Applying AHP technique *to choose Product Type in Paper factories*

M. Solemani Diarjan[1], Dr. Majid Azizi [2], **

1. Master Science Degree Student of Department of wood & paper sciences and industries, Faculty of Natural Resources College of Agriculture and Natural Resources, University of Tehran, email: solemani.diarjan@ut.ac.ir

2. Professor at Department of wood & paper sciences and industries, Faculty of Natural Resources, College of Agriculture and Natural Resources, University of Tehran, Email: mazizi@ut.ac.ir, Website: http://can.ut.ac.ir/member/azizi.aspx

Abstract

One of the substantial concerns of investor in the paper and cardboard industry in order to obtain maximum efficiency & profit is selecting the right product to manufacture, therefore this study carry on in Iran to avoid manufacturer to make wrong decision cause previously some investor in paper market failed just in case didn't let all major criteria to be considered.

To find out the best product for the paper and cardboard produce in a factory located in the center of Iran in the first stage we ask 20 experts in different filed of paper and cardboard participate in this survey and while we get all respond from them according to Delphi technique we summarize it, arrange second survey and collect all date and obtain all major criteria accepted by all participants.

Then in the second stage we design a AHP framework, ask 10 expert participate in the survey, while we get all respond from them and collect all the data according to the analytic hierarchy process (AHP) technique and usage of Expert choice software by pairwise comparison of each criteria and obtaining the weight of each alternative and analyzing all data we obtain the most profitable alternative to produce to gain most possible profit for the investor.

1-Introduction

Artisans or investor need to spend lots of money to set up a production line but it's really hard to make the decision manufacture what kind of product, surely we have already study market and gets guide from different expert but not all the same. We get different idea. It's too risky to follow one expert idea. If its wrong decision, we may lose lots of investment.

The goal is to manufacture the kind of cellulose product to have the most possible profit to promote our success.

The problem is designing the paper production line, construction of the infrastructure of the paper and cardboard production line, Manufacturing pulping and paper machinery, and as well as the installation of related auxiliary machinery takes a long time at a high cost which not easily to modify if we want to change the product type.

Our scenario is firstly by using Delphi method we obtain all major criteria from expert with different point of view such as sales manager, production manager to ensure all major criteria to be consider and improve the study accuracy and then we use the result to design new survey according to AHP method, the final result will be use in Expert Choice software to pave the way to make the judgment.

2- Literature review

Nowadays paper and cardboard project is so costly; an investor should know all the criteria such as competitors, material cost, market demand, available share market, energy consumption, energy cost, availability of raw material & etc. It's important for investor to consider all criteria, major criteria that have the most affection on selecting a product. Thanks to the Delphi method, which can obtain all major criteria or even major alternatives after 2-3 rounds of the survey, the major criteria that have the most affecting in making a decision.
Weight of each criterion can be concluded from the paired comparison between the criteria using the AHP method, which represents the importance of criteria, (Banaeian, Nielson, 2015)

The AHP for decision-making is a theory of relative measurement based on paired comparisons used to derive normalized absolute scales of numbers whose elements are then used as priorities (Saaty, 2000). AHP method is a solution for comparison and rated major criteria against each other, by this way we got each criterion a score from participation in our survey.

We compare each pair of alternative with respect to each criterion. In comparing the two alternatives, we asked which alternative decision-making team preferred with respect to each of the main criterion in level 2 (Ozden Bayazit, 2005).

Many experts are invited to grade the impact of all indicators on the target. Experts can give evaluating information on the importance of the indicators according to their own professional knowledge and experience (Chong Wu, 2019). Once again, we obtain a score for all major criteria from different points of view of an expert who has enough knowledge about paper and cardboard industries but in different filed like sales manager of paperboard and production manager, CEO, etc. Unfortunately, previously make decision of what kind of paper product to make didn't assume seriously and mostly done as a traditional way or just consider some general criteria and not enough frame work offer to investor as a source of making decision to manufacture a product.

3-Hypotheses/ Objectives

As the investor need to be assure of the right decision, in this research we design a framework to propose important & practical way to ensure the right decision making.
3-1 Major Criteria:

3-1-1 General criteria: some criteria are essential and obvious that have most affection so we prepare a questionnaire indicated them and let the expert modify it by giving score to each criteria the while we analyze the result if all expert have same opinion we add or omit the criteria otherwise we indicate in the second round to get the idea of the rest of survey team.

3-1-2 Major Criteria: in final round of Delphi survey, by collecting the data from previous survey we design final survey and let all data to be finalized by all expert to obtain all major criteria that are accepted by survey team.

3-1-3 Major alternatives: we indicate almost all alternatives in the first survey and let the expert deciding which product is not worth to manufacture by giving its score and we do

same by analyzing the result to obtain final alternatives which all expert agree on it in final survey.

3-2 The most profitable product:

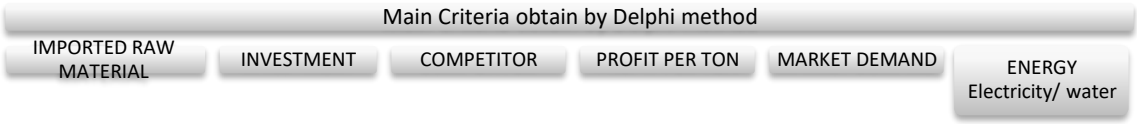
Analytic hierarchy process (AHP) technique is the tool which makes a bridge between alternatives, criteria and makes a judgment on which alternative is the best to select. We may not see the calculation while we use Expert Choice software. Without AHP techniques may increase the risks and mistakes as we could not consider all criteria and do not obtain its weight in each alternative.

4- Research Design/ Methodology

we design a procedure and framework to select the best Cellules product among the alternatives by using Delphi method and AHP technique.

4-1 Delphi method

4-1-1 Major criteria: we design a questionnaire with some primary criteria, in the first round of survey, the expert modify it by giving low score to worthless criteria and giving high score to important ones, after collect the result of survey and analyze and modify it we design second questionnaire and let the all expert see the result of first survey, we continue the survey till all criteria accepted by all expert as major criteria, in the survey we find out expert believe in electrical energy consumption should be consider while fuel consumption is not important as the gas is cheap in the region and not too much difference consumption in different type of product,



4-1-2 Alternatives: So then we do the same for the alternative to find the range of product that appropriate in Iran market, in the first survey we almost indicate all possible alternatives and then expert in two round amend the list of alternative by giving its score and we analyze the survey and omit not appropriate alternatives, the result is the alternatives that all expert agree on it.

4- 2 AHP technique:

we design the AHP model framework to obtain pair weight comparison of each criteria against other criteria. Table 1 help group of expert give its score to each criteria,

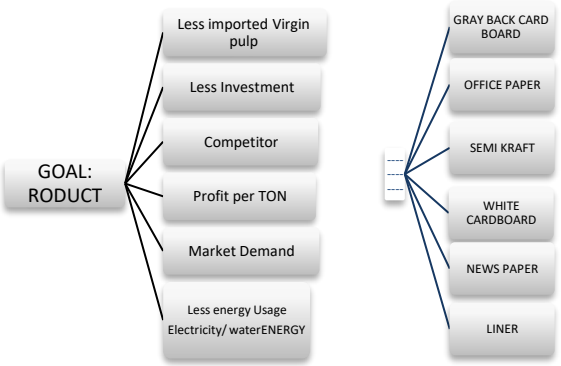


Figure 1: AHP Model Criteria Alternatives

Value of a_{jk}	Interpretation
-9	k absolutely more important than j
-7	k is strongly more important than j
-5	k is more important than j
-3	k is slightly more important than j
1	J and k is equally important
3	J is slightly more important than k
5	J is more important than k
7	J is strongly more important than k
9	J is absolutely more important than k

Table 1: Table of relative score

There will be a good result if the survey candidate has a different background in the paper and the cardboard field, from sales manager point of view the profit per TON is the most important criteria while for the Production manager's point of view the Market demand is much more important.

Survey sheet No.1	Benefit per Ton	Less Investment	Less energy usage electricity/ water	Less imported Virgin pulp	Competitor
Market Demand	-2	4	4/5	2	2
Profit per TON		6	3/5	4	3
Less Investment			2/2	-4	-5
Less energy Usage Electricity/ water				-4/2	-5/-4
Less imported Virgin pulp					-3

Table2: Pairwise numerical comparison Survey table for the criteria pairwise comparison fill out by an expert.

We design a seven-table survey, one as is said criteria pairwise comparison while the other six-table survey is obtaining the weighting value of alternatives against each other respect to each criterion. Table2 is an example of the weighting value of alternatives concerning one of the criteria “Competitor”,

Respect to: Competitor	Office paper	Semi Kraft	white Top Card Board	Newspaper	Liner
Gray Back card Board	-2	6	5	2	5
Office Paper		5	3	2	3
Semi Kraft			-4	-3	-2
white Top Card Board				2	2
News Paper					2

Table3: One example of a survey table for weighting value of alternatives concerning Competitor

The accuracy of our study and our performance depends on how accurate is our survey and how much the expert has knowledge of the paper and cardboard business. The result will be valid for the specific time and case as the situation rapidly change in availability of raw material, competitor, market demand, Prices and paper, and cardboard sales market.

5-Data/ Model Analysis

By using AHP we firstly make the structure of Hierarchy, the Goal is to determine which alternative has the most weighting value among the other as we obtain all data from our survey just need to find out which alternatives have the most priority.
As it is illustrated in table 4 Market demand on Office paper and Benefit per ton has the highest impact on selecting Gray Back cardboard while less Imported Virgin pulp and Less investment has highest advantages on semi Kraft.

	Ideal mode	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise
AID	Alternative	Market demand (L: /252)	Benefit per TON (L: /364)	Less investment (L: /046)	Less energy usage electricity (L: /667)	Less energy usage water (L: /333)	less imported virgin pulp (L: /084)	Competitor (L: /131)
A1	Gray Back Card							
A2	☑ Gray back card	/796	1/000	/470	/578	/673	/551	/991
A3	☑ Office paper	1/000	/485	/159	1/000	/998	/173	1/000
A4	☑ Semi kraft	/444	/195	1/000	/542	/366	1/000	/133
A5	☑ White Top Card	/222	/341	/258	/678	/798	/393	/425
A6	☑ News paper	/352	/164	/417	/620	1/000	/949	/383
A7	☑ Liner	/150	/241	/687	/694	/562	/901	/224

Table4: shows the weighting value of alternatives concerning each criterion.

That means there will be a big advantage regarding market demand if we manufacture Office paper and there will be highest advantage regarding profit per TON if we manufacture the Gray back cardboard. AHP let us consider all advantages

and risks to obtain each alternative weighting value concerning all criteria and enable us to make the best decision. For this case of the study, Gray back cardboard has the highest priority to manufacture with fewer risks

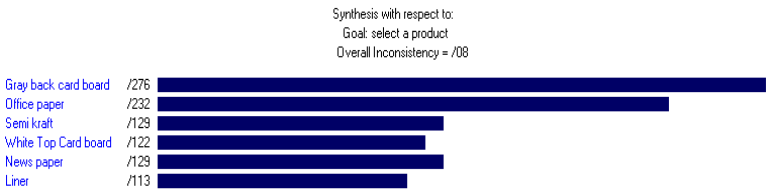


Figure2: illustrated the synthesis analysis alternatives concerning Goal

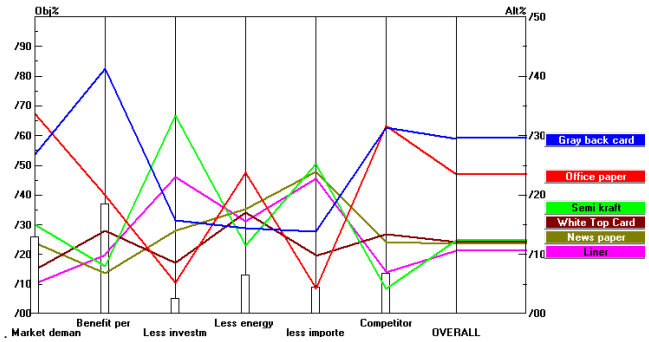


Figure 3: illustrate sensitivity graph

At the end of the research we do a sensitivity analysis to determine which indicator is more sensitive, by analyzing the sensitivity

6- Limitations

Despite all effort to obtain best solution and framework still there is some aspect that affects our study, changing situation in market demand, new competitors, new factories which still not supply their product in the market, mistakes made by an expert in the survey can weak our study and need to pay attention more.

7- Conclusions

7-1 Since the paper and cardboard industry has huge investment and a big market its necessary to select cellulose product by AHP modeling and Delphi techniques.

7-2 For more accuracy and better result we should consider the survey very seriously and select the right expert with enough knowledge of paper industry.

7-3 In this case of study the investor selects Gray back cardboard according the result of this study, if not he may select other products which may have better market demand but less profit or more competitor which has many risks and disadvantages.

8- Key References

1- Saaty, T. L. (2000). *Fundamentals of decision making with analytic hierarchy process, paperback* (pp. 15213–15213). Pittsburgh, PA: RWS Publications.

2- Chong Wu, Zijiao Zhang, Wei Zhong, "A Group Decision-Making Approach Based on DST and AHP for New Product Selection under Epistemic Uncertainty", *Mathematical Problems in Engineering*, vol. 2019

3- Ozden Bayazit, 2005, Use of AHP in decision making for flexible manufacturing system, Journal of Manufacturing Technology Management Vol. 16 No. 7

4- Narges Banaeian, Hossein Mobile, Izabela Ewa Nielsen& Mohamoud Omid, Definition and approaches in green supplier selection – a case study for raw material and packaging of food industry, Production & Manufacturing Research , An Open Access Journal, Volume 3, 2015 - Issue 1