AHP and INNOVATION STRATEGY as PROJECT PORTFOLIO MANAGEMENT

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Sajjad Khaksari, Politecnico di Torino, March 2017

ABSTRACT

The following technical report with some improvement describes the "chapter 9" of the project called: "Strategic Management of Technological Innovation Concerning The Battery Electric Vehicles (BEV). The "Chapter 9" [1] agglutinates all chapters of "case 4" in which the BEV project introduces a real company case study (Workhorse Group Inc.). Chapter 9 takes performances of Analytic Hierarchy Process (AHP) method which has developed by professor Thomas L. Saaty in the 1970s. Also, the following report proposes to contribute an optimizing decision-making framework for some authentic Multiple-Criteria Decision-Making (MCDM) circumstances.

Furthermore, the "supplementary resources" are available in the attachment of the Battery Electric Vehicles project. Remark that the "_sdmod" stands for the formats of "SuperDecisions Software". The "_sdmod" formats adopted in "part c" of the project concerning the definition of AHP Tree and the related arguments regarding the Innovation Strategy as Project Portfolio Management (PPM). Also, the "PPM-F.xls" file format includes the "Solver" and the results of "part a" and "part b".

PART A - CATEGORIZE THE R&D

The "part a" began with introducing the Workhorse case study and some questions base on the available information. Questions require researchers to categorize the Workhorse R&D segments and try to organize their innovation activities. Also, the section asks a question concerning the dimension of the appropriate projects to set the differences among those innovative projects. Besides, the "part a" requires an applied research and a basic financial analysis among the mentioned projects portfolio. Finally, the "part a" of the research asks to distinguish between the platforms, products, and customized project requirements. However, the henceforth part of following technical report is based on the information available on Workhorse Group Inc. website [2] and the FORM 10-K [3] of the UNITED STATES, SECURITIES AND EXCHANGE COMMISSION Washington, D.C. 20549, December 2015. Also, in this part the market researchers try to categorize the Workhorse R&D and its innovation activities (Fig. 9.1).

WORKHORSE GROUP INC. R&D ORGANIZATION

Financing Conditions

<table>
<thead>
<tr>
<th>Workhorse Inc.</th>
<th>Project Portfolio</th>
</tr>
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<tbody>
<tr>
<td>Workhorse Inc. as a national Ohio-based company</td>
<td>Workhorse R&amp;D and innovation activities</td>
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</tbody>
</table>

Fig. 9.1: Workhorse Group Inc. R&D Organization

In addition, the Excel file (PPM-F.xls) available in attachment illustrates the Workhorse Inc. financing condition and monitoring its core or implemented research approach, between Workhorse Inc. project responsibilities (see Fig. 9.3 and Fig. 9.4).

PART B - NEXT GENERATION PROJECT

The "part b" works amid introducing the interest of the Amedeo family (fiction name) to evaluate the Workhorse’s R&D projects, based on real data. In appropriate, they desire to examine and assess the development activities of latest versions of two leading Workhorse product the "lines A and B". The Fig. 9.2 outlines the project portfolio while the projects A1, A2, A3, B1 and B2 are platform project, and they possess a "Next Generation Project" (A#.1 or B#.2). Ordinarily, the 45 Full-Time Equivalent (FTE) resources are available for the R&D activities, and resources can be increased up to 10% by using external resources at an additional cost of approximately four (4) k€ per man/month.

Also, "part b" ponders on the project portfolio shown in Fig. 9.2, concerning the two products A and B by analyzing and computing the Expected Commercial Value (ECV) and the Productivity Index (PI) indicators for each project. Besides, it tries to find out a succinct graphical representation for the portfolio such as bubble charts, pie charts, resource workload charts by employing the appropriate variables. In addition, "part b" attempts to optimize the Workhorse project portfolio with a math programming model utilizing the Excel Solver. The Objective Functions might maximize the ECV of selected projects and minimize the cost of overtime. Recognizing that the Resource Capacity Constraints requirement includes the possibility of using overtime human resources. Furthermore, by constraining the Next Generation Projects, those tasks can not be activated if in the previous year of the corresponding new product has not been launched.

Another challenge occurs when the designers investigate to take out those constraints and recount the optimal solutions. Do the results change? If yes, in what terms might be considered a value of the new product development for the projects? Also, extra difficulty transpires during the evaluation of new profitability regarding the immediate termination of the product A. The question is what the financial consequences would be?

PART C - AHP TREE AND CRITERIA STRATEGIC ALIGNMENT

The "part c" defines an AHP Tree to illustrate the Criteria Strategic Alignment into the company objectives (see Fig. 9.5). In this recent part, the crucial challenge is how the circumstances might be modified if the enterprise business strategy distinguished as a "Definitely Cost Oriented" strategy?
The decision making in a complex environment is an extremely complex issue specially when distress is genuine and mis-designing might generate financial collapses, human resource opposes, and environmental damages. In that complex, knotty, and complicated condition, the Analytic Hierarchy Process (AHP) [4] for Decision Making and the Analytic Network Process (ANP) [5] might assist project managers to optimize their decisions. The Analytic Network Process (ANP) is the most comprehensive framework for the analysis of societal, governmental, and corporate decisions that is available to the decision-maker.

AHP and ANP methods allow analyzers to include all the factors and criteria, tangible and intangible that have bearing on making the best decision. In fact, Analytic Hierarchy Process (AHP) is a decision-making framework used for Multiple-criteria decision-making (MCDM) [6] which is a sub-discipline of operations research because explicitly estimates multiple conflicting criteria in decision making.

Therefore, the AHP is a structured technique for organizing and analyzing complicated decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s [7] and has been extensively studied and refined since then [8]. In addition, Thomas L. Saaty supervised the Super Decisions software that implements the ANP for decision making [9] in networks and makes it available free to researchers and educators at www.superdecisions.com [10]. Also, in the section of “Sample Models”, from the SuperDecisions website, examples of some models developed with the SuperDecisions software are available and organized by model type and by subjects. Extending into the sub-subject of the “Automobile industry” [11] some interesting cases are developed concerning the Ford Explorer Decision, Porsche SUV Decision, and Alternative Fuel.

They as other pathfinder companies, regularly face the remarkably complex problems concerning the ordering schedules and prioritizing the various strategic or innovative decisions (Multi-decisions) [12]. The structure of case demonstrates the strategic criteria concerning the Project Portfolio Management (PPM) deal with Amedeo’s family dilemmas. The following AHP structure provides the case judgement based on the basic information, knowledge, pairwise comparison, and reasons to derive the position of priorities to which the company aspire to allocate and spread their efforts and their enterprise resources. Although the Amedeo’s family as many other pioneer companies are not as thrilled about the old technologies in vehicle industry because of their looking forward customer’s needs and because of their market competency forecasting system.

The critical various criteria such as Product Design, Financial Factors (ECV, PI, NPV), Forecasting the future Marketshare, Technical or Financial Risks, and after all the Resource Commitments. In that striking critical circumstances, the AHP method might assist the companies to reduce significantly their frustration of lost and help them to increase their profits (as a strategic goal). The AHP technique and the SuperDecisions demands users to introduce three (3) fundamental CLUSTERS concerning Goal, Criteria, and implemented Alternatives.

The following Fig. 9.6 illustrates the screenshot of Main Network window from the AHP for Workhorse Inc. case study in environment of SuperDecisions V3.0 [14]. Also, Fig. 9.6 includes the three (3) mentioned above clusters and the complete implementation of the project. As mentioned previously in abstract the supplementary resource file format called “AHP Workhorse.smmd” is available in the attachment of the BEV [15] project. Notice that the “.smmd” stands for the SuperDecisions file format. The Fig. 9.6 shows the GOAL CLUSTER including its “1Goal Node” and its four (4) strategic criteria: RISK, CONTRIBUTION, COSTS, and PROFIT (Summed up according to Fig. 9.5). The full criteria for the projects simplified in these only four roots. However that is evident these criteria have some sub-criteria such as Planned Costs, Sunk Costs, and Cost to Production concerning COST node. Putting sub-criteria into a hierarchical model might improve its accuracy, and it can improve the syntonization and sensitization of results.

Belatedly, the third CLUSTER includes all available alternative projects: A1, A1.1, A2, A2.1, A3, B1, B1.1, B2 and B2.1 (according to Fig. 9.5). Once analyzer arranges the clusters, and he/she obtained their associated nodes, that is time to “Select parent (from) node’s and connect them to the “Child (to) cluster’s. These parents nodes and their child windows are shown in left side of Fig. 9.6. Then by clicking on the “1Goal Node” analyzer can select the criteria and by clicking on the Judgments tabs, that might be possible to enter in assessments mode where making the pairwise comparisons is predicted. (see Fig. 9.7)

Then by performing the same assessment progress for other clusters and nodes, the AHP network will be complete (see the Fig. 9.8). However, in this phase of the analyzing process, the comparison network of the project optimization would be possible.

Nevertheless, besides of pairwise comparison questionnaire mode, there are other four (4) possible modes for entering assessments: Graphical, Verbal, Matrix, and Direct. The Fig. 9.9 illustrates the screenshot of the “Matrix Mode” concerning the “1Goal Node” while the direction of the arrow indicates the criterion in which the mentioned criteria is more important (e.g. PROFIT is further preferable than COST). Additionally, the change of the dominant elements is possible by double-click on their relative arrows.

Ultimately, by click and mark the judgments set as a “Completed Comparison”, since the nodes are connected, the concluding result of “Inconsistency” will be reliable (Fig. 9.10). The Results revealed that the “CONTRIBUTION” or the “Competency” of the Project. Also, results determined the profitability (ECV, NPV, and PI) of both distinguished preferable nodes are connected, the concluding result of “Inconsistency” will be reliable (Fig. 9.10). © Sajjad Khaksari (2017) - Torino
Furthermore, the snap "Inconsistency Report" would be available by clicking on the "Computing" tab where the Fig. 9.11 illustrates the results concerning the criteria nodes. The second cell of Fig. 9.11, COST versus PROFIT (in red color), has a "Current Value" of 8.000000. It means that the "PROFIT"s are more important than "COST"s [see the Fig. 9.9 as the previous view of Matrix Mode, where the red arrow indicates the PROFIT].

By the way, this important topic resembles to be reasonable, since the incubators are usually eager to financially invest in R&D activity of the new products (or new technology) whenever those innovative outcomes might increase their profit. However, the Best Value of 3.626568 (in red color as well) indicates the optimization because of the other criteria judgments. For example, the "COST" should be a bit less preferable than the "PROFIT", and if analyzers revise the corresponding judgment to a red judgment of 3.626568, the "New Inconsistency" value would be 0.053830. This is a suggestion of SuperDecisions software that seems reasonable as well because practically when the Planned Costs, Sunk Costs, and Cost of Production in an innovative project increase so much, the probability of distant obtaining a fruitful and profitable project will decrease dramatically. After all, the desirable and feasible results might be illustrated by clicking and by ordering to synthesize the whole network. Fig. 9.12 revealed the overall synthesized priorities for the alternatives of AHP networks concerning the Workhorse Inc. projects. As respects, only the weight of B1 and B2.1 criterion is swayed the half of the entire evaluation [16]. Also, due to the fact that, the goal cluster was to increase the Profit and decrease the failure, the product line B has considered as the top ranked alternative.

Fig. 9.10: Oriented Results

By the way, this important topic resembles to be reasonable, since the incubators are usually eager to financially invest in R&D activity of the new products (or new technology) whenever those innovative outcomes might increase their profit. However, the Best Value of 3.626568 (in red color as well) indicates the optimization because of the other criteria judgments. For example, the "COST" should be a bit less preferable than the "PROFIT", and if analyzers revise the corresponding judgment to a red judgment of 3.626568, the "New Inconsistency" value would be 0.053830. This is a suggestion of SuperDecisions software that seems reasonable as well because practically when the Planned Costs, Sunk Costs, and Cost of Production in an innovative project increase so much, the probability of distant obtaining a fruitful and profitable project will decrease dramatically. After all, the desirable and feasible results might be illustrated by clicking and by ordering to synthesize the whole network. Fig. 9.12 revealed the overall synthesized priorities for the alternatives of AHP networks concerning the Workhorse Inc. projects. As respects, only the weight of B1 and B2.1 criterion is swayed the half of the entire evaluation [16]. Also, due to the fact that, the goal cluster was to increase the Profit and decrease the failure, the product line B has considered as the top ranked alternative.

Fig. 9.11: Inconsistency Report

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Fig. 9.12: Overall Synthesized Priorities For The Alternatives & Ideals, Normals, And Raw

Before the conclusion of this paper, it is imperative to mention that the SuperDecisions software is puissant enough to offer a "Graphical Sensitivity" [17] of the "AHP network". The software would help users to create a graphical sensitivity. Also, users are able to select the "Computations" and then "Sensitivity" command. Moreover, by selecting the "Edit" pop-up window, and by determining the Independent Variable (that is possible to take to the Sensitivity input selector box), and users might change the "Independent Variable" into their Goals. In fact, Fig. 9.13 illustrates the Sensitivity Analysis of the Workhorse Inc. AHP model for the main network.

Fig. 9.13: Sensitivity Analysis

Indeed, in Sensitivity Analysis’ output, the products from line B (B1 orange color, and B2.1 pink color) are graphically communicated as two top-rated project alternatives. The graphical representation of Sensitivity is available in other four different modes such as Plot, Piechart, Horizontal Bar-chart, and Bar-chart (Fig. 9.14, Fig. 9.15, Fig. 9.16, and Fig. 9.17).

FURTHER READING AND BWM

Recollect that for further research and for reading more concerning the classifications and relative computations, the "sdmod" SuperDecisions file and the Excel file regarding this article is available in BEV attachments. Also for additional reading, besides the AHP as a multi-criteria decision-making (MCDM) problem solver, the author recommends researchers those are interested in MCDM investigations to read the Jafar Rezaei (2015), Best-worst multi-criteria decision-making method, Elsevier B.V. ScienceDirect, Omega, Volume 53, June 2015 [18][19]. The Best-Worst Method (BWM) is a new proposed method to solve the multi-criteria decision-making (MCDM) problems. The BWM aims to solve MCDM problems according to the best (e.g. most desirable, most important) [20] and the worst (e.g. least desirable, least important) criteria those initially identified by the decision-maker. Furthermore, pairwise comparisons are then conducted between each of those two criteria (Best and Worst) and the other criteria while a maximin problem is expressed and solved to determine the weights of different criteria.

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APPENDIX I

Fig. 9.14: Sensitivity Analysis Plot

Fig. 9.15: Sensitivity Analysis Piechart

Fig. 9.16: Horizontal Bar-Chart

Fig. 9.17: Sensitivity Analysis Bar-Chart
REFERENCES


[4] The analytic hierarchy process (AHP)


[6] Multiple-criteria decision-making (MCDM)


[16] B1 criterion + B2.1 criterion = 0.196706 + 0.279488 = 0.476194


[18] Dr. J. Jafar (Zahraei) - TU Delft, Transport and Logistics Group.


