International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 7, Issue 4 Ver. I (April 2018), PP. 37-45

A Factorial Analysis of Delay Causalities in Seismic Reconnaissance: Implications for Petroleum Exploration In Tbe Niger Delta

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ABSTRACT: A field study was conducted in Benin-Sapele locale of Niger Delta to understand the role of influencive factors identified to be associated with delay causation in seismic reconnaissance. The principal component analysis (PCA) of Factor Analysis was used to analyse a total of 262 daily observations of time(in hours)encountered in seismic surveys undertaken in the locale thereof. The PCA employed was effective in achieving parsimony by reducing the factor dimension from fourteen variables to mere five platoons which were creatively labelled: data sampling activities, logistics, permission matters, instrument integrity, and random events. Our results suggest that human factors, terrain and logistics are the most offensive influences and that the perceived current restiveness in the region is a backlash of unfettered exploration and production activities which cause vegetal disorientation, oil spillage, gas flaring and other several exploration-induced epiphenomona that are detrimental to ichthyofaunal beings. It is the belief of the authors that the results of this study will be helpful in strategic planning and control of seismic projects where the complexion of these factors needs to be better understood and proactive measures crafted to whittle down their impacts on seimic reconnaissance.
KEYWORDS: risk society, palaeogeomorphology, synstratigraphy, facies, data tectonics, ichthyofaunal

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Date of Submission: 28-04-2018 Date of acceptance: 14-05-2018

I INTRODUCTION

The Niger Delta Basin has a peculiar petroleum geography that is associated with rollover anticlines defined along synsedimentary normal faults. Hydrocarbon deposits have been found to be associated with these stratigraphic features. The purpose of seismic exploration is to identify a stretch of impervious bedrock with folded layers of trapped porous oil-bearing soil as overhead. Petroleum explorations in this basin have been hampered by several socio- economic, technical, and political issues that warrant special investigation.

Besides the fundamental logistic and technical realities concentric to palaeogeomorphological investigations, the political and community-related issues that unfold from time to time, the necessary geophysical quality assurance procedures which sometimes vitiate the process of obtaining subsurface lithological and petrophysical interpretations and predictions, a myriad of extraneous factors are also there which coalesced with the foregoing to cause delays in geophysical surveys. Most geophysical firms undertaking seismic reconnaissance in the Niger Delta have become leery of possible community disturbances. This type of concern has arrested their enthusiasm in managing seismic projects. In recent times, the problem has degenerated to the level of abducting expatriates engaged in exploration and production. The implication for the economic health of the country and global energy situation is grave and therefore calls for proper examination. The focus of this research is sharpened by these problems

Past studies in the Nigeria flank of Niger Delta Basin had focused on oil spillage and general problem of ecological pollution. As, for example, Osuji, et al [I]. The authors claim that the geophysical survey activities often carried out in the Niger Delta together with some dredge spoils, among other things, were responsible for recurrent vegetal disorientation observed in the area .There views, put together, appear to portray the habitations and inhabitants there as risk society . Synstratigraphic studies connected with investigation of facies, sedimentary reservoirs, palaeogeomorphology, etc. abound. The works: Zeng & Calvert [2), Wagner et aI [3], Itoh, et aI (4)" and Mrlina & Cajz [5] are typical. Back et at [6] reported on the study in which 3D seismic data and synoptic analysis of them were undertaken in order to make sedimentologic interpretations. The research was carried out in the shallow-oft shore Niger-Delta in Nigeria. They found out that when 3D- seismic data were supported with wireline data they show ability to support evaluation of the sedimentary response to data tectonics. Mann et al [7J applied seismic reflection profiling data in conjunction with Fishers' coordinateJ of known reefs in the area to conduct the zonation of ichthyofaunal habitat.

Also, MacBeth & Shams [8] analyzed seismic data gathered through P-wave time lapse 3D OBC instrumentation. They noted that, appropriately, seismic surveys could be a useful tool for palaeo-direction studies in clastic reservoirs. It should be observed that although several studies have been conducted on seismic surveys in the Niger Delta in question, there is dearth of studies focusing on factorial analysis of delay causative agents in seismic surveys. Thus the principal aim of this study is to identify the key variables that are associates with delay causelities during seismic surveys and to ascertain the overall economic implications for all stakeholders. Seismic reconnaissance entails movement of humans and equipment through unfamiliar terrains, sometimes under peor weather conditions. The situation is exacerbated when wire lines, geophones and similar equipment have to be positioned appropriately irrespective of the geomorphology of an area in order to foster the acquisition of tomographic data.

II METHODOLOGY

Data concerning 9-month field work in seismic survey in Edo State (part of Niger Delta) from United Geophysical Nigeria Limited (UGNL), located in Benin City, Edo state Nigeria. The data pertain to time (in hours) associated with key activities involved in seismic survey**.** These activities were considered as factors sometimes referred to as variables, and the experimental runs over a period of nine months were recorded and taken as our base data matrix. The data matrix formed the basic input into the PCA software employed, otherwise called statisti XL. The software generated the results depicted in tables 2,3,4 and 5.

The data used are primary observations from seismic surveys. The exact field surveyed is located at Ologbo, near Sapele, in Ikpoba- Okha Local Government Area of Edo State. T'- field measures 200km^2.

Fourteen (14) field observations were recorded daily for a period of 262 days spanning 9 months from June 2001 through February 2002.

The fourteen factor as shown overleaf include:

Table 1: Fourteen delay causative variables

Travel time (x_1), Daily Test (x_2), Line Formation (x_3), Waiting on shooters (x_4), Recording time (x_5), Line fault (x_6,) Waiting on permit (x_7),	Waiting on weather (x_8) Waiting on spread (x_9), Instrument fault (x_9), Labour unrest/community Disturbance (x_1), Flooding (x_{12}), Others (x_{13}) and Production (x_{14}),

There are some other companies that undertake seismic survey as, for example, China National Petroleum Company, a subsidiary of (BGP) and the 9-month data were obtained from UGNL because the former focused on off-shore seismic activities while UGNL are on-shore based. Fig. 1 shows the index map of Nigeria & Cameroon .

Fig. 1: Index map of Nigeria & Cameroon.

III RESULTS

Fig. 2 shows the seismic data. It details the seismic composition of the earth formation with particular reference to the folds and troughs of layers of earth crust as well as possible locations of petroleum traps.

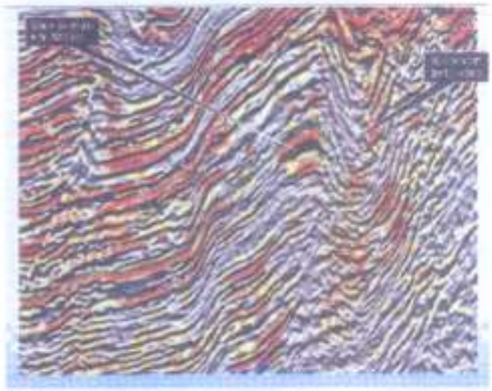

Fig. 2: Seismic data.

Several roller anticlines running longitudinally, as contorted stratigraphs, can be perceived from the seismic image. In the Niger Delta Basin, petroleum accumulation is associated with these stratigraphic features.

Table 2 depicts the descriptive statistics of our experimental data.

Table 2: Descriptive Statistics of Our Data Matrix

Variable	Mean	Std Dev	Std Err	N
X_1	2.430.	1.481	0.091	262
X_2	0.112	0.255	0.016	262
X_3	0.755	0.758	0.047	262
X_4	0.332	0.643	0.040	262
X_5	1.314	1.373	0.085	262
X_6	0.496	0.847	0.052	262
X_7	0.968	2.297	0.142	262
X_8	0.562	1.381	0.085	262
X_9	0.296	1.037	0.064	262
X_{10}	0.233	0.805	0.050	262
X_{11}	0.159	0.965	0.060	262
X_{12}	0.971	2.736	0.169	262
X_{13}	0.421	1.049	0.065	262
X_{14}	0.545	0.563	0.035	262

Travel times (X_1) appear to contribute most to delays and to a lesser extent, recording times (X_5) and waiting on permit (X_7). However, at present, community issues have become a daunting challenge for oil prospecting and producing companies. The expatriates are now being abducted and sometime released for some big ransome

Table 3 captures the nature and trend of intercorrelations among the 14-variables studied.

Table 3: Correlation Matrix of Fourteen Delay Causative Variables

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
X_1	1.000	-0.010	0.121	0.068	0.065	0.046	-0.285	-0.099	0.014	0.082	-0.065	-0.447	0.027	0.067
X_2	-0.010	1.000	0.143	0.081	0.123	0.006	-0.052	-0.059	-0.031	-0.067	-0.061	-0.110	-0.050	0.122
X_3	0.121	0.143	1.000	0.169	0.194	0.156	-0.238	-0.059	-0.076	-0.038	-0.073	-0.318	-0.010	0.192
X_4	0.068	0.081	0.169	1.000	0.153	0.069	-0.188	-0.176	-0.010	-0.085	-0.042	-0.172	-0.088	0.262
X_5	0.065	0.123	0.194	0.153	1.000	0.103	-0.180	-0.233	-0.108	-0.110	-0.094	-0.301	-0.169	0.795
X_6	0.046	0.006	0.156	0.069	0.103	1.000	-0.143	-0.147	-0.058	-0.062	-0.091	-0.172	-0.099	0.199
X_7	-0.285	-0.052	-0.238	-0.188	-0.180	-0.143	1.000	-0.096	-0.098	-0.087	-0.047	-0.123	-0.076	-0.186
X_8	-0.099	-0.059	-0.059	-0.176	-0.233	-0.147	-0.096	1.000	-0.088	-0.061	-0.061	0.063	-0.033	-0.269
X_9	0.014	-0.031	-0.076	-0.010	-0.108	-0.058	-0.098	-0.085	1.000	-0.017	-0.047	-0.102	-0.040	-0.086
X_{10}	0.082	-0.067	-0.038	-0.085	-0.110	-0.062	-0.087	-0.061	-0.017	1.000	-0.026	-0.082	-0.022	-0.089
X_{11}	-0.065	-0.061	-0.073	-0.042	-0.094	-0.091	-0.047	-0.061	-0.047	-0.026	1.000	-0.059	0.039	-0.087
X_{12}	0.447	-0.110	-0.318	-0.172	-0.301	-0.172	-0.123	0.063	-0.102	-0.082	-0.059	1.000	-0.133	-0.320
X_{13}	0.27	0.050	-0.010	-0.088	-0.169	-0.099	-0.076	-0.033	-0.040	-0.022	0.039	-0.133	1.000	-0.118
X_{14}	0.067	0.122	0.192	0.262	0.795	-0.199	-0.186	-0.269	-0.086	-0.089	-0.087	-0.320	-0.118	1.000

Table 4 highlights the unrotated factor loadings

Table 4: Initial Factor

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
X_1	0.361	0.678	-0.024	0.080	-0.113	0.087	0.064	0.135	-0.139	0.120	-0.511	-0.237	-0.045	0.103
X_2	0.258	-0.123	0.121	-0.296	-0.208	-0.417	0.377	-0.480	0.090	-0.341	-0.285	0.143	-0.006	0.020
X_3	0.499	0.223	0.278	-0.310	-0.116	-0.094	-0.124	-0.217	-0.060	-0.014	0.507	-0.422	-0.033	0.052
X_4	0.448	-0.035	0.149	0.113	0.242	-0.298	-0.047	-0.253	-0.008	6.689	0.016	0.269	0.033	0.045
X_5	0.773	-0.349	-0.083	0.009	0.061	0.189	0.241	0.274	0.020	-0.118	0.049	-0.014	0.279	0.086
X_6	0.364	-0.025	0.142	0.100	-0.158	0.188	-0.780	-0.135	-0.027	-0.288	-0.111	0.267	0.023	0.053
X_7	-0.324	-0.330	-0.693	-0.178	-0.429	-0.079	-0.095	-0.057	-0.115	0.187	0.066	-0.018	-0.041	0.131
X_8	-0.364	0.096	0.513	-0.328	-0.231	0.082	0.175	0.349	-0.351	0.035	0.122	0.359	-0.027	0.075
X_9	-0.054	0.232	-0.081	-0596	0.000	-0.621	0.061	0.230	-0.060	-0.263	0.240	0.065	-0.014	0.063
X_{10}	-0.074	0.373	-0.093	0.363	-0.147	0.533	0.301	-0432	0.136	-0.044	0.251	0.216	-0.003	0.049
X_{11}	-0.123	0.096	-0.268	-0.192	0.717	0.056	-0002	-0.207	-0.503	-0.220	0.020	0.051	-0.015	0.053
X_{12}	-0.568	-0.461	0.432	0.210	0.246	0.087	0.002	-0.085	0.254	-0.024	-0.119	-0.228	-0.058	0.157
X_{13}	-0.121	0.423	-0.189	-0.436	0.270	-0.084	-0.088	0.201	0.640	-0.046	0.076	0.176	0.004	0.064
X_{14}	0.814	-0.319	-0.092	0.040	0.100	0.153	0.135	0.214	0.069	-0.063	0.051	0.116	-0.322	0.007

Fig 4 shows the scree plot of the extracted factors, i.e. the plot of 14 components against their eigenvalues in sync with Cattel [9]. The scree plot points up that 6 factors can reasonably explain the observed variations in the variables studied (count points from the left of plot to the elbow kick).

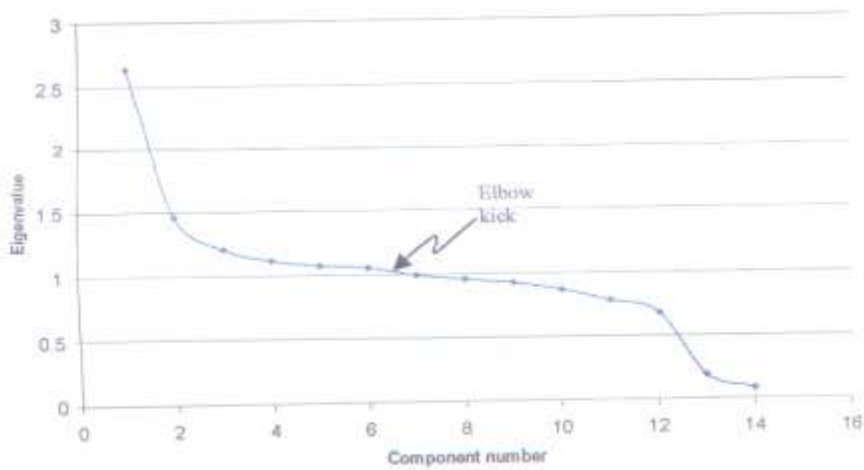

Table 5 shows the eigen-values, i.e. the explained variance which supports the decision to extract 6 factors based on eigenvalue, $\lambda \geq 1$.

Table 5 Explained Variance (Eigenvalues)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12	Factor 13	Factor 14
Eigenvalues	2.636	1.4558	1.204	1.112	1.073	1.052	0.990	0.954	0.923	0.864	0.777	0.678I	0.192	0.087
%	28.831	10.417	8.597	7.9.943	7.661	7.518	7.068	6.816	6.591	6.172	5.551	4.842	1.374	0.619
Cum %	18.831	29,249	37.845	45.789	53.450	60.967	68.036	74.852	81.443	87.615	93.166	98.008	99.381	100.000

However, only five (5) factors which explain 53.45% of the observed variations had been extracted. The decision to extract only 5 factors is hinged on the ground that the principal objective of the study is parsimony i.e. data reduction. It was therefore decided to extract 5 factor which happens to be the minimum number of factors that can explain at least 50% of the observed variation

The varimax rotated factors extracted are shown in table 6

Table 6: Final rotated factor matrix

FACTORS LABELS		Data sampling	Logistics	Permitting delays	Instrument integrity	Community	
Variables	Description	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Communalities
X_1	Traveling	0.011	0.698	0.246	0.240	-0.025	0.607
X_2	Daily Test	0.086	0.136	0.011	-0.403	-0.199	0.228
X_3	Line formation	0.105	0.444	0.345	-0.367	-0.151	0.485
X_4	Shooters	0.402	0.039	0.362	-0.021	-0.008	0.295
X_5	Recording	0.787	0.090	0.097	-0.252	-0.172	0.730
X_6	Line fault	0.227	0.140	0.160	-0.044	-0.299	0.189
X_7	Permitting	-0.042	-0.052	-0.948	-0.078	-0.023	0.910
X_8	Weather	-0.631	-0.063	0.180	-0.319	-0.171	0.566
X_9	Spread	-0.031	0.023	0.062	0.635	-0.102	0.419
X_{10}	Instrument fault	-0.129	0.227	-0.006	0.478	-0.098	0.306
X_{11}	Labour Unrest	0.101	-0.101	0.064	0.018	0.789	0.647
X_{12}	Flooding	-0.293	-0.842	0.168	0.046	-0.027	0.826
X_{13}	Others	-0.227	0.330	-0.003	-0.131	0.560	0.492
X_{14}	Production	0.827	0.114	0.131	-0.217	-0.151	0.784

It is instructive to notice from the communalities of table 6 that 91% of the intercorre1ations between variable 7 (waiting on permit) and other activities was accounted for by the 5 factors. However, in the context of line fault (variable X_6,) only 18.90,10 of such interrelationship is accounted for by the 5 extracted factors.

Moreover, table 7 hierarchically orders the factors in descending order of criticality with regards to associated delays (down time). It is obvious from the table that the four major factors that cause delays in seismic surveys include travel time, recording time, flooding and waiting on permit, in that order, and the least contributor is daily test.

Table 7: Factor ranking

Field Data	**Description**	**Total Hours**	**% Contribution**	**Cumulative**	**Rank**
X_1	Travel time	638.26	26.9	26.9	1
X_5	Recording time	344.36	14.51	41.41	2
X_{12}	Flooding	254.38	10.72	52.13	3
X_7	Waiting on permit	253.67	10.7	62.85	4
X_3	Line formation	197.74	8.33	71.16	5
X_8	Waiting on weather	147.22	6.2	77.36	6
X_6	Line fault	129.98	5.48	82.84	7
X_{13}	Others	110.40	4.65	87.49	8
X_4	Waiting on shooters	87.04	3.67	91.16	9
X_9	Waiting on spread	77.57	3.27	94.43	10
X_{10}	Instrument fault	61.03	2.57	97	11
X_{11}	Community/labour unrest	41.57	1.75	98.76	12
X_2	Daily test	29.41	1.24	100	13

Perhaps the most significant result of our study is that principal component Analysis has facilitated the clustering of the fourteen factors into smaller dimensions (5 groups) which had been creatively labeled and presented in what follows.

(1) Data sampling activities

This is a bipolar (mixed signs) cluster. As it is evident ITom table (9), production activity is a meritorious

Table 9 : Data Sam lin Activities

Creative label / Variable	Data sampling Activities	Factor loadings
X_4	Waiting on shooters	+0.402
X_5	Recording time	+0.787
X_8	Waiting on weather	-0.631
X_{14}	Production Activities time	+0.827

factor because it wields the highest factor loading in the platoon. Recording time is also meritorious per se by same reasoning. The two factors are crucial in time management. Waiting on weather is an idle time (non-productive), hence it is loaded negatively. Waiting on shooters is a mediocre.

(2) Logistics

The three factors in this platoon are concerned with the practical organization that is necessary for successful seismic operation. They are bipolar factors.

Table (10) : Logistics

Creative label / Variable	Logistics	Factor loadings
X_1	Travel time	+0.698
X_3	Line information time	+0.444
X_{12}	Time to triumph over flooding influences	-0.842

The meritorious variable (Xl2) is negatively loaded thus signifying that it whittles down seismic effort. Travel time is a middling; it varies directly with line formation (a mediocre), i.e. they work together.

(3) Permission Matters

Table (11) deals with permission matters. The two variables therein are opposing, i.e. they vary inversely. Waiting on permit is a meritorious variable. It wields the highest factor loading and is therefore considered as the most influencive factor. If permit is not obtained from the community authorities, seismic work cannot commence. Waiting on shooters, to some extent, contribute to delay; it is a mediocre.

Table (11): Permission

Creative label / Variable	Permission Matters	Factor loadings
X_4	Waiting shooters	0.402
X_7	Waiting on permit	-0.948

(4) Instrument integrity

Table (12) depicts another regime of variables that is associated with the integrity of seismic facilities employed.

Table (12) Instrument

Creative label / Variable	Instrument	Factor loadings
X_2	Daily Test time	-0.403
X_3	Line information time	-0.367
X_9	Waiting on spread	0.635
X_{10}	Instrument fault orientated delay	0.478

They are, as is the case with the preceding variables, bipolar which comprise mostly mediocres. They' are therefore less influencive.

(5) Random Events

Finally, we have a platoon of noisy variables which are more or less sporadic incidences.

Table (13): Random Events

Creative label / Variable	Random Events	Factor loadings
X_6	Line fault	0.227
X_{11}	Line unrest	0.789
X_{13}	Miscellanity	0.560

Labour unrest is practically influencive; line faults occur occasionally. There are also other issues that are miscellaneous in the way they happen and are generally encapsulated under miscellnity.

Table 8 depicts the general trend of delay over the period of 9 months for the factors investigated.

Table: 8 Trend of delay

Variable	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
X_1: travel time	65.93	93.7	51.37	55.85	58.15	73.94	104.93	86.17	48.22
X_2: daily test	2.42	5.03	4.14	5.28	4.13	1.87	1.42	2.62	2.50
X_3: line formation	16.74	24.33	18.50	32.59	25.15	31.15	19.68	16.02	13.58
X_4: waiting on shooters	3.06	6.98	10.71	4.35	17.62	21.93	4.27	12.93	5.19
X_5: recording time	29.92	19.57	33.88	41.39	33.31	44.68	34.09	48.78	58.74
X_6: line fault	10.33	5.46	16.26	27.85	17.87	12.57	20.27	13.41	5.96
X_7: waiting on permit	40.86	20.39	27.32	18.43	21.15	17.05	28.73	75.61	4.13
X_8: waiting on weather	23.09	48.5	24.11	24.7	3.34	8.81	14.67	0	0
X_9: waiting on spread	0	5.35	0.13	10.99	30.98	23.01	5.93	1.18	0
X_{10}: instrument fault	0	0.1	2.49	3.3	1.6	17.66	15.67	16.07	4.14
X_{11}: labour unrest/community disturbance	0	15.5	0	0	0	12.02	3.72	7.79	2
X_{12}: Flooding	73.14	37.3	84.92	0	48.45	0	6.57	4	0
X_{13}: Others	13.51	13.91	6.26	31.89	12.03	2.35	24.69	1.12	4.64
X_{14}: production	6.5	8.49	11.11	21.36	19.07	15.26	15.4	21.84	23.88

IV DISCUSSION

The principal component analysis employed has facilitated the reduction of larger set of data (262 measurements of activity times) into 5 set of dimensions. Management of these fewer dimensions are relatively easier than the 14 variables earlier studied. Seismic project managers can now concentrate on the 5 dimensions in formulating strategies and policies. Tactical planning may be concerned with the entire 14 variables. Moreover, the clusters have provided a basis for assigning duties to seismic survey teams who should concentrate on specific areas, so that factors clustering offensive variables can easily be known and handled with dispatch.

It is important to note that majority of the factors (clusters) studied are peculiar to Niger Delta especially human factors, terrain and logistics. The human factors aspect requires tact and diplomacy (social technology). The perceived restiveness had been linked to stem from oil spillage, devegetation, gas flaring and other human activities that are detrimental to ichthyofaunal beings. Osuji et al confirms these claims.

Perhaps it is necessary to say that the results of this study are valid because the model employed (PCA) used actual measurements from seismic surveys. The factor matrix was rotated 9 times (iteration) before obtaining the final result. Column and row optimization was achieved. Besides, there were no spurious variables. Moreover, the scree plot and the eigenvalues used confirm that the factors extracted were adequate. Our results are therefore generalizable.

Implications

It is normal in 3D seismic project to broach and drilt about 100,000 holes in one month, which translates to over 1,200,000 holes in a year. In these holes, explosives are charged and detonated. Forests and other vegetations are destroyed. The accompanying noises scare ichthyofaunal inhabitants. The more influencive these identified variables are, the more delay they cause in seismic operations and the costlier the exploration. This observation is corroborated by Osuji et al [1].

The most critical of these variables now is the community restiveness. Oil exploration and production activities have declined on account of this development. This certainly directly affects the Nigerian OPEC quota from time to time. A multiplier effect is implied. A political solution beyond the scope of this paper should be sought. Perhaps a referendum is desirable.

V CONCLUSION

The delay causalities in seismic survey have been analyzed and dimensioned into five platoons

for better management. Strategic planning & control of seismic projects could now be focused in these five areas in order to whittle down the impact of those variables in seismic reconnaissance.

ACKNOWLEDGEMENT

The authors acknowledge the assistance of Nigerian Petroleum Development Corporation for providing the field data used in this study.

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A.C. Igboanugo.“ A Factorial Analysis of Delay Causalities in Seismic Reconnaissance: Implications for Petroleum Exploration In Tbe Niger Delta” International Refereed Journal of Engineering and Science (IRJES), vol. 07, no. 04, 2018, pp. 37–45.