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The Analytic Hierarchy Process Based Supplier Selection Approach for Collaborative Planning Forecasting and Replenishment Systems

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Abstract

A new business practices like Collaborative Planning Forecasting and Replenishment (CPFR) has emerged as a promising solution to eliminate demand and supply uncertainty through improved coordination and communicationsbetween supply chain partners. One of the critical decisions in CPFR implementation is the selection of strategic partners that will furnish necessary information and materials in a timely and effective manner. But, supplier selection is a complicated process. This process needs evaluation of multiple criteria and various constraints associated with them. Therefore, an Analytic Hierarchy Process (AHP) is used for supplier selection problem. In AHP technique the alternatives are weight under multiple attributes thereby developing a numerical score to rank each decision alternatives based on how well each alternative meets them. Finally, this paper draws conclusions on the need for an AHP approach in order to select the optimal supplier in CPFR.

Keywords:Collaborative planning forecasting and replenishment (CPFR), Supply chain management (SCM), Analytic hierarchy process (AHP).

1Introduction

Collaborative Planning Forecasting and Replenishment (CPFR) is a collaborative initiative aimed at making supply chain management more efficient and effective. CPFR emphasizes collaboration, coordination and trust between trading partners to achieve improvements in supply chain management, this requires executing effective supplier selection decisions. Selection of appropriate suppliers is a challenging issue. Analytic Hierarchy Process (AHP) has been a popular approach for supplier selection and has applied by a number of researchers and practitioners (Barbarosogluand Yazgac, 1997; Hill and Nydick, 1992; Narasimhan, 1983). The AHP method was introduced by Saaty (1980). This method elicits preferences through pair wise comparisons in which the decision maker (DM) considers the relative importance of two factors at a time with respect to a common higher level criterion; the DM indicates the intensity of preference of one factor over another as a point estimate(in classical AHP) or a fuzzy term/number (in fuzzy AHP) on an appropriate scale. In general, evaluation and calculation in AHP can be divided into four stages: (1) scoring the alternatives under each criterion, (2) weighting the criterion, (3) calculating the final score, and (4) ranking and final decision (Ghazanfari and Nojavan, 2004). Thus, AHP is a method for ranking decision alternatives and selecting the optimal supplier combination. The AHP enables the decision-makers to structure a complex problem in the form of a simple hierarchy and to evaluate a large number of quantitative and qualitative factors in a systematic manner under multiple criteria environment in confliction (Cheng et al., 1999). Traditionally, supplier offering the lowest price was selected. Today, supplier's selected after evaluating performance across many different areas. Considering the existing problem of incorrect supplier selection initiated because of paying too much attention to one factor only, such as price, quality, transportation cost etc. The AHP model is used to select supplier more accurately in order to alleviate the problem of supplier selection in food industry.

This paper deals with development of AHP framework to investigate the problem of supplier selection in food industry under different criteria. Information and the priority weights of elements were obtained from a decision-maker of the company using direct questioning or a questionnaire method.

2 Literature Review

CPFR is the most powerful process of consumer satisfaction by building strong relationships between trading partners. Utilizing the principles CPFR, a retailer and consumer goods firm would work together jointly to create sales and order forecasts (Folinas et al., 2004). Under CPFR, both buyer and seller collaborate by correcting, adjusting and proposing prices and quantities to reach an agreement on a unique forecast, so that buyer's purchases forecast and seller's sales forecast coincide (M.Caridi et al., 2006). Williams (1999) described how Procter and Gamble (P&G) took advantage of CPFR in a supply chain to create value for the corporation, trade partners and consumers. Tien-Hsiang Chang et al.,(2007) proposes and test A-CPFR model in a retailer-supplier context with a view to improving forecasting accuracy and then reducing the "bullwhip effect" in the supply chain. Selection of appropriate suppliers in supply chain management is a challenging issue. Therefore, a novel hierarchical evaluation framework is used to assist the expert group to select the optimal supplier (Tseng M.L. et al., 2009). There are several solution approaches to the supplier selection problem in the literature some of which are Analytic Hierarchy Process, Fuzzy Analytic Hierarchy Process, Data Envelopment Analysis, Mixed Integer Programming, TOPSIS, Fuzzy TOPSIS, QFD, Fuzzy QFD, Analytic Network Process and Expert Systems (Aktepe and Ersoz, 2011). The literature review of supplier selection problem shows that AHP is one of interesting and common methods which has been used for assessment and selection of suppliers. Generally, when we face to a multicriteria decision making problem in the second level of hierarchy and sub-criterion and alternatives in the next levels, AHP would be an ideal technique for ranking of alternatives (Khorasani and Bafruel, 2011). Corner,J.L. and Corner,P.D. (1995) have carried research work on characteristics of decisions in decision analysis practice. According to them in today's highly competitive environment, an effective supplier selection process is very important for the success of any organization. The research work deals with a brief review of the literature regarding AHP technique and its relevancy to its application in vendor selection process. Saaty,T.L. (1990) stated that the Analytic Hierarchy Process is a set of axioms that carefully delimits the scope of the problem environment. It is based on the well-defined mathematical structure of consistent matrices and their associated Eigen vectors ability to generate true or approximate weights. Trianthapillou,E. (1995) has performed comparative study on various decision making processes. As per the author, decision criteria used for vendor selection can be different depending on the size of a buyer organization. Large companies use a different set of criteria and a formal approach when selecting suppliers compared to small and medium sized enterprises. AHP makes the selection process very transparent and it also reveals the relative merits of alternative solutions for a multi-criteria decision making (MCDM) like supply selection problem.

3 AHP Frameworks for Supplier Selection Process

Saaty (1980) stated that AHP is often applied for supplier selection problem. The main reason is that this technique can rank the suppliers based on the relative importance of criteria.The four step procedure of this approach is given as follows;

Step1. Define criteria for supplier selection

Evaluation and selection of suppliers is a typical multiple criteria decision making (MCDM) problem involving multiple criteria that can be both qualitative and quantitative. These criteria may vary depending on the type of product being considered and include many judgmental factors. The various criteria those are important for supplier selection in CPFR, as evident from discussions with experts are, Cost, Quality, Timeliness, Collaboration, Trust, Co-ordination, Demand Information, Order Visibility as shown in figure 1. Before start of the framework; as per the AHP method, the structured interview with three experts of the company to evaluate the best criteria.

Step2. Decision hierarchy formulation

The application of AHP begins with a problem being decomposed into a hierarchy of criteria so as to more easily analyzed and compared in an independent manner as shown in table 1. After this logical hierarchy is constructed, the decision makers can systematically assess the alternatives by making pair-wise comparisons for each of the chosen criteria. After all comparisons have been made, and the relative weights between each one of the criteria to be evaluated have been established, the numerical probability of each alternative is calculated. The higher the probability, the better chances the alternative has to satisfy the final goal of the portfolio. The goal of our problem in selecting the supplier for food industry is identified in the first level. The second level (criteria) contains Cost, Quality, Timeliness, Collaboration, and Trust as shown in figure 2.

Step3. Constructing the comparison matrix

The comparison between two elements using AHP can be done in different ways. However, the relative importance scale between two alternatives suggested by Saaty is the most widely used. Attributing values that vary from 1 to 9, the scale determines the relative importance of an alternative when compared to another alternative, as we can see in table 2.

Step4. Synthesis of priorities and the measurement of consistency

The pair-wise comparisons of the criteria of supplier selection problem generate a matrix of relative rankings for each level of the hierarchy. After all matrices are developed, eigenvectors or the relative weights and the maximum eigen value (λmax) for each matrix are calculated. It is used for calculating the consistency ratio (CR) of the estimated vector in order to validate whether the pair-wise comparison matrix provides a completely consistent evaluation. Table 3 shows the value of the Random Consistency Index (RI) for matrices of order 1 to 10 obtained by approximating random indices using a sample size of 500. The RI varies dependingupon the order of matrix.

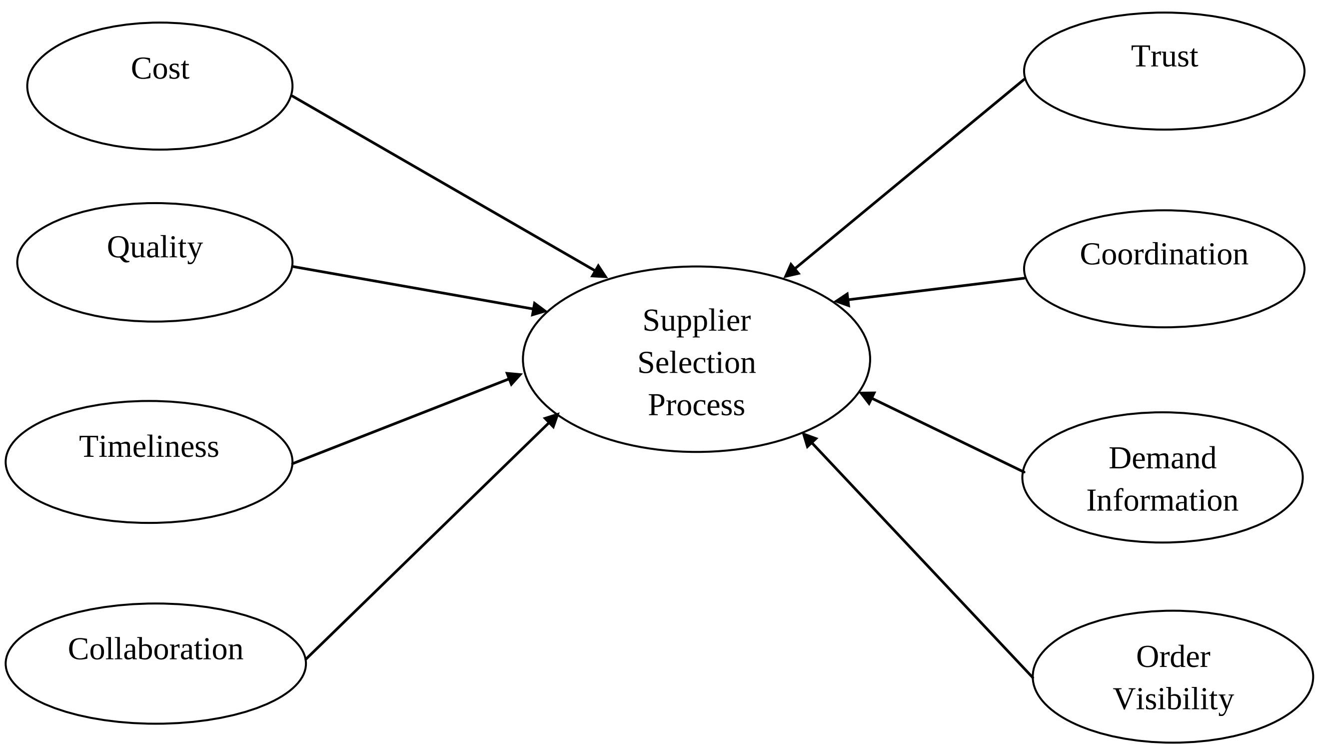

Fig.1: Criteria for Supplier Selection Process

Table1. Criteria Evaluation for Supplier Selection Process

	R (1)	R (2)	R (3)	1 2 3 4 5	Average
Cost	5	4	5		4.66
Quality	4	4	5		4.33
Timeliness	5	5	4		4.66
Trust	5	5	4		4.66
Coordination	3	4	3		3.33
Collaboration	5	4	5		4.66
Demand Information	3	4	4		3.66
Order Visibility	3	2	3		2.66

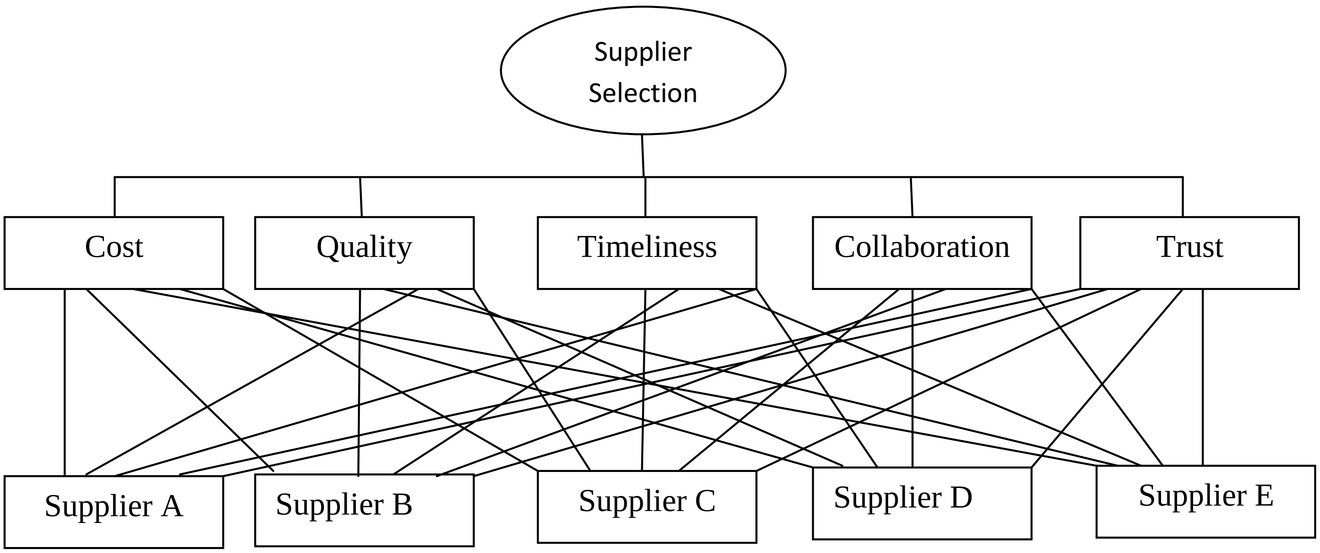

Fig.2: The Hierarchical Structure for Supplier Selection

Table2. The Saaty Rating Scale

Scale	**Numerical Rating**	**Reciprocal**
Extremely Preferred	9	1/9
Very Strong to Extremely	8	1/8
Very Strongly Preferred	7	1/7
Strongly to Very Strongly	6	1/6
Strongly Preferred	5	1/5
Moderately to Strongly	4	1/4
Moderately Preferred	3	1/3
Equality to Moderately	2	1/2
Equally Preferred	1	1

Table.3: Values of Random Consistency Index (RI)

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table.4: Overall Preference Matrix

Criteria for Supplier Selection	Cost	Quality	Timeliness	Collaboration	Trust	n^{th} root priority weight	Eigen vector (λ)
Cost	1	1/3	2	1/4	1/3	0.560	0.090
Quality	3	1	4	2	2	2.16	0.348
Timeliness	1/2	1/4	1	1/3	1/5	0.383	0.0617
Collaboration	4	1/2	3	1	1/5	1.037	0.167
Trust	3	1/2	5	5	1	2.064	0.332
Sum	11.50	2.58	15	8.58	3.73	6.204	1.000

[0.090, 0.348,0.0617,0.167, 0.332]

λ1=[(1* 0.090) + (1/3* 0.348) + (2* 0.0617) + (1/4* 0.167) + (1/3* 0.332)] = 5.353

Similarly, λ2 = 5.350, λ3 = 5.11, λ4 = 5.70, & λ5 = 5.78

Maximum eigen value (λmax) = $\frac{\lambda 1+\lambda 2+\lambda 3+\lambda 4+\lambda 5}{5}$ = 5.46

Therefore Consistency Index (C.I.) = $\frac{\lambda max-n}{n-1}$

$$= \frac{5.46-5}{5-1} = .115$$

Therefore Consistency Ratio (C.R.) = CI /RI = .115 / 1.12 = 0.10

Saaty argues that a CR □0.1indicates that the judgments are at the limit of consistency though CR's □ 0.1 (but not too much more) have to be accepted sometimes. In this instance, we are on safe ground.

A CR as high as, say, 0.9 would mean that the pair wise judgmentsare just about random and are completely untrustworthy.

Table.5: Comparison Matrix for Cost

Pair wise comparison	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	n^{th} root priority weight	Eigen vector (λ)
Supplier A	1	1/2	2	1/3	1/4	0.608	0.100
Supplier B	2	1	3	3	2	2.047	0.337
Supplier C	1/2	1/3	1	1/4	1/5	0.383	0.063
Supplier D	3	1/3	4	1	1/3	1.059	0.174
Supplier E	4	1/2	5	3	1	1.974	0.325
	10.5	2.66	15	7.58	3.78	6.071	1.000

$\lambda 1 = 5.337, \lambda 2 = 5.632, \lambda 3 = 5.298, \lambda 4 = 5.436, \lambda 5 = 5.324$

$\lambda max = 5.405$

CI = 5.405 – 5 / 5-1 = 0.101

CR = 0.101 / 1.12 = .090

Table.6: Comparison Matrix for Quality

Pair wise comparison	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	n^{th} root priority weight	Eigen vector (λ)
Supplier A	1	1/3	3	1/2	1/3	0.698	0.115
Supplier B	3	1	4	2	2	2.168	0.358
Supplier C	1/3	1/4	1	1/5	1/4	0.334	0.055
Supplier D	2	1/2	5	1	1/2	1.201	0.198
Supplier E	3	1/2	4	2	1	1.643	0.271
	9.33	2.58	17	5.70	4.08	6.044	1.000

$\lambda 1 = 5.118, \lambda 2 = 5.198, \lambda 3 = 5.276, \lambda 4 = 5.138, \lambda 5 = 5.206$

$\lambda max = 5.187$

CI = 5.187 – 5 / 5-1 = 0.046

CR = 0.046 / 1.12 = 0.041

Table.7: Comparison Matrix for Timeliness

Pair wise comparison	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	n^{th} root priority weight	Eigen vector (λ)
Supplier A	1	1/2	1/4	3	2	0.944	0.141
Supplier B	2	1	3	5	4	2.605	0.389
Supplier C	4	1/3	1	6	7	2.236	0.333
Supplier D	1/4	1/5	1/6	1	8	0.616	0.092
Supplier E	1/2	1/4	1/7	1/8	1	0.294	0.043
	7.75	2.28	4.55	15.12	22	6.695	1.000

λ1 = 5.537, λ2 = 5.917, λ3 = 5.644, λ4 = 5.262, λ5 = 5.274

λmax = 5.726

CI = 5.726 – 5 / 5-1 = 0.181

CR = 0.181 / 1.12 = 0.16

Table.8: Comparison Matrix for Collaboration

Pair wise comparison	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	n^{th} root priority weight	Eigen vector (λ)
Supplier A	1	1/4	1/5	5	6	1.084	0.134
Supplier B	4	1	1/3	7	6	2.236	0.278
Supplier C	5	3	1	9	8	4.042	0.502
Supplier D	1/5	1/7	1/9	1	6	0.452	0.056
Supplier E	1/6	1/6	1/8	1/6	1	0.225	0.027
	10.36	4.55	1.76	22.16	27	8.039	1.000

λ1 = 5.566, λ2 = 5.522, λ3 = 5.430, λ4 = 6.076, λ5 = 6.212

λmax = 5.761

CI = 5.761 – 5 / 5-1 = 0.190

CR = 0.190 / 1.12 = 0.16

Table.9: Comparison Matrix for Trust

Pair wise comparison	Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	n^{th} root priority weight	Eigen vector (λ)
Supplier A	1	1/3	1/2	4	5	1.272	0.178
Supplier B	3	1	3	5	6	3.063	0.428
Supplier C	2	1/3	1	8	7	2.062	0.288
Supplier D	1/4	1/5	1/8	1	5	0.5	0.069
Supplier E	1/5	1/6	1/7	1/5	1	0.248	0.034
	6.45	2.02	4.76	18.20	24	7.145	1.000

$\lambda 1 = 5.166$, $\lambda 2 = 5.549$, $\lambda 3 = 5.474$, $\lambda 4 = 5.871$, $\lambda 5 = 5.761$

$\lambda max = 5.554$

CI = 5.554 – 5 / 5-1 = 0.138

CR = 0.138 / 1.12 = 0.12

Table.10: Option Performance Matrix (OPM) of the Eigenvectors for Suppliers ABCDE

Suppliers	Cost	Quality	Timeliness	Collaboration	Trust
A	0.100	0.115	0.141	0.134	0.178
B	0.337	0.358	0.389	0.278	0.428
C	0.063	0.055	0.333	0.502	0.288
D	0.174	0.198	0.092	0.056	0.069
E	0.325	0.271	0.043	0.027	0.034

This matrix suggested that supplier B is better than others in terms of cost, quality, timeliness and trust whereas supplier C is better in collaboration. Multiply OPM by the relative value vector (RVV) to obtain the vector for selecting the supplier.

For supplier A

(0.090 × .100) + (0.348 × 0.115) + (0.0617 × 0.141) + (0.167 × 0.134) + (0.332 × 0.178) = 0.139

Similarly,

For supplier B = 0.367,

For supplier C = 0.224,

For supplier D = 0.122,

For supplier E = 0.142.

Table.11: Overall Priority Matrix

Sr. No.	Supplier	Priorities	Rank (Preferences)
1	A	0.139	IV
2	B	0.367	I
3	C	0.224	II
4	D	0.122	V
5	E	0.142	III

4 Conclusion

In this article, an AHP framework for strategic supplier selection has been proposed. The threelevel of AHP framework assessing decisionmakers to identify and evaluate the supplier selection. Finally, the results show the frameworks are able to assist decision makers to examine the strengthsand weaknesses of supplier. However, efficacy of evaluation at the initial levels depends on the accuracy and the value of the judgment provided by the experts. The proposed methodology can be utilized for selecting alternative decisions related to, production planning decisions, product development process,order production, logistics management and site selection. These issues need to be further investigated, but this article provides the initial step in this process.

References

Adnan Aktepe, SuleymanErsoz, 2011. A Fuzzy Analytic Hierarchy Process Model For Supplier Selection And A Case Study. International Journal of Research and Development, 3 (1), 33-37.

Barbarosoglu, G., T. Yazgac, 1997. An Application of the Analytic Hierarchy Process to the Supplier Selection Problem. Production and Inventory Management Journal, 18 (1), 14-21.

Cheng, C.H., Yang, K.L., Hwang, C.L., 1999. Evaluating Attack Helicopters by AHP Based on Linguistic Variable Weight. European Journal of Operational Research, 116, 423-435.

DimitrisFolinas, Vicky Manthou, Marianna Sigala, MaroVlachopoulou, 2004. E-volution of a supply chain: cases and best practices. Internet Research, 14 (4), 274-283.

Hill, R.P., R.J. Nydick, 1992. Using the Analytic Hierarchy Process to Structure the Supplier Selection Procedure. International Journal of Purchasing and Materials Management, 28 (2), 31-36.

M. Caridi, R. Cigolini, D. DeMarco, 2006. Linking autonomous agents to CPFR to improve SCM. Journal of Enterprise Information Management, 19 (5), 465-482.

Mehdi Ghazanfari, MajidNojavan, 2004. Reducing inconsistency in fuzzy AHP by mathematical programming models. Asia Pacific Journal of Operational Research, 21 (3), 379-391.

Narasimhan, R., 1983. An Analytical Approach to Supplier Selection. International Journal of Purchasing and Materials Management, 19 (4), 27-32.

Omit Khorasani, MortezaKhakzarBafruel, 2011. A FUZZY AHP APPROACH FOR EVALUATING AND SELECTING SUPPLIER IN PHARMACEUTICAL INDUSTRY. International Journal of Academic Research, 3 (1), 346-352.

Saaty, T.L., 1990. How to Make a Decision: The Analytic Decision Process. European Journal of Operations Research, 48, 9-26.

Tien-Hsiang Chang, Hsin-Pin Fu, Wan-I Lee, Yichen Lin, Hsu-ChihHsueh, 2007. A study of an augmented CPFR model for the 3C retail industry. Supply Chain Management: An International Journal, 12 (3), 200-209.

Triantaphyllou, E., Mann, S.H., 1995. Using The Analytic Hierarchy Process For Decision Making in Engineering Applications: Some Challenges. International Journal of Industrial Engineering: Applications and Practice, 2 (1), 35-4.

Tseng Ming-Lang, Jui Hsiang Chiang, Lawrence W. Lan, 2009. Selection of optimal supplier in supply chain management strategy with analytic network process and choquet integral computers. Industrial Engineering, 57, 330-340.

Williams, S.H., 1999. Collaborative planning, forecasting, and replenishment. Hospital Material Management Quarterly, 21 (2), 44-58.