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AN APPLICATION OF THE AHP METHODOLOGY TO THE EVALUATION OF RISK FACTORS IN AGRICULTURE

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ABSTRACT

Risk has several dimensions or variables in the agriculture industry, and prioritizing them may help with decision-making. Knowing the significance of these risk variables for various agricultural operations, as well as how they vary by geographic zone, is, on the other hand, useful knowledge for agricultural growth. The goal of this research was to identify the most important risk factors for farmers in Central South Chile. Climate, pricing and direct cost fluctuation, human factor, and commercialization were all utilized to create a decision structure using the multi-criteria Analytical Hierarchical Process (AHP) approach. Overall, the findings revealed that there are no significant discrepancies in the weightings of various risk variables. The most significant component (0.30) was price and cost fluctuation, whereas the least important element was climate (0.20). It also verified that the weightings derived for the various risk variables had geographical variations, resulting in different risk ratings for the various agricultural activities depending on geographic area.

KEYWORDS: *AHP, Analytical Hierarchical Process, Multi-Criteria Decision, Risk Analysis.*

1. INTRODUCTION

As a consequence of many sources of uncertainty, risk is present in all agricultural management decisions, and as long as farmers have varied risk preferences, the choices they make will be conditioned to a lesser or greater degree by a risk-minimizing process[1]. Furthermore, the growing importance of uncertainty as a result of climate change and globalization necessitates the development of technologies to effectively manage various sources of uncertainty.

Several research in agricultural economics have been published that assess farmer risk preferences, create models to explain how a farmer chooses from a collection of random options, or model a particular source of risk. In general, all of these studies concentrate on a small number of risk variables, leaving out many quantifiable and non-measurable risk factors[2]. To this end, the literature has paid less attention to determining the significance of various risk factors in affecting farmers' choices, as well as developing management tools to aid the decision-making process.

In agriculture, there are five different types of risk: productivity risk, marketing risk, financial risk, human risk, and environmental risk[3]. Each of these factors influences the farmer's

choice, but the proportional significance of each has not been examined in recent research. This paper attempts to close the gap by estimating weightings that quantify the significance of various risk variables on a farmer's risk rating of a set of productive options. To accomplish these goals, a multi-criteria optimization approach was used, which included variables that influence the choice to start an agricultural business. To this end, Saaty proposed the Analytical Hierarchical Process (AHP), which breaks down a final goal into a hierarchy of criteria and sub-criteria[4], [5]. This structure enables a complicated choice to be resolved via a series of binary comparisons that eventually lead to a conclusion. The ultimate goal in this instance was to create a risk-level-based rating of agricultural operations. To prioritize the activities, a first level of decision criteria was used, which consisted of four elements or risk criteria, each of which was divided into two sub-factors that were evaluated in a second hierarchical level.

2. MATERIALS AND METHODS

The AHP technique has three major advantages[6], [7]:

- It produces an intuitive answer when applied to empirical issues;
- the findings are difficult to manipulate;
- It allows for the determination of the relative significance of the sub-criteria examined in the choice problem[8].

Due to the considerable flexibility gained in constructing decision issues, as well as the explicit inclusion of the subjective assessments of various experts, this approach has been extensively spread, resulting in outcomes that maintain an objective basis for decision making. It also allows for the establishment of an inconsistency level in expert judgments, which is utilized as a metric for the quality of the data uncovered in the exercise.

2.1. Materials:

A panel of competent informants comprised of eight prominent producers and seven agricultural experts was used in the research. Those questioned were dispersed across the Bo Bo, La Araucana, and Los Lagos regions in order to cover the country's center southern zone. Agriculture is seen as a traditional activity in the study region, despite the fact that agricultural methods differ throughout the zone. Cereals, dairy, and cattle farming are the most significant activities. Sugar beet output is 82 percent, wheat is 71 percent, and bovine meat is 49 percent in these three areas[9].

2.2. Methods:

The problem's primary goal was to evaluate productive activities according to their risk level. To do this, a list of seven viable options was compiled. Option ranking created a hierarchical structure with four criteria that matched to four distinct risk variables, each with two sub-criteria. Without duplicating any combination, each informant was asked to compare pairs of productive alternatives using each of the criteria and sub-criteria that were used as parameters to assess the different pairs of productive alternatives being examined. The last stage was to compare the sub-criteria and criterion in pairs, utilizing the decision problem's primary goal as a comparison parameter.

Comparisons were conducted using Saaty's numerical scale, which ranges from 1 to 9, with 1 indicating equal liking for both options and 9 indicating the greatest degree of preference for the first option. The number is preceded by a negative sign when the second option is chosen.

Responses from those who participated in the interview are summarized in a matrix $A = (a_{ij})$, where $a_{ij} = w_i/w_j$ reflects the weightings of the alternative i with regard to j, and w is the priority vector generated from the informant answers. As a result, the matrix is written as:

$$A = (a_{ij}) = \begin{bmatrix} 1 & w_1/w_2 & \cdot & w_1/w_n \\ w_2/w_1 & 1 & \cdot & w_2/w_n \\ \cdot & \cdot & \cdot & \cdot \\ w_n/w_1 & w_n/w_2 & \cdot & 1 \end{bmatrix}$$

Matrix A is repeated for each criteria, then for each sub-criterion, and finally for the problem's goal, resulting in the creation of 13 matrices in this instance.

Matrix A has a dimension of n x n, which corresponds to the total number of productive options being compared. Matrix A has the following properties: a) It is reciprocal, i.e., $a_{ij} = 1/a_{ij}$ for all i,j = 1, 2,...., n; b) We may get $a_{ii} = 1$ from the former; c) If all judgments are completely consistent, then $a_{ij} = a_{ik}a_{kj}$. If (c) is true, the components of matrix A do not include any mistakes of judgment, thus $a_{ik}a_{kj} = w_iw_k/w_kw_j = w_i/w_j = a_{ij}$ must be true for every i,j,k = 1, 2,...., n.

3. DISCUSSION

3.1. Activity Selection, Criteria, and Decision-Making Problem Structure:

In 2006, a study of a representative sample of producers in Chile's central southern zone found the most significant activities and risk factors. The frequency with which the activities chosen for this research emerged as the primary activity in the sample is shown in Table 1. In addition, Table 2 depicts the farmers' prioritizing of a diverse set of risk variables. Climate, pricing and cost fluctuation, human risk, and commercialization were the chosen variables or risk criteria, according to Table 2.

For each criterion, two sub-criteria were developed, with representativeness, relevance, and the potential of future objective knowledge about them serving as the core elements of the decision. A panel of agricultural experts assisted in the development of the sub-criteria. This data was used to build the decision problem structure. The structure of the choice issue is shown in Figure 1, along with the specifics of the sub-criteria.

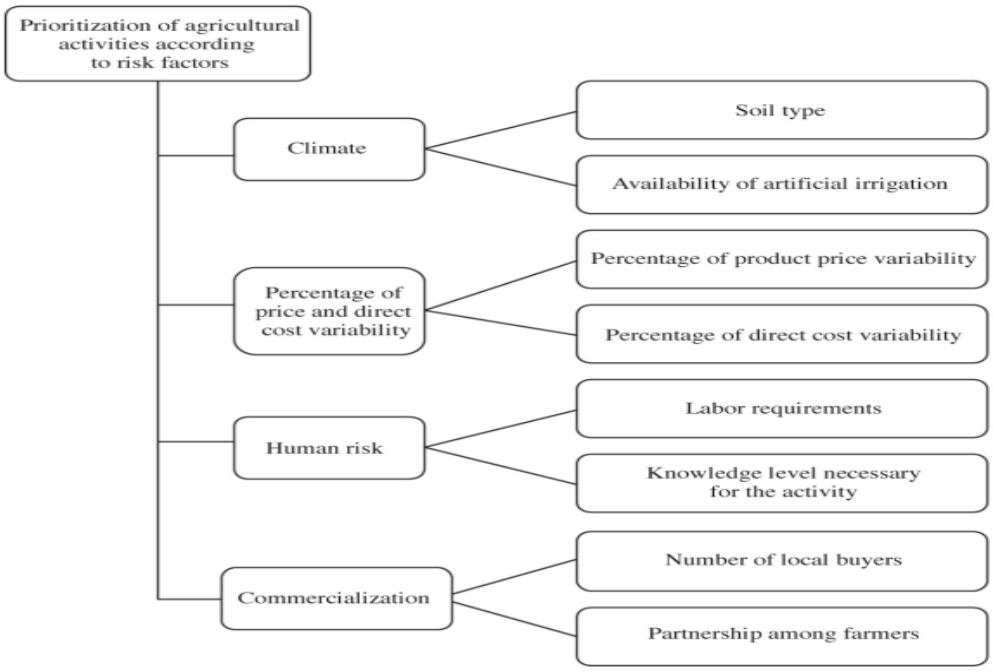

Figure 1. Structure of Analytical Hierarchical Process (AHP) decision model[10]

The choice model was organized in this manner, with four main criteria and eight sub-categories. To create the matrices, informed agents conducted interviews to gather comparisons between pairs of activities for each sub-criterion. Questions were always asked in order, beginning with the lowest limit sub-criterion. The individual being interviewed was asked for the relative comparison of each pair of sub-criteria after the comparisons for each set of sub-criteria were completed. Finally, as the interview progressed, comparisons between criteria were made.

TABLE 1. ACTIVITIES USED FOR BINARY COMPARISONS

Nº	Group	Description	Frequency as main activity (%)
1	Fruit trees	Apple and cherry trees	0.3
2	Berries	Blueberry, raspberry, strawberry, and blackberry	2.8
3	Cereals	Wheat, oat, corn, barley, triticale, and candeal wheat	22.4
4	Cattle	Bovine and ovine	15.9
5	Dairy	Bovine	47.4
6	Crops for industrial use	Sugar beet, canola, lupine, chicory, legumes, and freezing corn	7.5
7	Vegetables	Potatoes, asparagus, onion, and tomatoes	3.7

TABLE 2. PRODUCER PERCEPTION OF MAJOR RISK FACTORS IN THE AGRICULTURAL SECTOR

	Percentage of responses in accordance with importance of score[1]					
Risk factors in the agricultural sector	1	2	3	4	Mean	Ranking
Climatic factors	66	29	3	3	1.43	1
Product price variability	54	43	2	1	1.49	2
Variability of farm inputs	50	45	3	2	1.57	3
Market access for the sale of products	43	46	7	4	1.73	4
Labor costs	37	50	8	6	1.82	5
Duty and phytosanitary barriers	38	41	14	8	1.91	6
Government policies and regulations	39	38	14	9	1.94	7
Fluctuations in the value of the U.S. dollar	38	36	14	11	1.99	8
Variability of fuel prices	28	50	14	8	2.01	9
Concentration of the industry that I supply to	30	46	13	10	2.03	10
Variability of interest rates for financing	26	46	17	12	2.14	11
Free trade agreements and globalization of markets	27	43	18	12	2.15	12
Environmental regulations	21	52	15	11	2.17	13

[1]1 = Very important, 2 = important, 3 = undecided, and 4 = not important.

3.2. Prioritization Results:

The primary goal of this research is to determine the weighting for each of the risk variables used as criterion and sub-criteria using the choice problem framework. Weightings for each component are given in Table 3. It can be observed that the weightings varied between 20% and 30%, with no significant imbalance. This indicates that each risk factor was given the same amount of weight. The stated weighting is based on the risk variables that were provided as part of the exercise. However, since these risk variables were picked from a large sample of farmers' rankings, it is reasonable to infer that they correlate to those often chosen in decision-making. Furthermore, the findings may be extrapolated in real-world decision-making. As a result, the weighting produced may be read as the proportion that each component affects the activity's overall risk perception. In this instance, the most important risk element was price and cost fluctuation, which accounted for 30% of the overall risk perception, while climate accounted for 20% of the whole risk perception.

TABLE 3. GENERAL PRIORITIZATION OF CRITERIA AND SUB-CRITERIA

Criteria	Priority	Sub-Criteria	Priority
Climate	0.200	Soil	0.464
		Availability of artificial irrigation	0.536
Percentage of price and direct cost variability	0.301	Percentage of product price variability	0.416
		Percentage of direct cost variability	0.584
Human risk	0.260	Labor needs	0.466
		Necessary knowledge level	0.534
Commercialization	0.239	Number of local buyers	0.397
		Partnership among farmers	0.603
CR (Inconsistency)	0.001		

Table 4 shows a priority of agricultural activities as a consequence of this research. This table displays the risk value given to each activity for which a relative risk indicator may be calculated. Cattle farming was the least hazardous activity in the center southern zone of the nation, followed by cereal crops, and berries were the most risky. In all three areas, the perceived danger level for fruit trees and industrial crops was comparable, and the risk level for both activities decreased as we moved southern. Dairy production, on the other hand, increased its risk level in the southern areas, moving from an intermediate risk level to the second most dangerous agricultural activity in the Los Lagos Region. A potential reason may be found in the increased presence of large dairy farms that are influenced by climatic circumstances.

TABLE 4. GENERAL PRIORITIZATION OF AGRICULTURAL ACTIVITIES ACCORDING TO RISK FACTORS

Nº	Agricultural activity	Priorities by Region			
		Bío Bío Region	La Araucanía Region	Los Lagos Region	General
1	Cattle farming	0.074	0.077	0.103	0.088
2	Cereals	0.09	0.116	0.107	0.106
3	Fruit trees	0.169	0.134	0.128	0.139
4	Crops for industrial use	0.165	0.0139	0.123	0.143
5	Dairy	0.128	0.142	0.178	0.154
6	Vegetables	0.154	0.194	0.166	0.169
7	Berries	0.221	0.198	0.195	0.201

4. CONCLUSION

The four risk variables were given a similar relative significance in the results, however the percentage price and cost fluctuation were given a greater weighting than human risk, which was ranked second at 0.30 and 0.26, respectively. With a value of 0.20, the climate component received the least attention. When it came to price and cost fluctuation as a percentage, cost was more important than price variability. Despite significant variations in actual producing systems, climate, and prevailing production orientations, prioritizing of agricultural activities by area showed modest heterogeneity. Berry picking was found to be the riskiest activity, while cow husbandry was shown to be the safest. Some variations may be seen when the findings are broken down by area. The perceived risk of dairy farming in the Los Lagos Region was greater than in the Bo Bo Region. Fruit trees and industrial crops, on the other hand, exhibited comparable risk levels in all three areas, and the perceived danger for these activities reduced as one moved south.

It may also be deduced that risk variables did not have the same proportional significance in all activities, suggesting that each one has its own unique characteristics. These findings revealed that risk variables had varying impacts on various activities, making generalizations difficult. Similarly, it was discovered that the relative significance of risk variables varied by

location, resulting in direct impacts on the prioritizing of agricultural operations in different areas.

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