
• Product on promotion (New/Current)	Customer	2 - 3 M	High	Actionable	Ext. Important	Extra cost
• Exclusive brand details	Customer	2 - 3 M	High	Actionable	Ext. important	Extra cost
• Occasional promotions	Customer	1- M	Medium	Sometimes	Ext. Important	No cost
• Local forecast	Customer	3 - 4 M	Medium	Actionable	Important	No cost
Seasonality/Special dates/Govt. matters • Winter, Spring, Summer, Autumn • Weather/Temperature • Easter / Christmas/New year • Back to School/ others (uniform dress material) • Govt policy on imports/exports	Customer & Public data	Always	High	Actionable	Important	No cost
Trend and product life cycle information						
• Growth/decline	Own & customer	Always	High	Actionable	Important	No cost
• Trend for new/established products	Customer/3Ps/Trade fairs	Sometimes	Medium	Sometimes	Important	Extra cost
Competitor information • Similar products • Different products	Customer/3P	Most of the time	Medium	Actionable	Ext. important	Extra cost
Complicating factors						
• Non availability of full POS data	Customer	Not available	--	Not Actionable	Important	Extra cost
• Discount sales	Customers/3P	Sometimes	Medium	Actionable	Ext. important	Extra cost
• Regional preferences	Own/3P/Trade fairs	Always	Medium	Sometimes	Important	Extra cost
• Cannibalisation	Own/ 3P	Sometimes	Low	Sometimes	Important	Extra cost

6.3.1 Analysis of RDM –Textile Co.

The evaluation of the RDM of Textile Co. (see Table 6-6) suggested exchange of promotional information, seasonal, trend and competitors information. Before including the information in forecasting and replenishment processes, it is important for the managers to check and improve the quality of the information. The information on some of the complicating factors such as discount sales, product returns and local preference are available to Textile Co. but the reliability of these data are not high. Hence, the quality attributes of the data need to be checked. The analysis of RDM suggests that the managers should continue exchanging the SC information with special attention to some of the attributes that are mentioned as ‘check’.

For example, although the promotional information is useful in supply chain planning, the cost of obtaining promotional information is high. Hence, managers’ intervention is essential to reduce the cost. Similarly, the cost, reliability and availability of discount sales information need attention of managers. Currently, Textile Co. uses available information (from downstream partners) on sales, inventory, local forecast and discount sales in their forecasting and replenishment. It is important for the company to improve the quality of this information to improve SC performance.

Table 6-6 Analysis of RDM of Textile Co.

→Information attributes ↓Demand factors & information signals	Source	Availability (in months)	Reliability/ Accuracy	Action-ability	Importance	Cost	Evaluation	
Type of Customers	Wholesaler; Retailer						**Useful/not**	**Need to check**
Promotional information • Duration of promotion • Product on promotion • Exclusive brand details • Occasional promotions • Local forecast	 Customer Customer Customer Customer Customer	 3 - 4 M 2 - 3 M 2 - 3 M 1- M 3 - 4 M	 Medium High High Medium Medium	 Actionable Actionable Actionable Sometimes Actionable	 Ext. important Ext. Important Ext. important Ext. Important Important	 No cost Extra cost Extra cost No cost No cost	 ✓ ✓ ✓ ✓ ✓	 Reliability Cost Cost Reliability Reliability
Seasonality/Special dates/Govt. matters • Winter, Spring, Summer, Autumn • Weather/Temperature • Easter / Christmas/New year • Back to School/ others (uniform dress material) • Govt policy on imports/exports	Customer & Public data	Always	High	Actionable	Important	No cost	✓	-----
Trend and product life cycle • Growth/decline • Trend for new/established products	 Own & customer Customer/3Ps/Trade fairs	 Always Sometimes	 High Medium	 Actionable Sometimes	 Important Important	 No cost Extra cost	 ✓ ✓	 ----- Cost, reliability
Competitor information • Similar products • Different products	Customer/3P	Mostly	Medium	Actionable	Ext. important	Extra cost	✓	Cost, reliability
Complicating factors • Non availability of full POS • Discount sales • Regional preferences • Cannibalisation	 Customers Customers/3P Own/3P/Trade fairs Own/ 3P	 Not available Sometimes Always Sometimes	 -- Medium Medium Low	 Not Actionable Actionable Sometimes Sometimes	 Important Ext. important Important Important	 Extra cost Extra cost Extra cost Extra cost	 ✓ ✓ ✓ ✗	 Availability, Action-ability Reliability, cost Reliability, cost Reliability, cost

6.4 What is RDM for collaborating companies?

The proposed RDM can be adopted by any company involved in SC collaboration (or CPFR) and information exchange. This is especially useful when two or more companies are involved in information sharing for collaborative forecasting and/or replenishment. As the main objective of RDM is identifying the demand factors to improve forecast accuracy, every piece of demand information needs to be checked for its related attributes. Subsequently, this plan can help the mangers to trace any data, its source and other related attributes through a single framework. Developing RDM can simplify the decision making on whether to incorporate that particular information in the forecast process or not. Subsequently, RDM can also assist major decisions on future SC collaboration on information exchange.

In the case of Soft Drink Co. sales promotions are a very important business strategy and hence collaboration with downstream partners is essential to exchange promotional plans. RDM can list the SC information along with its attributes so as to visualise the importance of information in planning, forecasting and replenishment. In case of a poor forecast or a poor supply chain performance, Soft Drink Co. can revisit/re-evaluate the RDM to order to identify areas for further improvement.

In the case of Textile Co., the construction of the Reference Demand Model will help the company to identify the role of the information and its contribution to forecasting. An initial list of the product demand factors and the various sources of information will help the company to systematically identify the importance of information. By tracing the highly valued pieces of information and valuable customers, Textile Co. can establish collaboration with reliable customers. Ultimately, the RDM can help the company to understand the role of each player in SCM and forecasting.

However, the RDM also has some limitations. As long as the retailers execute sales promotions as planned earlier, the RDM will help to guide the forecasters. Deviations from the original plan and inaccurate information will make RDM less effective. For SC information marked with medium or low attributes values, the supply chain collaboration need to be re-planned/re-evaluated to ensure the quality of the information so as to have reliable and action-able information.

6.5 Summary

This chapter explained the purpose of developing RDM. It also described the role of SC information in developing RDM. The key ideas to construct a RDM were explained through three steps. A step-by-step approach for developing a Reference Demand Model was explained with an example from Soft drink Co. Steps 1 and 2 explained the systematic approach for listing SC information and corresponding attributes. In step 3, the factors are evaluated. The development and analysis (evaluation and interpretation) of RDM aims to serve as a decision tool for the companies for their supply chain collaboration and information exchange to improve forecast accuracy. This can help managers to understand the actual value of information in SC collaboration.

Chapter 7 Cross Case analysis - Qualitative study

7.1 Introduction

This chapter analyses all of the cases discussed in Chapters 4 and 5, and Appendix-I. This chapter begins by explaining the various roles played by each case company in the supply chain. Then a detailed cross-case comparison is discussed to clarify the role of case companies in MTO and MTS environment. Based on the case analysis, MTO and MTS products are further classified as ‘easy to forecast’ and ‘difficult to forecast’. Using a two dimensional framework of products and forecasts, this research has suggested suitable forecast techniques to the case companies. This chapter answers the research questions 1 and 2.

Question 1 – “What types of collaborative arrangement exist between manufacturers and buyers, and what type of information is being exchanged to facilitate CPFR?”
Question 2 – “What technique can be used to decide on the level of information exchange in CPFR?”

7.2 Role of the case companies in the supply chain

As suggested by Yin (1994), in this research six different types of cases are considered for descriptive analysis. The prime focus in this research is to better understand the collaborative arrangement with downstream partners in each of the companies, with particular focus on forecasting and replenishment, and the information needs to facilitate these two processes.

With reference to Table 7-1, this research can be classified as Type 2 of basic designs for case studies (Yin, 1994). Multiple cases are chosen under the single unit of analysis – information exchange in collaborative supply chains (Voss et al., 2002).

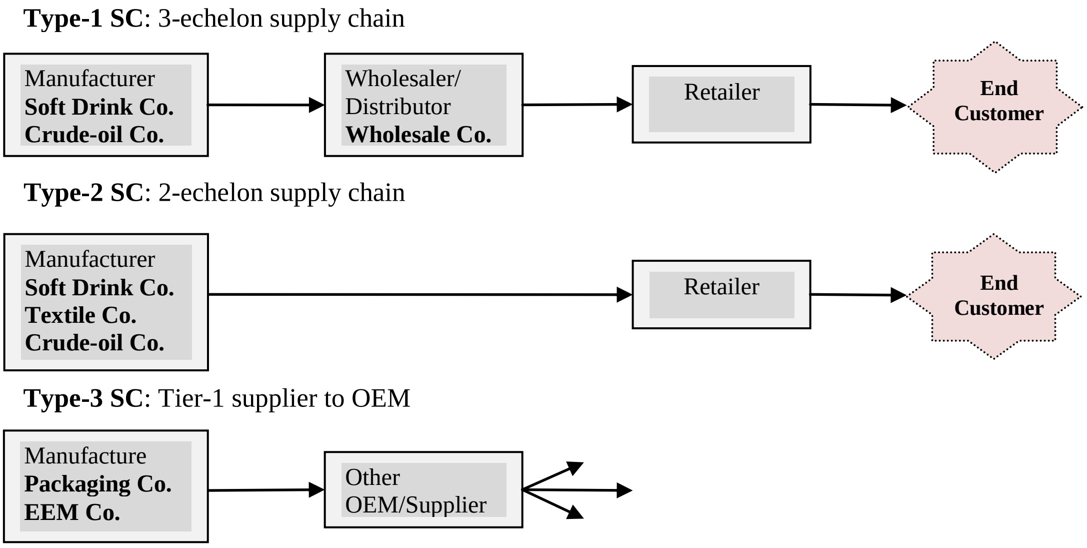
Table 7-1 Basic designs for case studies

	Single case designs	**Multiple case designs**
Holistic- single unit of analysis	Type 1	**Type 2**
Embedded- multiple units of analysis	Type 3	Type 4

Source: Yin, (1994)

The case companies selected for this study play different roles in the supply chain. Figure 7-1 shows the main role of case companies in the supply chain. For instance, Soft Drink Co. has two main roles. One role is manufacturer and supplier to retailers (Study -1) and another role is manufacturer and supplier to wholesalers (Study-2). Study-1 is Type-2 SC and Study-2 is Type-1 SC (see Figure 7-1).

Figure 7-1 Main role of case companies studied


Type-1 SC: 3-echelon supply chain
Manufacturer
Soft Drink Co.
Crude-oil Co.
Wholesaler/
Distributor
Wholesale Co.
Retailer
End Customer
Type-2 SC: 2-echelon supply chain
Manufacturer
Soft Drink Co.
Textile Co.
Crude-oil Co.
Retailer
End Customer
Type-3 SC: Tier-1 supplier to OEM
Manufacture
Packaging Co.
EEM Co.
Other
OEM/Supplier

Crude-oil Co. has two roles to play: distributor to wholesalers and distributors to retailers. Hence, Study-4 Crude-oil Co. is classified as Type-1 SC and Type-2 SC (see

Figure 7-1). The majority of products of Textile Co. is sold through retailers and hence it is classified as Type-2 SC. Packaging co. and EEM Co. distribute their products to other original equipment manufacturers (OEM) and hence they are classified as Type-3 SC.

The purpose of collaboration in the case companies are mainly to forecast and/or timely replenish. Accordingly, each of the case company differs on their information need, which is analysed further in the following sections.

7.3 Cross-case comparison

Table 7-2 reports the case study details of all of the six cases considered in this research. This cross case detail outlines the products of the company in the environment of MTS and MTO. Except Packaging Co. and EEM Co., all the other companies mainly have MTS environment. The supplier base of Crude-oil Co. and Wholesale Co. are local operators, while the other companies have global supply base. Except Crude-oil Co. all of the other companies have more than 5 suppliers. Customers of Soft Drink Co. and Crude-oil Co. are operating locally within the country. However, all of the other companies are also dealing with global customers. Most of the products of the case companies are considered as functional while textile products are considered as fashion driven and electrical products are considered as innovative. All the companies have more than 5 product lines with more than 15 stock keeping units (SKU).

Soft Drink Co. is one of the oldest companies of all the cases considered. Crude-oil Co. is in the market for more than 50 years with mature products, while the life cycle stage of other products are either in mature or growth stage. The shelf life of all of the products varies from 2 days to 2 years and more. The production and distribution lead time also varies widely from 2 days to 6 months. Except Crude-oil Co. all the companies have low supply uncertainty. But demand uncertainty of promotional products is high while demand varies from low to medium for other products under MTO and MTS environment.

The use of SC information for forecasting and replenishment is different for all these companies. This is mainly because the main purpose of collaboration in each of the case companies are of two types: promotional forecasting and timely replenishment. The companies involved in promotional sales (Soft Drink Co. and Textile Co.) exchange detailed information with downstream partners for forecasting while the others exchange limited or less detailed information with downstream partners and mainly for timely replenishment. To facilitate such information exchange, each of the case companies engages in a different level of SC collaboration with downstream SC partners.

Soft Drink Co. and Textile Co. are involved in intense SC information exchange with downstream partners especially for promotional sales. The RDM analysis of these two cases (Chapter 6) has explained the role of the SC information in forecasting. The role of RDM in CPFR can be summarised as follows.

Table 7-2 **Case study details**

	Soft Drinks Co. Study-1 (Chapter 4)	Wholesale Co. Study-2 (Chapter 4)	Textile Co. Study-3 (Chapter 5)	Crude-oil Co. Study-4 (Chapter 5)	Packaging Co. Study-5 (Appendix-I)	EEM Co. Study-6 (Appendix-II)
Environment	MTS	MTS	40% MTO 60 % MTS	MTS	MTO	75% MTO 25% MTS
• Location of suppliers	Mostly UK, Europe	UK	Yarn : India Machinery: Switzerland, Italy	India	Jute: India Paper: India Machinery: India, Japan	India , Australia
• Number of suppliers	5-10	N/A	10-30	1	5-15	5-10
• Location of customers	UK	UK	Europe, USA, UK, Dubai, Abu Dhabi, & India	India	India, Japan (more than 100 Customers)	India, Australia, Thailand, Malaysia, Korea, Japan, Iran, Australia, Indonesia, Saudi Arabia, Qatar, India
• Number of customers	> 4000	> 400	> 200	> 2000	>100	> 50
• Type of customers	Retailers	Retailer/Local shops/Independent	Wholesalers/Retailers	Distributors wholesalers/ retailers	OEM/ Wholesalers	OEM/Wholesalers
Position of case company in SC*	Type-2	Type-1	Type-1 and Type-2	Type-1	Type-3	Type-3
Product type	Functional	Functional	Fashion driven	Functional	Functional	Innovative
Number of product lines/ product families	10	N/A	5	6	5	5
Number of SKUs	>80	>50	>50	>15	Unlimited	Unlimited
Product life cycle length	Very long	Very long	Short	Very long	Long	Short or Medium
Product life cycle stage	Growth / Mature	Growth /Mature	Growth	Mature	Growth	Growth

	Soft Drinks Co. Study-1 (Chapter 4)	**Wholesale Co. Study-2 (Chapter 4)**	**Textile Co. Study-3 (Chapter 5)**	**Crude-oil Co. Study-4 (Chapter 5)**	**Packaging Co. Study-5 (Appendix-I)**	**EEM Co. Study-6 (Appendix-II)**
Product shelf life (Short/Medium/ Very long)	2 days - 6 months (Short)	2 days – 6 months (Short)	2 - 6 months (Short)	Very long	1-2 years (Medium)	Very long
Total lead time	2 - 3 days	1-3 days	6 weeks – 8 weeks	Real time basis (refining 24 hours)	3-4 days (excluding logistics)	One week – six months
Supply uncertainty	Low	Low	Low	Medium	Low	Low
Demand uncertainty	Normal sales-Low Promotions-High	Low	Normal sales-Low Promotions-High	Low	Low	MTS-Medium MTO- Low
Main reasons for demand fluctuation	Promotions	Sales at downstream	Promotions, seasons, trend	Price, new vehicles and new customers	Government policy and new product introduction of downstream partners	New projects and new regulations on safety products
Main reasons for collaboration with downstream members	• Promotions • Timely replenishment	• Timely replenishment	• Promotions • Timely replenishment	• Timely replenishment	N/A	N/A
Main reasons for collaboration with upstream members	Timely replenishment	Timely replenishment	Timely replenishment	Timely replenishment	• Timely replenishment • New projects information	• Timely replenishment • New projects information
Purpose/ information exchange	• Forecasting • Replenishment	Replenishment	• Forecasting • Replenishment	Replenishment	Replenishment	Replenishment
Technology used to communicate and for information exchange	Web based	Online ordering system	Advanced communication: Blackberry for all partners and workers to check email; kiwi to contact Switzerland and Germany, Skype to communicate with UK and USA.	Advanced automated inventory status, emails, web server, SMS, phone and fax	Simple communication: Telephone, fax and emails	Simple communication : Telephone, fax and emails, web based information exchange is under development to check inventory position.

	Soft Drinks Co. Study-1 (Chapter 4)	Wholesale Co. Study-2 (Chapter 4)	Textile Co. Study-3 (Chapter 5)	Crude-oil Co. Study-4 (Chapter 5)	Packaging Co. Study-5 (Appendix-I)	EEM Co. Study-6 (Appendix-II)
Important information exchanged - downstream	EPOS, promotion plans, inventory, price, delivery time, order, feedback	Inventory, order	Promotional sales discount, trend, seasonal, order, replenishment plans inventory, local forecast, feedback	Inventory, replenishment plans, order, feedback	Inventory, production, order, local forecast	Inventory, production, order, local forecast, MRO
Information used in forecasting	Historical sales promotional plans, local forecast, special days	Historical sales	Historical sales promotional plans, local forecast, seasons and trend	Historical sales	Historic sales	N/A
Information used in replenishment	Sales forecast, inventory status, EPOS	Inventory status	Historical sales, discount, trend, production, logistics, Government policy	Inventory status	Inventory status	Inventory status

* see Figure 7-1

7.4 Role of RDM in case companies

This research suggested some constructive steps to analyse the SC information obtained from downstream partners. The construction of RDM is an ideal way of aggregating various types of SC information and their attributes for decision making. Three steps are suggested to construct RDM. While, steps 1 and 2 of RDM list all of the possible demand factors along with their characteristics, step 3 of RDM involves evaluating and interpreting the RDM. This approach can guide managers to decide either to stop information exchange or continue information exchange. Sometimes it is also suggesting the managers to revisit RDM for future collaborations. It is interesting to note that although these decisions are common for all of the companies, the purpose of the supply chain information is different for each of the case companies. However, RDM can be used as a common technique to decide on the level of information exchange in CPFR (research Question 2).

Some of the case companies use the selected SC information for replenishments while the others use the same type of information for forecasting. For example, the historical sales information is used by the Soft Drink Co. for forecasting and EPOS data is used for replenishment; however, the sales information is used mainly for the long-term planning in Packaging Co. but not for the short term-forecasting.

The products of all of the six cases companies studied can be classified under two main categories MTO and MTS. Demand forecasting of MTS products, such as Crude-oil Co. and Wholesale Co. are rather simple in comparison to the other MTS environments. Hence, MTS products can be further classified into ‘easy to forecast’ and ‘difficult to forecast’. It is important to note that the short term forecasting is more important for MTS products than MTO products. This is because in a MTO environment, orders are received from customers and hence demand is known. For MTS products the demand forecast is important to avoid the bullwhip effect (Lee and Padmanabhan, 1997). Accurate demand forecasts can help reducing stock-out and excess inventory. Based on the levels of difficulty to forecast demand in MTS environments, different forecasting approaches could be applied.

From the analysis of cases, it is clear that soft drink products and textile products are difficult to forecast when sales promotions are offered by retailers. To forecast these products, different demand factors need to be identified. Identifying important demand factors is possible through the Reference Demand Model (RDM). The RDM can help forecasters to systematically list all possible types of SC information and also to identify potential SC information that can be received from downstream partners. The analysis of RDM will guide supply chain planners on what information has to be exchanged. More sophisticated forecast techniques such as multiple regression modelling can be used to better match the demand with explanatory factors. In summary, it is possible to say that ‘difficult to forecast MTS environments’ can use both RDM and regression models to improve forecast accuracy and timely replenishment (see Table 7-3). Difficult to forecast MTS situation may arise in the following cases:

- Sales promotions (functional products)
- Products with short shelf life or life cycle (e.g. fashion driven products)
- After market spare parts
    - Saturn (case of after-sales service by Cohen et al., 2000)
    - EEM Co. for Maintenance Revamping and Overhauling (MRO)

Wholesale Co. and Crude-oil Co. are in a MTS environment but the demand is rather smooth. Hence, it should be easy for them to forecast the demand using standard forecasting techniques. However, supply chain collaboration with downstream partners is essential to make end customers' demand visible and also to ensure timely replenishments.

Table 7-3 Suggested techniques

		Forecasts	
		Easy to Forecast	**Difficult to forecast**
Environments	**MTS**	**Wholesale Co.** **Crude-oil Co.** **Type-1 SC** • **Standard forecasting techniques** • **Make end customer demand visible** • **VMI**	**Soft Drink Co.** **Textile Co.** **Type-2 SC** • **Reference Demand Model** • **Multiple regression Models** • **VMI**
	MTO	**Packaging Co.** **EEM Co.** **Type-3 SC** **N/A**	**---**

Currently, Wholesale Co. does not use any mathematical forecasting techniques, and the company places rather irregular replenishment orders to Soft Drink Co., and not benefitting from the quantity discounts offered (i.e. when orders are placed as full truck loads). Soft Drink Co. has better forecasting and inventory management capabilities. We also showed that simple forecasting techniques could be used to predict the demand and that (R ,Q) inventory models (with the order quantity adjusted to a full truck load) could be applied. Wholesale Co. would benefit from reduced inventory levels, while maintaining high service and at the same time earning the quantity discounts when it would engage in a closer collaboration with Soft Drink Co. That collaboration could involve making end customer demand visible, applying simple forecasting procedures and (R,Q) inventory policies (with possibly joint replenishments for the slower moving items) and perhaps even engaging in a VMI arrangement with Soft Drink Co.

Crude-oil Co. maintains a good collaborative relationship with downstream SC partners so as to make timely replenishments. Currently, the company exercises VMI and inventory pooling with some retail customers. This inventory pooling facility case can be extended to others to obtain full benefit of SC collaboration. Demand variability of MTS products at Wholesale Co. and Crude-oil Co. are low, and hence the demand for these two products can be determined by simple forecasting techniques. This forecasting technique can be for example, simple moving average, exponential smoothing or Holt-Winter's method.

Companies operating in a MTO environment such as Packaging Co. and EEM Co. do not make any short-term forecast using the SC information from downstream partners. Supply chain information from downstream partners may be used to make long term forecasts and material resource planning. The supply chain collaboration appropriate to each case company is discussed further in the next section.

7.5 Supply chain collaboration in the case companies

7.5.1 Current practice and suggestions

Soft Drink Co. maintains a good collaborative relationship with downstream partners, especially retailers. Hence, the promotional sales information is well communicated in most cases. The relationship of Soft Drink Co. with Wholesale Co. is relatively new and is not well established in terms of information exchange. This is reflected in the high order variability. By establishing collaboration with up- and downstream partners, Wholesale Co. can improve the visibility of end customer demand, and pass it on to Soft Drink Co. Engaging in a VMI arrangement with Soft Drink Co. could be highly beneficial (regular replenishment orders in full truck loads).

Textile Co. believes that establishing the basic communication at transactional level is enough with new customers or relatively new customers. Currently, Textile Co. motivates existing customers for future collaboration through providing free samples. If these ‘free samples’ sell well in the local market, customers may plan the future promotion in collaboration with Textile Co. The communication between the two parties concentrates on promotional sales only. In other words, the information exchange between Textile Co. and their customers is elaborate at the time of promotions but restricted at other times. This relationship (promotional sales) is generally extended by the company further on future business expansions.

Crude-oil Co. has well established collaboration and VMI with downstream partners (nearly 20 percent of its customers) to ensure timely replenishment. This arrangement can be extended further for the remaining customers. EEM Co. and Packaging Co. do not maintain well established downstream supply chain collaboration as they do not find much value in downstream SC information. These two companies can think of establishing upstream supply chain collaboration. As most of the products are MTO, the collaboration with upstream SC partners may help the companies to have raw materials on time for production.

7.5.2 New perspective of SC collaboration

This research has considered functional products, fashion products and innovative products in MTS and MTO environments. However, the demand fluctuations of functional products are not the same for all cases considered in this study. Some of the companies have promotional sales as a regular feature of business strategy. Study-1 and Study-3 considered soft drink products (functional products) and textile products (fashion driven products). According to Lee (2002) functional products will have low demand variability compared to innovative (fashion apparels) products. However, the demand patterns are highly fluctuating for these two products as the sales are affected by promotions. Analysis of these cases suggested considering all possible SC information to improve forecasting and replenishment. Hence, for Textile Co. and Soft

Drink Co. a high level collaboration with downstream SC partners will be beneficial. In simple terms, CPFR will be ideal for these two companies. Table 7-4 reports the supply chain collaboration strategy of the case companies.

Table 7-4 Supply chain collaboration strategy

		Forecasts	
		Easy to Forecast	**Difficult to forecast**
Environments	**MTS**	**Medium collaboration - VMI**	**High collaboration - CPFR**
	MTO	**Low collaboration**	---

MTS products of Wholesale Co. and Crude-oil Co. are easy to forecast. In these two cases information from downstream SC partners is required to ensure timely replenishment. Information to be exchanged includes aggregated end customer demand and inventory status. Based on stock levels, the replenishment can be made on time. Hence, vendor managed inventory (VMI) is suggested to these two companies. MTO products of Packaging Co. and EEM Co. do not benefit much by information from downstream SC partners. Hence, simple transaction-based collaboration is suggested for these two companies. In summary, it is possible to conclude that MTS environments where forecasting is difficult require a high level of collaboration with downstream SC partners (e.g. CPFR), MTS environments where forecasting is easy require a medium level of collaboration with downstream SC partners, whereas in MTO environments a low level of collaboration with downstream SC partners should be sufficient (see Table 7-4).

While the previous literature identified that different levels and degrees of collaboration were possible (Larsen et al, 2003; Danese, 2007), this current research related supply chain information with the type of product environments and their demand forecasts difficulty to decide on the appropriate level of supply chain collaboration. This can be considered as one of the key contributions to the literature.

7.6 Summary

All the cases analysed in this chapter were of two types: MTS and MTO. In a MTS environment, SC information from downstream partners helped short-term forecasting and replenishments. In a MTO environment, SC information from downstream was not used for short-term forecasting but for long-term planning. Some MTS products were easy to forecast while the others were difficult to forecast. Easy to forecast MTS products can be controlled by simple forecasting techniques and collaboration with have downstream supply chain to make end demand visible. Difficult to forecast MTS products, must ideally be supported with downstream SC collaboration in order to obtain detailed demand information. A Reference Demand Model and multiple regression techniques (or causal forecasting techniques) were suggested in this case. Downstream SC collaboration was not found important in MTO environments. Three levels of collaboration (low, medium and high) were suggested.

Chapter 8 Data Description

8.1 Introduction

This chapter discusses the sales related data from Soft Drink Co. The data consists of the promotional details from four different retailers who run promotions at different times and include duration and timing of promotions, types of promotions, promotional features/display, price discount and weekly sales. Sales promotions specific to each retailer have a different impact on sales even for similar products. In this research, the data of about 50 different products sold by four leading retailers in the UK were analysed. The data is described in this chapter together with the scales used to represent the observed promotional information.

8.2 Data collection methodology

As explained in the previous chapter, the case study with the Soft Drink Co. involved field visits, direct observations and interviews to develop a RDM. In the process of validating the RDM, weekly sales data were collected. The accuracy of the data was first checked by comparing with the promotional calendar and, whenever necessary, clarified through discussion with the principal or key informant in the case company. The principal or key informant is the person in the case company who is best informed about the data used in this research (Voss et al., 2002).

The following characteristics were collected from the four retailers along with the weekly sales data.

- Types of promotion
- Size of promotion (includes display location, number of stores)
- Duration of promotion (number of promotional weeks)
- Price discount
- Number of different promotions offered during the promotion weeks

- Feature (advertisements-any sports events/coupons)
- Special days/holidays
- Christmas/Easter
- Local weather (temperature)
- Unplanned in-store promotion (if available)
- Timing of the promotion
- Product life cycle (new or established products)
- Customers’ preference (faster moving or slower moving products)

Although most of the information could be obtained directly from the company’s promotional calendar, some other pieces of information (such as unplanned in-store promotions, features, and special days) needed further clarification from the principal informant of the case company. Table 8-1 shows the types of promotions and the number of promotions over a period of 3 years (2005-2007) at the four different retailers (referred in this thesis as R1, R2, R3 and R4).

In Table 8-1, the last column ‘total promotions’ represents the total number of promotions offered by each of the four retailers for some common products. Some retailers offered more promotions for 2ltr bottles while others offered more promotions for 500ml bottles. For example, R1 offered 200 promotions for 2ltr bottles in total during 2005-2007 whereas the other three retailers offered 202, 135 and 195 promotions respectively. For 6-packs 330ml cans, R1 offered 195 promotions, R2 offered 243 promotions, R3 offered 172 promotions and R4 offered 215 promotions. For 500ml bottles, R2 offered promotion throughout the year 2006; this is represented as ‘Y’ in Table 8-1. R3 did not offer any promotion for 500ml bottles. R1 and R4 offered 84 and 92 promotions respectively on 500ml bottles.

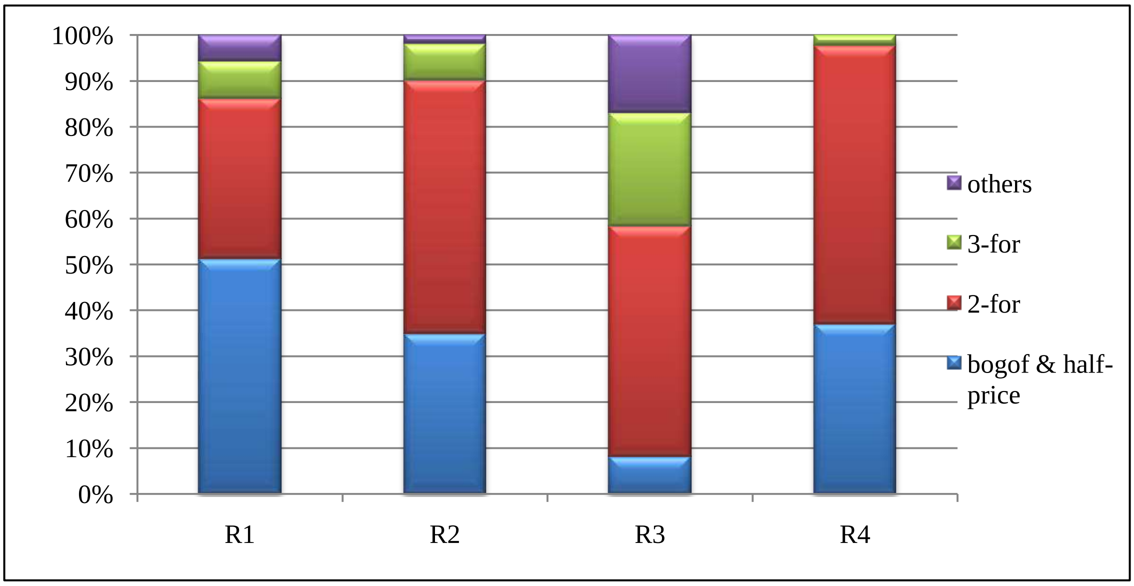
Table 8-1 Number of promotions at retail stores' for leading products

Type and number of promotions																	Total promotions			
	'bogof'/half price				2 for £				3 for £				Other promotion							
Products	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**
2lt-P1	12	10	2	9	4	11	4	7	-	-	3	-	2	1	5	-	18	22	14	16
2lt-P2	11	10	2	9	4	11	4	7	-	-	4	-	2	1	5	-	17	22	15	16
2lt-P3	11	6	-	9	4	8	-	7	-	-	-	-	2	1	-	-	17	15	--	16
2lt-P4	11	10	-	9	4	11	-	7	-	-	-	-	2	1	-	-	17	22	--	16
2lt-P5	11	6	-	9	4	8	-	7	-	-	-	-	2	1	-	-	17	15	--	16
2lt-P6	-		-	-	4	10	4	13	8	2	8	6	-	-	5	-	12	12	17	19
2lt-P7	-		-	-	4	16	4	12	8	2	8	6	-	-	5	-	12	18	17	18
2lt-P8	9	7	-	8	4	12	4	7	-	-	3	-	1	-	5	-	14	19	12	15
2lt-P9	9	7	-	8	4	12	4	7	-	-	3	-	2	-	5	-	15	19	12	15
2lt-P10	9	-	-	8	4	-	4	7	-	-	3	-	2	-	5	-	15	--	12	15
2lt-P11	9	7	-	7	4	12	4	5	-	-	3	-	2	-	5	-	15	19	12	12
2lt-P12	9	7	-	5	4	12	4	5	-	-	3	-	3	-	5	-	16	19	12	10
2lt-P13	9	-	-	5	4	-	4	6	-	-	3	-	2	-	5	-	15	--	12	11
Total	**110**	**70**	**4**	**86**	**52**	**123**	**40**	**97**	**16**	**4**	**41**	**12**	**22**	**5**	**50**	**0**	**200**	**202**	**135**	**195**
6pk-P1	2	4	-	-	-	9	3	-	1	6	1	-	1	2	-	-	4	21	4	--
6pk-P2	11	8	2	9	4	9	8	7	3	-	4	-	-	-	1	-	18	17	15	16
6pk-P3	9	8	2	-	5	9	8	-	3	-	4	-	-	-	1	-	17	17	15	--
6pk-P4	9	7	2	14	5	9	8	6	3	-	2	-	-	-	1	-	17	16	13	20
6pk-P5	9	7	2	11	5	9	7	6	3	-	1	-	-	-	1	-	17	16	11	17
6pk-P6	4	4	2	3	1	9	5	18	4	6	2	-	4	-	-	-	9	19	9	21
6pk-P7	4	4	2	3	1	9	5	18	4	6	2	-	-	-	-	-	9	19	9	21
6pk-P8	4	4	2	3	-	9	5	18	4	6	2	-	-	-	-	-	8	10	4	21

Type and number of promotions																				
	‘bogof’/half price				**2 for £**				**3 for £**				**Other promotion**				**Total promotions**			
Products	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**
6pk-P9	11	8	2	10	4	9	8	6	-	-	4	-	-	-	1	-	15	17	15	16
6pk-P10	11	8	2	10	5	9	8	6	-	-	4	-	-	-	1	-	16	17	15	16
6pk-P11	11	8	2	10	4	9	8	6	-	-	4	-	-	-	1	-	15	17	15	16
6pk-P12	11	7	2	11	4	9	9	6	-	-	2	-	-	-	1	-	15	16	14	17
6pk-P13	11	7	2	11	4	9	9	6	-	-	2	-	-	-	1	-	15	16	14	17
6pk-P14	11	7	2	11	5	9	9	6	-	-	2	-	-	-	1	-	16	16	14	17
Total	**118**	**91**	**26**	**106**	**47**	**126**	**100**	**109**	**25**	**24**	**36**	**0**	**5**	**2**	**10**	**0**	**195**	**243**	**172**	**215**
500ml -P1	-	-	-	-	7	Y	-	16	-	-	-	-	-	-	-	-	7	--	--	16
500ml -P2	-	-	-	-	7	Y	-	16	-	-	-	-	-	-	-	-	7	--	--	16
500ml -P3	6	-	-	1	8	Y	-	11	-	-	-	-	-	-	-	-	14	--	--	12
500ml -P4	6	-	-	1	8	Y	-	11	-	-	-	-	-	-	-	-	14	--	--	12
500ml -P5	6	-	-	1	8	Y	-	11	-	-	-	-	-	-	-	-	14	--	--	12
500ml -P6	6	-	-	1	8	Y	-	11	-	-	-	-	-	-	-	-	14	--	--	12
500ml -P7	6	-	-	1	8	Y	-	11	-	-	-	-	-	-	-	-	14	--	--	12
Total	**30**	**0**	**0**	**5**	**54**	**0**	**0**	**87**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**84**	**--**	**--**	**92**
Juice-P1	-	5	-	-	3	-	3	-	-	4	-	-	1	1	1	-	4	10	4	--
Juice-P2	-	5	-	-	3	-	3	-	-	4	-	-	1	1	1	-	4	10	4	--
Juice-P3	-	-	-	-	8	11	19	15	-	2	7	-	-	-	-	-	8	13	26	15
Juice-P4	-	-	-	-	8	11	19	15	-	2	7	-	-	-	-	-	8	13	26	15
Total	**0**	**10**	**0**	**0**	**22**	**22**	**44**	**30**	**0**	**12**	**14**	**0**	**2**	**2**	**2**	**0**	**24**	**46**	**60**	**30**

Some retailers offered more bogof while others gave more 2-for and 3-for promotions. Figure 8-1 shows the percentage of each type of promotions offered by different retailers. The retailer R1 offered more bogof and half-price promotions (51 percent) while the retailers R2, R3 and R4 offered more 2-for promotions. R1 offered less 3-for and other promotions (6 to 8 percent). R2 offered around 55% of 2-for promotions, which is the highest of all of its promotions. Nearly half of the promotions offered by R3 were 2-for promotions. R4 offered 61 percent of 2-for promotions. This percentage split of promotional types included only leading or major selling products.

Figure 8-1 Percentage of types of promotions offered by four retailers

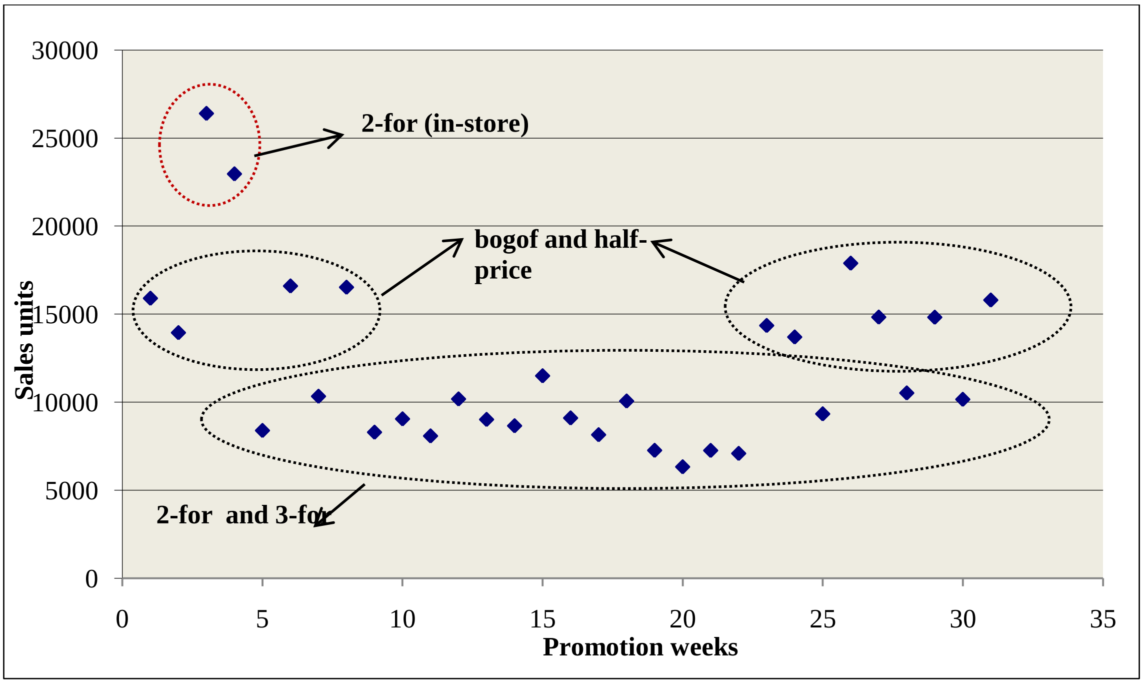


Other details on promotions such as display location and percentage discount are different for different promotions and cannot be presented in a single table or figure. The presence or absence of these characteristics may affect sales. For example, bogof promotions may have a huge sales uplift while 3-for promotions may not have such a big impact on sales.

The data will be further analysed in chapters eight and nine through structural equation models and multiple linear regression models.

(Hair et al., 2006) suggested that data should be cleared to be error free before using it for further analysis. For example, a lower (than average) sales figures during a promotional event may cause ambiguity either on the sales data or on the promotion calendar. In the case of Soft Drink sales data, such problems were solved by double checking the actual sales events with the principal informant. Careful cross-checking for any unusually high or low sales and discussions with the company officials ensured error free data.

Figure 8-2 Example of average sales during promotions at R2 for 2ltr bottles



For instance, in Figure 8-2, there were two instances of promotional sales exceeding 20000 units[4] which prompted further enquires for such an unusually high demand. Though this particular promotion was mentioned as 2-for in the promotion calendar, it was later noted that those two sales were the 2-for promotions but with unusually low prices. The retailer R2 stuck to the previously agreed promotion type but reduced the price during the promotion. This resulted in unusually high sales in these two instances.

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[4] 1unit represents a case of 24 or 48 cans or bottles

To ensure error free data, sales of all leading products (2ltr pet bottles, 500ml pet bottles and 6-packs of 330ml cans) were plotted separately in graphs for each retailer. On analysing the graphs, unusual sales (either very high or very low) during promotions were identified. Such discrepancies were discussed with the Soft Drink Co. and clarified before they were used in structural equation models and multiple regression forecast models.

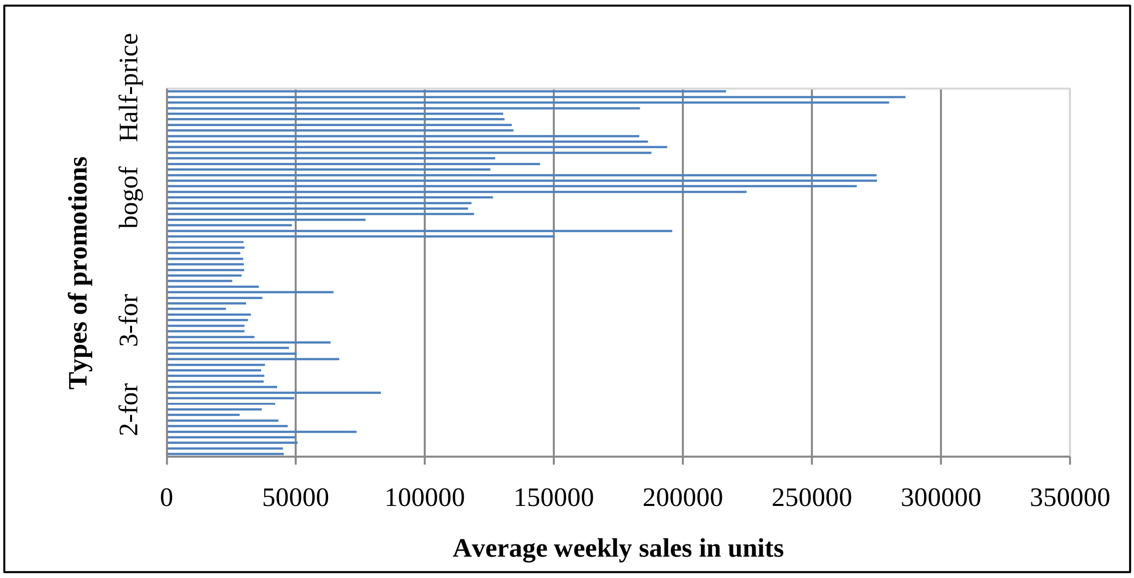
8.3 Scales used to represent quantitative data

A promotional event is a major explanatory factor of demand , but it incorporates many elements namely (i) type of promotion, (ii) size of promotion, (iii) duration or number of promotional weeks, (iv) price discount and (v) promotional features. There are also other elements which will improve sales independently or in conjunction with the promotions such as (vi) special days (Christmas/Easter/holidays) and (vii) seasonality and average temperature. Some factors such as (viii) product life cycle, (ix) sales period and (x) customers' preference are not often used in the data analysis. The impact of each of these factors was visualised by plotting the actual weekly sales against the presence and absence of each factors (see Figure 8-2 and Figure 8-3). The scales used for representing the promotional and the non-promotional elements are of two types - one is continuous such as percentage discount and temperature, and the another is categorical such as presence or absence of special display (0 or 1) and type of promotions (1 to 5 scale).

(i) Type of promotion is a promotional mechanism used in the retail outlets. As given in the case study of Soft Drink Co. in Chapter 4, the company offers 5 different types of promotions – half-price, bogof, 2-for, 3-for and others. In general for all the retailers, normal weeks without any promotion are marked with '0'and all the other promotional events are marked with '1'. Only for retailer R4, the type of promotion is categorised under ordinal scale of one to five with 5 representing half-price and 1 representing other promotions. This is because the retailer R4 runs various promotions at the same time in different outlets for some products.

(ii) **Size of promotion** represents the number of stores running the promotion. This also includes the number of prominent display locations attached to the promotional events. Some retailers, like R4, prefer to run promotions at superstores and small stores at different times, while others prefer to run promotions at the same time in all outlets. For retailers R1 to R3, the display of promotion is marked as '0' for no special display and '1' for special display at gondola end or plinth or end aisle display.

Figure 8-3 Example of average sales during promotions at R4 for 2ltr



All of the retailers except R4 run similar promotions at all of their retail outlets in a particular period of time. The retailer R4 follows different types of promotions at various retail outlets at the same time or different period of time. From Figure 8-3, it can be seen that for R4, 2-for and 3-for promotions have registered sales in the range of 30000 units to 80000 units. Whereas, bogof and half-price sales are in the range of 50000 units to 280000 units. In this case, 2-for and 3-for promotions were run in the small outlets and bogof and half-price promotions were run in superstores at different period of time. For retailer R4, the size of promotion is measured in the ordinal scale 1 to 5.

(iii) The duration or length of the promotion is the number of weeks that the promotion is run by each retailer. This is normally between one to four weeks. Occasionally, the promotions will continue for eight weeks. From the data analysis, it was understood that generally the shorter duration of promotion show a better sales uplift than longer promotions. Similarly, too many promotions in a year do not necessarily give a better sales uplift. The duration of promotions is measured as a continuous variable in weeks.

(iv) Price discount or sales price is another important factor influencing customers' purchase behaviour. The same price discount may have a different impact on sales when more packs are involved. For example, the half-price, bogof and buy two-get-two-free promotions result in the same price discount of 50% compared with the normal price.

The percentage discount is calculated as follows:

Percentage discount = (Base price - promotional price)/Base price

The base price refers to the price at normal times without promotion. For most promotions, the percentage discount varies between 20 and 50 percent. For example, when the normal price of 2l pet bottle is £1.75, customers will benefit from a 14% price discount on '2-for £3' promotions (Percentage discount = (1.75-1.5)/1.75 = 0.1428). As mentioned earlier, different promotional strategies such as bogof, 2-for and 3-for will have a different impact on sales, though sometimes they may have the same percentage of discount on price. Specifically, the promotion types 2-for and 3-for will have the same percentage discount; but, the number of units per sale will be different. In other words, the buyer needs to buy two units in 2-for promotion or three units in 3-for promotions to benefit from the promotional sales. For example, in a buy-two-get-two-free promotion, a customer has to buy four units compared to one unit only under a half-price mechanism. Though both the types of promotions result in the same 50% price discount, the impact of a half-price promotion on sales is typically bigger than the impact of bogof or buy-two-get-two-free promotions. The sales price can be included in the models and is a continuous variable. The percentage discount variable can model different types of promotions, and possibly eliminate some of the categorical variables.

(v) Promotional features involve marketing activities that are related to improve brand image and sales**.** According to Soft Drink Co., product exposure generally improves sales and hence Soft Drink Co. tries a variety of promotional features. The company spends a proportion of its profit on marketing activities such as advertising. For example, commercial advertisements during prime time television programs attract more sales. Some in-store advertisement also involves advertising cost that includes location of display and sign boards. For example a gondola end display attracts more sales than usual display on the shelves. But all the products will not be displayed in gondola end as the cost attached to this display is quite high. Rather than considering the cost of advertisement and its impact on sales, in this research, the presence or absence of advertisement is considered as a categorical variable of ‘0’ or ‘1’. For retailer R4 there are a number of display locations available and each one of these locations is different in terms of cost of advertisement and sales uplift. For R4, display location is represented through ordinal scale 1 to 5.

(vi) Special days: Sales of soft drink products do increase during holidays and special events. Normally festivals like Christmas and Easter increase sales. These dates are collected from the publicly available calendar. Special days are also modelled by a categorical variable of ‘1’ or ‘0’.

(vii) Seasonality and **local weather** impact the sales of soft drinks. Historical local temperature (monthly average) is considered for further data analysis. This is collected from the website of www.metoffice.gov.uk. In further analysis, the local temperature is considered as a continuous variable.

(viii) Product life cycle: The impact of promotions on well established products may be different from new products that are just introduced in the market. For example, when the company introduced the 'zero-range', these products were heavily advertised in the media. The sales data in these periods may not be a good reference for predicting the demand when the product becomes more mature. We have categorized the products in two groups: The recent (new) products and the well-established products, and for those products where we had data spanning the two life-cycle phases, we have truncated the time series so as to remove the introductory phase.

From 2005 to 2007, Soft Drink Co has introduced 25 to 50 new varieties in carbonated drinks. All of these new products are not usually introduced at the same time in all of the retailers. Some products are introduced specifically through one retailer. For example, if Cola drink is introduced through retailer R4, then the Orange drink may be introduced through retailer R3.

(ix) Sales period in the calendar year is the week in the year. It is a number running from 1 to 52. This sales period is meant to capture the sales fluctuation in a time series data.

(x) Customers' preference for the product is identified from the historical sales data. Similar products on promotion at the same time responded differently for each retailer. Based on the volume of sales in the group of products, it was marked from 1 to 5 in an ordinal scale. For example, a fast moving orange drink with the highest sales, among a group of similar orange drinks, will have the highest customer preference with the scale 5. Another orange drink with 'no-sugar' with the next higher sales volume will be in the scale of 4.

The scales used to represent the sales volume and the other exploratory variables are either categorical or continuous variables as summarised in Table 8-2.

Table 8-2 Scales used in the data analysis

Variables	Retailers R1, R2 and R3	Retailer R4
Type of promotion	Categorical variable (0/1) 1-promotion,0-no promotion	Ordinal variable (1,2,3,4,5) 5-half-price;1-other promotions
Size/display of promotion	Categorical variable (0/1) 1-special display; 0-no special display	Ordinal variable (1,2,3,4,5) 5-superstore special display; 1-no special display
Duration of promotion	Continuous variable	Continuous variable
Price discount	Continuous variable	Continuous variable
Promotional feature	Categorical variable (0/1) 1-special feature; 0-no special feature	Ordinal variable (1,2,3,4,5) 5-most advertisement 1- least advertisement
Special days	Categorical variable (0/1) 1-special day; 0-no special day;	Categorical variable (0/1)
Local weather	Continuous variable	Continuous variable
Life cycle	Categorical variable (0/1) 1-mature product; 0-recent product	Categorical variable (0/1) 1-mature product; 0-recent product
Sales period	Continuous variable	Continuous variable
Customer preference	Ordinal variable (1,2,3,4,5) 5-most preferred product;1-least preferred product	Ordinal variable (1,2,3,4,5) 5-most preferred product;1-least preferred product
Weekly sales volume	Continuous variable	Continuous variable
Number of packs	Continuous variable	Continuous variable

Other factors such as competition and complicating factors (given in case study Chapter 4) are not quantified as they are more of qualitative in nature. These are left for judgemental decision making. This research study suggested that the company should analyse their historical sales data and also to have further discussion with the retailers.

Similar to the local temperature and customer preference, another important factor which alters the sales of different products is the customers’ product consumption (drinking habit). Health awareness among local communities may increase the sale of non-carbonated and fruit juice in place of carbonated soft drinks. Although it is not considered for the data analysis, this report suggested that the company should include it in their judgemental planning and forecasting.

In order to explain the characteristics of the data used for structural equation modelling and regression analysis, descriptive data analysis was conducted using a sample of the data. This is further explained in the next section.

8.4 Descriptive analysis of sample data

A sample of sales data of 6-packs 330ml cans for retailer R1 was considered for this descriptive analysis. The product considered is this analysis is a relatively new product, introduced in the market in mid 2004. The data includes three years (2005-2007) of weekly sales data. The sample is selected in such a way that products were on promotion at the retail outlet at the same period of time and belonged to a similar category. Please see Table 8-3, which lists the maximum, minimum and average number of sales during promotional and non-promotional weeks. In this table average sales volume (in cases) per promotional week is differentiated under three categories. Column one ‘all types of promotions’ represent the average weekly sales during promotion irrespective of the type of promotion. Column two ‘type of promotion’ represents the promotional sales during promotional week for a particular type of promotion. In column three ‘presence of display, Christmas’ represents the promotional weekly sales with special display during Christmas and during other times.

Table 8-3 Promotional and non-promotional sales

				Average sales/promotion week		
			Statistic	**All type of promotions (1)**	**Particular promotion type (2)**	**Presence of Display (D) Christmas (C) (3)**
Normal sales	Mean		538			
	95% Confidence Interval for Mean	Lower Bound	516.73			
		Upper Bound	559.41			
	Median		517.31			
	Std. Deviation		332.35			
	Minimum		147			
	Maximum		4036			
Promotional sales	Mean		3141	3187 (Week1) 3192 (Week2) 3147 (Week3) 3026 (Week4) 2829 (Week5) 1756 (Week6)	2135 (others) -- (3-for) 1773 (2for) 3899 (bogof) -- (half-price)	3447 (D) 4036 (C&D)
	95% Confidence Interval for Mean	Lower Bound	2951.45			
		Upper Bound	3329.86			
	Median		2479.81			
	Std. Deviation		2418.33			
	Minimum		542			
	Maximum		17325			

From the given statistic, it is clear that the average promotional sales increased to 5.8 (=3141/538) times of normal sales. From column (1), it can be seen that the promotional sales in weeks one to three were stable and then the sales started declining. By week six the promotional sales had declined by nearly 45% of the average promotional sales. In the column (2), the sales with bogof promotions reached the highest sales figure with an average of 3899 units per promotion week. The impact of promotional display is evident from the sales figure given in column (3). The average promotional sales with special display increased the sales to 3447 units. The special display during Christmas increased the sales to 4036 units.

Table 8-3 also indicates some other difficulties. For example, the maximum sales during normal weeks are 4036 and minimum sales during promotional weeks are 542, which are not exactly representing the actual normal and promotional sales respectively. In this case, it was important to correct information from different sources such as promotional calendar, sales data and temperature. Still, the statistic of sales did not match with the promotional calendar or other public information, in such cases it was necessary to clarify this with of the company's key informant.

Through these discussions with the company, it was identified that the maximum sales volume of 4036 during normal weeks was an indication of a promotion running in the store, but not indicated in the calendar. Similarly, the minimum sales volume of 542 during a promotional week is corresponding to 'no promotion' in the store.

The data description and descriptive analysis clearly indicate that the promotional sales are related to type of promotions, promotional weeks, percentage discount and many other demand factors. The correlation between all of these variables with reference to sales is calculated using the Pearson correlation coefficient in Chapter 9.

8.5 Summary

This chapter introduced the sales data and various details related to promotions. The reliability of the data was guaranteed through rigorous cross-checking and clarification with the case study company. The scales used to represent the promotional and non-promotional elements in the data were explained in detail to facilitate further analysis in the following chapters on structural equation modelling and multiple linear regression models. The next chapter will introduce measurement models and structural equation models.

Chapter 9 Structural equation modelling

9.1 Introduction

A set of demand factors identified using the case study of Soft Drink Co. in Chapter four have been used in developing RDM in Chapter six. From the RDM of Soft Drink Co. four major demand factors namely promotions, special days, seasons and customer preference were identified. To identify the inter-relationships among these demand factors and actual sales volume, a structural equation modelling approach is used in this research. In the process of developing the structural equation model (SEM), a conceptual demand-factor relationship is established as a logical sequence for the Reference Demand Model explained in Chapter 6. Based on this conceptual demand-factor model research hypotheses are developed. Anderson and Gerbing's (1988) two-step approach to structural equation modelling is incorporated in testing these hypotheses. The research hypotheses are then tested using sales data of Soft Drink Co. with a major retailer (R4) in the UK.

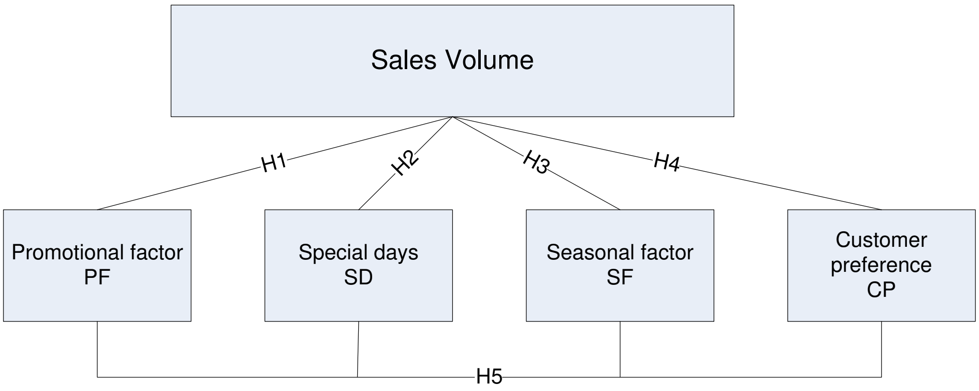
This chapter presents the procedural expansion of model constructs and the description of model fit indices. The measurement model and the structural equation models are presented and discussed in this chapter. The structural equation model represents the inter-relationship among promotional factors, special days, seasonal factors and customer preferences. The direct and indirect effect of these demand factors on sales volume are also analysed through these models. The proposed SEMs aim to serve as a tool to categorise the demand factors specific to 2ltr pet bottles, 500 ml and 6-packs of 330ml cans in a more general form.

9.2 Conceptual demand-factor model and hypotheses development

The role of demand information on various supply chains was discussed in greater detail in the case studies in Chapter 4. Then the RDM specific to the Soft Drink Co. was developed in Chapter 6. Demand factor information for forecasting purposes was also discussed in these two chapters. Further quantitative analyses of the demand information identified from the RDM of Soft Drink Co. are discussed in this chapter. From the RDM, the demand factors are grouped mainly in four latent constructs. The underlying relationships among these four latent constructs are tested in this chapter.

In this chapter, the influence of the four factors in the products' sales volume is hypothesised (See Figure 9-1). The conceptual model demand-factor model has set five hypotheses to test the relationships among factors (latent constructs). This model is validated using actual sales data to form a structural equation model.

Figure 9-1 Conceptual demand-factor model



Recent technology advancement has created many avenues for marketing opportunities such as internet advertisements, television advertisement, text messages etc (Swaminathan and Tayur, 2003). Apart from these media advertisements, in-store display location may also have a great impact on sales (Cooper et al., 1999). In Soft Drink Co., collaborating partners decide on the type of promotions, the timing of promotions and the display location in advance. In this chapter, for the purpose of the

SEM analysis, the sales data of retailer R4 for three years (2005-2007) is considered. This is mainly because the retailer R4 runs a variety of promotions at different periods of time in many stores.

9.2.1 The influence of promotional strategies on sales volume

Traditionally, promotions are intended to boost normal sales through the adoption of some specific promotional sales strategies combined with price discounts. From the case study of the Soft Drink Co. (Chapter 4), it has been found that the type of promotion decides product pricing, which varies widely across various promotions. The promotional factors (latent construct – PF) includes four variables such as

- Type of promotion (PF1)
- Size of promotion (PF2)
- Duration of promotion (PF3)
- Price discount (PF4)

As explained in Chapter eight (see Table 8-2 for scales used in the data analysis)Table 8-2 Scales used in the data analysis, The type of promotion can be save x%, buy 3-for £x or buy 3 for 2, 2-for £x, buy-one-get-one- free (bogof) and half-price. The type of promotion, size of promotion and period of promotion are represented through the scale of 1-5. The size of the promotion is reflected either in the display location or in the number of stores participating in the promotional sales. For example, the display location in a normal store is on the shelf, end aisle or gondola and will have different impacts on sales. These are represented with the scale of 1, 2 and 3 respectively. At the same time, display location on shelves and gondola end at big stores will be measured as 4 and 5. Please note that the big stores do not offer end aisle for display. Both the retailers and the manufacturer collaboratively decide on the display location. Some of the display locations may incur extra costs. All the parties involved in promotional sales may bear some of the costs.

Duration of promotion and price discount are continuous variables. The duration of the promotion may be short duration (1 to 4 weeks), or longer duration (4 to 8 weeks). The sales volume throughout the promotional weeks is not the same (Cooper et al., 1999); in certain cases the sales in the first week will be very high and then the sales will gradually decline, but in some other cases the sales for the first 5 weeks will be stable and then slowly start declining. During this period, the marketing department works in coordination with production team for production and replenishment. The promotional planning also includes decision making especially for price discounts. Every aspect of the promotion may have a different impact on sales but the overall rationale or expectation is that sales will grow. This argument builds the first hypothesis.

Hypothesis 1: Promotional factors have a positive influence on overall sales performance

9.2.2 Influence of non-promotional demand factors on sales

Some other demand factors (other than promotions) have also been indentified in Chapter 6, when the RDM of Soft Drink Co. was discussed. These non-promotional factors are grouped in this chapter as Special days, Seasonal factor and Customer preference. These three non-promotional factors are described below.

Generally, sales of soft drinks during holidays and festivals are expected to be higher than during normal days. In this research, this particular factor on holidays and festivals is represented as ‘Special days’, which is similar to ‘holidays’ in previous research studies (Cooper et al., 1999; Divakar et al., 2005). In addition to holidays, the factor ‘Special days’ in this research includes main festivals of the UK such as Christmas and

Easter, and also includes other holiday or celebration periods such as school vacation, mothers' day/father's day, valentines' day and bank holidays. In short, the factor 'Special days' (latent construct – SD) includes two variables –

- Festivals (SD1)
- Any other holidays or special occasions (SD2)

Both of these variables of latent factor 'Special days' are represented through categorical values (0/1).

The next non-promotional demand factor is seasonal factor (latent construct- SF) that includes

- Temperature (SF1)
- Sales period (SF2)

The variable 'temperature' represents the average temperature of the month. Another variable that has close relationship with temperature is the season of the year (winter, spring, summer and autumn). The season of the year has been specified in previous research using days or weeks of the year (Cooper et al., 1999). Hence, in this research, the variable 'sales period' represents the week of the year. The idea of representing the week of the year is to avoid missing any seasons. Both these variables, temperature and sales period, are continuous scales.

The next group of two variables are used to represent customer preference collectively. The first variable is called 'product rank'. In general, the volume of sales of a product is the indicator of the customers' preference for a product among a group of similar products (Dube, 2004). This is referred to as 'product rank' of a product, which is based on sales volume of the product. Products rank of a product in this research is interpreted as the buyers' choice for the product among a group of similar products of Soft Drink Co. It should be noted that the rank does not include comparison with competitors' brands. Product rank is represented through an ordinal scale from 1 to 5. The second variable of customer preference is the distinction between new and established products. In Soft Drink Co., the sales of established products are always different from new products. In summary, the factor ‘customer preference’ (latent construct - CP) has two variables -

- Product ranks (CP1)
- New/established products (CP2)

The new or established products are represented through a dichotomous scale (0/1). In general, the absence of promotion is represented through ‘0’ for all the above variables (see Table 8-2).

The objective of this chapter is to recognise the relationships underlying the demand of different products: 2ltr and 500ml pet bottles, and 6-packs of 330ml cans. The case study with the Soft Drink Co. has helped to understand the marketing practices on promotions for these products. Promotions are a major contributor to sales volume and need to be coordinated between the manufacturer (Soft Drink Co.) and retailers. The collaborative planning decides on the period of promotion, display location for promotional items, marketing strategies, etc. The case study findings have been used to formulate the research hypotheses.

The first non-promotional factor is ‘Special days’-SD. Normally, festive seasons like Christmas or Easter, regional holidays such as bank holidays or school vacations and other occasions like Valentines Day or Mothers Day will increase sales. Although the case company does forecast sales during Christmas using historic sales data, they do not give much attention to the other special days. In the demand-factor model, all these festivals and special occasions are included in the name of Special days. As the historical sales data shows increased sales during the above mentioned special days (especially for 2ltr pet bottles), it is wise to test its reliability using SEM. Hence, the second hypothesis is as follows.

Hypothesis 2: Special days influence overall sales performance positively

The second non-promotional factor is related to the seasonal factor. For products like soft drinks, sales volume generally depends on the local weather or temperature (Divakar et al., 2005). From the sales data of Soft Drink Co. it is understood that high temperatures has increased the sales of 500ml bottles in many retail outlets. Based on this observation, the next hypothesis is formulated as follows:

Hypothesis 3: Seasonal factors have positive impact on overall performance of sales

All the products from a same manufacturer will not have consistent sales volume throughout a year. Some products may capture more market share than the others. Even similar products are valued differently by consumers at different periods of time (Sun, 2005; Ailawadi et al., 2009). Based on the sales volume, the products are ranked under five different levels to represent the customer preference. The new products and established products are not perceived equally by the customers. The preference for new product and established products is different and it is reflected in the sales volume. The next hypothesis is relating customers' preferences with the overall sales performance.

Hypothesis 4: Customer preference of the product influences overall performance of sales

Hypotheses 1 to 4 have established relationship between each of the latent construct with latent construct 'overall performance of sales'. Some of all of the first order latent constructs such as seasonal factor and promotional will have a positive relationship (Cooper et al., 1999). This relationship may influence the overall performance of sales. For example, the sale of soft drinks during Christmas will have different sales volume in comparison to the sale of soft drinks during Christmas with bogof type of promotions.

In this case, Seasonal factor and Promotional factors are acting together to improve the sales. Hence, it will be ideal to find the inter-relationship among latent constructs and overall performance of sales. Based on this argument, the next research hypothesis is formulated as follows:

Hypothesis 5: Significant relationship among promotional factors, special days, Seasonal factors and customer preference will influence overall performance of sales.

The exploratory nature of hypothesis 5 intends to identify the inter-relationship among promotional and non-promotional factors (special days, seasonal and customer preference). This analysis will also assist in identifying the direct and indirect effect of these relationships on overall influence of sales.

9.3 Data

The data for our analysis includes sales data for 25 different soft drinks, over the past three years (2005-2007). For the purpose of the comparison of SEM models of 2ltr bottles, sales data of two different retailers (R2 and R4) are considered. These data are mainly considered for studying characteristics of demand factors with respect to promotional sales but not for studying the changing interest of buyers. Hence, it is not treated as a longitudinal study (Hair et al., 2006, pp-876). The case study research, reported in Chapter 4, has been used to identify company specific data for pricing, marketing strategies (advertising), local festivals, special days, and customers' preference for each product. In addition, publicly available information on holidays, local festivals and temperature have also been used.

The data analysis was initiated with the sales data for a single product or a group of similar products promoted at the same period of time, which forms the basic measurement model. The data matrix was first checked for coding errors (see Chapter

8). In case of any mismatch of sales figure and promotions, it was corrected through information from the key informant (Voss et al., 2002).

The distribution of the complete data set specific to 2ltr products was confirmed satisfactory from the descriptive statistical analysis. Table 9-1 reports the results of descriptive analysis namely, mean, standard deviation (SD) and correlation matrix. This is for a group of six similar 2ltr products promoted at the same period of time. The promotional variables are significantly correlated to each other at $p < 0.01$ level. The correlation values vary from 0.262 to 0.795. It represents that each of the variables under the construct 'promotional factors' are distinctly representing the characteristics of promotional sales (Mishra and Shah, 2009).

The non-promotional construct 'Special days' has two variables- festivals and holidays. These two variables are significantly correlated to each other at $p < 0.01$ level with correlation value 0.386. The festivals and the holidays are significantly correlated to the period of promotion with value of 0.127 and 0.100 respectively at $p < 0.01$. The next non-promotional construct 'Seasonal factor' has two variables – temperature and time period. Both of these variables are correlated with value 0.182. Temperature has a high significant correlation with size of promotion and price discount. But, temperature has a negative correlation with festivals and holidays. The negative correlation of temperature with festivals shows that the main festivals in the UK are happening during low temperature (example Christmas). The last non-promotion construct 'customer preference' has two correlated variables – product rank and new/established products. It is important to note that these two variables are not correlated to any other variables of the other three constructs.

Table 9-1 Descriptive statistics of first order observed variables

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. PF1 Promotion type	1.472	1.676	1									
2. PF2 Size of promotion	0.331	0.749	.539**	1								
3.PF3 Duration of promotion	1.285	1.764	.719**	.262**	1							
4. PF4 Price discount	0.138	0.183	.795**	.741**	.595**	1						
5. SD1 Festivals	0.021	0.142	0.056	-0.064	.127**	-0.02	1					
6. SD2 Holidays	0.123	0.329	0.039	-0.067	.100**	0.02	.386**	1				
7. SF1 Temperature	13.275	4.918	-0.015	.296**	-.095**	.218**	-.170**	-.086*	1			
8. SF2 Time period	26.809	15.107	-0.05	-0.014	-.079*	-0.063	.232**	.069*	.182**	1		
9. CP1 Products ranks	3.730	1.670	-0.032	0.011	-0.037	-0.003	-0.007	-0.003	0.013	0.002	1	
10.CP1 New/Established	0.433	0.496	0.016	-0.024	0.027	0	0.011	0.006	0.003	0.023	-.870**	1

n = 826 observations & **-Correlation is significant at the 0.01 level (2-tailed);*-Correlation is significant at the 0.05 level (2-tailed).

9.4 Model constructs

A two stage procedure is adopted to test the conceptual framework (Anderson and Gerbing, 1988). In the first stage, SPSS 15 has been used for Exploratory Factor Analysis (EFA) and for Confirmatory Factor Analysis (CFA). This is mainly for developing and testing the basic conceptual model to develop into a structural equation model. In the second stage, Amos 16 has been used for structural equation modelling (SEM) to assess the overall fit of the conceptual framework for the demand-factor model. The complete data set of a single product group is used as input in estimating the measurement model using the method of maximum likelihood. Before developing structural equations, a brief note on latent construct, path analysis, measurement model and structural model is given below:

Latent construct is a variable generally used in structural equation modelling (SEM). This is used to measure the variable that cannot be measured directly but can be estimated through other observed variables.

Path analysis, a subset of structural equation modelling, is a statistical technique that is used to examine causal relationships between two or more variables or latent constructs. In this research, Amos is used to specify path diagrams to show hypothesized relationships among various demand factors. As structural equation model is a combination of path analyses.

In general, SEMs are given in two steps: constructing measurement model(s) and testing the structural model (Hair et al., 2006; Hoyle 1995). The measurement model (i.e., structural model under examination) deals with the relationships between measured variables and latent variables (Mishra and Shah, 2009). The structural model deals with the relationships between latent variables only. The SEM is usually represented with a visual diagram (Hair et al., 2006).

Stage 1: Measurement model construction

In this stage, the conceptual model is tested to validate the latent constructs and also to ensure suggested fit (Mishra and Shah, 2009; Hair et al., 2006). A total of ten observed variables are used to form four latent constructs: promotional factors, seasonal factors, special days and customer preferences (see Figure 9-1). Principal component analysis is conducted to identify the number of groups formed in identified variables. To validate these groups, the varimax rotation method with Kaiser Normalization is used. The eigen value of one or more is used to identify the number of factors. Any element with a factor loading smaller than 0.4 is not considered for further analysis as they will not measure specific construct (Hair et al., 2006). The results of Exploratory Factor Analysis are given in Table 9-2. The percentage of variance explained by these ten variables is 68.28%. This represents the amount of stability of the construct.

Table 9-2 Exploratory factor analysis for 2ltr pet bottles

Constructs	Variables	Factor loadings			
Promotional factor (PF)	PF1	0.913			
	PF2	0.727			
	PF3	0.776			
	PF4	0.932			
Special days (SD)	SD1		0.835		
	SD2		0.724		
Seasonal factor (SF)	SF1			0.792	
	SF2			0.629	
Customer preference (CP)	CP1				0.737
	CP2				0.699

As suggested by Anderson and Gerbing (1988), the Confirmatory Factor Analysis (CFA) is conducted to verify the overall fit of the model and also to assess the reliability and validity of each item. A basic model is developed upon our conceptual model. The results of CFA are given in Table 9-3. The first three constructs are highly significant at p < 0.01 level, whereas the last construct ‘product’ fails the Bartlett’s test of sphericity (not significant) although the Kaiser-Meyer-Olkin’s (KMO) measure of sampling adequacy has a 0.5 value (Hair et al., 2006). Hence, this construct (CP) is dropped from further analysis of 2ltr bottles.

Table 9-3 Results of confirmatory factor analysis (Factor loading) -2ltr pet bottles

Constructs→ Observed variable ↓	Promotional Factors	Special days	Seasonal factor	Customer preference	Total variance explained
PF1	0.915				71.32 %
PF2	0.748				
PF3	0.761				
PF4	0.936				
SD1		0.833			70.05 %
SD2		0.841			
SF1			0.769		59.99 %
SF2			0.780		
CP1				0.723	52.31 %

n = 826 observations; p-value <0.01 for all factor loadings.

From the case analysis, it was identified that the product ranks were important factors that control the sales of Soft drink products. Also, the variable ‘product ranks (CP1)’ have shown significantly higher factor loading. Hence, this is considered for further analysis and connected directly to the latent construct overall performance of sales (Mishra and Shah, 2009).

The CFA confirmed the significance of the entire path between observed variables and first order latent variables with $p < 0.01$. The construct validity of the model is explained through the percentage of variance extracted (Fornell and Larcker, 1981). All of the three factors have more than 50% variance extracted with a factor loading ranging from 0.723 to 0.936. The reliability of all of the three latent constructs is verified as good using Cronbach alpha as $\alpha = 0.63$. Here, Cronbach alpha ≥ 0.60 is valid in this exploratory case (Nunnally, 1978). Hence, the construct validity and the construct reliability of the model shown in Figure 9-1 are satisfactory. Furthermore, the constructs are tested for discriminant validity to check how each construct is distinct from the other (Anderson and Gerbing, 1988; Hair et al., 2006). Using SPSS, the inter-correlation among the latent constructs was calculated. None of the values of correlation contains 1.0, it is concluded that each construct is distinct from the other (Mishra and Shah, 2009).

The model fit is verified using several recommended fit indices - normed chi-square (χ^2/df), comparative fit index (CFI), goodness-of-fit index (GFI), incremental fit index (IFI), Trucker Lewis Index (TLI) and root mean square error of approximation (RMSEA) at 90% confidence interval (CI). Table 9-4 explains each of the fitness indices used with suggested cut-off points.

Table 9-4 Description of model fit indices

Fit index used	Description	Suggested cut-off
χ^2/df	Normed Chi-square : Chi-square divided by degree of freedom	< 4
CFI	Comparative fit index compares the model fit with a baseline model	> 0.90 > 0.90
GFI	Goodness-of-fit index indicates how well the model reproduces the covariance matrix among the observed variables.	> 0.90
IFI	Incremental fit index: Group of goodness of fit indices that assesses how well a specified model fits relative to some alternative baseline model.	> 0.90
TLI	Trucker Lewis index	< .07
RMSEA	Root Mean Square Error of Approximation	≥ 90%
CI	Confidence interval	

Source: Hair et al (2006); Baumgartner and Homburg (1996); Bentler et al., (2001)

The measurement model (see Figure 9-2) considers the relationships of first order latent constructs with the corresponding variables. In this model all three of the first order factors have covariance relationship with each other. The model fit indices listed in Table 9-5 are admissible which is reflected in the significant factor loading. The model fit has GFI = 0.988, CFI = 0.989, χ^2 = 45.42 with df = 18, normed χ^2 = 2.52, IFI = 0.990, TLI = 0.979 and RMSEA = 0.043 at 90% CI. This model exceeds the suggested level of fit in empirical research (Shah and Goldstein, 2006).

9.5 Stage 2: Model construction and testing

Structural models

In stage 2, structural equation modelling is used for observing the hypothesised demand-factor relationships. This is mainly based on the concept of structural relationships as explained by Hair et al. (2006). A structural theory is a conceptual representation of the relationships between constructs. It can be expressed in terms of a structural model that represents the theory with a set of structural equations and is usually depicted with a visual diagram (Hair et al., 2006). In this research, before developing a complete structural model, two trial models are established to confirm relationships among constructs (Mishra and Shah, 2009). These trial models are named as structural model 1 (SM-1) and structural model 2 and (SM-2).

The demand of the soft drinks is influenced by promotions, holidays, seasons and customer preferences (Cooper et al., 1999; Divakar et al., 2005; Dube, 2004). This idea constitutes the first model (SM-1) by including the overall performance of sales as the effect of the first order constructs. Hence, in the second model, the latent construct called ‘overall performance of sales’ is introduced as an improvement to the measurement model. This model also has all of the correlated first order constructs. This model show a good fit index with normed χ^2 = 3.379, GFI = 0.981, CFI =0.983 and RMSEA =0.054 at 90% CI. The fit result of SM-1 (see Figure 9-3) is almost similar to the measurement model and the advantage of this model is confirmed by its significant factor loading and the significant structural links compared to the first order factor models (Venkatraman, 1989).

The fit indices of the SM-1 are considered as complete as it satisfies the fit statistics suggested in Table 9-4. But the covariance relationship between the constructs ‘promotional factor’ and ‘seasonal factor’ is not significant. The next improvement to this model is totally free from the covariance between these two latent constructs - ‘promotional factor’ and ‘seasonal factor’. This improved model (SM-2) also has a suggested fit index and reflects the hypothesised ideas of demand-factor model. In the model SM-2 (see Figure 9-4), the model fit has normed $\chi^2 = 3.244$, GFI =0.981, CFI = 0.983, RMSEA of 0.052 and R^2 (explanatory power of various independent factors on dependent variable) of sales is 0.70. This fit index is well under the suggested fit (Kline, 1998). The covariance relationship between latent constructs promotional factors and special days are significant at $p < 0.05$. The negative correlation of - 0.09 between the constructs promotions and special days is significant at $p < 0.05$, which represents that the promotions are not planned during special days all the time. In other words, not many promotions are executed during holidays.

Similarly, the correlation value between the special days and the seasonal factors is - 0.23 and significant at $p < 0.01$. This represents the fact that the high temperature and festivals are not happening at the same time. This relationship does not show any implication other than the obvious fact that Christmas (in the UK) is celebrated at a time when the temperature is low. The covariance relationship has not shown any strong evidence of relationships between any two latent constructs. After removing these covariance relationships among first order latent constructs, the model fit has not changed much in the model (see Figure 9-5). Hence, it becomes clear that although there is an inter-relationship existing among the latent constructs, these relationships are not highly influencing the overall performance of sales. The fit indices of all the models are listed in Table 9-5. The final model is considered as the complete structural equation model for further analysis. In the complete structural model, the degree to which the endogenous factor ‘sales’ can be determined is calculated through R^2 (Sohn et al., 2007).

Table 9-5 Model summary of structural equation models – Fit indices

	χ^2 (df)	Normed χ^2	CFI	GFI	IFI	TLI	RMSEA (90% CI)
MM	45.42 (18)	2.52	0.989	0.988	0.990	0.979	0.043 (0.028,0.059)
SM-1	81.09 (24)	3.379	0.983	0.981	0.983	0.968	0.054 (0.041,0.067)
SM-2	81.09 (25)	3.244	0.983	0.981	0.983	0.970	0.052(0.040,0.065)
Complete SM	101.02 (27)	3.741	0.978	0.976	0.978	0.963	0.058 (0.046,0.070)

MM-Measurement Model; SM-Structural Model

Figure 9-2 Measurement model

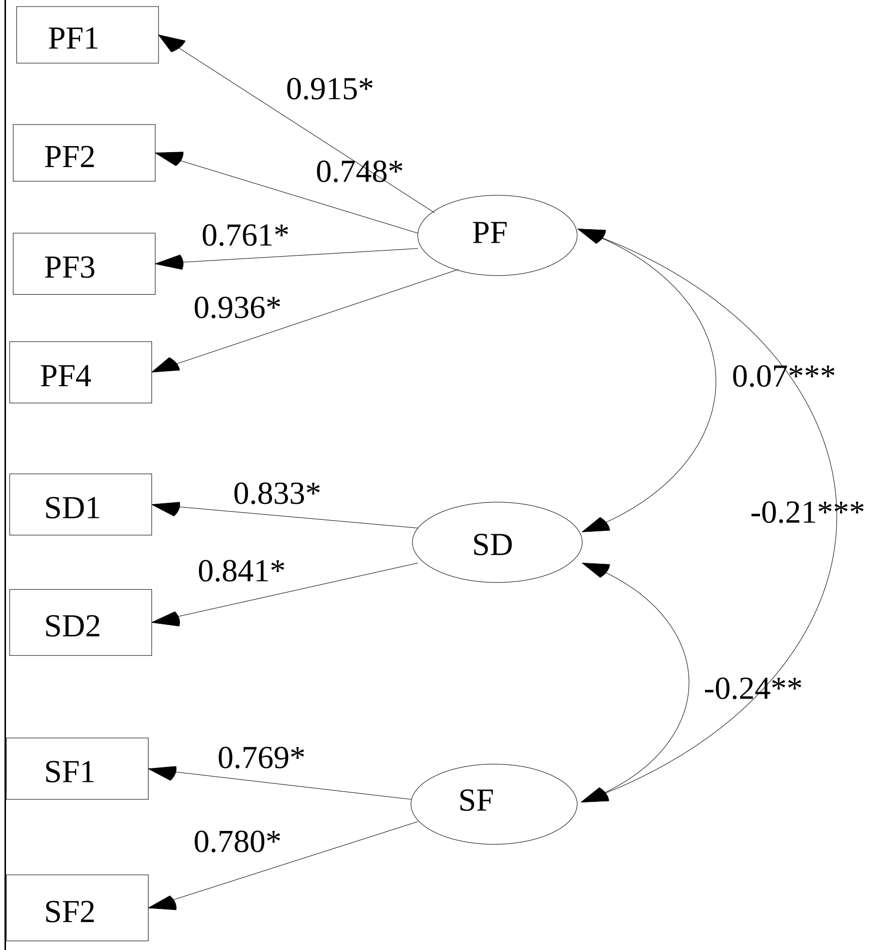
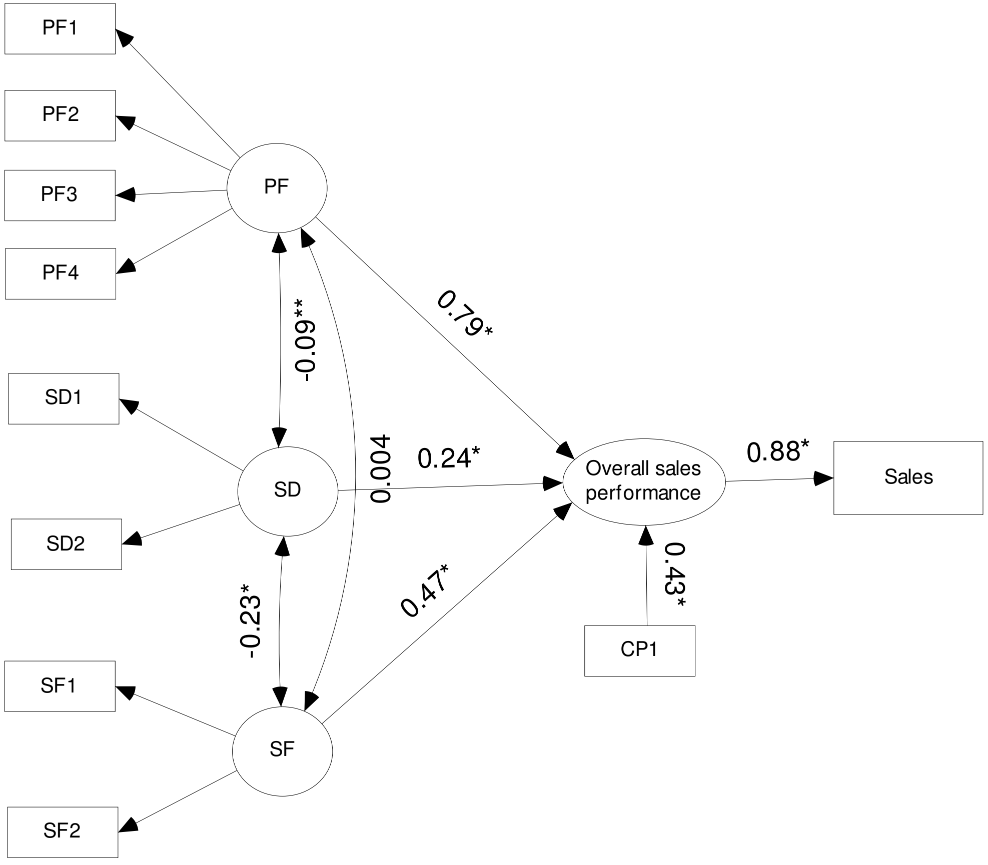

PF1
PF2
PF3
PF4
0.915*
0.748*
0.761*
0.936*
PF
0.07***
-0.21***
SD1
SD2
0.833*
0.841*
SD
-0.24**
SF1
SF2
0.769*
0.780*
SF

Figure 9-3 Model - 1


PF1
PF2
PF3
PF4
PF
0.79*
-0.09**
SD1
SD2
SD
0.004
0.24*
Overall sales performance
0.88*
Sales
0.43*
CP1
-0.23*
0.47*
SF1
SF2
SF

*****-significant at p < 0.10 ; ** -significant at p < 0.05; *- significant at p < 0.01**

Figure 9-4 Model - 2

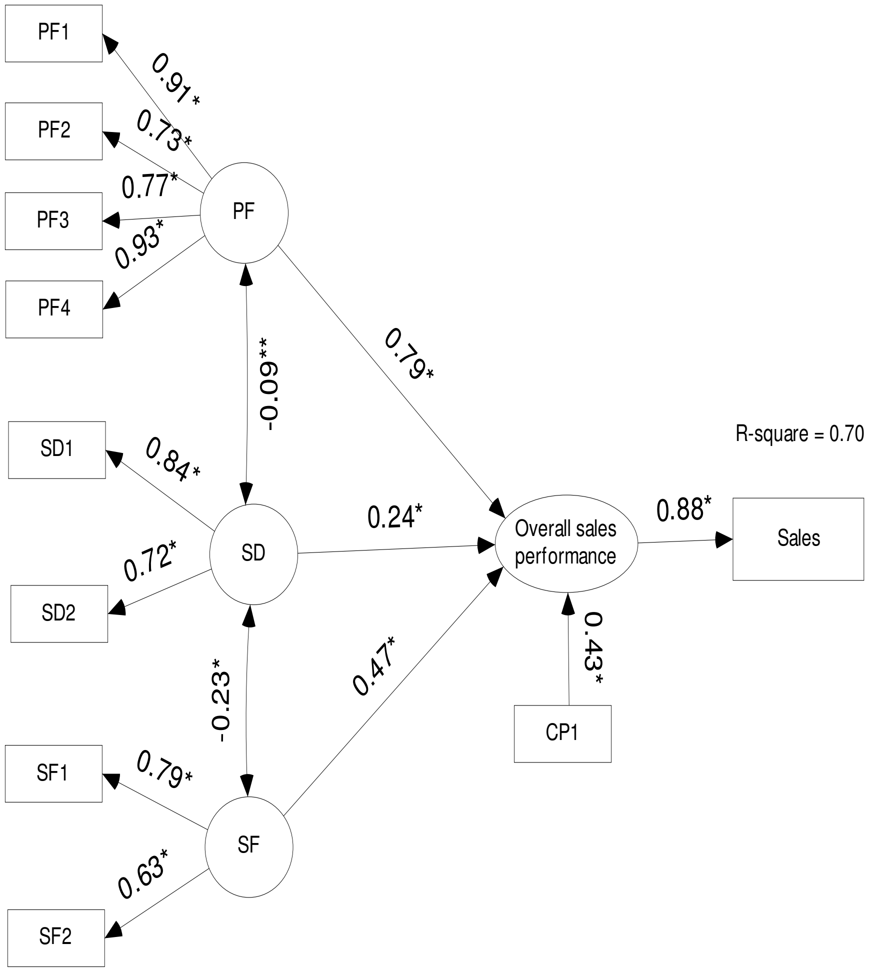
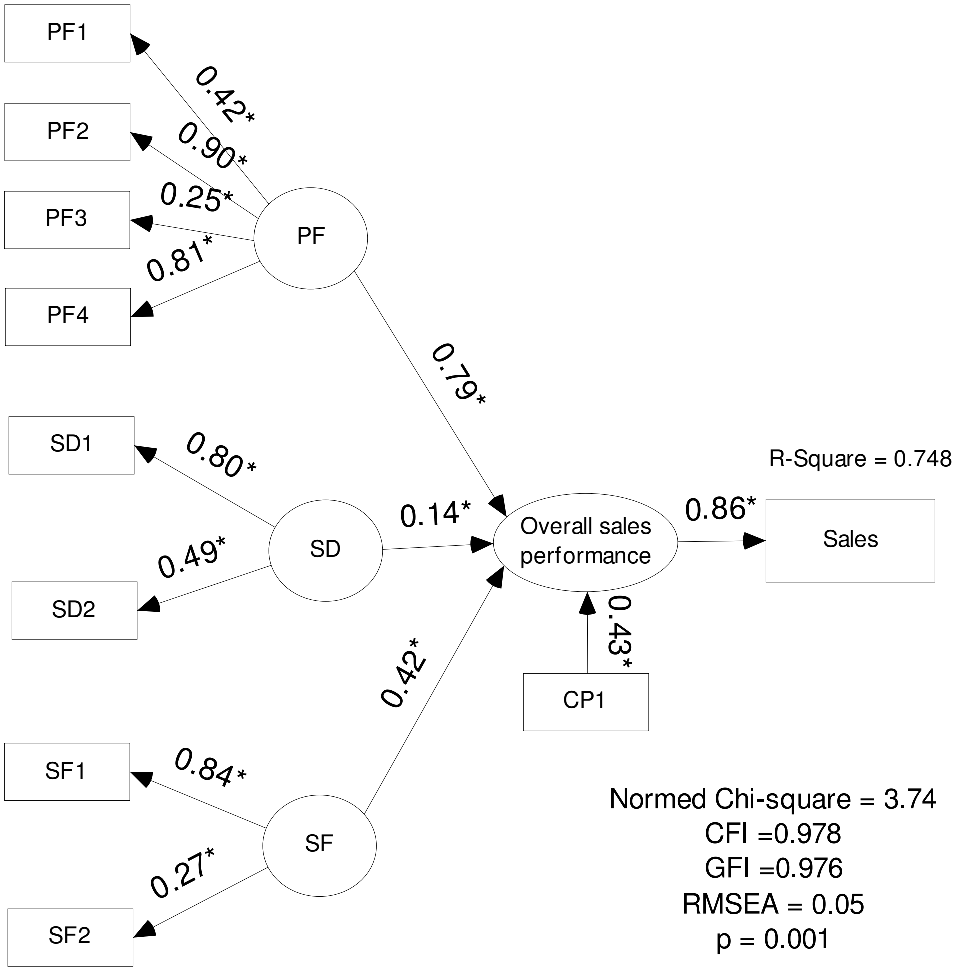

PF1
PF2
PF3
PF4
0.91*
0.73*
0.77*
0.93*
PF
-0.09**
0.79*
SD1
SD2
0.84*
0.72*
SD
0.24*
-0.23*
0.47*
SF1
SF2
0.79*
0.63*
SF
Overall sales performance
R-square = 0.70
0.88*
Sales
0.43*
CP1

Figure 9-5 Complete structural equation model of demand -2ltr pet bottles


PF1
PF2
PF3
PF4
0.42*
0.90*
0.25*
0.81*
PF
0.79*
SD1
SD2
0.80*
0.49*
SD
0.14*
R-Square = 0.748
Overall sales performance
0.86*
Sales
0.43*
CP1
0.42*
SF1
SF2
0.84*
0.27*
SF
Normed Chi-square = 3.74
CFI =0.978
GFI =0.976
RMSEA = 0.05
p = 0.001

** Significant at $p < 0.05$; *- significant at $p < 0.01$

9.6 Structural equation model for 2ltr pet bottles

The structural model aims to represent the conceptual framework of demand-factor relationship. In the structural model (Figure 9-5) all of the second order factors are significant with $p < 0.01$. In order to validate this model different data samples from the same population, retailers R4 and R2, are used (Sharma, 1996). Model fit is admissible with two different sets of sample of data from the same population (see Table 9-6). All of these fit indices are given in the Table 9-6. Both data sets have shown good fit indices with normed chi-square of 3.741 and 4.495. R^2 (explanatory power of various independent factors on dependent variable) of sales is 0.748 and 0.573 in these data sets. It is evident from the results that the structural model fits well for the given samples; it can be concluded that the hypothesised demand-factor model is valid. Results of the empirical analysis are further explained in the next section.

Table 9-6 Testing of structural model for different data sets of 2ltr pet bottles

	χ^2 (df)	Normed χ^2	CFI	GFI	IFI	TLI	RMSEA (90% CI)	R^2 of Sales
Data set1 R4	101.02 (27)	3.741	0.978	0.976	0.978	0.963	0.05 (0.046,0.070)	0.748
Data set2 R2	121.37 (27)	4.495	0.978	0.978	0.978	0.964	0.05 (0.046,0.066)	0.573

9.7 Analysis of the model for 2ltr pet bottles

It is worth mentioning in detail the reasons for not choosing the models SM-1 and SM-2 as a complete model. In the SM-1, the promotional factors are not significantly correlated (correlation is zero) with seasonal factors namely temperature and the time period of sales. This indicates that the promotional factors are independently and directly influencing sales volume. This is further confirmed through the structural model as the promotional factor has direct impact on the sales with path coefficient of 0.79 at the significance level $p < 0.01$. This proves the first hypothesis that the promotional factor has a direct positive impact on the overall performance of sales. Hence, in the next model, the covariance relationship between promotional factors and seasonal factors is removed.

In the SM-2, the construct ‘special days’ is not positively correlated with the other two constructs but has a significant covariance relationship; which indicates that the decrease in temperature may have negative influence on special days. It is true that in the UK Christmas is the most important festival that happens in winter (low temperature). Similarly, the correlation between the constructs ‘special days (SD)’ and ‘promotional factors (PF)’ has significant negative correlation. This indicates that the promotions are offered during non-special days.

In the final model, the direct significant impact of special days and seasonal factors on overall performance of sales is evident through the path coefficients 0.14 and 0.42 significant at $p < 0.05$ respectively. Here, it can be noted that in the structural model the missing covariance relationship among constructs does not affect the model fit but for small changes in the loadings between the paths -- special days and overall performance of sales, seasonal factors and overall performance of sales. The variation explained (R^2) by the final structural equation model is higher compared to the variation explained in SM-2 ($R^2 = 0.70$). This clearly states the completeness of the final model (Mishra and Shah, 2009). This structural model of 2ltr bottles proves the next two hypotheses (H2 and H3) that ‘special days’ and ‘seasonal factors’ have a positive impact on overall performance of sales. The customer preference (product ranks) on overall performance of sales has a path coefficient of 0.43 at significance level of $p < 0.01$. This makes the fourth hypothesis valid. That is, the customer preference has a positive impact on overall performance of sales.

Regarding Hypothesis 5, the interrelationship between promotional and seasonal factors is not significant. However, the inter-relationship between promotional factors and special days as well as special days and seasonal factors is significant but negatively correlated. None of these relationships have shown a considerable impact on overall performance of sales. Thus the hypothesis 5 is not supported. Hence, it can be asserted that the promotional and non-promotional factors are not related to each other in such a way to make an impact on the overall performance of sales.

The structural model for 2ltr pet bottles is further tested for 500ml pet bottles and 6-pack of 330ml cans. The first measurement model is considered as a base model to test the inter-relationships among various constructs. This is mainly because the measurement model incorporates all of the possible relationships among latent constructs.

9.8 Structural equation model for 6packs-330ml cans

To identify the relationships among various demand factors of 330ml cans, the same approach is applied for 6-packs of 330ml cans as explained in the analysis of 2ltr pet bottles. Based on the level of significance, the demand factors are removed or retained for further analysis. First, the principal component analysis is conducted to identify the groups of variables. The procedures followed in the exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are exactly the same as the analysis of 2ltr pet bottles. Table 9-7 shows the results of EFA for the 6-pack 330ml cans.

Table 9-7 Exploratory factor analysis for 330ml cans

Constructs	Variables	Factor loadings (6packs)			
PF	Type	0.975			
	Size	0.829			
	Period of promotion	0.738			
	Price	0.954			
SD	Festivals		0.741		
	Holidays		0.844		
SF	Temperature			0.754	
	Time period			0.776	
CP	Product rank				0.803
	New/Established				-0.788

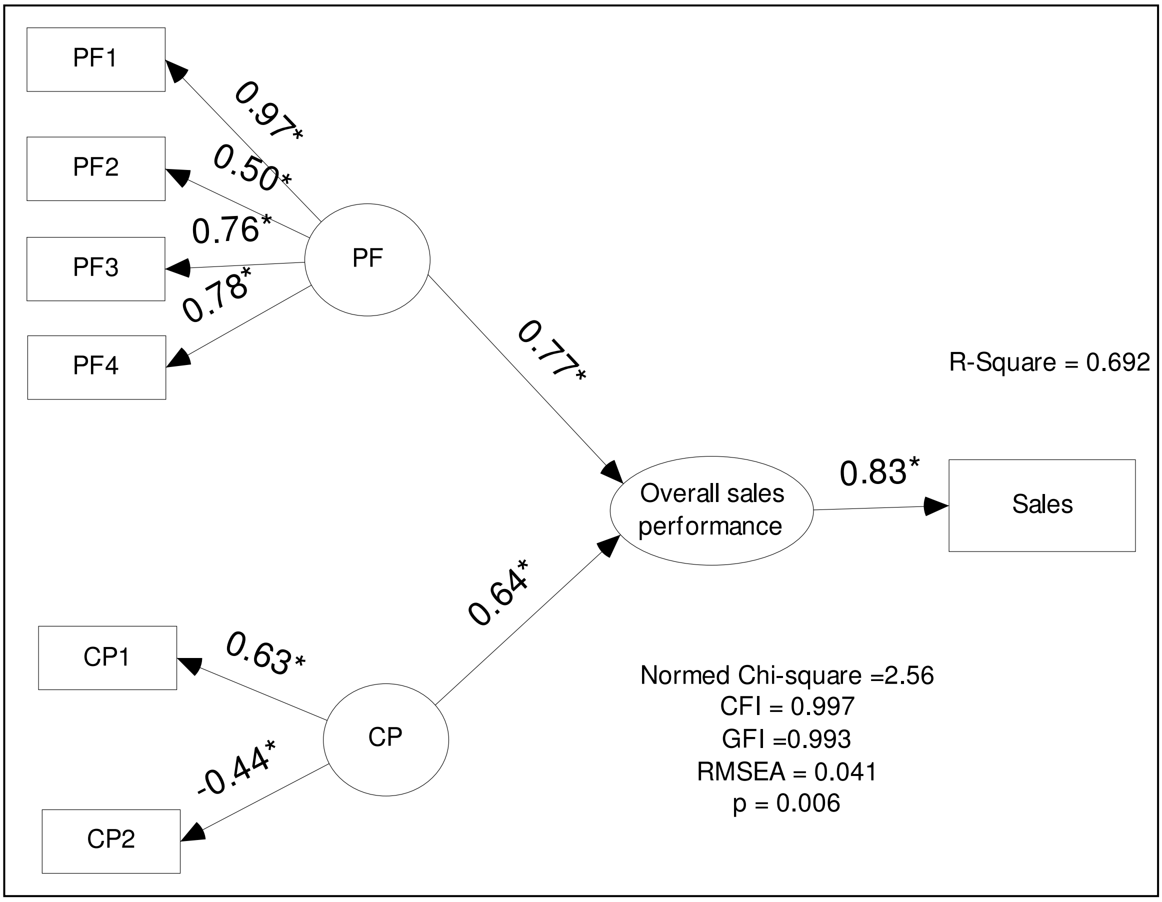
The total variance explained in EFA is 70.61%. CFA is conducted to confirm the demand factors under each latent variable. All of the four factors identified the first order variables as significant with factor loadings above 0.709. The results of the CFA analysis are given in Table 9-8.

Table 9-8 Results of confirmatory factor analysis (Factor loading) - 330ml cans

Constructs→ Observed variable ↓	Promotional factor	Special days	Seasonal factor	Customer preference	Total variance explained
PF1	0.976				77.52 %
PF2	0.827				
PF3	0.743				
PF4	0.955				
SD1		0.827			66.28 %
SD2		0.801			
SF1			0.769		58.91%
SF2			0.766		
CP1				0.799	57.05%
CP2				-0.709	

The measurement model including covariance relationship with all four latent constructs is considered for further testing with sales data of 6-packs of 330ml cans. Figure 9-6 shows the structural equation model for 6-pack 330ml cans.

Figure 9-6 Structural model of 330ml cans


PF1
PF2
PF3
PF4
PF
0.97*
0.50*
0.76*
0.78*
0.77*
R-Square = 0.692
Overall sales performance
0.83*
Sales
0.64*
CP1
CP2
CP
0.63*
-0.44*
Normed Chi-square =2.56
CFI = 0.997
GFI =0.993
RMSEA = 0.041
p = 0.006

*- significant at $p < 0.01$

Unlike 2ltr bottles, 6-packs of 330ml cans do not have special days and seasonal factors as significant latent functions of the overall performance of sales. However, the promotional factors are highly significant (at $p < 0.01$) to explain the overall performance of sales with a path coefficient of 0.77. All of the observed elements of promotional factors have significantly high loadings in the range of 0.5 to 0.97. The construct ‘customer preference’ also has a positive and significant impact on the overall performance of sales. The path coefficient of customer preference with overall performance of sales is 0.64, significant at $p < 0.01$. The observed item, ‘product rank (CP1)’, has a significant loading of 0.63 at $p < 0.01$ on the latent construct ‘customer preference’. Another observed item of this construct namely ‘new product/established product’ has a negative significant loading -0.44.

No significant covariance relationship is found between the latent constructs the ‘customer preference (CP)’ and the ‘promotional factor (PF)’. This means that the promotional factors are independent of the customer preferences. Both of these factors have a positive impact on the overall performance of sales. This result proves hypothesis H1 and H4 that the promotions and customer preferences positively influence the overall performance of sales. However, H2, H3 and H5 are not supported for 6-packs of 330ml cans model. In other words, there is no evidence that special days and seasonal factors have a positive impact on the overall performance of sales of soft drink 6-pack of 330ml cans. None of the four demand factors are significantly related to each other.

9.9 Structural equation model for 500ml pet bottles

Table 9-9 and Table 9-10 show the results of exploratory factor analysis and confirmatory factor analysis for 500ml bottles.

Table 9-9 Exploratory factor analysis for 500ml bottles

Construct	Variable	Factor loadings			
PF	Type	0.833			
	Size	0.734			
	Period of promotion	0.888			
	Price	0.840			
RF	Festival		0.790		
	Holidays		0.871		
LF	Temperature			0.774	
	Time Period			0.743	
CP	Product rank				0.879
	New/established				-0.861

The total variance explained in EFA is 71.57%. Further to EFA, confirmatory factor analysis is conducted to confirm the demand factors under each latent variable. All of the four factors identified significant first order variables with factor loadings above 0.74. The measurement model is considered for further testing with 500ml sales data.

AMOS 16 is used for testing model fit. Initially, the factor loadings between the first order latent constructs and overall performance of sales factors are analysed.

Table 9-10 Results of confirmatory factor analysis (Factor loading) 500ml bottles

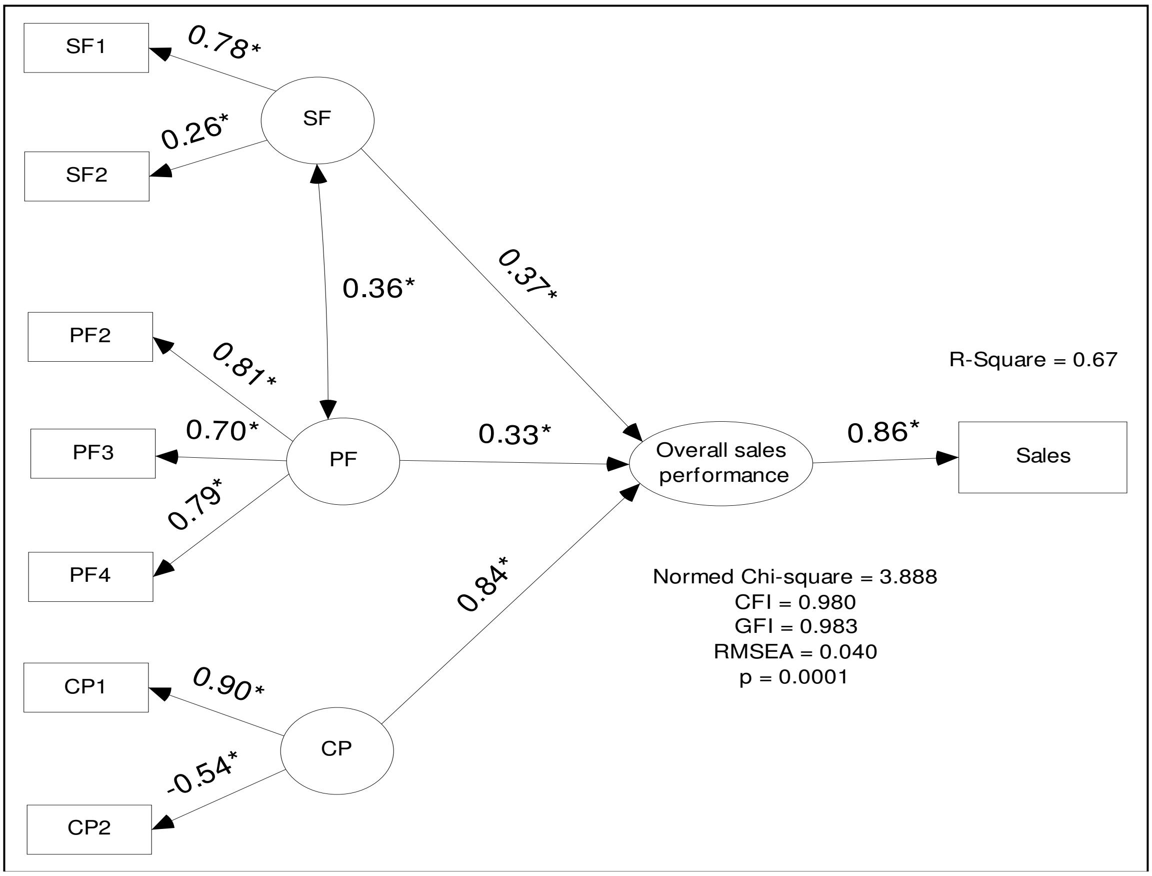
Constructs→ Observed variable ↓	Promotion Factor	Special Days	Seasonal Factor	Customer preference	Total variance explained
Type	0. 832				
Size	0. 759				
Period of promotion	0.895				
Price	0.827				68.80%
Festival		0.858			
Holidays		0.842			72.26%
Temperature			0.775		
Time Period			0.704		54.81%
Product rank				0.879	
New/established				-0.818	72.09%

Figure 9-7 shows the structural equation model for 500ml pet bottles. The overall performance of sales of impulse-buy products (500ml bottles) are influenced by promotions, seasonal factors and customer preferences. However, unlike 2ltr bottles and 6-packs of 330ml cans, these products do not have type of promotion as significant factor. All of the other promotional factors namely size or display of promotion, period of promotion and price discount have significant loadings with the latent construct ‘promotional factor’ (loading are 0.81, 0.70, 0.79 respectively), the type of promotion does not have significant loading. This is mainly because there is only one type of promotion offered on 500ml pet bottles. The latent construct ‘promotional factor’ has a significant path coefficient of 0.33 on the overall performance of sales.

Other non-promotional factors also have significant factor loadings with their respective items (variable). The temperature and the time period have significant loadings of 0.78 and 0.26 respectively with first order construct namely ‘seasonal factor’ at $p < 0.01$. Subsequently, this latent factor has proved its significant impact on the overall performance of sales with path coefficient 0.37. The variables namely ‘product ranks’ and ‘new product/established’ have significant loadings of 0.9 and -0.537 with the latent construct ‘customer preference’. Here, the negative loading represents the negative impact of new products on customer preference. The construct ‘customer preference’ has a path coefficient of 0.84 with overall performance of sales.

From the structural equation model of 500 ml pet bottles (see Figure 9-7), it is clear that the demands for 500ml bottles are influenced by the promotional factor (PF), the seasonal factor (SF) and the customer preferences (CP). But the demand for 500ml bottles is more dependent on the CP with highest path coefficient of 0.84 than PF and SF.

Figure 9-7 Structural equation model of 500ml pet bottles


SF1
0.78*
SF
0.26*
SF2
0.37*
0.36*
PF2
0.81*
R-Square = 0.67
PF3
0.70*
PF
0.33*
0.86*
Overall sales performance
Sales
0.79*
PF4
0.84*
Normed Chi-square = 3.888
CFI = 0.980
GFI = 0.983
RMSEA = 0.040
p = 0.0001
CP1
0.90*
CP
-0.54*
CP2

*- significant at $p < 0.01$

In this model (see Figure 9-7), the promotional factors and the seasonal factors are related to each other with significant (at $p < 0.01$) correlation value of 0.36. This indicates that the company offers more promotions during high temperature. Both of these factors have a significant positive effect on the overall performance of sales. This results indicates that promotional factors, seasonal factors and customer preference are positively related to the overall performance of sales (i.e., H1, H3 and H4 are supported). The latent construct ‘special days (SD)’ is not significant to explain the overall performance of sales and hence hypothesis H2 is not supported. As this model has a positive significant covariance relationship between promotional factor (PF) and seasonal factor (SF), it can be inferred that the combined effect of promotions and seasonal factors will a have positive impact on sales, that supports hypothesis H5.

9.10 Discussion

Analysing the structural equation models for 3 different product sizes namely 2ltr pet bottles, 6-packs of 330ml cans, and 500ml pet bottles gives a clear indication of the different factors and their impact on sales. This has guided me to understand the impact of promotional and non-promotional demand factors on the demand. The demand for big/family packs such as 2ltr and 6packs do not behave similarly in terms of both the promotional and the non-promotional factors. The demand of each size has a different set of demand factors. The model specific to impulse-buy products (500ml) is somewhat similar to the model of 2ltr packs. However, during special days 500ml products are not on promotion, this makes the two models different from each other. Other non-promotional factors such as seasons and customer preference also play important roles in the demand. Customer preference has been found to be significant in the models of 500ml and 6-pack of 330ml cans. The significant demand factors of each of these three products are shown in Table 9-11.

The promotional factor is a very common demand factor in all of the three models. But the type of promotion is not very important in the promotional sales of 500ml products.

Table 9-11: Significant demand factors

Demand factors	2ltr pet bottles	6-packs of 330ml cans	500ml pet bottles
Promotional factor			
Type of promotion	✓	✓	✗
Promotion display	✓	✓	✓
Promotion week	✓	✓	✓
Percentage discount	✓	✓	✓
Seasonal factor			
Temperature	✓	✗	✓
Time period	✓	✗	✓
Special days			
Festivals	✓	✗	✗
Holidays	✓	✗	✗
Customer preference			
Product ranks	✓	✓	✓
New product/established products	✗	✓	✓

The seasonal factor is found to be important for 2ltr and 500ml but not for multipacks. The special days are important only for the sales of big family pack such as 2ltr. However, the demand factor ‘special day’ is not at all an important demand factor for the other two product sizes. Customer preference is important in the demand of all the products.

9.11 Summary

This chapter presented the formulation and analysis of measurement model and structural equation models. The structural equation models described the relationship among various demand factors. The technique and analysis was applied to three different pack sizes: 2ltr pet bottles, 6-packs of 330ml cans and 500ml pet bottles. The analysis indicated that each pack will have different set of demand factors. This result along with the Reference Demand Model will be useful for Soft Drink Co. to better understand the factors that explain demand and to try to improve forecasts. The underlying demand structure for each pack size is further used in the next chapter for the formulation of regression based forecasting models.

Chapter 10 Multiple Linear Regression Forecast Models

10.1 Introduction

The case study with Soft Drink Co. and subsequent development of Reference Demand Model (RDM) has helped in identifying several promotional and non-promotional demand factors. As explained in Chapter 9, it has been verified that these demand factors have significant underlying relationships with sales using the structural equation models. In this chapter, the demand factors, specific to each pack size, will be used for developing multiple linear regression models (MLRM). SPSS 15 and MS Excel are used for implementing the models on a computer. The procedural approach is explained in detail, and applied to analyse the promotional sales data of four retailers. The resulting regression models are used for forecasting and the forecast accuracy of the models is compared with the accuracy of the traditional forecast method used by the Soft Drink Co.

This chapter discusses the MLRMs with reference to the research questions set in Chapter three. The results of these models are linked to the observations from Reference Demand Models of Chapter 6. The findings are discussed in a view to improving the supply chain collaboration of the Soft Drink Co.

10.2 Promotional sales factors

In this research, the weekly sales data of the years 2005 and 2006 are used for the purpose of developing MLRMs. Based on the Reference Demand Model of Soft Drink Co., all of the available sales related information explaining each promotional sale is considered for MLRM. This aims to function as a base line model for each product on promotion.

In this chapter, sales data of all four retailers is considered for the formulation of linear regression forecast models. The demand factors identified from the RDM of Soft Drink Co. are evaluated in the regression analysis. Some demand factors such as the size of the promotion (representing the number of stores running the promotion) are not considered (because, it is relevant only to the retailer R4). Instead, a common demand factor namely 'structure of promotion', generally available for all the retailers, will be considered. All of the quantifiable demand factors (explanatory variables) identified through RDM are considered for the development of MLRM (see Table 8-2). Other complicating factors of demand such as cannibalisation and unplanned in-store promotions are not considered for regression as these factors need to have judgmental intervention.

10.2.1 Rules for developing MLRM

In the initial round of analysis, sales (dependent variable) was considered as a function of all the available factors (independent variables). Based on their significance level, the models included only the significant factors with $p \leq 0.05$ in the regression equation and omitted all of the other insignificant factors. SPSS (step-wise regression) and MS Excel were used to identify the significance level of each demand factor. In this attempt, different combinations of variables were considered to obtain a high R^2 (explanatory power) value. Some models with highly significant variables and high R^2 had a negative constant value for the intercept (base sales). As the base sale cannot be a negative number, any such model was not considered. In those cases, the next possible model with a meaningful combination of explanatory variables was identified. To maintain uniformity in every analysis, the significance level of $p \leq 0.05$ was set as entry criteria for all the independent demand factors. The models were also checked for multi-collinearity. If two or more demand factors are highly correlated then the model will have the problem of multi-collinearity. Variance inflation factor (VIF) of 10 and above indicates a multi-collinearity problem. The models were checked for VIF of 10 or above in SPSS output (Hair et al., 2006). In summary, the following simple rules were employed while developing MLRMs.

- Simple model with a few explanatory variables
- Meaningful models with appropriate sign of coefficients
    - As the sales price decreases, the demand will increase; hence the coefficient for the variable ‘price’ should be negative
    - As temperature increases, sales will increase; hence the coefficient for the variable ‘temperature’ should be positive
    - In general all promotions normally increase sales; hence the sign of promotional factors should be positive
- Try to model all different types of promotions that happened in the past
- Use more continuous variables than categorical variables
- High R^2 (explanatory power of various independent factors on dependent variable)

Figure 10-1 shows two examples of regression models and outputs. In the first example, which is for a new product, the sale (dependent variable) is a function of various factors (independent variables): percentage discount, bogof, location and promotion. The adjusted R^2 is 0.75, which is good for a new product with relatively a few data. But the intercept (base sale) is negative. Therefore, this model will not be appropriate to be used as a forecast model. In the second example in Table 10-1, which is for an established product, the sale is dependent on Christmas, percentage discount and type of promotion (bogof). In this model, all of the explanatory variables are significant and the overall model has high R^2. This model is considered as acceptable because the total sales or base sales will not be negative. Only the models satisfying the above mentioned simple rules are considered for further analysis.

Table 10-1 Examples of output

Regression Statistics	
Multiple R	0.874
R Square	0.763
Adjusted R Square	0.751
Standard Error	1959.034
Observations	79

	Coefficients
Intercept	-7688.105
Percentage discount	2563.387
bogof	6700.791
Location (0/1)	2956.247
Promotion (0/1)	1979.557

Regression Statistics	
Multiple R	0.950
R Square	0.902
Adjusted R Square	0.899
Standard Error	550.459
Observations	110

	Coefficients
Intercept	843.728
Christmas (0/1)	727.522
Percentage discount	6630.052
bogof (0/1)	425.130

10.3 Development of Multiple Linear Regression Models

Based on the above mentioned rules, regression model for each product are developed. A simple example (see the second example of Table 10-1) of a regression equation is as follows:

$$Y = x_0 + ax_1 + bx_2 + cx_3$$

Here, Y is weekly sales level

x_0 is base sale

'a' is a coefficient of variable x_1- Christmas (0/1)

'b' is a coefficient of variable x_2 - Percentage discount (continuous variable)

'c' is a coefficient of variable x_3 - bogof (0/1)

It is important to note that all the variables x_1, x_2, x_3 are significant with $p \leq 0.05$.

In simple terms,

Sales Y = 843.7282 + 727.5218 (Christmas) + 6630.052 (Percentage discount) +425.1297 (bogof)

The weekly sales during normal days with no promotions will be 844 units

$Y = 843.7282 + 727.5218 (0) + 6630.052 (0) + 425.1297 (0)$

$Y = 843.7282$ units

The weekly sales during Christmas with no promotions will be 1571 units

$Y = 843.7282 + 727.5218 (1) + 6630.052 (0) + 425.1297 (0)$

$Y = 843.7282 + 727.5218 = 1571. 25$ units

The promotional sales during Christmas with 'bogof' type of promotion will be 5311 units.

$Y = 843.7282 + 727.5218 (1) + 6630.052 (0.5) + 425.1297 (1)$

$Y = 5311.41$ units

The regression fit was made, based on the weekly sales data in the years 2005 and 2006. The regression model will then be used for out of sample accuracy check. The sales data of the year 2007 is used for out of sample accuracy check. By plugging the value of explanatory variables, the weekly sales volume will be forecasted. For every promotion, the MLRM forecast will be compared with the actual sales. A common measure of forecast accuracy, the mean absolute percentage error (MAPE) is used for accuracy check (Fildes and Goodwin, 2007; Makridakis et al., 1998, pp-605).

Here, MAPE = abs {(Actual sales – Forecast sales)/Actual sales} * 100.

The forecast accuracy is calculated as 100% – MAPE.

The same procedure of developing MLRM and a forecast accuracy check is carried out for almost all of the leading products of retailers R1 to R4.

10.4 The MLRM for Retailer R1

To begin with, the sales data of the year 2005-2006 for retailer R1 is considered for the regression analysis. As mentioned earlier in Chapter 8, the weekly sales Y is regressed against demand factors say F1 to F8. In this chapter, the following eight quantifiable demand factors (explanatory variables) identified through RDM are considered for the development of MLRMs.

F1– Type of promotion (others/3for/2for/bogof)
F2 – Structure of promotion (display location-GE/End aisle/Plinth/Side aisle/others)
F3 – Special days/Holidays (yes/no)
F4 – Christmas (yes/no)
F5 – Percentage discount
F6 – Product life cycle (new/established)
F7 – Temperature
F8 – Presence/absence of promotion

Initial results of this analysis have revealed that the contribution of each factor in forecast accuracy is different for different products. Some of the factors such as percentage discount and type of promotion are not significant for a few products. However, these two factors are highly influencing the sales of many other products. In a few other cases, although R^2 (explanatory power of demand factors on sales) is high, certain promotions are not explained fully. For examples refer to the model, using the sales data of 500ml pet bottles, in Figure 10-1, in which the adjusted R^2 is 0.91, based on 2 years sales data. The output of the regression equation is given in Table 10-2.

Table 10-2 Summary output - Example 1

Regression Statistics	
Multiple R	0.953
R Square	0.908
Adjusted R Square	0.906
Standard Error	222.996
Observations	100

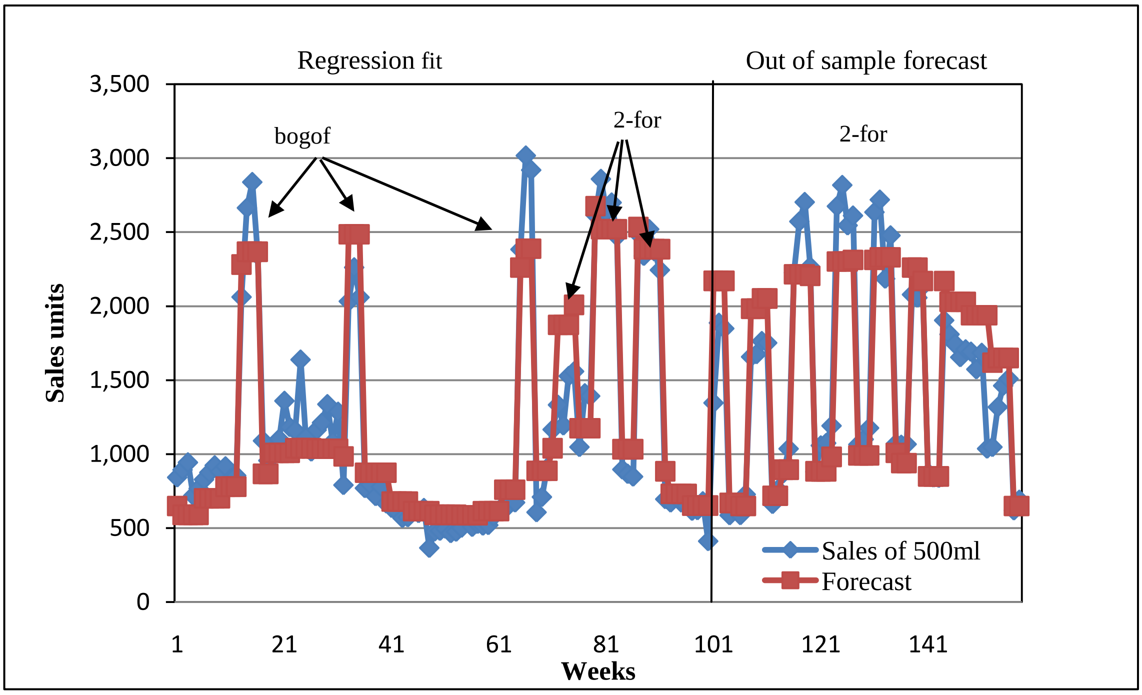
ANOVA

	df	SS	MS	F	Significance F
Regression	2	47473950	23736975	477.345	6.26E-51
Residual	97	4823524	49727.05		
Total	99	52297474			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	368.880	62.477	5.904	5.22E-08	244.880	492.879
Temperature	34.596	4.562	7.584	2.03E-11	25.542	43.649
Percentage discount	3001.5	117.693	25.503	8.48E-45	2767.912	3235.088

This regression model has only two significant explanatory variables; one is the percentage discount and the other is the temperature. See Figure 10-1.

Figure 10-1 Example 1- Regression and forecast (Orange drink 500ml)



From Figure 10-1, it appears to be sufficient to use just the percentage discount variable to model the impact of the past promotional events on sales. But, it is important to note that this particular model could not be used to predict sales for events which haven't occurred in the past (e.g., 3-for or half price). The base level sales is 369 units with the coefficient of the temperature variable equal to 34.595 and with the coefficient of percentage discount variable equal to 3001.5 (i.e., each percent of price discount increases the sales by 3001.5 units).

The resulting regression equation is:

Y = 368.8794+34.595 (temperature) + 3001.5 (percentage discount)

For out of sample accuracy check the sales data of the year 2007 is used. The sales forecast for the year 2007 is calculated by specifying appropriate values for the explanatory variables - temperature and percentage discount. As mentioned before, the temperature is available from public data and information on percentage discount is available from the 2007 promotion calendar. Then the sales forecast for 2007 is compared with the actual sales volume of 2007. The average forecast accuracy in this case is 86 % with an average of 14 % MAPE.

For better understanding of the regression models developed, another example using the sales data of 6-packs of 330ml cans is given in Figure 10-2.

This model included 'bogof &GE', '2-for' and 'percentage discount' as explanatory variables. The resulting regression equation is:

Y = 435.30 + 968.03 (bogof and GE) +2760.93 (percentage discount) +462.73(2-for)

The output summary of the model is listed in Table 10-3.

Figure 10-2 Example 2 - Regression and forecast (6-pack of 330ml cans)

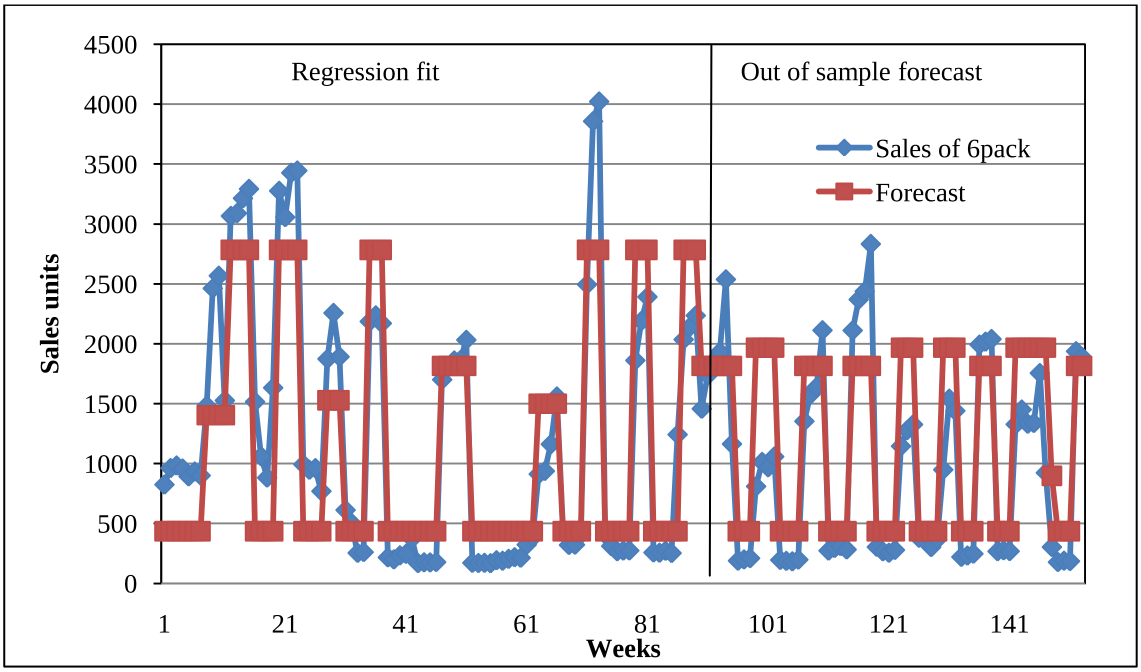


Table 10-3 Summary output - Example 2

Regression Statistics	
Multiple R	0.909
R Square	0.827
Adjusted R Square	0.820
Standard Error	462.613
Observations	84

ANOVA

	df	SS	MS	F	Significance F
Regression	3	81568392	27189464	127.0474	2.44E-30
Residual	80	17120829	214010.4		
Total	83	98689221			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	435.297	68.208	6.382	1.06E-08	299.558	571.035
Bogof and GE	968.027	173.651	5.574	3.25E-07	622.449	1313.604
percent discount	2760.929	310.522	8.891	1.44E-13	2142.97	3378.889
2-for	462.727	189.371	2.443	0.017	85.867	839.586

In this second example, although all of the three explanatory variables are highly significant, the forecast accuracy is not as good as the previous case. The out of sample forecast accuracy in this case is just 69% (i.e., MAPE 31%) although the adjusted R^2 (= 0.82) is high. Later, it was found that some changes to the original promotional plan were the main reason for the differences in the forecasts and actual sales. The MAPE of 31% is higher compared to the previous example. Hence, a high R^2 does not always guarantee high forecast accuracy. Rather it can be argued that a higher R^2 can result in better forecast accuracy if the same promotions are continued in the forecast period (2007) as those that were offered in the period the regression model is based on (2005-2006).

Further analysis of the sales data revealed that not all products follow the same sales structure/pattern. Hence, the products are classified under different categories based on the significant demand factors for each product. Table 10-4 shows the R^2 value and the significant explanatory factors for different products at retailer R1. Various combinations of the explanatory variables were considered in order to obtain meaningful models with high R^2 values. The models (for 53 different products) are classified in 15 different types (see Table 10-4), indicating that more than one product had the same model structure (i.e., the same explanatory demand factors). Grouping of similar products for example 2ltr bottles or 500ml bottles or 6-packs cans makes the forecasting easier.

These 15 models have almost the same set of factors as suggested in SEM. For example, SEM suggested that the sales of 2ltr pet bottles would be influenced by promotional factors, special days and seasonal factors. This is also found to be true in most of the MLRMs of 2ltrs. Usually, the same promotions are offered at the same times for similar products (e.g., all 2ltr bottles with different flavours are on ‘bogof’ during Christmas). This explains why the regression models for different but similar products have the same structure.

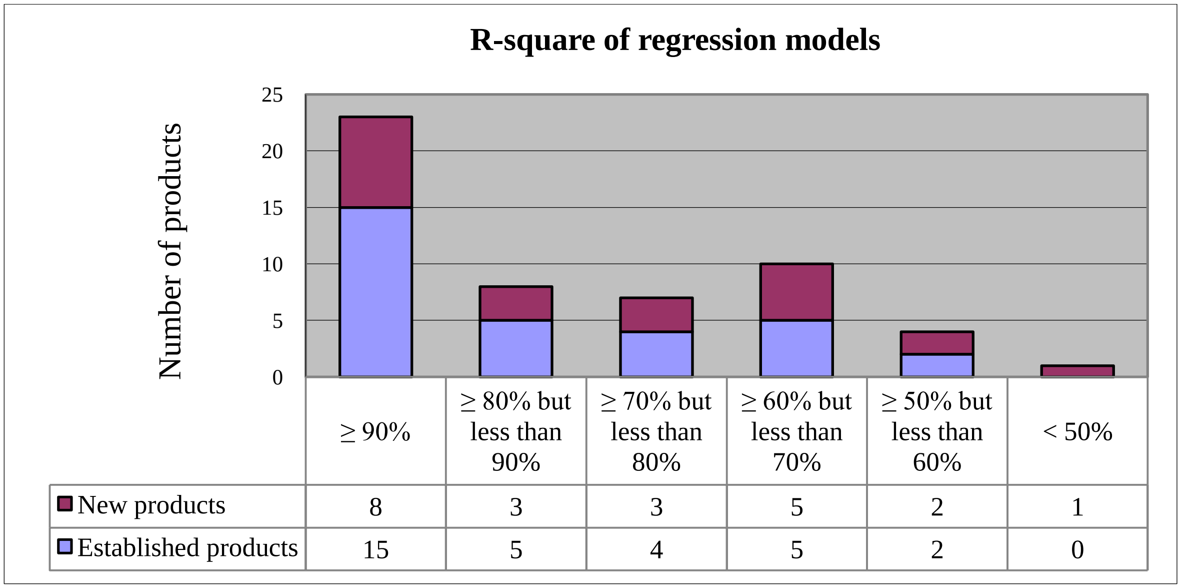
Table 10-4 R^2 value in regression analysis

	Main Demand factors	Products	R-square
M 1	Percentage discount	P1A-2ltr	0.92
	Location (GE)	P1B-2ltr	0.82
	Christmas	P1C-2ltr	0.74
	Temperature		
M 2	Percentage Discount	P2A-2ltr	0.97
	bogof	P2B-2ltr	0.95
	Christmas	P2C-2ltr	0.91
		P2D-2ltr	0.95
		P2E-2ltr	0.95
M 3	Percentage Discount	P3A-2ltr	0.96
	Bogof and GE	P3B-2ltr	0.96
	Christmas	P3C-2ltr	0.95
M 4	Percentage Discount	P4A-2ltr	0.85
	Bogof and GE	P4B-2ltr	0.83
		P4C-2ltr	0.94
		P4D-6pk	0.68
		P4E-6pk	0.72
		P4F-6pk	0.77
		P4G-6pk	0.73
M 5	Percentage discount	P5A-500ml	0.53
	Temperature	P5B-500ml	0.51
		P5C-500ml	0.56
		P5D-500ml	0.91
		P5E-500ml	0.89
		P5F-500ml	0.91
		P5G-500ml	0.90
		P5H-500ml	0.91
M 6	Percentage Discount	P6A-2ltr	0.92
	Christmas	P6B-2ltr	0.92
M 7	Percentage discount	P7A-500ml	0.66
	bank holiday / special day	P7B-500ml	0.63
	Promotion(y/n)		
M 8	Percentage discount	P8A-500ml	0.90
	Bogof	P8B-6pk	0.78
M 9	Percentage discount	P9A-6pk	0.63
	bogof and GE		
	Temperature		
M 10	Promotion(y/n)	P10A-10pk	0.61
	Temperature	P10B-10pk	0.63
		P10C-10pk	0.64
M 11	Percentage discount	P11A-500ml	0.64
	bank holiday / special day		
M 12	Percentage discount	P12A-1.5ltr	0.87
		P12B-1.5ltr	0.87
		P12C-500ml	0.42
		P12D-500ml	0.79
		P12E-500ml	0.87
		P12F-5pk	0.91
		P12G-5pk	0.91
		P12H-6pk	0.68
		P12I-6pk	0.65
		P12J-6pk	0.77
		P12K-6pk	0.58
		P12L-6pk	0.80
		P12M-6pk	0.73
M 13	bogof	P13A-6pk	0.97
	3 for		
	2 for		
	Temperature		
M 14	bogof	P14A-6pk	0.96
	3 for		
	2 for		
M 15	bogof	P15A-6pk	0.95
	3 for		

10.5 MLRMs explained

Nearly 42% of all products at retailer R1 are in the growth stage of the product life cycle. These products are mentioned as ‘new or recent products’. The products in the maturity stage are named as ‘established products’ by the case company. In the MLRMs, the promotional sales of established products are very well explained by the demand factors with a maximum $R^2 = 0.97$. In general, the demand for most of the products is explained well (with R^2 values in the range of 0.50 to 0.80) by the explanatory variables identified from the RDM (see Figure 10-3). Although many of the more recent products are explained well by the demand factors identified from the RDM, there are some products which need more time and more information (i.e., more data points) to make more accurate forecasting.

Figure 10-3 Extent of explanation of linear models



	≥ 90%	≥ 80% but less than 90%	≥ 70% but less than 80%	≥ 60% but less than 70%	≥ 50% but less than 60%	< 50%
■ New products	8	3	3	5	2	1
■ Established products	15	5	4	5	2	0

Using the MLRMs, the regression fit is compared with the actual sales to find MAPE of promotional sales in the years 2005-2006. Then, the out-of-sample forecast accuracy using 2007 data is estimated through the same regression models. A special consideration is given for the results with MAPE of above 30%. These results were discussed further with the case company officials. Table 10-5 shows the MAPE during the regression period (2005-2006) and during the forecast period (2007) for retailer R1. This table has two parts - the first part has detailed MAPE values for established products and the second part has detailed MAPE values for new products.

Table 10-5 Average MAPE during regression period and forecast period – R1

	Type of promotion and MAPE of established products							
Products	**bogof**		**2 for £**		**3 for £**		**Other promotion**	
	Regression	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**
P1A-2ltr	--	--	0.93	6.30	0.82	13.30	--	--
P1B-2ltr	--	--	3.58	5.97	4.12	10.59	--	--
P2A-2ltr	8.26	7.6	0	29.19	--	--	--	17.44
P2D-2ltr	8.34	6.15	0	15.45	--	--	--	9.12
P3A-2ltr	3.08	12	16.53	35.53	--	--	--	6.26
P3B-2ltr	7.54	10.26	12.04	33.99	--	--	--	1.43
P3C-2ltr	7.86	36.19	17.82	15.68	--	--	--	12.77
P13A-6-pk	10.7	10.25	0	--	11.78	15.31	--	53.67
P14A-6-pk	12.74	6.01	0	--	8.79	22.32	--	--
P8B-6-pk	17.22	1.4	--	--	5.63	8.89	--	--
P9A-6-pk	25.22	14.78	4.55	30.12	--	--	--	--
P12H-6-pk	16.89	22.4	27.63	53.97	--	--	--	--
P12I-6-pk	20.14	20.77	16.77	57.03	--	--	--	--
P4F-6-pk	15.28	12.47	17.09	17.93	--	--	--	--
P12J-6-pk	11.83	19.85	17.38	12.76	--	--	--	--
P12L-6-pk	11	14.63	13.13	14.66	--	--	--	--
P5A-500ml	--	--	3.43	10.66	--	--	--	--
P5B-500ml	--	--	3.89	12.43	--	--	--	--
P5D-500ml	8.6	28.09	35.88	12.77	--	--	--	--
P5E-500ml	7.61	36.22	43.01	9.51	--	--	--	--
P5F-500ml	10.12	41.86	40.43	18.07	--	--	--	--
P5G-500ml	9.97	32.06	35.76	11.93	--	--	--	--
P5H-500ml	8.14	41.45	41.47	19.01	--	--	--	--
P10A-10-pk	--	--	0	25.06	--	--	--	--
P10B-10-pk	--	--	0	23.21	--	--	--	--
P10C-10-pk	--	--	0	15.21	--	--	--	--
P12A-1.5ltr	18.14	11.04	--	67.17	--	--	52.86	6.15
P12B-1.5ltr	19.15	11.36	--	63.63	--	--	49.26	3.33
P8A-500ml	15.69	56.36	23.95	59.21	--	--	--	--
P12D-500ml	35.67	25.43	26.98	53.36	--	--	--	--
P6A-2ltr	11.99	0.45	7.41	10.48	--	--	--	--
P6B-2ltr	17.05	23.35	2.76	14.99	--	--	--	--
Weighted avg.MAPE	**13.62**	**18.56**	**13.76**	**21.09**	**4.92**	**14.08**	**51.06**	**12.09**
Number of promotions	**141**	**64**	**48**	**112**	**23**	**5**	**2**	**13**
Overall MAPE - forecast		**19.47**						

Type of promotion and MAPE of recent products								
Products	**bogof**		**2-for**		**3-for**		**Other promotion**	
	Regression	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**
P1C-2ltr	--	--	0.7	30.3	--	79.06	--	--
P2B-2ltr	10.32	26.98	0	24.96	--	--	--	46.01
P2C-2ltr	8.69	17.14	0	1.92	--	--	--	19.23
P2E-2ltr	4.38	23.45	0	13.82	--	--	--	19.23
P4A-2ltr	9.62	16.07	66.1	37.88	--	--	--	15.31
P4B-2ltr	12.6	11.47	77.32	38.14	--	--	--	21.88
P4C-2ltr	10.83	33.55	22.4	15.44	--	--		9.92
P15A-6pk	--	7.72	--	--	20.43	34.55	--	--
P4E-6-pk	24.57	26.39	28.77	30.73	--	--	--	--
P4D-6-pk	17.95	21.08	14.19	25.03	--	--	--	--
P4G-6-pk	10.13	19.8	20.13	22.07	--	--	--	--
P12K-6-pk	15.56	20.3	21.77	2.46	--	--	--	--
P12M-6-pk	17.16	20.56	30.57	27.09	--	--	--	--
P5C-500ml	--	--	32.45	12.7	--	--	--	--
P12F-5-pk	--	--	26.7	--	--	--	3.53	--
P12G-5-pk	--	--	27.41	--	--	--	3.14	--
P12C-500ml	--	--	--	6.72	--	--	46.27	21.54
P7B-500ml	--	67.76	38.15	--	--	--	--	65.81
P7A-500ml	--	70.75	38.61	--	--	--	--	69.6
P12E-500ml	19.45	16.42	25.32	58.57	--	--	--	--
P11A-500ml	38.64	55.07	--	--	--	--	--	--
Weighted MAPE	14.86	25.94	27.51	22.04	20.43	56.81	24.80	33.28
Number of promotions	83	50	40	36	1	2	4	24
Overall MAPE- forecast		**26.81**						

Table 10-5 shows four different promotions, namely bogof, 2-for, 3-for and other types. Since retailer R1 has not given many half-price promotions, they are included within the bogof promotions. The overall MAPE for the established and recent products are 19.47% and 26.81% respectively. As the regression forecasts showed good accuracy, the same procedure can be applied for other retailers. However, before testing the MLRMs with other retailers, it is important to check the advantage of the suggested method (regression method) over the current forecasting method followed by the case company. The case analysis (see Chapter 4) of Soft Drink Co. has provided a good insight into the current practice of the company's promotional planning and forecasting. With the help of the demand analysts, I retraced their forecast calculations and then compared them with MLRM calculations. This is further explained in the following section.

10.6 Advantage of using Multiple Linear Regression Models

The Soft Drink Co. currently follows a simple forecasting method, which is referred to as the ‘traditional method’. This method projects historical sales onto similar promotional events in the future. In other words, when the customer demand analysts have to make a forecast for 2ltr pet bottles of a particular flavour, they look at how this (or most similar) promotion performed on this product in the most recent past, and then they use the actual historical sales as a forecast for the future. In order to understand the advantage of using regression models, these are compared with Soft Drink Co.’s traditional forecasting method in terms of forecast accuracy (see Figure 10-4). This figure illustrates both traditional and regression based forecasts in comparison to the actual sales. The traditional method shows good performance for forecasting normal sales but fails to perform well for some promotional events.

Figure 10-4 Comparison of traditional and regression forecasts

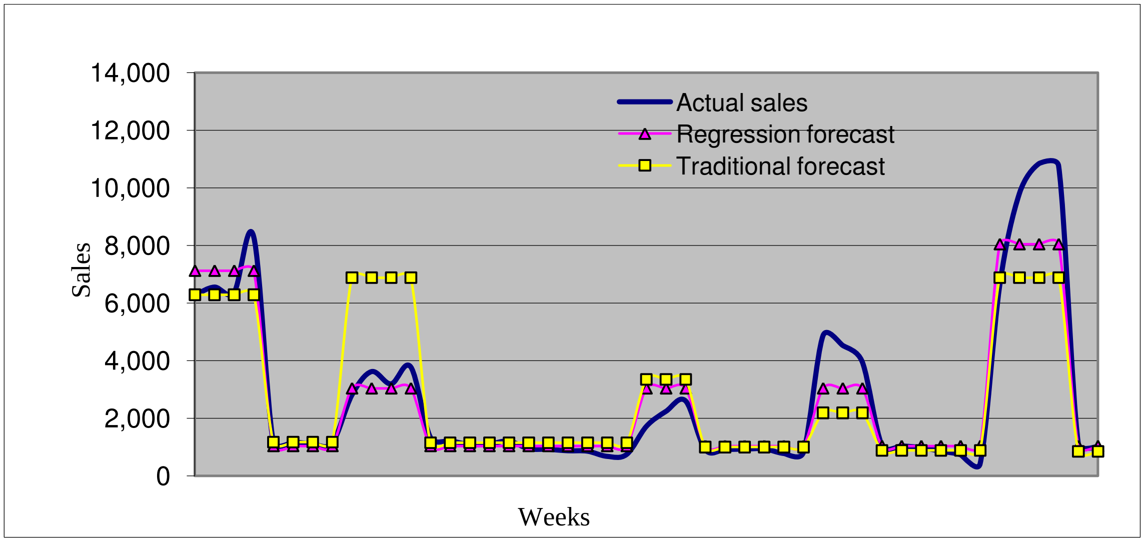


Table 10-6 reports the performance of both traditional and regression forecasts on different products at retailer R1. The table shows the average MAPE and the number in parenthesis represents the number of promotions offered in forecast period (2007). The number of promotions mentioned as ‘1’ in parenthesis represents non availability of historical sales details.

Comparison of MLRMs with traditional forecast shows that the regression forecasts with explanatory variables, identified from the RDM, could do far better than the traditional method (see Table 10-6).

The weighted MAPE for each type of promotion using regression and traditional forecast are calculated. Table 10-6 shows the detailed results for both the methods. For established products, the regression forecasts resulted in a lower MAPE value compared to the traditional method. For instance, by using the regression method the MAPE of bogof promotions of established products is dropped by 5.54%, in comparison to the traditional method. Similarly the MAPE of 3-for promotions is dropped by 53.41% and the MAPE of other promotions is dropped by 23.51%. However, the MAPE of 2-for promotions on established products is about the same for both of the methods. In case of recent products, the MAPE on bogof is reduced by 5.15%, the MAPE on 2-for is reduced by 7.17%, the MAPE on 3-for is reduced by 42.71 % and the MAPE on other promotions is reduced by 25.62%. For the more recent products, all of the promotions are better predicted by the regression method compared with the traditional method. Hence, it is very clear that that the overall forecast accuracy can be improved by the regression method. This shows the advantage of the MLRMs over the traditional method.

Table 10-6 Comparison of regression and traditional forecasts for R1 (year 2007)

Established Products	MAPE bogof		MAPE 2-for		MAPE 3-for		MAPE Other promotions	
	RF	TF	RF	TF	RF	TF	RF	TF
P1A-2ltr	--	--	6.30 (3)	18.10 (3)	13.30 (1)	23.07 (1)	--	--
P1B-2ltr	--	--	5.97 (3)	16.68 (3)	10.59 (1)	16.59 (1)	--	--
P2A-2ltr	7.60 (3)	23.71 (3)	29.19 (2)	30.22 (2)	--	--	17.44 (2)	51.65 (2)
P2E-2ltr	6.15 (3)	22.96 (3)	15.45 (2)	30.50 (2)	--	--	9.12 (2)	60.21 (2)
P3A-2ltr	12 (3)	9.76 (3)	35.53 (2)	46.68 (2)	--	--	6.26 (2)	21.24 (2)
P3B-2ltr	10.26 (3)	8.23 (3)	33.99 (2)	27.66 (2)	--	--	1.43 (2)	11.85 (2)
P3C-2ltr	36.19 (3)	26.04 (3)	15.68 (2)	15.93 (2)	--	--	12.77 (2)	19.59 (2)
P13A-6pk	10.25 (2)	9.25 (2)	--	--	15.31 (1)	99.95 (1)	--	--
P14A-6pk	6.01 (2)	11.39 (2)	--	--	22.32 (1)	99.94 (1)	--	--
P8B-6pk	1.40 (2)	15.15 (2)	--	--	8.89 (1)	97.91 (1)	--	--
P9A-6pk	14.78 (4)	25.97 (4)	30.12 (3)	5.38 (3)	--	--	--	--
P12H-6pk	22.40 (4)	30.37 (4)	53.97 (3)	15.46 (3)	--	--	--	--
P12I-6pk	20.77 (4)	29.45 (4)	57.03 (3)	17.97 (3)	--	--	--	--
P4F-6pk	12.47 (4)	22.55 (4)	17.93 (2)	11.42 (2)	--	--	--	--
P12J-6pk	19.85 (4)	26.07 (4)	12.76 (2)	12.54 (2)	--	--	--	--
P12L-6pk	14.63 (4)	16.36 (4)	14.66 (2)	7.06 (2)	--	--	--	--
P5A-500ml	--	--	10.66 (4)	14.94 (4)	--	--	--	--
P5B-500ml	--	--	12.43 (4)	30.03 (4)	--	--	--	--
P5D-500ml	28.09 (1)	41.15 (1)	12.77 (7)	16.70 (7)	--	--	--	--
P5E-500ml	36.22 (1)	41.15 (1)	9.51(7)	11.97 (7)	--	--	--	--
P5F-500ml	41.86 (1)	51.54 (1)	18.07 (7)	19.92 (7)	--	--	--	--
P5G-500ml	32.06 (1)	44.07 (1)	11.93 (7)	15.94 (7)	--	--	--	--
P5H-500ml	41.45 (1)	55.23 (1)	19.01 (7)	25.85 (7)	--	--	--	--
Number of promotions	**50**	**50**	**74**	**74**	**5**	**5**	**10**	**10**
Weighted MAPE	**17.02**	**22.56**	**18.95**	**18.51**	**14.08**	**67.49**	**9.40**	**32.91**
Recent products	**Bogof - MAPE**		**2 for - MAPE**		**3 for - MAPE**		**Other promotions - MAPE**	
	RF	**TF**	**RF**	**TF**	**RF**	**TF**	**RF**	**TF**
P1C-2ltr			30.03 (3)	45.09 (3)	79.06 (1)	100 (1)		
P2B-2ltr	26.98 (3)	25.16 (3)	24.96 (2)	80.66 (2)	--	--	46.01 (2)	56.32 (2)
P2C-2ltr	17.14 (3)	26.78 (3)	1.92 (2)	7.3 (2)	--	--	19.23 (2)	73.47 (2)
P2E-2ltr	23.45 (3)	22.77 (3)	13.82 (2)	19.18 (2)	--	--	19.23 (2)	77.72 (2)
P4A-2ltr	16.07 (3)	23.30 (3)	37.88 (2)	58.57 (2)	--	--	15.31 (2)	16.72 (2)
P4B-2ltr	11.47 (3)	8.93 (3)	38.14 (2)	60.21 (2)	--	--	21.88 (2)	37.37 (2)
P4C-2ltr	33.55 (3)	33.09 (3)	15.44 (2)	17.82 (2)	--	--	9.22 (2)	16.97 (2)
P15A-6pk	7.72 (1)	32.32(1)	--	--	34.55 (1)	99.03 (1)	--	--
P4E-6pk	26.39 (4)	25.20 (4)	30.73 (3)	19.17 (3)	--	--	--	--
P4D-6pk	21.08 (4)	42.65 (4)	25.03 (3)	5.47 (3)	--	--	--	--
P4G-6pk	19.80 (4)	22.78 (4)	22.07 (2)	24.40 (2)	--	--	--	--
P12K-6pk	20.03 (4)	27.36 (4)	2.46 (2)	9.97 (2)	--	--	--	--
P12M-6pk	20.56 (4)	25.19 (4)	27.09 (2)	13.40 (2)	--	--	--	--
P5C-500ml			12.70 (4)	26.47 (4)	--	--	--	--
Number of promotions	**39**	**39**	**31**	**31**	**2**	**2**	**12**	**12**
Weighted MAPE	**21.16**	**26.29**	**21.80**	**28.97**	**56.81**	**99.52**	**21.81**	**46.43**

Numbers in parenthesis ( ) represents the number of promotions offered in forecast period; RF- regression forecast; TF- traditional forecast

10.7 MLRM for Retailer R2

A similar regression analysis was carried out for retailer R2. This resulted in 16 MLRMs for 50 different products. Table 10-7 shows the MAPE during the regression period (2005-2006) and during the forecast period (2007) for retailer R2. The overall MAPE for established products is 22.76% and for recent products is 24.05%.

Compared to bogof and 2-for promotions the number of 3-for and other promotions are fewer. The retailer R2 has offered many new promotions and hence the historical sales reference is not available for new type of promotions. This is resulted in poor forecast accuracy (high MAPE) for other promotions. For example, the products 2ltr-P3, 2ltr- P5 and 6pk-P3 in Table 10-7 show a high MAPE and these promotions were not offered during regression period (2005-2006). However, the overall performance of forecast models of R2 is good.

Table 10-7 Average MAPE during regression period and forecast period – R2

	Type of promotion and MAPE of mature products							
Products	**bogof**		**2-for**		**3-for**		**Other promotions**	
	Regression	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**
2ltr-P1	--	--	16.87	12.25	3.89	1.38	--	--
2ltr-P2	--	--	20.17	25.82	3.44	0.15	--	--
2ltr-P3	13.54	26.02	9.43	15.73	--	--	--	85.81
2ltr-P4	16.39	21.76	13.56	15.34	--	--	--	51.53
2ltr-P5	37.21	23.58	8.29	2.29	--	--	--	112.32
2ltr-P6	26.11	--	13.28	--	--	--	--	36.56
2ltr-P7	10.98	14.8	19.41	20.02	--	--	--	26.39
2ltr-P8	9.77	41.88	8.95	21.05	--	--	--	41.71
2ltr-P9	4.37	20.5	12.7	9.2	--	--	--	35.14
2ltr-P10	9.15	17.35	12.75	17.46	--	--	--	44.3
6pk-P1	5.18	19.1	54.42	21.54	10.33	59.95	--	40.54
6pk-P2	2.24	16.85	51.8	19	4.44	50.91	--	20.2
6pk-P3	4.43	22.47	34.9	13.41	12.18	54.9	--	109.7
6pk-P4	22.24	47.46	8.22	9.22	--	--	--	--
6pk-P5	32.8	6.33	17.97	4.45	--	--	--	--
6pk-P6	16.44	9.36	13.43	20.85	--	--	--	--
6pk-P7	23.43	10.94	13.89	8.76	--	--	--	--
6pk-P8	28.21	7.15	8.96	8.84	--	--	--	--
6pk-P9	29.59	17.72	14.38	22.26	--	--	--	--
6pk-P10	19.55	35.29	19.36	15.8	--	--	--	--
6pk-P11	8.09	36.04	8.09	11.07	--	--	--	--
6pk-P12	42.14	7.25	30.51	36.8	--	--	--	--
6pk-P13	19.39	12.38	14.57	21.21	--	--	--	--
500ml -P1	--	--	22.69	1.78	--	--	--	--
500 ml -P2	--	--	3.51	16.53	--	--	--	--
500 ml-P3	--	--	61.23	23.13	--	--	--	--
500ml-P4	--	--	1.24	15.89	--	--	--	--
500ml -P5	--	--	5.54	16.41	--	--	--	--
500ml -P6	--	--	6.12	26.45	--	--	--	--
500ml -P7	--	--	15.17	16.9	--	--	--	--
500ml-P8	--	--	5.67	14.09	--	--	--	--
10pk-P1	--	--	16	17	--	107	--	--
10pk-P2	--	--	9	23	--	18	--	--
10Pk-P3	--	--	22	15	--	--	--	--
10Pk-P4	--	--	7	10	--	--	--	--
10Pk-P5	--	--	12	22	--	--	--	--
1.5ltr-P1	--	--	13.65	57.49	--	--	--	--
1.5ltr-P2	--	--	25.07	35.2	--	--	--	--
500ml-P9	--	--	4.27	21.48	--	--	--	--
500ml-P10	--	--	10.82	--	--	--	--	--
2ltr-P11	10.82	10.9	27.74	23.97	27.91	14.13	42.36	--
2ltr-P12	17.9	8.14	13.8	3.08	17.9	29.6	0	--
Number of	**105**	**60**	**219**	**106**	**23**	**15**	**2**	**14**
Weighted	**20.32**	**20.29**	**17.55**	**16.97**	**12.96**	**36.57**	**21.18**	**62.47**
Overall MAPE-forecast		**22.76**						

	Type of promotion and MAPE of recent products							
	bogof		**2 for**		**3 for**		**Other promotion**	
Products	**Regression**	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**
5Pk-P1	--	29.63	--	54.34	--	--	--	15.65
5Pk-P2	--	21.15	--	37.82	--	--	--	34.31
5Pk-P3	--	12.78	--	10.01	--	--	--	0.00
5Pk-P4	--	8.88	--	14.79	--	--	--	0.00
500ml-P11	--	--	--	--	--	--	7.35	30.84
500ml-P12	19.38	22.94	--	33.52	--	--	31.92	--
5Pk-P5	2.64	2.27	9.47	25.04	--	--	--	--
1ltr-P1	2.64	4.9	11.19	27	--	--	--	--
Number of	**10**	**21**	**3**	**18**	**--**	**--**	**3**	**8**
Weighted	**16.03**	**18.8**	**10.62**	**31.23**	**--**	**--**	**15.54**	**21.67**
Overall MAPE-forecast		**24.05**						

The accuracy of the regression models was compared with the traditional forecasting method. Similar to retailer R1, also in this case the regression models outperformed the traditional method (see Table 10-8). While considering bogof and 2-for promotions, the regression method considerably improved the forecast accuracy (for example, MAPE of 26.33 is reduced to 21.49 in bogof).

The use of the regression method on 3-for and other types of promotions also showed improved forecast accuracy compared to the traditional method. However, the accuracy of both approaches is not very good. The reason behind this is that very few 3-for promotions were offered in the past. In other words, the 3-for promotions and the other types of promotions do not have enough history to support good forecasting.

Table 10-8 Comparison of regression and traditional forecasts for R2 (year 2007)

Products	MAPE-bogof		MAPE-2-for		MAPE-3-for		MAPE-Other promotions	
	RF	TF	RF	TF	RF	TF	RF	TF
2ltr-P1	--	--	12.25 (2)	12.30 (2)	1.38 (1)	29.04 (1)	--	--
2ltr-P2	--	--	25.82 (2)	23.54 (2)	0.15 (1)	28.57 (1)	--	--
2ltr-P3	26.02 (4)	27.9 (4)	15.73 (3)	2.94 (3)	--	--	85.81 (1)	192.03 (1)
2ltr-P4	21.76 (4)	29.4 (4)	15.34 (3)	7.66 (3)	--	--	51.53 (1)	35.30 (1)
2ltr-P5	23.58 (4)	38.25 (4)	2.29 (3)	7.76 (3)	--	--	112.32 (1)	186.96 (1)
2ltr-P6	--	--	--	--	--	--	36.56 (1)	176.24 (1)
2ltr-P7	14.8 (4)	15.36 (4)	20.02 (3)	79.74 (3)	--	--	26.39 (1)	84.20 (1)
2ltr-P8	41.88 (4)	24.01 (4)	21.05 (3)	86.8 (3)	--	--	41.71 (1)	40.54 (1)
2ltr-P9	20.5 (4)	14.8 (4)	9.2 (3)	9.78 (3)	--	--	35.14 (1)	89.27 (1)
2ltr-P10	17.35 (4)	19.93 (4)	17.46 (3)	82.45 (3)	--	--	44.3 (1)	94.48 (1)
6pk-P1	19.1 (2)	26.32 (2)	21.54 (2)	40.34 (2)	59.95 (1)	107.94 (1)	40.54 (2)	118.59 (2)
6pk-P2	16.85 (2)	26.98 (2)	19 (2)	35.08 (2)	50.91 (1)	103.44 (1)	20.2 (2)	68.24 (2)
6pk-P3	22.47 (2)	40.27 (2)	13.41 (2)	28.54 (2)	54.9 (1)	82.47 (1)	109.7 (2)	167.25 (2)
6pk-P4	47.46 (2)	35.91 (2)	9.22 (3)	26.58 (3)	--	--	--	--
6pk-P5	6.33 (2)	24 (2)	4.45 (3)	18.51 (3)	--	--	--	--
6pk-P6	9.36 (2)	21.9 (2)	20.85 (3)	48.21 (3)	--	--	--	--
6pk-P7	10.94 (2)	25.38 (2)	8.76 (3)	17.4 (3)	--	--	--	--
6pk-P8	7.15 (2)	19.24 (2)	8.84 (3)	19.75 (3)	--	--	--	--
6pk-P9	17.72 (2)	37.10 (2)	22.26 (3)	30.05 (3)	--	--	--	--
6pk-P10	35.29 (2)	39.01 (2)	15.8 (3)	20.31 (3)	--	--	--	--
6pk-P11	36.04 (2)	30.74 (2)	11.07 (3)	20.42 (3)	--	--	--	--
6pk-P12	7.25 (2)	22.47 (2)	36.8 (3)	20.51 (3)	--	--	--	--
6pk-P13	12.38 (2)	22.33 (2)	21.21 (3)	22.21 (3)	--	--	--	--
500ml-P1	--	--	1.78 (1)	19.55 (1)	--	--	--	--
500ml-P2	--	--	16.53 (1)	18.32 (1)	--	--	--	--
500ml-P3	--	--	23.13 (1)	38.64 (1)	--	--	--	--
500ml-P4	--	--	15.89 (1)	28.97 (1)	--	--	--	--
500ml-P5	--	--	16.41 (1)	22.87 (1)	--	--	--	--
500ml-P6	--	--	26.45 (1)	37.79 (1)	--	--	--	--
500ml-P7	--	--	16.9 (1)	28.78 (1)	--	--	--	--
500ml-P8	--	--	14.09 (1)	17.23 (1)	--	--	--	--
Number of promotions	**54**	**54**	**69**	**69**	**5**	**5**	**14**	**14**
Weighted average MAPE	**21.49**	**26.33**	**13.64**	**31.14**	**33.46**	**70.29**	**55.33**	**114.80**

Number in the parenthesis ( ) represents the number of promotions offered in forecast period

The MLRMs with weekly sales data for the retailers R3 and R4 are developed. Further results of MAPE using MLRMs for the retailers R3 and R4 are given in Table 10-9 and Table 10-10. Similar to previous cases, using weekly sales data of 2005-2006, the regression models are developed while the sales data of 2007 is used for forecast accuracy check.

Table 10-9 MAPE during regression period and forecast period – Retailer 3

	Type of promotion and MAPE of established products-R3							
Products	**bogof**		**2-for**		**3-for**		**Other promotions**	
	Regression	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**	**Regression**	**Forecast**
2ltr-P1	0 (1)	15.29 (1)	17.26 (3)	42.95 (1)	20.68 (2)	24.3 (1)	16.98 (4)	16.86 (1)
2ltr-P2	0 (1)	48.54 (1)	13.59 (3)	30.38 (1)	10.69 (2)	58.67 (1)	23.01 (4)	74.90 (1)
2ltr-P3	--	--	13.99 (3)	14.44 (1)	3.58 (2)	47.21 (1)	17.66 (4)	21.35 (1)
2ltr-P4	--	--	22.65 (3)	33.97 (1)	8.99 (2)	25.65 (1)	29.26 (4)	79.17 (1)
2ltr-P5	--	--	37.47 (3)	57.56 (1)	48.75 (2)	15.03 (1)	34.21 (4)	77.23 (1)
2ltr-P6	--	--	32.2 (3)	40.19 (1)	5.07 (2)	20.44 (1)	18.92 (4)	80.86 (1)
2ltr-P7	--	--	13.74 (3)	18.62 (1)	3.98 (2)	43.93 (1)	25.25 (4)	26.39 (1)
2ltr-P8	--	--	22.38 (3)	16.84 (1)	8.57 (2)	65.01 (1)	28.80 (4)	25.83 (1)
2ltr-P9	--	--	8.39 (1)	23.55 (3)	8.49 (7)	1.29 (1)	8.85 (4)	74.17 (1)
2ltr-P10	31.41 (1)	--	41.75 (2)	--	12.53 (1)	14.53(3)	--	--
2ltr-P11	--	60.27 (1)	--	36.37 (6)	--	--	--	5.47 (2)
6pk-P1	14.18 (2)	--	15.85 (2)	36.37 (3)	11.44 (1)	52.40 (1)	--	--
6pk-P2	19.50 (2)	--	14.39 (2)	33.78 (3)	19.95 (1)	31.32 (1)	--	--
6pk-P3	--	--	--	28.31 (3)	--	16.65 (1)	--	--
6pk-P4	108.05 (2)	--	51.16 (5)	54.23 (4)	--	73.95 (2)	31.56 (1)	--
6pk-P5	105.14 (2)	--	64.29 (5)	56.66 (2)	--	151.93 (1)	0(1)	--
6pk-P6	92.97 (2)	--	30.04 (5)	17.03 (4)	--	9.73 (2)	0(1)	--
6pk-P7	134.36 (2)	--	54.71(5)	38.84 (4)	--	43.74 (2)	32.62 (1)	--
6pk-P8	119.24 (2)	--	23.46 (4)	36.58 (4)	--	82.59 (2)	65.48 (1)	--
6pk-P9	12.95 (2)	--	51.73 (5)	18.52 (3)	26.51 (2)	26.51 (2)	49.47 (1)	--
6pk-P10	34.78 (2)	--	31.13 (5)	10.14 (3)	66.23 (2)	66.23 (2)	0 (1)	--
Other-P1	--	--	--	5.85 (3)	--	--	--	0 (1)
Other-P2	--	--	--	10.75 (3)	--	--	--	0(1)
Other-P3	--	--	19.95 (14)	13.83 (5)	23.82(3)	7.34 (4)	--	--
Other-P4	--	--	14.77 (14)	12.70 (5)	3.06(3)	21.17 (4)	--	--
Other-P5	--	--	8.65 (14)	16.26 (5)	11.20 (3)	8.36 (4)	--	--
Other-P6	--	--	14.97 (14)	14.83 (5)	7.52 (3)	11.72 (4)	--	--
Other-P7	--	--	21.12 (14)	7.93 (5)	7.94 (3)	21.32 (4)	--	--
Other-P8	--	--	--	98.29 (2)	--	159.39 (2)	--	50.74(5)
Other-P9	--	--	--	125.96 (2)	--	76.88 (2)	--	64.64 (5)
Weighted average MAPE	**62.56**	**41.37**	**24.40**	**28.84**	**14.89**	**37.60**	**23.04**	**46.29**
No. of promotions	21	3	135	85	45	52	43	23
Overall MAPE- forecast		**34.33**						

Number in the parenthesis ( ) represents the number of promotions offered in respective period

Table 10-9 shows the overall MAPE of 34.33% for forecast period 2007. Compared to previous results for retailers R1 and R2, this result is not very impressive. Retailer R3 offered fewer promotions in the year 2007 and in addition the type of promotions has shifted; the number of bogof promotions in 2007 is just 3 compared to 21 in the regression period (years 2005 -2006), The number of bogofs is somewhat compensated by more 2-for and 3-for promotions. But the promotional mix has changed and this may explain the poorer performance of the regression models.

Table 10-10 MAPE during assessment period and forecast period – Retailer 4

	Tesco-Type of promotion and MAPE of established products							
Products	bogof		2-for		3-for		Other promotions	
	Regression	Forecast	Regression	Forecast	Regression	Forecast	Regression	Forecast
2ltr-P1	--	--	5.4 (6)	8.4 (7)	18.72 (6)	--	--	--
2ltr-P2	--	--	8.07 (6)	13.18 (7)	8.37 (6)	--	--	--
2ltr-P3	12.22 (5)	14.67 (4)	19.94 (5)	18.56 (2)	--	--	--	--
2ltr-P4	14.69 (5)	18.33 (3)	22.92 (5)	13.88 (2)	--	--	--	--
2ltr-P5	8.08 (5)	9.38 (3)	23.78 (5)	7.11 (2)	--	--	--	--
2ltr-P6	18.07 (5)	20.85 (3)	29.16 (5)	2.80 (2)	--	--	--	--
6pk-P1	0.36 (2)	10.48 (1)	15.59 (12)	27.44 (6)	--	--	--	--
6pk-P2	2.79 (2)	12.59 (1)	15.71 (12)	19.77 (6)	--	--	--	--
6pk-P3	15.53 (5)	13.78 (5)	41.19 (3)	30.26 (3)	--	--	--	--
6pk-P4	13.32 (7)	15.50 (4)	9.11 (3)	11.27 (3)	--	--	--	--
6pk-P5	15.53 (7)	20.43 (4)	17.21 (3)	26.10 (3)	--	--	--	--
6pk-P6	8.19 (7)	16.5 (4)	5.07 (3)	21.93 (3)	--	--	12.88 (1)	--
500ml-P1	--	--	4.52 (10)	9.35 (6)	--	--	--	--
500ml-P2	--	--	4.69 (10)	7.72 (6)	--	--	--	--
500ml-P3	1.42 (1)	--	11.32 (8)	8.94 (3)	--	--	--	--
500ml-P4	2.80 (1)	--	8.81 (8)	21.88 (3)	--	--	--	--
500ml-P5	0.99 (1)	--	4.86 (8)	13.43 (3)	--	--	--	--
500ml-P6	0.93 (1)	--	5.85 (8)	4.57 (3)	--	--	--	--
500ml-P7	0.49 (1)	--	16.66 (8)	15.86 (3)	--	--	--	--
500ml-P8	0.62 (1)	--	4.35 (8)	6.09 (3)	--	--	--	--
Other-P1	--	--	19.67 (9)	15.24 (6)	--	--	--	--
Other-P2	--	--	14.17 (9)	18.52 (6)	--	--	--	--
Other-P3	--	--	15.31 (9)	14.39 (6)	--	--	--	--
Other-P4	--	--	5.99 (9)	14.33 (6)	--	--	--	--
Weighted avg. MAPE	**11.63**	**16.65**	**12.27**	**15.04**	**13.55**	**--**	**12.88**	**--**
Number of promotions	**56**	**32**	**172**	**100**	**12**	**--**	**1**	**--**
Overall MAPE for forecast		**14.88**						

	Type of promotion and MAPE of recent products							
Products	bogof		2-for		3-for		Other	
	Regression	Forecast	Regression	Forecast	Regression	Forecast	Regression	Forecast
2ltr-P7	--	--	11.07 (2)	13.41 (7)	9.48 (2)	--	--	--
2ltr-P8	31.58 (5)	25.57 (4)	22.98 (5)	15.72 (2)	--	--	--	--
2ltr-P9	10.46 (4)	21.53 (3)	21.97 (3)	24.55 (2)	--	--	--	--
2ltr-P10	3.91 (2)	2.42 (3)	2.48 (3)	2.21 (2)	--	--	--	--
2ltr-P11	22.94 (5)	--	12.28 (5)	19.81 (1)	--	--	--	--
6pk-P7	12.90 (7)	13.10 (7)	23.6 (3)	28.87 (3)	--	--	1.57 (1)	--
6pk-P8	15.97 (7)	35.57 (4)	--	--	--	--	46.23 (1)	--
6pk-P9	9.23 (7)	3.62 (4)	2.44 (3)	8.77 (3)	--	--	8.37 (1)	--
Weighted avg. MAPE	**15.92**	**16.90**	**14.58**	**15.58**	**9.48**	**--**	**18.72**	**--**
Number of promotions	**37**	**25**	**24**	**20**	**2**	**--**	**3**	**--**
Overall MAPE - forecast		**16.31**						

For retailer R4, the MAPE for forecast is very low and models are very good. The overall weighted MAPE of the established products is 14.88% and of the recent products is 16.31%. The results are summarised in Table 10-10. In Table 10-9 and Table 10-10,‘other products’ represents either 500ml or 330ml drink with unusual pack sizes of 5 or 10.

10.8 Forecasting sales uplift

Another approach to estimate the impact of promotions by Soft Drink Co. is to estimate the sales uplift. As all the promotions intend to improve normal sales, the calculation of sales uplift (over and above the normal sales) during each promotion helps the planner to decide their future promotions. The sales uplift is the ratio of the average sales during promotional events (normally 4 weeks) and the average normal base sales level during non-promotional weeks. For forecasting demand of some products (e.g., 5-pack orange juice and 5-pack cherry drink), Soft Drink Co. is using this uplift ratio in their traditional forecast method.

To test the forecast accuracy using the uplift method, the sales data of retailers R1 and R2 are considered. The new MLRMs consider sales uplift as a dependent variable Y. All of the other independent demand factors remain the same. These MLRMs, forecast the sales uplift for the year 2007. The MAPE of this uplift method is then compared with other methods, namely the traditional method and the standard regression method. Table 10-11 and Table 10-12 summarise the results of three forecasting methods at retailers R1 and R2. In these two tables, for each product, the first row shows the MAPE using three different forecasts methods and the second row shows the sales factors (independent variables) used in the forecasting models. In the these tables ‘PD’ represents percentage discount, ‘X-mas’ represents Christmas and ‘temp’ represents temperature.

Table 10-11 Comparison of MAPEs in three forecasts – Retailer R1

	MAPE		
Products	**Traditional method**	**Regression method**	**Uplift method**
2ltr	20.59	9.80	12.75
		PD,X-mas,temp,display	PD,temp,display
2ltr	16.64	8.28	13.75
		PD,X-mas,temp,display	PD,temp,display
6pk	54.60	12.78	19.75
		bogof,2for,3for,temp	bogof
6pk	55.67	14.17	15.45
		bogof,2for,3for	bogof
6pk	56.53	5.15	24.94
		PD,bogof,display	bogof
6pk	15.68	22.45	42.74
		PD,bogof,display	PD
6pk	22.92	38.19	34.30
		PD,bogof,display,2for	PD
6pk	23.71	38.90	26.80
		PD,bogof,display	PD
6pk	16.99	15.20	41.94
		Bogof,2for,display	PD
2ltr	32.86	23.09	31.07
		PD,bogof,display	PD
2ltr	35.50	23.83	20.85
		PD,bogof,display	PD
6pk	22.19	28.56	37.79
		PD,bogof,display	PD
6pk	23.59	20.94	20.22
		Bogof,2for,display	PD
6pk	19.30	23.83	18.23
		Bogof,2for,display	PD
Average MAPE	**29.77**	**20.37**	**25.76**

Table 10-12 Comparison of MAPEs in three forecasts – Retailer R2

	MAPE		
Products	**Traditional method**	**Regression method**	**Uplift method**
2ltr	20.67	6.82	27.17
		Temp,X-mas,holiday,display	PD,base sale,display
2ltr	26.06	12.99	34.06
		Temp,X-mas,holiday,display	PD,base sale,display
2ltr	74.29	42.52	30.73
		PD,bogof,X-mas	bogof
2ltr	24.12	29.54	26.52
		PD,bogof,X-mas	bogof
2ltr	77.66	46.06	32.05
		PD,bogof,X-mas	bogof
2ltr	59.77	20.40	22.80
		PD,temp,X-mas	PD,display
2ltr	50.45	34.88	29.59
		PD,temp,X-mas	PD,display
2ltr	49.53	27.82	22.67
		PD,X-mas	PD,display
2ltr	88.47	30.83	24.82
		PD,X-mas	PD,display
6pk	88.96	39.86	35.75
		PD,bogof,X-mas,temp	PD
6pk	68.92	18.53	39.93
		PD,bogof,X-mas,temp	PD
6pk	92.75	66.09	22.21
		bogof,temp,X-mas,display	PD,base sale
6pk	31.25	28.34	33.90
		PD,bogof,X-mas,temp	PD
6pk	21.26	5.39	14.56
		PD,bogof,X-mas,temp	PD
6pk	35.06	15.11	30.49
		PD,bogof,temp	PD
6pk	21.39	9.85	21.80
		PD,bogof,X-mas,temp	PD
6pk	19.50	8.00	15.00
		bogof,prom(y/n)	PD
6pk	33.58	19.99	30.01
		PD,bogof,X-mas	PD
6pk	29.66	25.55	27.98
		PD,bogof,X-mas	PD
6pk	25.58	23.56	27.20
		PD,bogof,X-mas	PD
6pk	21.49	22.03	16.11
		PD,bogof	PD
6pk	22.27	16.80	21.63
		PD,bogof,X-mas	PD
Average MAPE	**44.67**	**25.04**	**26.68**

The uplift method averages the sales volumes to obtain the sales uplift ratio. For example, if the total number of promotions per year is 10 then the uplift method will use 10 data points (each promotion with a period of 4 to 6 weeks is converted into a single data point). Regression models with more data points may improve the model fit (Makridakis et al., 1998). Hence, in the uplift forecast method, the products promoted at the same period of time with similar demand structure were grouped together. This approach has helped to obtain more data points to form meaningful regression models.

Comparison of all the three methods indicates that the uplift method can be used as an alternative forecast method. In Table 10-11, at retailer R1, the overall MAPE of - regression method is 20.37% and uplift method is 25.76%. It can be seen that for most of the 2ltr bottles, the regression forecasts using weekly sales achieved better accuracy than the uplift method.

In Table 10-12, at retailer R2, the overall MAPE of - regression forecast is 25.04% and uplift forecast is 26.68%. It can be seen that for some 2ltr bottles, the accuracy of uplift method is better than the standard regression method and for some 6-pack of 330ml cans, the accuracy of regression method is better than the uplift method. Compared to the traditional forecast method, both of the suggested forecasting methods, regression method and uplift method, have performed well (see Table 10-11 and Table 10-12). It is important to mention that the regression models, with weekly sales data or with uplift ratio, used explanatory variables identified through the Reference Demand Model. This answers the research Question 4 that **the inclusion of demand factors identified through the RDM improves forecast accuracy**.

10.9 Discussion of MLRMs

The regression analysis revealed significant factors of sales for every single product. The out of sample accuracy check for forecasting models, based on MLRMs, showed an improved performance for many products. It is interesting to note that the structure of some regression forecast models are similar because many products have similar exploratory variable when they are on promotion at the same period of time. Table 10-13 reports the summary of the results of - the MLRMs using weekly sales data and uplift ratio, and the traditional forecast. The MAPE of regression forecast and uplift forecast are much lower than that of traditional forecast.

Table 10-13 Summary of results

	Regression Forecast			**Traditional forecast**		**Uplift forecast**		
Retailer	**Average R^2**	**Average MAPE**	**No. of products**	**Average MAPE**	**No. of products**	**Average MAPE**	**No. of products**	**Comments**
R1	0.81	19.26	37	26.21	37	25.76	14	Number of promotions (2-for and other) are almost double in the test period
R2	0.63	21.43	31	38.94	31	26.68	22	Very consistent promotions in the training and the test period (except other promotions)
R3	0.54	34.33	30	--	--	--	--	Very inconsistent promotional mix in the training and the test period
R4	0.74	15.59	32	--	--	--	--	Very consistent promotions in the training and the test period (except other promotions)

From Table 10-13, it can be seen that the R^2 of retailer R2 is 0.63, which is lower than the R^2 of retailer R1 (=0.81). Still, the forecasts accuracy of both of the retailers is the similar with average MAPE of about 20%. This is mainly because, the type of promotions offered at retailer R2 in the test period 2007 is almost similar to that of training period (2005-2006). From Table 10-7, it can be seen that the retailer R2 has offered nearly the same number of promotions for established products, for bogof, 2-for and 3-for promotions in the test and the training period. But, the retailer R2 has offered more new promotions. For example, the number of other promotions is 2 during training period whereas it is 14 during test period. This has elevated the MAPE of other promotions to 62.47% for the mature products (see Table 10-7). Still, the overall performance of MLRMs for the retailer R2 is good.

In the case of the retailer R1, the number of bogof promotions offered in the training period and the test period for bogof has not changed much. However, all the other promotions (2-for, 3-for and other new promotions) have doubled in the test period. This has complicated the accuracy of the forecasts models. Some regression models with high R^2 also have not shown good accuracy. For example, the regression model for a product P15-A in Table 10-5 has high R^2 (=0.95) value and the MAPE for 3-for promotions in the training period and the testing period are 20.43% and 34.55% respectively. The higher MAPE in the testing period may be due to the fact that there was just one 3-for promotion in the years 2005-2006. Due to lack of historical sales data, the forecast accuracy was low. Still, the accuracy achieved through MLRMs is higher than the traditional method (see Table 10-6 for 3-for and other promotions).

In the case of retailer R3, the regression models have the average R^2 of 0.54 and the average MAPE of 34%. The number of bogof promotions given in training period has reduced to 3 from 21. Instead, more 2-for and 3-for promotions have been offered. This change in promotional mix has considerably reduced the forecast accuracy.

In the case of the retailer R4, the average R^2 is 0.74 and the average MAPE is 15.59 %. Among all the four retailers, the retailer R4 has achieved the highest forecast accuracy. This may be due to the fact that the number of promotions offered in the training period and the test period are almost the same and no new promotions are introduced in the test period. This retailer is highly consistent in executing the promotions as planned earlier (matching with the promotional calendar).

Based on the above discussions of the forecast models at four retailers, it is possible to classify the products into two main categories. One is the products that can be accurately forecasted and the other is that the products that cannot be accurately forecasted.

Products can be accurately forecasted

- if the same types of promotion with almost the same promotional features happened in the past will continue in the future
- if the promotional mix remains more or less the same
- if the sales uplift remains the same

Products cannot be accurately forecasted

- if more new promotions happen in the test period (no history)
- if the promotional mix changes significantly

For example, a retailer may be offering the same number of promotions but change the promotional mix from 2-for to 3-for. Although the new 3-for promotions have the same percentage discount, customers need to buy three units per sale. Sometimes, these promotions have recorded a lower uplift in the sales than anticipated.

Table 10-14 Promotional sales uplift in R1 and R2 and MAPE

	Training Period (2005-2006) Sales Uplift						Testing period (2007) Sales Uplift (MAPE)			
	2005			2006						
	bogof	2 for	3 for	bogof	2 for	3 for	bogof	2 for	3 for	Others
P1 R1 Uplift	-	-	-	-	1.5	1.42	-	2.37 (6.3)	3.02 (13.3)	-
R2 Uplift	-	1.7	-	-	0.93	1.1	-	1.13 (12.25)	1.73 (1.38)	-
P2 R1 Uplift	-	-	-	-	1.44	1.54	-	2.31 (5.97)	3.11 (10.59)	-
R2 Uplift	-	1.54	-	-	0.79	0.99	-	1.00 (25.82)	1.38 (0.15)	-
P3 R1 Uplift	10.08	2.26	-	4.93	2.68	-	6.06 (7.6)	5.17 (29.19)	-	3.9 (17.44)
R2 Uplift	4.15	2.15	-	4.15	2.23	-	3.7 (26.02)	1.88 (15.73)	-	0.82 (85.81)
P4 R1 Uplift	7.41	2.1	-	12.79	6.48	-	12.26 (26.98)	5.06 (24.96)	-	7.78 (46.01)
R2 Uplift	3.49	1.7	-	3.18	1.98	-	2.98 (21.76)	1.63 (15.34)	-	2.71 (51.53)
P5 R1 Uplift	7.79	2	-	4.38	2.1	-	5.25 (6.15)	2.97 (15.45)	-	3.96 (9.12)
R2 Uplift	4.33	1.81	-	2.66	1.89	-	2.95 (23.58)	1.87 (2.29)	-	0.84 (112..32)
P6 R1 Uplift	6.06	2.21	-	4.82	2.79	-	6.69 (12)	5.3 (35.53)	-	4.07 (6.26)
R2 Uplift	3.25	2.28	-	3.58	2.55	-	3.1 (14.8)	2.13 (20.02)	-	0.91 (26.39)
P7 R1 Uplift	21.19	3.56		10.22	6.08		14.01 (16.07)	5.52 (37.88)		8.79 (15.31)
R2 Uplift	3.47	2.08	-	3.25	2.31	-	4.95 (41.88)	1.86 (21.05)	-	3.22 (41.71)
P8 R1 Uplift	4.74	1.97		4.42	2.54		4.95 (10.26)	4.16 (33.99)		3.28 (1.43)
R2 Uplift	3.28	2.38	-	3.43	2.32	-	3.24 (20.5)	2.2 (9.2)	-	0.93 (35.14)
P9 R1 Uplift	25.22	3.24		11.81	6.6		11.92 (11.47)	4.95 (38.14)		7.65 (21.88)
R2 Uplift	4.11	2.19	-	3.7	2.33	-	4.35 (17.35)	2.04 (17.46)	-	1.07 (44.3)
P10 R1 Uplift	8.88	2.88	-	7.47	3.36	-	8.38 (36.19)	4.07 (15.68)		5.25 (12.77)
R2 Uplift	-	-	-	-	-	-	-	-	-	-
P11 R1 Uplift	35.71	3.92	-	6.71	3.45	-	6.93 (33.55)	3.35 (15.44)		4.4 (9.92)
R2 Uplift	-	-	-	-	-	-	-	-	-	-
P12 R1 Uplift	22.65	4.21	5.5	22.7	-	5.87	24.32 (10.25)	-	7.83 (15.31)	0.39 (53.67)
R2 Uplift	4.17	1.34	1.65	-	1.9	2.44	7.71 (19.1)	3.08 (21.54)	4.06 (59.95)	1.99 (40.54)

Numbers in parenthesis ( ) represent MAPE

It is important to mention that the sales uplift is not the same for all products in the promotions. Table 10-14 reports the promotional sales uplift at two retailers on some of the top selling products (P1, P2, etc.). Mean absolute percentage error (MAPE) is reported for each product during the testing period in the parenthesis. The sales uplift of some products, say P7, P9 and P11 of R1, were in the range of 21-35 times normal sales in the year 2005. However, the sales uplift of these products in 2006 and 2007 were not so high compared to that of 2005.

Such huge demand fluctuations challenge accurate forecasting. Hence, the inclusion of more demand factors in the forecasting is suggested in this research. In the case of no sales uplift (e.g. P1 and P2 in R2) either the promotional plans were suspended and the information not passed to the manufacturer, or changes occurred after the planning stage but not updated in the calendar.

While, this research suggests Soft Drink Co. to include the demand factors identified through the Reference Demand Model in the forecasting, it also encourages the company to check the following list to ensure improved forecast accuracy.

- ➢ Change in promotional mix
- ➢ Impact of promotions
    - High uplift in the training set
    - Low uplift in the test set
- ➢ Variability in sales volume for some promotions
    - More variability in the training set may reflect in high variability in the forecast
- ➢ Very few observations in the training set for some type of promotions (less historical data)

More variability in the promotions and less historical sales data will affect the forecast accuracy considerably. For example, if there is an excess inventory of bespoke packs of 2ltr bottles promoted during the football season (with a special logo on the packs) in a retail store, then the retailer will continue promotion without informing the manufacturer. This will show more variability in the sales data. High level of collaboration among Soft Drink Co. and the retailers can help improving information exchange and also avoid major changes in the promotional mix. This may subsequently reduce the variability.

10.10 Summary

This chapter described the method of developing simple regression models using data from Soft Drink Co. Multiple linear regression models were developed for major selling products at four retailers of Soft Drink Co. using the training data set (sales during 2005-2006). The results of the MLRMs were used to forecast the test data set (promotional sales of 2007) at these four retailers. These forecasts were then compared with the traditional forecast method being used in the case company. A detailed report on results of each retail sales analysis was given. On proving the advantage of the MLRMs, regression forecast method was applied to all the retailers' sales forecasts. Another regression model using sales uplift ratio was also suggested in this chapter. This uplift forecast method showed improved accuracy compared to the traditional forecasts. Hence, the uplift method was suggested as an alternative forecast method. The combinational forecast of regression method and uplift method can help the company to further improve the performance.

Chapter 11 Discussions and conclusions

11.1 Introduction

This chapter combines all observations and results obtained from the qualitative and quantitative analysis described in previous chapters. The results of the qualitative analysis include observations from case studies and analysis of the conceptual Reference Demand Models, the results of the quantitative analysis include observations from SEM models and multiple linear regression models. Irrespective of the methodology used, all of the analyses confirm that the exchange of supply chain information helps forecasting and hence may improve supply chain processes.

The concept of Reference Demand Model suggested a structured approach either to progress on the current mapping of supply chain information with supply chain partners or to identify the possible future mapping of supply chain information. The steps suggested to analyse the RDM intended to direct managers in decision making on information exchange to support CPFR. Structural equation models and regression models were then suggested to analyse promotional sales data of Soft Drink Co.

The findings of this research with reference to three different methodologies are further discussed in this chapter. The scope for future research on CPFR is discussed at the end of this chapter.

11.2 Discussions of case studies and conceptual model

It was observed from the case studies, Soft Drink Co. and Textile Co. in particular, that it is important to indentify the relevant factors that explain demand. Both cases relate to MTS environments with products that are rather difficult to forecast (due to the presence of promotions). This research proposed constructing a RDM to gain more insight in the possible demand factors as well as to decide on the level of collaboration and information exchange. In addition a high level of collaboration between the manufacturer and downstream supply chain partners seems necessary in these environments. Hence, techniques such as CPFR may be helpful to improve supply chain performance. In terms of information exchange, historical sales data and promotional calendars are key to ensure good forecasting, whereas EPOS data and inventory status are required to ensure timely replenishment and avoid stock-outs and excess inventory (through VMI).

In MTS environments where demand is rather smooth (Wholesale Co. and Crude-oil Co.), simple (standard) forecasting approaches can be used to predict demand. In these environments a medium level of collaboration seems sufficient. The focus is on making end customer demand visible (to avoid the bullwhip effect) and perhaps engage in VMI arrangements if the manufacturer has better forecasting/inventory management capabilities. In that case it is also important to monitor/exchange EPOS data and the inventory status.

In MTO environments (Packaging Co. and EEM Co.) there is no need for short term forecasts. Hence, a low level of collaboration with the downstream SC partners should be sufficient. Historical sales data and other demand details may be useful for long term planning and forecasting.

11.2.1 Discussion of Quantitative Models

For the Soft Drinks Co., which is dealing with four major retailers, promotions have a big impact on sales. Exchange of promotional plans is essential for accurate forecasting and timely replenishment. The information on other factors such as holidays, temperature, and market preference on products is also important to improve forecast accuracy. However, this non-promotional information is currently not incorporated in the company's forecasting approach. Relationships among promotional factors, seasonal factors, special days and customer preferences are explained in structural equation models (SEM). The results of SEM clearly indicated that the sales of all products, irrespective of the size, were influenced by promotions. The demand of impulse-buy products (500ml bottles) and 2ltr bottles were also influenced by seasonal factors. Special days were not always influencing the sales of 500ml bottles and 330ml cans. The SEM analysis did not show much interaction between various demand factors. The SEM results revealed the general underlying structure of demand factors. This answers the research Question 3 - How are the different demand factors related to sales?

The demand factors listed in RDM and SEM were further used for developing multiple linear regression models. The sales forecast of the sales using regression models demonstrated improved accuracy. But good accuracy was not guaranteed if less accurate promotional details were used. Hence, these regression models cannot be used or should be used with care when the promotional mix changes over time. A high forecast accuracy is an indication for a good forecasting model with reliable explanatory factors. In case of lower forecast accuracy one can revisit RDM or try to improve the availability of accurate information through collaboration with supply chain partners. This answers the research Question 4 - Can the identified demand factors from RDM help improving forecast accuracy?

11.3 Contribution to knowledge

This research makes three primary contributions to the existing literature. Firstly, the formulation of 'Reference Demand Model' from the cases studied is a new concept in the area of supply chain collaboration. This approach has not been explored in the literature in detail (Aviv, 2007). This research has suggested the companies involved in collaboration to develop a specific RDM suitable for their environment. The steps suggested for evaluating the RDM will guide company's managers to better understand the required level of collaboration with other supply chain members for information exchange, planning and forecasting. A RDM is especially useful in MTS environments where forecasting is difficult.

This research also suggested steps to analyse the RDM so as to understand the importance of information exchange for forecasting and promotional planning. By developing the RDM and also by developing a procedure for analysing RDM, this research made two important sub-contributions to the existing literature of supply chain collaboration and forecasting. The first sub-contribution lies in the result that the inclusion of identified demand factors from RDM improves forecast accuracy. However, it is important for the collaborating partners to obtain reliable information from other supply chain partners. Only high quality information can guarantee high quality forecasts (Busetti, 2006). The second important sub-contribution is the role of RDM as a tool to improve supply chain collaboration and forecasting. On revisiting RDM periodically and also on comparing forecasts with actual sales one can improve the collaborative arrangements.

Secondly, identifying the underlying structure of demand through SEM has not been attempted in the literature so far. Especially in the area of supply chain collaboration and information exchange for demand forecasting, this is the first attempt to use SEM for identifying the general demand factors for products under promotional sales. In this research, SEM models have suggested a specific set of demand factors for 2ltr bottles, 6-packs of 330ml cans, and impulse-buy products such as 500ml bottles. This has given a clear idea of the effect of promotions and other factors on the sales of different products. Structural equation models have also indicated the role of demand factors in groups of products that are common to all the retailers. The idea of applying SEM for identifying the underlying demand structure can be extended to other manufacturing companies that are involved in supply chain collaboration.

The third contribution of this research is suggesting multiple linear regression models for forecasting, using the identified explanatory variables in RDM and SEM. Although regression models have been used in the literature for forecasting, the structured procedure of identifying demand factors through RDM and using the same demand factors subsequently in the forecast models were not attempted in the past.

The sales forecasts using multiple linear regression analysis proved advantageous over the traditional method used by the company. The comparison of SEM and MLRM gives a clear idea of the role of the demand factors for each product. In the case of poor forecasts, managers may look for missing demand factors and revisit the RDM or look for the underlying causes why the forecasts were poor (e.g. due to changes in the promotional mix, inaccuracies in the promotional calendar, unplanned or un-communicated in-store promotions).

This systematic approach for identifying the appropriate demand factors and using the same factors in simple linear regression forecast models will help in assisting managers to improve forecast accuracy and reduce time of forecast calculations. The approach of integrating RDM and regression forecast models have been highly appreciated by Soft Drink Co. and is currently being used by the company.

This research also suggested three levels of collaboration. In MTS environments with high demand variability (difficult to forecast), a high level of collaboration with downstream SC partners – CPFR is suggested. In MTS environments with low demand variability (easy to forecast), a medium level of collaboration with downstream SC partners is suggested (making end customer demand visible and VMI). In MTO environments, a low level of collaboration with the downstream SC partners should be sufficient.

11.4 Scope for future research

In this research, case studies played an important role in understanding the collaborative arrangement between manufacturers and downstream supply chain partners. This helped to develop a conceptual model called RDM, representing demand factors and their characteristics. The demand factors identified through RDM are subsequently used in SEM and MLRM to understand the underlying structure of demand and also for forecasting the sales. The combination of these three methods can be viewed as a comprehensive tool for improving forecast accuracy.

The approach used in this research was well appreciated by the case companies especially by Soft Drink Co., Wholesale Co., Textile Co. and Packaging Co. The companies believed that the RDM could influence management decision making on promotional sales and could also lead to the renewal of collaboration agreements. Soft Drink Co. is currently using some of the best performing forecast models, suggested from this study. This research can be extended for different sectors such as pharmaceutical, aerospace and automotive industry etc. In all the cases, it is important to ensure a good intra-organisational relationship and high quality information before proceeding with supply chain collaboration (Mena et al., 2009; Flynn et al., 2010; Forslund and Jonsson, 2007).

Constructing a RDM could be interesting to better understand the factors that drive demand of (repairable) spare parts (for example after sales service). Demand factors in this environment could include: the installed base, failure rates, repair-ability and durability of components, trade-in or upgrade programmes, life cycle aspects, usage rates etc.

This research has also identified the need for supply chain collaboration with upstream partners especially in MTO environments. In MTO companies, such as Packaging Co. and EEM Co., short term forecasting is not so important because the company receives orders from customers, hence demand is known. But material requirements planning is vital to ensure compliance with due dates and making sure the company get raw materials from its suppliers on time. A close relationship with upstream supply chain members may help them to have smooth production process with shorter lead times and also to ensure timely replenishment. Similar to a Reference Demand Model, a reference supply model (RSM) can be developed to facilitate the supply side collaboration. Constructing a RSM may assist companies in

- Make or buy decisions
- Supplier selection based on lead time/workloads/quality/reliability etc.
- Information exchange

Future research on RSM can potentially guide the managers to decide on what information needs to be exchanged with upstream SC partners. Such information exchange can guide them to decide on whether to make or buy raw materials required for production. For example, Packaging Co. is currently producing its raw material (fabric). But in case of urgent orders, to reduce lead time, the company buy fabric from other suppliers. In this case, RSM can guide managers to choose the right supplier. A RSM may be particularly interesting in MTO environments with a complex supply base and stringent capacity constraints (necessitating frequent make or buy decisions). Aerospace companies such as Rolls Royce are an example of this category.

There is another possible extension of this research by considering product returns. In recent years, increased consumer rights and environmental awareness have increased the number of product returns. Company dealing with product returns or operating a closed loop supply chain, can construct a reference return model (RRM).
This RRM may help the company to understand

- where do returns come from
- what is the quality/timing/reliability of the returned products
- Why/when/who returned the product

This research was based on cases of MTO/MTS companies producing functional, fashion driven and innovative products. To make the findings of these cases more general, a larger number of cases could be analysed, considering other environments. Cases similar to Saturn (after-market spare parts) and Sports Obermeyer can be considered (Cohen et al., 2000; Fisher et al., 1994). This will help to draw a general conclusion on the information need in different supply chains and for different products.

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Appendix-I Case study-5

Packaging material manufacturing company

1. Company Profile

Packaging material manufacturing company is a well established active producer of packaging materials in India (hereafter Packaging material manufacturing company will be referred to as Packaging Co.). The company has been serving the packaging industry for more than four decades since its creation in 1966. It has four manufacturing units in various parts of India namely Chennai, Nellore, Bangalore and Mumbai. Packaging Co. produces a variety of packaging materials such as flexible water proof packing materials, polyprophelene woven bags, Agronit bags and Jumbo bags. The company has a special manufacturing division for producing Jumbo bags for orders from many industries such as petrochemical, mineral, dyeing and natural food material (pharmaceutical). Packaging Co. is mainly operating in the local Indian market, but their products, especially the Jumbo bags, are being used by their customers to export their goods and machinery internationally. The company also produces ‘Filling & Discharging machinery’ which is used for filling and discharging of Jumbo Bags. These machines are manufactured with technical collaboration from another UK company. The quality of Packaging Co.’s products is important to receive repeat orders from their customers.

The annual turnover of the company is 100 Crores Indian Rupees which is equivalent to 25 million US Dollars[*]. The company employs 125 personnel in its production department. The company holds nearly 20% of the market share in the local packaging industry. Fierce competition forces Packaging Co. to be innovative with periodic revision of the company's strategy.

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[*] (1USD ≈ 41.6 Indian Rupees in December 2007)

2. Business strategy of Packaging Co.

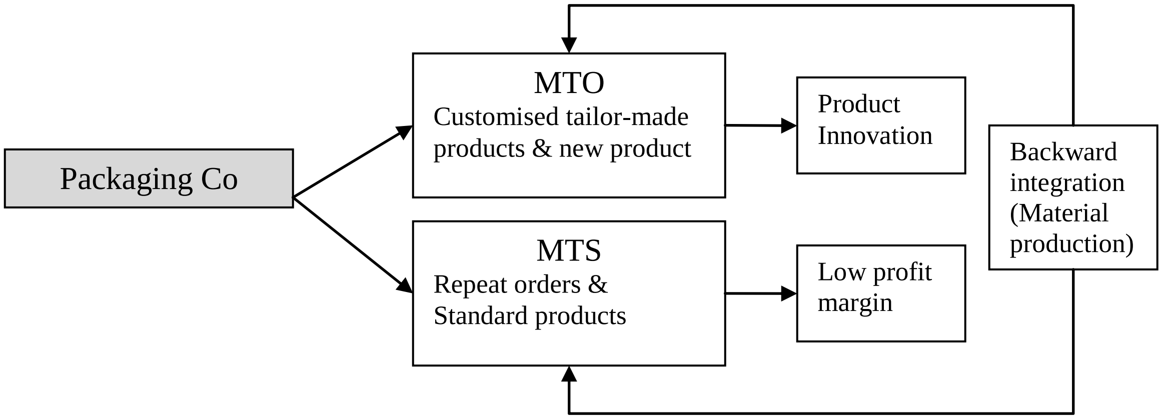
The Jumbo bags are also known as FIBC - Flexible Intermediate Bulk Containers (Bulk Bags) in the packaging industry. These Jumbo bags are normally classified as functional products (Fisher, 1997) as long as it does require any particular specification such as size or UV (Ultra Violet) treatment. Demand for these products is heavily dependent on customers' demand and capacity expansion plans. The customers' business plans, such as sales promotions, have a great impact on the demand of Packaging Co.'s products. This is mainly due to the fact that Packaging Co. is neither original equipment manufacturer nor direct seller to retailers. Instead the products of Packaging Co. are supplied to other manufacturers. Packaging Co. plays the role of a Type-3 SC (see Figure 1-3). Packaging Co. deals with more than 100 customers, 60% of which mainly operate in the local market. These customers need both Jumbo and other packaging materials. The remaining 40% of customers are exporting their products in the Jumbo bags only. The demand for Jumbo bags is mainly from the manufacturers operating internationally and a relatively small fraction from the local market (wholesalers or producers of machinery and petrochemical products).

The two main business strategies of Packaging Co. are: (1) maintaining a low price with a low profit margin on standard products, and (2) introducing more innovative products such as Jumbo bags with long life UV treatments and easy to handle bags etc. In order to compete in the market Packaging Co. keeps its profit margin as low as possible (4% of the cost of production). The company understands that in the competitive business market, total dependability on cost leadership can only be a short term advantage and hence Packaging

Co. tries to introduce innovation in their products. Initially, the group opted for specialisation in manufacturing ‘Waterproof Packing Materials’. Gradually the group has added plastics processing units like ‘Extrusion coating’ and ‘Film extruding’ to be up to date with the technological developments in the packaging industry. An in-house Research & Development department was set up in 1986 to develop innovative and cost effective packaging.

In India, Packaging Co was the first manufacturer to introduce the concept of the Jumbo Bags. These bags can handle up to 2,000 Kilograms per bag. The efforts in the area of Research & Development have been successful and in addition Packaging Co. has received various national and international awards. Recently, the company started the backward integration, a process of converting ‘polyprophelene’ into fabric. The polyprophelene is one of the main raw materials for Jumbo bags. This backward integration process has helped the company to save considerable costs on raw materials and has also made the company self sufficient on raw materials (input). Other advantages of the backward integration include a reduction of the processing lead time by 20-25% and more production flexibility. Packaging Co. schedules the production of Jumbo bags based on their own raw materials (fabric) production. Without a doubt, this arrangement helps to reduce inventory and guarantees on-time delivery. Packaging Co’s lead time had also reduced noticeably (by 20%) after the introduction of backward integration. According to Packaging Co, MTO products need innovation to survive the market competition and MTS products need to be competitive in their pricing. Both of these strategies, being innovative and cost leadership help the company be a market leader in the packaging industry (see Figure 1).

Figure 1 Business strategy of Packaging Co


Packaging Co
MTO
Customised tailor-made products & new product
MTS
Repeat orders & Standard products
Product Innovation
Low profit margin
Backward integration (Material production)

Although, the products of Packaging Co. can be classified as functional products, they are not made to stock, except for standard products, because of the various sizes, shapes and UV treatments. UV treatment limits the 'shelf life' of a product. Packaging Co maintains a safety stock with a raw material inventory of about 25% of the expected orders and a finished product inventory of about 10% of expected order.

3. Capabilities

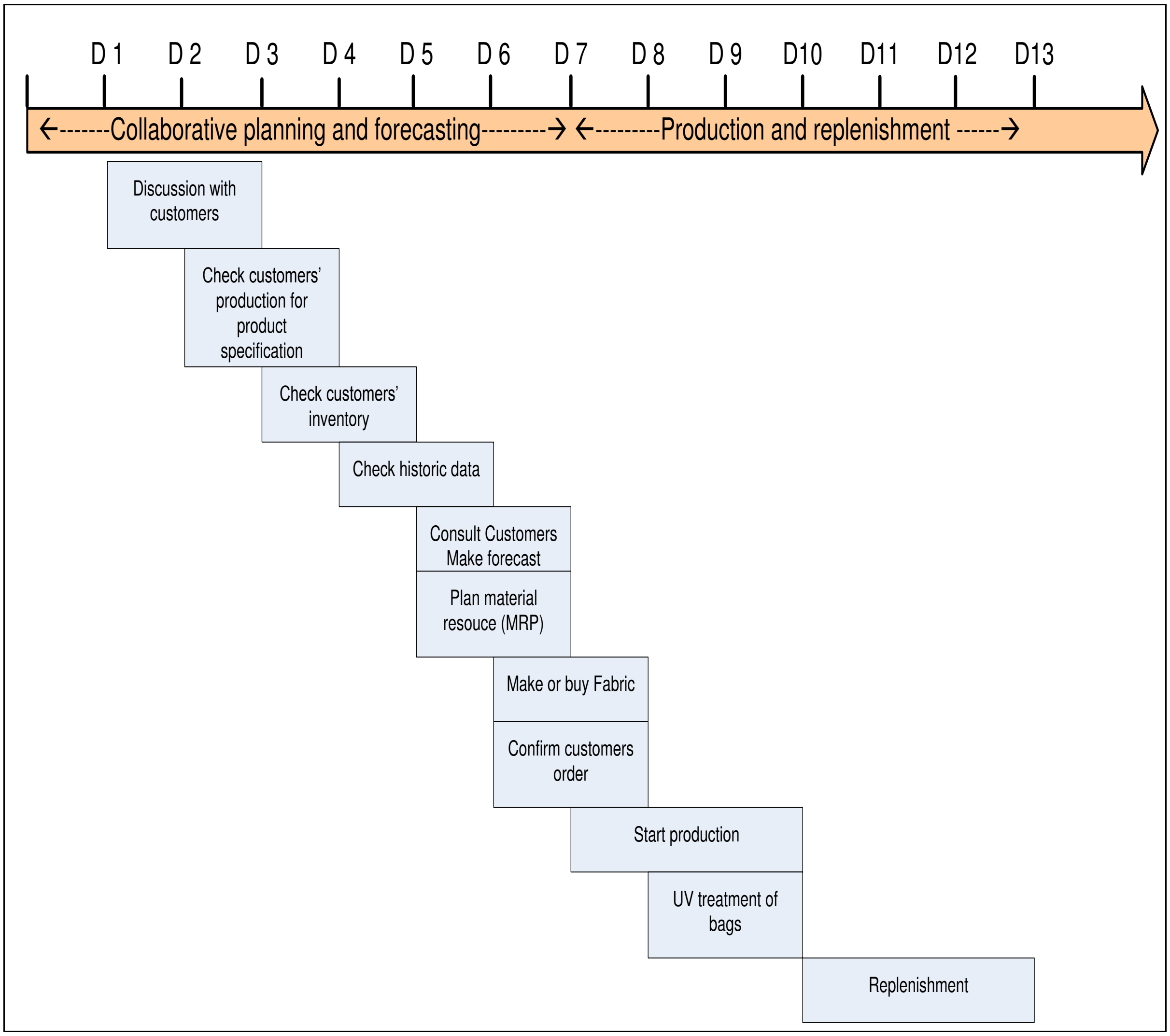
Although Packaging Co is a relatively new company in terms of supply chain collaboration, it maintains an effective but simple communication technology. On the other hand Packaging Co has a well established production and logistics capabilities which are explained below.

3.1. Production and logistics capabilities

Packaging Co believes in upgrading their technology periodically. Generally, the capacity expansion of Packaging Co. is dependent on their customers' expansion plan as Packaging Co.'s demand is directly proportional to their customers demand. These customers are not end customers or retailers. The customers of Packaging Co. are either manufactures of finished products or suppliers to manufacturers. Any production expansion in the customers' plants will therefore induce more demand for Packaging Co.'s products.

The company periodically expands their production base to support more businesses. Revision and upgrade of existing technology takes place on average, every three years. The current production capacity is 1000 bags per day. Recent expansion of production capacity in Packaging Co. is expected to increase the company's market share into double its present value. Figure 2 illustrates the production planning cycle at Packaging Co.

Figure 2 Planning cycle at Packaging Co


D 1
D 2
D 3
D 4
D 5
D 6
D 7
D 8
D 9
D10
D11
D12
D13
←-------Collaborative planning and forecasting---------→ ←---------Production and replenishment ------→
Discussion with customers
Check customers' production for product specification
Check customers' inventory
Check historic data
Consult Customers Make forecast
Plan material resouce (MRP)
Make or buy Fabric
Confirm customers order
Start production
UV treatment of bags
Replenishment

The production of jumbo bags normally takes 2 to 3 days, provided raw materials are available. Otherwise, the production process will take an additional 1-2 days for converting polyprophelene into fabric. In most of the cases the production includes UV treatment of bags.

In the past years, Packaging Co. encountered logistical problems as their production site is situated away from their customers'. This caused delays in replenishment and also increased logistical costs. Recently the company has purchased transportation vehicles to move finished products from the factory to the nearest distribution hub, from where all the products are delivered to the customers using cheap logistics providers. This arrangement has helped Packaging Co. to reduce its logistical costs.

3.2. Communication and forecasting capability

Most of Packaging Co.'s communication with their customers is through an iMail Server. This is one of the advanced recent communication technologies, which works well independently or in combination with other technologies such as an Email server, SMTP, POP3 and IMAP. The company's recent upgrade of communication technology has reduced complexity and communication has become easier. Packaging Co. believes that their recent investment will improve communication and help avoiding replenishment delays. Packaging Co.'s production plans are dependent on their forecasts which in turn, are dependent on their customers' productions capacity, production plan and product demand. This necessitates Packaging Co.'s production capacity to be aligned with their customer requirements.

4. Supply chain collaboration and information exchange

Packaging Co. has around ten suppliers and hence supply uncertainty is highly unlikely. The relationship with suppliers is not felt very important except for knowing Government regulations on the product introduction and specification. On the other hand, the relationship with the clients is very important to be successful in the competitive market. Packaging Co. is managing more than 100 customers. A healthy relationship benefits a smooth flow of product and information.

For production planning, Packaging Co. needs input from their customers for the design, size and other specifications like weight tolerance and UV treatment. Collaboration between Packaging Co. and their customers assist them to produce materials according to customers' requirement. The company is also determined to replenish stocks on time. Hence, supply chain information from customers is essential to be responsive to any future orders. Packaging Co. has a good understanding that not all of the information exchanged among supply chain partners is actionable. For example, bags with new specifications cannot be produced immediately without planning and scheduling. This exercise may also require additional machinery in production. To avoid lost sales, Packaging Co. is interested in establishing intensive collaborations with their customers in the planning stage for product specification. This collaboration further continues in forecasting, production, and replenishment.

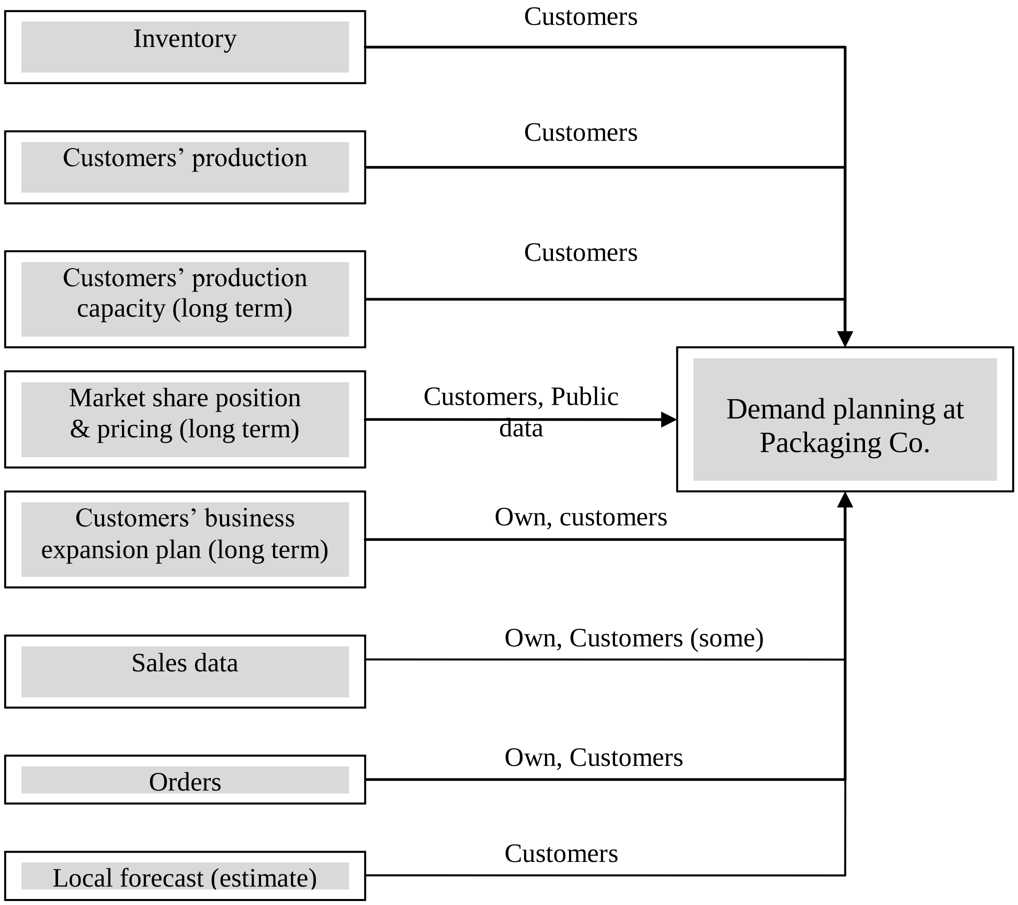
Collaboration with established customers in the market brings in future business (more demand) for Packaging Co. products. Packaging Co. checks their customers' reputation from published market data before it initiates collaboration. Once the collaboration relationship is established, Packaging Co.'s representative starts working closely with the customer to follow their production. This helps the company to make customised products (e.g., bags of different size with UV treatment and water proof) to the customers at a short period of time. Information from customers on their sales and local forecast based on customers' promotional and seasonal data facilitates Packaging Co. to agree upon a common forecast figure. Readily available order data is also being used by the company for its future plans and production.

5. Importance of SC information

Interviews with supply chain process managers of companies revealed that the production planning and forecasting is mainly based on eight types of information input: inventory, customers' production, capacity, market share, business plans, sales data, order information and local forecasts (see Figure 3). Unlike other suppliers who work closely with end customers, Packaging Co. needs only historic sales information but not EPOS. Here local forecast refers to expected demand forecasted by Packaging Co.'s customers.

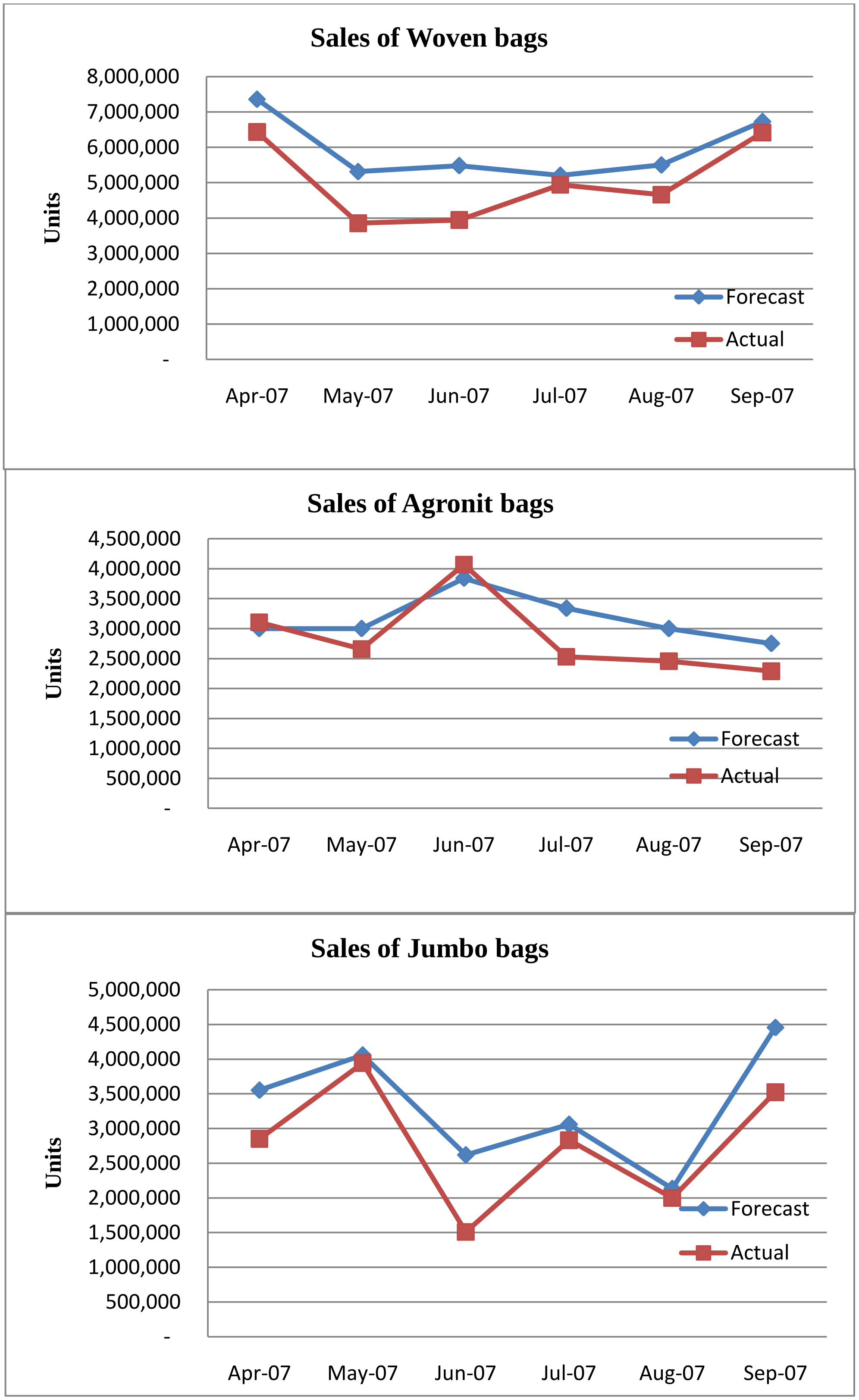
While considering the information needed, the technology involved in exchanging the information also needs to be considered. Delayed information will not have any benefit for improving forecasting and production plans. Packaging Co. claims to receive information very quickly through basic communication such as telephone, fax and electronic mails through iMail server. The accuracy of the information appears to be very high and this was also evident from the past performance of the company.

Figure 3 Information exchange in Packaging Co supply chain


Inventory
Customers
Customers' production
Customers
Customers' production capacity (long term)
Customers
Market share position & pricing (long term)
Customers, Public data
Demand planning at Packaging Co.
Customers' business expansion plan (long term)
Own, customers
Sales data
Own, Customers (some)
Orders
Own, Customers
Local forecast (estimate)
Customers

Based on the available supply chain information, Packaging Co. forecasts its demand (see Figure 3). Currently the company is achieving around 70 - 75 % forecast accuracy. From Figure 4, it is clear that the actual sales and forecast sales of Jumbo bags, Agronit bags and Woven bags are very close for most of the periods from April 2007 to September 2007. In May 2007 the actual sale and forecast are almost the same for Jumbo bags. Such forecasts are further used for production planning of Packaging Co.

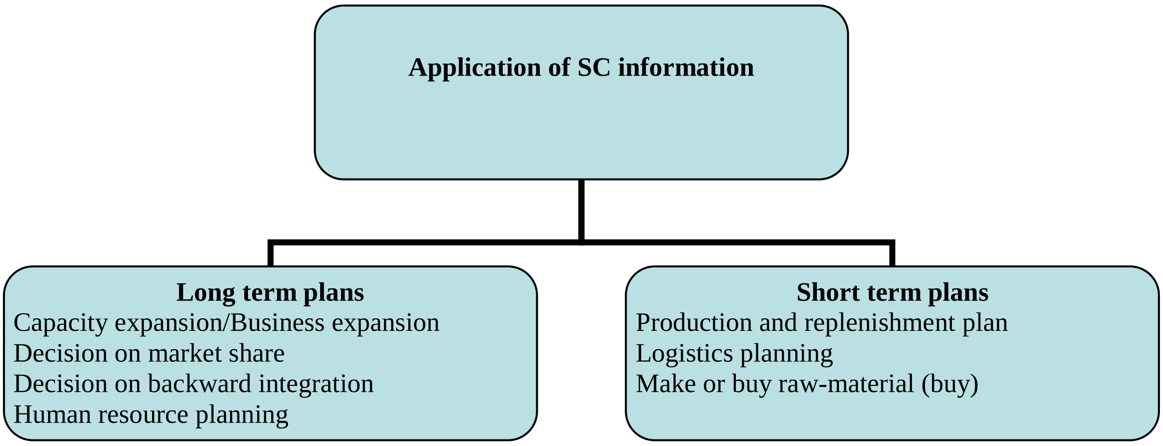
Figure 4 Sales and forecasts at Packaging Co.



6. Role of information in Packaging Co.

Supply chain information is being used for long term as well as short term planning at Packaging Co. (see Figure 5). Capacity expansion plans are made periodically based on sales. In addition forecasts are needed for longer and intermediate term human resource planning such as whether to hire part time or full time workers.

Figure 5 Influence of forecast in organizational planning


Application of SC information
Long term plans
Capacity expansion/Business expansion
Decision on market share
Decision on backward integration
Human resource planning
Short term plans
Production and replenishment plan
Logistics planning
Make or buy raw-material (buy)

Sharing SC information at Packaging Co. involves very little technology; and hence the role of technology is not found as very essential for the exchange of this information. Meanwhile, product specification and historical sales data of customers are being sent through iMail to avoid any mis-specification in future. Hence, it requires a very minimal help of information technology (see Table 1). The availability of an ample source of public information makes ‘market share’ of partners very transparent. Orders are placed through iMail or telephone. Promotion plans of customers are discussed in detail with Packaging Co, which requires human interaction and collaboration rather than technical support. As most of the data processing is being done through MS Office tools, the company has not made large amount of investment on technology apart from investing on iMail set up.

Table 1 Needs for information exchange

Supply chain information	Level of collaboration
Order data	Basic communication
Product specification	Basic data transfer technology – iMail
Market share position	Public data
Production capacity	Collaboration -- Human interaction
Inventory	Collaboration -- Human interaction
Sales data	Collaboration-Basic data transfer technology – iMail
Expansion plans	Collaboration -- Human interaction
Local forecast	Basic communication

Appendix-II Case study-6

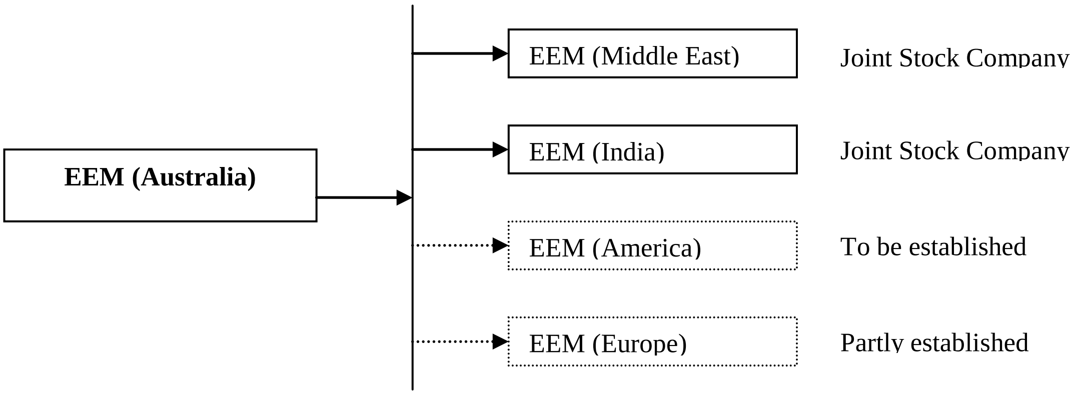
Electrical Equipment Manufacturing Company

1. Company Profile

1.1. General

Electrical Equipment Manufacturing Company (EEM Co.) is a private company based in Melbourne, Australia. For over five decades (Since 1949), EEM Co. has been functioning as manufacturer and supplier of 'Explosion Protected Lighting' and Electrical equipment of high quality for domestic and international markets. EEM products are used by oil companies in Australia and are exported to over 20 countries in the Asia-pacific and Middle East regions. Due to its global operation, it has manufacturing plants and distribution centres across the world. (see Figure 1)

Figure 1: Organisational structure of the company


EEM (Australia)
EEM (Middle East)
Joint Stock Company
EEM (India)
Joint Stock Company
EEM (America)
To be established
EEM (Europe)
Partly established

Source: EEM Co.

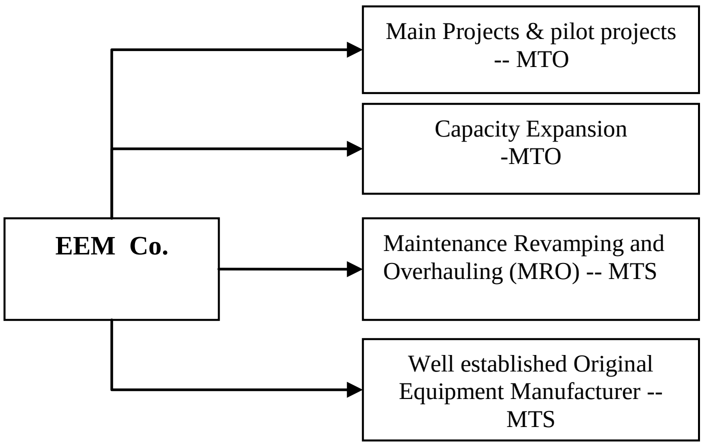
To maintain its high standards, EEM Co. keeps its organisational structure straightforward and simple. Almost all the branches and franchises of this company try to adopt a similar organisation structure as the parent company, EEM Australia. EEM Co. in India and Middle East countries have an established business and manufacturing base. However, EEM in Europe is still under development. The company is looking forward to expanding their business in the USA.

1.2. Local

The case study company ‘EEM India’, is located in Mumbai, India. It manufactures flameproof electrical equipments such as lighting for hazardous areas with full back-up support from Australia. The EEM products are recognised across the world under the names of Toyo, UDHE, KPG, EIL, among others. In India, EEM Co.s’ products are used by major (clients) companies including IOCL, Clough Engineering, ONGC and Chemtrols. EEM India has at least 28 major clients. EEM India makes products for orders from their parent company and local clients. The company takes part in major projects of the local Government and private sector. Nearly 50 percent of their production facility is devoted to serving local demands. In order to utilise the plants’ capacity to its maximum, the company plans in coordination with other supply chain partners. The company has different business strategies for manufacture to order (MTO) and manufacture to stock (MTS) products. The main projects and preliminary projects (pilot) with established clients always follow MTO.

The company’s production capacity expansion is based on the orders from the established clients. EEM Co. is also involved in regular maintenance services such as revamping and overhauling, which is considered as MTS. The company is a regular supplier of spare parts to well established original equipment manufacturers such as Reliance in India. In this case, the company follow MTS strategy (see Figure 2). In general, it is possible to say that the company has Type-3 SC for both MTS and MTO products.

Figure 2: Business strategies


Main Projects & pilot projects -- MTO
Capacity Expansion -MTO
EEM Co.
Maintenance Revamping and Overhauling (MRO) -- MTS
Well established Original Equipment Manufacturer -- MTS

1.3. Global

Today, the company has truly become a global player by having offices in many parts of the world and supplying goods to more than 20 countries worldwide. With its head office in Melbourne, Australia, EEM's network is spread widely from Japan and Korea to India and beyond to Saudi Arabia. The EEM group has firm plans to enter into European and American markets in the near future. Due to its worldwide operations it needs wider supplier coordination from different companies. The main projects can be from any country, but completion of the project is the sole responsibility of the company and hence all the partners work collectively towards the final goal. For example, a project can be from China, the designer can be from Europe, the Engineering consultant can be from India, and the contractor can be from Australia or US. A high level of internal collaboration becomes absolutely essential in each project.

1.4. Product details & standards

The Research and Development (R&D) team at EEM Co. use computer aided drafting techniques to produce a full range of products such as Flameproof (Exd), Increased safety (Exe), Dust excluding ignition proof (DIP) and Pressurised (Exp) electrical equipments. Recently, EEM Co. also launched Petrochemical and Corrosive Liquid Handling products. The product range for this division included composite hoses, couplings and tanker fittings, which blended well with EEM's explosion proof product range.

EEM products are tested by internationally recognised Testing and Certifying bodies. The Australian AS/NZS Standards for explosion protected electrical equipment are in line with IEC standards (International Electrotechnical Commission) and are similar to American standards. EEM's key objective is to improve products and processes through an ongoing commitment to research and development. This has made EEM a successful and reputed global technology organisation.

2. Supply chain processes at EEM

Nearly half of the production is meant for orders from the parent company. This necessitates EEM India to work closely with parent company in Australia. Usually the production lead time takes about four weeks to finish small projects and it may be up to even 8 weeks depending on the size of the project. This time period includes delivery at the specified warehouse or plant at OEM’s production site. The orders from the local clients are directly dealt with by the company and hence planning, production and replenishment is the sole responsibility of the local management. Based on the local orders, EEM Co. commits their delivery time to the parent company. This helps them for material resource planning to maintain uninterrupted production and timely replenishment.

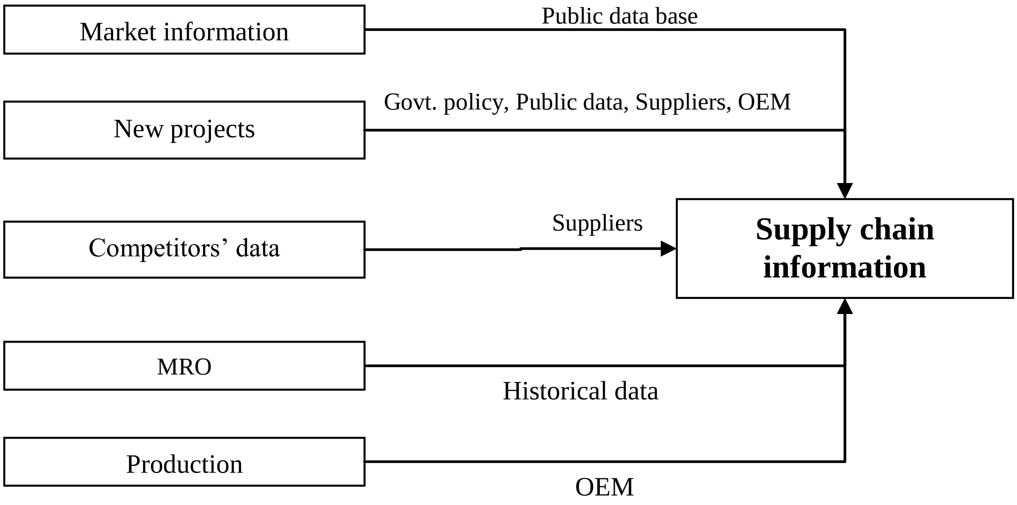
EEM Co. tries to improve the capacity utilisation by operating the machines to a maximum of 18 hours a day. The MTS products are produced only when the orders from the main projects are low. The products of EEM have a long shelf life (2 years), but the holding costs and obsolescence costs are huge. Hence, the company tries to avoid over production. MTS products are manufactured based on historical sales details. The company maintains 25% of annual demand as safety stock for MTS production.

3. Supply chain collaboration at EEM

EEM's international operation demands high quality standard products. To maintain its global standing, the business processes of EEM involve many suppliers and customers in their supply chain. As a result, information sharing is an integral part of all its operations. Relationships with suppliers are used for both information flow and raw material flow. This information flow includes competitors' business and future projects; but it is of a highly informal in nature. Though the reliability and accuracy of competitors' data is not fully guaranteed, it is important to plan the future business.

As EEM is a main supplier to many original equipment manufacturers (OEM), the demand of OEM products triggers the demand for EEM's products. Hence, knowledge of market rating and the market potential of OEMs are essential for the company's demand planning. The market information is easily available in the public data base. Good supply chain collaboration with downstream members (OEM) helps the company to know about their future projects and hence production planning is made less complicated. In recent days, planning has become a joint process between EEM and their customers (suppliers and buyers) by involving all collaborative supply chain partners. The SC collaboration is also felt to be important for sales coordination in various countries around the world.

Figure 3: Information flow in SC of EEM


Market information
Public data base
New projects
Govt. policy, Public data, Suppliers, OEM
Competitors' data
Suppliers
Supply chain information
MRO
Historical data
Production
OEM

OEM—Original Equipment Manufacturer; MRO—Maintenance Revamping and Overhauling

4. Summary

The case study of EEM has given an insight on the limited use of information exchange and demand planning in a MTO Company (tier 2 and tier 3 suppliers). Although the basic information flow is good in the SC, the impact of information is highly unlikely in the supply chain process as it is neither controlled by a single player nor maintained by all members. Hence, developing and using a Reference Demand Model with the available information is a complicated task unless supply chain information flow is standardised.

Appendix–III Interview Questions

Proposed open ended questions for case company interviews

Name of the Company: **Product line:**

Interviewee's position in the Company:

Company profile/background

1. When was the company established?
2. How many product plants do you have in the UK/India? Where are they located?
3. What is annual turn over of the company?
4. How many full time/part time employees are associated with the company?
5. What is your market share in this industry specific to the UK/India?

Business strategy

1. As a manufacturer how do you categorize your product (MTS/MTO)?
2. What is your main business strategy? (product differentiation, cost leadership etc.,)

Capabilities-Production

1. What is rate of production?
2. What is the average number of orders placed by your customers per day?
3. Is current production capacity sufficient to meet demand?
4. Will you accept order above your production capacity?
5. What do you consider as your strength in production technology?
6. What is the lead time of the product under normal condition (duration from receiving order till time to market)?
7. What is the shelf life (sale life) for the product?
8. How quickly can you produce for special orders?
9. How frequently do you introduce new products?

Capabilities-Communication and information exchange

1. How do you communicate with your supply chain partners? – technology, frequency
2. Supply chain management techniques -VMI/CPFR/others
3. Who does observer data and who does send to you?
4. How quickly can you react to the urgent demand?

Capabilities- Logistics and others

1. Where are your distribution centres (DC) located in the UK/India?

2. Can you explain the logistical operations—for e.g., factory to DC and then to customers?
3. Who does manage logistics for your company? How do you manage logistics related issues?

Supply chain partners

A) Supply side

1. Do you have supply uncertainty for raw materials?
   If yes, a) how well in advance do you know the situation? b) How do you get this information? c) How do you handle this uncertainty?
2. How many suppliers do you have? Can you describe how you collaborate with your suppliers to facilitate forecasting, material flow and production planning?
3. What supply chain management - collaboration do you use in your company (such as CPFR, VMI etc.)?
4. In case of VMI, do you have your representatives at DC or each retail outlet?
5. What is the benefit of having collaboration with suppliers?
6. What do you feel on future benefits?

B) Customers side

1. How many customers do you have?
2. Do you collaborate with your customers? Describe the collaborative arrangement with your customers.
3. Based on the above question-- Do you collaborate on promotional plans?
4. What is the main focus of this collaborative arrangement?
5. What type of relationship do you establish with your clients for information sharing?
6. Are you involved in any collaborative arrangement for a specific time period?
7. What is the normal duration for collaborative partnership?
8. What technology is used for information sharing?
9. Who does provide information?
10. What is your policy on incentive sharing for information exchange?

Inventory policies

1. Can you describe the inventory policies used in the company?
2. What are the lead times, average inventory levels, number of SKUs etc.?

Importance of information

1. What are the different types of information you use to forecast demand?

2. Who does provide this information? Who does observe this information?
3. How do you get this information – media and technology?
4. How often do you exchange information?
5. How reliable are these information?
6. How quickly can you react to this information?
7. What is the most important information to have accurate forecast and why?
8. In your opinion, what other data will help improving forecast?

Forecasting demand

1. How do you manage demand forecasting?
2. Do you incorporate all the data (discussed earlier) in your forecasting?
3. What are the main information and sub information do you use for forecasting?
4. How accurate are the forecasts?
5. Based on forecasting what changes do you incorporate in your production and /or planning?
6. How much in advance do you plan promotions?