Multi-Criteria Analysis of Advanced Planning System Implementation

Claudemir L. Tramarico, Valério A. P. Salomon and Fernando A. S. Marins
São Paulo State University (UNESP)
Engineering School, Campus Guaratinguetá
Guaratinguetá, SP, 12516-410, Brazil
claudemir.leif@terra.com.br, salomon@feg.unesp.br, fmarins@feg.unesp.br

Abstract

The implementation of Advanced Planning Systems (APS) software may offers to Supply Chain Management (SCM) planning and optimization functionalities to industrial processes. A complete assessment of APS implementation should involve multiple criteria. Analytic Hierarchy Process (AHP) is worldwide multi-criteria analysis method. The Benefits, Opportunities, Costs, and Risks (BOCR) is a model developed from AHP theory. BOCR model allows a flexible analysis and potentially richer as opposed to only costs and benefits analysis. For APS implementation benefits are regarding to customer services, internal business processes and modular architecture issues; Opportunities relates to flexibility in adapting to changes, errors reducing, innovation and learning; Costs relates to project on budget, project on time and SCM costs; and Risks are associated with data, process, and user fit. The objective in this paper is to present a model for the assessment of APS implementation

Keywords: Advanced Planning System, Analytic Hierarchy Process, Supply Chain Management

1. Introduction

Advanced Planning Systems (APS) has gained relevance and attention from the academic and practitioner communities over the past decade. The acronym APS involves some synonyms such as “Advanced Planning and Scheduling”, “Advanced Production System” and “Advanced Planning System” (Pittman and Atwater, 2016). In practice, is a computational system that uses advanced mathematical algorithms, or logic, to perform optimization or simulation on finite capacity scheduling, sourcing, capital planning, resource planning, forecasting and demand management.

APS enables companies to optimize plans according to financial, strategic objectives and create plans that meet multiple objectives (Vidoni and Vecchietti, 2015). On the other hand, in APS the planning functionality is radically improved over Enterprise Resource Planning (ERP), but it is essential for a good result that the user is familiar with the basics APS functionalities (Hvolby and Jensen, 2010).

The main question of this empirical research is: How to assess the implementation of APS? There are many problems related to the implementation of APS, such as project management, choice of modules and transition from “go live” to normal operation (Ivert and Jonsson, 2014).

Assess of APS implementation is about the quantitative and qualitative aspects and are based on multi-criteria. Multi-criteria decision-making, also known as MCDM, is essential in decision-making processes. Analytic Hierarchy Process (AHP) is a leading MCDM method with the large number of publications in international journals (Tramarico et al., 2015; Wallenius et al., 2008). The objective of this paper is to present a model for the assessment of APS implementation.

2. Literature review

The APS architecture is based on the principles of hierarchical planning that includes the business function: procurement, production, distribution, and sales. The modules consider long, mid, and short-term as the planning horizon (Fleischmann and Meyr, 2003). In Figure 1 APS exhibit a common framework, that includes the business function.

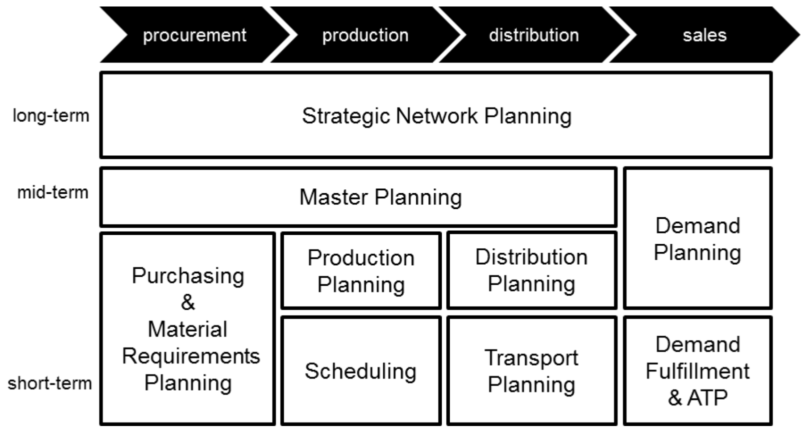

Figure 1. APS modules covering the SC planning framework (Fleischmann and Meyr, 2003)

The APS modules details are presented as (Pittman and Atwater, 2016; Stadtler, 2005, Fleischmann and Meyr, 2003):

- **Demand planning** – the process of combining statistical forecasting techniques and judgment to construct demand estimates for products or services both high and low volume, lumpy and continuous across the SC from the suppliers' raw materials to the consumer's needs.
- **Strategic network planning** – A planning interval of several years can be assumed when designing the structure of a SC. The location of production sites, warehouses, geographical customer areas to serve are laid out.
- **Master planning** – a group of business processes that includes the following activities: includes forecasting and order servicing, production and resource planning, and master scheduling.
- **Purchasing & material requirements planning** – master planning as well as short-term production planning and detailed scheduling provide directives for calculating procurement quantities to be planned within the module purchasing and material requirements planning.
- **Production planning and scheduling** – modules deal with lot sizing, machine assignment, scheduling and sequencing.
- **Distribution planning** – concerns the tactical constrains within the distribution system, such as the regular transport links, delivery areas, and allocation of sources.
- **Transport planning** – the function of planning, scheduling, and controlling activities related to mode, vendor, and movement of inventories into and out of an organization.
- **Demand fulfillment &ATP** – covers the arriving of customer orders, and comprises the tasks of order promising, availability of materials and due date setting.

3. Method

The foundations of the AHP include of the Fundamental Scale of Absolute Numbers (Saaty, 2010) to consult experts about the problems alternatives and criteria, generating a pairwise comparison matrix (***A***). In the sequence, using Linear Algebra concepts, as the eigenvector (***w***), and eigenvalue (λ_{max}), it is possible to get their relative priorities.

The Benefits, Opportunities, Costs and Risks (BOCR) model considers four types of merits or criteria proposed to represent the different clusters, which define the interactions with respect to the control hierarchy established, used in many decision-making problems where ***B*** is opposed to ***C***, while ***O*** is opposed to ***R***. ***B*** indicates the alternatives that produce the greatest benefit, ***O*** indicates opportunities, while ***C*** and ***R*** indicate alternatives with more costs or risk of each alternative (Saaty and Ozdemir, 2005).

One great advance in AHP practice is the "absolute measurement", also known as "ratings" (Saaty, 1986). In absolute measurement, alternatives are compared with standard levels, instead of pairwise comparisons. Relative measurement has been most applied than ratings, even the latter being present in software packages (Creative Decisions Foundation, 2017; Incorporated Expert Choice, 2017). Since in relative measurement alternatives must be pairwise compared, their number must be less-than or equal to nine, that is, "seven, plus or minus two" (Saaty and Ozdemir, 2003). In absolute measurement, there is no bound for the set of alternatives. Another advantage from using ratings is the opportunity to avoid biases. With alternatives being comparing each other, two by two (relative measurement), some historical trends could be kept in mind. Comparing alternatives with a standard (absolute measurement) seems to provide a less partial or unbiasedly measurement.

The AHP application can be summarized on few steps, including hierarchy construction, pairwise comparison, consistency verification, and results (De Felice and Petrillo, 2013).

4. Analysis of APS implementation

The research was conducted, by assessment sessions with experts, in a major chemical plant that belongs to a multinational group, located in the State of Sao Paulo, Brazil. The integrated planning approach, as demand planning, production planning & scheduling and strategic networking planning, i.e., the APS modules implemented by the researched company.

The objective of the proposed model is to analyze the APS implementation. The criteria were Benefits, Opportunities, Costs, and Risks. The sub-criteria were customer service (***B1***), internal business process (***B2***), modular architecture (***B3***), errors reducing (***O1***), flexibility in adapting to changes (***O2***), – innovation and learning (***O3***), project on budget (***C1***), project on time (***C2***), SCM costs (***C3***), data fit (***R1***), process fit (***R2***), and user fit (***R3***). Demand Planning, Strategic Networking Planning and Production Planning & Scheduling were the analyzed alternatives, i.e., the APS modules implemented by the plant that was the study object.

A typical decision problem requires us to choose the best solution with respect to a set of criteria. The hierarchy is constructed from the top down. The objective, criteria and sub-criteria were grouped, resulting in a hierarchy to analize APS implementation (Figure 2).

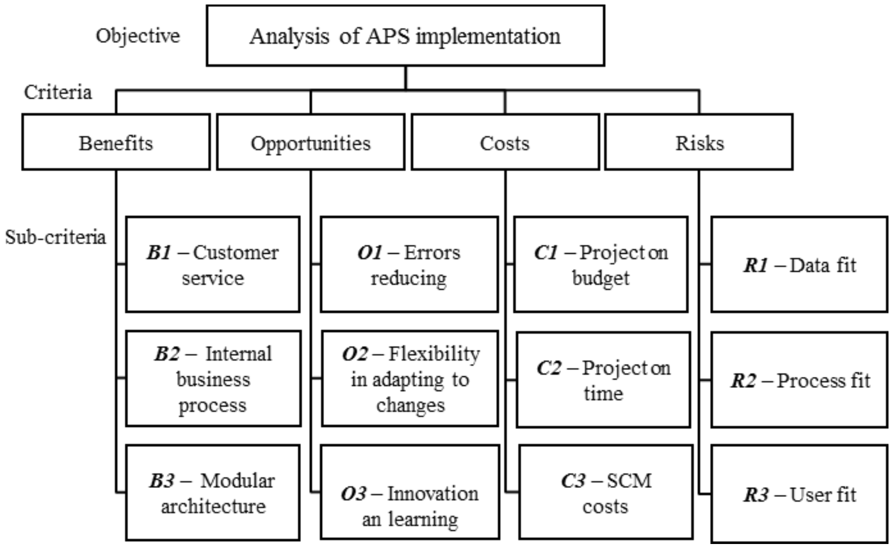

Figure 2. Hierarchy of APS implementation assessment

Local priorities for all attributes can be obtained normalizing the right eigenvector for the aggregated comparison matrices. After the achievement of all judgments for criteria and sub-criteria, the overall priorities were calculated by multiplying the priority values of each criterion by the sub-criteria weight, for instance: ***B1*** overall priority = 0.38 × 0.25 = 9%; ***B2*** overall priority = 0.11 × 0.25 =3%; ***B3*** overall priority = 0.51 × 0.25 = 13%; The same procedure was performed to ***O1***, ***O2***, ***O3***, ***C1***, ***C2***, ***C3***, ***R1***, ***R2***, and ***R3***. The overall priorities of performance attributes can be observed in Table 1.

Table 1. Overall priority

	Criteria and sub-criteria	Local priority	Overall priority
Benefits		**0.25**	**0.25**
	B1 – Customer service	0.38	0.09
	B2 – Internal business process	0.11	0.03
	B3 – Modular architecture	0.51	0.13
Opportunities		**0.25**	**0.25**
	O1 – Errors reducing	0.15	0.04
	O2 – Flexibility in adapting to changes	0.69	0.17
	O3 – Innovation an learning	0.16	0.04
Costs		**0.25**	**0.25**
	C1 – Project on budget	0.46	0.12
	C2 – Project on time	0.30	0.07
	C3 – SCM costs	0.24	0.06
Risks		**0.25**	**0.25**
	R1 – Data fit	0.20	0.05
	R2 – Process fit	0.60	0.15
	R3 – User fit	0.20	0.05

The absolute measurement is used to rank independent alternatives one at a time in terms of rating intensities for each of the criteria. The level of performance corresponding to the attributes in linguistic scales varies from "Poor" to "Excellent". The reason for the adoption of the absolute measurement is because it has the potential to significantly reduce conflicts in decision making processes (De Felice and Petrillo, 2013). Table 2 presents the intensity levels or the quality degrees set for the APS assessment alternatives.

Table 2. Absolute measurement

Level	Priority
L1 – Excellent	1
L2 – Very good	0.83
L3 – Good to very good	0.67
L4 – Good	0.50
L5 – Poor to good	0.25
L6 – Poor	0

The sub-criteria were pairwise compared, and the alternatives were rated. Ideal synthesis.

The results of the alternatives indicate "Very good" to ***B1***, ***B3***, ***O3***, ***C2*** and ***C3***, "Good" to ***B2*** and ***O2,*** "good to very good" to ***O1*** and ***R3,*** "Excellent" to ***O1, R1*** and ***R2*** for Demand Planning. Table 3 shows results for Strategic Networking Planning and Production Planning & Scheduling. The priorities for alternatives (Table 3) were added to aggregate the priorities summing quantitative performances weighted by overall priorities of sub-criteria.

Table 3. Quantitative performance

Alternative	***B1***	***B2***	***B3***	***O1***	***O2***	***O3***	***C1***	***C2***	***C3***	***R1***	***R2***	***R3***	Priority
	9%	**3%**	**13%**	**4%**	**17%**	**4%**	**12%**	**7%**	**6%**	**5%**	**15%**	**5%**	
Demand planning	0.83	0.50	0.83	0.67	0.50	0.83	1	0.83	0.83	1	1	0.67	**0.80**
Strategic networking planning	0.83	0.25	0.83	0.83	1	1	0.83	1	0.83	0.50	0.83	0.67	**0.84**
Production planning & scheduling	0.67	0.83	0.83	0.67	1	1	0.83	0.83	1	0.50	1	0.67	**0.86**

In results, the priorities for alternatives achieved 80% for Demand Planning, 84% for Strategic Networking Planning and 86% for Production Planning & Scheduling. These results were presented to the managers of the company, who validated them as consistent and feasible.

5. Conclusions

The aim of this paper was to assess the APS implementation considering BOCR. The proposed model and the results provided evidences of the APS implementation in a global chemical corporation. In this AHP application, absolute measurement was adopted instead of the original relative measurement: 6 percent points for Production Planning & Scheduling over Demand Planning and 2 percent points for Production Planning & Scheduling over Strategic Networking Planning. These findings evidenced the success of the APS implementation in the studied chemical plant.

Finally, by means a real application, this article has illustrated how an APS implementation assessment model should be applied to appraise implementation system. We believe to have made significant contributions to the APS literature. A new approach based on Analytic Network Process is suggested as a further research. Consider the existence of dependence and interrelations between alternatives and apply the Analytic Network Process (Saaty and Ozdemir, 2005).

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Biography

Claudemir L. Tramarico received his Bachelor in Mathematics and MSc in Production Engineering from Sao Paulo State University in 2012. He obtained his PhD in Engineering from Sao Paulo State University in 2016. His works have appeared in International Journal of Analytic Hierarchy Process, Journal of Cleaner Production, Procedia Computer Science and several Brazilian journals on industrial engineering. He is Master CPIM Recognized Instructor at APICS. Currently, develop a post-doctoral research at the Sao Paulo State University and working as a Supply Chain Education Consultant. He is member of APICS.

Valerio A. P. Salomon received his Bachelor and MSc in Industrial Engineering from the Federal University of Itajuba in 1994 and 1998. Subsequently, he obtained his PhD in Engineering from University of Sao Paulo in 2004 and developed a post-doctoral research at the University of Pittsburgh in 2007. Currently, he is working as an Associate Professor at the Department of Production at the Sao Paulo State University. His works have appeared in International Journal of Analytic Hierarchy Process, International Journal of Production Research, International Journal of Project Management, International Journal of Quality and Reliability Management, and several Brazilian journals on industrial engineering. His research area includes multi-criteria decision analysis, operations management and quality management.

Fernando A. S. Marins received his Bachelor from UNESP in 1976, the MSc in Operations Research from Technological Institute of Aeronautics in 1981, his PhD in Operations Research from University of Campinas in 1987 and developed a post-doctoral research at the Brunel University-London in 1994–1995. Currently, he is working as a Full Professor at the Department of Production at the Sao Paulo State University. His works have appeared in several international journals related to the areas of operations research, supply chain management and logistics, analytic hierarchy process, and production research, among others.