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NEW STRATEGY FOR CONTRACTOR ASSESSMENT VIA CORE KEY PERFORMANCE INDICATORS

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ABSTRACT

The paper aims to develop the assessment strategies in the construction industry in an attempt to achieve end-project goals. No methods are available for an assessment strategy for the contractors based on evident aspects. The Key Performance Indicators (KPIs) draw guidelines and give a roadmap for the decision makers. It helps to select the most appropriate contractor to implement the proposed projects. The Egyptian Federation for Construction and Building Constructions did not provide an assessment plan for the technical experiences through scientific indicators. This paper therefore attempts to provide the core KPIs in the construction field. All KPIs are presented with the different selection methods. These will then be rated and the core KPIs will be selected according to scientific theories. The main objective of the study is to develop a new strategy for contractor assessment via core KPIs in the tendering stage. The study uses a scientific path starting with theoretical and analytical studies, followed by a pilot case study to verify the validity in the practical field. The conclusions highlight the different levels affected by the core KPIs.

KEYWORDS: Key performance indicators, Contractor, Cost indicator, Client indicator, Time indicator, Quality and technical assessment.

1. INTRODUCTION

The building and construction authorities are striving to establish a fixed framework as a roadmap for the legislations and draw the right relations among all the stakeholders in this industry. It provides a standard quality assessment system for construction projects. The construction field has a many stakeholders such as project managers, clients, consultants, contractors, employees, governmental authorities, suppliers, investors, third parties, financial firms (banks), pressure groups, trade associations, and communities. The contractor ranks fourth among the stakeholders ranking based on their highest influence on project spheres. The contractor has the power to achieve quality standards [1]. It is a challenge to identify contractors that

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perform high-quality level and how select the most appropriate contractor based on the project specific conditions [2]. In Egypt, mainly governmental projects, there is no clear contractor's assessment strategy, even though each contractor presents technical and financial reports during the tendering phase focusing on their experience. There are no clear indicators that would help the decision makers to select the most appropriate contractor even in the public-private partnership [3].

The Egyptian Federation for Construction and Building Constructions (EFCBC) represents the official authority in Egypt for the construction industry. It aims to take care of the common interests of its members, represent them in authorities, regulate the conditions of the profession, and develop their methods. It created the conditions of registration, classification rules, and ranking report [4]. In a selection process, a number of criteria are taken into consideration such as qualifications, resources held or bid price and compiled in a criteria matrix to select the best suitable one for implementing construction projects avoiding any loss [5]. EFCBC did not present a contractors' assessment plan for their technical experiences via scientific indicators. These indicators represent vital roles that contribute to the assessment criteria .

The purpose of this study is to provide the core Key Performance Indicators (KPIs) in the construction field. The study will present definitions of KPIs in the construction industry and show the different selecting methods. All KPIs will then be rated according to previous researches. Finally, the core KPIs will be selected according to scientific theories.

The study will then propose the core KPIs which can be used by the tendering committee for assessing the technical contractors experience or their technical reports.

The main objective of the study is developing a new strategy for contractor assessment via core KPIs during the tendering stage. It is believed that using KPIs methodologies in assessing the contractor's technical experiences will create a strong competition in the Egyptian construction market. The research will consider the core KPIs that can be easily modified to adopt specific conditions of the proposed project and also, to aid the decision makers in explaining the vital reasons for the elimination

of excluded contractor. This will be applied on real case study to verify its validity in the practical field.

Finally, the conclusions of the study will be drawn offering recommendations for the current states and propositions for further researches concerning the same issue.

2. MATERIALS AND METHODS

2.1 Key Performance Indicators Definitions and Selection

The KPI Program was propelled by the UK Best Practice Program in 1998. The government, through national and regional offices, upholds this program. The motivation behind the KPI program is to empower estimation of project and organizational performance throughout a large number of projects of the construction industry to monitor the performance of the industry [6]. These KPIs are presently broadly utilized inside the construction industry to measure performance and drive improvement [7]. The KPIs have many definitions with different approaches. The study will present the most prevalent KPIs.

KPIs defined in 2003 are "compilations of data measures used to assess the performance of a construction operation" [8]. On the other hand, in 2010, they were defined as "explication performance measures that have mainly been used in the construction industry to benchmark construction projects against each other and to indicate whether improvements are being made" [9]. In 2011, KPIs were defined as financial and non-financial indicators that organizations use in order to estimate and fortify how successful they are, aiming at previously established long lasting goals [10]. In 2012, Haponava and Humaidi, outlined that the concept behind using KPIs is based on the concept of benchmarking used in business processes and products in other industries. They suggested that KPIs are helpful to compare the actual and estimated project performance in terms of effectiveness, efficiency, and quality of workmanship and product. [11, 12]. Finally, the most recent definition in 2019, is that KPIs is made from a combination of one or a few measurements and coordinates the setting of a specific industry, organization, department, individual or task/project. A KPI does not just tell if something is positive or negative, it specifies what bearing it

has on its motivation of accomplishing objectives and beating difficulties, and if these objectives are coordinated by the procedure [13]. Determining applicable KPIs requires vital planning and considerable effort. It is often tempting to select metrics that are the easiest to measure, yet in the event that they are not the correct ones for a specific site, precious time and effort will be spent on setting up a KPI program that does not yield results [14]. KPIs can be gathered by recognizing existing KPIs and by planning KPIs appropriate for the association or project. KPIs expect to give answers to questions identified with key performance. It is significant to characterize precisely what ought to be estimated and key performance questions expected to capture important factors concerning strategic objectives. An important aspect when identifying and designing KPIs is to select the right number of KPIs, not too many and not too few [15]. To choose the right KPIs many researches and studies were conducted to determine KPIs and recommended a list of different techniques that can be used to select KPIs. Some of these techniques are listed below [16]:

- Remove unnecessary and duplicated measures.
- Formulate the measure in a way that is clear and easy to understand.
- Consider strengths and feasibilities of each measure.
- Identify unintended consequences for the measures.
- Decide what actions to take in order to minimize the unintended consequences.

Six desirable characteristics were proposed [17] when designing KPIs:

- Indicators should be derived from the company’s strategy.
- The purpose of the indicator must be made explicit.
- Data collection and methods of calculating performance must be clear.
- All stakeholders must be involved in the selection of the indicators.
- The indicator should take account of the organization.
- The indicators should change as circumstances change.

2.2 Key Performance Indicators Rating

KPI Working Group confirmed the purpose of the KPI is to enable project and organizational performance measurement throughout the construction industry. They developed a KPI framework which consists of seven main groups: time, cost, quality, client satisfaction, client changes, business performance, health and safety [18]. They argued that the measure of project success can no longer be restricted to the traditional indicators which are cost, time and project quality [19]. Different KPIs are used by different researchers and each indicator describes project performance in different way. The following indicators were the most common KPIs used in the literature. Table 1 summarizes KPIs according to their references.

Table 1. KPIs according to their references.

Years	1998	2000	2002	2004	2005-09	2010	2011	2012	2013	2014	2014	2016	2018	2018
References	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]
Predictability (design and construction)												√		
Predictability time, cost	√				√									
Variance cost, time					√									
Construction cost	√	√	√	√	√		√	√	√	√		√	√	
Construction time	√	√		√	√	√						√	√	
Indicators schedule							√	√	√	√				
Productivity	√		√		√									
Under budget						√								
Profitability and benefit	√		√		√		√				√			√
Safety	√			√	√	√								
Defects	√	√			√	√						√		

Table 1. KPIs according to their references, (Cont.).

Years	1998	2000	2002	2004	2005-09	2010	2011	2012	2013	2014	2014	2016	2018	2018
References	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]
Client satisfaction	√	√		√	√		√		√	√		√	√	√
Quality		√		√			√	√	√	√			√	
Functional requirements							√							
Efficiently						√				√				
Effectiveness						√								
Benchmarks									√					
Specifications						√	√							
Business performance		√												
Disputes						√								
Risk			√											
Project status			√											
Decision effectiveness			√											
Customer commitment			√											
Stakeholders				√		√			√		√			
Contractor satisfaction					√									
Project management			√											
Safety management													√	
Procurement									√					
Communication				√					√					
Environment				√	√									
Social indicators					√									

Table 1. KPIs according to their references, (Cont.).

Years	1998	2000	2002	2004	2005-09	2010	2011	2012	2013	2014	2014	2016	2018	2018
References	[20]	[21]	[22]	[23]	[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]	[32]	[33]
Growth market share							√				√			
Reputation professional image							√							
Human resources									√					
Financial stability											√		√	
Impact on Long Term Benefits											√			

2.3 Core Key Performance Indicators Selection Process

There are many key performance indicators in the construction industry. The present work summarizes and presents all these indicators starting from 1998 to 2018 assigning different weights based on their references. The number of appearance of each indicator over the past 20 years is indicated and this is considered as an important weight -as a core key- for each indicator. Table 2 ranks KPIs in a descending order according to their weights. The construction cost as a KPI is the most important indicator in construction industry. It presents the top value for achieving end-project goals. It seen from Table 2, that the rest of the important keys such as client satisfaction, construction time, quality, profitability and benefit, defects, stakeholders, safety, indicators schedule and productivity. All KPIs which are not mentioned in the above table appeared only one or two times according to their references.

The selection process will apply Pareto Analysis to make a decision about which KPIs will be considered to be the core KPIs and will be applied on the case studies.

Table 2. Core KPIs in construction industry.

Important KPIs	Weight
Construction cost indicator (CCI)	11
Client satisfaction indicator (CSI)	10
Construction time indicator (CTI)	7
Quality indicator (QI)	7
Profitability and benefit indicator (PBI)	6
Defects indicator (DI)	5
Stakeholders indicator	4
Safety indicator	4
Indicators schedule	4
Productivity indicator	3

Pareto analysis is a suitable tool for deciding what to work on. It is applied to identify and define the significant few components or segments of a design or deciding to focus on the elements which more effective. Pareto analysis is defined as an effective technique using statistical processes for the selection of a limited number of tasks or indicators that produce significant overall effect. It uses the Pareto principle as the 80/20 technique. This technique indicates that by doing 20% of your task you can generate 80% of the benefit of doing the whole job. Hence, the large majority of vexing problems (80%) are produced by a few key causes (20%) [34].

Hence, the study will apply KPIs according to their weight. From the literature review, there are thirty-seven (37) indicators in the construction industry. As per Pareto Analysis, the study will consider core KPIs which are allocated in the 20% zone. These were then ranked in a descending manner according to their weights as shown Table 3. These core KPIs are:

1- Construction cost indicator (CCI)

2- Client satisfaction indicator (CSI)

3- Construction time indicator (CTI)

4- Quality indicator (QI)

5- Profitability and benefit indicator (PBI)

6- Defects indicator (DI)

The study believes that these core indicators will present vital keys to ass the performance of contractors on achieving the end-project goals.

2.4 Application of Core Performance Indicators

2.4.1 Identify the pilot case study

In this section, the analytical study will be carried out on an actual pilot case study. The vital aspects for selection of the pilot case studies is based on the research strategy that is to consider the same project type when evaluating previous projects to get more accurate results.

- Projects type: Educational Project.
- The owner: Educational Buildings Authority.
- Clients: The pupils
- Contractors: who will evaluate previous projects.
- The quality requirements: the research will assume the quality level minimum is achieved with key performance indicators.
- Projects description:

Project A consists of one educational building with one floor including kinder garden classes, primary classes, preparatory classes, laboratories, library, and services spaces. Project B consists of one educational building with four floors including kinder garden classes, primary classes, laboratories, library, administrative rooms, multifunctional rooms, developed laboratory and services spaces (wet areas-clinic-prayer).

3. RESULTS AND DISCUSSIONS

3.1 Core Key Performance Indicators Discussions

First core KPI: Construction cost indicator (CCI).

Construction cost indicator is based on calculating the cost deviation between the estimated cost of construction and the actual cost. All data are obtained from the General Authority for Educational Buildings as shown Table 3.

Table 3. Construction cost indicator (CCI) analysis.

Construction cost indicator (CCI) analysis		
Items	Contractor A	Contractor B
Estimated cost of construction, EGP	175,390,0	452,052,6.75
Construction contract cost, EGP	175,390,0	45,2052,6.75
Actual construction cost, EGP	170,904,0	383,877,7
Cost Deviation= (Actual total project cost – Initial predicted project cost/ Initial predicted project cost) x 100		
Cost Deviation	-2.5%	-15%
Actual construction cost after iron and cement variation, EGP	_____	431,862,4
Cost Deviation	_____	-4.4%
CCI = (Estimated cost of construction / Actual construction cost) x 100		
CCI	102.6	104.6

Second core KPI: Client satisfaction indicator (CSI)

Client satisfaction indicator is calculated by providing a set of key performance indicators that measure client satisfaction with the project that can be used to assess whether the projects meet the expectations of the clients as shown Table 4. All data are obtained from the General Authority for Educational Buildings.

There are three sub indicators as follow:

A- Client Satisfaction with Product (CSI-A): It expresses the satisfaction and acceptance of the owner of the product to specific standards.

B- Client Satisfaction with Service (CSI-B): It expresses the owner's satisfaction with the service to specific standards

C- Client satisfaction with work as per the criteria set by the client (CSI-B): It expresses client satisfaction with the product according to its requirements.

Third core KPI: Construction time indicator (CTI)

Construction time indicator also will be calculated by comparing the time deviation between the estimated time and the actual time as shown Table 5. All data are obtained from the General Authority for Educational Buildings.

Table 4. Client satisfaction indicator (CSI) analysis.

Client satisfaction indicator (CSI) analysis		
Items	Contractor A	Contractor B
CSI-A	The owner (Educational Buildings Authority) received the works on time for the project according to the standard and technical specifications	
	96.67	94
CSI-B	As overall performance, speed and reliability of service, co-ordination between team members, ability to innovate.	
	100	80
CSI-C	As low running costs, bright and spacious working space, low maintenance costs, built on time, built within budget, defect free at 'available for use' stage	
	100	62

Table 5. Construction Time indicator (CTI) analysis.

Construction time indicator (CTI) analysis		
Items	Contractor A	Contractor B
Estimated construction time, weeks	32	34
Construction contract period, weeks	32	34
Actual construction period, weeks	32	53
Time Deviation = (Actual total project duration – Initial predicted project duration/ Initial predicted project duration) x 100		
Time Deviation	on time	55.8%
CTI = (Estimated time of construction / Actual construction time) x 100		
CTI	100	64.15

It is seen that Contractor B took more than the estimated time for the project up to 53 weeks and completed all defects of the project in sixteen months.

Forth core KPI: Quality indicator (QI).

Quality indicator will be measured by commitment to technical specifications for each contractor. The study will consider technical specifications shown in Table 6. All data are obtained from the General Authority for Educational Buildings.

Table 6. Quality indicator (QI) analysis.

Quality indicator (QI) analysis		
Items	Contractor A	Contractor B
Tests and initial delivery	100	100
Playground equipment	100	100
Pavements and corridors	95	85
External sanitary and electricity	95	80
Electrical and sanitary fittings	100	95
Doors and windows	95	95
Façade finishes	95	95
Flooring and finishes	95	90
Tile roofs	90	90
Insulation against heat	90	90
Concrete tendencies	90	90
Insulation against moisture	95	95
Paintings	100	100
Electrical and sanitary connections	100	90
Reinforced concrete structure	100	100
Replacement and ordinary concrete	100	100
Excavation	100	100
Site processing and licenses	100	100
Actual total project quality	1740 point	1695 point
Initial predicted project quality	1800 point	1800 point
Quality Deviation = (Actual total project quality – Initial predicted project quality/ Initial predicted project quality) x 100		
Quality Deviation	-3.33%	-5.83%
QI = (Estimated quality of construction / Actual construction quality) x 100		
QI	103.4	106.2

Fifth core KPI: Profitability and benefit indicator (PBI)

Profitability and benefit indicator will be measured by the financial efficiency for each contractor. The financial efficiency is a right indicator for whole cash flow

including cash in and cash out. So, the profitability and benefit indicator are strongly related with the financial efficiency. All data are obtained from the General Authority for Educational Buildings.

Contractor (A) implemented the project on time with financial efficiency and covering the costs of the project. Contractor (B) did not implement the project on time due to the lack of sufficient budget to cover costs of the project as shown Table 7.

Table 7. Profitability and benefit indicator (PBI) analysis.

Profitability and benefit indicator (PBI) analysis					
Contractor A		Contractor B			
Month No.	Value	Month No.	value	Month No.	value
1	100	1	100	9	75
2	100	2	100	10	70
3	100	3	90	11	65
4	100	4	100	12	65
5	100	5	99	13	60
6	100	6	95	14	60
7	100	7	85	15	60
8	100	8	80	16	60
Actual Profitability and benefit	800 point		1264 point		
Initial predicted Profitability and benefit	800 point		1600 point		
Profitability and benefit Deviation = (Actual Profitability and benefit – Initial Profitability and benefit / Initial Profitability and benefit) x 100					
Quality Deviation	0 %		-21 %		
PBI = (Estimated Profitability and benefit / Actual Profitability and benefit) x 100					
PBI	100		126.6		

Sixth core KPI: Defects indicator (DI)

Defects indicator will be measured by monitoring the defects and the cost of repairing these defects for each contractor as shown Table 8. All data are obtained from the General Authority for Educational Buildings.

Table 8. Defects indicator analysis.

Defects indicator				
Items	Contractor A		Contractor B	
	% of defects / each activity	Repairing defects cost, EGP	% of defects / each activity	Repairing defects cost, EGP
Mosaic Tile	1%	266.1	2%	2435.4
Ceramic Tile	1%	219.3	1%	496.5
Sidewalks Tile			2%	59.1
Wooden Doors	1%	331.3	5%	2813.5
Wooden Windows	1%	453.8	1%	1371.1
Fence of wood sectors			2%	41.4
Iron protection for windows	2%	939.6		
Granite coating for stairs			1%	4.8
A lavatory Toilet	3%	108		
Oriental Toilet	3%	36		
Hand Wash Basin	3%	165		
Analysis Reinforced Concrete Tank	1%	350		
Collecting Reinforced Concrete Tank	1%	350		
Polyethylene water tanks			5%	750
inspection Room	7%	448	2%	130
Fire Box	1%	50		
Electric Circuit	7%	420		
Isolated Aluminum Ground Cable	3%	540		
Cost of Client Claims = Cost of Repairing Claims (Defects) / Total Project Cost				
Cost of Client Claims	0.28%		0.19%	
DI = 100 - (Cost of Client Claims)				
DI	99.7		99.8	

3.2 Core Key Performance Indicators Results

The core key performance indicators are summarized for each indicator as shown Table 9. The ideal value for each one is 100. If the value of the indicator is more than 100 this means this indicator achieved less than the end-project goals. If the value of indicator less than 100 its means this indicator achieved more than the end-project goals. Each case (more than 100 or less than 100) are undesirable. The construction

cost indicator was more than 100 in our case meaning that it achieved less than the estimated cost. It is not an ideal case and many questions arise about where the error is.

The decision makers or the tendering committee members whose are assessing the contractors must consider the project conditions. The assessment process must be adapted to specific conditions of the proposed project. Each project has different circumstances that determine its goals. According to the end-project goals, the tendering committee could decide which contractor is more appropriate via core key performance indicators.

Table 9. Core KPIs results.

Core Key Performance Indicators	Code	Contractor A	Contractor B
Construction cost indicator	CCI	102.6	104.6
Client satisfaction indicator	CSI		
A- Client satisfaction indicator with product	CSI-A	96.67	94
B- Client satisfaction indicator with service	CSI-B	100	80
C- Client satisfaction indicator with work as per the criteria set by the customer	CSI-C	100	62
Construction Time indicator	CTI	100	64.15
Quality indicator	QI	103.4	106.2
Profitability and benefit indicator	PBI	100	126.6
Defects indicator	DI	99.7	99.8

4. CONCLUSIONS

The developed new strategies need more effective tools to be able to achieve the end – project goals and their needs. The upcoming projects are more complex in all architectural dimensions as a result of the new technologies and our life developments. It is believed that if a new road map for top management and the decision makers is not established, they will not be able to face vexing problems in the construction industry. It also believed that the key performance indicators have shown to be great

tools for contractor assessment. The core key performance indicators approach is one of the practical new strategies focusing on how we can achieve quality of life.

The contractor assessment initiative via the core key performance indicators approach will help to get more savings at many levels. The study has concluded that the core KPIs affect many levels. These levels are summarized as follow:

- At the Government polices level:

  The authority responsible for the construction sector should make a new legislation to obligate all technical committees to use and consider the key performance indicators to improve the performance quality for all projects.

  Using core key performance indicators at the contractor assessment process guarantees for the Government a more scientific rational analysis to achieve the end-project goals as end- user needs.

  The Egyptian Federation for Construction and Building Constructions (EFCBC) must consider the new legislation as a framework based on core KPIs approach. The new framework achieves contractors' equity by assessing their executed projects. It will draw a new strategy for developing the construction process.

- At the decision makers and consultants' level:

  The study urges decision makers and consultants to apply the core KPIs initiative in the tendering phase to get a concentrated value and certain index for the contractor assessment process. This initiative guarantees for all parties a fair evaluation (without favoritism) of what it achieves not only the end – project goals but also improve all technical aspects in the projects. Applying the core KPIs in the projects will mitigate the vexing problems that are linked by cost variation especially in the Middle East owing to the unstable economic conditions. Consultants will achieve the core aims of their projects according to the project management triangle. The first side of triangle is the cost, it will be within the budget when applying first core KPI, construction cost indicator and profitability and benefit indicator. The second side of the triangle is time. It will be within the project duration planed when applying the construction time indicator. The third and final side of the triangle is

the quality. This is obtained by applying the Quality indicator, defects indicator and Client satisfaction indicator.

- At investors level:

  The study advises investors to be sure from the key performance indicators of the contractor who will award the upcoming projects, that it will achieve the feasibility aspects and can eliminate any problems in the early phase in their project as a proactive step. Hence, this will be fruitful for them.

- At contractors level:

  Using the key performance indicators initiative in measuring the quality of the contractor's performance will create strong competition in the construction market, and hence every contractor will look forward to get a higher index to be better.

  All contractors companies must hire quality experts or consultants in house. They will improve all activates in their companies which will draw a right roadmap for KPIs. These companies will be ready for any assessment process from outside authority.

- At the researchers level

  The study recommends for applying the KPIs process by a clear scientific framework on all construction projects life cycle starting from pre-project phase, planning and design phase, project mobilization phase and project operation phase till the project close -out and termination phase.

It is recommended to apply the core KPIs, rated in this work and validated in the case study. Applying the core KPIs methodology will result in more earnings and will introduce more quality aspects within the construction industry. Also, other disciplines in the construction field should apply the core KPIs to measure all performance quality criteria for the different activities of the project.

DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interests.

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استراتيجية جديدة لتقويم المقاول عن طريق مؤشرات أداء رئيسية

لم يقدم الاتحاد المصري للتشييد والبناء خطة لتقويم الخبرات الفنية للمقاولين باستخدام المؤشرات والدراسات العلمية ولذا يقدم البحث مؤشرات أداء المقاولين خلال العشرين سنة الماضية وتصنيفها طبقاً للتحليلات البحثية من اختيار المؤشرات الرئيسية وفقًا للنظريات العلمية بهدف تطوير استراتيجية جديدة لتقويم المقاول في مرحلة المناقصة من خلال تلك المؤشرات حيث أن استخدام منهجيات مؤشرات الأداء الرئيسية في تقويم الخبرات التقنية للمقاول يجعل المنافسة قوية في سوق البناء، هذا وقد بدأت منهجية البحث بالدراسة النظرية ثم التحليلية ثم دراسة لحالة تطبيقية للتحقق العملي من تلك المنهجية وصولا الي النتائج والتوصيات.