An Application of Analytical Hierarchy Process (AHP) for Affect Factor to Corn Price in Thailand Market

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***Abstract*—Problems today become more complex which related to multi-dimensions of criterions. The difficulty of making decision needs the specific tool to cope with such varieties of concerns. Corn harvesting is one of the most complicated problems which farmers need some information to make decision prior farming. And they such factors effect to corn price also. This research aims to seek for the set of important information related to corn price by collecting contents from literature and experts. Fourteen contents have been collected and validated by Index of Item-objective congruence process. The validated contents would be applied for data gathering. A model was constructed and scored across each pair of contents by using the Analytical Hierarchy Process approach. For confidence interval at 95 percent and margin of error at 15 percent, the sample size would be 171 questionnaires to be collected. All questionnaires would be tested for consistency. The result of this research found that there are 4 main factors affect to corn price in Thailand market, e.g., chicken export rate, corn import rate, weather and soybean price at 14.50%, 15.15%, 14.86% and 13.05% respectively. The result of this research would bring more understanding of these factors to corn price in future research.**

***Index Terms*—analytical hierarchy process, decision making, index of item-objective congruence**

I. Introduction

Corn is regarded as one of the most important industrial drop and critical to the lives of both humans and animals. It can be used in businesses and variety applications, e.g., the use of corn as pharmacological activities by Milind and Isha [1], Pimentel and Patzek [2] mentioned the use of corn as raw material for ethanol production, starch, food for human, animal feeds or even high fructose syrup by Parker *et al.* [3], etc. Regards to the wide range of applications of corn in term of demand, but the supply of corn production is unstable due to some factors. One of the main causes is price influencing. There were plenty of research on factors effect to corn prices but only in some dimensions. Whittaker [4] studied only the effects of planted acreage of corn, corn yield, weather and ethanol production to corn price. Wescott and Hoffman [5] have established corn price forecasting model and found that stock-to-use factor also affects to corn price. They also mentioned that corn and soybeans compete with each other for farmer's production decision. Government programs have also been important in influencing farm-level prices of corn and wheat. Condon *et al.* [6] mentioned that each billion gallon expansion in ethanol production yields a 2-3 percent increase in corn prices on average. Saghaian [7] studied for the linkage of oil-ethanol-corn and mentioned that there is a strong correlation among oil and commodity prices but in a mixed model. And the effect of the exchange rate to corn price has been studied by Haque [8] and concluded that corn price is more sensitive to exchange rate in developing country. Even researches on the corn price effect are plenty. But farmers or even government are still unclear for factors or set of factors which affect to corn price. The benefits of this research would support for future research to formulate the potential factors affect to corn price and forecasting the crop more efficiently.

II. Methods

The research was designed to be 4 phases and separated to be 8 steps as demonstrated in Fig. 1. The first phase is to seek and collect potential factors from researches. Regards from works of literature, there are factors have been collected and demonstrated in Table I. The second phase comprises 2 steps, rating score by experts in step 2 and contents validation in step 3.

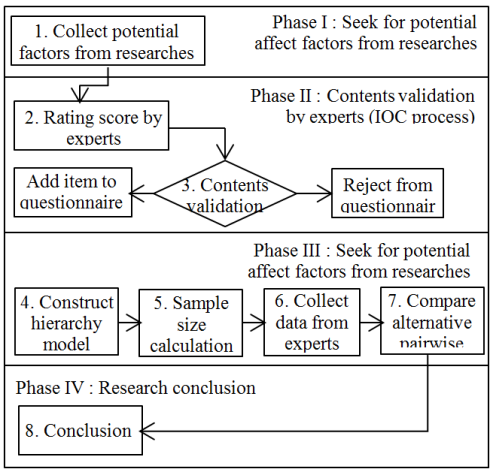

Figure 1. Research work flow.

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TABLE I. COLLECTED FACTORS FROM LITERATURES

No	Factor	Researcher
1	Ethanol production	Condon et.al (2013), Saghaian (2010), Whittaker (2013)
2	Exchange rate	Haque (2012)
3	Planting acreage	Whittaker (2013)
4	Oil price	Saghaian (2010)
5	Corp yield	Whittaker (2013)
6	Weather	Whittaker (2013)
7	Stock-to-use	Wescott and Hoffman (1999)
8	Soybean price	Wescott and Hoffman (1999)
9	Government program	Wescott and Hoffman (1999)

In step 2, the collected factors have been scored by experts using Index of Item-objective congruence proposed by Rovinelli and Hambleton [9]. The scoring explanations are 1 for items which clearly tap objective, 0 for unsure/unclear and -1 for the items which clearly does not tap objective. The contents shall be selected to add in the questionnaire for use in the next step. Step 3 is the contents validation using IOC. Even some factors were collected to score by experts. There are some additional contents recommended by experts for scoring. The scoring results demonstrated in Table II. If most of experts agreed for the average result. This research was scored by 3 experts. Hence, the accepted score from IOC process would be at least 0.67 points on average. From Table II, the result from IOC process indicated that there are only 9 of 14 factors have been agreed by experts.

TABLE II. RATING SCORE RESULT USING IOC BY EXPERTS

No	Factor	Group	Expert 1	Expert 2	Expert 3	Average	Selected
1	Ethanol production	Literature	-1	-1	1	-0.33	N
2	Exchange rate	Literature	-1	-1	-1	-1.00	N
3	Planting acreage	Literature	1	1	1	1.00	Y
4	Oil price	Literature	-1	-1	-1	-1.00	N
5	Corn yield	Literature	-1	0	1	-	N
6	Weather	Literature	1	1	1	1.00	Y
7	Stock-to-use	Literature	1	1	1	1.00	Y
8	Soybean price	Literature	0	1	1	0.67	Y
9	Government programs	Literature	-1	-1	0	-0.67	N
10	Corn production	Recommend	1	1	1	1.00	Y
11	Import rate	Recommend	1	1	1	1.00	Y
12	Wheat price	Recommend	1	1	1	1.00	Y
13	Chicken export rate	Recommend	1	1	1	1.00	Y
14	Season	Recommend	1	1	1	1.00	Y

The third phase is to construct an analytical hierarchy process model (Fig. 2). The Analytic Hierarchy Process (AHP) has been developed by Thomas Saaty of the Wharton School of Business [10], [11]. It was developed as a reaction to the finding that there is a miserable lack of common, easily understood and easy-to-implement methodology to cope with multi-criteria decision- making problems. It has been used in various businesses and applications for making decision in complex problems. Arabameri [12] created AHP model to assess locating fire stations among multiple criteria decision making. Sharma and Pratap [13] applied AHP to prioritize the various risks for supply chain within the organization. Syamsuddin [14] has constructed AHP model to aid managers to make decision by using several what-if scenarios for information security issues. Triantaphyllou and Mann [15] applied AHP to make the final decision on the evaluation of a set of alternatives in terms of a number of decision criteria in many engineering applications. Lee [16] has also implemented AHP in term of information security risk analysis. The use of AHP is to solve contractor prequalification problem in project management by Harbi [17]. Bayazit [18] applied AHP model to make decision for implementing flexible manufacturing system in a tractor manufacturing plant. Or even Schmidt *et al.* [19] has applied AHP to solve the limitation resources in healthcare research. The collected criterions would be constructed into a hierarchy of goal (factors affect to corn price) and alternatives as demonstrated in Fig. 3 (The fourth step). The questionnaire would be developed by pairing each alternative with each other, e.g., planting acreage with the weather, planting acreage with stock-to-use, planting acreage with soybean price until the last pair.

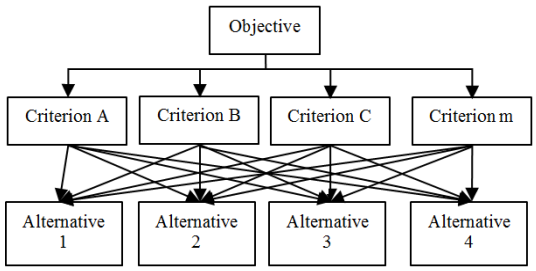

Figure 2. The analytical hierarchy process model.

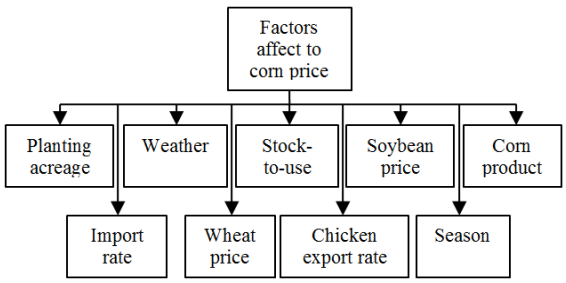

Figure 3. AHP model for the research.

The fifth step of the research is to determine the appropriate size of sample for questionnaires to be collected. Singh [20], Krejcie and Morgan [21] have introduced sample size calculation formulae as indicated in formula 1 to 3.

$$SE_M = \frac{\sigma}{\sqrt{N}} \quad (1)$$

$$\sqrt{n} = Z\frac{\sigma}{E_M} \quad (2)$$

$$n = \left(Z\frac{\sigma}{E_M}\right)^2 \quad (3)$$

where n=size of the sample, σ = standard deviation of the population, E_M = percent of sampling error. The designed confidence interval and margin of error for questionnaires

were set to be 95 percent and 15 percent respectively. Hence, the sample size for the research would be $n = \left(\frac{1.96}{0.15}\right)^2 = 170.74$ or round up the number to be 171 samples to be collected.

Considering the *N:p* ratio, Cattell [22] recommended this ratio should be in the range of 3 to 6. Regards to the number of pairs are 36. To use the number of questionnaire at 171 would bring *N:p* ratio at 4.75 which stand in recommended range.

To make data more reliability in data collection for the sixth step, the questionnaires have been spread to the related person across agriculture business group. Total 174 samples have been collected from 34 of the department of agriculture officers, 113 farmers, 27 agricultural product traders to cover total needed sample size.

The seventh step is to compare alternative pairwise. This step is to measure the consistency of the answer for any questionnaires. For example, if factor A is twice as preferable to B, and B is twice as preferable to C, then, in the case of perfect consistency, the decision maker should prefer A four times to C. Deviation in these judgments are represented by the consistency ratio [23].

Saaty [10] proved that for the case of the absolutely consistent reciprocal matrix, the largest eigenvalue (λ_{max}) is equal to the size of comparison matrix, or λ_{max} = n and Consistency Index (CI) = 0. The measure of CI as deviation or degree of consistency using the following formula

$$\lambda_{max} = \sum_{i=1}^{n}\left[\sum_{j=1}^{n} a_{ij} w_j\right] \quad (4)$$

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \quad (5)$$

where CI = consistency index, λ_{max} = *maximum eigenvalue, n = number of orders*

If the comparison matrix is not absolutely consistent then λ_{max} >n, the need to measure the level of inconsistency, Consistency Ratio (CR), which is a comparison between Consistency Index (CI) and Random Consistency Index. If the value of Consistency Ratio is smaller or equal 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, the subjective judgment revision is needed. The Random Consistency Index (RI) for different values of n is presented in Table III.

$$\mathrm{CR} = \frac{(\mathrm{CI})}{(\mathrm{RI})} \quad (6)$$

where CI = consistency index, RI = random consistency index

TABLE III. RANDOM CONSISTENCY INDEX FOR DIFFERENT VALUES OF N

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

All collected questionnaires have to be tested for consistency. The questionnaires with consistency ratio smaller or equal 10% would be accepted. The pairwise comparison matrix is presented in Table IV below.

The matrix needs to be normalized by dividing them with their sum of each column to make them equal 1. The normalized pairwise comparison matrix is presented in Table V.

TABLE IV. AVERAGE PAIRWISE DATA GATHERED FROM EXPERTS

Factor	A	B	C	D	E	F	G	H	I
A. Planting acreage	1.00	0.23	0.44	0.32	0.44	0.21	0.35	0.14	0.55
B. Weather	4.33	1.00	2.69	1.50	1.91	0.63	1.41	0.37	2.26
C. Stock-to-use	2.25	0.37	1.00	0.71	0.63	0.31	0.92	0.23	1.27
D. Soybean price	3.17	0.67	1.41	1.00	1.56	0.66	1.65	0.45	1.72
E. Corn production	2.27	0.52	1.58	0.64	1.00	0.43	0.94	0.27	1.61
F. Import rate	4.87	1.60	3.22	1.51	2.35	1.00	2.13	0.43	2.39
G. Wheat price	2.88	0.71	1.08	0.60	1.06	0.47	1.00	0.41	1.89
H. Chicken export rate	6.97	2.68	4.26	2.20	3.74	2.35	2.45	1.00	3.60
I. Season	1.82	0.44	0.79	0.58	0.62	0.42	0.53	0.28	1.00
Total	29.56	8.23	16.48	9.06	13.30	6.46	11.39	3.59	16.29

TABLE V. THE NORMALIZED PAIRWISE COMPARISON MATRIX

Factor	A	B	C	D	E	F	G	H	I	Ave. x 100
A. Planting acreage	0.034	0.028	0.035	0.034	0.033	0.032	0.031	0.040	0.034	3.25
B. Weather	0.146	0.122	0.166	0.166	0.143	0.097	0.124	0.104	0.139	13.38
C. Stock-to-use	0.076	0.045	0.061	0.078	0.047	0.048	0.081	0.066	0.078	6.45
D. Soybean price	0.107	0.081	0.086	0.110	0.117	0.103	0.145	0.127	0.105	10.90
E. Corn production	0.077	0.064	0.096	0.071	0.075	0.066	0.083	0.075	0.099	7.83
F. Import rate	0.165	0.194	0.196	0.166	0.177	0.155	0.187	0.119	0.147	16.73
G. Wheat price	0.097	0.086	0.066	0.067	0.080	0.072	0.088	0.114	0.116	8.73
H. Chicken export rate	0.236	0.326	0.258	0.243	0.281	0.363	0.215	0.279	0.221	26.91
I. Season	0.062	0.054	0.048	0.064	0.047	0.065	0.046	0.078	0.061	5.82
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	100

III. RESULTS

This research demonstrated the use of Index of Item-Objective Congruence (IOC) to validate factors effect to corn price in Thailand market which gathered from literatures and experts. The result found 9 items could be used to develop questionnaires and collect data from 174 related people in business. To ensure the consistent of

data, all collected questionnaires were tested the consistency with consistency index. The AHP model was constructed from average data among all collected questionnaires and found that value of λ_{max}, consistency index and consistency ratio for the average value of all questionnaires are 9.120, 0.015 and 0.010 respectively. From theoretical, the value of λ_{max} should be equal to n. The value of λ_{max} is very close to n value and the value of consistency ratio is smaller than 10 percent. Hence, the consistency is acceptable. The normalization process has been done and indicated in Table V. The result indicated in Table VI shows that there are 3 factors which have high effect rate to corn price in Thailand market with total impact rate at 57.02%, e.g., chicken export rate, corn import rate and weather at 26.91%, 16.73% and 13.38% respectively.

TABLE VI. RANKING OF AFFECT FACTORS TO CORN PRICE

No	Factor	Percent
1	Chicken export rate	26.91
2	Corn import rate	16.73
3	Weather	13.38
4	Soybean price	10.90
5	Wheat price	8.73
6	Corn production	7.83
7	Stock-to-use	6.45
8	Season	5.82
9	Planting area	3.25

IV. CONCLUSION

The problem of this research is to seek for factors which effect to corn price in Thailand market. There are 14 factors have been gathered from literatures and experts and screened out by using index of item-objective congruence. The application of AHP in this research is to prioritize the effect factors to corn price from many factors. It uses very basic consideration by pairwise comparing. And its ability to translate complex questions into stepwise comparisons. The process of testing consistency of collected data of AHP also supports researchers to ensure the consistent of collected data from experts systematically. The result shows that there are 3 factors which have high effect rate to corn price with total impact rate at 57.02%, e.g., chicken export rate, corn import rate and weather at 26.91%, 16.73% and 13.38% respectively. Hence, the result would enable us to prioritize effect factors to corn price in Thailand market. The future research would develop time-based forecasting model by using these factors. Hence, the control of corn harvesting would be more efficiently.

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