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Agen Based Modeling for Corn Supply Chain Risks Identification and Sales Negotiation in PTPN VIII

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Abstract

PTPN VIII is a state-owned company in West Java cultivating several kinds of commodities, and still have three marginal farmlands with a total size of 3000 hectares open for investment for corn. The type of corn that would be produced is corn feed for poultry needs. Three agents are involved in this agent-based model: the farmers (or cooperatives), PTPN VIII, and the buyers of the corn yields. All agents face risks in doing their businesses which hamper or reduce their probability of achieving their business goals. The potential risks are identified using fuzzy reasoning method. The three blocks of farmland have different levels of fertility. Farmers are expected to compete for the hunt of farmland to rent for cultivating corns, until their funds run out. They must prepare the land, procure their best corn seeds, plant and maintain the crops, and eventually harvest, dry and sell their corn yield. The dryness of the corn grains dictates the selling price. The buyers will buy the corns until their demands are fulfilled for the particular season. There will be a negotiation process between agents to reach an agreement. Each agent seeks to achieve its goal. This is why agent-based modelling is employed. Netlogo software is used to develop the model. Based on fuzzy reasoning method the obtained result shows that the most potential risk is quality risk. The negotiation results show that when both buyer and seller experience heightened degree of risk appetite, the shortest negotiations are achieved.

1. INTRODUCTION

PT Perkebunan Nusantara VIII (PTPN VIII) is an Indonesian state-owned agroindustrial estate engaged in crops cultivation, processing and sales development of agricultural plant commodities such as tea, rubber, quinine, cocoa, palm oil in West Java. PTPN VIII plans to offer its spare marginal farmland to the farmers to grow and sell corn, which are currently in high demand.

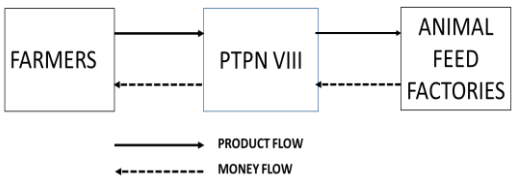

Figure 1.
The three parties in the corn supply chain

There are many (groups) of farmers and investors who need lands to be cultivated and generate income by cultivating it and sell the crops. The buyers are the animal feed industries for whom corn is the most important component for their main products.

This study intends to develop a model to study the business interaction patterns between actors in corn supply chain as shown in Figure 1. In addition the study considers the risk factors which may affect the price negotiation process. Risk identification needs to be done as a first step in preventing and mitigating risks that occurs within the supply chain actors (Yustisar, 2018; Suharjito et al., 2010). Risk factors are used as determinants for simulation scenarios, while negotiation process considers each actor's degree of patience as one of the variables that influences the simulation output. The issues taken from these references are the type of risks identified, and the level of risks faced by the parties involved. Other aspect is the fuzzy reasoning using Fuzzy AHP process. The problem approach uses agent-based modeling because this method can be used to identify, measure and simulate the phenomena that occurs after a dynamic emergent interaction takes place between parties who have different behaviors and goals.

Negotiation is a bidding process by conferring to reach mutual agreement between each parties involved (Wardani et al., 2015). In the agroindustry context, the negotiations that are carried out on

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product prices. The model is used to seek the highest risks faced by the actors, and the best negotiated prices for the parties involved in achieving their subsequent business goals.

2. LITERATUR REVIEW

2.1 Corn supply chain

The main parties involved in corn supply chain are the supplier, which consists of corn farmers, collectors, and importers, companies which are raw material users, and customers. However, the uniqueness of the corn supply chain in Indonesia is the existence of middlemen who have big influence to the farmers. Some middlemen also function as collectors, wholesalers and even importers who supply corn to animal feed factory and agribusiness companies (Ardiani, 2016).

2.2 Fuzzy reasoning method to measure supply chain risk

Risks can cause losses and risk management could cut the domino effect of the risks. Risk management goal is to minimize losses and raise chances of profitability. Suharjito et al (2010) explains that supply chain risk management implies knowledges, whether its strategies or operations to assess long terms and short term risks. Tang and Musa (2011) describes supply risk chain management through coordination or teamworks between supply chain partners.

The magnitude of risks is influenced by several factors such as human factors, workplace factors, material and equipment factors, and others which are difficult to measure in traditional ways (Zeng et al., 2007). The assessment can be described using brainstorming or checklist techniques, combined with the fuzzy reasoning membership and weighed using the Analytical Hierarchy Process (AHP) method. In this method there are five phases, namely (1) the initial phase, (2) the Index Factor (FI) measurement phase, (3) the Risk Likelihood (RL) and Risk Severity (RS) phase, (4) the fuzzy inference phase, and (5) the Output Modification phase.

2.3 Negotiation

An agricultural pricing mechanism achieved through a process of negotiation is superior to cost-based or auction-based pricing in achieving goal congruence and evaluating subunit performance (Handayati et al., 2019). The negotiation process in defining agreed prices can be illustrated by considering the degree of risk appetite of negotiators. The degree of risk appetite of both customer and supplier are captured to illustrate the impact on the duration, agreed price and result of negotiations (Yang et al., 2018).

2.4 Agen Based Modelling (ABM)

ABM is used for this model because we can identify the business phenomenon after the emergence and dynamic interaction between the parties (called the agents) in the system. Each agent has its own different business behaviour and goals, variables and parameters (Wilensky and Rand, 2015). ABM dictates some few simple rules to code the behaviour of the agents and their interactions. The modeller conducts a simulation with the variables and the parameters such that the required performance of the business activities of the agents are achieved. The modeller then monitor and interpret the output performance resulted. (Helbing, 2012). Netlogo open-source software version 6.0.1 is used to develop the simulation model.

3. RESEARCH METHODOLOGY

3.1 Overall framework

Figure 2 shows the overall methodology flowchart of this study. There are four phases of this study:

1. Preliminary Phase, which focuses on formulating the problem.
2. Following the problem formulation Data Preparation and Collection Phase is conducted.
3. Data Processing Phase, performed on the collected and sorted data. In this phase the techniques of Unified Modeling Language (UML) is used. The conceptual model of the corn supply chain is developed using the Use Case Diagram.
4. Final Phase, which analyses the results and concludes the study.

Figure 3 shows the Fuzzy Reasoning procedure to determine the magnitude of the corn supply chain risks (RM), using fuzzy membership definition of all factors, defining the inference rules, and later perform the defuzzification process to arrive at the crisp figures of the risk levels. Meanwhile, Figure 4 shows the diagram of conducting the negotiation between the seller and the buyer to arrive at the agreed prices. This is the area where the agent based model are developed and simulated to seek the optimal figures of the prices.

3.2 Fuzzy reasoning procedures

This procedure has five phases as follows:

(1) The Preliminary Phase

This phase defines the membership function (MF) of Contribution Factors (CFs), Index Factors (FI), Risk Likelihood (RL), and Risk Severity (RS) of the identified risks.

(2) The Measurement Factors Index (FI) Phase

After the score and priority weights of the risk factors are obtained, the factor index (FI) values of each risk FI is calculated using equation (1):

$FI^* = \sum_{i=1}^{n} S_i^* w_i'$ i = 1, 2, ., n .....(1)

Where S_i* is the fuzzy aggregated score, and w_i' is the weight value of FI, while n equals 11.

(3) Measurement of RL and RS Phase.

Based on the results of the measurement of the impact of risk (Risk Likelihood) and the chance of risk (Risk Severity), then conversion for aggregated STFNs is performed using equations (2) and (3), then the value of RL* and RS* is calculated.

$RL^* = RL_1 \otimes c_1 \oplus RL_2 \otimes c_2 \ldots RL_m \otimes c_m \ldots$. (2)

$RS^* = RS_1 \otimes c_1 \oplus RS_2 \otimes c_2 \ldots \oplus RS_m \otimes c_m$.)……..……..(3)

Where c_1, c_2, .., c_m is the value or weight allocated by each of the three experts.

(4) Fuzzy Inference Phase.

In this phase, the conversion of the STFN aggregate on FI*, RL*, and RS* into fuzzy sets is seen by looking at the graph of membership function (MF). From the results of these 3 factors, the fuzzy inference process is defined using "if-then" rules to find the crisp risk magnitude (RM).

(5)Modification Output Phase.

The results obtained from the analysis of the previous stage are modified into the crisp figures of the risk magnitude.

The ABM model is written in Netlogo software version 6.0 which is open-source, developed by the team at the Northwestern University in Evanston, IL.

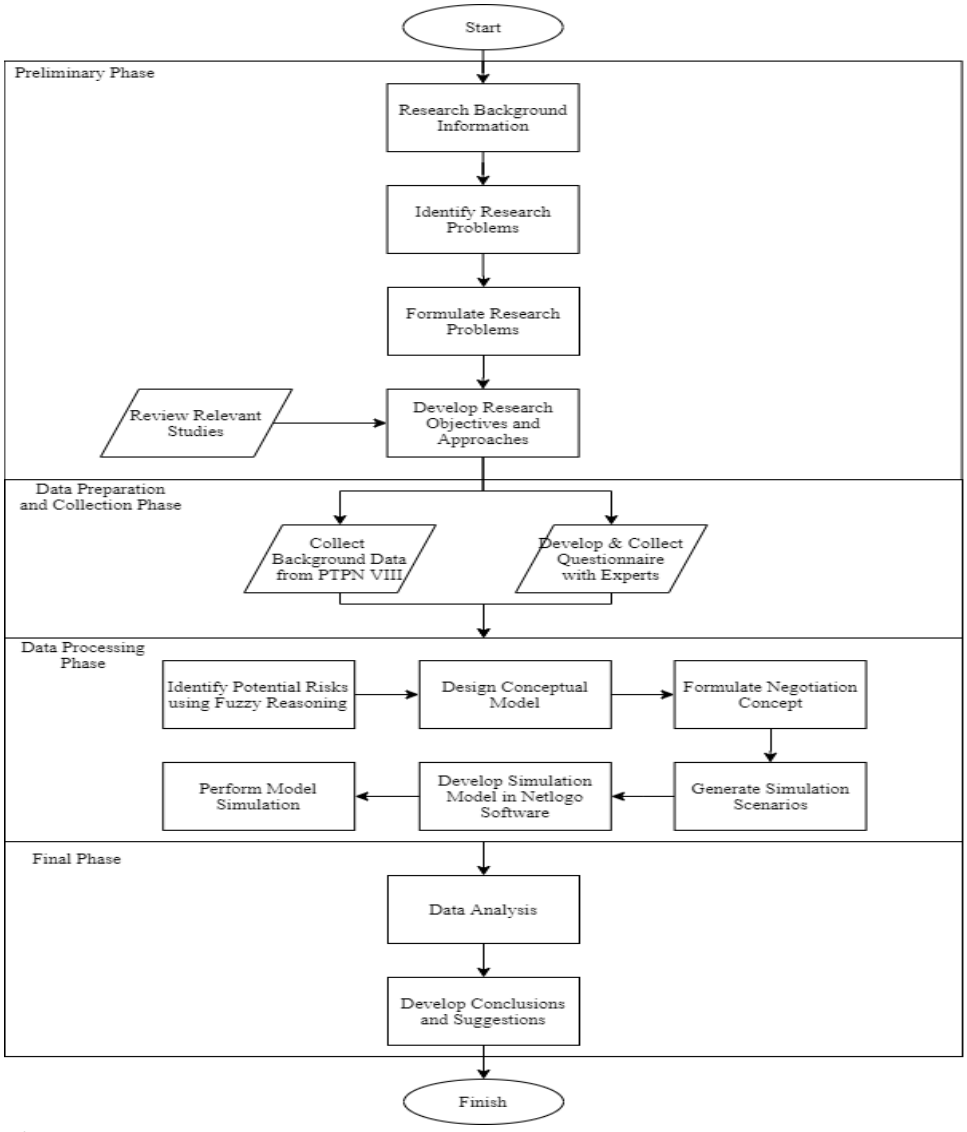

Figure 2.
Overall research flowchart

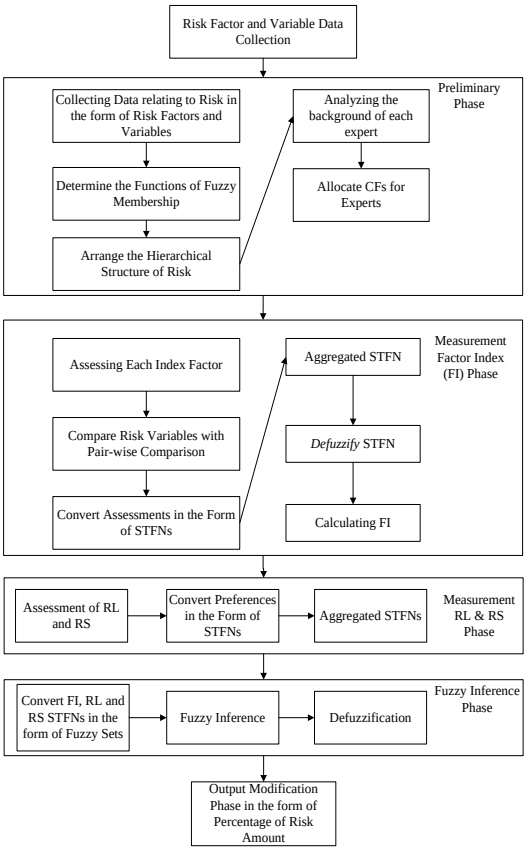

Figure 3.
Fuzzy reasoning method flowchart
(Source: Zeng et al., 2007)

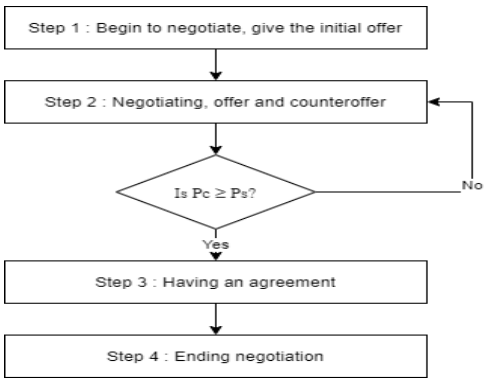

Figure 4.
Negotiation procedures

4. RESULTS AND DISCUSSION

4.1 Data collection

The office of PTPN VIII is located in Sindangsirna area, in Bandung, West Java. Most of the observations and interviews to obtain information are conducted here. The main resource persons or experts are the managers in the Plant Division, Research and Development Division, and the Corn Project Manager. Interviews were conducted directly with the resource persons using lists of prepared questions. Conclusions on the answers are confirmed with the resource persons. When some answers are later found insufficient or unclear, clarifications are conducted through e-mail or mobile texting.

Data collected are the general description and operations of the company, supply chain flow and literature studies which are used as reference material to find out the risks that exist in the corn supply chain at PTPN VIII.

4.2 Data processing

4.2.1 Potential risks identification using fuzzy reasoning

Risk identification on PTPN VIII is done by literature study and through interviews with experts. Table 1 lists the collected 44 risk variables which are grouped into 11 risk factors.

Table 1.
List of risk factors and risk variables

Risk Factors	Risk Variables
Environment	Natural disasters
	Pests and diseases
	Government policy
	Security
	Sociocultural and political conditions
	Competitor's product
Technology	Low technology mastery
	New technological developments
	Technology availability
Price	Inflation
	Exchange rates and bank interest
	Low quality of the product
	Supply amount
Supply	Diversity of supply quality
	Supplier loyalty
	Supply availability
Transportation	The choice of transportation mode
	Transportation time uncertainty
	Road safety
	Damage on the road reduces product quali
Market	Market structure
	Price fluctuations
	Consumer rejection
	Quality standardization in the market
Production	Capacity
	Process
	Production technology usage
	Quality of raw materials
Information	Forecasting methods usage
	Information distortion
	Information transfer methods usage
Quality	Season
	Transportation method
	Inventory
	Variation in supply quality
	Production process
Inventory	Supply uncertainty
	Demand uncertainty
	Depreciation and degradation of quality
	Geographical location
Partnership	Partner selection
	Communication network breakdown
	Transportation network breakdown
	Partner commitment

Preliminary Phase

The stage defines the membership function (MF) of Contribution Factors (CF), Index Factors (FI), Risk Likelihood (RL), and Risk Severity (RS). Table 2 shows the MF of CFs from the three resource persons. The data processing uses linguistic variables with a triangular MF, except for

the RM, which uses the trapezoidal MF. The factor index is defined to have 5 levels: Very Poor (VP), Poor (P), Fair (F), Good (G), and Very Good (VG). For risk likelihood (RL) and risk severity (RS), 5 levels are defined: Very Low (VL), Low (L), Fair (F), High (H) and Very High (VH). The magnitude of the risk (MR) has 4 levels: Negligible (N), Minor (Mr), Major (Ma) and Critical (C). Figure 5 shows the Membership Function diagram for FI, RL, and RS, while Figure 6 shows the MF for Risk Magnitude.

Table 2.
MF of Contribution Factors (CFs)

Experts	Background	CF values
E1	Plant Division	CF1 = 0.25
E2	Research and Development Division	CF2 = 0.25
E3	Project Manager	CF3 = 0.5

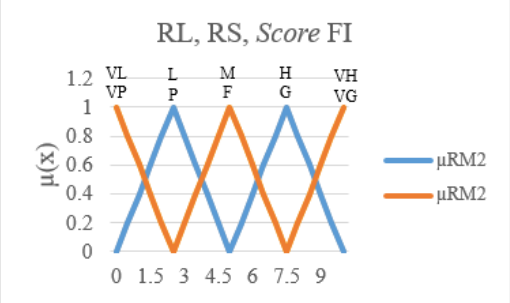

Figure 5.
MF for FI, RL, and RS

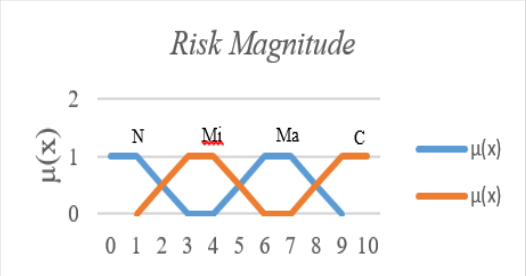

Figure 6.
Membership functions for RM

Measurement of Factors Index (FI)

Based on the calculation results using equations 1 through 9, the index factor values of each risk factor are obtained, these results can be seen in Table 3.

Measurement of RL and RS

Based on the results of the measurement of the impact of risk (Risk Likelihood) and the chance of risk (Risk Severity), then conversion for aggregated STFNs can be obtained using equations 2 and 3, then the value of RL* and RS* is obtained in Table 4 and Table 5.

Table 3.
FI for each risk factor

Risk Factor	FI*			
Environment	0,87	1,91	2,09	3,82
Technology	0,41	1,80	1,96	3,45
Price	0,53	1,94	2,11	3,68
Supply	0,79	1,57	1,64	2,93
Transportation	1,36	3,03	3,22	4,85
Market	0,90	2,27	2,41	3,88
Production	0,35	1,00	1,17	2,70
Information	1,12	1,72	1,88	3,24
Quality	0,64	1,31	1,54	3,60
Inventory	0,49	1,87	2,04	3,61
Partnership	0,31	1,21	1,39	3,01

Table 4.
List of RL for each risk factor

Risk Factor	RL*			
Environment	2,50	5,00	5,25	7,50
Technology	1,25	3,75	4,00	6,25
Price	1,88	3,75	4,00	6,25
Supply	1,25	2,50	2,75	5,00
Transportation	1,25	3,13	3,25	4,38
Market	1,25	3,13	3,38	5,63
Production	1,25	3,13	3,38	5,63
Information	1,25	2,50	2,75	5,00
Quality	4,38	6,88	7,13	9,38
Inventory	0,00	1,25	1,50	3,75
Partnership	0,00	1,25	1,50	3,75

Table 5.
List of RS for each risk factor

Risk Factor	RS*			
Environment	3,13	5,63	5,88	8,13
Technology	0,63	3,13	3,38	5,63
Price	3,75	6,25	6,50	8,75
Supply	1,25	3,75	4,00	6,25
Transportation	3,13	5,63	5,81	7,50
Market	1,88	4,38	4,63	6,88
Production	3,75	6,25	6,50	8,75
Information	1,88	4,38	4,63	6,88
Quality	4,38	6,88	7,13	9,38
Inventory	4,38	6,88	7,13	9,38
Partnership	3,75	6,25	6,50	8,75

Fuzzy Inference Phase

In this phase, the conversion of the STFN aggregate on FI*, RL*, and RS* into fuzzy sets is seen by looking at the graph of membership function (MF). From the results of these 3 factors, it can be seen that the relationship is using "if-then-rule" rules to measure the RM. Table 6 is an example to show the outcome of RM results after running the rules.

Table 6.
Table *Outcome Rule* for quality risk factor

Factor Index		Risk Likelihood		Risk Severity		Min Values	RM
				Fair	0,75	0,743	C
		Fair	0,75	High	0,75	0,75	C
				Very High	0,5	0,5	C
				Fair	0,75	0,75	C
Very Poor	0,743	High	0,75	High	0,75	0,75	C
				Very High	0,5	0,5	C
				Fair	0,75	0,5	C
		Very High	0,5	High	0,75	0,75	C
				Very High	0,5	0,5	C
				Fair	0,75	0,523	Ma
		Fair	0,75	High	0,75	0,75	C
				Very High	0,5	0,5	C
				Fair	0,75	0,75	C
Poor	0,523	High	0,75	High	0,75	0,75	C
				Very High	0,5	0,5	C
				Fair	0,75	0,5	C
		Very High	0,5	High	0,75	0,75	C
				Very High	0,5	0,5	C
				Fair	0,75	0,562	Ma
		Fair	0,75	High	0,75	0,75	C
				Very High	0,5	0,5	C
				Fair	0,75	0,75	C
Poor	0,562	High	0,75	High	0,75	0,75	C
				Very High	0,5	0,5	C
				Fair	0,75	0,5	C
		Very High	0,5	High	0,75	0,75	C
				Very High	0,5	0,5	C

Modification Output Phase

Based on the analysis of the previous stage, highest results were obtained for the quality risk factor which shows a risk magnitude of 8,71 (see Table 7). The next step is to do a defuzzification to convert fuzzy values into numerical values. Table 7 shows the results for each risk factors.

Table 7.
Risk magnitude of each risk factor

Risk Factors	Risk Magnitude
Environment	3,78
Technology	7,00
Price	7,60
Supply	7,00
Transportation	5,93
Market	6,14
Production	7,60
Information	4,60
Quality	8,71
Inventory	7,00
Partnership	7,00

4.2.2 Conceptual model

The corn supply chain model consists of three agents, namely (group of) farmers, PTPN VIII, and the animal feed factories (as buyers). Each agent owns different attributes. Figure 7 shows the use case diagram for farmland rent model, while Figure 8 is for corn sales model. The negotiation simulation is done sequentially. First the farmland rental model is run, and the results are entered into the corn sales model.

The key activities of farmers are associated with farmland rent, and gain revenue from corn sales. The key activities of buyers are associated with corn purchase. PTPN VIII holds a unique position. PTPN VIII key activities revolves around both farmland rent and corn sales transaction. In the context of farmland rent, PTPN VIII act as the supplier that provides land to be rented by farmers, and they are involved in a negotiation process for the rent cost.

In the context of corn sales transaction, PTPN VIII acts as an agent that conduct the corn price negotiation with the buyers on behalf of the farmers.

This is to help the farmers gain most profitable deals for their corn yields.

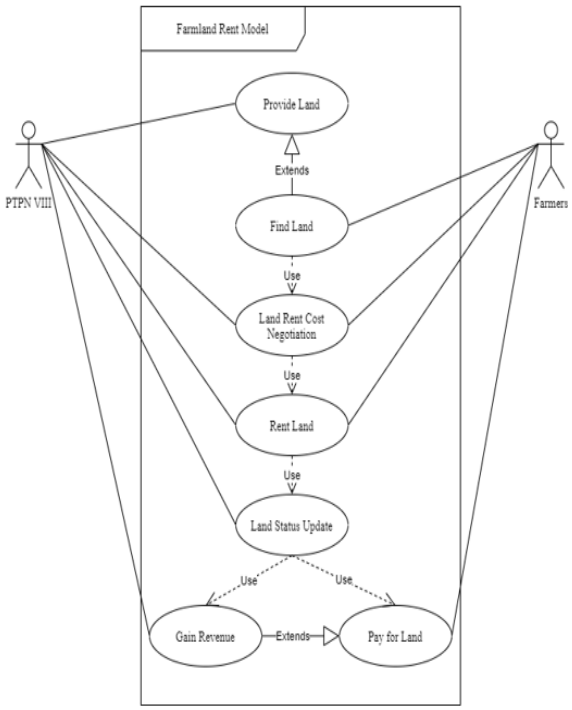

Figure 7.
Use case diagram for farmland rent model

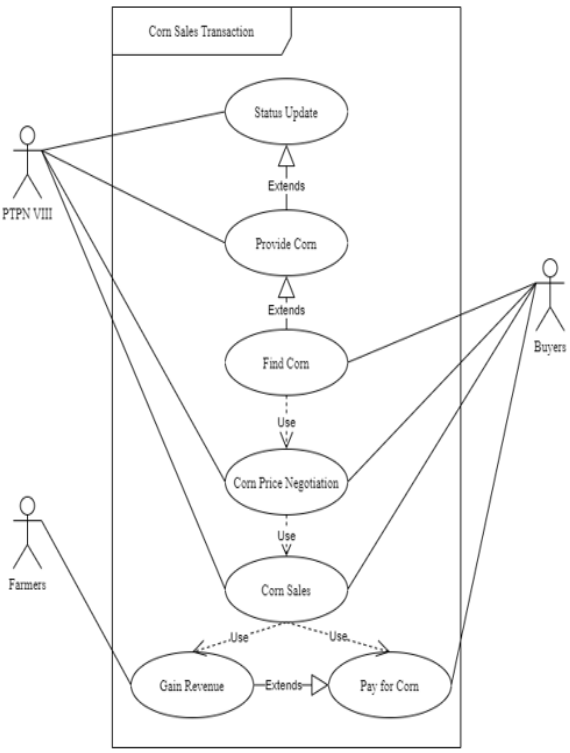

Figure 8.
Use case diagram for corn sales model

4.2.3 Negotiation

The scenario for price negotiation simulation is based on the variability of model's parameter. The variables are the offered price from PTPN VIII (Ps), and the counter offer price of the farmers (Pc). The parameters are the degree of risk appetite of PTPN VIII (As), and degree of risk appetite of the farmers (Ac). In Rent Cost Negotiation (RCN) 1, 2, and 3, the same value of As 0,2 is used. Meanwhile, the Ac values vary from 0,2 to 0,6. The fastest agreement is reached for a larger Ac value, followed by a smaller Ac value in sequence. This indicates that the higher the Ac, the faster the negotiations will end or the agreement price will be reached. But the number of negotiation iteration is inversely proportional to the value of the agreement price reached. The higher the Ac value, the higher the final transaction price agreed. This indicates that Ac is directly proportional to the final agreement price and inversely proportional to the length of negotiation or the number of iterations. This is shown on Table 8 and Figure 9.

In the corn price negotiation (CPN) model, one additional parameter is added, namely the level of corn dryness. This additional parameter is the result of identifying potential risks which shows that quality risk is the most potential. Now, the effect of the risk can be observed in the model simulation. The higher the dryness the higher the buyer is willing to pay, which means higher selling price. This is shown on Table 9.

Table 8.
Rent cost negotiation scenarios

Scenario number	Pc value	Ps value	ac value	as value
RCN1	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,6	0,2
RCN2	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,5	0,2
RCN3	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,2	0,2
RCN4	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,6	0,5
RCN5	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,5	0,5
RCN6	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,2	0,5
RCN7	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,6	0,6
RCN8	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,5	0,6
RCN9	Rp 7.500.000 per Hectare	Rp 13.500.000 per Hectare	0,2	0,6

Table 9.
Corn price negotiation scenarios

Scenario number	Final corn price
CPN1	Rp3.262.955
CPN2	Rp3.250.000
CPN3	Rp3.250.000
CPN4	Rp3.925.121
CPN5	Rp3.925.000
CPN6	Rp3.925.000
CPN7	Rp4.575.191
CPN8	Rp4.575.000
CPN9	Rp4.575.000

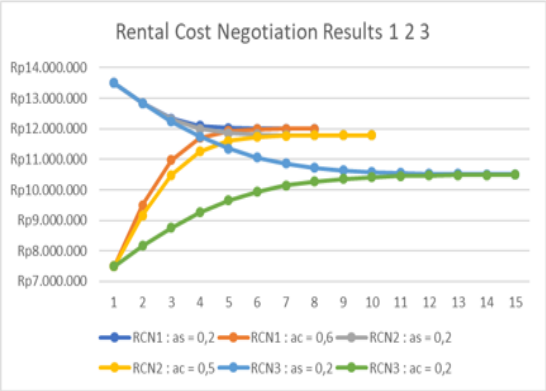

Figure 9.
Rental cost negotiation results for RCN 1, 2, and 3

4.2.4 Simulation scenarios

Following the conceptual model, two simulation models are developed in sequence, the farmland rent model and the corn sales price model. The simulation scenarios are developed around the model's relevant parameters. Table 10 shows the simulation scenario for farmland rent (FLR) negotiation model. The parameter for this model is farmers' capital (low, medium, high), so the scenario is developed around the values of farmland rent cost and the level of the farmer's capital.

For corn sales simulation model, there are two parameters namely the corn dryness level (low, medium, high) and corn demand level of the buyer (low, medium, high). An additional parameter is the occupied land area which is obtained from the farmland rent model simulation. Thus the scenario is developed by combining several corn dryness level, buyer's corn demand level, and occupied land area. This is shown in Table 11.

4.2.5 Development of the netlogo model

PTPN VIII has three farmland estate blocks in West Java, namely the Wangunreja, Cikumpay, and Jalupang estates with a total area of 3000 hectares. PTPN VIII wants to rent-out its block of farmland in parts of 10 hectares, so we have 300 parts to be rented. The sites of the parts are randomly made available to the farmers. PTPN VIII set the same rental cost for all three farmland blocks. When a part of farmland is already rented by a particular farmer, it can not be rented to another. Figure 10 shows the Netlogo Interface with the rent cost as the parameter.

The values of occupied land area from the farmland rent (FLR) model simulation is then entered into the corn sales model as one of the input parameter. Another input parameters are corn demand level (by the buyer) and agreed corn prices previously determined by the corn price negotiation process. Figure 11 shows the Netlogo Interface appearance for these chosen parameter.

The negotiation processes follows the diagram described in Figure 4. This process is translated into Netlogo software codes.

4.2.6 Simulation results

The simulation results using the Netlogo software are put on Table 12 and Table 13. PTPN VIII reaches the highest income in scenario FLR 9 that is IDR 40.500.000.000, which is when the rent cost is set at the value of IDR 13.500.000,- /hectare and high farmers capital level.

Low corn dryness level occurs in scenario CSP 1, 4, 7, 10, 13, and 16. This simulation provides highest farmers revenue for scenario CSP16 with IDR 69.238.000.000, while the corn demand level is high. Medium corn dryness level occurs in scenario CSP 2, 5, 8, 11, 14, and 17. From each of the mentioned scenario number above, the highest farmers revenue is obtained at scenario CSP17 that is IDR 83.618.200.000, which occurrs when corn demand level is high. High corn dryness level occurs in scenario CSP 3, 6, 9, 12, 15, and 18. From each of the mentioned scenario number above, the highest farmer's revenue is obtained at scenario CSP 18 that is IDR 97.474.949.000, which occurs when corn demand level is high.

Low corn demand level occurs in scenario CSP 1, 2, 3, 4, 5 and 6. The highest farmer's revenue of IDR 48.718.175.000 is obtained at scenario CSP3, when corn dryness level is high. Medium corn demand level occurs in scenario CSP 7, 8, 9, 10, 11 and 12. The highest farmer's revenue is obtained at scenario CSP 12 that is IDR 97.168.425.000, occurs when corn dryness level is high. High corn demand level occurs in scenario CSP 13, 14, 15, 16, 17, and 18. The highest farmer's revenue is IDR 97.474.949.000, which is obtained at scenario CSP18 when corn dryness level is high.

Table 10.
Farmland rent model simulation scenarios

Scenario number	Rental cost	Farmers capital level	Farmers capital value
FLR1	Rp10.500.000	low	Rp 2.500.000,- for each farmer
FLR2	Rp10.500.000	medium	Rp 3.500.000,- for each farmer
FLR3	Rp10.500.000	high	Rp 4.500.000,- for each farmer
FLR4	Rp7.500.000	low	Rp 2.500.000,- for each farmer
FLR5	Rp7.500.000	medium	Rp 3.500.000,- for each farmer
FLR6	Rp7.500.000	high	Rp 4.500.000,- for each farmer
FLR7	Rp13.500.000	low	Rp 2.500.000,- for each farmer
FLR8	Rp13.500.000	medium	Rp 3.500.000,- for each farmer
FLR9	Rp13.500.000	high	Rp 4.500.000,- for each farmer

Table 11.
Corn sales model simulation scenarios

Scenario number	Corn dryness	Corn price	Buyers corn demand level	Buyers corn demand value	Occupied land blocks
CSP1	low	Rp3.250	low	10.650 Tons per period	180
CSP2	medium	Rp3.925	low	10.650 Tons per period	180
CSP3	high	Rp4.575	low	10.650 Tons per period	180
CSP4	low	Rp3.250	low	10.650 Tons per period	300
CSP5	medium	Rp3.925	low	10.650 Tons per period	300
CSP6	high	Rp4.575	low	10.650 Tons per period	300
CSP7	low	Rp3.250	medium	21.300 Tons per period	180
CSP8	medium	Rp3.925	medium	21.300 Tons per period	180
CSP9	high	Rp4.575	medium	21.300 Tons per period	180
CSP10	low	Rp3.250	medium	21.300 Tons per period	300
CSP11	medium	Rp3.925	medium	21.300 Tons per period	300
CSP12	high	Rp4.575	medium	21.300 Tons per period	300
CSP13	low	Rp3.250	high	42.600 Tons per period	180
CSP14	medium	Rp3.925	high	42.600 Tons per period	180
CSP15	high	Rp4.575	high	42.600 Tons per period	180
CSP16	low	Rp3.250	high	42.600 Tons per period	300
CSP17	medium	Rp3.925	high	42.600 Tons per period	300
CSP18	high	Rp4.575	high	42.600 Tons per period	300

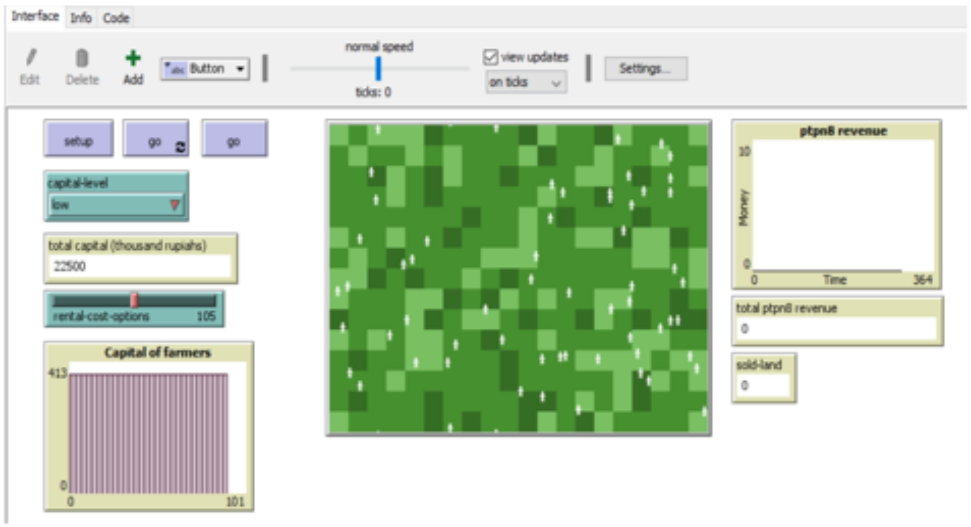

Figure 10.
Farmland Rent Model Interface

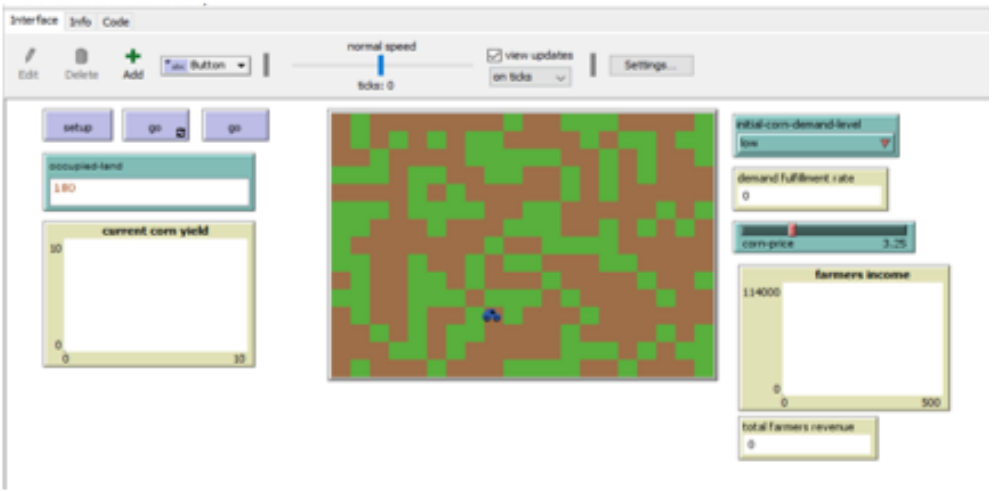

Figure 11.
Farmland Rent Model Interface [based on occupied land area]

Table 12.
Farm rent model simulation results

Scenario number	PTPN VIII Revenue	Occupied land blocks
FLR1	Rp18.900.000.000	180
FLR2	Rp31.500.000.000	300
FLR3	Rp31.500.000.000	300
FLR4	Rp22.500.000.000	300
FLR5	Rp22.500.000.000	300
FLR6	Rp22.500.000.000	300
FLR7	Rp16.200.000.000	120
FLR8	Rp24.300.000.000	180
FLR9	Rp40.500.000.000	300

Table 13.
Corn sales model simulation results

Scenario number	Farmers revenue	Buyers demand fulfillment
CSP1	Rp34.391.500.000	99,36%
CSP2	Rp41.765.925.000	99,91%
CSP3	Rp48.719.175.000	99,99%
CSP4	Rp34.424.000.000	99,45%
CSP5	Rp41.542.200.000	99,38%
CSP6	Rp48.682.575.000	99,92%
CSP7	Rp42.233.750.000	61,01%
CSP8	Rp51.284.050.000	61,34%
CSP9	Rp61.035.075.000	62,63%
CSP10	Rp34.404.500.000	99,39%
CSP11	Rp83.335.600.000	99,68%
CSP12	Rp97.168.425.000	99,71%
CSP13	Rp41.739.750.000	30,15%
CSP14	Rp53.234.775.000	31,83%
CSP15	Rp61.735.050.000	31,67%
CSP16	Rp69.238.000.000	50,01%
CSP17	Rp83.618.200.000	50,01%
CSP18	Rp97.474.949.000	50,01%

4.2.6 Limitation of this research

There are some limitations when this model was being developed as follows:

- Product being studied is only one, namely: corn,
- Only two animal-feed factories are studied,
- Only 3 levels of supply chain are discussed: Farmers, PTPN VIII, and animal-feed factories,
- Only farmers capital, land rent cost, corn dryness and risk appetite are considered for the negotiation process.

When these limitations are overcome there will be many opportunities open for future researches. While this is a first new effort to conduct a study in the area of cooperation between PTPN VIII, farmers and the animal feed factories, the future opportunities are theoretically limitless.

5. CONCLUSION

From the results obtained in the previous chapter, the following conclusions are obtained:

1. The study identified 11 risk factors and 44 risk variables. The risk factors are environment risk, technology risk, price risk, supply risk, transportation risk, market risk, production risk, information risk, quality risk, inventory risk, and partnership risk. The fuzzy reasoning method provides the most potential risk to the corn supply chain is the quality risk with the risk magnitude value of 8,71.
2. The negotiation results show that when both buyer and seller experience heightened degree

of risk appetite, the shortest negotiations are achieved. Moreover, different combinations of risk appetite on the part of the buyer and supplier suggest that the same value of buyer's and supplier's risk appetites will produce a mutually acceptable price.

3. The highest income of PTPN VIII is obtained at IDR 40.500.000.000, when the land rent cost is set at the value of IDR 13.500.000,- /hectare and the farmers capital level is high. Hence, the highest income of farmers is IDR 97.168.425.000, which occurs when corn dryness level is high and corn demand level is also high.

6. REFERENCES

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