PREDICTING THE LOST LABOUR VALUE IN CONSTRUCTION PROJECTS WITH LINEAR MODELS

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Abstract
Inspite of the extensive literatures on lost labour estimation methods in construction project circle, some of the methods in use continue to raise spurious doubt and consistency questions in terms of giving repeatable value when applied to different construction scenarios. Clients, constructors and consultants are left to their fate of selecting a method for evaluation of their claims on the basis of situation specifics occasioned by this limitation. This study responded by investigating selected case studies of construction projects in Heavy and Civil Engineering Projects by quantifying their lost labour values on the basis of leonard and Moselhi's framework, arising from the statistical propensity which the data tend to exhibit, linear models were developed to predict the lost labour value of construction work items on the differential iteration of baseline and actual output of labour in terms of ManHour. This gave a consistent and holistic approach to the estimation of lost labour value in construction projects without regards to circumstances of application.

Keywords: *Estimated/planned ManHour, Expended ManHour, ManHour earned, Earned value.*

Introduction

So many literatures exist on the numerous methods of estimating lost labour. But great credit is due to Bore herding, J.D & Alrcon (2004), in its recommended practice No. 25R-03 on estimating lost labour productivity in construction claims for harmonizing them into a body of knowledge. However, in view of their relative merits, and pitfalls, this paper accordingly responded with a generalized predictive model to estimate or measure lost labour. The various methods for measuring lost labour have been enumerated in http:www.AACE.com (2004) with accompanied discussions on their potency. Inadvertently these methods are somewhat not predictive, but rather deterministic.

One of the major limitations observed in Report No. 25R-03 is the contemporaneous project documentation estimation as a legitimate way to calculate damages in terms of awards and claims. Further, North American legal systems acknowledged these limitations that damages cannot always be calculated with mathematical certainly. Due to their deterministic nature on the basis of their procedure rather than predictive, procedures must be followed to the later if any meaningful result must be obtained.

The thrust of this paper emphasis that lost labour can be mathematically computed on the basis of earned value trackers as output and actual baseline variables which include Estimated/Planned ManHour, ManHour expended and ManHour Earned. On the same Report document (No. 25R-03) it also gave a caveat, that the procedure need not be an exert science. The justification for the indeterminacy has been accounted for in the works of Schwartzkopf (1995) on non empiricism of data for estimation, conditions

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for the application of estimation factors in hydra headed causes/circumstances and situational application with regards to the phase of the project. Further argument was advanced to deconstruct the claim to scientific basis of the methods with regards to the methods inability to respond to the reasonableness of the contractor's planned productivity.

This paper therefore made a conscious effort to standardize the quantification of lost labour productivity by responding with a predictive model from earned value tracking variables.

Theoretical Framework

This paper intends to develop a predictive model for the measurement or estimation of lost labour using earned value tracking variables. The author identified these variables to be estimated/planned ManHour, ManHour expended and ManHour earned. From these parameters a compliant model is developed on the basis of Federal M.O & Pigneri S.C (1993) framework on generalized linear model, who noted that the structural component of a model must have firstly. A random component, specifying the conditional radiance of the response variable, having i^{th} item of 'n' independent observation, given the values of the explanatory variables (earned value trackers) in the model.

Secondly, there exists a linear predictor that is a linear function of regressors;

$$\eta_i = \infty + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots\ldots\ldots\ldots\ldots\ldots + \beta_{ik} x_k \text{ ([24])} \quad [1]$$

Thirdly, there exist in the model, a smooth and invertible linearizing link function, g(.), which transforms the expectation of the response variable, $\mu_i \equiv E(Y_i)$, to the linear predictor:

$$g(\mu_i) = i = \propto + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots\ldots\ldots\ldots\ldots\ldots + \beta_{ik} x_k \quad [2]$$

And on the basis of the invertability of the link function we can have the model linearize as;

$$\mu_i = g^{-1}(i) = g^{-1}(\propto + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots\ldots\ldots\ldots\ldots\ldots + \beta_k x_{ik}) \quad [3]$$

This turns out to be a linear model which can transform expected response or a nonlinear regression model for the response. Working on a count data of Man -Hour loses we associated it with a probability identity of the poison distribution;

$$p(y) = \mu^{\intercal} y \times e^{\intercal}(-\mu)/y^{\intercal}! \quad \{y = 0, 1, 2 \ldots\ldots\ldots\ldots\ldots\ldots \quad [4]$$

This will require the model to comply with the distribution function such that as μ increases, it becomes more symmetric and approximates to a normal.

Where

$\propto$ = Regression function constant

β_i = Coefficients of variables

x_i = Regression variables

$g^{-1}(.)$ = Invertible linearizing link function

$i = \mu_i$ = Linear predictor

$E(Y_i)$ = Expectation function of the response variable

$P(y)$ = Poisson distribution function

μ = Count rate parameter which is equal to the expectation and variance of a Poisson distribution.

Statement of Research Problem

Recent incursions made into the study of lost labour estimation have shown the willingness of researchers to develop a mathematical approach to the measurement of lost labour as a problem of concern in the industry and academia. In the lights of this, Bore Herding J.D & Alrcon L.F (1993) had shown that estimation on the basis of labour cost can be used to ascertain damages, particularly of mention is the total labour cost owned model and the total unit cost method which unfortunately lacks sophistication for need of mathematical operations (matrix conjecture, differentiation, integration etc.) Furthermore, Dartner, A.D & Thomas, R.H (1985) deduced a set of weak logit models for computing total labour cost earned

$$Log_e T_{LCO} = 7.973 \times 10^{-13} T_{LCE} - 0.09 Log_e T_{LCP} \quad [5a]$$

$$T_{LCO} = -1.067 e^{-1.4 \times 10^{-12} T_{LCE}} + A_{CC} \quad [5a]$$

On a likert scale of 5, he showed the significant relationship between reliability level of lost labour estimating methods and the tracking methods used for the estimate,

$$\Re_{estm} = 0.096 + 0.983 \Gamma tckm \quad [5c]$$

With tracking methods having weights of, workers activities timing methods 3.88, schedule of labour Day work 3.67, a ppropriation of gang size 3.35, weather forecast 3.51 and contemporaneous records of labour output 3.34. He noted that mere substitution of the tracking methods' weight will show reliability level. He also related the total labour cost paid total labour co st expended and acknowledged contractor's complain as

$$T_{LCO} = -1.067 e^{6.27 \times 10^{-12} T_{LCE}} + A_{CC} \quad [6]$$

And on the basis of continual difference between output baseline of ManHour and Actual output, he related the difference to lost labour with;

$$LL = 0.947 - 0.01 (L_{OB} + L_{OA}) \quad [7]$$

Where

$Log_e T_{LCO}$ = Natural log of total labour cost owed
T_{LCE} = Total labour cost expended
$\Re_{estm}$ = Reliability level of lost labour estimating method
Γ_{tckm} = Lost labour tracking method
T_{LCP} = Total labour cost paid
LL = Lost labour
L_{OB} = Labour output baseline
L_{OA} = Labour output actual
A_{CC} = Acknowledged contractor's complain

Additionally, the following works are called to mind in the estimation of lost labour class, D.J. (1992) Shewartziopf.w, (1995) Thomas, H.R & Carmen, N. (1994) on studies made on labour productivity measurement related to learning curve. The works of Thomas, H.R. & Rayner,K.A (1994) **can be referred to** in specialized studies related to overtime and time shift framework for measurement of lost labour. Specialized studies relating to project characteristic as a basis of lost labour estimation can be found in the works of those studies made in connection with changes, cumulative impact and rework towards estimating lost labour can be

Found in works of; Swhewartzkioff. W.

(1995)[17]. Those Studies made in relation to accelerated job procedure for lost labour estimation are referenced from the works of Bore herding, J.D & Douglas F.G (1981)[5] Chen, M.T, (1992)[6], Foster, B, (1986)[10], Hanieko, j,b & Henry N.C (1991)[12]. Studies made in reference to weather parameters can be found in Abele G, (1986)[1]. Finally, specialized studies made in respect to project management factor inexhaustible include McCally B .M (1999)[14]. These studies heralded the assemblage of lost labour estimating techniques which has been ascertained by AACE that each method is characterized by varying degree of reliability.
In spite of these advances most of these methods require, or constitutes stages of procedure that eventually culminate to an answer and none of these method rightly out showed the predictability of lost labour value owing to their indirect and unempirical approaches which renders most of the methods deterministic rather than predictive.

Research Method

Results from this study originated from data collected from achieve retrieved case studies on ManHour losses from Twelve (12) Heavy and Civil Engineering projects constituting a total of Ninety two (92) work items. This paper referenced the subsisting approach for evaluating lost labour productivity using the differential method of computation. In this approach Koelm, E & Brown, G (1995)[13] in line with the superior Mc Cally, B.M (1990)[14] framework provided for the computation of labour productivity index (PI) as the ratio of earned hours to actual or expended bases hours. The lost labour productivity was then computed from;
LL_p = (1 PI) X 100%. PI = earned hours ÷ actual/expended hours.
However, the approach used by companies to track lost labour hours varies accordingly but conceptually tied to the leonard formulation around weekly performance measures by tabulating for;

- Earned Work Hours, (EWH) = Percentage Complete X Unit rate Work Hours (WH).
- Credit Work Hour (CWH) = Original budget unit rate X Unite Complete.
- Schedule performance Index (SPI) = earned work hour ÷ Estimated planned work hour.
- Cost Performance Index (CPI) = earned work hour ÷ actual or expanded work hour.

In the foregoing parametric computation for lost labour productivity, each work item is assumed to have different units of work or subtask integrated in the Work Brake down Structure (WBS). The unit for each piece is an aggregate of the estimated or planned hour.

McEniry's Garte work clarified the complexity associated with the concept that the actual or expended contract hours are not the estimated base contract bid hour, but rather the total actual inefficiencies. The only invalid reason that tend to discredit the Leonard's framework for evaluation of lost labour productivity in spite recent versions and the critiques of Gavin D.G (1990) under the auspices of the construction industry institute report (2002) on coping with extras is on the research project made by Hanna, A.S Russel, J.S Gotzion T.W (1999) disagreeing with some of the credit attributed to Mc Cally B.M (1999) study on the basis that no published court decision indicate that the approach has been accepted in predicting the cumulative loss of labour productivity. However, industries, academia, consulting firms and learned societies continue to apply

the Leonard's method for computing the lost labour productivity. The outcome of lost labour value for the 92 items of work was used to generate a predictive model.

Field Survey Results

Table 1.0: Lost Labour output from Road Construction Project

	Work item	Qty	Unit	Earned value tracker				
				Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1.	Concrete Road	214	m^3	4.8	64	56	12.5	1.17
2.	Waterproofing	1406	m^2	18	24	21	12.5	1.17
3.	M.S dowel Bars in expansion	30	Tons	52	70	61	12.9	1.17
4.	Concrete kerbs installation	428	m	72	96	84	12.5	1.17
5.	Expansion	229	m	43	57	50	12.3	1.16
6.	Kerbs placement in curved plan	107	m	52	70	61	12.9	1.17
7.	Stone paving	412	m^2	65	86	76	11.6	1.17

Table 2.0: Lost Labour output from Timber Jetty Project

	Work item	Qty	Unit	Earned value tracker				
				Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1.	Timber pile	12	m^3	104	138	121	12.3	1.17
2.	Pile shoe	8	Nr	86	114	100	12.3	1.16
3.	Handle and pitch	8	Nr	56	75	65	13.3	1.16
4.	Driving piles	32	m	59	78	69	12.7	1.17
5.	Longitudinal	3	m^3	34	45	40	11.1	1.18
6.	Transverse timber member q	4	m^3	38	50	44	12.0	1.16
7.	Diagnosed timber member 5	5	m^2	41	52	48	7.8	1.17
8.	Timber decking	6	m^3	66	88	77	12.5	1.17
9.	Bolts, nuts and washers fixing	64	Nr	84	112	98	12.5	1.17
10.	Spikes fixing	160	Nr	36	48	42	12.5	1.17

Table 3.0: Lost Labour output from Crude Storage Facility

	Work item	Qty	Unit	Earned value tracker				
				Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1.	Tank Storage 6m deep	1050	m^3	86	114	100	12.3	1.16
2.	Trench for 450mm diameter cast iron pipe 3m deal	10	m	48	64	56	12.5	1.17
3.	Ditto 4.5m deep	20	m	41	55	48	12.7	17
4.	Brake out and reinstate conc. Road.	3	m	37	49	43	12.2	1.16
5.	Brake out and reinstate	1	M	104	138	121	12.3	1.16
6.	Take up, clean and re-lay conc. Kerb	1	m	29	39	34	12.8	1.17
7.	Embankment around storage tank	445	m^2	38	50	44	12	1.16
8.	Turfing	333	m^3	56	74	65	12.2	1.16

Table 4.0: Lost Labour output from Geo Technical Process

	Work item	Qty	Unit	Earned value tracker				
				Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1.	Mobilization	1	Item	68	90	79	12.2	1.16
2.	Plan	1	Item	48	64	56	12.5	1.17
3.	Chemical consolidation	20	m^3	84	112	98	12.5	1.17
4.	Electro-osmosis injection process	33	m^3	111	148	130	12.2	1.17

Table 5.0: Lost Labour Output from Liquefied Natural Gas Waterproofing Project

Work item	Qty	Unit	Earned value tracker				
			Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1. Asphalting	64	m^2	51	68	60	11.8	1.18
2. Waterproofing	53	m^2	63	84	74	11.9	1.17
3. Rending	64	m^2	30	40	35	12.5	1.17
4. Waterproofing coating	64	m^2	45	60	53	11.7	1.17
5. Angle fillet nibs	138	m	29	39	34	12.8	1.17
6. Lining to sumps	47	m	19	25	22	12	1.16

Table 6.0: Lost Labour output from Wet-Well and Pump Chamber Project

Work item	Qty	Unit	Earned value tracker				
			Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1. Wet-well excavation	45	m^3	42	56	49	12.5	12.5
2. Ditto Pipe inlet nib	14	m^3	18	24	21	12.5	12.5
3. Ditto hard rock material	3	m^3	12	16	14	12.5	12.5
4. Concrete blinding 80m thick	14	m^2	29	39	34	12.8	12.8
5. Concrete grade 25/19	19	m^3	34	45	40	11.1	11.1
6. Form work rough & smooth	133	m^3	52	70	61	12.9	12.9
7. Surface finish	19	m	10	13	12	7.7	7.7
8. Benching	2	m^3	27	40	32	20	20

Table 7.0: Lost Labour output from subway construction project

Work item	Qty	Unit	Earned value tracker				
			Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1. Bulk excavation	372	m^3	83	97	97	11.8	1.17
2. Concrete base	56	m^3	66	77	77	12.5	1.17
3. Ditto walls	74	m^3	69	80	80	13.0	1.67
4. Ditto roof slab	44	m^2	71	83	83	11.7	1.17
5. Parapet walls	3	m^3	31	36	36	14.3	1.16
6. Rough battered	261	m^2	28	33	33	10.8	1.18
7. Ditto smooth	369	m^2	33	39	39	11.4	1.18
8. Narrow widths in U-shaped end	160	m	39	46	46	11.5	1.18
9. Surface finish wood float	268	m^2	51	60	60	11.8	1.18

Table 8.0: Lost Labour Output from Crude Effluent Canal Project

Work item	Qty	Unit	Earned value tracker				
			Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1. Site clearance	1000	m	34	45	40	11.1	1.18
2. Excavation	1309	m^3	96	128	112	12.5	1.17
3. Concreting floor/walls	556	m^3	53	70	62	11.4	1.17
4. Form work	1420	m^2	38	51	44	13.7	1.16
5. Surface finish	560	m^2	19	25	22	13.7	1.16

Table 9.0: Lost Labour Output from Gravity Sewer of Crude Distillation Intrusion Plant Project

Work item	Qty	Unit	Earned value tracker				
			Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1. Excavation 3m deep	225	m	58	77	72	6.5	1.24
2. Excavation 4.5m deep	675	m	62	83	73	12.0	1.18
3. 540mm diameter pipe with flexible	900	m	33	44	39	11.4	1.18
4. Concrete cradle	151	m	69	92	83	9.8	1.20
5. Excavation in 1.5m for 400mm diameter cast iron pipe	122	m	38	50	43	14.0	1.13
6. Ditto 400mm diameter pipe in 3m depth	778	m	41	54	48	11.1	1.17
7. Installation of 400mm diameter pipe (4 legs)	900	m	51	64	58	9.4	1.14
8. Distribution and laying of pipe	900	m	19	33	27	18.18	1.42
9. Tylon flexible joint	225	m	23	41	29	29.3	1.26

10.0: Lost Labour Output from Quay Wall Construction Project

Work item	Qty	Unit	Earned value tracker				
			Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1. Mobilization	1	Item	50	66	62	6.1	1.2.4
2. Excavation	300	m^3	100	133	125	6.0	1.25
3. Sub foundation	100	m^3	50	65	65	7.7	1.20
4. Support steel	100	Tons	270	350	340	5.6	1.26
5. Piping	25	m	60	80	72	10	1.20
6. Boiler/Installation	30	Item	90	120	115	4.2	1.28
7. Utilities	1	Item	50	67	64	4.5	1.28
8. Startup	1	Item	80	105	100	4.8	1.25
9. Clean up	1	Item	100	132	125	5.3	1.25
10. Demolition	1	Item	50	36	27	2.5	0.54

Table 11.0: Lost Labour output from Condensate Boiler Project

	Work item	Qty	Unit	Earned value tracker				
				Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1.	Driving Sheet pile	588	m^2	86	114	112	1.8	1.30
2.	Concrete in pile	67	m^3	30	40	39	2.5	1.30
3.	M.S steel in forks	18	Tons	32	47	43	8.5	1.30
4.	Driving 13.5mthick	31	m	64	53	48	9.4	0.75
5.	Strip head of pile	31	m	29	30	27	10.0	1.04
6.	Blinding concrete	196	m^2	26	30	27	10.0	1.04
7.	R.C Concrete in platform beam, counterfeits copying	230	m^3	101	130	126	3.1	1.25
8.	Shuttering	450	m^2	64	85	81	4.7	1.27
9.	Placement m.s reinforcement	38	Tons	38	51	47	7.8	1.24
10.	Installation 3.5m long tie rods/nuts	80	Nr	45	57	41	28.1	0.94

Table 12.0: Lost Labour output from petrochemical extrusion bottling plant

	Work item	Qty	Unit	Earned value tracker				
				Estimated/ planned ManHour	Man Hour Expended	Man Hour Earned	Lost Labour Productivity	S.P.I
1.	Set up			24	32	28	12.5	1.17
2.	Material handling			20	60	52	13.3	2.6
3.	Production run			64	95	90	5.26	1.41
4.	Q.C check			12	33	30	9.1	2.5
5.	Packaging			24	68	62	8.8	2.58
6.	Loading and shipping			12	30	31	3.33	2.58

SPI = Schedule Performance index

Table 13.1a: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1.	321[a]	.103	.083	4.08357

a.Predictors: (Constant), Man Hour Earned, Estimated Man Hour.

Table 13.1b: ANOVA[b]

Model	Sum of Squares	df	Mean Square	f	Sig.
1 Regression	170.539	2	85.269	5.113	.008[a]
Residual	1484.120	89	16.676		
Total	1654.659	91			

a.Predictors: (Constant), Man Hour Earned, Estimated Man Hour.
b.Dependent Variable: Lost Labour Productivity

Table 13.1c: Coefficient

Model	Unstandardized		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant}	12.590	.798		15.779	.000
Estimated ManHour	.101	.066	.797	1.543	.126
ManHour Earned	-.110	.053	-1.063	-2.058	.043

a.Dependent Variable: Lost Labour Productivity

Table 13.2a: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1.	.623[a]	.389	.375	3.37124

a.Predictors: (Constant), Man Hour Earned, Estimated Man Hour.

Table 13.2b: ANOVA[a]

Model	Sum of Squares	df	Mean Square	f	Sig.
1 Regression	643.152	2	321.576	28.295	.000[a]
Residual	1011.507	89	11.365		
Total	1654.659	91			

a. Predictors: (Constant), Man Hour Earned, Estimated Man Hour.
b. Dependent Variable: Lost Labour Productivity

Table 13.2c: Coefficient[a]

Model	Unstandardized		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant}	11.101	.696		15.966	.000
Estimated ManHour	.606	.090	6.229	6.714	.000
ManHour Earned	-.671	.096	-6.485	-6.990	.000

a. Dependent Variable: Lost Labour Productivity

Table 13.3: ANOVA Test on Estimated ManHour, ManHour Expended and ManHour Earned against Lost Labour Productivity

Table 13.3a: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1.	.624[a]	.389	.368	3.38997

a.Predictors: (Constant), Man Hour Earned, Estimated Man Hour.

Table 13.3b: ANOVA[a]

Model	Sum of Squares	df	Mean Square	f	Sig.
1 Regression	643.371	2	214.457	18.662	.000[a]
Residual	1011.287	89	11.492		
Total	1654.659	91			

a. Predictors: (Constant), Man Hour Earned, Estimated Man Hour.
b. Dependent Variable: Lost Labour Productivity

Table 13.3c: Coefficient[a]

Model	Unstandardized		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant}	11.109	.701		15.836	.000
Estimated ManHour	-.008	.057	-.062	-.138	.000
ManHour Expended	.610	.095	6.269	6.414	.000
ManHour Earned	-.668	-6.464	-6.464	-6.841	.000

a. Dependent Variable: Lost Labour Productivity

Model specification

It is convenient to associate any two or more variable in this study with three or more variable and attempt to show their corresponding relation. Depending on the axes of perspective, when the variables are operated simultaneously, they may show a monotonic decreasing or increasing tendency or one variable is increasing while the other is decreasing, or no such relationship exist between them. Regression analysis was carried to formulate the models in this study. The model is specified as;

$$LL_p = \beta_0 + \beta_1 \xi_{mh} + \beta_2 \xi^{\partial}_{mh} + \varepsilon_i$$

$$LL_p = \beta_0 + \beta_1 \xi^{\partial\partial}_{mh} + \xi^{\partial}_{mh} + \varepsilon_i$$

$$LL_p = \beta_0 + \beta_1 \xi_{mh} + \beta_2 \xi^{\partial\partial}_{mh} + \beta_3 \xi^{\partial}_{mh} + \varepsilon_i$$

Where;

$\xi^{\partial\partial}_{mh}$ = ManHour Expended

ξ^{∂}_{mh} = Earned ManHour

ξ_{mh} = Estimated Manhour

Discussion on the Results

Three (3) generic lost labour productivity models were generated from the field survey results iterated from 12 heavy and Civil Engineering projects with ascertained 92 work items evaluated from earned value variables. The models were subjected to ANOVA test to show the internal consistency of data used for the modeling. At 10% significant level, the data showed spuriou s doubt and as such were significant to the level of showing linearity dependence in compliance with the three structure components for generalized linear models.

The conduct of the experimentation was done at three (3) stages or steps. The first step was to earned (ξ^{∂}_{mh}). From table 12.0 showing ANOVA test on the variable from output data, gave a regressed model in tandem with Federal , M.O & Pigneris. .C. (1993) framework on generalized linear model.

$$LL_p = 12.590 + 0.101\xi_{mh} - 0.110\xi^{\partial}_{mh} \quad [8]$$

The knowledge from this is that lost labour can actually be predicted on the foreknowledge of estimated ManHour planned and iterated expended ManHour by mere substitution from which cost can be pro-rated on the basis of time related charges rather than method related charges.

Accordingly, a second phase model from table 13.0 was examined between expended ManHour $\xi^{\partial\partial}_{mh}$ and ManHour earned ξ^{∂}_{mh} and the preponderance of the data gave a regressed model consistent with the [24] theorem on generalized linear model structu re as;

$$LL_p = 11.101 + 0.606\xi^{\partial\partial}_{mh} - 0.671\xi^{\partial}_{mh} \quad [9]$$

The knowledge herein is that this model, somewhat predict lost labour value on the basis of information offered for end tracking variables of expended ManHour and ManHour earned which has no reference to the bid estimated/plan ned ManHour of a work item. The two (2) trackers are sufficient to determine the lost labour.

The third grand and unified model encompassing the three earned tracking variables from table 14.0 were subjected to a linerizing link conjecture to give a regres sed model of;

$$LL_p = 11.109 - 0.008\xi_{mh} + 0.610\xi^{\partial\partial}_{mh} - 0.668\,\xi^{\partial}_{mh} \quad [10]$$

This model showed that lost labour productivity can be estimated on the basis of interpolation from the three earned value trackers estimated/planned ManHour (ξ_{mh}), expended ManHour ($\xi^{\partial\partial}_{mh}$) and ManHour earned (ξ^{∂}_{mh}). This will tend to respond to reasonableness of evaluating contractors planned productivity level.

Conclusion

In this study, three (3) generic models were developed for predicting lost labour value in construction process. This was on the basis of data retrieved from archival source by instruction process. This was on the basis of data retrieved from archival sources by instrument of analysis of variance (ANOVA) to develop a regressed model. These models were shaped structurally to comply with subsisting theorem of generalized linear models. Accordingly they are presumed responsive to the estimation of lost labour without conditions to circumstances or situations which previous deterministic methods limited estimation to. The cost implication from the lost can be retrieved by prorated from work item rate using the work breakdown structure to isolate labour cost derived from time related charges from material cost.

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