COST PREDICTION MODELS OF COMPONENTS OF BUILDING AND CIVIL ENGINEERING CONSTRUCTION IN AKURE TOWNSHIP AND ITS ENVIRONS, ONDO STATE, NIGERIA

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ABSTRACT

Forecast models for predicting future cost and prices of selected material, labour and equipment components both for building and civil engineering construction activities within the study area were generated based on past cost and price data collected. Prices, wages and hiring rate data for a defined period (2000-2010) were collated and stored in a database after which they were used to generate price indices using the Laspeyres index. A univariate (single variable) time series model was used to generate a forecast of future prices of the same selected components after the raw data had been adjusted by removing the effect of inflation. Series of analysis were carried out to ensure that effect of external forces like inflation, market forces etc. were removed giving a 'constant' (deflated) monetary value. The model was used to generate future cost and price data with subsequent error analysis carried out to verify the accuracy of the model. The generated models were found to be good descriptors of the price trends of the selected components with high degree of correlation.

Key words: Forecast, Laspeyres index, Univariate, Inflation, Correlation.

1.0 INTRODUCTION

Historically, the major goals in a construction project are budget (cost), time and quality (Chan et al, 1999) and the construction industry is known to be a risky industry with uncertainties that management has to contend with and these make construction cost estimates probabilistic rather than of the deterministic nature expected by the society. Giwa (1988) revealed that price or cost fluctuation was the major source of contract sum overrun accounting for 26-98% in his study.

Also, the construction industry is a major segment and the highest employer of labour in the economy (Seeley, 1996). This means that for every adjustment in the economy, the construction industry will be the most affected segment. Nigeria has experienced unstable times economic wise in the recent times, the trend of which has been uncoordinated prices of materials and plants as well as the overhead and profit to the contractors. Example of this is a bag of cement that was sold in July 2000 for ₦600 became ₦1,200 in February 2006 and now ₦2,250 five years later. The increase about 100% and 86% increase respectively which is only a representative of the upshot of prices within the last decade.

Akinsola (2007) recognised that as the industry has no specific magic in its own to control the prices of material used in this segment of the economy there is a dire need for proper cost planning and the use of accurate forecasting methods to determine the cost of construction to the contractor and the price of the overall project activity to the owner.

Cost and price prediction serve as an invaluable tool in the evaluation of cost (or price) fluctuations, utilizing previous cost data to enable proper construction cost planning for future construction works. Since construction costs are incurred over the entire construction phase of a project, it is often necessary to determine the amounts to be spent in various periods to derive the cash flow profile, especially for large projects with long durations.

DESCRIPTION OF THE STUDY AREA

Akure Township which is situated in Ondo state in Nigeria which is the case study is one of the numerous cities being visited by a wave of industrialization. The situation of various institutions; commercial, educational and industrial in the last decade has caused a great increase in the level of construction works in the area particularly in the area of building construction.

Government involvement in creating conducive environment both for the citizens and also interested investors has also caused an increase in the level of civil engineering construction within the state.

2.0 MATERIALS AND METHODS

The study area was split into regions and cost and price data gotten for selected material and labour components for a defined period (2000-2010) which was further divided into quarters (i.e. Jan-Mar, Apr-Jun, etc.) via the use of questionnaires administered to construction materials merchants, local government equipment hiring offices, quarries with skilled (educated) staff and relevant unions and associations, Journals, Price books and cost sheets were also consulted with a market survey carried out to determine the validity of the claims and also to obtain current prices. The data was inputted into database software (INDEXA) that was created for the research work with subsequent grouping and tabularization of data gotten from various sources.

The raw data gotten was then deflated by deducting the inflationary amount to give the actual price worth of the various components selected within the given period. Inflation rates where gotten form the national bureau of statistics (NBS). The deflated prices where further analysed using a moving average iteration taking a period of two (using climatic seasonality i.e. rainy and dry season). This was done until a close to linear graph plot was gotten which could be modelled with a high degree of correlation (R^2 value).

The difference between the trendline of the model equation and the actual deflated amounts were estimated to give the individual seasonal effects and averages for each quarter gotten to give the average seasonal effect. The forecast model was given as;

FORECAST MODEL = MODEL EQUATION + ASE

Where,

ASE = Average Seasonal Effect

LIMITATIONS OF PRICE/COST STUDIES

Challenges and limitations faced during the carrying out of the price/cost studies include;

- Products/outputs of construction activity (houses, apartments, schools, bridge, etc.) are seldom exactly comparable with one another. Differences arise due to variations in the plans/specifications, production location (building site), etc for each product are particularly heterogeneous.
- Regional price differences which have a major impact on costs, prices, size, style, construction materials used methods used etc could not be obtained for past years.
- No or improper price recording or recording of transactions mostly by materials merchants created a major challenge with the collation of price data, most couldn't even remember the last price fluctuation or the time it happened.
- Corrupt practices of the traders also affected the data gotten has some of them did not want to produce their records for fear that we could be agents of a regulatory authority or monitoring agency.
- Language barrier posed another serious problem as mostly the market survey had to be carried out in the local dialect (i.e. Yoruba) which the research students were not to fluent in.
- Market forces to an extent also affected the price data gotten. There could be as much as a 10% difference in the price of materials within the same market. Most market only set a minimum amount for which the traders could go no lesser but granted leave to them to place prices varyingly above the standard regulated prices.
- Price of materials fluctuated varyingly within the period of the market survey due to government policy, the recent instruction for the President for the prices of cement to reduce to N1500 caused a sudden drop in the price of cement from N2250 in May to N1800 in June signifying a 20% decrease in price within a month.
- Lack of technical education and reading and writing skills was also a major limitation as the questionnaire couldn't be administered to some of the respondents.

ACCEPTANCES, ADJUSTMENTS AND REJECTIONS

Not all data collected were accepted for the use of the research work.

- Data gotten from depots and wholesale outlets were accepted and adjustments made to the data by comparing them with the current market prices and data gotten from market survey.
- Wage rates determined by the associations and wage fixing authorities were accepted with no adjustments made as they were the regulated wages for the respective job descriptions.
- Price data gotten from price books were compared with prices gotten from market survey and necessary adjustments made, preferences were given to standard price books used in quantities price estimation (e.g. NIQS journal, Building quarterly).
- Data gotten from ministry and government agencies were taken without adjustments.
- Were data was sourced from more than one point within the same area (e.g. sawmills, cement merchants, block makers etc) only congruent prices were selected.

RESULTS AND DISCUSSIONS

MODEL EQUATIONS

MATERIALS COMPONENT PRICE MODELS

The model equation for ordinary Portland cement is given as:

$y = 0.2659x^2 + 28.151x + 265.31 + ASE$

$R^2 = 0.9391$

The model equation for Sharp Sand is given as:

$y = 1.1417x^2 - 9.4167x + 2619.8 + ASE$

$R^2 = 0.9147$

The model equation for 1"x12" (25mmX300mm) timber type is given as:

$y = 0.007x^4 - 0.7092x^3 + 23.081x^2 - 239.45x + 1010.7 + ASE$

$R^2 = 0.9134$

The model equation for floor tiles is given as:

$y = 0.0024x^4 - 0.2197x^3 + 6.6987x^2 - 62.647x + 881.19 + ASE$

$R^2 = 0.9651$

where;

x= number coefficient for year quarter starting from 2000 (e.g. 1,2,3...)

R^2= Correlation coefficient

ASE = Average Seasonal Effects

The model graphs are given in figure 1 in the appendix.

LABOUR COMPONENT COST MODELS

The model equation for carpenters is given as:

$y = 0.5834x^2 + 0.8469x + 754.96 + ASE$

$R^2 = 0.9671$

The model equation for masons is given as:

$y = 0.2184x^2 + 14.59x + 223.86 + ASE$

$R^2 = 0.9723$

The model equation for iron benders is given as:

$y = 1.1219x^2 - 22.207x + 878.82 + ASE$

$R^2 = 0.9608$

The model equation for labour is given as:

$y = 0.2184x^2 + 14.59x + 223.86 + ASE$

$R^2 = 0.9723$

where;
x= number coefficient for year quarter starting from 2000 (e.g. 1,2,3...)
R^2= Correlation coefficient

The model graphs are given in figure 2 in the appendix.

EQUIPMENT COMPONENT COST MODELS

The model equation for bulldozer is given as:
$y = 38.798x^2 - 1205.5x + 59923 + ASE$
$R^2 = 0.8727$

The model equation for grader is given as:
$y = 23.794x^2 - 759.57x + 31240 + ASE$
$R^2 = 0.8694$

The model equation for pay loader is given as:
$y = 32.584x^2 - 1073.3x + 33797 + ASE$
$R^2 = 0.8633$

The model equation for excavator (320&330 avg) is given as:
$y = 32.584x^2 - 1073.3x + 33797 + ASE$
$R^2 = 0.8633$

The model equation for tipper (single) is given as:
$y = 1.4578x^2 + 63.466x + 4110.5 + ASE$
$R^2 = 0.7382$
where;
x= number coefficient for year quarter starting from 2000 (e.g. 1,2,3...)
R2= Correlation coefficient

The model graphs are given in figure 3 in the appendix.

QUARTERLY AVERAGE SEASONAL EFFECT

The various seasonal effects for the respective selected components indicating the average difference between the model equation and the actual cost/price (deflated) data gotten are given in tables 1, 2 and 3 in the appendix

FORECAST AND ERROR ANALYSIS

The forecast models were used to generate predictive estimates for future costs and prices and the values gotten compared against real-time cost and price for the same period.
The forecast models generated were found to be excellent predictors of trends for material prices and cost of labour for the respective selected components, but a very poor predictor of equipment hiring costs which remain stable over a long period of time. Errors were within the range of -12% and 16% with majority falling within the 10% error limit restriction for accuracy of single variable regression.
Forecast values and error analysis tables are given in the appendix.

CONCLUSION

The ability to forecast the future prices is of immense advantage to the civil engineer, being able to predict future costs and making preparations for it in forms of clauses and sideline agreements within the contract ensures that contracts are executed with both parties (i.e. the client and the contractor) benefitting at the end of the day in form of little or no cost overrun, quality of project execution, no abandonment of project etc.

As with predictive analysis changes could occur, which annul the values gotten from the model equation. Government policies, market forces, national economy and even prayers could affect the real-time price and cost of construction indices. Example is the implementation of the reduction of cement prices by the executive arm of government to N1500 by May/June 2011, this led to a drop in prices of cement as against the predicted price from the model.

The forecast models were found to be excellent descriptors of the price trends of their respective index components, with correlations to the actual values being close to 1, except that of ¾" granite which was poorly correlated, basically due to lack of data for appropriate modelling.

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APPENDIX

Table 1: Average Seasonal Effect of Selected Material Component.

QUARTER	ORDINARY PORTLAND EMENT	SHARP SAND PER DITTO	1'X12'	FLOOR TILES	EMULSION PAINT PER 4 LITRE TIN
JAN-MAR	221.64	481.01	101.33	163.79	255.32
APR-JUN	204.61	465.68	108.79	169.56	170.56
JUL-SEP	182.64	541.97	169.46	164.32	112.92
OCT-DEC	160.18	482.60	134.29	147.57	110.97

Table 2: Average Seasonal Effect of Selected Labour Component.

QUARTER	CARPENTERS	MASONS	IRON BENDERS	LABOUR
JAN-MAR	248.96	230.73	187.35	180.65
APR-JUN	198.09	203.92	244.93	130.86
JUL-SEP	162.01	199.06	193.03	98.54
OCT-DEC	197.45	175.35	165.33	98.54

Table 3: Average Seasonal Effect of Selected Equipment Component.

	BULLDOZER		PAY	EXCAVATOR
QUARTER	D6&D7	GRADER	LOADER	320&330 AVG.
JAN-MAR	10466.65	5551.82	6188.80	17959.60
APR-JUN	9053.55	4707.62	5069.31	14604.17
JUL-SEP	8278.42	4238.78	4437.93	12706.91
OCT-DEC	8278.42	4238.78	4437.93	12706.91

Table 4: Quarterly forecast (2011-2012) for selected material components

YEAR	QUARTER	CEMENT	AGGREGATE	TIMBER	TILES	PAINTS
		ORDINARY PORTLAND CEMENT	SHARP SAND PER DITTO	1'X12'	FLOOR TILES	EMULSION PAINT PER 4 LITRE TIN
2011	**JAN-MAR**	2292.20	4989.00	1154.32	1612.07	3185.28
	APR-JUN	2327.51	5068.15	1255.69	1704.61	3396.30
	JUL-SEP	2358.42	5241.20	1438.44	1799.85	3655.60
	OCT-DEC	2389.37	5280.87	1557.08	1898.65	3992.43
2012	**JAN-MAR**	2504.77	5380.61	1713.39	2046.89	4498.13
	APR-JUN	2542.22	5468.89	1949.49	2202.65	4797.94
	JUL-SEP	2575.25	5651.08	2282.21	2366.89	5148.82
	OCT-DEC	2608.34	5699.89	2566.74	2540.71	5580.02

Table 5: Quarterly forecast (2011-2012) for selected labour components

YEAR	QUARTER	SKILLED LABOUR			
		CARPENTERS	MASONS	IRON BENDERS	LABOUR
2011	JAN-MAR	2223.42	2314.63	2338.71	1503.312
	APR-JUN	2226.49	2354.01	2476.16	1488.00
	JUL-SEP	2245.50	2416.95	2506.40	1490.58
	OCT-DEC	2337.22	2462.67	2563.07	1525.92
2012	JAN-MAR	2446.16	2589.08	2671.71	1643.80
	APR-JUN	2453.90	2634.92	2818.15	1630.22
	JUL-SEP	2478.43	2704.33	2857.35	1634.55
	OCT-DEC	2573.96	2756.50	2923.01	1671.64

Table 6: Quarterly forecast (2011-2012) for selected equipment components

YEAR	QUARTER	EQUIPMENTS				
		BULLDOZER	GRADER	PAY LOADER	EXCAVATOR	TIPPER*
		D6&D7			320&330 AVG.	SINGLE
2011	JAN-MAR	94708.10	50794.02	57669.90	167988.10	11176.85
	APR-JUN	94614.17	50832.43	57879.00	168694.36	11176.30
	JUL-SEP	97247.70	52339.94	59767.89	174300.53	11263.01
	OCT-DEC	99728.01	53840.80	61790.07	180377.63	11464.97
2012	JAN-MAR	104474.15	56702.28	65628.29	173672.48	11978.85
	APR-JUN	104690.60	56931.05	66098.05	193395.48	11989.96
	JUL-SEP	107634.51	58628.91	68247.62	199787.09	12088.33
	OCT-DEC	110425.21	60320.12	70530.47	206649.63	12301.95

Table 7: Error Table for forecast cost and prices of selected components

COMPONENT	FORECAST PRICES	ACTUAL PRICES	ERROR	% ERROR
Ordinary Portland Cement	2292.1962	2250	42.1962	1.87538667
Sharp Sand	4988.997	5000	-11.003	-0.22006
3/4" granite	4036.571	3500	536.571	15.3306
1"X12" timber	1154.325	1200	-45.675	-3.80625
Floor tiles	1612.069	1700	-87.931	-5.1724118
Emulsion Paint	3185.282	2900	285.282	9.83731034
Carpenters	2223.42	2500	-276.58	-11.0632
Masons	2314.63	2500	-185.37	-7.4148
Iron Benders	2338.706	2500	-161.294	-6.45176
Labour	1503.315	1500	3.315	0.221
Bulldozer (D6&D7)	94708.1	85000	9708.1	11.4212941
Grader	50794.02	45000	5794.02	12.8756
Payloader	57669.9	50000	7669.9	15.3398
Excavator (320&330 avg.)	167988.1	145000	22988.1	15.8538621
Tipper (Single)	11176.85	10000	1176.85	11.7685

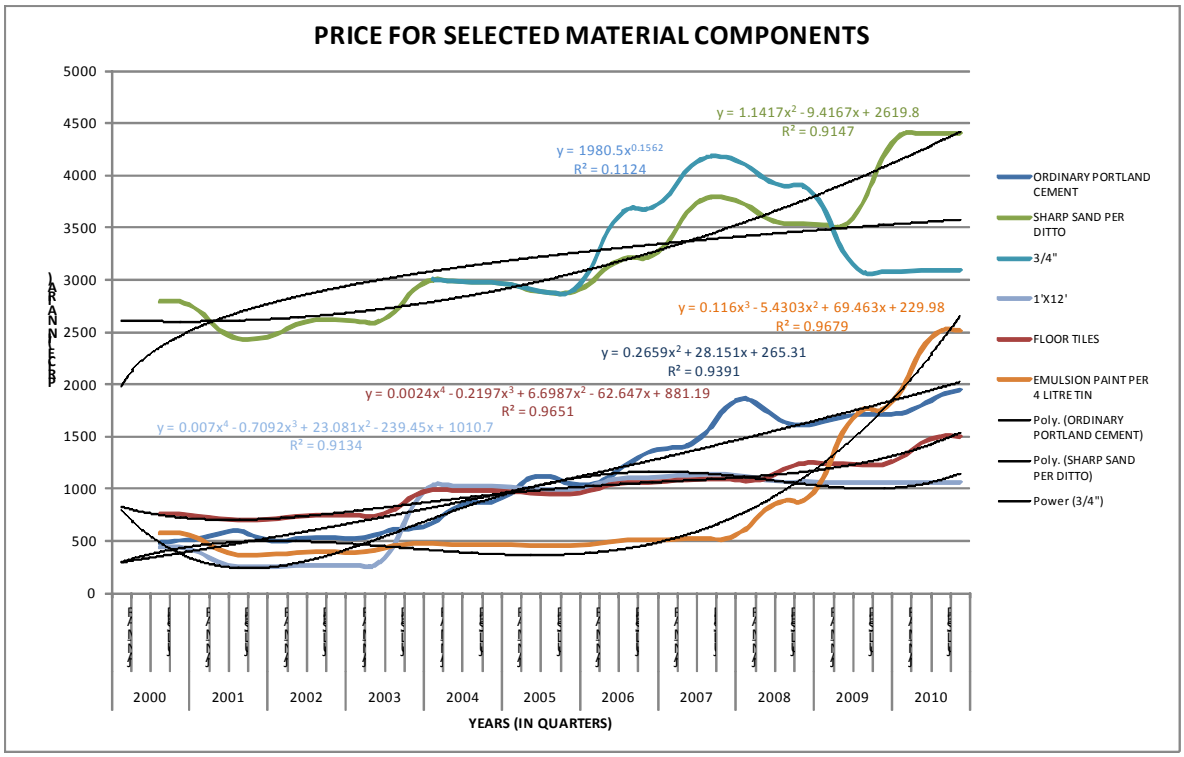

Figure 1: Model Graphs for selected Material components

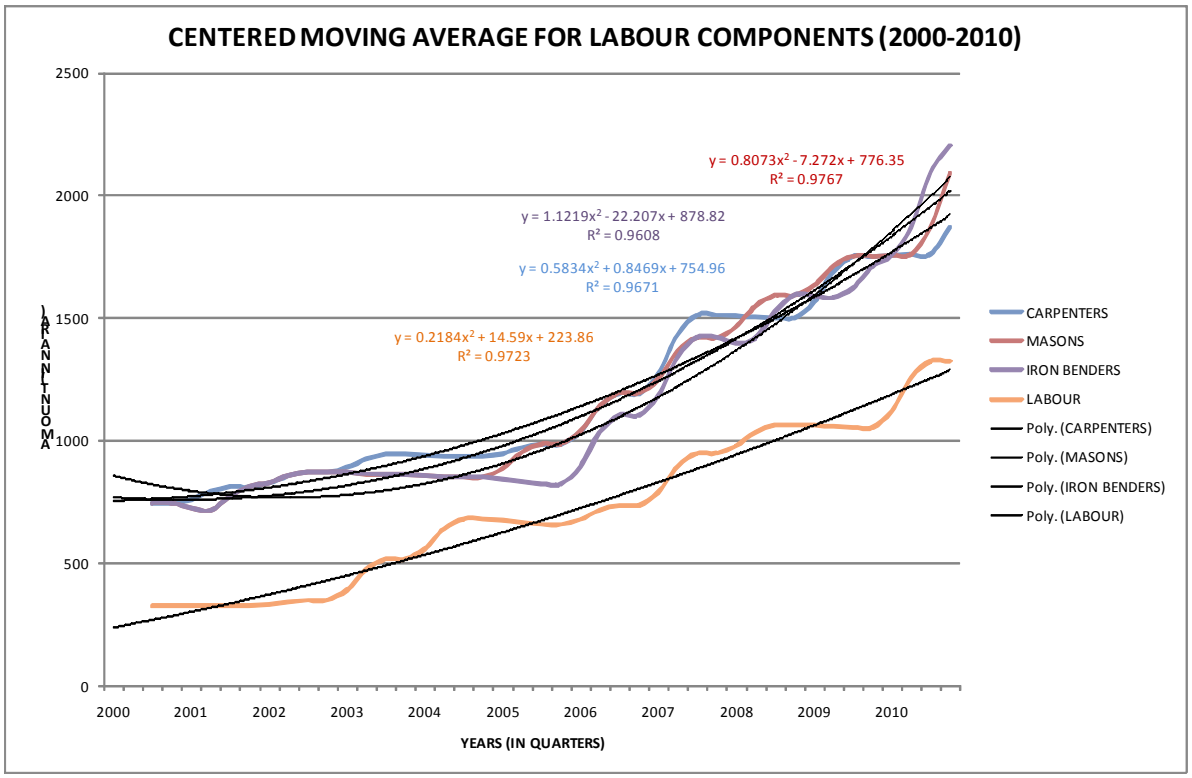

Figure 2: Model Graphs for selected Labour components

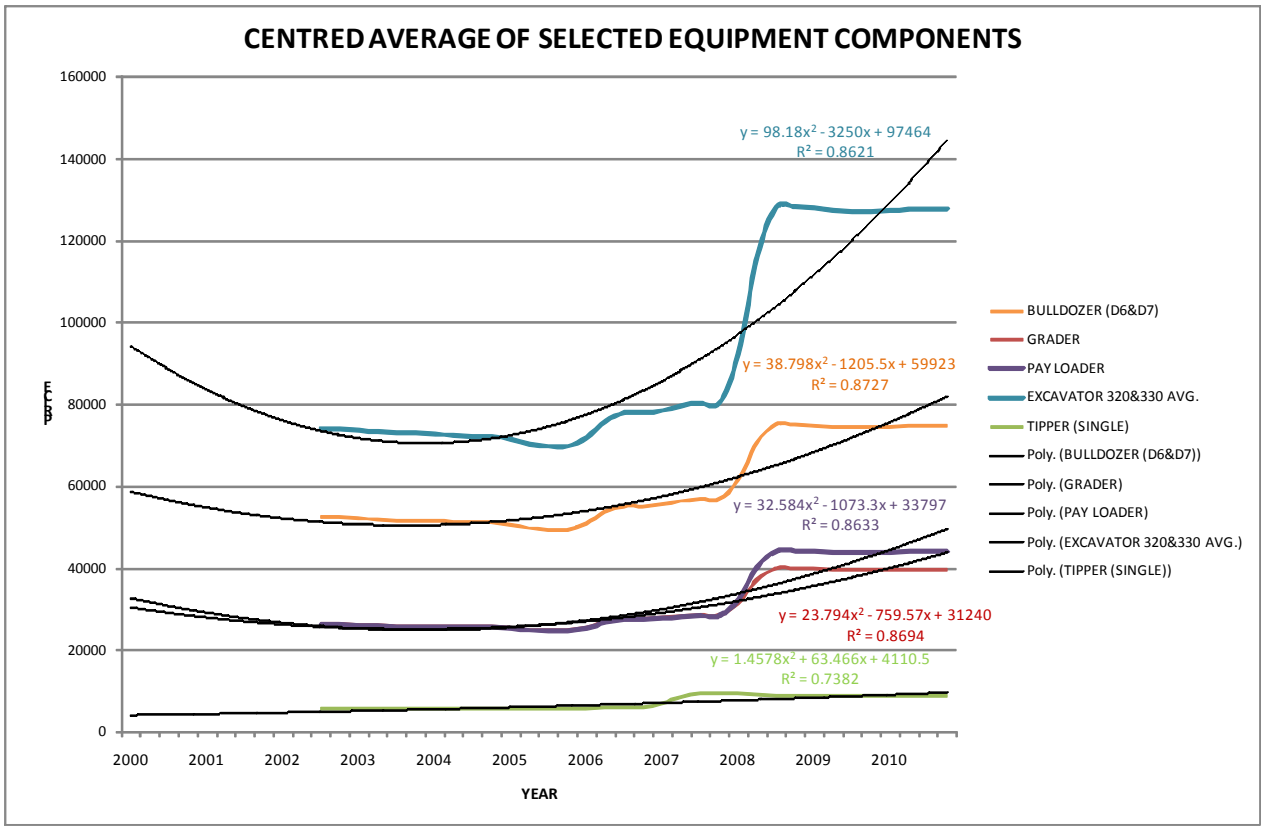

Figure 3: Model Graphs for selected Equipments components