Eduvest - Journal of Universal Studies
Volume 4 Number 10, October, 2024
p- ISSN 2775-3735- e-ISSN 2775-3727

ANALYSIS OF INVENTORY CONTROL IN THE DOWNSTREAM FUEL SUPPLY CHAIN : AN INDONESIAN PRESPECTIVE

Pandu Raymutia[1], Tresna Priyana Soemardi[2]
[1,2] Universitas Indonesia, Indonesia
Email: pandu.raymutia@gmail.com, tresna.p.soemardi@gmail.com

ABSTRACT

This research focuses on determining the level of inventory in a downstream supply chain for fuel products in Indonesian oil and gas company prespective. The variability in supply and demand is a problem in maintaining the stability of services to the consumers. High inventory costs that are completely borne by the company are also a problem that needs to be controlled. Therefore, determining inventory levels is very important to mitigate the variability of supply and demand that occurs with optimum inventory costs. This research designs a probabilistic model by considering variability in supply and demand to determine safety stock so that the correct level of Fuel Product inventory at each Storage Point can be determined. This research method is quantitative research based on empirical data. It is hoped that the research results will be able to obtain inventory control which can be taken into consideration by oil and gas company in managing the downstream supply chain of fuel products.

KEYWORDS *Inventory management, Supply Chain Management, Downstream Fuel Supply Chain*

INTRODUCTION

According to the Ministry of Energy and Mineral Resources, the energy sector industry is industrial activities or energy supply businesses which consist of production, distribution and consumption of energy resources. The energy sector is very important for driving economic growth, ensuring energy security, improving public health, encouraging technological innovation, and advancing a country's social justice (Kumar & Barua, 2022). One type of energy sector industry is oil and gas. This sector involves the exploration, extraction, refining, and distribution of crude oil and natural gas. This includes activities such as drilling operations,

How to cite:	Pandu Raymutia, Tresna Priyana Soemardi (2024). Analysis of Inventory Control in the Downstream Fuel Supply Chain : An Indonesian Prespective. *Journal Eduvest. 4*(10): 8820-8829
E-ISSN:	2775-3727
Published by:	https://greenpublisher.id/

offshore and onshore production facilities, pipelines, refineries, and petrochemical plants. Companies engaged in oil and gas exploration and production, as well as those involved in refining and marketing petroleum products, are part of this industry (Munyaka & Yadavalli, 2022).

Indonesia is an archipelagic country, The level of supply reliability using tankers is very dependent on the performance of the transportation mode, infrastructure reliability, as well as weather and natural factors. Geographical conditions at each fuel terminals are different, limiting the types of transportation that can be used to carry out supplies (Gonçalves et al., 2020).

To support the various needs of this type of transportation, the supporting infrastructure that fuel terminals must have is also different. For example, for receiving/distribution using Tankers & Barges, fuel terminals requires jetty infrastructure and fuel line facilities, for the Pipeline mode a sterile pipe line and a strong pump is needed to distribute fuel products over long distances and for the train carriage mode a rail facility is required (Kolias et al., 2011). train. Because the products distributed are hazardous materials, to ensure the availability of fuel products in the community, the entire infrastructure needs to be integrated and have high reliability.

Based on this background, this research was conducted to analyze inventory control in the downstream fuel supply chain to optimize the company's inventory operational costs and increase certainty of product availability (Hançerlioğulları et al., 2016). This research is also directed at inventory strategies to determine appropriate inventory evenly.

Formulation of the problem

- What is the appropriate inventory level for fuel products for company’s operating conditions to meet current demand?
- What is the impact of controlling inventory levels for fuel products on inventory costs?

Research Objective

By examining the empirical data that will be obtained, the objectives of this research are:

- Determine the appropriate inventory level for fuel products
- Knowing the effect on inventory cost efficiency of by controlling inventory levels for fuel products

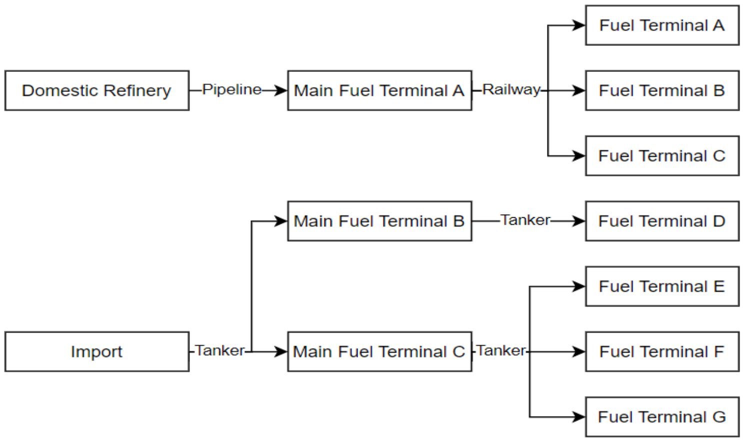
Literature Review

The downstream supply chain in the oil and gas industry encompasses the processes involved in distributing and delivering petroleum products to end-users. It is a complex and highly integrated system that plays a crucial role in meeting global energy demands. The downstream supply chain process can be broadly summarized into several key stages:

- Storage and Transportation: Refined products are stored in tanks at refineries and terminals before being transported via pipelines, ships, trucks,

or rail to distribution points. Efficient logistics and transportation networks are critical to ensuring a continuous and reliable supply.
- Distribution: Once products reach distribution points, they are further transported to regional storage facilities and depots. From these locations, the products are distributed to retail outlets and other end-users through a network of pipelines, trucks, and other means of transportation.
- Retail: The final stage involves the sale of petroleum products to end-consumers through retail outlets such as gas stations. This includes managing inventory, dispensing fuel, and providing other services to consumers (Sharma & Bhat, 2013).

The downstream supply chain in the oil and gas industry faces challenges such as supply - demand uncertainty, logistics disruptions, high inventory cost and the obligation to fullfill all consumers demand without stockouts.



This research will focus on how to manage the inventory in storage stage (Fuel Terminal) by having the right level of safety stock, the risk of a stockout occurring due to uncertainty on the demand and supply side, the causes of which are largely outside the company's control, can be minimized and can still provide good service to customers in terms of product availability.

Inventory Functions and Types:

Inventory control plays a significant role in shaping a company's operational functions, influencing aspects such as consumer demand anticipation, production process facilitation, quantity discount utilization, and protection against price changes and inflation. To accommodate these functions, companies manage four types of inventories: raw material, work-in-process, MRO (maintenance, repair, and operations), and finished goods.

Independent Demand and Inventory Models:

In the context of independent demand, where one item's demand is not dependent on others, the Basic Economic Order Quantity (EOQ) model is widely employed. The EOQ model, based on certain assumptions, proves to be a commonly used and easy-to-use technique for inventory management. Assumptions include known and constant demand, instantaneous inventory receipt, consistent lead time, and consideration of only variable costs related to ordering and storing.

Parameters for Inventory Reliability:

The idealized sawtooth pattern of inventory usage over time, characterized by constant demand and uniform supply depletion, is a theoretical model. Achieving inventory reliability in practice involves calculating lead time, safety stock, and reorder point (ROP) parameters. Safety inventory levels are determined by factors such as uncertainty in demand and supply and the availability of the desired product. Replenishment policies, either continuous or periodic review, also influence cycle inventory and safety stock (Talluri et al., 2004).

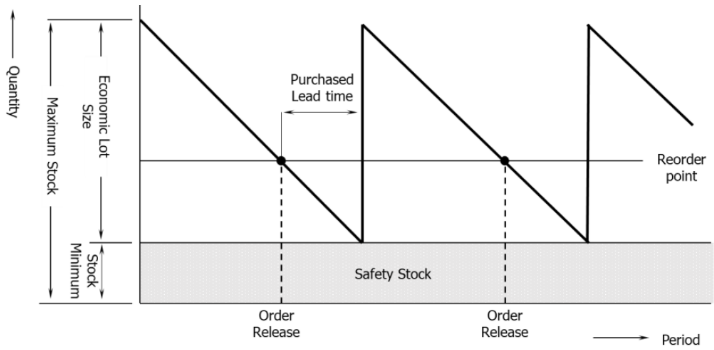


Figure 2. ROP in the EOQ situation with safety stock

- *Lead Time*

  Evaluation of the distribution of demand during lead time :

  $$Mean\ Demand\ during\ Lead\ Time$$
  $$\boldsymbol{DL=D\ x\ L}$$
  $$Standard\ Deviation\ of\ Demand\ During\ Lead\ Time,$$
  $$\boldsymbol{\sigma L=\sqrt{L\sigma D2+D2sL2}}$$

- *Safety Stock*

  Next, safety stock is calculated using the following formula :

  $$Safety\ Stock$$
  $$\boldsymbol{ss=Fs-1(CSL)\ x\ \sigma L=NORMINV\ (CSL)\ x\ \sigma L}$$

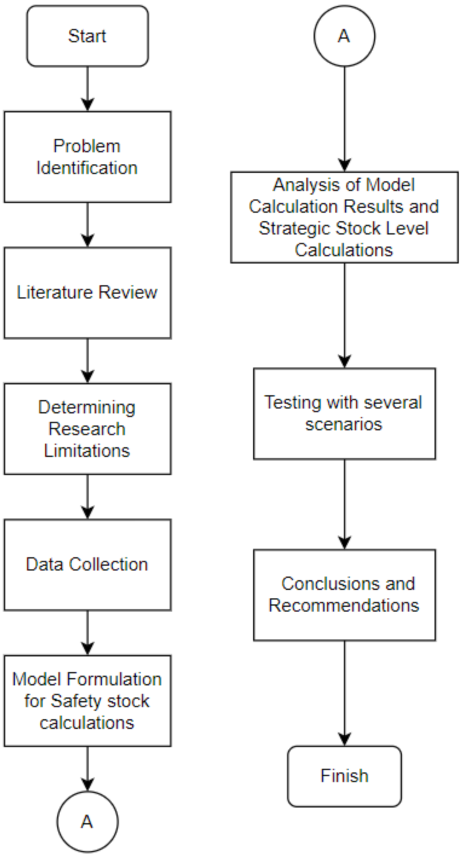
  Where :

  D : Average Demand per period
  σD : Standard Deviation of Demand per period
  L : Average lead time for replenishment
  sL : Standard Deviation of Lead time
  σL : Standard Deviation of Demand during lead time
  CSL : Cycle Service Level

Costs Associated with Inventory:

Inventory serves to improve customer service levels, but the funds invested represent an opportunity cost for the company. Supply chain managers must weigh the pros and cons of high and low inventory levels, considering holding costs (warehouse, facilities, handling, etc.) and ordering costs (purchasing, administrative handling, transportation, etc.). Holding costs are a reason to keep inventory levels low, and these costs include components such as the cost of capital, obsolescence cost, handling cost, occupancy cost, and others.

RESEARCH METHOD



This research will be carried out in several stages as follows; [Problem Identification] This is the initial stage that starts from problems found in the field. [Literature Review] A literature search was carried out in the form of theory and previous research and its relevance was further studied for solving the problems that had been identified. [Determining Research Limitations] Determining boundaries in research includes the variables that will be used in the research. [Data collection] At this stage, the necessary data will be collected from internal company sources, both primary and secondary data. The primary data used is the result of discussions with the company function. Secondary data used includes Sales realization data, Lead Time realization data, Reception capacity data, Storage capacity data, Revenue capacity data, Data on modes and supply patterns. [Probabilistic Model Formulation for Safety stock calculations] A safety stock model was formulated based on a model developed in previous research which considered variations in demand and supply. [Analysis of Model Calculation

Results and Strategic Stock Level Calculations] At this stage, an analysis of the results of the model calculations is carried out so that the correct inventory position conditions is known. [Testing with several scenarios] At this stage, efforts to improve the situation and conditions where disruption to the supply chain occurs are carried out. [Conclusions and Recommendations] at this stage, conclusions are drawn from the research that has been carried out and recommendations are made to the company regarding the results of the research that has been carried out.

RESULT AND DISCUSSION

Analysis

Demand Variable

From the demand data obtained we visualized as in figure xx, data processing was carried out, monthly sales data during that period were analyzed using a normality test (Kolmogorov-Smirnov test method) and several descriptive statistical parameters were calculated such as mean and standard deviation. Table xx presents the analysis results for each fuel terminal.

Figure 4 Data collected for Fuel Demand

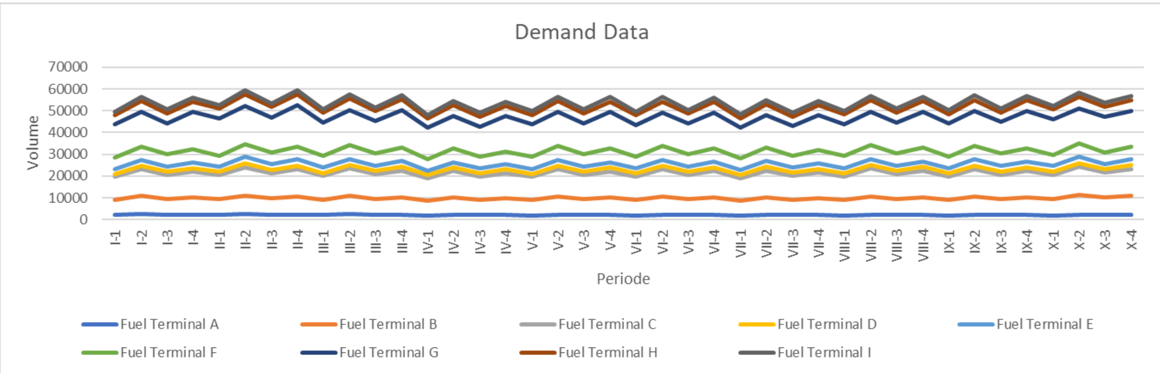


Table 1 Results of Descriptive Statistics for Fuel Demand and Normal Test (Kolmogorov Smirnov)

Statistik	Fuel Terminal A	Fuel Terminal B	Fuel Terminal C	Fuel Terminal D	Fuel Terminal F	Fuel Terminal G	Fuel Terminal H	Fuel Terminal I	Fuel Terminal J
N Sampel	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Mean	2,159.84	7,703.01	11,626.30	1,565.41	2,544.70	5,810.01	15,601.75	4,716.23	5,810.01
Std Dev	151.35	565.98	795.72	108.17	197.23	414.65	1,196.16	323.30	414.65
Dmax	0.13	0.11	0.12	0.14	0.06	0.09	0.08	0.13	0.09
KS Tabel	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Hasil Uji	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal

The average or mean is the sum of all values/data in a population/sample divided by the number of values/data in the population/sample, while the standard deviation is the average deviation of each value in the population/sample from the population/sample mean value.

From the results of data processing in Table 1 above, with all Kolmogorov Smirnov (KS) calculations > 0.170 (95% degree of confidence) then fuel demand data in all these locations can be said to be normally distributed and the average and standard deviation of demand in each location can be obtained from each location.

Lead Time Variable

From the supply data obtained, data processing is then carried out. From the results of data processing using the Kolmogorov-Smirnov Normality Test, it can be seen that the lead time data for the supply of fuel to all fuel terminals is not normally distributed. then a normality test was then carried out using kurtosis and skewness ratio analysis.

Figure 5 Mean Data for Fuel Supply Lead Time

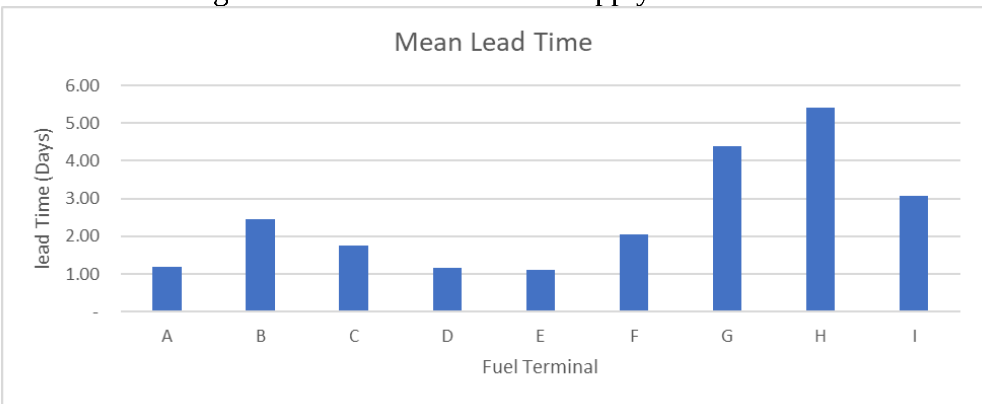


Table 2 Results of Descriptive Statistics for Fuel Demand and Normal Test (Skuwness Kurtosis)

Location	Mean Lead Time	Max Lead Time	Standard Dev	Skewness	Kurtosis
Fuel Terminal A	1.20	2.00	0.40	1.4966	0.2416
Fuel Terminal B	2.46	7.00	1.30	1.0304	0.9334
Fuel Terminal C	1.76	5.00	0.94	1.0730	0.3418
Fuel Terminal D	1.16	2.00	0.37	1.8241	1.3376
Fuel Terminal F	1.11	2.00	0.31	2.5216	4.3903
Fuel Terminal G	2.04	5.00	1.00	0.8819	0.5134
Fuel Terminal H	4.38	9.00	1.82	0.2711	- 0.1958
Fuel Terminal I	5.42	10.00	1.91	0.0807	- 0.4090
Fuel Terminal J	3.08	6.00	1.12	0.0619	0.0619

In Table 2, it can be seen that the skewness ratio (Statistic/Std. Error) of all fuel terminals except the Fuel Terminal F is between -2 and +2 which can be categorized as normally distributed. Specifically for Fuel Terminal F, the leadtime data available is leadtime = 1 day (freq. 245 days) and leadtime = 2 days (freq. 30), the leadtime data is 2 days because the fuel Terminal is not operational on Sundays. Researchers assess that the data can still be used because it is a routine condition and not a special incident.

Safety Stock Calculation

After data processing and analysis related to variability in demand and supply, the next step is to calculate the standard deviation of demand during lead time by adding variability in demand and lead time Chopra (2019). Next, the safety and cycle stock is calculated for each location using a service level of 99.9% as seen in Table 3 below.

Tabel 3 Safety Stock Calculation Result

Storage Point	Safety Stock (KL)	Cycle Stock (KL)
Fuel Terminal A	425	339
Fuel Terminal B	4,874	2,472
Fuel Terminal C	8,195	4,115
Fuel Terminal D	286	238
Fuel Terminal E	390	369
Fuel Terminal F	2,815	1,550
Fuel Terminal G	15,478	9,986
Fuel Terminal H	4,386	3,340
Fuel Terminal I	1,010	746

Determining strategic inventory limits is carried out by creating categories (index) from the results of the probabilistic safety and cycle stock models. By calculating the safety stock and stock cycle for each location, we can know the strategic limits for fuel supply that must be maintained at each location to anticipate variability in demand and supply while still minimizing inventory costs. The following are the inventory limit categories/indexes used:

Tabel 4 Strategic Stock Level Parameters

	Index 1	Index 2	Index 3	Index 4	Index 5
Safety Stock	0-50%	50-100%	100%	100%	100%
Cycle Stock			0-20%	20-40%	>40%

From the strategic stock level reference in table 4. then the next step is to calculate the fuel inventory limits at each location:

Tabel 5 Calculated Strategic Stock Level

Storage Point	Index 1	Index 2	Index 3	Index 4	Index 5
Fuel Terminal A	213	425	493	561	
Fuel Terminal B	2,437	4,874	5,368	5,863	
Fuel Terminal C	4,098	8,195	9,018	9,841	
Fuel Terminal D	143	286	333	381	
Fuel Terminal E	195	390	464	538	>Index 4
Fuel Terminal F	1,407	2,815	3,125	3,435	
Fuel Terminal G	7,739	15,478	17,475	19,473	
Fuel Terminal H	2,193	4,386	5,054	5,722	
Fuel Terminal I	505	1,010	1,159	1,309	

Sensitivity analysis using demand and lead-time variability

The results obtained from data processing on safety stock, cycle stock and strategic inventory limits, the next step is to test the results with several scenarios. This test can be said to be a sensitivity analysis model to changes in existing boundaries or variables. In this research, scenario testing is based on changes in demand and supply (including probabilistic elements or deviations from demand and lead time).

The strategic inventory limits applied are Index 4, because index 4 shows very good resistance to deviations in demand and/or supply. (100% Safety Stock + 40% Cycle Stock). From the results of the Demand and supply lead time test, under normal conditions and deviations up to 120% demand and 150% lead time, the safety stock limits obtained can provide good supply resilience. in terms of inventory resilience, the amount of supply deviation is directly proportional to the level of resilience required, the greater the supply deviation that occurs, the greater the inventory required.

Potential Cost Saving

Tabel 6 Inventory Cost Saving

Storage Point	Proposed		Current		Current - Proposed (USD)
	Ops Safety Stock (KL)	Inventory Cost (USD)	Safety Stock (KL)	Inventory Cost (USD)	
Fuel Terminal A	561	439,836	6,494	5,093,438	4,653,602
Fuel Terminal B	5,863	4,598,731	23,159	18,165,647	13,566,916
Fuel Terminal C	9,841	7,719,289	34,955	27,417,738	19,698,449
Fuel Terminal D	381	298,697	4,706	3,691,630	3,392,933
Fuel Terminal F	538	421,984	7,651	6,001,043	5,579,059
Fuel Terminal G	3,435	2,694,018	17,468	13,701,459	11,007,441
Fuel Terminal H	19,473	15,273,773	46,907	36,792,846	21,519,073
Fuel Terminal I	5,722	4,488,548	14,180	11,122,048	6,633,500
Fuel Terminal J	1,309	1,026,548	5,570	4,369,080	3,342,532
Total	47,122	36,961,425	161,090	126,354,930	89,393,505

From the results of the inventory limits that have been obtained, a comparison is then made with the inventory costs required to manage the current minimum inventory. Based on the quantitative analysis comparison table above, it can be said that there is a significant savings of inventory cost.

CONCLUSION

This study presents a model for controlling an Indonesian oil and gas company's safety stock levels. The suggested model enables the inclusion of both supply and demand variations in the safety stock assessments. We presented the savings that the new model would bring about by contrasting it with the company's current inventory system.

We conclude the following guidelines for the efficient management of the company's safety stocks: 1. Place emphasis on the forecasting models' accuracy, since this leads to better demand estimation and more precise safety stock setting. 2. Raise the accuracy of lead-time estimation and its variability. The sensitivity analysis shows that the variations in lead-time and demand have a significant impact on the safety stock levels.

REFERENCES

Gonçalves, J. N. C., Carvalho, M. S., & Cortez, P. (2020). Operations research models and methods for safety stock determination: A review. *Operations Research Perspectives*, *7*, 100164.

Georgios D.Kolias, SophiaP.Dimelis, VasiliosP.Filios, An Empirical Analysis of Inventory turnover behaviour in Greek Retail Sector : 2000-2005, International Journal Production Economics (2011) 143-153

Hançerlioğulları, G., Şen, A., & Aktunç, E. A. (2016). Demand uncertainty and inventory turnover performance: An empirical analysis of the US retail industry. *International Journal of Physical Distribution & Logistics Management*, *46*(6/7), 681–708.

Kolias, G. D., Dimelis, S. P., & Filios, V. P. (2011). An empirical analysis of inventory turnover behaviour in Greek retail sector: 2000–2005. *International Journal of Production Economics*, *133*(1), 143–153.

Kumar, S., & Barua, M. K. (2022). A modeling framework and analysis of challenges faced by the Indian petroleum supply chain. *Energy*, *239*, 122299.

Munyaka, J. B., & Yadavalli, V. S. S. (2022). Inventory management concepts and implementations: a systematic review. *South African Journal of Industrial Engineering*, *33*(2), 15–36.

Sunil Chopra, Supply Chain Management: Strategy, Planning, and Operation [7 ed.], Pearson Education Limited (2019)

Regulation of the Indonesian Downstream Oil and Gas Regulatory Agency Number 9 of 2020 concerning the Provision of Operational Oil Fuel Reserves

Sharma, S. K., & Bhat, A. (2013). An empirical exploration of supply chain design factors and their influence on supply chain performance. *International Journal of Business Performance and Supply Chain Modelling*, *5*(3), 239–257.

Talluri, S., Cetin, K., & Gardner, A. J. (2004). Integrating demand and supply variability into safety stock evaluations. *International Journal of Physical Distribution & Logistics Management*, *34*(1), 62–69.