

RELIABILITY ANALYSIS OF CRUDE OIL EXPLORATION IN NIGER DELTA, NIGERIA

Udoumoh, Enobong Francis*

Department of Mathematics/Statistics/Computer Science, University of Agriculture, Makurdi, Nigeria.
udoumoh.francis@uam.edu.ng

Ekpo, Anthony

Department of Mathematics/Statistics/Computer Science, University of Agriculture, Makurdi, Nigeria.
tony21ng@yahoo.com

Samuel Adakole Augustine

National Bureau of Statistics, Abuja, Nigeria.
samadakole@nigerianstat.gov.ng

Abstracts

Nigeria depends on the oil industries for about 95% of export earnings and 85% of government revenue. Most of the oil exploration is done in the Niger Delta region of the country, and it is characterized by incessant spills. This work examines the reliability of oil exploration by some oil companies operating in the Niger Delta using parametric and nonparametric approaches. Here reliability is defined as the probability that an oil company will operate without spill over some time period t . Finding reveals that oil exploration by Nigeria Agip Oil Company (NAOC), Shell Petroleum Development Company (SPDC), Mobil Producing Nigeria-Exxon Mobil in Nigeria (MPN) and Chevron Nigeria Ltd, SEPLAT Petroleum Development Company, TOTAL Nigeria, Pipelines and Product Marketing Company (PPMC), ESSO Exploration and Production Nigeria Ltd, ADDAX Petroleum Development Nigeria Limited, Niger Delta Petroleum Resources Ltd (NDPR), Shell Nigeria Exploration and Production Company (SNEPCO), and Pan Ocean Oil Corporation (Nigeria) Ltd (POOCN) in the Niger Delta area of Nigeria is characterized by frequent spills that occur in approximately 1, 3, 3, 6, 37, 45, 51, 63, 97, 183, 207, and 342 days respectively.

Key Words: Oil-Spill; Parametric; Nonparametric; Estimation.

1. Introduction

Crude oil spillage is one of the major environmental problems facing the Niger delta region of Nigeria since the first commercial production by Royal Dutch Shell in 1958. Oil spills have been reoccurring and exerting deleterious impact on the ecosystem. These have led to contamination of drinkable water, serious pollution and obliteration of vegetation, wildlife and resort centres, as well as destruction of lives and properties along the Nigerian coastal area. Oil spills have negatively impacted on the natural resources upon which many Niger Delta communities have their source of livelihood. The Niger Delta region is rated as the most spills impacted and oil polluted area in the world, see Raji and Abejide (2013), Zabbey(2009). It is estimated that Nigeria depends on the oil sector for 95% of her export earnings and 85% of government revenue and most of the exploration is done in the Niger Delta, Kadafa (2012). However, most people of the region are living in abject poverty and have been exposed to a number of health perils. This is because most people in this region depend on agriculture for their livelihood. This has resulted to youths' agitation and restiveness, which births kidnapping, thuggery, thefts, and other social vices. Some factors identified to be responsible for oil spillage in the zone include corrosion of oil pipes and tanks, sabotage, port operation and inadequate care in oil production operations and engineering drills. For more recent information on the impacts and causes of oil spills refer to the publication of Amnesty International (2013). Raji and Abejide, (2013) made an assessment of environmental problems associated with oil spill and gas flaring, tracing that among the

various factors responsible for environmental pollution, oil pollution was also a factor with attendant effects on water and land degradation. Kadafa (2012) made an historical review of the number of oil spills and quantity lost in the Niger Delta between 1976-2000. He concluded that while the quantity of oil spilled was on the decrease, oil spill incidences were on the increase.

We have noticed that many research works on oil spills in Nigeria focuses more on the number (incidence) of spills, causes of spills, economic and environmental impacts, and security implications, Oshwofasa & Anuta (2012), Our interest rather is to study the time interval at which spills occur in the Niger Delta region using reliability models. We define reliability as the probability that an oil company will operate without a spill over some period of time t . This research will attempt to answer this basic question: how often do crude oil spills occur?

2 Methods

2.1 Model

Reliability is defined as the probability that a system will function over some time period t . For the purpose of this work, we are concern with the system of oil exploration by some oil companies in the Niger Delta region of Nigeria. We assume that the system fails once there is a spill. From our data, time to failure, T for all companies follows a weibull distribution, except that of NAOC which did not fit any parametric distribution. Suppose T is weibull, the probability density function is given as

$$f(t) = \frac{\beta}{\theta} \left(\frac{t}{\theta}\right)^{\beta-1} e^{-\left(\frac{t}{\theta}\right)^\beta}, \beta > 0, t \geq 0, \theta > 0$$

where β and θ are the shape and scale parameters respectively. θ is also known as the characteristics life, reliability function is given as

$$\begin{aligned} R(t) &= \exp\left\{-\int_0^t \frac{\beta}{\theta} \left(\frac{t}{\theta}\right)^{\beta-1} dt\right\} \\ &= e^{-\left(\frac{t}{\theta}\right)^\beta} \end{aligned}$$

Failure rate function is given as

$$h(t) = \frac{\beta}{\theta} \left(\frac{t}{\theta}\right)^{\beta-1}$$

Mean time to failure is

$$MTTF = \theta \Gamma\left(1 + \frac{1}{\beta}\right)$$

And variance

$$\sigma^2 = \theta^2 \left\{ \Gamma\left(1 + \frac{2}{\beta}\right) - \left[\Gamma\left(1 + \frac{1}{\beta}\right) \right]^2 \right\}$$

where $\Gamma(x)$ is the gamma function defined as $\Gamma(x) = \int_0^\infty y^{x-1} e^{-y} dy$

We used the maximum likelihood estimation for para

To analyse the data from NAOC we considered the nonparametric approach using Kaplan-Meier estimation method. See Ebeling (1997) for details.

2.2 Data and Analysis

The data used for this research has its source from National Oil Spill Detection and Response Agency (NOSDRA). The agency which is under the Ministry of Environment is charge with the responsibility of detection of oil spill and monitoring responses from all oil producing companies. The data has, among other information, the record of oil spills (irrespective of quantity) incidence with dates from January, 2006 to May, 2014 from 16 oil companies operating in the Niger Delta. With this information, inter event (of spill) times were generated. A total of 6288 oil spill incidences with volume 211377.165 bbl were recorded from the 16 oil companies. However, 4 out of the 16 oil companies recorded only one incidence of spill. We then considered 12 companies in our reliability analysis. See Figure1 and 2 for the plots on the incidence and volume of oil spill by companies within the period. The Niger Delta is situated in the southern part of Nigeria, occupies a surface area of about 112,000 square kilometres, representing 12% of Nigeria’s total surface area. Its present population is estimated to be about 30 million people, living in approximately 3000 communities (NDDC 2006), making it one of the most densely populated regions of Africa.

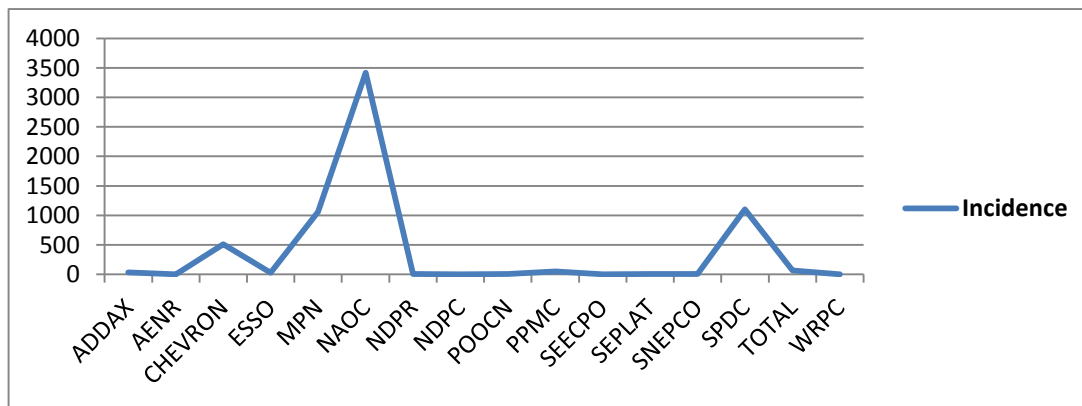


Figure1: A plot of Incidence of Oil Spill in Niger Delta (2006-May,2014)

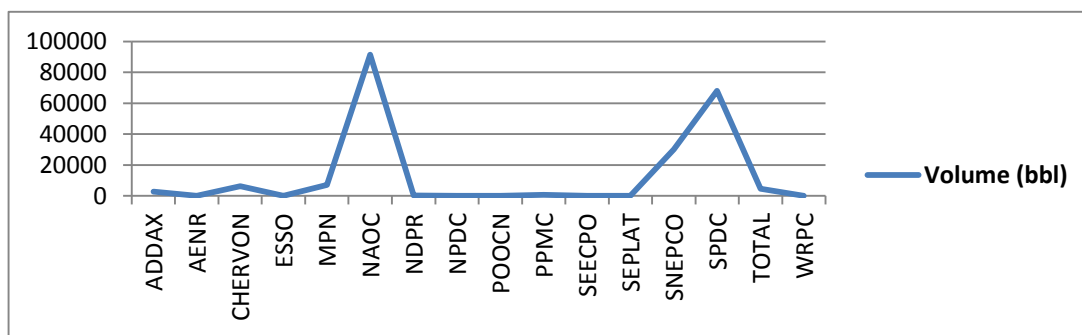
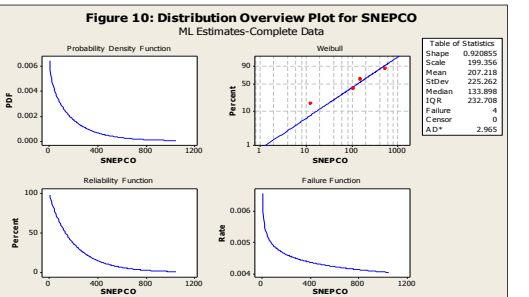
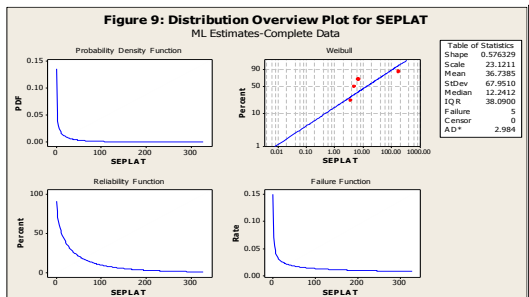
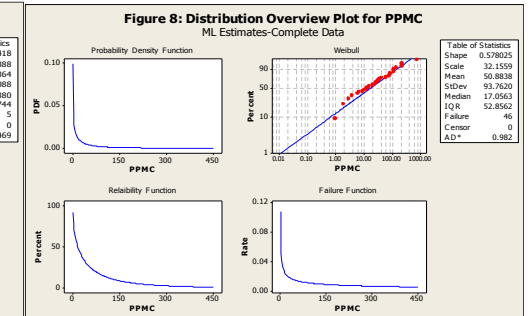
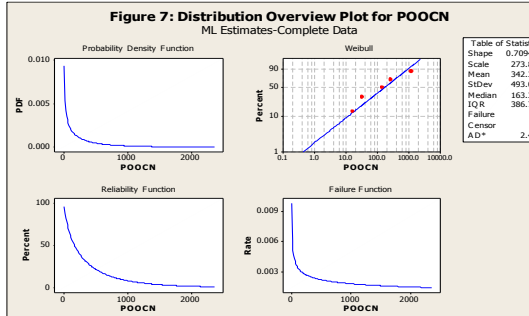
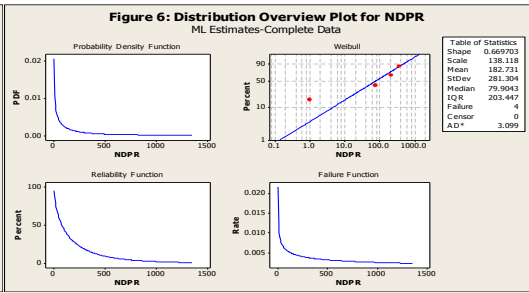
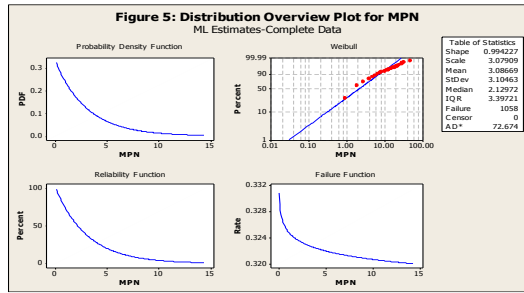
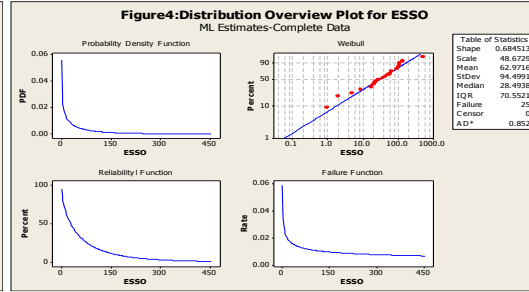
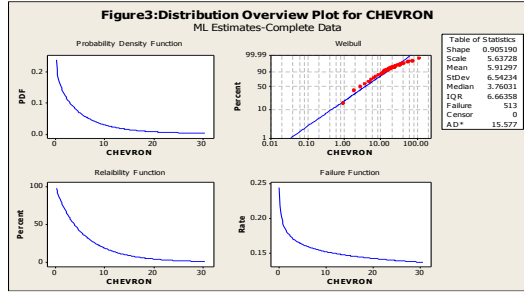
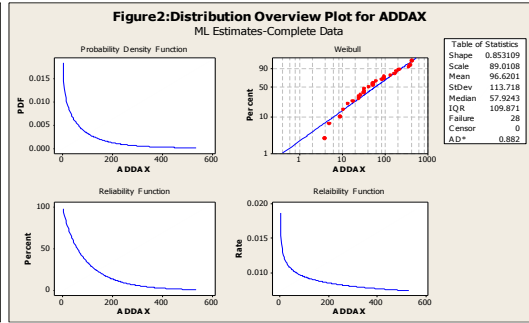
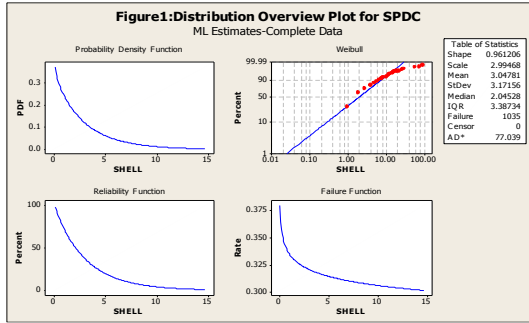


Figure 2: A plot of the Volume of Oil Spilled in Niger Delta (2006-May,2014)

3.0 Results and Discussion



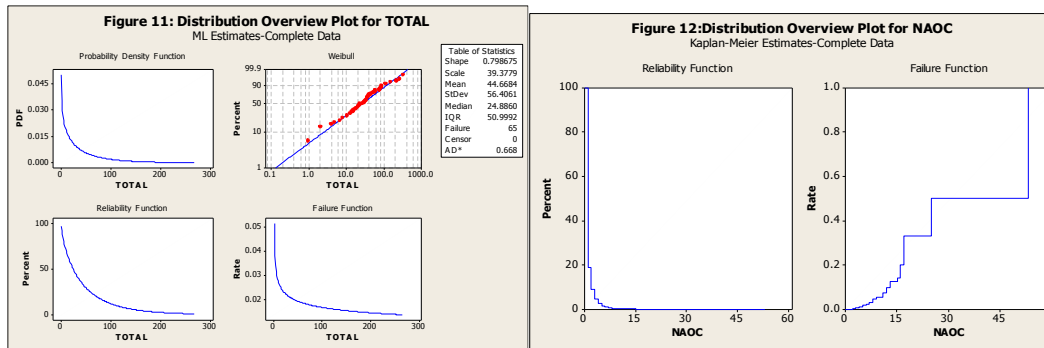


Figure 1 -11 presents the parametric distribution overview plots for SPDC, ADDAX, CHEVRON, MPN, NDPR, POOCN, PPMC, SEPLAT, SNEPCO, and TOTAL respectively. Each overview showcases failure time graphs, namely, probability density function, probability plot, reliability function, and failure function. It can be seen that all the points are approximately on the straight line on the weibull probability plot, so the weibull distribution is a good choice for the parametric analysis. All the reliability function graphs are decreasing which indicates that system reliability decreases with time. In particularly, the probability that SPDC will carry out its operations without spill within 5 days is about 0.19, while the probability that TOTAL will operate without spill for 28 days is about 0.48. Failure functions for all the companies are decreasing, an indication for early failure. Figure 12 present the nonparametric distribution overview for NAOC, with decreasing reliability function graph. In this case the probability that the NAOC will operate without spill for at most a day is 0.19.

In table 1, we present the summary of the estimates of relevant parameters for the reliability analysis for each of the oil company. Column 2 shows that all the shape parameters are less than one ($\beta < 1$), a confirmation of systems with early failure. Column2 has scale parameters, which is the value(in days) by which 63.2% of all failures would have occurred. In column 8, MTTF's are presented with the least value from NAOC=1.4310 and the highest from POOCN=342.4048.

Table 1 : Summary of reliability analysis by company

| Company | Shape | Scale | Mean | StD | IQR | AD* | MTTF |
|---------|--------|---------|---------|---------|---------|--------|----------|
| SPDC | 0.9612 | 2.9947 | 3.0478 | 3.1716 | 3.3873 | 77.039 | 3.0477 |
| ADDAX | 0.8531 | 89.0108 | 96.6201 | 113.718 | 109.871 | 0.882 | 96.6212 |
| CHEVRON | 0.9052 | 5.9129 | 5.9129 | 6.5423 | 6.6636 | 15.577 | 6.2021 |
| ESSO | 0.6845 | 48.6729 | 62.9716 | 94.4991 | 70.5521 | 0.852 | 62.9827 |
| MPN | 0.9942 | 3.0791 | 3.0867 | 2.1297 | 3.3972 | 72.672 | 3.0871 |
| NAOC | - | - | 1.4310 | - | 0 | - | 1.4310 |
| NDPR | 0.6697 | 138.118 | 182.731 | 281.304 | 203.447 | 3.009 | 182.7715 |
| POOCN | 0.7094 | 273.888 | 342.364 | 493.088 | 386.744 | 2.469 | 342.4048 |
| PPMC | 0.5780 | 32.1559 | 50.8838 | 93.7620 | 52.8562 | 0.982 | 50.9124 |
| SEPLAT | 0.5763 | 23.1211 | 36.7385 | 67.9510 | 38.0900 | 2.984 | 36.7602 |
| SNEPCO | 0.9209 | 199.356 | 207.218 | 225.262 | 232.708 | 2.965 | 207.2106 |
| TOTAL | 0.7986 | 39.3779 | 44.6684 | 56.4061 | 50.9992 | 0.668 | 44.6703 |

4 Conclusions

A reliability analysis on oil exploration in the Niger Delta region of Nigeria was carried out. This research answer a basic question : how often do oil spills occur in the region based on individual companies? From this analysis it can be said that crude oil exploration in the Niger Delta region of Nigeria is characterized by incessant spills. Oil companies and security operatives can leverage on the information provided here for effective management of oil exploration and security detailing to curb crude oil spill due to assignable causes like poor operation and vandalism.

References

Amnesty International Report 2013.

Ebeling, Charles E. (1997). An Introduction to Probability and Maintainability Engineering. *McGraw Hill*, USA.

Egbe, R E and Thompson, D (2010). Environmental Challenges of Oil Spillage for Families in Oil Producing Communities of the Niger Delta Region. *JHER*, Vol.13, 24-34.

Kadafa, Adati Ayuba (2012). Environmental Impacts of Oil Exploration in the Niger Delta of Nigeria. *Global Journal of Science Frontier Research Environmental and Earth Sciences*. Vol.12; 3.18-28.

NDDC bulletin 2006

Oshwofasa, Bright O. and Anuta David E. (2012) Environmental Degredation and Oil Industry Activities in the Niger-Delta Region. *African Journal of Scientific Research*. Vol. 9, No. 1.

Raji, AOY and Abejide, TS (2013):An Assessment of Environmental Problems Associated with Oil Pollution and Gas Flaring in the Niger Delta Region, Nigeria. *Arabian Journal of Business and Management Review*. Vol. 3, No.3. 48-62.

Zabbey(2009). Paper presented at the on "Petroleum and Pollution-Does that Impact human right?" Co-organized by Amnesty International, Forum Syd and Friends of the Earth, Kulturhuset, Stockholm, Sweden.