Paper from Proceeding of the National Conference on Innovative Developments in Science, Technology & Management (NCIDSTM-2015) Organized by Ganga Technical Campus, Soldha, Bahadurgarh, Haryana (India) March 1st 2015 Published by International Journal of Engineering Sciences Paradigms and Researches (IJESPR) with ISSN (Online): 2319-6564, Impact Factor: 2.20 and Website: www.ijesonline.com

Project Portfolio Management with Analytic Hierarchy Process in an Automotive Industry

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Abstract

The product development process is considered a strategic function for the organizations. In order to survive and be profitable in a competitive environment, companies adopt portfolio management. It is expected that an organization will be able to prior projects and make strategic decisions by using portfolio management methods. However, implementing those methods is considered one of the most important barriers for the companies since there is a gap between theory and practice. This paper presents results from a research developed in a multinational automotive company. The main objective of this research was to prioritize New Product Development projects. NPD projects prioritization is a Multiple Criteria Decision Making (MCDM) problem. Analytic Hierarchy Process was applied to solve this decision-making problem. Mathematical Modeling, a research method of qualitative strategy was initially adopted. This paper consists of an case study in one of the most important automotive companies.

Keywords: *Analytic Hierarchy Process, automotive industry, Multiple Criteria Decision Making, new product development(NPD).*

1. Introduction

The importance of New Product Development (NPD) has been significantly increased in the last years. Archer and Ghasemzadeh (1999) emphasized that there are usually more projects available for selection than can be undertaken within the physical and financial constraints of a firm. According to Cooper, Edgett and Kleinschmidt (2000), there are two ways for a business to succeed at NPD: doing projects right, or doing the right projects. Most of project management prescriptions follow the first way, what they call an "elusive goal". De Reyck et al. (2005) highlighted that the prioritization, alignment and selection of projects to compose a company's portfolio should ensure that all the areas of the organization's strategy are properly addressed.

This works presents results from a research developed in a multinational automotive company. Prioritize NPD projects was the main objective of the research. Priority of NPD projects is a Multiple Criteria Decision Making (MCDM) problem. Mathematical Modeling (ARIS, 1995) using Analytic Hierarchy Process (AHP) was used for this study. A mixed quantitative-qualitative strategy was followed and concepts of Case Study were included in the research.

2. Theoretical Concepts

2.1. New Product Development Projects

New products are resulted from projects performed by a firm aiming competitive advantage. The main requirement to assure this advantage is the development of a product which features satisfy customers' needs and expectations. NPD implies to the organization in the innovation promoting and Research & Development (R&D) investing to create radically new concepts. This is as a key requirement for business success [4]. Firms that consistently define, resource and execute NPD projects significantly more effectively and efficiently than their competitors are rewarded by significant strategic advantage [20].

A project portfolio is a group of projects that are carried out under the sponsorship or management of a particular organization [1]. NPD prioritization is a stage of Project Portfolio Management. This stage enhances company to concentrate in fewer but more worthwhile projects [6]. In Project Portfolio Management, projects are often scored according to financial indicators, success probability, and alignment with business's objectives. These scores are provided by experts, but, some difficulties were often faced, as, for instance, conflicting criteria consideration, uncertainty or risk in the available data, and a great number of feasible projects to prioritize.

Priority of NPD projects is a Multi-Criteria Decision Making (MCDM) problem and reasons of the choice for AHP include the availability of a web-software to its application. The use of this platform facilitate the decision making process.

2.2. Analytic Hierarchy Process

A fundamental aspect of the AHP is making paired comparisons of homogeneous activities or items (SAATY, 2010b). This aspect implies in the first limitation of AHP to solve the NPD projects priority problem. That is, the NPD projects have to be homogenous. If there are one or more projects clearly better than other projects, according to diverse and important criteria, the AHP may not be directly applied. The sets of projects must be divided in two or more sets, and then, the AHP could be used to prioritize the projects inside the sets. Independency among the NPD projects is other limitation of AHP application. That is, the choice for a project must not cause any impact in the choice for another project.

Another interesting aspect for AHP application is the **pair wise** comparisons number. The AHP application considering nine criteria and five alternatives will need 190 comparisons. A comparisons matrix needs $n(n-1)/2$ comparisons to be fully completed (SAATY, 2001). Incomplete Pairwise Comparisons (IPC) is an algorithm developed to reduce the comparisons number, allowing the group to focus on discussion rather than the laborious task of complete, in full, each comparisons matrix (HARKER, 1987). After n comparisons, the algorithm indicates what should be the next one. Or else, the decision maker is informed that the non provided comparisons will no longer change the priorities. IPC calculations are based in the graph-theoretic structure of the pairwise comparisons matrix and the gradient of its Right Eigenvector.

Despites its limitations, from the middle of the 1980s, AHP is the MCDM method with the highest number of scientific publications [19]. As major part of those works reports case studies, possibly, AHP has more real world applications than any other MCDM method. But, IPC was not widely applied as AHP. One reason may be the fact that, unlike AHP, there is no very well know software that facilitates IPC implementation. Usually, academic or commercial AHP software deals with the main principle of IPC: the reduction on the number of comparisons. That is, the software provides priorities for matrices with $(n-1)$ comparisons. But, there is no AHP software that performs IPC's next steps: to indicate if the comparisons could stop, or else, to indicate what comparison should be the next one.

A difficulty in group decision making is that the decision makers are frequently reluctant to reveal their true opinions[5]. So, commercial versions of AHP software can be applied with special hardware. The hardware allows some secret to group members, since they can make their comparisons and other members do not instantly know them, as it happens in an open session. But, the use of hardware has two disadvantages: the first one is the cost. The second disadvantage of using hardware is the need of putting all group members in a room to get simultaneous comparisons. This way, new versions of AHP software were developed aiming the use of Internet to reduce these disadvantages. These are the web-based versions of AHP software.

There are several possibilities to aggregate the pairwise comparisons individually provided by a group. One is aggregating each comparison provided by the group member into aggregated comparisons matrices. Another possibility is aggregating the overall priorities of the alternatives from each group member into an aggregated vector of priorities. The first procedure is the indicated one when the group members. This procedure is commonly referred as Aggregation of Individual Judgments (AIJ).

3. AHP application

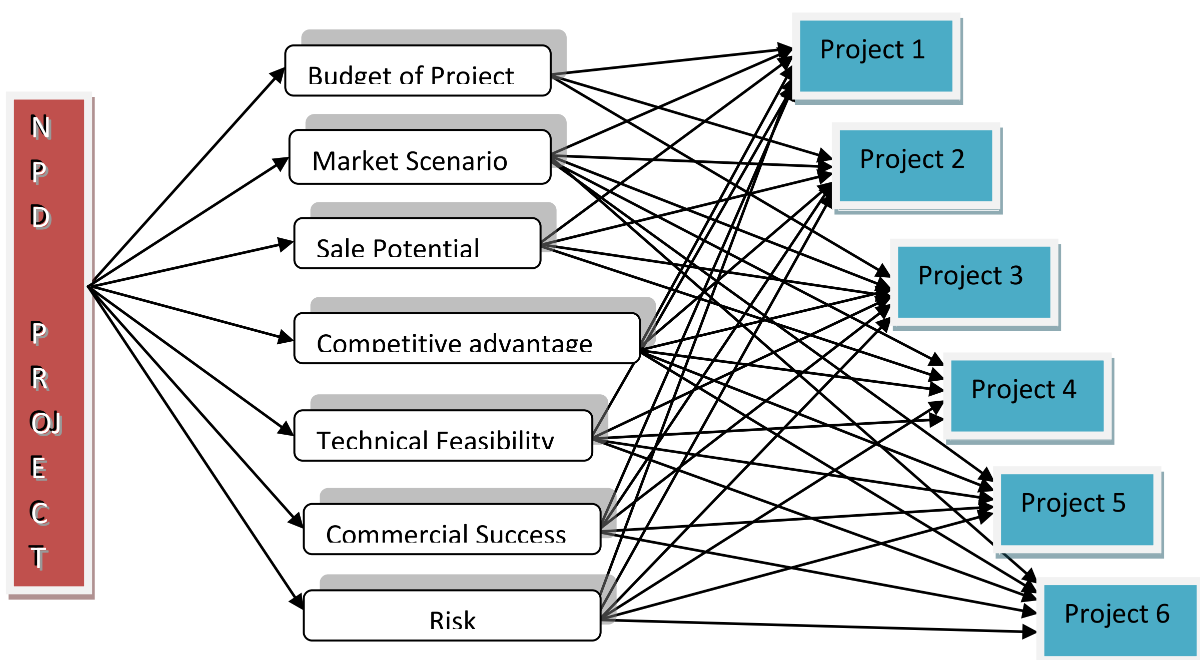
These work reports results from a research developed at an automotive production plant located in india. This plant is one of 10 units of a multinational group, having more than

5000 employees It is one of the 30 largest precision components suppliers worldwide.

According to procedures for the whole group, R&D projects must be analyzed on seven criteria: Budget (amount of money to be expended within the project), Sales Potential (based on volume and price, for the next 3 years), Market Trend (based on industry trends, customer surveys, and government policies), Competitive Advantage (compared to benchmark competitors), Technical Success (possibility of the project result in a good product), Commercial Success (possibility of the new product to be sold with profit), Risk (degree of difficulty).

Three company managers of the Plant were considered as experts to provide these comparisons. Expert 1 was the Plant's Design and Development having experience of 10 years in the same type of industry. Expert 2 was a Senior Process Planning Manager. He has worked in the Plant since 2001. Expert 3 was the Quality Dy. Manager of the Plant. He has worked for the group for 20 years. Expert 1 was responsible for planning and implementation of several R&D projects. All experts had basic knowledge in AHP. So, a web-based version of AHP software was considered as a suitable tool to facilitate the pairwise comparisons collection from the experts.

Figure 1 presents the hierarchical structure for the NPD projects prioritization. With seven criteria and six alternatives, 126 pairwise comparisons would be necessary to fulfilled eight matrices, from every expert.



An academic version of web-based AHP software was used to make the data collection and processing. After input of the hierarchical structure in the software, the experts were defined as evaluators. Then, message to each expert was given with short instructions to access and input their opinions in the website. The experts were also personally contacted and informed on the research's objectives. This version of AHP software deals with the main principle of IPC: the reduction on the number of comparisons. By default, this software only asks the comparisons from two diagonals above the main diagonal of a comparisons matrix, as presented in Table 2.

It can be observed that for the 7 criteria it would be necessary 21 comparisons. But, the software only asked 11 comparisons. For the whole hierarchy only 74 comparisons were made by every expert.

Tables 3 to 5 present the comparisons among the criteria, provided by Experts 1 to 3, respectively. The experts were considered as equally important. That is, the comparisons had the same weight when aggregated. The whole data collection spends less than one month.

Table 6 presents the vectors of overall priorities obtained from the comparisons provided by the experts. This table also presents two other vectors: the one obtained with AIJ (provided by the software) and another obtained with the arithmetical mean of individual priorities. It can be seen, in this case, that Project 2 would be the Priority 1 project, no matter the aggregation way was the followed one.

The software provided additional analysis, as the Sensitivity Analysis or the Concordance Degree on the input data. But, the experts, and this work's co-authors, including two workers on the MG Plant, were very satisfied with the prioritization.

Table 1. NPD projects in Design and Development

Project	Name	Critical Description and Application
1	Development of Cam Rear Brake	Forging of product in split forging machine, Serrations are critical To be used in braking system of two wheeler
2	Self Tapping Screws	Clamp Load Analysis SAE 1010 Low Carbon Steel For low alloy and plastic application
3	Titanium Alloy Fasteners	High strength to Weight ratio with fatigue strength To modern engines of low friction and high resistance for Aviation Engines.
4	Heat Resistant Components	High Tensile and Steel Rupture Properties Hot Forging, INCONEL 718 alloys Used for Aviation Engines
5	Drive Shaft for 4 wheeler	Close Tolerance and Grinding 10 microns For engines, case hardening, SCM-415 steel
6	Connecting Rod Bolts	Cyclic Loading Automotive Engine Application for 4 Wheelers

Table 2. Order of collect the comparisons from experts.

	C1	C2	C3	C4	C5	C6	C7
Budget of the project (C1)	1	1	7th	-	-	-	-
Market Scenario (C2)	-	1	2nd	8th	-	-	-
Expected sales (C3)	-	-	1	3rd	9th	-	-
Competitive advantage (C4)	-	-	-	1	4th	10th	-
Technical feasibility (C5)	-	-	-	-	1	5th	11th
Commercial success (C6)	-	-	-	-	-	1	6th
Risk (C7)	-	-	-	-	-	-	1

Table 3. Comparisons from Expert 1 on the criteria to prioritize NPD projects.

	C1	C2	C3	C4	C5	C6	C7	Weight (%)
Budget (C1)	1	1/6	7	-	-	-	-	11
Sales potential (C2)	-	1	6	6	-	-	-	27
Market trend (C3)	-	-	1	4	1/6	-	-	6
Competitive advantage (C4)	-	-	-	1	7	1/6	-	9
Technical success (C5)	-	-	-	-	1	1/7	1/6	7
Commercial success (C6)	-	-	-	-	-	1	7	30
Risk (C7)	-	-	-	-	-	-	1	10

Table 4. Comparisons from Expert 2 on the criteria to prioritize NPD projects.

	C1	C2	C3	C4	C5	C6	C7	Weight (%)
Budget of the project (C1)	1	1/8	1/8	-	-	-	-	2
Market Scenario (C2)	-	1	1/2	1/2	-	-	-	14
Expected sales (C3)	-	-	1	1/2	3	-	-	24
Competitive advantage (C4)	-	-	-	1	4	2	-	35
Technical feasibility (C5)	-	-	-	-	1	3	5	13
Commercial success (C6)	-	-	-	-	-	1	5	10
Risk (C7)	-	-	-	-	-	-	1	2

Table 5. Comparisons from Expert 3 on the criteria to prioritize NPD projects.

	C1	C2	C3	C4	C5	C6	C7	Weight (%)
Budget of the project (C1)	1	1/5	1/3	-	-	-	-	2
Market Scenario (C2)	-	1	4	1	-	-	-	18
Expected sales (C3)	-	-	1	1/5	1/3	-	-	5
Competitive advantage (C4)	-	-	-	1	4	4	-	25
Technical feasibility (C5)	-	-	-	-	1	4	1/4	11
Commercial success (C6)	-	-	-	-	-	1	7	4
Risk (C7)	-	-	-	-	-	-	1	35

Table 6. Comparisons from Expert 3 on the criteria to prioritize NPD projects.

	Expert 1 (%)	Expert 2 (%)	Expert 3 (%)	AIJ (%)	AMP (%)
Project 1	23	14	16	16	18
Project 2	17	23	22	20	21
Project 3	12	18	16	16	15
Project 4	19	18	14	16	17
Project 5	15	11	17	15	14
Project 6	14	16	15	17	15

AIJ = Aggregation of Individual Judgments, AMP = Arithmetical Mean of Priorities.

Table 7. Vectors of overall priorities.

	C1	C2	C3	C4	C5	C6	C7	Weight (%)
Budget (C1)	1	1/6	7	-	-	-	-	12
Sales potential (C2)	-	1	6	6	-	-	-	26
Market trend (C3)	-	-	1	4	1/6	-	-	8
Competitive advantage (C4)	-	-	-	1	7	1/6	-	9
Technical success (C5)	-	-	-	-	1	1/7	1/6	7
Commercial success (C6)	-	-	-	-	-	1	7	30
Risk (C7)	-	-	-	-	-	-	1	10

4. Conclusions

This work presented a group decision making in the prioritization of NPD projects in a multinational automotive company. A web-based version of AHP software was used. This software aids the efficiency and effectiveness of AHP application. That is, reducing the number of pairwise comparisons from 126 to 74, was an important factor to obtain confident data, in only one month. More important than that, the results from data processed with AHP theory was validated by the company.

The use of only three experts was not a software limitation. They were considered as the most important people to be heard, at that moment. The criteria used in the MCDM were provided by an internal procedure by the automotive company. Meanwhile, these criteria can be adopted for the prioritization of NPD projects by diverse companies.

The academic version of web based AHP software shows as a very useful tool. That is, it was well succeeded for the research proposal reposted in this work. This way, company considers acquiring a commercial license of the software. But, this decision must be subjected to future work.

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