OPEN ACCESS Asian Journal of Scientific Research

ISSN 1992-1454
DOI: 10.3923/ajsr.2017.

Research Article

Improved Methodology in Risk Analysis with Stochastic Simulation for Termination of Indonesia's Fuel Subsidy

[1]Adinda Yuanita, [2]Andy Noorsaman Sommeng and [1]Anondho Wijanarko

[1]Department of Chemical Engineering, University of Indonesia, Jalan Kampus UI, Kukusan, Depok, Kota Depok, 16424 Jawa Barat, Indonesia
[2]Directorate General of Electricity, Ministry of Energy and Mineral Resources, Indonesia. Jl. H.R. Rasuna Said, Blok X 2, Kav. 7-8, Kuningan, 12950 Jakarta, Indonesia

Abstract

Background and Objective: The Indonesian fuel oil supply chain system is a complex system influenced by probabilities and uncertainties. This study intends to solve issues in Supply Chain Risk Management (SCRM) in a complex Indonesian fuel system through investigating variables in multivariate data and risk management framework, as well as to develop new market structure potential. **Materials and Methods:** The study offers a stochastic optimisation simulation based on Monte Carlo sampling and a risk-based compliance audit on the existing system of Supply Chain Risk Management (SCRM) using a state-of-the-art FIRST (Fairness, Independent, Reliable, Sustainable, Transparent) likelihood factor. This is combined with sensitivity analysis, where risk measures are determined pursuant to non-metric data as indicator variables of consequences factors using focus group discussion mechanism multivariate data analysis. **Results:** The result of this research showed that Monte Carlo simulation-based methods for stochastic optimisation of risk measures, supported by FIRST new variables as likelihood factor, can produce a level of priority that represents new integrated risk mitigation solution. It allows integrated and measured investigation and problem solving of complex system, such as security of a subsidised fuel supply in Indonesia and identification of other potential risks in supply chain risk management for market structure development. **Conclusion:** This study provides a theoretical and practical contribution to the use of Monte Carlo sampling in simulation optimisation of risk measures by formulating new likelihood factors. Subsequently, risk analysis can be performed because of repeated simulated correlation in optimisation (cross-entropy), which is useful for researchers as well as practitioner.

Key words: Fuel oil, supply chain, subsidy, FIRST factor, stochastic simulation

Received: Accepted: Published:

Citation: Adinda Yuanita, Andy Noorsaman Sommeng and Anondho Wijanarko, 2017. Improved methodology in risk analysis with stochastic simulation for termination of Indonesia's fuel subsidy. Asian J. Sci. Res., CC: CC-CC.

Corresponding Author: Adinda Yuanita, Department of Chemical Engineering, University of Indonesia, Jalan Kampus UI, Kukusan, Depok, Kota Depok, 16424 Jawa Barat, Indonesia Tel: +62818111210

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The ability to produce and store fuel oil in Indonesia is still very poor compared with the needs of the population. Hence, Indonesia currently relies heavily on imported fuel oil. Indonesia, a country with more than 17,000 Islands and 250 million people, is heavily dependent upon the availability of fuel oil as the driving force of its economic activity, transportation, electricity and military[1]. Any disruption in the supply chain of fuel oil in Indonesia has a significant impact. The fuel oil supply chain in Indonesia is very complex due to several factors, such as declining domestic production capacity of crude oil, the procurement of imported fuel oil and crude oil and distribution challenges in an archipelago system. In addition to that, inefficient refineries, lack of storage capabilities, the subsidy mechanism and world oil price fluctuations as well as regulations are also some other factors that influences the disruption of the fuel oil supply chain. To improve the fuel oil supply chain in Indonesia, practitioners and policymakers must deal with uncertainty and a vast number of variables in fuel oil distribution to create an integrated solution model with proper mitigation priorities[2]. Due to the complexity of the issue as well as considerably high probability and uncertainty heavily affecting this research, the Monte Carlo sampling-based stochastic simulation method in the risk analysis framework is used as it is the most reliable practice. The state-of-the-art FIRST factor's value resulting from Focus-Group Discussion (FGD) combined with the sensitivity analysis determines the priority of integrated risk mitigation handling. Therefore, implication of the new model design will result in a faster risk mitigation time.

The fuel oil distribution chain in Indonesia is regulated by the government of Indonesia through the Downstream Oil and Gas Regulatory Agency as a regulator and state-owned enterprise as the main operator. Primarily, the fuel oil supply chain in Indonesia is divided into four Commercial Distribution Areas (CDAs) that serve the Indonesian regions as shown in Fig. 1. CDA I covers Sumatera and surrounding areas, CDA II covers the Islands of Java, Bali, Madura and surrounding areas, CDA III includes the Islands of Kalimantan, Sulawesi, Maluku, Papua and surrounding areas and CDA IV covers the Nusa Tenggara Islands. The four CDAs serve around 70 million kilo litres per year, or 1.2 million barrels per day of fuel oil distribution, to serve the nationwide needs, according to data from the Downstream Oil and Gas Regulatory Agency[1]. The types of fuel oil distributed are subsidised fuel oil: RON 88, diesel, kerosene[3] and non-subsidised fuel oil: RON 90, 92, 94 and Avtur. The highest consumption of fuel oil is RON 88 or premium for the transportation sector, amounting to around 53% of the overall daily national consumption[1].

The infrastructure of fuel oil distribution, such as production facilities, refineries, storage capacity, transportation and filling station facilities, Indonesia is deficient. The capacity of Indonesia's crude oil production is below 800,000 barrels per day and some of the total production is not usable for domestic needs due to the differences in Indonesia's refinery input specifications. Ten refineries have total processing capacities of 1.15 million barrels of crude oil per day and process 635,000 barrels of domestic oil with a total output of 680,000 barrels of fuel oil per day[4]. To meet national demands for fuel oil, Indonesia imports both crude oil and fuel oil. Imports of fuel oil are equivalent to 500,000 barrels per day. Indonesia's fuel oil storage capacity is around 8.3 million kilolitres, including both state-owned and privately-owned enterprises, according to the Downstream Oil and Gas Regulatory Agency in 2017. If the

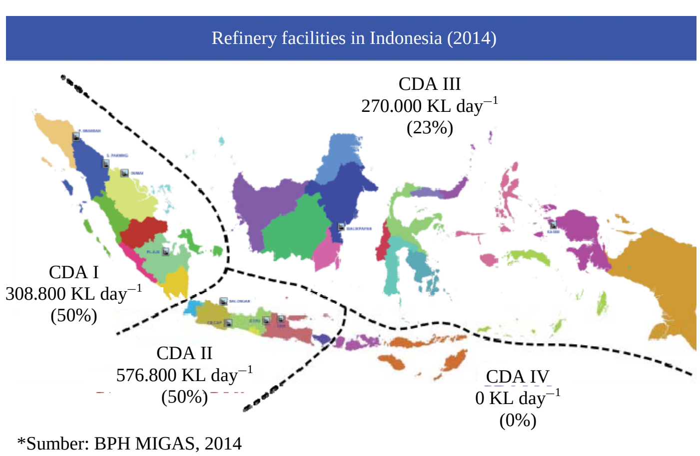

Fig. 1: Refinery facilities and commercial distribution area

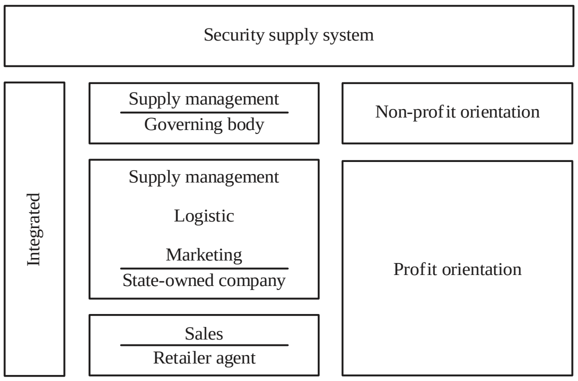

Fig. 2: Security supply system

average realisation of fuel oil in 2011-2015 is divided by the storage capacity, then Indonesia has only 40 days of energy security[4]. The greatest storage capacity exists on Java and Bali, because these areas have the highest fuel oil consumption. Indonesia owns 1,530 land transportation storage facilities and 403 tanker fuel storage units[4]. The total capacity of the land transport facilities is 22,884 kilolitres and the total capacity of sea transport facilities is 1,841,175 kilolitres[5]. Filling stations in Indonesia are dominantly owned by state-owned enterprises with 6,894 stations in both inland and shore areas[5]. Private and foreign companies, such as Total, Shell, AKRA and Petronas, have dozens of filling station, but these are only on Jakarta and Bandung and only distribute non-subsidised fuel oil. The fuel oil is distributed and transported by land trucks, ship tankers, airplanes or combinations of transport methods.

The government of Indonesia has authority to determine and maintain the price of fuel oil for the welfare of Indonesia's people. It provides subsidies for fuel oil, regulated by law, to sell it at a price lower than the procurement cost. The targets of fuel oil subsidies are poor people, who need fuel oil to reduce their economic burden, like fishermen. Subsidised fuel oil products include diesel, kerosene and RON 88[3]. The selling price of fuel oil in Indonesia is based on the Mean of Platts Singapore (MOPS) price index, plus the cost of storage, distribution, transportation and dealer margins, as well as surcharges and taxes reduced by the subsidy.

The initial observations of an examination of the fuel oil distribution system in Indonesia are as follows[2]:

- There are differences in profit and non-profit orientation between supply management and supply facilities. Therefore, an integrated system is needed to solve the issue as shown in Fig. 2
- There is no parameter of success that can indicate a balance between fuel oil selling quotas and realisations. Therefore, control and monitoring systems are needed so that there is a balance of the time of distribution, volume of realisation and target consumers as shown in Fig. 3
- There is no standard and continuous compliance audit system to measure the supervision of fuel oil distribution system in Indonesia. Figure 4 shows an example of a comprehensive annual compliance audit system in a supply chain system
- There are uncollaborated laws between multiple relevant stakeholders, as shown in Fig. 5. These,

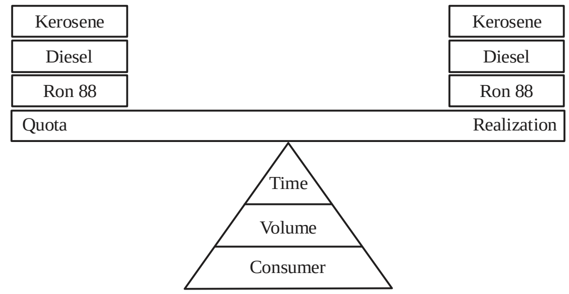

Fig. 3: Balance between quota and realization

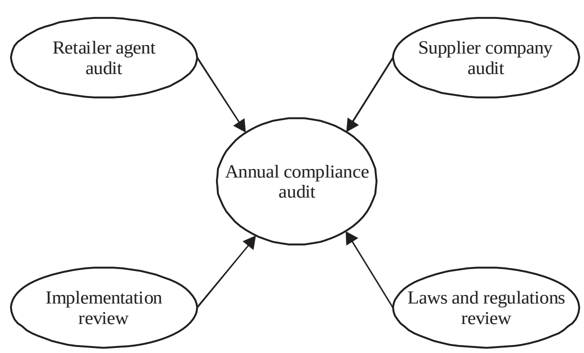

Fig. 4: Annual compliance audit in supply chain system

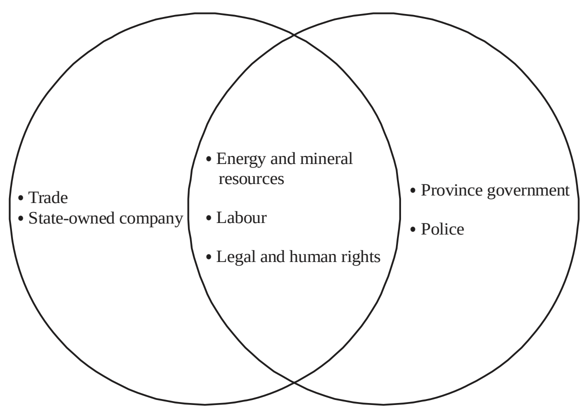

Fig. 5: Fuel oil stakeholders

indeed, could be synergised to supervise a fuel oil distribution system at the regional, provincial and national levels

Based on these initial observations, this research aims to provide an assessment framework for a fuel oil distribution system in Indonesia, that incorporates the vast number of uncertain variables and components, through Supply Chain Risk Management (SCRM). Risk analysis examines the risks as products of the occurrence probability and consequences from the failure of an activity[1]. Therefore, SCRM[6] can quickly perform risk analysis and offer mitigation when there is a change in the supply chain system, so that the availability of supply is not interrupted. The application of a SCRM system on Indonesia's fuel oil system is expected to give an assessment of the existing systems and regulations on the fuel oil distribution, based on the risks involved. Hence, this process that will create a sustainable supply chain management system that is able to maintain the prosperity of economy, the environment and social welfare[7]. Therefore, the output of this research has the potential to help millions of Indonesian people and support the country's economic condition by proscribing an excellent fuel oil monitoring system. It also has scholarly benefits, with a contribution of new research.

This study proposes to solve the problems in Indonesia's current fuel oil distribution and improve the system using SCRM methods, providing mitigation priorities.

MATERIALS AND METHODS

Risk analysis on the SCRM of fuel oil assesses the risk (R) of an event in the supply chain by measuring the probability (F) and consequence (C) factors with the research method conducted qualitatively and quantitatively as shown in Fig. 6. Regulations and legislation govern the supply chain of fuel oil implementation mechanism; thus, the measurement of the probability (possibility of irregularity occurrence) can use articles in the legislation as indicator variables (Fj. n), while consequence factors (Cm. n), in case of irregularity in the supply chain, use the results of the study regarding the impacts of irregularities in the implementation of fuel oil provision.

An initial risk assessment from CDA was conducted using a bivariate correlation analysis method as an initial framework for research. The factors that determine the four CDAs are the levels of consumption or sales of fuel oil, population density, distribution costs and the availability of infrastructure. Therefore, the equation to determine

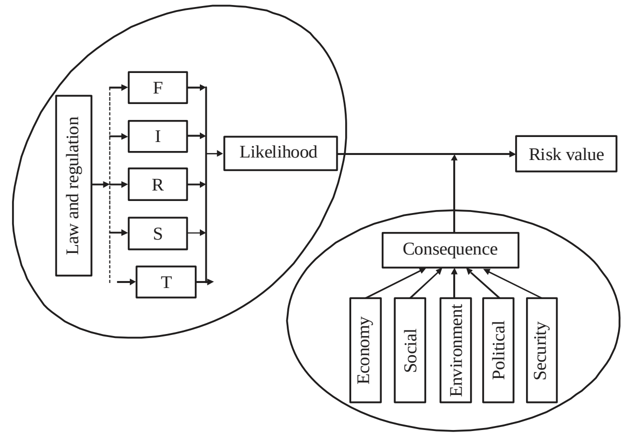

Fig. 6: Risk value calculation and assessment based on likelihood and consequences

overall risk value obtained is the risk value per CDA (Rw). So, Rj = Rw. To undertake risk mitigation throughout the risk arising in Indonesia, it is necessary to formulate priority levels to identify the highest to the lowest values of risk, in order to set the priority of mitigation plans. The formulation of priority levels that affect risk is influenced by variables based on government regulations regarding the CDA.

Risk analysis optimisation of fuel oil distribution in Indonesia, which is influenced by uncertainty and probability, can only be performed by stochastic optimisation[8-10], using Monte Carlo sampling in the risk analysis framework: "FIRST". FIRST is an abbreviation encompassing (F1), Independent (F2), Reliable (F3), Sustainable (F4) and Transparent (F5) factors. The FIRST[2] concept presented by this researcher is an assessment and monitoring framework for fuel oil distribution in Indonesia. The concept was developed because the fuel oil distribution should be fair and targeted to the consumer in need, free of conflicts of interest in the procurement process and distribution, reliable to the consumer, with availability assured and have all processes and information related to subsidies and pricing openly published and transparent.

After obtaining the optimisation results, sensitivity analysis is conducted to give mitigation priority to the problem in Indonesia's fuel oil distribution, so an optimal market structure for fuel oil can be formed.

Statistical analysis: This study used multivariate data analysis to model the fuel oil system. The methods used were factor analysis to identify correlated variables in one factor, discriminant analysis to identify and distribute independent variables and dependent variables[2].

Table 1: Index priority calculation

Variable	CDA I	II	III	IV
K	308,800	576,800	270,000	0
D	837,881	1,650,562	913,300	80,959
S	1,468	3,414	1,308	148
H	50,630,931	140,501,347	38,286,644	9,432,302
B	480,793	135,219	1,170,265	67,290
Pw	0.006	0.004	0.007	0
Gw	105.307	1,039.065	32.716	140.174
Rw	327.516	39.607	894.698	454.662
Iw	0.017	0.012	0.024	0.009

Table 2: Percentage of index priority

Variable	CDA (%) I	II	III	IV
K	27	50	23	0
D	24	47	26	2
S	23	54	21	2
H	21	59	16	4
B	26	7	63	4
Pw	22	25	20	33
Gw	31	7	33	30
Rw	27	33	16	25
Iw	24	27	20	29
Qw	26	23	22	29

K: Refinery capacity (L), D: Storage capacity (L), S: Dealer number, H: Population, B: Luas wilayah (m^2), Pw: Sales index, Gw: Population density index, Rw: Distribution cost index, Iw: Infrastructure index and Qw: Average index

RESULTS AND DISCUSSION

Bivariate correlations: In Table 1 and 2, it appears that the current division of CDA into four regions is appropriate. The ratios shown are balanced when comparing refinery capacity, storage capacity, number of dealers and population in each CDA. Meanwhile, when looking at the size of the CDA region, it appears that CDA III is very wide and unbalanced, with a population that results in a very high distribution cost in CDA III. The priority index value of the regional area and the high distribution index in CDA III distributed the average number of the priority index (Qw3) to the lowest (22%), meaning that CDA III has a high potential of risk. The amount of Pw3 means that the magnitude of potential abuse of fuel oil distribution exists.

Priority index is different from risk value. The priority index paradigm is when the variable sales level is high, meaning the area has a small risk, so that the priority of improvement or mitigation becomes low. In the distribution charts shown in Fig. 7, it is seen that the CDA determinant variable is unbalanced, so there are many irregularities or deviations. Meanwhile, on the deviation value, based on the priority index, the CDA with the highest deviation value is CDA IV, followed by CDA III, CDA II and CDA I.

Table 3: Results of risk simulation of CDA I

CDA I	R1	R2	R3	R4	R5	WR
Trials	10^6	10^6	10^6	10^6	10^6	10^6
Base case	12.81	8.66	7.09	8.07	6.37	9.45
Mean	6.92	5.49	6.55	6.18	5.30	6.33
Median	6.88	5.45	6.50	6.15	5.26	6.33
Standard deviation	0.35	0.53	0.38	0.57	0.53	0.21
Variance	0.12	0.29	0.15	0.33	0.29	0.04
Skewness	0.40	0.32	0.42	0.29	0.33	0.18
Kurtosis	2.66	2.78	2.53	2.82	2.77	2.93
Coefficient of variability	0.05	0.10	0.06	0.09	0.10	0.03
Minimum	6.00	3.95	5.55	4.53	3.82	5.52
Maximum	8.42	7.86	7.88	8.76	7.76	7.43
Range width	2.41	3.91	2.32	4.23	3.93	1.90
Mean std. error	0.00	0.00	0.00	0.00	0.00	0.00

Table 4: Results of risk simulation of CDA II

CDA II	R1	R2	R3	R4	R5	WR
Trials	10^6	10^6	10^6	10^6	10^6	10^6
Base case	11.9	12.46	6.25	8.02	7.86	9.4
Mean	6.42	5.58	6.17	6.24	5.39	6.12
Median	6.4	5.54	6.16	6.21	5.33	6.11
Standard deviation	0.27	0.33	0.22	0.39	0.49	0.15
Variance	0.07	0.11	0.05	0.16	0.24	0.02
Skewness	0.38	0.43	0.26	0.36	0.43	0.19
Kurtosis	2.71	2.58	2.72	2.75	2.61	2.93
Coefficient of variability	0.04	0.06	0.04	0.06	0.09	0.02
Minimum	5.72	4.62	5.51	5.13	4.03	5.55
Maximum	7.52	6.86	7.01	7.88	7.35	6.88
Range width	1.80	2.24	1.50	2.75	3.33	1.32
Mean std. error	0.00	0.00	0.00	0.00	0.00	0.00

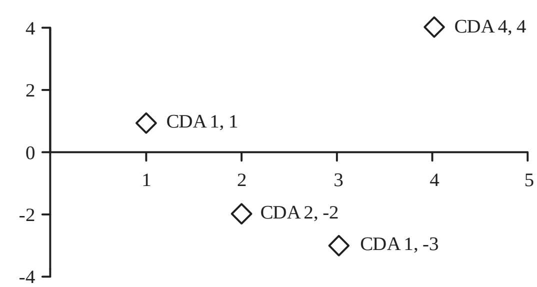

Fig. 7: Deviation per Commercial Distribution Area (CDA)

Crude monte carlo simulation: In order to simulate the risk value distribution of Supply Chain Risk Management (SCRM) of fuel oil, we used the Monte Carlo method with an 85% confidence level, continuous decision-making and forecast determination with 95% precision and an absolute unit of 0.05. This distribution simulation was repeated as much as possible, so that accuracy is increasingly guaranteed. Therefore, in this risk analysis, the simulation was performed one million times. Table 3-6 show the risk simulation results with the Monte Carlo method for each CDA.

Table 5: Results of risk simulation of CDA III

CDA III	R1	R2	R3	R4	R5	WR
Trials 10^6	10^6	10^6	10^6	10^6	10^6	
Base case	12.81	8.66	7.09	8.70	6.37	9.45
Mean 6.92	5.49	6.55	6.18	5.30	6.33	
Median	6.88	5.45	6.50	6.15	5.26	6.33
Standard deviation	0.35	0.53	0.38	0.57	0.53	0.21
Variance	0.12	0.29	0.15	0.33	0.29	0.04
Skewness	0.40	0.32	0.42	0.29	0.33	0.18
Kurtosis	2.66	2.78	2.53	2.82	2.77	2.93
Coefficient of variability	0.05	0.10	0.06	0.09	0.10	0.03
Minimum	6.00	3.95	5.55	4.53	3.82	5.52
Maximum	8.42	7.86	7.88	8.76	7.76	7.43
Range width	2.41	3.91	2.32	4.23	3.93	1.90
Mean std. error	0.00	0.00	0.00	0.00	0.00	0.00

Table 6: Results of risk simulation of CDA IV

CDA IV	R1	R2	R3	R4	R5	WR
Trials 10^6	10^6	10^6	10^6	10^6	10^6	
Base case	12.81	12.24	7.09	9.62	6.89	10.11
Mean 6.83	5.65	6.47	5.71	5.45	6.22	
Median	6.88	5.61	6.41	5.68	5.43	6.21
Standard deviation	0.3	0.33	0.41	0.44	0.39	0.18
Variance	0.09	0.11	0.16	0.2	0.16	0.03
Skewness	0.36	0.42	0.47	0.34	0.27	0.19
Kurtosis	2.72	2.59	2.53	2.74	2.84	2.91
Coefficient of variability	0.04	0.06	0.06	0.08	0.07	0.03
Minimum	6.00	4.62	5.51	4.45	4.08	5.55
Maximum	8.14	6.99	7.9	7.77	7.34	7.11
Range width	2.14	2.38	2.40	3.31	3.26	1.56
Mean std. error	0.00	0.00	0.00	0.00	0.00	0.00

Table 7: Comparison of risk value and average of index priority

	CDA				
Variable	1	2	3	4	Metric
Fairness (R1)	6.84	6.71	7.31	7.16	N
Independent (R2)	5.96	5.96	6.06	6.02	N
Reliable (R3)	6.41	6.4	6.99	6.94	N
Sustainable (R4)	6.4	6.67	6.79	6.20	N
Transparent (R5)	5.99	5.94	5.94	5.87	N
Avg. risk value (Rw)	6.26	6.27	6.55	6.40	

Table 8: Risk mitigation probability factor

		Level of priority (L)					
CAT	NO	Rw1	Rw2	Rw3	Rw4	L(fj)n	L(fj)n (%)
F	1	7.03	5.81			12.84	20
	2			6.82	4.50	11.32	18
I	3	1.10	1.34	1.31	0.77	4.43	7
R	4	1.28	1.64	4.26	5.12	12.29	19
S	5	3.97	5.23			9.21	14
	6			4.05	4.28	8.33	13
T	7	0.99	2.89			3.88	6
	8			1.25	0.66	1.85	3

Formulation of risk mitigation priority level: In the Table 7, the results of the simulated risk analysis graph show the problem in each CDA through the value of the risk obtained. The priority of the risk value in each CDA needs to be formulated to rank the highest to the lowest risk value, in order to prioritise the mitigation plans.

Risk mitigation priority level: Factors affecting the priority (L)[2] determination of the risk value to be mitigated include the risk value of each CDA (Rwt), the sensitivity level of $S_{w.t(Fj.n)}$ (%) and the priority index value of each CDA $Q_{w.t}$ (%) formulated in the level of priority equation per probability factor (priority level) as shown in Eq. 1. There are several probability factors with high sensitivity percentage levels, indicating that mitigation is needed to reduce the value at risk. Therefore, it is necessary to determine the priority of the risk value that has to be immediately mitigated, in order to rank the risk value that will be spread over each CDA:

$$L_{fj.n} = \sum L_{wt(Fj.n)} = \sum \frac{S_{w.t(Fj.n)}(\%) x R_{w.t}}{Q_{w.t}(\%)} \quad (1)$$

Based on the Eq. 1[2] to determine the priority level ($L_{f\,j.n}$), the percentage of the priority of each risk value of probability factor of $L_{f\,j.n}$ (%) that needed to be mitigated was obtained. Therefore, in accordance with the principle of Supply Chain Risk Management (SCRM), the risk values can be prioritised to be efficiently and effectively mitigated according to the level of importance. Equation 2 is used to determine the priority levels:

$$L_{fj.n}(\%) = \frac{(L_{fj.n}) \times 100\%}{\sum L_{fj.n}} \quad (2)$$

Mitigation plan determination according to priority levels: After calculating the priority level of each probability factor in which the risk value was high enough to require mitigation, next, based on the equation of priority level with the sensitivity value variable, the region risk value and priority index, mapping of the priority level and the risk value was obtained. The level of priority of the mitigation factors are rearranged with the higher percentages ranked as higher priority as shown in Table 8-9 and Fig. 8.

Levels of priority: Based on the stochastic simulation results, the risk mitigation priority level to solve fuel oil supply chain problems in Indonesia was obtained. Below are the associated problems that exist in each priority level.

Determination of volume allocation of subsidised fuel oil for transportation: The government of Indonesia gives fuel oil subsidies so Indonesian people can have access to energy at affordable prices and ease the overall economy. However, the

Table 9: Level of priority per probability factor

Factor probability	Rank
Determination of volume allocation of subsidized fuel oil for transportation	1
The scheduling time for fuel oil subsidy distribution to the fishermen	3
Control of fuel oil provision, distribution and transportation facilities for business entities	6
High distribution costs due to Commercial Distribution Area (WDN) determination for subsidized fuel oil	2
Realization of user control of subsidized fuel oil at the dealer or filling station	4
Limited facilities for transportation and storage of fuel oil facilities	5
Socialization of economic price vs subsidy	7
Socialization on the supervision and control of certain types of fuel oil	8

Table 10: Indonesia budget 2005-2014[12]

Year	Capex (Trillion IDR)	Subsidy (Trillion IDR)	Portion (%)
2005	32.88	95.59	290.72
2006	54.95	64.21	116.85
2007	64.28	83.79	130.35
2008	72.77	139.10	191.15
2009	75.87	45.03	59.35
2010	80.28	82.35	102.38
2011	117.85	165.16	140.14
2012	145.10	211.87	146.02
2013	180.86	209.99	116.11
2014	229.50	249.49	108.71
Avg	105.43	134.65	140.20

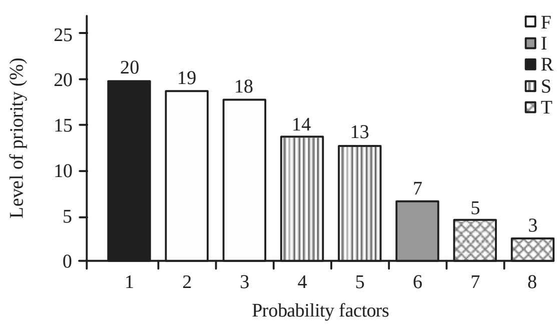

Fig. 8: Level of priority in mitigation plan with FIRST category, F: Fairnes, I: Independent, R: Reliable, S: Sustainable, T: Transparent

fuel oil subsidy budget expenses have been a burden on Indonesia's fiscal capacity for capital expenditures for things like infrastructure, health and education. Subsidy pay outs peaked in 2014 with 250 trillion rupiahs[11] and have been averaging 140% of capital expenditures during year 2005-2014[12], as shown in Table 10. The implementation of subsidies is not reaching the intended recipients, poor people and is more likely to be enjoyed by wealthier people. The data showed that 53%[13] of fuel oil subsidy allocations are enjoyed by private vehicle users, which means that the subsidy benefits the upper middle class.

Scheduling time for fuel oil subsidy distribution to fishermen: According to the Presidential Instruction No. 15 Year of 2011, the Minister of Energy and Mineral Resources should facilitate the availability of fuel oil subsidy for fishermen. Statistics show[13] that there are 7.87 million poor fishermen in Indonesia, or approximately 25.14% of the total poor national population of 31.02 million people. Fishermen are very dependent upon fuel oil for sailing and fishing as their main income. Fuel oil is the biggest component in the operating expenses for fishermen, so higher fuel oil prices will directly reduce to their income.

The realisation of subsidised fuel oil distribution to fishermen is much lower when viewed from the national consumption and realisation data in 2014, in which it only reached 65%[4]. This is due to several reasons, such as: The subsidised fuel oil requirement data are not well calculated and predicted, fuel oil distribution is not in time with the fishing season, the administrative procedures for fishermen to obtain subsidised fuel oil from related agencies are complicated, there is abuse of subsidised fuel oil usage by industries and ships that should not be subsidised, fishermen not staying in one location because of the catch season, making the fuel oil consumption vary by area and the inability for fishermen to use credit at authorised filing stations and thereby using unauthorised dealers where data is not recorded[14].

High distribution costs due to Commercial Distribution Area (CDA) determination for subsidised fuel oil: Distribution patterns and modes in commercial distribution areas are not yet optimal in distributing fuel oil in Indonesia. The distribution costs for certain CDAs are still very expensive; for instance, the Papua area has been selling fuel oil at a price of around five times[14] the retail price set by the government. Inadequate road infrastructure causes expensive transportation modes like airplanes to be used to distribute fuel oil to filling stations. This causes the prices paid by Indonesian people to be different and higher than the sale price set by the government.

Realisation of user control of subsidised fuel oil at the dealer or filling station: The government of Indonesia has made various policies to supervise and control subsidised fuel oil distribution to reach the correct target, poor people. The programmes and policies are based on the Regulation of the Minister of Energy and Mineral Resources No. 12 Year of 2012 and No. 1 Year of 2013. The programmes and policies include the RFID programme[14], the Fishermen Card programme[14] and the termination of subsidised fuel oil distribution in certain places. These, however, have not been effective, because the programme has not been able to control and monitor the distribution of subsidised fuel oil.

Limited facilities for transportation and storage of fuel oil: The capacity of fuel oil storage tank facilities throughout all areas in Indonesia is quite alarming because the current facilities can only store less than 40 days of fuel oil consumption[5]. In addition, the facilities are not spread evenly throughout all areas in Indonesia. It is the same with transportation facilities, which are very limited. In case of a long disruption in supply or an emergency, Indonesia would quickly lack reserves to cover national fuel oil demands.

Control of fuel oil provision, distribution and transportation facilities for business entities: The problems that exist in the distribution and procurement of fuel oil are as follows. First is the inadequate production capacity of refineries in Indonesia, which can only produce about 50% of the national fuel oil demand[5]. The crude oil type that can be processed is also limited, due to the age of the refineries. There have been no big investments to build new refineries to reduce fuel oil imports. Second, filling stations availability is concentrated in western Indonesia, especially in Jakarta, Java and Sumatra. Eastern Indonesia is severely lacking in filling stations. The authorised shore filling facilities for fishermen are very limited, as well. Third, state-owned enterprises sell subsidised fuel oil with lower specifications and price quite cheaper than the price of non-subsidised fuel sold by private or foreign entities[15]. Therefore, private and foreign business entities cannot compete and further investment.

Communication of economical price versus subsidy: Socialisation of economical prices and subsidies should be regularly explained because governments often adjust prices for both subsidised and non-subsidised fuel oil based on world market oil prices. The socialisation of fuel oil prices is expected to create transparency and good governance. Moreover, all citizens in all over Indonesian areas will be aware of the adjustment prices and use the new prices immediately. The socialisation programme seems to be less successful because the programme to have a single fuel oil price throughout the Indonesia has not been fully implemented in all areas.

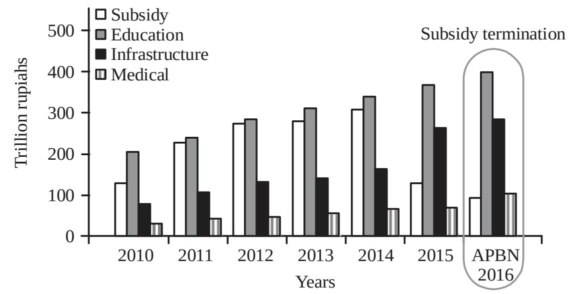

Fig. 9: Indonesia budget 2010-2016

Socialisation on the supervision and control of certain types of fuel oil: The efforts by the government to monitor and control the use of fuel oil subsidies are very poor, proven by the inefficiency, or outright failure of the RFID programme and fuel cards for fishermen and the incomplete implementation of the single price programme.

Termination of fuel oil subsidies: In accordance with the recommendations provided by the research on the main priority of mitigating fuel oil distribution issues, the Indonesian government terminated its fuel oil subsidy for RON 88, or premium and provided a fixed subsidy of Rp 1,000 for diesel, through Presidential Decree 141 Year of 2014. The fixed subsidy for diesel became Rp 500 on July 1, 2016 and this caused the fuel oil subsidy budget for 2015 and 2016 to fall to 60% of the average fuel subsidy budget and increase the budget for infrastructure and education expenditures by two fold as shown in Fig. 9. These policies taken by the Indonesian government are appropriate because the fuel subsidy has never been well targeted and tends to be misused for private car consumption by middle class people, rather than the poor, who are the main target of the subsidy.

The FIRST simulation revealed that the main priority of fuel oil distribution mitigation is the allocation of subsidised fuel oil volumes in accordance with the fuel oil subsidy termination policy by the government. The move is appropriate, due to an increased capital expenditure budget; in this way, other priority issues have a budget for completion. The increased budgets from transferred subsidy budgets can be used to solve other priorities, such as infrastructure development. This can reduce distribution costs, increase and revitalise refinery facilities in Indonesia, spur construction of more land filling stations, shore filling stations for fishermen and oil storage facilities.

Improvement in market structure of Indonesia's fuel oil: The termination of the subsidy programme has resulted in the

Indonesian government's improvement of Indonesia's fuel oil market structure. The improvements in market structure refer to the main objectives of the international standards framework and Indonesia's national energy policy. The international framework for energy is based on the "Four As"[16]: availability or sufficient supplies for 90 days by EIA Standard; accessibility to fuel oil supplies; affordability, or affordable fuel oil prices and acceptability of policies that can be financially, environmentally and legally accepted.

Indonesia's National Framework for fuel oil is meant to ensure fuel oil is available to be used as development capital, to reduce crude oil exports to meet domestic needs and to fully eliminate subsidies. To achieve the objectives of the framework, a suitable fuel oil market structure[17] must be able to maintain the availability of fuel oil supplies through diversification of suppliers, have reserves or stock of fuel oil in case of emergency, maintain the stability of the domestic market structure of fuel oil and have accessible information about world fuel oil stock availability and prices.

Recommendations given for Indonesia's fuel oil market structure by the researchers to conform to the international and national energy framework

Availability: Revitalise old refineries and build more oil refinery facilities so that Indonesia is capable of producing crude oil of all specification types, thus being able to produce oil domestically and reduce the import of crude oil as well as increasing diversification of supplies from different sources. Increase the number of storage facilities in Indonesia by 2-3 times of current ability from a 40 day supply to a minimum of a 90 days supply based on yearly national oil consumption. Construct more fuel oil and crude oil storage facilities and add filling stations in Eastern Indonesia and other underdeveloped areas so that Indonesia's economy can be evenly improved. Totally remove RON 88 or premium from the market, which is not on sale in the world fuel oil market so the availability or supply is maintained.

Accessability: Evenly develop land infrastructure in underdeveloped areas to reduce the distribution costs and to create more fuel oil access. Ensure consistency on fuel oil delivery schedules to remote areas. Construct fuel oil filling stations on land as well as shoreline filling stations for fishermen and communities so that they can buy cheaper fuel oil with economical or regulated prices. Fix distribution costs and sales margins schemes for remote areas so fuel oil can be delivered by business entities with economical prices for customers.

Affordability: Improve the market price structure mechanism that depends upon the Mean of Platts Singapore market by using another benchmark price, causing imported fuel oil to be purchased at a better price. Implement a single fuel oil price programme more intensely to rural and underdeveloped area.

Acceptability: Remove RON 88, which is worse in emissions compared to higher RON for better environmental impacts.

CONCLUSION

The complex problems with uncertain variables can be solved with risk analysis, using the supply chain risk management method optimised with stochastic simulation. This research has shown that the main mitigation priority of fuel oil distribution problem in Indonesia is subsidy, so the termination of fuel oil subsidies by the government is an appropriate policy. The formation of a new market structure for Indonesia's fuel oil must have the same principles as the national and international energy security framework.

SIGNIFICANCE STATEMENT

This study discovers the benefit of stochastic simulation optimisation in risk analysis with FIRST factor for a decision-making process that can be beneficial for both practitioners and researchers. This study will help researchers to uncover the critical areas of risk management simulation that many prior researchers were not able to explore. Thus, a new theory on risk measures may be found.

REFERENCES

1. Badan Pengkajian dan Penerapan Teknologi, 2016. Indonesia Energy Outlook 2016. 1st Edn., Pusat Teknologi Sumber Daya Energi dan Industri Kimia, Indonesia, ISBN: 978-602-74702-0-0.
2. Yuanita, A., 2012. Risk analysis study based on NFPA59A-2009 and ISO 31000 framework for utilization of Arun LNG plant facility as LNG receiving terminal and regasification facility. Master's Thesis, Faculty of Engineering, University of Indonesia.
3. GOI., 2004. Government regulations No. 36 year 2004 on downstream and natural gas business activity. Government of Indonesia (GOI), Indonesia. http://jdih.bphmigas.go.id/files/2015/10/PP_No_36_2004_Tentang_Kegiatan_Usaha_Hilir_Minyak_dan_Gas_Bu.pdf.

4. DGOG., 2015. Statistics oil and gas. Directorate General of Oil and Gas (DGOG), Ministry of Energy and Mineral Resources, Jakarta, Indonesia.
5. BPH Migas, 2017. Statistical data of Indonesian fuel oil. BPH Migas, Jakarta, Indonesia.
6. MIT., 2013. PwC and the MIT forum for supply chain innovation: Making the right risk decisions to strengthen operations performance. PricewaterhouseCoopers (PwC), Massachusetts Institute of Technology (MIT), Cambridge, MA., USA.
7. Formentini, M. and P. Taticchi, 2016. Corporate sustainability approaches and governance mechanisms in sustainable supply chain management. J. Cleaner Prod., 112: 1920-1933.
8. Hair, Jr. J.F., W.C. Black, B.J. Babin and R.E. Anderson, 2010. Multivariate Data Analysis. 7th Edn., Prentice-Hall, Upper Saddle River, NJ., USA., ISBN-13: 978-0138132637, Pages: 816.
9. Montgomery, D.C., 2012. Design and Analysis of Experiments. 8th Edn., John Wiley and Sons, New York, USA., ISBN-13: 9781118214718, Pages: 730.
10. Shapiro, A., 2003. Monte Carlo Sampling Methods. In: Stochastic Programming: Handbooks in Operations Research and Management Science, Volume 10, Ruszczyriski, A. and A. Shapiro (Eds.). Elsevier Science B.V., New York, pp: 353-425.
11. Lontoh, L., C. Beaton and K. Clarke, 2015. Energy subsidy review in Indonesia. 1st Edition, Volume 2, International Institute for Sustainable Development, Global Subsidies Initiative, Geneva, Switzerland, March 2015.
12. Salim, Z., B. Kumoro and K. Notonegoro, 2014. Fuel oil subsidy policy. The Habibie Center Activity Report, Jakarta, Indonesia.
13. TNP2K., 2011. Poor household in coastal/fishermen area. Tim Nasional Percepatan Penanggulangan Kemiskinan (TNP2K), Jakarta.
14. Suryawati, S.H. and T. Apriliani, 2015. Oil fuel subsidized distribution mechanism of small scale capture fisheries business. J. Kebijakan Sosial Ekonomi Kelautan Perikanan, 5: 37-46.
15. PricewaterhouseCoopers, 2008. A practical guide to risk assessment: How principles-based risk assessment enables organisations to take the right risks. PricewaterhouseCoopers (PwC), New York, pp: 1-36.
16. Asia Pacific Energy Research Centre, 2007. A Quest for Energy Security in the 21st Century: Resources and Constraints. Asia Pacific Energy Research Centre, Institute of Energy Economics, Tokyo, Japan, ISBN-13: 9784931482357, Pages: 100.
17. Yergin, D., 1991. The Prize: The Epic Quest for Oil Money and Power. 1st Edn., Simon and Schuster, New York, Pages: 885.