Al-Nahrain Journal for Engineering Sciences (NJES) Vol.20 No.5, 2017 pp.1064-1070

Modeling Contractor's Cash-in-Flow in Public School Building Projects in Karbala

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Abstract

Public school building projects in Karbala Province experiences payment problems due to improper cash-flow planning by both parties; contractors and clients. These payment problems lead to work stoppages and conflicts. This research aims at developing a suitable model to forecast the expected contractors' cash-in-flow in public school building projects in Karbala based on historical data. Complete sets of interim payments of (33) out of (38) school building projects finished in the years (2007-2012) in Karbala were interpolated using seven different regression methods namely; Polynomial, Gompertz, Morgan-Morgan-Finney, Logistic, Exponential, Gaussian and Linear in order to identify the best-suited model. It is found that the third degree polynomial model is more suitable for cash-in-flow forecasting of the case under study with coefficient of correlation of (97.89%) and standard error of (0.0441). Data of the remaining (5) projects were used to test the validity of the best-fitted model using Mean Absolute Percentage Error, Root Mean Square Error and Average Accuracy Percentage. The model is expected to be of high advantage in predicting contractors' cash-in-flow in public school building projects in Karbala, and consequently clients' cash-out-flow as well.

Keywords: Cash-flow Management, Forecasting S-curves, Financing Construction, Time-cost Model and Regression Methods.

1. Introduction

Although there are (532) primary and (233) secondary public school buildings in Karbala (MOEDU, 2014), there is a need to build a minimum of (300) additional public school buildings to solve the problem of double and triple occupancy in most of the existing school buildings in Karbala (Karbala Province Council, 2015), along with additional school buildings needed to meet future demand due to annual population growth of about (3.3%) (MOP, 2013). According to prevailing Iraqi contracts conditions which is mainly based on (FIDIC-Red Book), the client is obliged to pay the contractor's monthly installments called interim payments. The value of each interim payment is determined based on the value of the construction works actually done on site and (75%) of the value of materials supplied to site less the accumulated sum paid before, with some additional rules to be followed when paying for imported materials and equipment. Cash-flow forecasting is strongly advisable to be done regularly in order to be meaningful and the method adopted must be simple, easy and accurate enough (Khosrowshahi, 2001).

1.1 Problem Statement

One of the main problems confronted by any contractor is the delay in receiving payments from the client. To avert this, clients need to predict their cash-out-flow to know what funds are required to meet up with the contractor's expectation at the right time. It is essential for the clients to plan their cash-out-flow in advance, in order to ensure smooth functioning of the project. Similarly, credible cash-in-flow forecasting is essential for the survival of any contractor at all stages of work.

1.2 Research Objectives

This research aims at using historical data to develop a mathematical model that is able to predict the expected contractor's cash-in-flow (client's cash-out-flow) of typical public school building projects in Karbala early at the tendering stage. It is an extremely important issue for both local contractors and clients to help both parties to understand in advance (before a project begins) what cash-flow will be required during construction.

1.3 Research Justification

Contractors always require the incidence of interim payments from the client to maintain their working capital. On the other hand, clients are also concerned with assuring interim payments and being aware at when and how to allocate available funds. This necessitates that both parties must have a suitable tool for cash-flow prediction. The ability to predict the project cash-flow should help them both to improve their financial planning and control and to avoid stoppages and conflicts due to financial deficiency.

2. Literature Review

Cash-flow forecasting is the distribution of income and expenditure as a function of time (Kenley, 2003). Many researchers had carried out cash-flow forecasting studies at various stages of the construction project. In which the S-curve model is regarded as the fastest and easiest presentation of cash-flow (Banki and Esmaeeli, 2008). It is also noticed that Multi regression models are widely used for this purpose (El-Kholy, 2014).

Other researchers concluded that the cumulative frequency distribution of expenditures (or revenues) over time can be polynomial, or exponential (i.e. not necessarily be an S-curve) (Ng et al., 2001), (DeFond and Hung, 2003), (Mavrostas et al., 2005), (Park et al., 2005), (Matloob, 2005), (Blyth and Kaka, 2006), (Khosrowshahi and Kaka 2007), and (Tran and Carmichael, 2012).

However, no significant study has been found to be done in Iraq to identify the most suitable model to predict construction projects cash-flow at the tendering stage.

3. Data Collection and Preprocessing

Historical data were collected from past records of (38) public school building projects of typical design finished in Karbala during the years (2007-2012) where no significant inflation rates occurred. The contracts of all those projects were unit price contracts with bill of quantities which have been awarded to general contractors based on the lowest bid criterion at the Committee of Regions Development in Karbala Governorate. All The selected projects are the ones that were finished either within contracted time or with legally accepted delay according to the Contract Conditions and the Governmental Contracts Execution Regulations.

At first CurveExpert Professional program (version 2.3.0, 2016) was used to develop an individual mathematical cash-flow model for each of the first (33) projects based on their historical data in order to obtain suitable representative converted data at unified timings for all projects. This is because the interim payments were actually paid at different timings among the execution of each project. Then the results of these models at unified timings were used to develop a standard cash-flow model that can be used to predict the payments needed each time using the converted data shown in Appendix (B). The remaining five projects were set aside then used to test the validity of the best-fitted model.

4. Research Limitations

Variations were excluded in order to keep a unified work volume for all school projects. The sum of retentions of (5%) of total bid price released at preliminary and final acceptance was excluded as shown in Appendix (A) where (95%) of the total cost of each project is listed against (100%) of its total duration. Furthermore, the retrieval of the (20%) down-payment of each project was proportionally distributed among all of its interim payments.

5. Models Development

CurveExpert Professional program (version 2.3.0, 2016) was used to develop the best mathematical models. Seven powerful mathematical models were generated to forecast the cash-flow cases in hand. These models were; Polynomial, Gompertz, Morgan-Morgan-Finney, Logistic, Exponential, Gaussian and Linear. They are listed in a ranked order in the results pane of Fig. (1). Tables (1) to (7) illustrate the mathematical equation, coefficients values, and test statistics of each developed model.

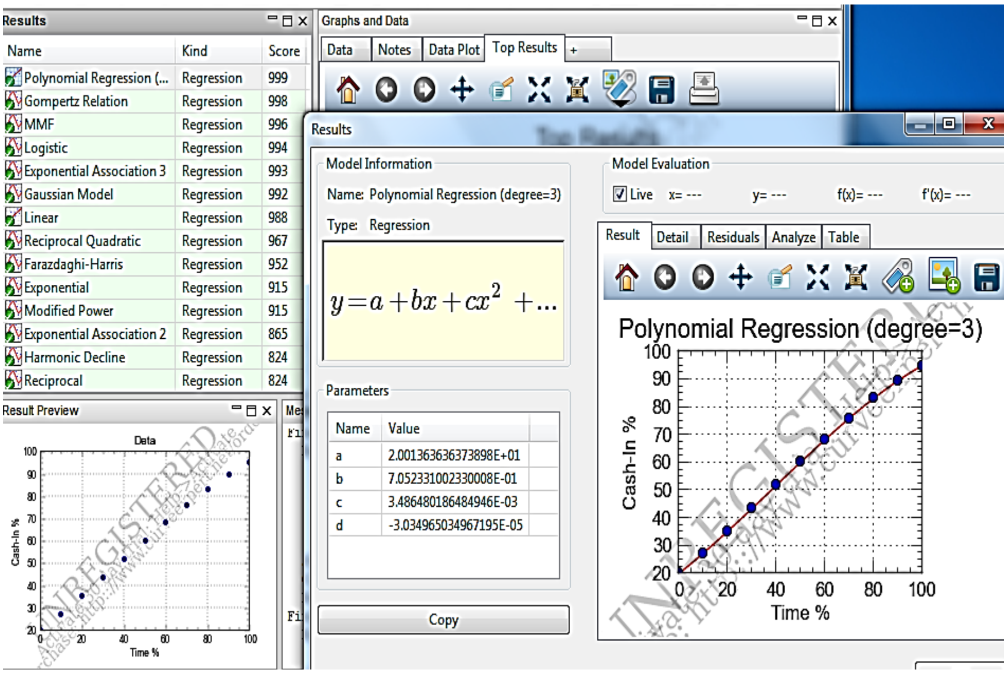

Figure 1: CurveExpert Professional program

Table 1: 3rd degree polynomial model

Equation: **y = a + bx + cx^2 + dx^3**						
Parameters				**Statistics**		
a	b	c	d	%R	$\%R^2$	Std. Error
20.01	0.705	3.48E-03	-3.035E-05	99.879	97.896	0.0441

Table 2: Gompertz Relation Model

Equation: $\mathbf{y = a * e^{-e^{b-c*x}}}$					
Parameters			**Statistics**		
a	b	c	%R	$\%R^2$	Std. Error
1.32E+02	0.63	1.75E-02	99.197	97.71	0.1744

Table 3: MMF Model

Equation: $\mathbf{y = \frac{a*b+c*x^d}{b+x^d}}$						
Parameters				**Statistics**		
a	b	c	d	% R	% R^2	Std. Error
2.03E+01	5.37E+02	2.33E+02	1.234	98.654	97.70	0.4405

Table 4: Logistic Model

Equation: $\mathbf{y = \frac{a}{1+b*e^{-c*x}}}$					
Parameters			**Statistics**		
a	b	c	%R	$\%R^2$	Std. Error
1.101E+02	4.147	3.22E-02	98.383	97.886	0.7498

Table 5: Exponential association model

Equation: $\mathbf{y = a * (b - e^{-c*x})}$					
Parameters			**Statistics**		
a	b	c	%R	$\%R^2$	Std. Error
2.01E+02	1.09	4.824E-03	98.28	97.545	1.2406

Table 6: Gaussian Model

Equation: $\mathbf{y = a * e^{\frac{-(x-b)^2}{2*c^2}}}$					
Parameters			**Statistics**		
a	b	c	%R	$\%R^2$	Std. Error
9.678E+01	1.155E+02	6.673E+01	98.25	97.469	0.9995

Table 7: Linear Fit Model

Equation: y = a + b*x				
Parameters		**Statistics**		
a	b	%R	$\%R^2$	Std. Error
20.52	0.722	98.445	97.109	1.3103

6. Most Suited Model

The third degree polynomial model proved to be the most suited model to represent the standard cash-flow curve in this case study for it has the higher coefficient of determination of (R2=97.89%) and the lower affordable Standard Error of (0.0441) as already shown in Table (1). A graphical representation of this model is shown in Fig. (2) where the effect of the (20%) down-payment is taken into account so that the curve does not start from zero cost. The model equation has the following general form.

$$\mathbf{Y = 20.01 + 0.71*X + 3.49E\text{-}3*X^2 - 3.03E\text{-}5*X^3 \ldots (1)}$$

where:

Y = 100 * Percentage of cumulative payment to the total cost, and

X = 100 * Percentage of passed time to the total time.

7. Model Validation

In order to test the validity (accuracy) of the developed model, data of five additional projects (cases number 34 to 38 in Appendix - A) which were considered as representative data from the targeted population but have not been used in the development of the model were utilized using the most common statistical measures of model efficiency namely; Mean Absolute Percentage Error, Root Mean Squared Error and Average Accuracy Percentage. The predicted cash-in-flow values of these five projects (computed using the best-fitted mathematical model) were compared to the actual data records and the results of coefficient of determination (R2), Mean Absolute Percentage Error (MAPE), Root Mean Square Error (RMSE) and Average Accuracy Percentage

(AA%) of each case are shown in Table (8). Knowing that:

$$MAPE = \left\{\sum_{j=1}^{n} \frac{|A-E|}{A} * 100\right\}/n \quad \ldots\ldots\ldots\ldots\ldots (2)$$

$$RMSE = \sqrt{\frac{\sum_{j=1}^{n}(E-A)^2}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

AA% = 100% - MAPE .... (4)

where:

A: actual value
E: predicted value
n: total number of cases

Table 8: Model Efficiency Parameter

Project No.	Parameters			
	R^2%	MAPE%	RMSE	AA%
34	95	-10.82	8.30	91.70
35	99	-0.88	1.93	98.07
36	96.7	-0.71	4.81	95.19
37	97	1.51	4.85	95.15
38	97.5	0.55	4.11	95.89

8. Conclusions

As a result of this research, a mathematical model is developed to be used as a tool for predicting the expected contractor's cash-in-flow (client's cash-out-flow) in public school buildings projects of typical design in Karbala. The model employed the third degree polynomial technique which proves, among seven other techniques, to be most suitable to develop this standard model with a high coefficient of correlation of (97.89%) and a low standard error of (0.0441). Validation tests using Mean Absolute Percentage Error, Root Mean Square Error and Average Accuracy Percentage showed a very good agreement between actual and predicted values.

This standard model provides a simple and practical tool that can easily be applied at the tendering stage based on the contract sum and duration already known at this stage. The model will enable both contractors and clients to forecast future cash-flows and hence potential project liabilities. It can also be used during the project execution time for cost control and claims resolution.

9. Recommendations

Public school buildings contractors and clients in Karbala is invited to use the developed model to estimate the amount and timing of funds needed for this type of public school building projects before submitting tenders which is also useful for cost control during the construction stage. They can utilize this model to preview the anticipated behavior of cash-flow in such projects, as an early reference for financial decisions.

10. Future Research

It is suggested to adopt the same methodology to develop more models to forecast the cash-flow of other types of projects with other types of design, purpose, and environment.

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Appendix (A)

Actual cash-flow percentages according to each specific equation for each public school building

Project Name/Cod		Actual Cumulative Values Converted to Nearest Percentages												Model Equation
1	3/21232/61	Time%	0	9	18	29	37	46	53	61	71	85	100	y = 21.865-0.0301*X+0.020*X^2-0.000093*X^3
		Cash%	20	23	24	26	32	40	47	56	67	82	95	
2	3/26838/61	Time%	0	9	21	30	49	60	75	87	100			y =20.12+1.245*X-0.005*X^2
		Cash%	20	30	45	54	69	76	85	91	95			
3	1919/2/21	Time%	0	6	20	35	45	53	61	76	87	100		y =19.49+0.587*X+0.011*X^2-0.0000915*X^3
		Cash%	20	23	34	50	60	67	75	86	92	95		
4	1/8250/21	Time%	0	8	19	30	51	70	84	90	100			y =18.507+1.389*X-0.006*X^2
		Cash%	20	28	42	54	74	86	91	93	95			
5	3/26838/61	Time%	0	10	20	31	39	51	58	71	77	100		y =15.181+2.26*X-0.022*X^2 + 0.0000734*X^3
		Cash%	20	26	54	69	76	83	86	90	91	95		
6	3/31465/61	Time%	0	12	19	46	57	67	73	87	100			y =15.345+0.914*X-0.0011*X^2
		Cash%	20	23	29	54	65	75	80	90	95			
7	Alsewada	Time%	0	7	19	36	54	65	77	89	100			y=2.718^(3.118+(0.0144*X))
		Cash%	20	25	30	38	49	58	69	81	95			
8	3/17023/61	Time%	0	5	23	36	43	50	56	62	74	100		y = 21.62+0.086*X+0.0133*X^2-0.000068*X^3
		Cash%	20	22	30	39	44	50	56	62	74	95		
9	4/2326/5	Time%	0	6	30	44	48	58	71	85	100			y=27.083*EXP(0.0126*X)
		Cash%	20	29	40	47	49	57	66	79	95			
10	1/18007/21	Time%	0	8	17	28	37	46	54	61	100			y =60.965+47.064* COS(0.02007*X+3.541)
		Cash%	20	21	26	34	42	49	57	64	95			
11	52054/61	Time%	0	12	24	34	44	57	73	86	100			y =17.065+1.04*X-0.0026*X^2
		Cash%	20	24	36	45	54	65	77	86	95			
12	53563/61	Time%	0	8	22	28	35	50	60	77	85	100		y =17.456+1.081*X-0.003*X^2
		Cash%	20	22	40	46	52	64	71	82	87	95		
13	3/571/34	Time%	0	10	13	24	39	54	61	73	90	100		y =19.873+0.75*X+0.006*X^2-0.00006*X^3
		Cash%	20	22	27	39	53	65	70	78	89	95		
14	3/376	Time%	0	7	22	37	59	72	85	91	100			y =180.224/(1+7.3*2.718^(-.0208*X))
		Cash%	20	25	32	42	58	70	82	87	95			
15	1/28745	Time%	0	14	32	39	48	66	79	86	100			y =19.154+0.857*X-0.001*X^2
		Cash%	20	29	44	50	57	71	81	86	95			
16	Al-Taqa	Time%	0	10	20	36	48	63	73	81	100			y =20.8+1.043*X-0.003*X^2
		Cash%	20	24	36	52	61	72	79	84	95			
17	Al-Khyrat	Time%	0	13	31	50	55	65	77	85	100			y =20.16+0.985*X+0.002*X^2
		Cash%	20	35	46	62	67	77	86	91	95			
18	3/376	Time%	0	8	27	35	43	53	65	79	100			y =20.977+0.47*X+0.009*X^2-0.000063*X^3
		Cash%	20	34	40	46	52	62	74	85	95			
19	3/13011/61	Time%	0	15	27	41	50	63	73	81	100			y =19.369+0.525*X+0.007*X^2-0.000047*X^3
		Cash%	20	27	38	50	57	68	76	82	95			
20	Umlhawa	Time%	0	11	28	46	54	60	71	86	100			y =19.59+0.999*X-0.0024*X^2
		Cash%	20	26	44	60	66	70	77	87	95			
21	1/1806	Time%	0	14	25	45	58	65	71	82	100			y =19.788+0.789*X+0.005*X^2 -0.000054*X^3
		Cash%	20	28	41	61	71	76	80	86	95			
22	Saif-Saad	Time%	0	14	29	40	52	56	72	82	100			y =19.003+1.111*X-0.0035*X^2
		Cash%	20	28	45	57	67	70	81	87	95			

Appendix (A) (continued)

Actual cash-flow percentages according to each specific equation for each public school building

Project Name/Cod		Actual Cumulative Values Converted to Nearest Percentages												Model Equation
23	25/4/3	Time%	0	12	25	33	40	46	62	74	100			y =20+0.703*X+0.0042*X^2 - 0.000037*X^3
		Cash%	20	24	38	46	52	57	69	78	95			
24	3/17017/61	Time%	0	7	19	31	51	69	81	84	100			y =20.964+0.269*X+0.0047*X^2
		Cash%	20	25	30	35	47	61	72	75	95			
25	Alsada-Elaared	Time%	0	6	15	25	39	55	72	87	100			y =2.718^(3.067+(0.015*X))
		Cash%	20	22	27	33	45	60	75	87	95			
26	Al-Farahidi	Time%	0	7	29	42	47	55	59	65	76	100		y =20.376-0.119*X+0.022*X^2-0.0001329*X^3
		Cash%	20	26	34	46	51	60	65	71	83	95		
27	3/45768/61	Time%	0	9	22	29	32	39	45	53	59	66	100	y =20.294+0.563*X+0.0142*X^2-0.000123*X^3
		Cash%	20	27	38	46	48	56	63	72	78	83	95	
28	Al-Yarmuk	Time%	0	11	30	43	56	58	69	83	100			y =20+0.65*X+0.009*X^2-0.00008*X^3
		Cash%	20	23	46	58	69	71	79	87	95			
29	1873/Abuzrent	Time%	0	7	19	31	51	69	81	84	100			y =22+0.465*X+0.01*X^2-0.00007344*X^3
		Cash%	20	22	31	42	60	76	85	87	95			
30	Umtob	Time%	0	6	15	25	39	55	72	85	100			y =19.39+1.058*X-0.00298*X^2
		Cash%	20	22	29	38	52	69	83	91	95			
31	Fatima bint Asad	Time%	0	7	29	42	47	55	59	65	76	100		y =19.593+0.76*X
		Cash%	20	26	39	51	56	63	67	72	82	95		
32	Alshurta	Time%	0	9	22	29	32	39	45	53	59	66	100	y =19.439+1.06*X-0.0031*X^2
		Cash%	20	23	39	47	49	55	60	66	70	75	95	
33	Al-Khawrnaq	Time%	0	8	30	43	56	58	69	83	100			y =20+0.632*X+0.008*X^2-0.0000681*X^3
		Cash%	20	25	44	56	68	70	79	88	95			
34	Al-Resala	Time%	0	7	19	36	54	65	77	89	100			Kept for validation test
		Cash%	20	28	31	39	50	59	71	85	95			
35	ALmelad	Time%	0	9	22	37	59	72	85	91	100			Kept for validation test
		Cash%	20	28	36	48	63	78	89	90	95			
36	23/28 Jadwel	Time%	0	14	32	39	48	66	79	86	100			Kept for validation test
		Cash%	20	25	40	59	65	78	80	92	95			
37	Al-Taawun	Time%	0	11	30	43	56	58	69	83	100			Kept for validation test
		Cash%	20	30	39	50	68	77	82	90	95			
38	Al-Abbas	Time%	0	10	30	44	48	58	71	85	100			Kept for validation test
		Cash%	20	35	49	50	55	66	75	83	95			

Appendix (B)

Converted Payments to be used to Develop the Standard Cash-flow Model

Project No.	Cumulative % Paid at each % Time elapsed										
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	21.87	20.76	23.10	28.32	35.87	45.19	55.72	66.90	78.17	88.98	95.45
2	20.12	32.07	43.02	52.97	61.92	69.87	76.82	82.77	87.72	91.67	95.31
3	19.49	26.37	34.90	44.53	54.71	64.90	74.55	83.10	90.00	94.72	95.00
4	18.51	31.80	43.89	54.78	64.47	72.96	80.25	86.34	91.23	94.92	95.09
5	15.18	35.65	52.17	65.16	75.08	82.36	87.44	90.76	92.76	93.89	95.9
6	15.35	24.38	33.19	41.78	50.15	58.30	66.23	73.94	81.43	88.70	95.63
7	22.59	26.09	30.13	34.80	40.19	46.41	53.60	61.90	71.49	82.56	95.12
8	21.62	23.74	28.12	34.33	41.99	50.67	59.97	69.49	78.80	87.52	95.08
9	27.08	30.72	34.84	39.52	44.83	50.85	57.68	65.43	74.21	84.18	96.01
10	17.61	22.12	28.20	35.60	44.01	53.10	62.51	71.86	80.76	88.88	95.18
11	17.07	27.21	36.83	45.93	54.51	62.57	70.11	77.13	83.63	89.61	95.96
12	17.46	27.96	37.84	47.10	55.74	63.76	71.16	77.94	84.10	89.64	95.04
13	19.87	27.91	36.79	46.15	55.63	64.87	73.51	81.19	87.55	92.23	95.35
14	21.71	26.01	30.99	36.69	43.15	50.33	58.21	66.69	75.64	84.89	95.67
15	19.15	27.624	35.894	43.964	51.834	59.504	66.974	74.244	81.314	88.184	95.90
16	20.80	30.93	40.46	49.39	57.72	65.45	72.58	79.11	85.04	90.37	95.32
17	20.16	29.78	38.94	47.64	55.88	63.66	70.98	77.84	84.24	90.18	95.88

18	20.98	26.51	33.47	41.48	50.15	59.10	67.97	76.37	83.92	90.25	96.02
19	19.37	25.27	32.29	40.15	48.56	57.24	65.92	74.30	82.11	89.06	95.33
20	19.59	29.34	38.61	47.40	55.71	63.54	70.89	77.76	84.15	90.06	95.12
21	19.79	28.12	37.14	46.50	55.89	64.99	73.46	81.00	87.26	91.93	96.00
22	19.00	29.76	39.82	49.18	57.84	65.80	73.06	79.62	85.48	90.64	95.11
23	20.00	27.41	35.44	43.87	52.47	61.03	69.31	77.10	84.18	90.32	95.53
24	20.96	24.12	28.22	33.26	39.24	46.16	54.02	62.82	72.56	83.24	96.02
25	21.47	24.94	28.98	33.67	39.12	45.45	52.80	61.35	71.28	82.81	95.56
26	20.38	21.25	25.73	33.02	42.31	52.81	63.73	74.26	83.61	90.98	95.97
27	20.29	27.22	36.25	46.64	57.66	68.57	78.63	87.10	93.24	94.32	96.21
28	20.00	27.32	35.96	45.44	55.28	65	74.12	82.16	88.64	93.08	95.66
29	22.00	27.58	34.71	42.97	51.90	61.07	70.04	78.36	85.60	91.31	96.44
30	19.39	29.67	39.36	48.45	56.94	64.84	72.14	78.85	84.96	90.47	95.98
31	19.59	27.19	34.79	42.39	49.99	57.59	65.19	72.79	80.39	87.99	95.05
32	19.44	29.73	39.40	48.45	56.88	64.69	71.88	78.45	84.40	89.73	95.32
33	20.00	27.05	35.30	44.32	53.72	63.09	72.01	80.08	86.89	92.04	95.13
Average	**20.00**	**27.38**	**35.30**	**43.51**	**51.86**	**60.17**	**68.29**	**76.03**	**83.23**	**89.68**	**95.00**

نمذجة التدفقات النقدية الداخلة للمقاول في مشاريع أبنية المدارس الحكومية في كربلاء

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الخلاصة

تعاني مشاريع أبنية المدارس الحكومية في محافظة كربلاء من مشاكل في دفع المستحقات نتيجة للتخطيط غير السليم للتدفقات النقدية من قبل كلا الطرفين، المقاول ورب العمل. وتؤدي مشاكل الدفع هذه إلى توقفات في العمل وخلافات. يهدف هذا البحث إلى تطوير نموذج مناسب لتخمين التدفقات النقدية المتوقعة الداخلة إلى المقاولين في مشاريع أبنية المدارس الحكومية في كربلاء بالاستناد إلى بيانات سابقة. تم توظيف مجموعات كاملة من الدفعات المتعاقبة لـ (33) مشروع من أصل (38) مشروع لأبنية مدارس حكومية منجزة خلال الأعوام (2007-2012) في كربلاء باستخدام سبعة طرق مختلفة لحساب الانحدار هي (Polynomial، Gompertz، Morgan-Morgan-Finney، Logistic، Exponential، Gaussian، و Linear) لأجل تحديد النموذج الأكثر ملائمة. ولقد وجد بأن نموذج (third degree polynomial) هو الأكثر ملائمة لتخمين التدفقات النقدية الداخلة للحالة قيد الدراسة بمعامل ارتباط قدره (97.89٪) وخطأ قياسي قدره (0.0441). أما بقية المشاريع الخمسة فقد استخدمت بياناتها لفحص دقة النموذج الأكثر توافقاً باستخدام (Mean Absolute Percentage Error، Root Mean Square Error، و Average Accuracy Percentage). ومن المتوقع أن النموذج سيكون ذي نفع كبير في التنبؤ بالتدفقات النقدية الداخلة لمقاولي مشاريع أبنية المدارس الحكومية في كربلاء وبالتالي التدفقات النقدية الخارجة لأرباب العمل.