



Evaluation of Legislation Adequacy in Managing Time and Quality Performance in Iraqi Construction Projects- a Bayesian Decision Tree Approach

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Abstract

Delay and quality defects are significant problems in Iraqi construction projects. During the period from 2003-2014, legislation has been changed to enhance the performance of construction project. This change is done by modifying some clauses of legislation and adding or deleting the others. The aim of this study is to evaluate the adequacy of these changes by using questionnaire and Bayesian decision tree model. 30 projects were taken for the period from 2003-2014. Performance of construction project was assessed on one hand by conducting a questionnaire which depend on the impact of legislation clauses on the time and quality performance, while on the other hand Bayesian decision tree model was developed in which qualitative estimate of time and quality performance by using KNIME program. The results of questionnaire estimate the delay from very low to very high and quality from very low to high in Iraqi construction industry. The results of Bayesian decision tree model reveal that the high percentage of construction projects were implemented with very high delay and high level of quality. The model gives good accuracy in prediction time and quality performance about 86.7%. These results show the enhancement in the quality performance is greater than the time performance under the legislative change. The model can assist the Iraqi legislator in evaluation the impact of legislation on time and quality performance of construction project.

Keywords: Time Overrun; Quality; Legislation; Naive Bayes; Gradient Boosting Decision Tree.

1. Introduction

The construction sector has a strategic role in improving economic sector of developed countries. In Iraq, construction projects are suffered from many problems in performance such as time, quality and cost [20]. The causes of delay in construction projects are: awarding of project to the lowest bidder price [11-14], delay of payments by owner [16], variation order during construction, politic environment of country [13, 14]. Quality are affected by several factors such as: provisions that related to selection of contractor [26, 27], experience of contractor [28, 29], skills of management leadership [28-30]. Deficiency in safety system [32, 27]. One of the policies to get the desired outcomes is modifying laws and regulation [14]. Legislations are important in Iraqi construction industry. It has important role in regulating the works, rights, and duties between parties of construction project [33]. These legislations in sometimes conflict with each other or with previous legislations and affect the performance of construction project [18]. One of the most practical approach for solving learning problem is Bayesian algorithm. Bayesian theory is a probabilistic approach for making decision under uncertain condition. In Bayes theory the frequency of events is used to determine the probability of their future [1]. One of the most Bayesian learning method is the Naive Bayes Classifier is consider one of the best learning method that is based on Bayesian theory. Decision tree one of the most common techniques in data mining. It's a

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graphical representation of rules which lead to a class. This study aims to investigate the impact of legislation on the time and quality performance in the Iraqi construction industry by using the questionnaire and Bayesian decision tree model.

2. Literature Review

Nemours studies have been done to determine delay and quality factors in construction projects. Assaf and Al-Hejji (2006) classified causes of delay of construction projects into nine categories and they concluded that the top important factors causing delay in construction project are variation orders during construction, delay in progress payment, defective planning and scheduling, Shortage of manpower and difficulties in finance on the part of the contractor [16].

Ewadh and Aswed (2007) divided the causes of delay of construction project into four categories: Contractor, Owner, Government regulation and External causes. They concluded that the top important causes of delay are Delay in laboratory tests, awarding contracts to the lowest bidder price, difficulties in finance the project by the contractor, sudden rise in the materials prices and incorrect estimation of contractor for contract duration [13]. Mahamid et al. (2012) concluded that the top five severe delay causes of road construction projects in the West Bank in Palestine are Political situation, separation of the West Bank, limited movement between areas, award project to lowest bidder price, payment delay by owner and lack of equipment [14]. According to Elawi et al. (2015) the factors of delay that contributed for the majority of time overrun were; acquisition of land, expertise lack of contractor, re-designing, and line services (haphazard underground utilities) [17]. One of the practices that required to reduce delay in construction projects is modifying laws and regulation that related to construction projects [14]. Callistus et al. (2014) concluded that the most critically factors influencing quality performance in Ghana are: practices of fraudulent and kickbacks, lack of coordination between contractors and designers, poor monitoring and feedback, lack of quality training for staff, deficiency of management leadership and lack of experience of contractor [28]. Abas et al. (2015) stated that contractor procurement unit, ISO certification, availability of technical person, problem communication, joint working and continuous improvement are the main that have direct impact on the quality performance of construction projects in Pakistan [31]. The study carried out by Raphael and Phillip (2016) revealed that the critical factors that influence the quality performance of government financed construction projects are: processes of project financing, contractors experience in construction industry, technology of project, availability of equipment and plant, procurement processes and system and the project manager skills and knowledge [29].

In order to enhance the performance of construction industry, legislations have been changed many times during the period from 2003 to 2014 [19]. The change covered many acts including; the General Term of the Civil Engineering Contracts [22], Governmental contracts implementation Instructions no.1 [21], federal budget act [34], Cabinet resolution no 395 [24], and the Registry Instructions of Iraqi Contractors [23], and the regulation of insertion of delayed bidder in implementation their contractual obligation in the delayed company list [25]. The effect of these changes could best be measured by Bayesian decision tree which is considered one of the most practical approach for solving learning problem. Bayesian theory is a probabilistic approach for making decision under uncertain condition [1]. The mathematical formula for this theory is as in Equation 1.

$$P(h|D) = \frac{P(D|h)p(h)}{p(D)} \quad (1)$$

P (h): represent the probability of hypothesis

P (D): the evidence, represent the probability of observation D

P (D|h): represent the likelihood of D that given h

P (h|D): represent the probability of h that given D

Naive Bayesian is statistical classifier based on Bayes' theorem. This classifier depended on simplify of assumption that the value of attribute is independent of other attributes values [36]. In mathematic that is mean.

$$P(D|h_i) \approx \prod_{k=1}^n p(D_k|h_i) \quad (2) [2]$$

Decision tree one of the most common techniques in data mining. It's a graphical representation of rules which lead to a value or class [3]. One of the widely-used in machine learning is gradient boosting decision tree (GBDT) that is used because of its accuracy, efficiency and interpretability [4]. GBDT used to achieve performances in many tasks of machine learning like prediction [5] and multi-class classification [6]. GBDT is an ensemble of decision tree models. In GBDT algorithm, learning process of decision tree is done by fitting the residual error in each iteration [4].

3. Methodology of Research

Research methodology involves of two parts, questionnaire and using techniques of data mining. 30 projects were taken and the questionnaire was distributed to different populations that includes the managers of these projects and engineers and the main stakeholders, about 15 people. This questionnaire included two parts, the part one was dedicated to the qualitative assessment of the change in time and quality level depending on the data that collected from the construction projects, while the second part of the questionnaire investigates the impact of legislation clauses on the performance of construction projects, the clauses of each legislation change are shown in Table 1.

Table 1. Clauses of legislation

| Clauses of contract that related to time and quality performance | Legislation change |
|---|----------------------------|
| Engineer power to issue variation order | Leg.1, Leg.2, Leg.3, Leg.4 |
| Preparation of location | Leg.2, Leg.3, Leg.4 |
| authorization of the head of contracting department to accept and analyze bid | Leg.2, Leg.3, Leg.4 |
| regulation that required to get the best tender | Leg.2, Leg.3, Leg.4 |
| Awarding of bid | Leg.1 |
| list of similar work and equipment that attached with tender | Leg.1 |
| scores that given for evaluation of tender | Leg.2, Leg.3, Leg.4 |
| Extension of time | Leg.1, Leg.2, Leg.3, Leg.4 |
| Payment | Leg.1, Leg.2, Leg.3, Leg.4 |
| Initial payment | Leg.1, Leg.2, Leg.3, Leg.4 |
| duration to authorize change order | Leg.2, Leg.3, Leg.4 |
| delay penalties | Leg.1, Leg.2, Leg.3, Leg.4 |
| condition of contractor experience | Leg.1, Leg.2, Leg.3, Leg.4 |
| condition of technical and accounting staff of contractor | Leg.1, Leg.2, Leg.3, Leg.4 |
| capital of the company of contractor | Leg.1, Leg.2, Leg.3, Leg.4 |
| declaration of estimated cost | Leg.4 |
| insertion of bidder | Leg.4 |
| Available of modern study on estimated cost | Leg.2, Leg.3, Leg.4 |
| Worker injury | Leg.1, Leg.2, Leg.3, Leg.4 |
| testing | Leg.1, Leg.2, Leg.3, Leg.4 |
| List of equipment | Leg.1 |
| source certification | Leg.3, Leg.4 |
| Condition of equipment | Leg.3, Leg.4 |
| Safety of work method | Leg.1, Leg.2, Leg.3, Leg.4 |

For analysis of legislation impact on time and quality performance, the researcher used KNIME analytics platform. KNIME (Konstanz Information Miner,) data analytics platform and an open source data its used for processing, analysis and integration [7].

4. Results and Discussions

Clauses of legislation were identified and assessed through questionnaire to evaluate the impact of these clauses on the time and quality performance of construction project. The acquired data was initially analyzed through statistical techniques by obtaining the mean for each clause with respect to impact on the time and quality performance. The scores provided by each respondent for all the listed clauses were treated using Statistical Package for Social Sciences (SPSS).the impact of each clauses was calculated by using below equation.

$$\text{Mean } (\bar{X}) = \sum_i^N f x_i / N \quad (3) [35]$$

Where:

(\bar{X}): The Mean

(X_i): The number of values of the variable X one for each observation

(f): frequency of class

(i): first number of observations

(N): number of observations

The outcomes of questionnaire reflect the improvement in the time and quality performance under changing in legislation. Time overrun estimates between very low and very high under the legislation from 2003-2014. Quality estimates between very low and high under legislation during the period 2003-2014. The data was obtained from questionnaire has been entered to the KNIME program to begin classification process. The process beginning with open the program and select Naive Bayes node and Gradient Booted trees node to determine qualitative analysis of legislation.

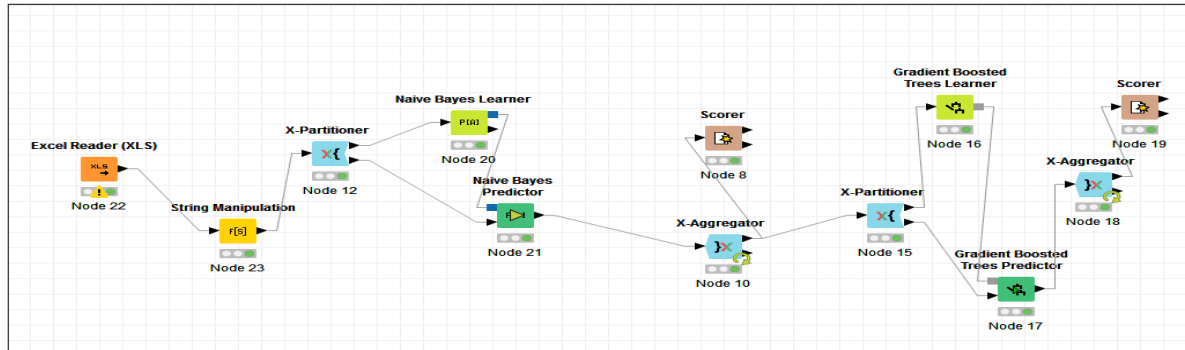


Figure 1. Work flow of Bayesian decision tree

The parameter that used to measure the performance of algorithm is [8]:

TP: represent the number of observations that actually positive and classified positive.

FP: represent the number of observations that actually positive and classified negative.

TN: represent the number of observations that actually negative and classified negative.

FN: represent the number of observations that actually negative and classified positive.

$$\text{Recall} = \frac{TP}{TP+FN} \tag{4}$$

$$\text{Precision} = \frac{TP}{TP+FP} \tag{5}$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN} \tag{6}$$

F-measure represent the integration of recall and precision [9]. Cohen's kappa coefficient used to measure the qualitative item in statistic in term of inter-rater agreement [10]. From the analysis process the results were obtained from Bayesian algorithm and Bayesian decision tree algorithm. These results showed the enhancement in the time and quality performance under the change in legislation.

Table 2. Gaussian distribution for change in project time

| | high | low | medium | very high | very low |
|-----------------|---------|----------|---------|-----------|----------|
| Count: | 6 | 3 | 4 | 12 | 2 |
| Mean: | 80.965 | 38.67 | 60.3075 | 227.6142 | 13.555 |
| Std. Deviation: | 4.40813 | 10.95315 | 7.4131 | 124.5631 | 3.45775 |
| Rate: | 22% | 11% | 15% | 44% | 7% |

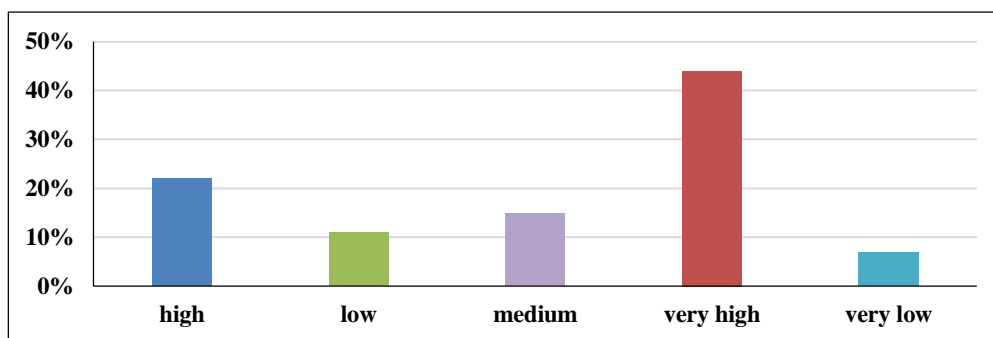


Figure 2. Distribution rate of the change in the project time

Results of classification model in Table 2 and Figure 2 show the range of the change in project time is between very low to very high and the highest percentage of project lie under very high and high level.

Table 3. Results of Naive Bayes classifier for the change in project time under legislation

| Row | True pos. | False pos. | True neg. | False neg. | Recall | Precision | Sensitivity | Septicity | F - means | Accuracy | Cohen |
|-----------|-----------|------------|-----------|------------|--------|-----------|-------------|-----------|-----------|----------|-------|
| high | 5 | 0 | 22 | 3 | 0.625 | 1 | 0.625 | 1 | 0.769 | ? | ? |
| Very high | 12 | 7 | 11 | 0 | 1 | 0.632 | 1 | 0.611 | 0.774 | ? | ? |
| low | 3 | 0 | 26 | 1 | 0.75 | 1 | 0.75 | 1 | 0.857 | ? | ? |
| medium | 3 | 0 | 26 | 1 | 0.75 | 1 | 0.75 | 1 | 0.857 | ? | ? |
| Very low | 0 | 0 | 28 | 2 | 0 | ? | 0 | 1 | ? | ? | ? |
| overall | ? | ? | ? | ? | ? | ? | ? | ? | ? | 0.767 | 0.655 |

Table 4. Results of Bayesian decision tree for the change in project time under legislation

| Row | True pos. | False pos. | True neg. | False neg. | Recall | Precision | Sensitivity | Septicity | F - means | Accuracy | Cohen |
|-----------|-----------|------------|-----------|------------|--------|-----------|-------------|-----------|-----------|----------|-------|
| low | 3 | 2 | 25 | 0 | 0.625 | 1 | 1 | 0.926 | 0.75 | ? | ? |
| high | 4 | 1 | 24 | 1 | 1 | 0.8 | 0.8 | 0.96 | 0.8 | ? | ? |
| Very high | 16 | 1 | 10 | 3 | 0.75 | 0.842 | 0.842 | 0.842 | 0.889 | ? | ? |
| medium | 3 | 0 | 27 | 0 | 0.75 | 1 | 1 | 1 | 1 | ? | ? |
| overall | ? | ? | ? | ? | ? | ? | ? | ? | ? | 0.867 | 0.773 |

Table 3 shows the results of naive Bayes model which indicate accuracy with 76%, the results of Bayesian decision tree model illustrate in Figure 4 that the accuracy of the model is 86.7%. This finding gives good accuracy in prediction the time performance depending on the questionnaire and Bayesian decision tree model.

Table 5. Gaussian distribution for quality of construction project

| | high | low | medium | very low |
|-----------------|---------|----------|----------|----------|
| Count: | 15 | 3 | 8 | 1 |
| Mean: | 21.6 | 9.66667 | 12.125 | 8 |
| Std. Deviation: | 8.36489 | 13.31666 | 11.49456 | 0 |
| Rate: | 56% | 11% | 30% | 4% |

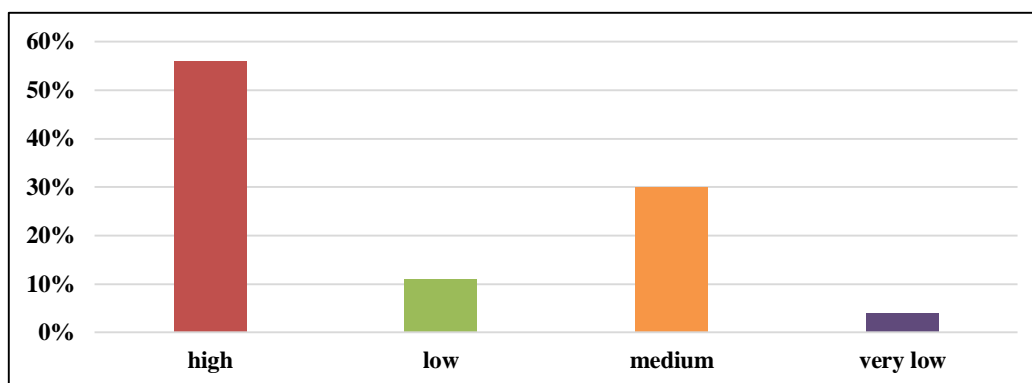


Figure 3. Distribution rate of the project quality performance

Results in Table 5 and Figure 3 that obtained from classification model show the range of quality is between very low and high and the highest percentage of project lie under high level.

Table 6. Results of Naive Bayes classifier for the project quality under legislation

| Row | True pos. | False pos. | True neg. | False neg. | Recall | Precision | Sensitivity | Septicity | F - means | Accuracy | Cohen |
|----------|-----------|------------|-----------|------------|--------|-----------|-------------|-----------|-----------|----------|-------|
| medium | 10 | 1 | 19 | 0 | 1 | 0.909 | 1 | 0.95 | 0.952 | ? | ? |
| high | 3 | 7 | 11 | 0 | 1 | 0.842 | 1 | 0.786 | 0.914 | ? | ? |
| low | 0 | 0 | 27 | 3 | 0 | ? | 0 | 1 | ? | ? | ? |
| Very low | 0 | 0 | 29 | 1 | 0 | ? | 0 | 1 | ? | ? | ? |
| overall | ? | ? | ? | ? | ? | ? | ? | ? | ? | 0.867 | 0.753 |

Table 7. Results of Bayesian decision tree for the project quality under legislation

| Row | True pos. | False pos. | True neg. | False neg. | Recall | Precision | Sensitivity | Septicity | F - means | Accuracy | Cohen |
|----------|-----------|------------|-----------|------------|--------|-----------|-------------|-----------|-----------|----------|-------|
| medium | 10 | 1 | 19 | 0 | 1 | 0.909 | 1 | 0.95 | 0.952 | ? | ? |
| high | 16 | 3 | 11 | 0 | 1 | 0.842 | 1 | 0.914 | 0.914 | ? | ? |
| low | 0 | 0 | 27 | 3 | 0 | ? | 0 | 1 | ? | ? | ? |
| Very low | 0 | 0 | 29 | 1 | 0 | ? | 0 | 1 | ? | ? | ? |
| overall | ? | ? | ? | ? | ? | ? | ? | ? | ? | 0.867 | 0.73 |

Table 6 and 7 show the results of Bayesian decision tree model in prediction quality performance in construction project. The results show the accuracy of the model is about 86.7%. These results indicate good accuracy in prediction the quality performance by using questionnaire and Bayesian decision tree model. These outcomes of the questionnaire and classification model reflects the gradual enhancement in the time and quality performance due to the change in the legislation in the studied period. The results show that the enhancement in quality performance is greater than in time performance. The difference between enhancement in quality performance and time performance can interpret by the nature of law in Iraqi construction industry.

5. Conclusion

Time overrun and quality defects are major problems in construction project. Legislation is applied to reduce this problem in Iraqi construction industry. Questionnaire and Bayesian decision tree model were developed for this purpose. 30 construction projects implemented during the period from 2003-2014 were taken and the questionnaire was distributed for 15 persons who work in the project. The questionnaire depended on the impact of legislation clauses on the time and quality performance of construction project. The results show that the delay between very low and very high the quality very low and high in Iraqi construction industry. These results reflect the impact of legislation on the project performance for the period 2003-2014. The Bayesian decision tree model, on the other hand, was developed by using KNIME program for qualitative analysis of legislation. The results of Bayesian decision tree model reveal that the high percentage of construction projects were implemented with very high delay and high level of quality .The model gives good accuracy for classification process that is about 86.7% for time and quality performance of construction project. The model can help the Iraqi legislator to assess the impact of legislation on time and quality performance of construction projects.

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7. Appendix

Results of questionnaire:

Table 1. Qualitative analysis of the change in time performance

| Year | Project | Qualitative analysis |
|------|---------|----------------------|
| 2005 | 1 | high |
| 2005 | 2 | very high |
| 2005 | 3 | very high |
| 2005 | 4 | high |
| 2008 | 5 | low |
| 2008 | 6 | high |
| 2008 | 7 | very high |
| 2008 | 8 | very high |
| 2009 | 9 | very high |
| 2010 | 10 | low |
| 2010 | 11 | low |
| 2010 | 12 | medium |
| 2010 | 13 | very high |
| 2010 | 14 | very high |
| 2010 | 15 | high |
| 2010 | 16 | low |
| 2010 | 17 | medium |
| 2010 | 18 | very high |
| 2010 | 19 | medium |
| 2011 | 20 | high |
| 2011 | 21 | very low |
| 2011 | 22 | very high |
| 2011 | 23 | high |
| 2011 | 24 | very high |
| 2011 | 25 | very high |
| 2012 | 26 | high |
| 2012 | 27 | medium |
| 2013 | 28 | very high |
| 2013 | 29 | very low |
| 2013 | 30 | high |

Table 2. Impact of legislation clauses on time performance

| Projects | | Clauses | | | | | | | | | | |
|--------------|--------|-----------|--------|-----------|--------|-----------|--------|--------|-----------|--------|--------|-----------|
| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 |
| Project 1 | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 |
| Quantitative | 3.8889 | 4.1389 | 3.4167 | 3.8333 | 3.25 | 3.75 | 3.2222 | 3.3611 | 4.0278 | 3.8611 | 3.4444 | 3.1667 |
| Qualitative | high | high | high | high | medium | high | medium | medium | high | high | high | medium |
| 2 | 4.1111 | 4.278 | 3.5556 | 4.3056 | 3.6667 | 4.3056 | 3.4167 | 3.6111 | 4.25 | 4.0833 | 3.8889 | 4.3333 |
| | high | Very high | high | Very high | high | Very high | high | high | Very high | high | high | Very high |
| Project 3 | 4.1111 | 4.2778 | 3.5556 | 4.3056 | 3.6667 | 4.3056 | 3.4167 | 3.6111 | 4.25 | 4.0833 | 3.8889 | 4.3333 |
| | high | Very high | high | Very high | high | Very high | high | high | Very high | high | high | Very high |
| 4 | 3.8889 | 4.1389 | 3.4167 | 3.8333 | 3.25 | 3.75 | 3.2222 | 3.3611 | 4.0278 | 3.8611 | 3.4444 | 4.1111 |
| | high | high | high | high | medium | high | medium | medium | high | high | high | high |

For period 2007-2008

| Projects | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 |
|----------|-----------|-----------|--------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--------|--------|-----------|
| 5 | 3.7778 | 3.4167 | 4 | 3.4444 | 3.5556 | 3.0833 | 4 | 3.4167 | 3.6944 | 4.0556 | 4.0278 | 4.0833 | 3.5556 | 3.5278 | 4.1111 |
| | high | high | high | high | high | medium | high | high | high | high | high | high | high | high | high |
| 6 | 3.7778 | 3.4167 | 4 | 3.4444 | 3.5556 | 3.0833 | 4 | 3.4167 | 3.6944 | 4.0556 | 4.0278 | 4.0833 | 3.5556 | 3.5278 | 4.1111 |
| | high | high | high | high | high | medium | high | high | high | high | high | high | high | high | high |
| 7 | 3.9444 | 3.75 | 3.7222 | 3.8333 | 3.8889 | 3.8611 | 3.8056 | 3.75 | 4.0833 | 4.4167 | 4.2222 | 4.3889 | 3.8889 | 3.4167 | 4.2222 |
| | high | high | high | high | high | high | high | high | high | very high | very high | very high | high | high | very high |
| 8 | 4.5278 | 4.2778 | 3.9444 | 4.2222 | 4.25 | 4.3611 | 4.5278 | 4.2778 | 4.3056 | 4.5556 | 4.4444 | 4.3889 | 3.8889 | 3.4167 | 4.4444 |
| | Very high | Very high | high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | high | high | Very high |

For period 2009-2011

| Projects | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 |
|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 9 | 4.5833 | 3.8333 | 2.8056 | 4.5833 | 4.4722 | 4.3611 | 4.3889 | 4.3611 | 4.4722 | 4.5278 | 4.5278 | 4.7222 | 4.4722 | 4.5278 | 4.4722 |
| | Very high | high | medium | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high |
| 10 | 2.3611 | 2.2778 | 2.1944 | 2.3889 | 2.4167 | 2.4722 | 2.3333 | 2.5278 | 2.4722 | 2.4444 | 2.4267 | 2.25 | 1.5833 | 1.6111 | 1.8333 |
| | low | low | low | low | low | low | low | low | low | low | low | low | Very low | Very low | low |
| 11 | 2.3611 | 2.2778 | 2.1944 | 2.3889 | 2.4167 | 2.4722 | 2.3333 | 2.5278 | 2.4722 | 2.4444 | 2.4267 | 2.25 | 1.5833 | 1.6111 | 1.8333 |
| | low | low | low | low | low | low | low | low | low | low | low | low | Very low | Very low | low |
| 12 | 3.1994 | 2.8889 | 2.8056 | 3.1389 | 2.7222 | 3.1389 | 2.8056 | 3.2778 | 3.1111 | 3.1111 | 3.1111 | 2.9444 | 2.5833 | 2.6111 | 2.6944 |
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | low | medium | medium |
| 13 | 4.5833 | 3.8333 | 2.8056 | 4.5833 | 4.4722 | 4.3611 | 4.3889 | 4.3611 | 4.4722 | 4.5278 | 4.5278 | 4.7222 | 4.4722 | 4.5278 | 4.4722 |
| | Very high | high | medium | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high |
| 14 | 4.5833 | 3.8333 | 2.8056 | 4.5833 | 4.4722 | 4.3611 | 4.3889 | 4.3611 | 4.4722 | 4.5278 | 4.5278 | 4.7222 | 4.4722 | 4.5278 | 4.4722 |
| | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high |
| 15 | 4.3333 | 4.0278 | 3.9444 | 3.7778 | 3.8056 | 3.6944 | 3.8611 | 4.0556 | 3.9722 | 4 | 4 | 4.0556 | 3.8889 | 3.4167 | 3.7222 |
| | Very high | high | high | high | high | high | high | high | high | high | high | high | medium | high | high |
| 16 | 2.3611 | 2.2778 | 2.1944 | 2.3889 | 2.4167 | 2.4722 | 2.3333 | 2.5278 | 2.4722 | 2.4444 | 2.4267 | 2.25 | 1.5833 | 1.6111 | 1.8333 |
| | low | low | low | low | low | low | low | low | low | low | low | low | Very low | Very low | low |
| 17 | 3.1994 | 2.8889 | 2.8056 | 3.1389 | 2.7222 | 3.1389 | 2.8056 | 3.2778 | 3.1111 | 3.1111 | 3.1111 | 2.9444 | 2.5833 | 2.6111 | 2.6944 |
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | low | medium | medium |
| 18 | 4.5833 | 3.8333 | 2.8056 | 4.5833 | 4.4722 | 4.3611 | 4.3889 | 4.3611 | 4.4722 | 4.5278 | 4.5278 | 4.7222 | 4.4722 | 4.5278 | 4.4722 |
| | Very high | high | medium | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high |
| 19 | 3.1999 | 2.8889 | 2.8056 | 3.1389 | 2.7222 | 3.1389 | 2.8056 | 3.2778 | 3.1111 | 3.1111 | 3.1111 | 2.9444 | 2.5833 | 2.6111 | 2.6944 |

| | | | | | | | | | | | | | | | | |
|----|-----------|--------|--------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--------|
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | low | medium | medium |
| 20 | 4.3333 | 4.0278 | 3.9444 | 3.7778 | 3.8056 | 3.6944 | 3.8611 | 4.0556 | 3.9722 | 4 | 4 | 4.0556 | 3.8889 | 3.4167 | 3.7222 | |
| | Very high | high | high | high | high | high | high | high | high | high | high | high | high | high | high | |
| 21 | 2.3611 | 2.2778 | 2.1944 | 2.3889 | 2.4167 | 2.4722 | 2.3333 | 2.5278 | 2.4722 | 2.4444 | 2.4267 | 2.25 | 1.5833 | 1.6111 | 1.8333 | |
| | low | low | low | low | low | low | low | low | low | low | low | low | low | Very low | Very low | low |
| 22 | 4.5833 | 3.8333 | 2.8056 | 4.5833 | 4.4722 | 4.3611 | 4.3889 | 4.3611 | 4.4722 | 4.5278 | 4.5278 | 4.7222 | 4.4722 | 4.5278 | 4.4722 | |
| | Very high | high | medium | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | |
| 23 | 4.3333 | 4.0278 | 3.9444 | 3.7778 | 3.8056 | 3.6944 | 3.8611 | 4.0556 | 3.9722 | 4 | 4 | 4.0556 | 3.8889 | 3.4167 | 3.7222 | |
| | Very high | high | high | high | high | high | high | high | high | high | high | high | high | high | high | |
| 24 | 4.5833 | 3.8333 | 2.8056 | 4.5833 | 4.4722 | 4.3611 | 4.3889 | 4.3611 | 4.4722 | 4.5278 | 4.5278 | 4.7222 | 4.4722 | 4.5278 | 4.4722 | |
| | Very high | high | medium | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | |
| 25 | 4.5833 | 3.8333 | 2.8056 | 4.5833 | 4.4722 | 4.3611 | 4.3889 | 4.3611 | 4.4722 | 4.5278 | 4.5278 | 4.7222 | 4.4722 | 4.5278 | 4.4722 | |
| | Very high | high | medium | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | Very high | |

For period 2012-2014

| Projects | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 | C16 | C17 |
|----------|-----------|-----------|-----------|-----------|----------|----------|-----------|-----------|----------|-----------|----------|-----------|--------|--------|-----------|-----------|--------|
| 26 | 3.7778 | 3.4167 | 4 | 3.4444 | 3.5556 | 3.0833 | 4 | 3.4167 | 3.6944 | 4.0556 | 4.0278 | 4.0833 | 3.5556 | 3.5278 | 4.1111 | 3.5556 | 3.75 |
| | high | high | high | high | high | high | high | high | high | high | high | high | high | high | high | high | high |
| 27 | 2.6111 | 2.8889 | 2.6111 | 2.7222 | 3.2222 | 3.0833 | 2.9444 | 3.1111 | 3.0556 | 2.5278 | 2.7778 | 3.1111 | 3.0833 | 3.0278 | 3.25 | 3.1944 | 3.2778 |
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | low | medium | medium | medium | medium | medium | medium | medium |
| 28 | 4.3889 | 4.3611 | 4.4722 | 4.3778 | 4.1111 | 3.0833 | 4.3333 | 4.2778 | 3.9167 | 4.3611 | 4.1944 | 4.4444 | 4.1389 | 3.9722 | 4.25 | 4.3056 | 4.0278 |
| | Very high | Very high | Very high | Very high | high | medium | Very high | Very high | high | Very high | high | Very high | high | high | Very high | Very high | high |
| 29 | 1.6111 | 1.5 | 1.5556 | 1.5556 | 1.5 | 1.5 | 1.75 | 1.75 | 1.5833 | 1.9444 | 1.805 | 1.4444 | 1.4444 | 2.0278 | 1.8056 | 1.6111 | 2.3333 |
| | Very low | Very low | Very low | Very low | Very low | Very low | Very low | Very low | Very low | low | Very low | low | low | low | low | low | low |
| 30 | 3.7778 | 3.4167 | 4 | 3.4444 | 3.5556 | 3.0833 | 4 | 3.4167 | 3.6944 | 4.0556 | 4.0278 | 4.0833 | 3.5556 | 3.5278 | 4.1111 | 3.5556 | 3.75 |
| | high | high | high | high | high | high | high | high | high | high | high | high | high | high | high | high | high |

Table 3. Qualitative analysis of the quality performance in different legislation period

| Year | Project | Qualitative analysis |
|------|---------|----------------------|
| 2005 | 1 | low |
| 2005 | 2 | medium |
| 2005 | 3 | low |
| 2005 | 4 | medium |
| 2008 | 5 | medium |
| 2008 | 6 | medium |
| 2008 | 7 | medium |
| 2008 | 8 | very low |

| | | |
|------|----|--------|
| 2009 | 9 | high |
| 2010 | 10 | high |
| 2010 | 11 | high |
| 2010 | 12 | medium |
| 2010 | 13 | high |
| 2010 | 14 | medium |
| 2010 | 15 | high |
| 2010 | 16 | high |
| 2010 | 17 | high |
| 2010 | 18 | high |
| 2010 | 19 | high |
| 2011 | 20 | low |
| 2011 | 21 | high |
| 2011 | 22 | high |
| 2011 | 23 | high |
| 2011 | 24 | medium |
| 2011 | 25 | high |
| 2012 | 26 | medium |
| 2012 | 27 | high |
| 2013 | 28 | medium |
| 2013 | 29 | high |
| 2013 | 30 | high |

Table 4. Impact of legislation clauses on the quality performance

For period 2003-2006

| Projects | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 |
|----------|--------|--------|----------|--------|--------|--------|----------|----------|--------|--------|--------|
| 1 | 2.0278 | 1.8333 | 1.4444 | 2.0278 | 1.8056 | 1.9722 | 1.7222 | 1.5833 | 2.4444 | 1.9444 | 2.0278 |
| | low | low | Very low | low | low | low | Very low | Very low | low | low | low |
| 2 | 2.6667 | 2.1944 | 2.1944 | 3.1389 | 2.9167 | 3.389 | 2.6389 | 2.2222 | 2.6667 | 3.3056 | 3.3056 |
| | medium | low | low | medium | medium | medium | medium | low | medium | medium | medium |
| 3 | 2.0278 | 1.8333 | 1.4444 | 2.0278 | 1.8056 | 1.9722 | 1.7222 | 1.5833 | 2.4444 | 1.9444 | 2.0278 |
| | low | low | low | low | low | low | low | low | low | low | low |
| 4 | 2.6667 | 2.1944 | 2.1944 | 3.1389 | 2.9167 | 3.389 | 2.6389 | 2.2222 | 2.6667 | 3.3056 | 3.3056 |
| | medium | low | low | medium | medium | medium | medium | low | medium | medium | medium |

For period 2007-2008

| Projects | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 5 | 2.9167 | 3.3056 | 3.3889 | 3.3056 | 2.7778 | 2.6667 | 2.5278 | 2.1944 | 3.1389 | 2.9167 | 3.1111 |
| | medium | medium | medium | medium | medium | medium | low | low | medium | medium | medium |
| 6 | 2.9167 | 3.3056 | 3.3889 | 3.3056 | 2.7778 | 2.6667 | 2.5278 | 2.1944 | 3.1389 | 2.9167 | 3.1111 |
| | medium | medium | medium | medium | medium | medium | low | low | medium | medium | medium |
| 7 | 2.9167 | 3.3056 | 3.3889 | 3.3056 | 2.7778 | 2.6667 | 2.5278 | 2.1944 | 3.1389 | 2.9167 | 3.1111 |
| | medium | medium | medium | medium | medium | medium | low | low | medium | medium | medium |
| 8 | 2.4167 | 1.9167 | 2.1944 | 2.0278 | 1.9444 | 1.9722 | 2.5278 | 2.1111 | 2 | 2.0556 | 1.8056 |
| | low | low | low | low | low | low | low | low | low | low | low |

For period 2009-2011

| Projects | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 9 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 10 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 11 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 12 | 2.9167 | 3.305 | 3.3889 | 3.3056 | 2.7778 | 2.6667 | 2.9444 | 3.0278 | 3.1389 | 2.9167 | 3.1111 | 2.6944 | 3.0278 |
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium |
| 13 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 14 | 2.9167 | 3.305 | 3.3889 | 3.3056 | 2.7778 | 2.6667 | 2.9444 | 3.0278 | 3.1389 | 2.9167 | 3.1111 | 2.6944 | 3.0278 |
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium |
| 15 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 16 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | high | high | high |
| 17 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 18 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 19 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 20 | 2.9167 | 3.305 | 3.3889 | 3.3056 | 2.7778 | 2.6667 | 2.9444 | 3.0278 | 3.1389 | 2.9167 | 3.1111 | 2.6944 | 3.0278 |
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium |
| 21 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 22 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 23 | 3.944 | 2.8611 | 3.8222 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 24 | 2.9167 | 3.305 | 3.3889 | 3.3056 | 2.7778 | 2.6667 | 2.9444 | 3.0278 | 3.1389 | 2.9167 | 3.1111 | 2.6944 | 3.0278 |

| | | | | | | | | | | | | | |
|----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium |
| 25 | 3.944 | 2.8611 | 3.8222 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | medium | high | high |
| 26 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | high | high | high |
| 27 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | high | high | high | high | high | high | high | high | high | high | high | high |
| 28 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | high | high | high |
| 29 | 2.9167 | 3.305 | 3.3889 | 3.3056 | 2.7778 | 2.6667 | 2.9444 | 3.0278 | 3.1389 | 2.9167 | 3.1111 | 2.6944 | 3.0278 |
| | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium | medium |
| 30 | 3.944 | 2.8611 | 3.8333 | 4.0833 | 3.8889 | 3.4444 | 3.6944 | 4.1111 | 4.0833 | 3.4722 | 2.8056 | 3.5 | 3.5556 |
| | high | medium | high | high | high | high | high | high | high | high | high | high | high |