Applications of Agent-based Modeling and Simulation of Fuel Distribution in Indonesia

Manahan Siallagan, Nana Juhana, Santi Novani, Utomo Sarjono Putro,
manahan_siallagan@yahoo.com, nanajuhana2003@yahoo.com, snovan8@yahoo.com, utomo@sbm.itb.ac.id

School of Business and Management
Institut Teknologi Bandung
Jl. Ganesha 10, Bandung, INDONESIA

1. Introduction

Fuel is vital both to the production sector and the people's mobility in their economic activities but the government of Indonesia faces difficulties to manage fuel distributions. Indonesia became a net oil importer in 2004, while it imports at market prices, state-owned Pertamina sells petroleum products to consumers at subsidized prices. As of April 2005, the Government owned Pertamina about $2.6 billion in fuel subsidies, putting pressure on the company's cash flow and on its ability to pay for imported petroleum products. This has affected oil supplies to the country, which now faces petroleum shortages.

In early September, the Government announced that current subsidy levels can no longer be sustained, and on 1 October, raised fuel prices by an average of 126.6%. As this will have a significant impact on low-income households, the Government will provide direct compensation, giving each household living on or below the poverty line 300,000 rupiahs (about $28) per quarter over the next year.

Pertamina desires to handle subsidized fuel oil distribution in Indonesia.Since fuel oil is usually smuggled overseas not the other way around, it causes a serious case such as illegal fuel, shortage of fuel, the accumulate of fuel, etc. For example "*Indonesian warship KRI Untung Suropati-872 that patrolled Maluku waters in the eastern part of Indonesia caught tanker KM NMSC-07 which carried 100 tons of fuel oil from China recently*" [4]. This case shows that fuel oil distribution in Indonesia has a big problem.

An opportunist actor was done a serious case for public demand to get a large profit. Interaction in this fuel oil distribution is very complex, there so many spot and actor which has a different behavior and dynamic character. In this research, we propose fuel oil distribution model, which consists of actors and each of them, can interact at each spot. Interaction between actors is influence by internal factor such as behavior of agent (honest or dishonest) and external factor such as issue (raised fuel price, illegal fuel oil, etc).

First, the interaction between spots is modeled by *agent-based modeling*. *Then* it proposes a fuel oil distribution in Indonesia without and with an issue about illegal fuel case, shortage of fuel, the accumulate of fuel, etc. *Finally*, it studies the behavior each actor at fuel oil distribution model and what factor that caused the trouble at fuel oil distribution especially at the city in Indonesia

2. Distribution System

Indonesia historically has maintained very large consumption subsidies for domestic retail fuel consumers, with products being sold at a steep discount from world market prices. Consumption of 2005 subsidized fuel oil has been successfully reduced from 59.6 million Kilo Liters to only 56.4 million Kilo Liters . While the sales of fuel oil with the economic price has exceeded the target as big as 5.9 million Kilo Liters with the realization of 6.4 million Kilo Liters [5].

In fuel distribution, Pertamina implements several methods to maintain its retail outlet through zero loses fuel oil distribution and win-win solution implementation for gas stations. Pertamina has also signed the contract on fuel oil's sales with big industries purchasing fuel oil more than 100 KL per month[5]. Here, Pertamina implements attractive marketing system.

Fuel distribution model in Indonesia can be seen at the following figure.

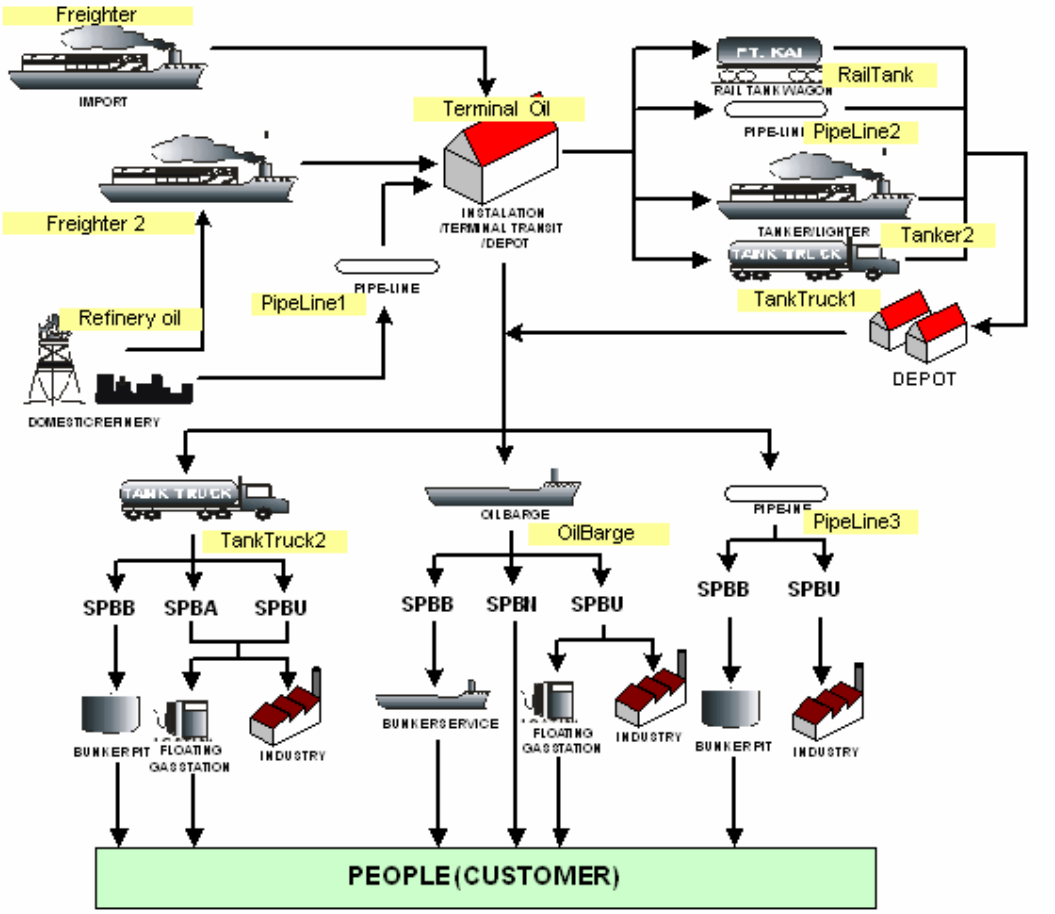


Figure1. Fuel Oil Distribution [6]

In Figure 1, state-owned oil and gas company Pertamina has a regulation and administrative functions for transferring to other entities, while its regulatory role was spun off to a new body, Oil and Gas Indonesia. Pertamina maintained its retail and distribution monopoly for petroleum products until July 2004. The spot of fuel oil distribution is refinery oil, terminal, depot, industry, SPBU (oil station), gas station, banker station and customer. This distribution is legal which conduct by Pertamina. Based on field research, the distribution path is build to distribute a consumer in the city.

Indonesia has seven refineries, with a combined capacity of 992,745 bbl/d [6]. The largest refineries are the 348,000-bbl/d Cilacap in Central Java, the 240,920-bbl/d Balikpapan in Kalimantan, and the 125,000-bbl/d Balongan, in Java [6]. PT Kilang Minyak Intan Nusantara, a joint venture of Al-Banader International Group of Saudi Arabia (40%), China National Electrical Equipment Corporation (40%) and PT Intanjaya Agromegah Abadi (20%), are planning to invest a total of $3 billion to build a refinery at Pare-Pare, South Sulawesi [6].

We will propose distribution model to get stabile condition, that is the role of distribution that will propose and without the events that can destroy a distribution path that will cause disquiet of society. The propose distribution model is can be seen in Figure 2.

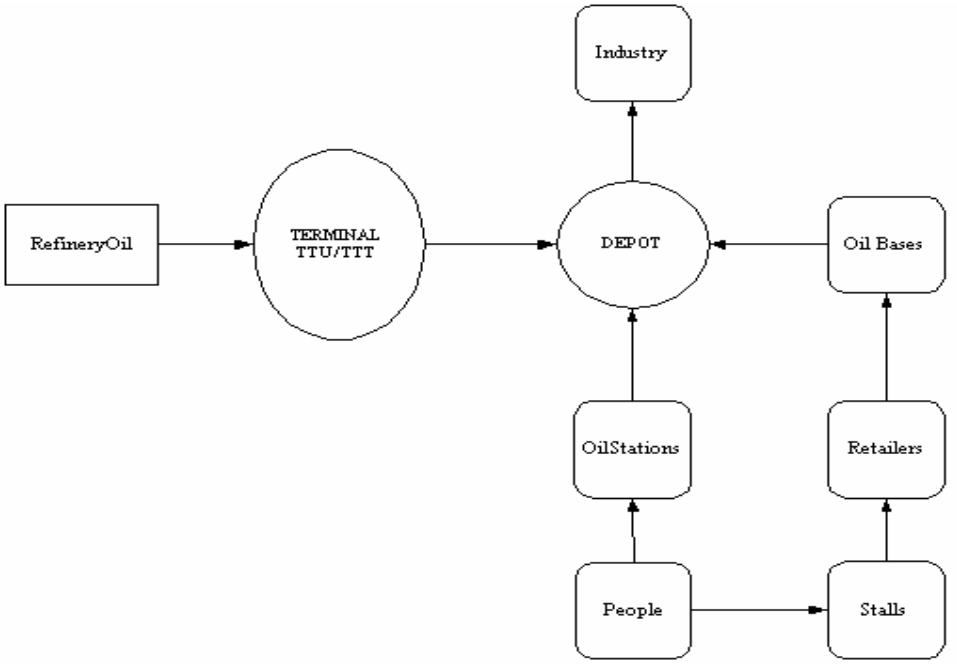


Figure2.FuelOilDistributionModel

After we obtain a stable distribution process, then we study trouble elements such as issue the raise of fuel price, illegal fuel to distributed system and the effort to reduce this trouble that can be seen in our simulation for this fuel distribution model. From this model, we can see the behavior of agents who involve in fuel distribution and the factor that can cause the trouble in the distribution model. The proposed model will use agent based modeling and simulation. The simulation model of fuel distribution is described by Figure 3.

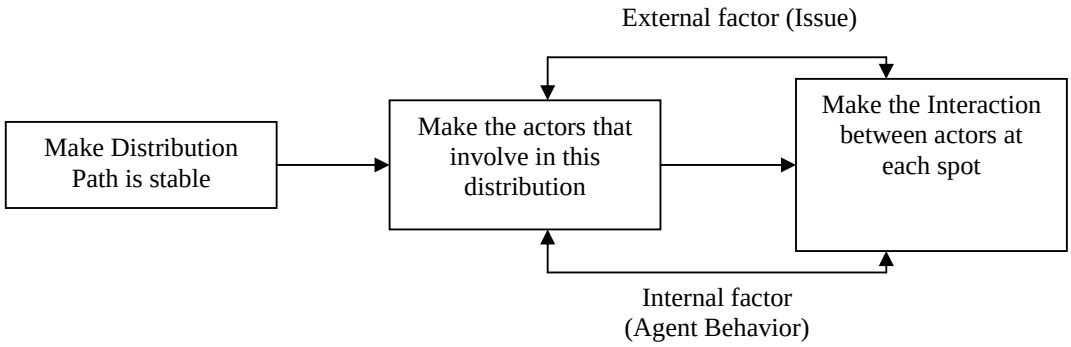


Figure 3. Simulation Model of Fuel Distribution

In Figure 3, we determine external factor as an issue that will make a trouble to distribution system, such as the raise price of fuel, illegal fuel, shortage of fuel, the accumulate of fuel, while we determine an internal factor as the behavior of agent at each spot which have honest and dishonest behavior.

3. Model Simulation

In this paper, we will build model simulation, which related with designing scenario. The first model is stable fuel oil distribution model. We assume that there are 2 supply chains that is regular and irregular. Regular supply chains is a supply from one spot to another spot legally at each distributed period, while an irregular supply is a supply that caused by spontaneity demand from one spot that had a less supply.

Refinery oil spot get a regular supply from source, terminal spot get a regular supply from refinery oil, depot spot get a regular supply from terminal, and another spot such as industry, oil gas station and oil base get regular and irregular supply from depot. Retailer's spot get a regular and irregular supply from oil base, while stall's spot request an irregular supply to retailer. The society request a supply to stalls or oil gas station and for they need daily. Industrial will use fuel oil for it self

Distributed procedure as follows:

```
For each time simulation
  If time period distribution
        Do distribute to refinery oil
  If arrival time regular to refinery
        Do distribute to terminal
  If arrival time regular to terminal
        Do distribute to depot
  If arrival time regular to depot
        Do distribute to industry, oil gas station and oil base
  If arrival time regular to oil base
        Do distribute to retailer
  If arrival time irregular to industry
        Add supply to industry
  If arrival time irregular to oil gas station
        Add supply to oil gas station
  If arrival time irregular to oil base
        Add supply to oil base
  If arrival time irregular to stalls
        Add supply to stalls
    Make consume of industry
  Make people demand to stalls
  Make people demand to oil gas station
  Make consume of society
  If supply of industrial spot<threshold of industry
        Do an irregular request (demand) to depot
    If supply of  oil gas station spot<threshold of oil gas station
        Do an irregular request (demand) to depot
    If supply of oil base spot<threshold of oil base
        Do an irregular request (demand) to depot
    If supply of retailer spot <threshold of retailer
        Do an irregular request (demand) to oil base
    If supply of stalls spot <threshold of stalls
        Do an irregular request to retailer
```

In this model, we assume that there is one source, one refinery oil, one terminal and one depot, while an industrial spot, oil gas station, oil base, retailer and stalls have a number X that could be set. The amount of society (people) could be set also.

At the first condition, each spot could be fill by agent. At refinery spot, terminal and depot have XA agent that could be set, while the amount of agent for the other spot could be set based on the amount of spot, For example, oil gas station have 30 stations, so there is 30 agent in this spot. Agents have a behavior that is behavior to act dishonest and behavior to act honest. Coding of behavior agent could be set this following:

Each behavior have potential degree from range 0/7 until to 7/7 that could be arrange to 3 binary digit, so there is 6 binary digit to represent the behavior of agent. For example:
Agent A has behavior coding

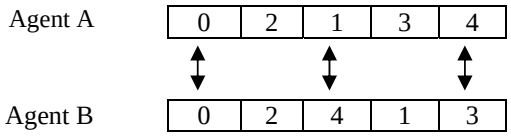
0	1	0	1	0	0

The above agent have potential degree 2/7 to act dishonest and 4/7 to act honest.

Agent has an interaction status, which decoded by arrangement of 5-array and the number 0 until to 5 fills each place in thus array, for example:

0	2	4	1	3

This interaction status will determine an interaction degree between agents to know that could or not to do the interaction from each spot, for example



Then degree of interaction is 3/5.

At the first condition, behavior of agent and degree of interaction is generated randomly. At the first model, there isn't interaction between agents from each spot. The objective is to see the result from distribution process that had been done. After we get a stable distribution process, at the second model we add trouble element that is an illegal transaction that had been done by agent and there is dishonest action from agent for each spot. At this model, agent could interact to do an illegal transaction that is one spot can get an illegal supply from distribution path. It caused by price of supply in refinery spot is cheaper than the price of supply in depot spot that is legal distribution path. The rule of interaction of agent is following:

Check degree of interaction
  If interaction
    If random< dishonest of agent A and random < dishonest of agent B
      Do the interaction

This rule explain that the interaction would be happen if both of agent has a high degree of interaction and transaction that would be happen if both of agent has a high dishonest action. This process will cause a leakage at distribution system. In normal condition, one spot will ask the supply if the capacity of spot had past the threshold of their capacity. If there is trouble, then each agent can ask an illegal demand, which have an objective to accumulate the fuel. In this model, it can relate with behavior of agent. The rule is following:

If random < dishonest of agent
  Make the request

In this rule, agent will make accumulating fuel oil, if degree of dishonest behavior of agent is high. This model can involve an external factor that is an issue that will make a trouble to distribution system. Issues could be appeared anytime and will hold on for current time. The existence of issue will give a negative reaction for agent. Negative reaction depends on weight of issue. Procedure to generate an issues, is following:

If Issue
  Time of issue = 0
  Length of time issue = random
  Weight of issue = random
While (Time of issue< length of time issue)
  Reaction of agent
  Weight of issue = weight of issue – (Time of issue/length of time issue)
  Time of issue++

Reaction of agent can be stated by the increase of dishonest degree of behavior.

At the third model, we can make the authority for this distribution system. The authority model that had been building is the model of Meta norm game with central authority [2]. Then Meta-norm gaming model with central authority could bee see in Figure 4.

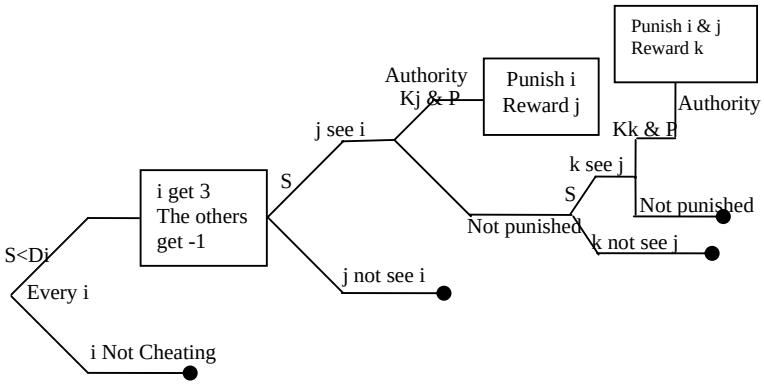


Figure 4 Meta-Norma Gaming with Authority Existence

In Figure 4, punishment that being given and reward for them who informed actors who did dishonesty was influenced by central authority careness factor and sanction and reward that been given also being determined by central authority. Individual strategy in this model is support and trust that have degree of $[0/7,7/7]$. The higher individual support level the more large its willingness to do attitude A and more higher individual degree of trust more large its willingness to report dishonesty that been seen (toward B attitude). This strategy will be generating randomly.

4. Simulation Result

In this part, we will present our simulation from the third model what had been done. Our simulation is use JAVA program. This simulation had been appear the issues event to look the performance of system for each scenario.

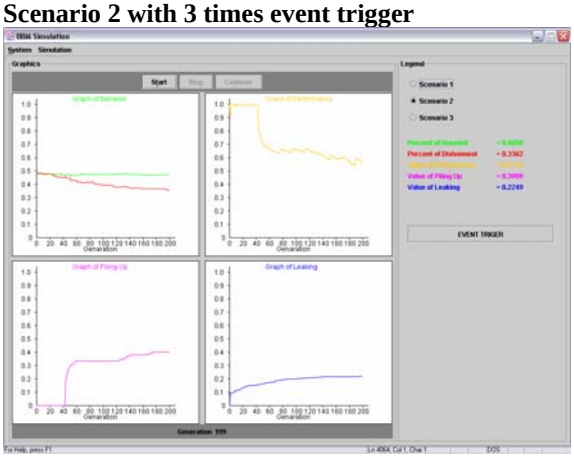
Scenario 1

At scenario 1, we could see that the process of distribution is run stable. It caused by the distribution path was good and there's no internal influence and external influence at this system so the performance of this system is not annoyed.

Scenario 2 without event trigger

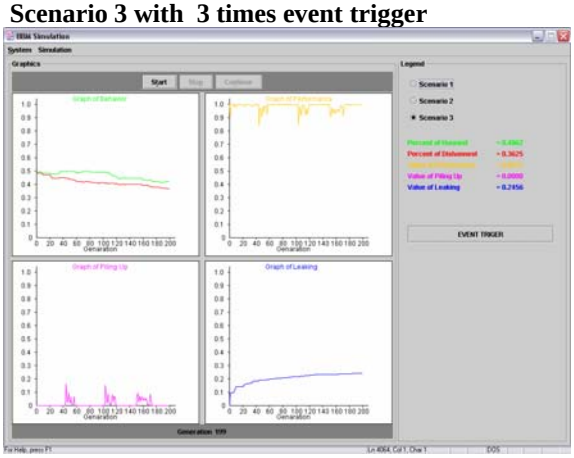
At scenario 2 without event trigger, we could see that there is an illegal transaction, but it's the rare event . It caused by the dishonest degree is lower than honest degree. The performance of system is less annoyed.

Scenario 2 with 3 times event trigger



At scenario 2 with 3 times event trigger, there is 3 issue (we generate 3 times), It could be seen that there is accumulate event and illegal transaction that cause the performance system decrease. It could be seen that, even thought honest degree of agent is higher than dishonest degree, the existence of issue could give the large influence for agent to act dishonest.

Scenario 3 with 3 times event trigger



At scenario 3 with 3 times event trigger, there is 3 issues (we generate 3 times), it could be seen that the accumulate event and illegal transaction could eradicate, so the performance of system could be increase again.

5. Conclusion

From the result of simulation, it could be seen that distribution path will annoyed if there is an emerge event (issues) which trigger the desire of agent to do an illegal transaction and arrest the distribution (accumulating a fuel). The existence of authority to distribution system is very useful for taking care for the system performance. In this model, event trigger is represent the influence for external factors such as the raise price of fuel, illegal fuel, shortage of fuel, the accumulate of fuel and the other factors which have the character of fret society, so it couldn't analyzed like what external factor that influence to behavior of agent. The next research will discuss about it.

6. Reference

[1]. Putro, Utomo Sarjono, (2000), Adaptive Learning of Hypergame Situations Using a Genetic Algorithm, IEEE Transactions on Systems.

[2]. Putro, Utomo Sarjono, (2005), Agent Based Simulation for Norm Enforcement, Proceeding of National Seminar on Modeling.

[3]. Axelrod, Robert. (1997). The Complexity of Cooperation. Agent-Based Models Of Competition And Collaboration, Princeton University Press, Princeton, New Jersey.

[4]. Antara News, The Organization of Asia Pacific News Agencies, "RI Navy Seizes Illegal Fuel Oil from China", 26 January 2006.

[5]. Asian Development Bank. 2005. "International Fuel Prices, The Challenge of High Oil Prices", Asian Development Outlook 2005 Update. Manila.

[6]. Oil and Gas in Indonesia.