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TOWARDS THE ASSESSMENT OF FACTORS THAT AFFECT TRANSACTION COSTS IN OIL AND GAS PROJECTS IN BRAZIL: AN EMPIRICAL STUDY

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ABSTRACT

The oil and gas industry in Brazil is going through a huge transformation since the discovery of extensive oil reserves in 2007. Oil companies turned their attention to Brazil, and so did the Brazilian government. Hence, this stimulates economic trade that is associated with significant transaction costs linked to these projects. This paper examines the impact of the predictability of the project owner's behavior, the predictability of the contractor's behavior, project management efficiency, and uncertainties in the transaction environment on transaction costs, in oil and gas projects in Brazil. To do so, we employed a survey method, by sending questionnaires to 1,500 project managers of major oil & gas companies that operate in Brazil. Data analysis using a PLS technique was applied to 235 usable responses. We discuss the implications of these findings.

Keywords: Project management; Transaction costs; Partial Least Squares; Empirical study.

INTRODUCTION: -

Risks and uncertainties are inherent to projects, because, by definition, a project is unique and, therefore, faces unknown factors (Meyer, Loch, & Pich, 2002; Carvalho & Rabechini, 2015). Predictability is one of the key elements to define the level of risk in a project (Atkinson, Crawford, & Ward, 2006). The higher the perceived risk, the higher the intrinsic cost of the project (Ellatar, 2009; Buvik & Tvedt, 2017; Chow, Cheung, & Chan, 2012; Chowdhury, 2005).

Time spent to determine the costs and expenses of a project is quite significant. This usually occurs because there are interests of all parties involved to maximize their results by seeking the best possible management at the lowest possible cost (Chow et al., 2012; Chowdhury, 2005). Therefore, the lack of mutual confidence between the parties, of agreement on management procedures, as well as on the most appropriate models to use, result in the search for contractual 'shields', which lead to an increase in costs, by creating contracts with defensive clauses (Barclay, 2008; Besner & Hobbs, 2006; Ogunlana, 2010). The values for reaching the project scope (Atkinson et al., 2006) will be charged to the contracting party, and will become part of the project's costs, according to Hillebrandt and Hughes (2000). However, not only the value for carrying out the project scope must be considered as the real cost of the project. Elements such as drafting contracts, the organization of bids and contract management, among others, which may result in costs of 'shielding' models created

to defend the contracts, should also be considered in the estimates, in order to achieve the best cost expectation. These costs are known as transaction costs (Coase, 1937).

The Transition Costs Theory (TCT) dates back to the 1930's. Commons (1931), Coase (1937), and years later Williamson (1985), are some of the most quoted authors for the development of this theory. One of the main premises of TCT is that management structures must align with transactions in order to minimize transaction costs (Williamson, 1994). Thus, we see the emergence of organizations focused on the management and coordination of transactions and mechanisms, to reduce the costs associated with these transactions (Li, Arditi, & Wang, 2013). This paper proposes to assess whether (i) the predictability of the project owner's behavior, (ii) the predictability of the contractor's behavior, (iii) project management efficiency, and (iv) uncertainties in the transaction environment, are determining factors to minimize transaction costs in oil and gas projects in Brazil.

This study is a replication of the research performed by Li et al. (2012), in the context of the oil and gas industry in Brazil. By doing so, the present research contributes for knowledge accumulation in this area, and draw insights on the factors that affect transaction costs in this relevant industry in Brazil.

This paper is divided in four sections. Section 2 presents the theoretical foundations that support the study. Section 3 describes the research method and the findings. Finally, the last section discusses these findings and their implications for research and practice, points to the study's limitations and offer suggestions for further research.

THEORETICAL BACKGROUND: -

Williamson (1975, 1981, 1985) suggests that organizations are distinct in their search for ways to minimize costs, and consequently their transaction costs, either on the part of project agents, economic agents or contracting and contracted parties. Through an economist's vision, it is possible to determine that the assumptions that underpin the transaction cost theory (TCT) are: (i) limited rationality of the economic agents, and (ii) the opportunism of their actions (Simon, 1959).
The concept of limited rationality (Simon, 1976, 1979) affects the decision-making process when building the contract defense models, because contracting and contracted parties do not acknowledge the complexities (Carvalho & Rabechini, 2015; Perminova, Gustafsson, & Wikstrom, 2008) and uncertainties of the scenarios, or their own lack of access to all information on technical and behavioral competencies (Lopes, Sbragia, & Qualharini, 2016). This is due to the lack of confidence in the agents that will be involved in the project, and to the poor record of good results (Buvik & Tvedt, 2017; Chow et al., 2012; Chowdhury, 2005).

For Simon (1976, 1979), there is strong evidence that, most of the time, rationality is limited. Because it is limited, rationality depends on the agent's behavioral decision-making process, and transfers the focus of the decision to a cognitive layer. The main concern, because of limited rationality, is that there are levels of choices, routines, scopes and time that meet acceptable levels of customer satisfaction, without harming the existing 'certainties' (Meyer et al., 2002). According to Wideman (1992), the distinction between unknown and certainty establishes the limits of the uncertainties' field.

However, for Burlamaqui and Fagundes (1993), due to the limitation of rationality and the dependence on the cognitive process of the agents participating in the project, the anticipation of events, the prediction of facts and the creation of corrective measures become quite complex, and tend to make the control systems more expensive. Among the key elements that contracting parties seek to control is opportunism, because there is no control or access to all information (Williamson, 1985). According to this author, opportunism is the combination of self-interest with malice that results from knowing the presence of asymmetries of information, which may give rise to moral risks and adverse selection. Therefore, opportunism can be defined as manipulation or concealment of information or intentions, in search of profits that change the contract's initial configuration. Information asymmetry is a constant, considering that one economic agent will always have greater knowledge of a project's information, not available to other participants in a transaction (Atkinson et al., 2006; Chow et al., 2012; Zhang & Ng, 2012). Opportunism may occur because there is not enough interest, from the party that has inside information, to behave ethically with regard to the participants, or due to mistrust of the other stakeholders (Chowdhury, 2005). This biased behavior ends up by increasing the time spent with models for 'shielding' the contracts and projects (Zhang & Ng, 2012), resulting in higher expenses for preparing contracts, getting support from lawyers, judicialization of contracts and demands, and especially in losing the ability to record the lessons learned (Zhang & Ng, 2012; Williamson, 1985).

Under an economic approach, transaction costs provide a framework that is useful for analyzing the inevitable differences of interest between the parties of a project (Winch, 1989). To get savings in transaction costs, one assumes the pre- or post-operational expenditures of a project, with the aim of reducing its uncertainties (Williamson, 1987).
Thus, transaction costs are different from other production costs, since these correspond to expenditures directly related to the transformation of inputs, and in a project, they are spent for preparing it; but transaction costs arise from an economic exchange in search of the lowest possible level of uncertainties (Williamson, 1987). With the intent of reducing them, the contracting and contracted parties seek to maximize their results and incur the smallest possible risks (Bañuls, López, Turoff, & Tejedor, 2006; Carvalho & Rabechini, 2015; Damodaran, 2010). Therefore, we can say that, from their efforts to reduce risks, the agents of a project have higher expenses with transaction costs, which lead to a higher cost of the project. Hence, there is a paradigm for the transaction, and it has received the attention of several academics on a wide variety of topics, such as: Jobin (2008), with a focus on governance, Whittington (2008), with a focus on project delivery, Lai (2000), who focuses on subcontracting, and Farajian (2010), who measures transaction costs.

It is worth noting that most studies on transaction costs are on theoretical aspects and have a qualitative bias. According to Li et al. (2012), it is possible to observe a lack of standard terminology within and across disciplines that investigate transaction costs. Williamson (1985) defines transaction costs as the expenses related to preparing proposals, negotiating, writing up the contracts and governance, as well as the controls before and after the project's contracts. Additionally, Joskow (1985) considers that the costs of acquiring and processing information, legal costs, costs of setting up and dismantling, expenses related to inefficiencies, and costs associated with breaches of contracts and penalties should be considered as transaction costs (Rahman & Kumaraswamy, 2002). Three basic attributes define the transaction costs in Williamson's (1985) view: the frequency, the uncertainty and the specificity of the assets involved. Transaction costs are expenditures of financial resources to plan, adapt and monitor the interactions between agents, thus ensuring that the contractual terms are fulfilled satisfactorily by the parties involved (Pondé, 1993). The studies about transaction costs have evolved over time, and some authors consider that it is a theory in evolution (Rahman & Kumaraswamy, 2002). By not being completely defined yet (Jobin, 2008), a large part of the decisions and expenses involved in transaction costs are also addressed under a behavioral perspective (Lai, 2000). This less analytical perspective tries to understand the predictability of the agents' attitudes, and believes that the transaction environment becomes less uncertain due to increased trust between the parties (Atkinson et al., 2006; Rahman & Kumaraswamy, 2002). The transaction costs considered in the paper are divided in two major groups (Li et al., 2012):

- Pre-contractual transaction costs: expenses that are incurred before the transaction itself occurs. At this stage, there are internal (project preparation) and external costs (consulting and support companies), according to Soliño and Gago dos Santos (2009). The most common expenses in this group are the costs of project feasibility assessments, environmental impacts, procurement and preparation of documents, among others. For Whittington (2008) and Dudkin and Valila (2006), expenses at this stage can vary between 0.4 percent and 8.8 percent of the contract value, depending on the negotiation.
- Post-contractual transaction costs: these are all the costs incurred after the contract is signed, but before it is finished, which were not foreseen in its product cost structure (Williamson, 1985); these costs may also refer to poor contract adaptation, efforts to correct project's direction, and unexpected events. Some of the costs in this phase are expenses with litigation, which may represent between eight percent and 14 percent of the contract, in the case of disputes, and expenses with design and support of operations (Whittington, 2008).

Considering what was previously stated, the paper assesses, as suggested by Li et al. (2012), whether (i) the predictability of the project owner's behavior, (ii) the predictability of the contractor's behavior, (iii) project management efficiency, and (iv) uncertainties in the transaction environment, are determining factors for reducing transaction costs in projects. In the next section, the proposed model and hypotheses are presented.

RESEARCH MODEL AND HYPOTHESES: -

According to Li et al. (2012) propositions, we considered the following independent variables, which are the determining factors that influence transaction costs: (i) predictability of the project owner's behavior, (ii) predictability of the contractor's behavior, (iii) project management efficiency, and (iv) uncertainties in the transaction environment. According to Burlamaqui and Fagundes (1993), as agents are unable to predict the behavior of other elements within the economic activity or system, this creates uncertainty, which in turn is responsible for the need of control systems to protect the agents that operate in the business environment. Under the economic approach, since transaction costs are unders-

tood as spending on a project in order to reduce uncertainties (Williamson, 1987), if the behavior of project agents is predictable, it is expected that expenditures will be reduced to plan, adapt and monitor interactions between agents, in order to ensure a satisfactory performance (Pondé, 1993).

H1: The predictability of the project owner's behavior (POB) leads to lower transaction costs (TC).

H1a: The predictability of the project owner's behavior (POB) positively affects project management efficiency (PME).

H1b: The predictability of the project owner's behavior (POB) positively affects the uncertainty in the transaction environment (UTE).

H2: The predictability of the contractor's behavior (PCB) leads to lower transaction costs (TC).

H2a: The contractor's behavior (PCB) positively affects project management efficiency (PME).

Likewise, if the agents' attitudes are predictable, the transaction environment becomes less uncertain due to increased trust between the parties; such uncertainty reduction should positively affect the efficiency of project management, by keeping the project manager's focused on the project and not on interpreting or mapping potential behavior changes of the project agents (Williamson, 1987).

H3: The greater the uncertainties in the transaction environment (UTE), the higher the transaction costs (TC).

Understanding that transaction costs are financial resources expended in order to guarantee a satisfactory delivery of the project (Pondé, 1993), we assume that an environment with high uncertainty requires a better planning, control and monitoring of projects' activities and of project agents, in order to assure the desired results.

H3a: A higher level of uncertainty in the transaction environment (UTE) directly affects the contractor's behavior (PCB).

In addition, in a transaction environment of high uncertainty, usually the contractor is the weakest economic agent, due to information asymmetry (Williamson, 1975, 1985); therefore, his behavior becomes less predictable, as a defense mechanism.

H3b: High uncertainty in the transaction environment (UTE) directly affects project management efficiency (PME).

In order to act correctly and efficiently, the project manager must be in line with the project agents, the stakeholders and, above all, have an understanding of the local environment forces. Thus, as uncertainty increases in the transaction environment, the efficiency of project management drops, through loss of focus and objectivity.

H4: If there is project management efficiency (PME), transaction costs (TC) will be lower.

When hiring a project manager, we assume that he is going to do the best work possible, taking care of the scope, term and cost of the project, so that the best possible result is achieved. Since transaction costs are the representation of a financial volume spent with contracts and controls to guarantee project delivery, if project management is efficient, transaction costs decrease, mainly the post-project costs. The research model presents the hypotheses that were tested in a graphic form, as shown in Figure 4:

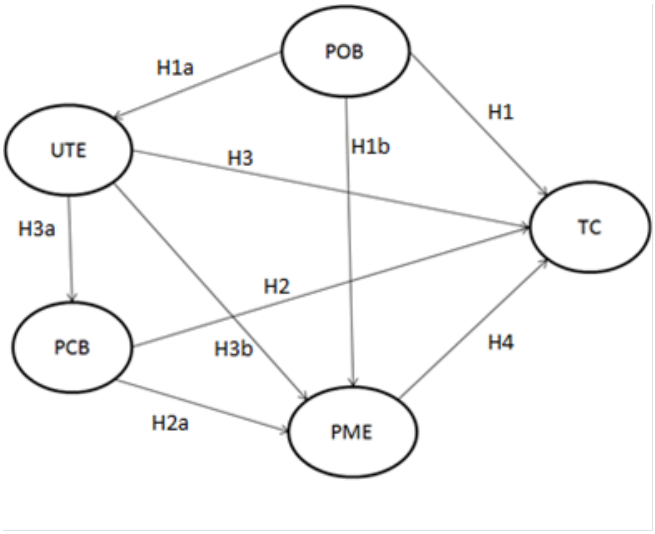

Figure 1. Path Diagram
Source: Li, Arditi and Wang, 2012

METHODS AND RESEARCH LIMITATIONS: -

This study uses a survey method to collect data. Data collection was carried out in Brazil, during the first semester of 2016. We sent a structured questionnaire to 1,500 project managers of large national oil & gas companies. We received back 235 questionnaires suitable for data analysis, which represent a 15% response rate. We applied the technique of structural equation modelling (SEM) known as partial least squares to test the hypotheses. SEM is a multivariate statistical technique used to analyze direct and indirect relations between independent or dependent variables. SEM is divided in two models: the measurement model that deals with measuring latent variables, such as the reliability and validity of the constructs; and the structural model that concerns the relationships between the constructs, and shows the amount of variance explained by the model (Hair et al., 2009).

Ribas and Vieira (2011) define SEM as a set of statistical techniques that include path analysis and factor analysis, integrating them into complete models of structural regression, while, at the same time, estimating the parameters of a series of linear regression equations that, although separated, are interdependent. For Fornell and Larcker (1981), the model of partial least squares corresponds to an application with multiple indicators of structural equations that is used to test and evaluate simultaneously the measurement model and the structural model proposed. To test the hypotheses, we adopted a structured questionnaire (Annex 01) suggested by Li et al. (2012), which was available online and addressed exclusively to project managers working in a Brazilian oil & gas company. All variables observed were drawn up in the form of statements, with answers on a 5-point Likert scale, where 5 means ‘strongly agree’ and 1 means ‘strongly disagree.’ The original questionnaire created by Li et al. (2012) was applied, but the results found after the partial least squares analysis were much lower than expected. This caused the need to adapt the model, in order to better understand the influence of the constructs proposed in the model for the Brazilian environment.

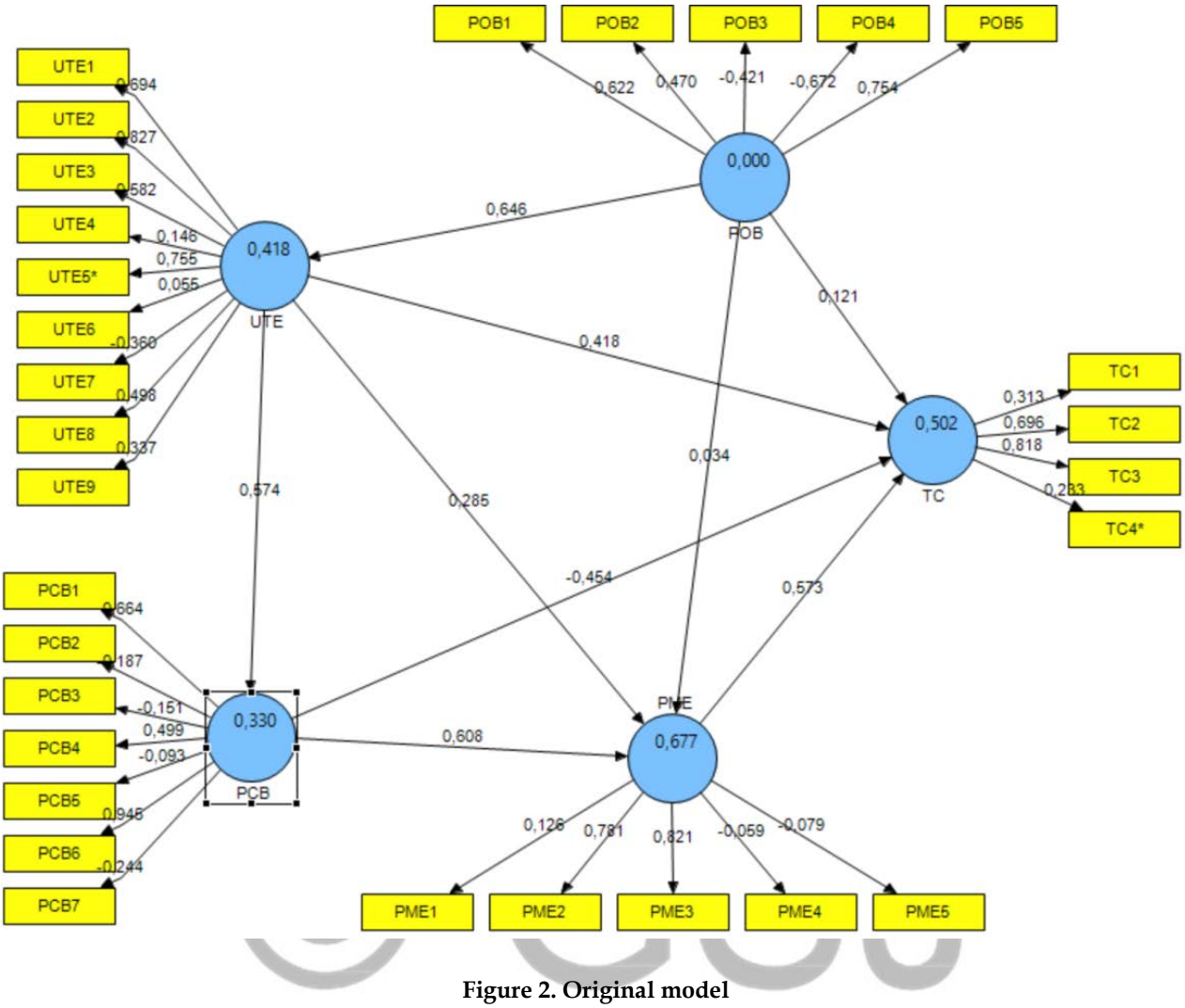

Figure 2. Original model
Source: Li, Arditi and Wang (2012)

When checking the reliability of the original model, with the sample of 235 respondents, we got the indicators for each of the constructs, as presented in Table 16.

Table 16. Reliability of the original model

	AVE	Composite Reliability	R. Square	Cronbach's Alpha
PCB	0,25	0,26	0,32	0,53
PME	0,32	0,52	0,69	0,14
POB	0,36	0,14	0	-0,21
UTE	0,28	0,66	0,41	0,57
Acceptance condition	0,5	0,7	-	0,7

None of the constructs presented reliability when working with the original model of Li et al. (2012). Therefore, to improve the work and gain relevance, we adjusted the model to enhance its quality. Table 17 shows the relevant observed variables, taken from the original model, and the authors that described them.

Table 1. *The adapted model*

Latent variables	Observed varibles	Description	Authors
Predictability of the owner´s behaviour - POB	POB1	A smooth relationship between parties may enhance cooperation, reduce disagreements, allow for easy resolution of conflicts, create stability in the owner's behaviour and hence reduce transaction costs	Kale and Arditi, 2001
Predictability of the owner´s behaviour - POB	POB2	Organizational learning may be effective if the lessons learned from completed projects are kept in the organizational memory and used in future projects, hence promoting stability in the owner's behaviour, and reduction of transaction costs.	Kululanga and McCaffer, 2001
Predictability of the owner´s behaviour - POB	POB3	A poorly defined scope and incomplete plans and specifications may increase the number of post-contract changes by owners, hence increasing uncertainty in the owner's behaviour and increasing transaction costs.	Oriyango, 1993
Predictability of the contractor´s behaviour - PCB	PCB1	The suspicion of unbalanced bidding, cheating and collusion may cause uncertainty in the bidding environment and cause the owner´s overall project costs to get higher, but it is hard to detect unbalancing and collusion, which may generate contentious change orders, all contributing to higher transaction costs.	Arditi and Chotibhongs, 2009
Predictability of the contractor´s behaviour - PCB	PCB2	Good relationships with previous clients may enhance cooperation and trust between owners and contractors, and create stability in the contractor's behaviour, hence lowering transaction costs.	Bresnen and Marshall, 2000
Predictability of the contractor´s behaviour - PCB	PCB3	Frequent material substitutions may cause frequent claims, fluctuations in product costs and higher transaction costs.	Molenaar et al, 2000
Project Management Efficiency - PME	PME1	Good leaders have a project vision and know how to align people with their goals, inspire their team to take cooperative actions and to achieve project objectives, in turn reducing transaction costs.	De Meyer, 2010
Project Management Efficiency - PME	PME2	Transaction costs are inevitably incurred in the decision-making process but making sound decisions reduces the amount of time spent on unexpected problems, minimizes disagreements and helps keep a project on schedule and within budget, hence reducing transaction costs.	Silva et al, 2008
Project Management Efficiency - PME	PME3	Effective and efficient communication will ensure that all team members are aware of decisions as soon as they are made, leaving no room for uncertainty in terms of individual responsibilities and goals, hence reducing transaction costs.	Silva et al, 2008
Uncertainty in the transaction environment - UTE	UTE1	High project complexity increases uncertainty in the transaction environment, hence increasing the cost of procurement.	Farajian, 2010
Uncertainty in the transaction environment - UTE	UTE2	When the scope of a project is not well defined, initial drawings and specifications are likely to change, prompting many claims and change orders that in turn increase transaction costs.	Farajian, 2010
Uncertainty in the transaction environment - UTE	UTE3	Incomplete plans and specifications may increase the number of disagreements and disputes, hence increasing transaction costs.	Dieckmann and Girard, 1995
Uncertainty in the transaction environment - UTE	UTE4*	Low bidders may create a less competitive procurement process, but may reduce transaction costs.	Farajian, 2010
Uncertainty in the transaction environment - UTE	UTE5	Incentive/disincentive clauses may motivate the contractor to minimize project duration, but may cause an increase in transaction costs.	Broome and Perry, 2002

We excluded variables POB3, POB4, PCB2, PCB3, PCB5, PCB7, UTE4, UTE6, UTE7 and UTE9, as they presented factorial load below 0.40 for the POB, PCB and UTE constructs. For the PME construct, in order to meet the recommendations of Hair et al. (2009), who postulates that a construct must have at least 3 observed variables, we decided to exclude the variable PME4, which had a load lower than 0.10. With the lower number of observed variables, they were renamed according to Table 18**:**

Table 2. *New Observed Variables*

Old OV	New OV
POB1	POB1
POB2	POB2
POB5	POB3
PCB1	PCB1
PCB4	PCB2
PCB6	PCB3
PME1	PME1
PME2	PME2
PME3	PME3
UTE1	UTE1
UTE2	UTE2
UTE3	UTE3
UTE5	UTE4
UTE8	UTE5

With this new configuration, the reliability indexes improved significantly, as did the factors. However, there was a small decrease in the determination coefficients of the constructs, as can be seen in Table 19:

Table 3. *Reliability of the proposed model*

	AVE	Composite Reliability	R. Square	Cronbachs Alpha
PCB	0,598	0,805	0,201	0,701
PME	0,503	0,701	0,642	0,703
POB	0,509	0,719	0	0,71
UTE	0,501	0,809	0,191	0,717
Acceptance Condition	0,5	0,7	–-	0,7

The questionnaire was then applied to a sample of project managers, with the objective of testing the transaction cost model described in this article, which allowed for various conclusions, discussions and observations.

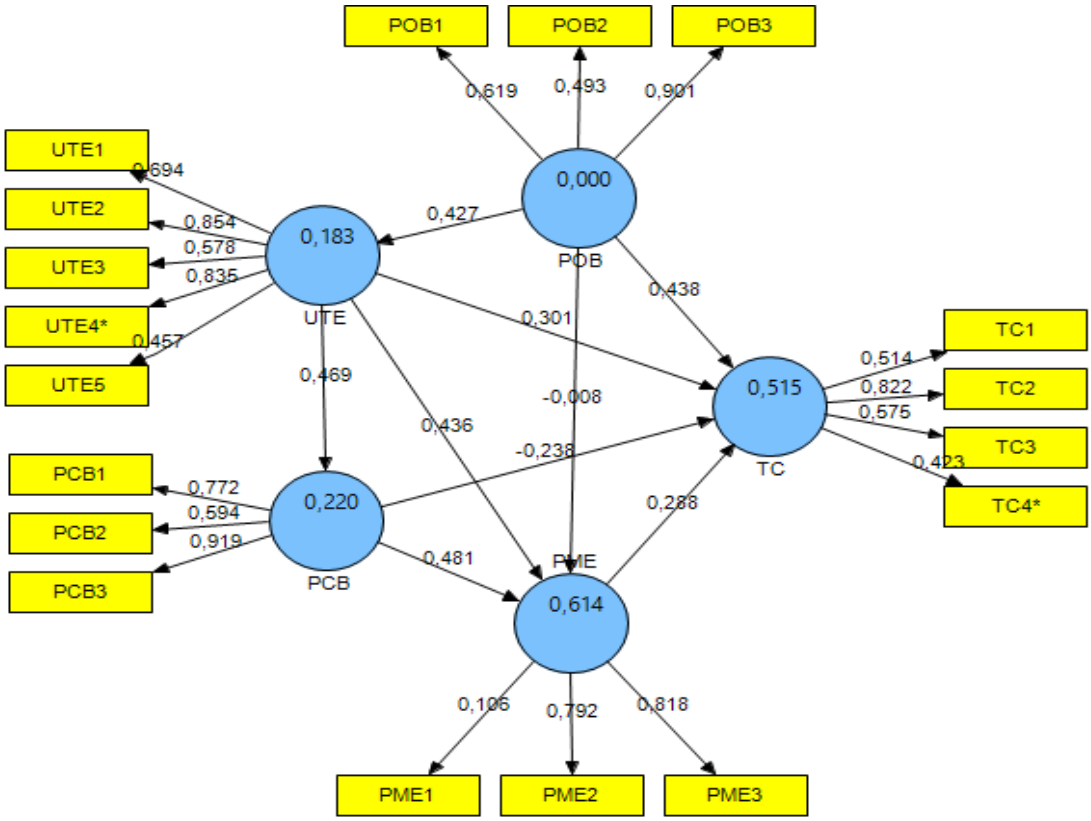

Figure 3. Adapted model diagram

After the model was adjusted to the Brazilian environment, the new variables are presented in Table 20, as follows, together with their constructs and acronyms. All variables observed were drawn up in the form of statements with answers on a 5-point Likert scale, where 5 means ‘strongly agree’ and 1 means ‘strongly disagree.’

Table 4. *Variables observed and constructs*

Observed Variables (OV)	OV's Acronym	Construct	Construct's Acronym
High project complexity increases uncertainty in the transaction environment, hence increasing the cost of procurement.	UTE1	Uncertainty in the transaction environment	UTE
When the scope of a project is not well defined, initial drawings and specifications are likely to change, prompting	UTE2	Uncertainty in the transaction environment	UTE
Incomplete plans and specifications may increase the number of disagreements and disputes, hence increasing transaction costs.	UTE3	Uncertainty in the transaction environment	UTE
Low bidders may create a less competitive procurement process, but may reduce transaction costs.	UTE4*	Uncertainty in the transaction environment	UTE
Incentive/disincentive clauses may motivate the contractor to minimize project duration, but may cause an increase in transaction costs.	UTE5	Uncertainty in the transaction environment	UTE
The suspicion of unbalanced bidding, cheating and collusion may cause uncertainty in the bidding environment and cause the owner's overall project costs to get higher, but it is hard to detect unbalancing and collusion, which may generate contentious change orders, all contributing to higher transaction costs.	PCB1	Predictability of the contractor's behaviour	PCB
Good relationships with previous clients may enhance cooperation and trust between owners and contractors, and create stability in the contractor's behaviour, hence lowering transaction costs.	PCB2	Predictability of the contractor's behaviour	PCB
Frequent material substitutions may cause frequent claims, fluctuations in product costs and higher transaction costs.	PCB3	Predictability of the contractor's behaviour	PCB
A smooth relationship between parties may enhance cooperation, reduce disagreements, allow for easy resolution of conflicts, create stability in the owner's behaviour and hence reduce transaction costs.	POB1	Predictability of the owner's behaviour	POB
Organizational learning may be effective if the lessons learned from completed projects are kept in the organizational memory and used in future projects, hence promoting stability in the owner's behaviour, and reduction of transaction costs.	POB2	Predictability of the owner's behaviour	POB
A poorly defined scope and incomplete plans and specifications may increase the number of post-contract changes by owners, hence increasing uncertainty in the owner's behaviour and increasing transaction costs.	POB3	Predictability of the owner's behaviour	POB
Good leaders have a project vision and know how to align people with their goals, inspire their team to take cooperative actions and to achieve project objectives, in turn reducing transaction costs.	PME 1	Project Management Efficiency	PME
Transaction costs are inevitably incurred in the decision-making process but making sound decisions reduces the amount of time spent on unexpected problems, minimizes disagreements and helps keep a project on schedule and within budget, hence reducing transaction costs.	PME2	Project Management Efficiency	PME
Effective and efficient communication will ensure that all team members are aware of decisions as soon as they are made, leaving no room for uncertainty in terms of individual responsibilities and goals, hence reducing transaction costs.	PME3	Project Management Efficiency	PME

Source: Adjusted model from Li, Arditi and Wang, 2012

The statement used for UTE4 was considered reversely, because it had been built as a negative in order to test prior reading and participants' knowledge regarding the research, thus avoiding biases or variations due to the respondents' lack of commitment to the study. We used the software SmartPLS 3.0 and SPSS in its version 23 for data analyses in SEM. After defining the model and the techniques used for the analysis, next stage shows the results achieved.

SAMPLING METHODS: -

The researched universe was composed of project professionals with decision-making capacity regarding transaction costs. The sample consisted of 235 respondents, which is 15% of the questionnaires sent (1500). By age group, the sample is composed of 21% professionals between 18 and 29 years old, 66% from 30 to 49 years old, and 13% professionals between 50 and 59 years of age. No respondent over 60 years old was part of the sample, as shown in Figure 7:

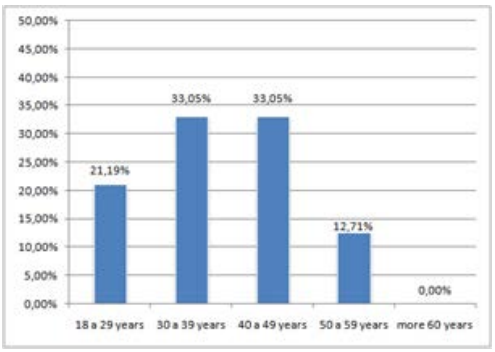

Figure 7. Age ranges

In terms of education, 70% of the professionals have completed a specialization course or MBA, 27% have a master's degree, and 3% have only an undergraduate degree, as shown in Figure 8:

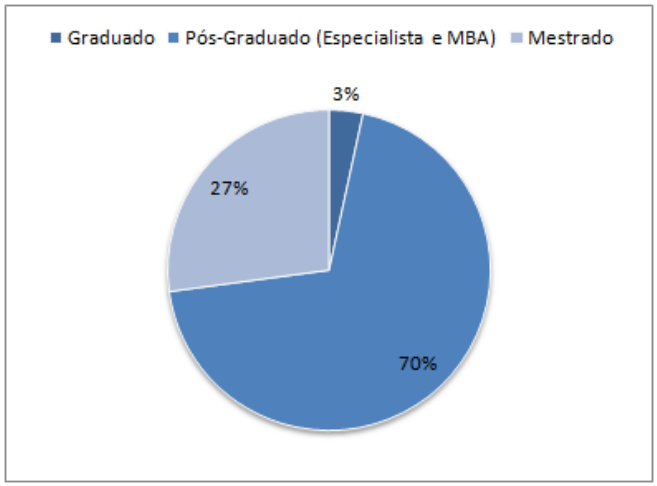

Figure 8. Education levels

As for years of experience in the market, more than 50% of the sample is composed of professionals with experience between 3 and 10 years of work, 37% between 11 and 20 years of professional experience, while 9% have over 20 years of activity, and the remaining 3% have less than 2 years of experience, as shown in Figure 9.

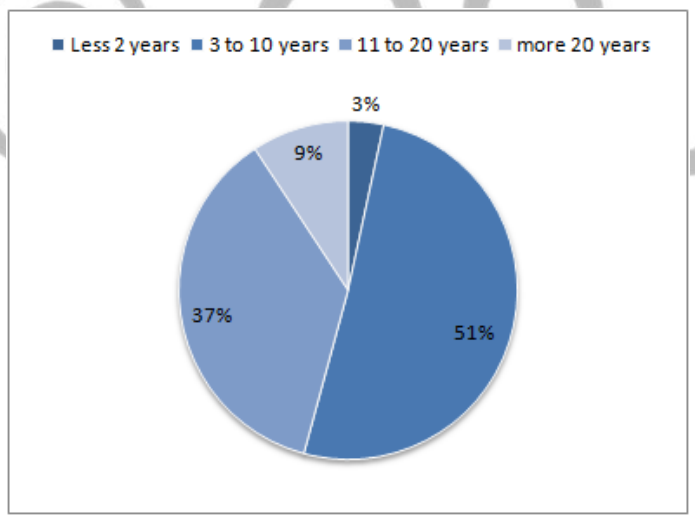

Figure 9. Years of experience

Regarding their managerial positions in companies, 62% are project managers, 19% hold a position of area manager, 3% are directors and 16% are coordinators, analysts or consultants, as presented in Figure 10.

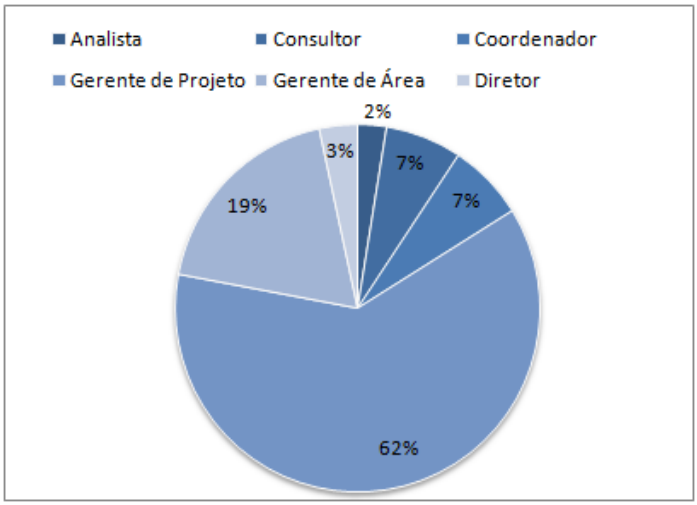

Figure 10. Position in the companies

RELIABILITY TEST:-

One of the most important stages in the analysis process of a SEM study is to assess the reliability of the data collection instrument. The following indicators were used to test the reliability and validity of the data collection instrument: composite reliability (CR), average variance extracted (AVE) and Cronbach's Alpha. For the instrument to be valid, it must have a value higher than 0.7 for Cronbach's Alpha (Hair et al., 2009), higher than 0.5 for AVE (Hair et al., 2009), and above 0.70 for CR (Ribas & Vieira, 2011) All variables were considered appropriate, according to the criteria proposed, as presented in Table 21, as follows:

Table 5. *Reliability of the new model*

V.O.	Cronbach's Alpha	Average Variance Extracted	Composite Reliability
POB	0.714	0.513	0.724
PCB	0.701	0.601	0.814
PME	0.703	0.501	0.701
UTE	0.718	0.502	0.820
TC	0.711	0.510	0.703

STRUCTURAL MODEL TEST:-

Once the instrument proved to be reliable, next step was to analyze the structural model. Figure 11 shows the factor forces that exist within each of the latent variables of the structural model evaluated, as follows:

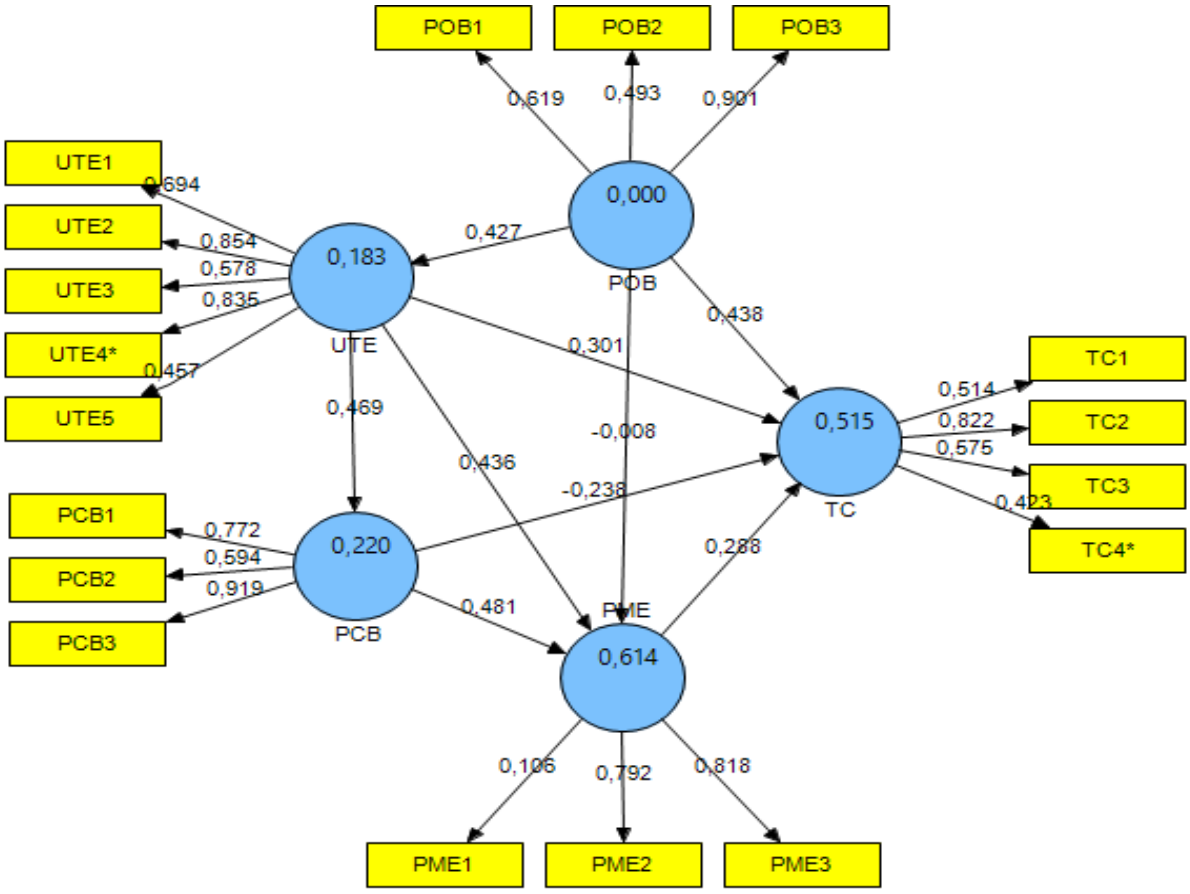

Figure 11. Adapted model diagram – factor forces

Observe in Figure 11 that variable PCB has a negative force of 0.238 in transaction costs. In addition, there is practically no factor pressure between POB and PME. However, the study sought to test the hypotheses presented earlier and, according to the correlation study between the latent variables, shown in Table 22, we cannot discard any of the hypotheses.

Table 6. *Correlation of Latent Variables*

	PCB	PME	POB	TC	UTE
PCB	1.00				
PME	0.68	1.00			
POB	0.20	0.27	1.00		
TC	0.19	0.44	0.59	1.00	
UTE	0.46	0.65	0.42	0.56	1.00

Table 23 presents the summary of the results of the hypotheses tests performed in this study. Considering that Hypothesis 2 (H2) and Hypothesis 1b (H1b) were rejected, and none of the others were, we can now consider some important ele-

ments that will be addressed in the discussion. These comments will focus on the factor strengths found, and especially on the effects observed in the model:

Table 7. *Summary of Results*

Hypothesis	Influence	Result
H1	Predictability of the project owner's behaviour on the transaction cost	Not Rejected
H1a	Predictability of the project owner's behaviour on the project management efficiency	Not Rejected
H1b	Predictability of the project owner's behaviour on the uncertainty in the transaction environment	Rejected
H2	Predictability of the contractor's behaviour on the transaction cost	Rejected
H2a	Predictability of the contractor's behaviour on the project management efficiency	Not Rejected
H3	Uncertainties in the transaction environment on the transaction cost	Not Rejected
H3a	Uncertainty in the transaction environment on the predictability of the contractor's behaviour	Not Rejected
H3b	Uncertainty in the transaction environment on the project management efficiency	Not Rejected
H4	Project management efficiency on the transaction cost	Not Rejected

DISCUSSION: -

The model presented in this paper was tested in Brazil, and its main objective was to check the influences of (i) the predictability of the project owner's behavior, (ii) the predictability of the contractor's behavior, (iii) the uncertainties in the transaction environment, and (iv) project management efficiency, on the transaction costs. We observed a greater effect on transaction costs reduction caused by the predictability of the owner's behavior. This can explain other questions that still exist, such as the low load of project management efficiency in reducing transaction costs, and the negative effect of the predictability of the contractor's behavior in reducing transaction costs. For the project manager, it is very relevant to know the type of contracting party involved. This is because the predictability of this agent is an element that tends to reduce litigation and changes in scope. Therefore, to know its history and its previous results is more important than its technical capacity, as shown by the existing history of unbalanced relations between contracting and contracted parties. This is especially true in public bodies, where we find contracts with poorly defined scopes and questionable control criteria. This was confirmed by the strength of the construct related to statement POB3, in the case of Brazil.

Next, we observed the uncertainties in the transaction environment, since they have a relevant weight in reducing the existing transaction costs. Once again, based on statement UTE2, we can point out that the contractor's inability to define the project clearly is responsible for increasing transaction costs. This problem can be exacerbated by a low volume of potential bidders, as shown in statement UTE4. In addition to this level of uncertainty, the potential complexity of projects can also cause an increase in transaction costs. With the lowest responsibility for reducing transaction costs, the question about project management efficiency can be considered as impaired in the case of Brazilian culture, in which the project manager is not seen as an agent of project changes, financial controls and operations. This criticism is corroborated by the low strength of statement PME1, which sees the project manager's skills as a tool for reducing transaction costs, which is different from statements PME3 and PME2, which have the highest values, respectively, and consider only the manager's ability to communicate as relevant for reducing transaction costs in project management. Next, it was possible to observe that the perception of the contractor's behavior has a low negative influence in reducing transaction costs. We believe that this phenomenon occurs due to the permanent mistrust shown by the contracting parties in relation to the companies they hire. This mistrust is confirmed by the strength of PCB3 and PCB1, which regard replacements of

materials without prior approval and suspicions of collusion, respectively, in projects' environments. On the other hand, a good relationship that results from previous projects (PCB2) has a low intensity in reducing transaction costs. According to the analyses with the intermediary hypotheses, almost no influence was observed in the relationship between the predictability of the owner's behavior and project management efficiency. This may occur because there is no direct relationship between the parties. And it is different from what we observed regarding the uncertainty in the transaction environment, in which the owner's behavior predictability has a strong load factor in the construct, which may be explained by the fact that the potential predictability of the owner reduces the uncertainties in the environment. The uncertainties in the transaction environment cause a strong effect on the predictability of the contractor's behavior, possibly because the uncertainties give rise to greater difficulty for the hired party to manage the project. Moreover, this can be explained by the strong relationship between the predictability of the contractor's behavior and project management efficiency, because uncertainty also has a significant effect on project management efficiency. Therefore, we can consider that, in Brazil's business environment, managers' concerns in relation to transaction costs in projects are much more focused on issues regarding the contracting party and the business environment than on the contracted party and its ability to manage the project efficiently. This can be considered predictable in an environment where, in most cases, projects' failures are due to factors outside the scope that was originally planned, such as regulatory changes, corruption and changes in the primary scope, among other issues. One possible way to better understand this issue is to carry out a qualitative analysis of project managers' real perceptions of the business environment for projects in Brazil. The search for tools to reduce the level of uncertainty in the relational environments of projects could reduce transaction costs, thus bringing to the market more effective and competitive projects.

Finally, the model has implications with on the fields of research, including: (i) projects involving public agents (Dias, M. 2018); (ii) project environment including non-market forces (Dias & Navarro, 2018); (iii) projects within retail business (Dias, M., et al., 2015; Dias, M. et al., 2015, 2014); (iv) Projects involving manufacturing industries (Dias, 2020b; Dias, M. and Davila, 2018; Dias, M. and Falconi, 2018; Dias, M., 2018); (v) governmental projects (Dias, M. & Navarro, 2017);) (vi) e-business negotiation projects (Dias & Duzert, 2017); (vii) streaming video industry (Dias, M., & Navarro, 2018); (viii) civil construction projects (Dias, M., 2018; Dias, M., 2016), (ix) debt collection negotiations (Dias, M., 2019, 2019b; Dias, M. and Albergarias, 2019); (x) civil aviation projects industry (Dias, 2019, 2019b, 2019c, 2019d); (xi) Negotiations involving project management environment (Dias, 2020); (xi) Compelled Circumstantial Forces in Project Management Environments (Lopes,R; Massioui,F; Bahli,B; Barros, S; Dias, M., 2021), amongst others.

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ANNEX 1 – DETERMINANTS OF TRANSACTION COSTS

Table 1. Determinants of Transaction Costs

Latent variables	Observed variables	Description
Predictability of the owner's behavior	Relationships with other parties	A smooth relationship between parties may enhance cooperation, reduce disagreements, and allow for easy resolution of conflicts, create stability in the owner's behavior, and hence reduce transaction costs.
	Experience in similar type projects	Organizational learning may be effective if the lessons learned from completed projects are kept in the organizational memory and used in future projects (Kululanga and McCaffer 2001), hence promoting stability in the owner's behavior, and reduction of transaction costs.
	Payment on time	Timely payments on the part of the owner eliminate uncertainty, may be conducive to fewer claims on the part of the contractor, and may minimize the frequency and magnitude of legal disputes (Ozorhon et al. 2010), hence reducing transaction costs.
	Organizational efficiency	The ability to produce maximum output given a set of inputs, or the ability to minimize input given a set of required outputs may allow a smooth operation, and a more stable environment, reducing transaction costs.
	Change orders	A poorly defined scope and incomplete plans and specifications may increase the number of postcontract changes by owners (Onyango 1993), hence increasing uncertainty in the owner's behavior and increasing transaction costs.
Predictability of the contractor's behavior	Bidding behavior	The suspicion of unbalanced bidding, cheating, and collusion may cause uncertainty in the bidding environment, may cause the owner's overall project cost to get higher, but it is hard to detect unbalancing (Arditi and Chotibhongs 2009) and collusion, and may generate contentious change orders (Manzo 1997), all contributing to higher transaction costs.
	Qualifications of the contractor	Competent contractors may operate efficiently and may promote a problem-free environment, hence contributing to a more stable environment with lower transaction costs.
	Relationships with subcontractors	Maintaining good relationships with subcontractors may positively and strongly affect general contractor performance (Kale and Arditi 2001), and may lower transaction costs.
	Relationships with previous clients	Good relationships with previous clients may enhance cooperation and trust between owners and contractors (Bresnen and Marshall 2000), and create stability in the contractor's behavior, hence lowering transaction costs.
	Experience in similar type projects	A company that performed well in previous projects with regard to schedule, budget, and quality may be expected to do equally well (Molenaar et al. 2000), and to lower transaction costs.
	Material substitution	Frequent material substitutions may cause frequent claims, fluctuations in product costs, and higher transaction costs.
	Frequency of claims	Claims may be settled amicably, but some can degenerate into unnecessary conflicts and disputes (Kumaraswamy 1997), and in turn, increase transaction costs.
Project management efficiency	Leadership	Good leaders have a project vision and know how to align people with their goals, inspire their team to take cooperative actions and to achieve project objectives, in turn reducing transaction costs (De Meyer 2010).
	Quality of decision making	Transaction costs are inevitably incurred in the decision-making process but making sound decisions reduces the amount of time spent on unexpected problems, minimizes disagreements, and helps keeping a project on schedule and within budget, hence reducing transaction costs.
	Quality of communication	Effective and efficient communication will ensure that all team members are aware of decisions as soon as they are made, leaving no room for uncertainty in terms of individual responsibilities and goals, hence reducing transaction costs (Silva et al. 2008).
	Conflict management	The potentially unpleasant consequences of conflict include frequently filed claims that sometimes end up in disputes, which in turn reduce project management efficiency and generate higher transaction costs (Arditi and Pulket 2010).
	Technical competency	The existence of technical competence, i.e., appropriate qualifications and experience, is conductive to speedy decisions, smooth operations, few reworks, and easy communication, all of which contribute to lower transaction costs (Carey et al. 2006).
Uncertainty in the transaction environment	Project complexity	High project complexity increases uncertainty in the transaction environment, hence increasing the cost of procurement (Farajian 2010).
	Project uncertainty	When the scope of a project is not well defined, initial drawings and specifications are likely to change, prompting many claims and change orders that in turn increase transaction costs.
	Completeness of design	Incomplete plans and specifications may increase the number of disagreements and disputes (Diekmann and Girard 1995), hence increasing transaction costs.
	Early contractor involvement	Facilitating contractors' contributions in the design stage may establish a trust-based cooperative relationship (Korczynski 1996; Eriksson and Pesämaa 2007), and may reduce transaction costs.
	Competition between bidders	Low bidders may create a less competitive procurement process (Farajian 2010), but may reduce transaction costs.
	Integration of design and construction	Improved integration, collaboration and communication in the interface between design and construction may reduce uncertainty in the transaction environment and reduce transaction costs (Vrijhoef and Ridder 2007).
	Bonding requirements	Bonding requirements may discourage opportunistic behavior on the part of the contractor (Mysen et al. 2011), and consequently may reduce transaction costs.
	Incentive/disincentive clauses	Incentive/disincentive clauses may motivate the contractor to minimize project duration (Broome and Perry 2002), but may cause an increase in transaction costs.
	Fair risk allocation	Transferring all risks to the contractor or retaining all risks may cause the owner's transaction costs to rise (Al-Sobiei et al. 2005). A fair allocation of risks between the parties may reduce transaction costs.