6
Analytic Hierarchy Process (AHP)

6.1
Introduction to Analytic Hierarchy Process

The AHP (Analytic Hierarchy Process) was developed by Thomas L. Saaty (1980) and is the well-known and useful method to obtain weights of each alternative in a multiple criteria decision-making problem. AHP requires the decision maker to provide judgments about the relative importance of each criterion, and then, specify a preference for each decision alternative using each criterion. The output of AHP is a prioritized ranking of the decision alternatives based on the overall preferences expressed by the decision maker.

Xia and Wu (2007) state that AHP consists of three parts: The hierarchy structure, the matrix of pairwise comparison ratios, and finally, the method for calculating weights. In AHP, a decision maker is asked to estimate pairwise comparison ratios with respect to strength of preference between subjects of comparison, thus the AHP is deeply related to human judgment

AHP has been used to support decision process for different problems like Assess supply chain risks when analyzing offshore sourcing alternatives for a US manufacturing company (Shoenherr et al, 2008), Assess and identify the best delivery network design method taking into account both qualitative and quantitative factors (Sharma et al., 2008), Select anti cancer drugs to be produced and distributed within the pharmacy department of a French hospital (Vidal et al., 2010), Perform value chain analysis of service and manufacturing activities of a global supply chain of a multinational construction equipment corporation (Rabelo, et al., 2007), Develop a model to assess the performance of small to medium sized manufacturing enterprises (Norita et al., 2006), Perform supplier selection with multiple criteria in volume discount environments (Xia and Wu, 2007), Model location analysis of international consolidation terminals (Min, H., 1994), Perform carrier selection (Bagchi, 1989), Propose a customer oriented approach to the warehouse network evaluation and design using a combination of Analytic Hierarchy Process (AHP) and Mixed Integer Linear Programming (MILP) (Korpela and Lehmusvaara 1999).

AHP has also been applied together with case study methods in different areas like Evaluation of critical success factors of ISO 14001 implementation in a case study in Malaysia (Sambasivan and Fei, 2008), Case study to the selection of a multimedia authoring system in software selection (Lai et al, 1999), Case study of design and evaluation of automated cellular manufacturing systems with simulation modeling and AHP approach (Chan and Abhary, 1996), just to give some examples available in the literature.

It is not the goal of this thesis to provide a detailed description of how AHP works, therefore, anyone interested in a comprehensive review of how to use AHP method, please refer to Saaty (1980). For a literature review on the integrated analytic hierarchy process and its applications, please refer to the work developed by Ho (2008), where he reviews the five tools that are commonly combined with the AHP process, like mathematical programming, quality function deployment (QFD), meta-heuristics, SWOT analysis and data envelopment analysis (DEA).

6.2
AHP Applied to Demand Driven Supply Chain Assessment Model

In this research, it is proposed to apply the AHP method to identify the weights for each component of the Demand Driven Supply Chain, and also for each category within each component, in order to ensure a consistent comparison, and a reliable overall score performance in the demand driven supply chain maturity model.

The first step of the method consists of decomposing the problem into a hierarchy structure, as illustrated in figure 48:

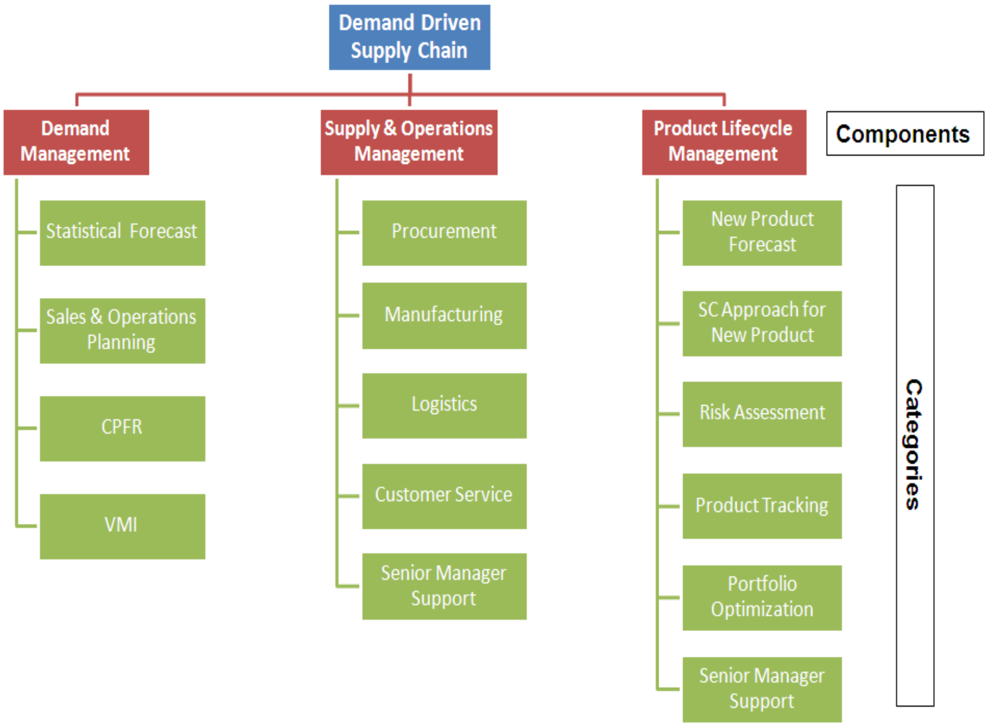


Figure 48 – Author's Hierarchy Structure for the Demand Driven Supply Chain Model

The second step consists of calculating the weights for components and categories. To that end, the author proposes to apply the priority scale developed by Saaty (1980) which follows the structure in table 19:

1) Priority Scale to be used when Defining Weights:		
Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Two components / categories have the same importance
3	Slightly importance of one over another	Experience and judgment slightly favor one component / category over another
5	Strong importance	Experience and judgment strongly favor one component / category over another
7	Very strong importance	A component / category is favored very strongly over another
9	Extremely more important	A component / category is extremely more important over another
2, 4, 6, 8	Intermediate values	When compromise is needed adjacent scale values

Table 19 – Priority Scale for the Pair Wise Comparison of Components and Categories in the DDSC Model (Saaty, 1980)

For the pairwise comparison, it will be applied the approximation method developed by Wolff (2008), that proposes to compare only one alternative with all others instead of making pair wise comparisons for all alternatives with each other, which considerably reduces the understanding of the method and the work required from decision makers in developing the comparisons, as well as facilitates the calculations. This is a very important aspect for this work, as the methodology will be applied in different countries worldwide, and the easier the approach, the better it will run. The only requirement of the method is to select the strongest component or category, and uses it as the basis for comparisons with all others, as it will considerably reduce the probability of inconsistencies in the judgmental process. For more information about the approximation method, please refer to Wolff (2008).

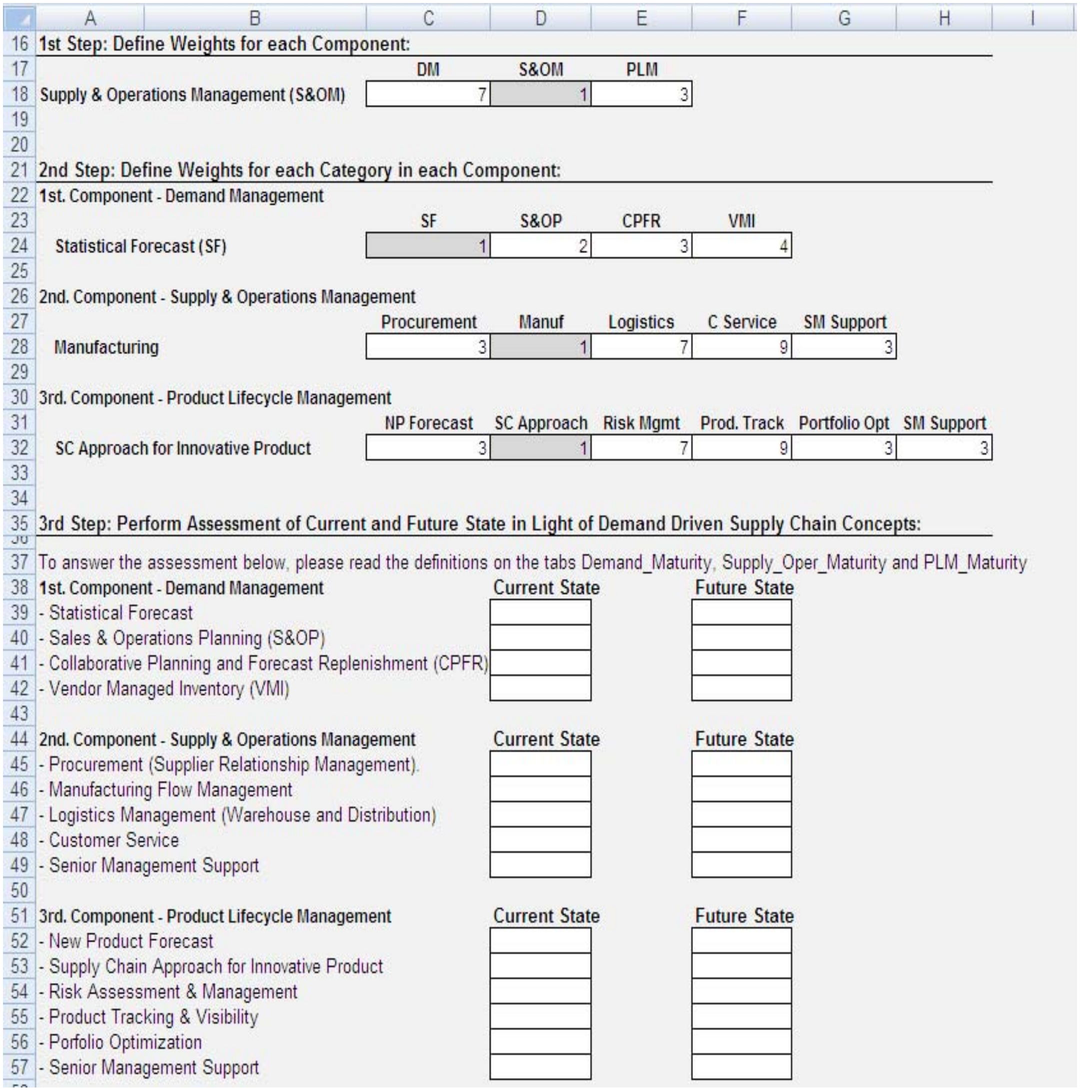
For this thesis, based on the author's experience of the industry where the validation study will be applied, it is proposed to consider the following as the basis for comparisons:

- Component:
  - Supply and Operations Management should be the basis due to its large impact in both cost and customer service.
- Categories:
  - For Demand Management, Statistical Forecast should be the basis due to the industry still applies the make to stock approach to optimize its asset base and reduce fixed cost.
  - For Supply and Operations Management, Manufacturing should be the basis due to the importance of having low cost associated with producing the products in order to be competitive in the market place.
  - For Product Lifecycle Management, Supply Chain Approach for Innovative Products should be the basis due to the strategy of launching new products in a fast pace to capture value and differentiate the company with customers and consumers.

The third step of the method consists of having supply chain directors identifying current and future states scores for their operations based on the definitions available in the maturity model which has 5 levels that were already described in section 6 of this thesis: Level 1 - Basic Push Operation, Level 2 - Optimized Push Operation, Level 3 - Hybrid Push - Pull Operation, Level 4 - Advanced Pull Operation, Level 5 - Optimized Pull Operation. For instance, if the SC director, after reading the maturity model, believes that his operation is still in level 1 for current state, he should enter number one into the respective field of current state in the spreadsheet.

It is important to highlight that it is not proposed in this study that all companies need to move to a high level 4 (advanced pull) or 5 (optimized pull) immediately, but instead, companies need to evaluate the competitiveness level of the marketplace where they operate, their organizational structure maturity, its supply chain complexity, which is aligned with the contingency theory described in the literature review done in chapter 2, and then, identify the next level to move that makes sense both from a financial and operational perspectives.

For implementing this approach, it was developed a standard spreadsheet that respondents just need to enter a few numbers and the spreadsheet provides the overall current and future states for one year horizon, based on the demand driven concepts, and also the individual scores for each category. The spreadsheet is illustrated in figures 49 and 50 below:



	A / B	C	D	E	F	G	H
16	1st Step: Define Weights for each Component:						
17		DM	S&OM	PLM			
18	Supply & Operations Management (S&OM)	7	1	3			
19							
20							
21	2nd Step: Define Weights for each Category in each Component:						
22	1st. Component - Demand Management						
23		SF	S&OP	CPFR	VMI		
24	Statistical Forecast (SF)	1	2	3	4		
25							
26	2nd. Component - Supply & Operations Management						
27		Procurement	Manuf	Logistics	C Service	SM Support	
28	Manufacturing	3	1	7	9	3	
29							
30	3rd. Component - Product Lifecycle Management						
31		NP Forecast	SC Approach	Risk Mgmt	Prod. Track	Portfolio Opt	SM Support
32	SC Approach for Innovative Product	3	1	7	9	3	3
33							
34							
35	3rd Step: Perform Assessment of Current and Future State in Light of Demand Driven Supply Chain Concepts:						
37	To answer the assessment below, please read the definitions on the tabs Demand_Maturity, Supply_Oper_Maturity and PLM_Maturity						
38	1st. Component - Demand Management		Current State		Future State		
39	- Statistical Forecast						
40	- Sales & Operations Planning (S&OP)						
41	- Collaborative Planning and Forecast Replenishment (CPFR)						
42	- Vendor Managed Inventory (VMI)						
43							
44	2nd. Component - Supply & Operations Management		Current State		Future State		
45	- Procurement (Supplier Relationship Management)						
46	- Manufacturing Flow Management						
47	- Logistics Management (Warehouse and Distribution)						
48	- Customer Service						
49	- Senior Management Support						
50							
51	3rd. Component - Product Lifecycle Management		Current State		Future State		
52	- New Product Forecast						
53	- Supply Chain Approach for Innovative Product						
54	- Risk Assessment & Management						
55	- Product Tracking & Visibility						
56	- Porfolio Optimization						
57	- Senior Management Support						

Figure 49 – Example of the Author's Spreadsheet to Input Answers

In the summary results spreadsheet showed in the example of figure 50, the supply chain director of the country under analysis can visualize the overall score result for his operation, as well as, the score results for each one of the 3 components of DDSC (e.g. Demand management, Supply & Operations management, and Product Lifecycle management).

In the specific example provided in figure 49, the overall score for the country is 1,48 , which is in the middle of a basic (level 1) to an optimized push level (level 2), and each component has the following scores: Demand management (2,0), Supply & Operations management (1,64) and Product Lifecycle management (1,22).

Demand Driven Supply Chain - Summary Results for CURRENT STATE

1. Demand Management		0,09		Current State	
Category	Weight within (1)	Overall Weight (2)	Score (3)	Score Within (1x3)	Overall Score (2x3)
Statistical Forecast	0,39	0,036	2	0,79	0,07
Sales & Operations Planning (S&OP)	0,08	0,007	2	0,16	0,01
Collaborative Planning (CPFR)	0,13	0,012	2	0,26	0,02
Vendor Managed Inventory (VMI)	0,39	0,036	2	0,79	0,07
Demand Management Score	1,00			2,00	0,18

2. Supply and Operations Management		0,45		Current State	
Category	Weight within (1)	Overall Weight (2)	Score (3)	Score Within (1x3)	Overall Score (2x3)
Procurement	0,12	0,054	2	0,24	0,11
Manufacturing	0,36	0,162	1	0,36	0,16
Logistics	0,12	0,054	2	0,24	0,11
Customer Service	0,05	0,023	2	0,10	0,05
Senior Management Support	0,36	0,162	2	0,71	0,32
Supply & Operations Management Score	1,00			1,64	0,75

3. Product Lifecycle Management		0,45		Current State	
Category	Weight within (1)	Overall Weight (2)	Score (3)	Score Within (1x3)	Overall Score (2x3)
New Product Forecast	0,05	0,022	1	0,05	0,02
Supply Chain Approach	0,33	0,151	1	0,33	0,15
Risk Assessment & Management	0,33	0,151	1	0,33	0,15
Product Tracking	0,07	0,030	1	0,07	0,03
Portfolio Optimization	0,11	0,050	2	0,22	0,10
Senior Management Support	0,11	0,050	2	0,22	0,10
Product Lifecycle Management	1,00			1,22	0,56

Score	Description
1	Level 1 (Basic Push Operation)
2	Level 2 (Optimized Push Oriented)
3	Level 3 (Hybrid Push-Pull Oriented)
4	Level 4 (Advanced Demand Driven - Pull)
5	Level 5 (Optimized Demand Driven)

Final Overall Score	1,48

Figure 50 – Spreadsheet with Example of Current State Scores