PREDICTION THE UNIT PRICE OF LABOR COST USING DYNAMIC SYSTEM IN WATER RESOURCES PROJECT

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ABSTRACT: Project financing is one of the important components in the construction project activity that define how much budget should be provided in a construction project activity. Financing of the project includes the supporting components which influence each other to the total project cost. Planning of project costs with components such as material, wage and equipment costs, may change with respect to external factors and general economic conditions in the country, thus requiring the prediction of unit price of labor's wage as one of its components. The dynamic wage financing simulation system using Vensim software to identify causal relationships between variables (CLD: Causal Loop Diagram) as well as the equation between variables (stock flow diagrams) is ideal for use in predicting the unit price of a wage of a construction worker. This financing system can be used to identify more clearly the relationship between the sub-components of labor costs, facilitate the simulation and decision-making in order to achieve the most optimal project costs in accordance with the interests of budget users. The results of the labor cost financing model have been verified and validated with E_1 = 3.65% <5% and E_2 = 6.26% <30%, so that it can be used to predict wage changes of workers for subsequent budget planning in order to achieve effectiveness, efficiency and accountability in the implementation of construction projects.

Keywords: Dynamic system, Prediction model, Unit price of labor cost

1. Introduction

The construction project is an activity that is unique because it involves a component of the various fields of science and limitation of cost, time and the objective has been established at the beginning. The successful implementation of construction projects is the balance between the three components namely the cost, time and quality. Costing in the implementation of the project should be planned in such a way so as to accommodate all the needs during the project while retain the principle of efficiency and accountability. The operation time is a period where the project would be done. The implementation time also depends on the items of work to be carried out and all the components. When the more detail work items should be analysed, the more precise timetable should be prepared and it will be closer to the real condition. The goal of a project is to achieve the great quality. Quality is an indicator of the success of the project accordance with the objective which is set at the beginning. Good quality has always been one indicator of the success of the project though to achieve the expected quality, it needs the consequences on other components such as the cost and time of implementation. These components are related each other, but the assessment of the project cost will be further analysed in this paper.

Project financing is the one of the important items in the implementation of construction work. Project financing is outlined in an analysis of the project cost budget containing the financial needs based on the needs of those items work to be performed during the operation of construction project. Project cost budgeting analysis is a cumulative value of each job contained in the unit price. It requires the design of an information system to support the financing of the project cost of the overall project.

Project financing system is an information system designed to make it easier for users (the project owner/holder of the budget, or the executor/contractor) in the implementation of development activities. This system is the result of the work cost analysis prepared in accordance with their respective scope of work. In general, project financing consists of direct and indirect cost.

Direct costs are those that directly affect the achievement of the project in the form of time quality and use of resources in the implementation of the project. The direct costs include the cost of unit price components consisting of wage costs, material costs and the cost of equipment that will directly affect the purpose of performing the work. While the indirect cost is the cost to be incurred in the effort to support the implementation of the work consists of general costs (overhead) and profits in accordance with the prevailing regulations. Overhead is calculated as the cost of procurement costs for each payment, cost management, accounting, training and auditing, licensing, registration, advertising, public relations and promotions. Indirect costs include the taxes to be paid in the implementation of development activities.

Major general costs and benefits are determined by considerations such as interest rates, inflation rates, overhead headquarters and field as well as the investment risk. In general, indirect costs are set not more than 15%.

2. Literature Review

Based on previous literature, so many researches have been done in the topics of cost estimation. The objectives of the researches spread in many areas such as exploration the influencing factors, purpose of cost estimation for bidding and development in cost estimation with soft computing model (Akintoye, 2000; Betlejewska & Potkany, 2015; Cheng, Tsai, & Sudjono, 2010; Cheng, Tsai, & Hsieh, 2009; Cheng Y. M., 2014; Huang, Li, & Xie, 2015; Idrus, Nurudin, & Rohman, 2011; Jorgensen, Halkjelsvik, & Kitchenham, 2012; Maryani, Wignjosoebroto, & Pratiwi, 2015; Wang, Wang, Tsui, & Hsu, 2012). This research focuses on the solution of cost estimation that has many causal relation factors for human resources wages.

2.1 Unit Price Analysis

Analysis of unit price is calculation of required labor cost, material cost and the cost of equipment to get the unit price or certain type of work. As shown in Figure 1, the preparation of unit price refers to the analysis of the cost required in development activities in which the description of the development costs are generally divided into direct costs and indirect costs.

Based on the direct cost of the work can be divided into components of labor, building materials and equipment that it directly affects the employment objective. The direct cost component will produce the basic material unit price, the unit price of basic wages and the unit price of tools.

The price of the basic unit is the price of component of the currency of payment in specific units, for example: building materials (m, m^2, m^3, kg, sack), equipment (unit of hour, day) and wages labor (man/ hour, day, month).

The unit price of labor is the basis of the costs incurred on the components of labor per unit of time to produce one unit of measurement of the particular job. Factors affecting unit price of labor cost include the amount of labor and skill levels. The unit price of labor cost is defined (based on minimum wage in region) in accordance with a per capita income of the population.

The unit price of labor cost is calculated using the following steps (see Figure 2):

a. Define the skill or workers,
b. Collecting wage data from the survey results and apply for job execution location,
c. The number of workers in a day and effective working hours,
d. Consider other costs such as health and safety in the analysis.

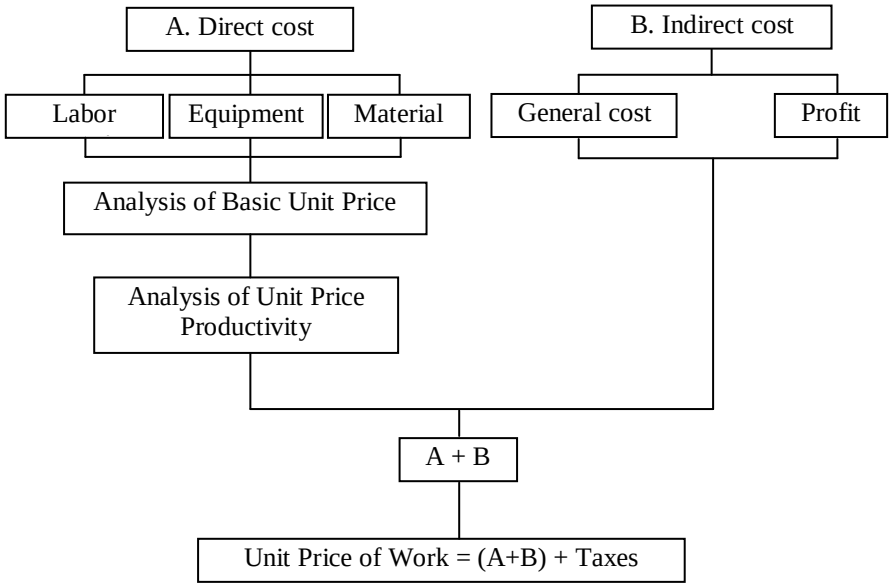

Figure 1 The Architecture of Unit Price Analysis in Construction

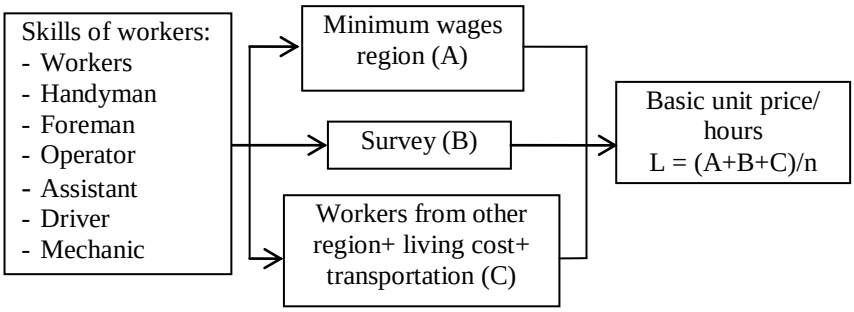

Figure 2 The Structure Analysis of Unit Price of Basic Wage

2.2 Dynamic Systems Approach

The initial step in developing a dynamic model is identification and definition of the problem. In the project planning, the element of time, quality and cost of the components should be considered to achieve the high performance of the project. This study only discusses the financing of the project as one element for achieving the project goal.

The scope of the analysis includes the handling of project financing and building maintenance or improvement of the performance capacity of public works, in particular on the analysis of wage employment in the field of water resources. The discussion consists of the following sub jobs (general works):

a. Earthwork
b. Masonry work (subject analysis)
c. Concrete work
d. Pile work
e. Dewatering work
f. Watergate and hydromechanics

Once the problem and scope are identified, a basic model is build. Then it is followed by conceptualizing the model that consists of a system components, CLD (Causal Loop Diagram)

and stock flow diagram from financing system wage jobs. The project financing system for the sub-system unit price consists of the following basic wage components:

a. Rate of labor cost
b. Index price of basic commodities
c. Cost living index
d. Level of prosperity index and rate of per capita income

The sub-system consists of the direct costs (unit price of work, work volume, taxes) and the indirect costs (profit, general cost, taxes).

2.3 Analysis of Condition Affected the Financing of The Project Worker's Wages

2.3.1 Per Capita Income

Per capita income contributes to workers' wages. The per capita income shows the prosperity of people and the cost of living and will determine the wage of workers (See Figure 3 and Table 1).

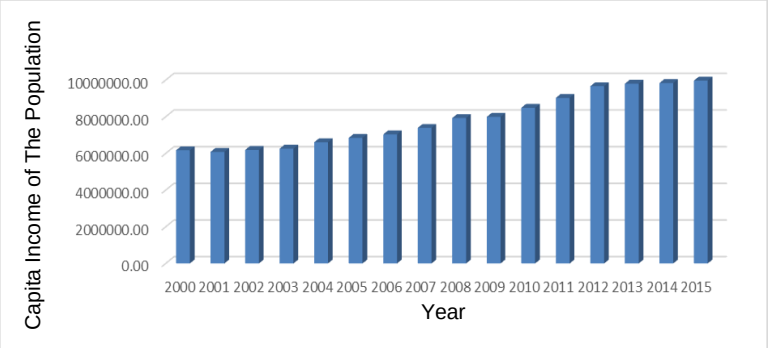

Figure 3 Per Capita Income of Worker in 2000-2015

Table 1 Per Capita Income of Worker in 2000-2015

Year	Capita Income of worker (IDR)				
	/Year	/Day	% Rate (x)	x - mean	$(x- mean)^2$
2000	6171342.91	19907.56	0.54%	2.80	7.84
2001	6083368.92	19623.77	1.43%	1.91	3.65
2002	6185375.02	19952.82	1.65%	1.69	2.86
2003	6258043.21	20187.24	1.16%	2.18	4.75
2004	6605845.36	21309.18	5.27%	-1.93	3.72
2005	6845163.54	22081.17	3.50%	-0.16	0.03
2006	7034952.80	22693.40	2.70%	0.64	0.41
2007	7392111.69	23845.52	4.83%	-1.49	2.22
2008	7927938.47	25574.00	6.76%	-3.42	11.70
2009	7994083.18	25787.37	0.83%	2.51	6.30
2010	8488596.72	27382.57	5.83%	-2.49	6.20
2011	9027335.72	29120.44	5.97%	-2.63	6.92
2012	9665117.07	31177.80	6.60%	-3.26	10.63
2013	9798899.43	31609.35	1.37%	1.97	3.88
2014	9834523.42	31724.27	0.36%	2.98	8.88
2015	9970416.19	32162.63	1.36%	1.98	3.92
		Mean	**3.34%**	**Varian**	**5.99**
				SD	**2.45**

2.3.2 Price Index of Basic Commodities

Price index of basic commodities will affect the rate of population consumption and the living cost index. The prosperity index and the price index of the basic commodities will influence the rate of worker's wage (See Figure 4 and Table 2).

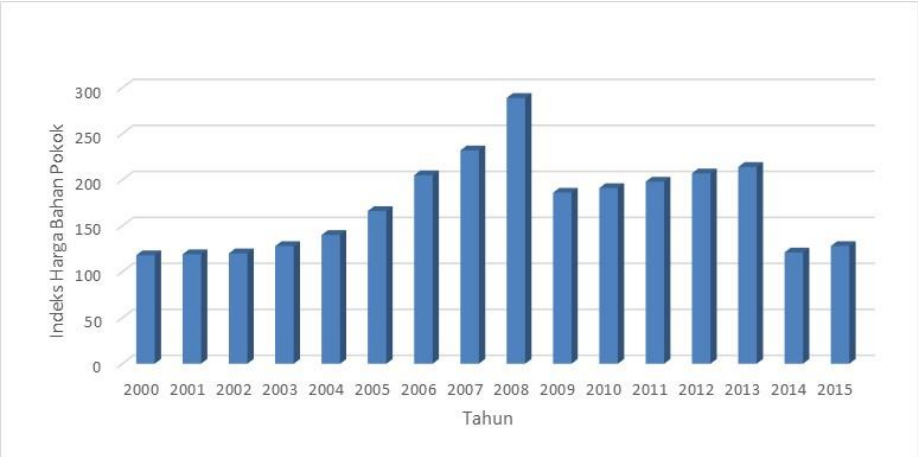

Figure 4 Price Index of Basic Commodities in 2000-2015

Table 2 Price Index of Basic Commodities in 2000-2015

Year	Price Index of Basic Commodities			
	Value	x	x - mean	$(x–mean)^2$
2000	118	3.39%	8.89	79.03
2001	119	0.84%	11.44	130.87
2002	120	0.83%	11.45	131.10
2003	128	6.25%	6.03	36.36
2004	140	8.57%	3.71	13.76
2005	166	15.66%	-3.38	11.42
2006	205	19.02%	-6.74	45.43
2007	232	11.64%	0.64	0.41
2008	289	19.72%	-7.44	55.35
2009	186	35.64%	-23.36	545.69
2010	191	2.62%	9.66	93.32
2011	198	3.54%	8.74	76.39
2012	207	4.35%	7.93	62.88
2013	214	3.27%	9.01	81.18
2014	121	43.46%	-31.18	972.19
2015	128	5.47%	6.81	46.38
Mean		**12.28%**	**Varian**	**170.13**
			SD	**13.04**

2.3.3 Labor's Wage

Human resource is a financial aspect that affects all of the project financing and the successfully of a project construction. There are various types of human resources in a project based on the skill level and the role in project implementation. In this study, we use the masonry as the major

human resource in the construction project. The data of mason's wage in Malang district used this analysis is shown in Figure 5.

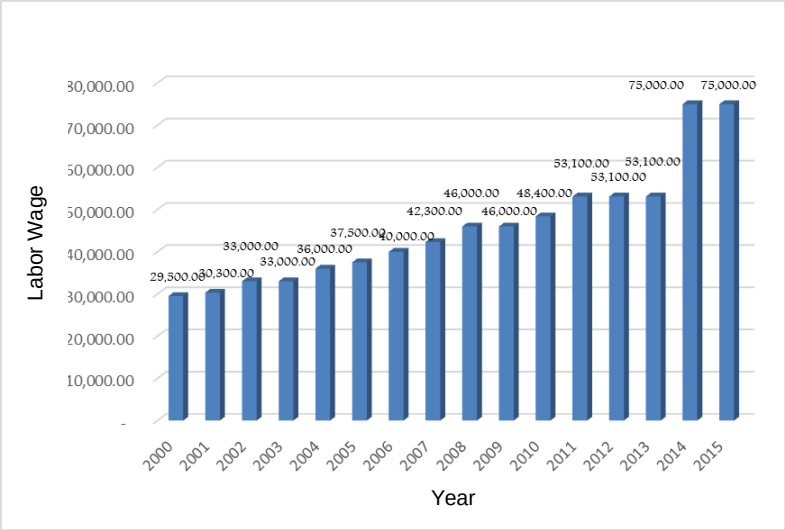

Figure 5 The Graph of Mason's Wage from 2000-2015

3. Method

3.1 Causal Loop Diagram

Causal Loop Diagram (CLD) diagram shows the relation of cause and effect between the variables that have been defined and whether the effect will give a positive or negative impact among interrelated components. CLD for the project financing model of worker's salary is shown in Figure 6.

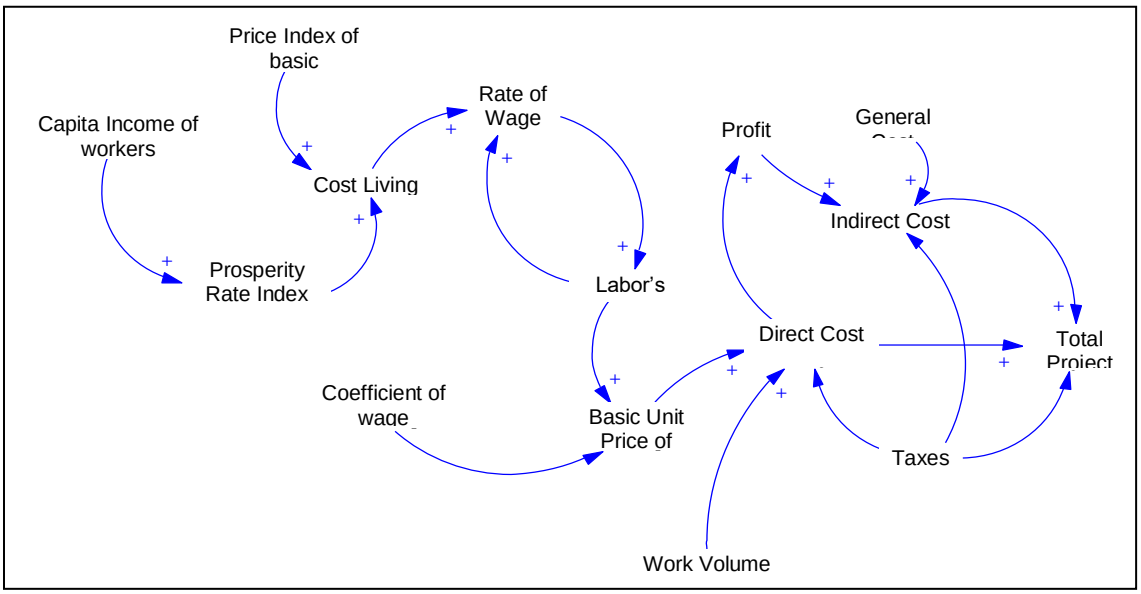

Figure 6 CLD of Construction's Labor Cost

3.2 Formulation of Labor Cost in Dynamic System

The CLD as shown in Figure 6 identifies the interaction between components in the system. In general, the financing system of a project is a series of calculations, which defines the financing of construction costs that can be obtained by accumulating the project cost budget of the work with the taxes should be paid. Direct cost will influence the indirect cost. Direct costs are influenced by the unit price and the accumulation of all the work items of the detailed breakdown of activities. Unit price depends on the volume of work performed. While the unit price of works is the accumulation of basic unit price of the activity, in this study it is the basic price of wage.

Wage is determined by the per capita income, which indicates the level of prosperity index. In addition, the basic commodity price index that occurs in the market greatly affects the market activity of the population, which is combined with the level of prosperity index can show the cost of living index that must be borne by the community. The living cost index can affect the great change in wages. If the living cost index shows a downward trend, which means a lower level of prosperity, the wage of worker is also low and vice versa. It is assumed that if per capita income increases and the living cost index is higher, then the wage of worker should also be increased. The relationships between the variables are formulated in the stock flow diagram as shown in Figure 7 and Figure 8.

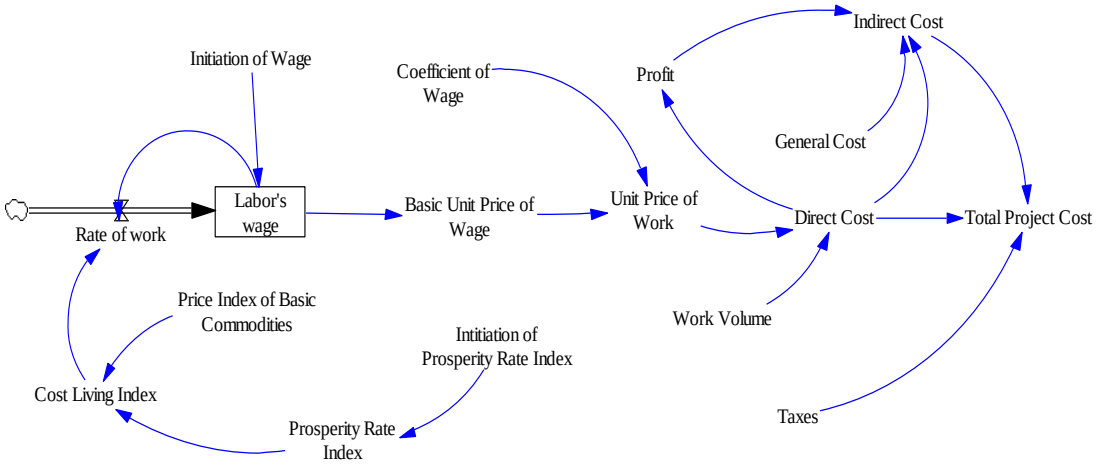

Figure 7 Stock Flow Diagram of the Basic Model

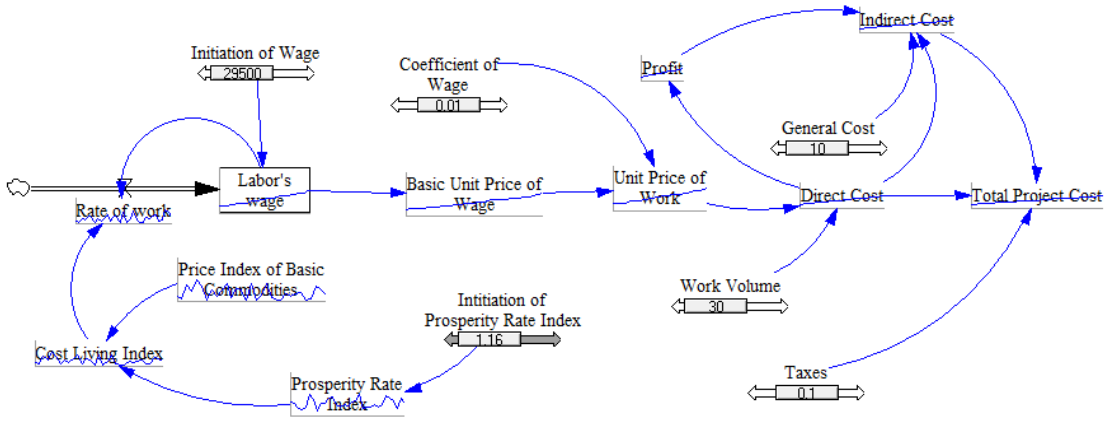

Figure 8 The Results of Running Model

4. Result

If the model is running well, i.e. there are no errors in the model formulation), the next stage is the validation process to ensure that the model has been prepared in accordance with the real condition. There are two steps in the validation stage as follows"

1. Mean comparison (E_1)

   This method is done by comparing the mean value of the simulation results with the mean value of the available data. The value of E_1 is calculated using the following formula:

$$E_1 = \left| \frac{\bar{S} - \bar{A}}{\bar{A}} \right| \quad (1)$$

   where

   $\bar{S}$ is the mean value of the simulation result,

   $\bar{A}$ is the mean value of the available data.

   The model is valid if the value of $E_1 < 5\%$.

2. Comparison of standard deviation (E_2)

   This method is the advanced stage when the previous validation step is fulfilled, i.e. the value of $E_1 < 5\%$. The method is done by comparing the value of the standard deviation of the simulation results with a standard deviation of available data. The value of E_2 is calculated using the following formula:

$$E_2 = \left| \frac{\bar{S}_S - \bar{S}_A}{\bar{S}_A} \right| \quad (2)$$

   where

   $\bar{S}_S$ is the value of the standard deviation of the simulation results,

   $\bar{S}_A$ is the value of the standard deviation of the available data.

   The model is valid if the value of $E_2 < 30\%$.

Validation is performed on the financing model of the salary of the worker, where the data is obtained from various sources such as from the Department of Irrigation in Malang Regency (Department of Irrigation, Malang Regency, 2015), Central Bureau of Statistics of Indonesia (BPS) and some other literatures started from 2000. The results of validation model give the value of E1=3.65% < 5% and the value of E2 = 6.26% < 30%. It means that the model has been validated properly, so we can do the scenarios if necessary, suppose that there is a significant change in per capita income as a parameter scenario or an estimate of non-local worker usage so that it is necessary to add a variable in the model as a structured scenario.

5. Conclusion

The results of the preparation and development of the financing model can model the wage of worker so that those who need a worker's wage analysis can use the model for further predictions. The results show that the model has been verified with no error and the model has been validated with the value of E1=3.65% < 5% and E2 = 6.26% < 30%. Scenario of the model can be done on the prepared model accordance with the needs.

For further research, it can analyse the more details and complex components in the system, so that the model of project financing will be obtained closer to real condition.

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