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An Integrated Organizational System for Project Source Selection in the Major Iranian Construction Companies

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Abstract: Studies show that procurement management and its processes strongly affect project success in the construction industry, because the project-oriented organizations in the construction industry prefer to buy goods and services from outside the project team and benefit from outsourcing. Hence, these organizations are continually facing different levels of procurement processes, and the establishment of a robust outsourcing system is crucial for success of their projects and development of their businesses. On the other hand, the housing projects are considered a significant sector of the construction industry in terms of the number of projects and the impact on the national economy. Traditionally, the key sources in conventional housing projects are the general contractors, the consultants and the suppliers. In this study, essential elements of an organizational system have been investigated by expert opinions and through the Delphi method, and all effective aspects of the source selection problem have been identified and integrated. Based on the research findings, procurement of housing construction projects should be organized in three organizational levels: development of the long list, preparation of the short list and selection of the most appropriate source by focusing on four main elements of the source identification method, criteria definition, evaluation arrangement and assessment model.

Keywords: source selection; contractor; consultant; supplier; construction projects

1. Introduction

Source selection is intrinsically a multi-criteria decision-making process and has been surveyed by many researchers. Although collaborative pre-contract planning can significantly reduce the risk of project failure [1,2], selection of qualified sources is still a critical issue that has major impacts on the project's success and indeed is a risk that should be managed in an appropriate way [2–5]. This decision and procurement efforts more generally have been considered as a pivotal factor of project success [6]. Generally, a qualified contractor, from the perspective of the construction project management, is considered as a major attainment element of time, cost and quality goals of the project [7–9]. Thus, project source selection is inherently a client-side problem, although contractors should develop internal systems and strict procedures for risk management of their corporation [10]. Ref [11] has explored the relationship between five selection criteria—financial standing, technical ability, management capability, health and safety and reputation—and seven project success factors—cost performance, schedule performance, quality performance, health and safety performance, relationship with project stakeholder, project scope and environmental performance. This study reveals a strong and clear relationship between the two sets of criteria that demonstrate the

significance of source qualification and its impact on the final achievements of the project. The source selection problem is also considered an effective factor in investment-based projects in the public–private partnership procurement method [2,12–15]. Fundamentally, source evaluation is highly significant in the construction industry due to its particular aspects like unique product, just-in-time material requirements, numerous stakeholders, temporary teams and on-site construction [16]. Qualification is the process of identification, categorization and classification of potential bidders by the owner or legal authorities and by applying predefined objective factors that will guarantee project success [17–19]. This problem has been surveyed in many research studies and at different execution phase levels. Prequalification procedures are often considered with the client in order to reduce uncertainties and improve projects' key success factors [3]. Buying processes especially in the public sector are mostly done on hard-bid and lowest-price selection. Meanwhile, two main drivers, namely demonstration of inefficiency in achieving quality purposes of the project and development of alternatives of project delivery systems, increase the application of quality-based methods of contractor selection [20]. Bid evaluation systems, particularly in the public sector are generally based on the lowest price due to rigid regulations of fairness [21,22], and these entities always hold the updated approved lists of sources. This prequalification process, which facilitates the evaluation of bids is mainly based on major financial, managerial, organizational, technical and reputation factors [21]. Ref [23] differentiates between two broad sets of selection studies, namely investigation of evaluation criteria and development of assessment model. On the other hand, in some investigations, authors implicitly differentiate between levels of contractor selection in the pre-contract phase [24]. Furthermore, based on [3], any source evaluation process can be divided into two different phases: determination of selection criteria and development of qualification methodology.

According to the above statements, the literature review clearly shows that source selection studies predominantly concentrate on contractor selection and mostly on the bid level. However, terms like long list and short list have been frequently used in the literature, but these levels have not been defined clearly and it is not determined which criteria are related to the long list and which should be applied to short list preparation. Therefore, the lack of an organizational system that encompasses all related sources and appropriate criteria in different levels of approved list preparation is obvious. In fact, the housing clients, depending on their business conditions and also regarding characteristics of the given project, use case-by-case planning to select appropriate sources. Reviewing the literature of the investigation shows that the current state of the knowledge of the source selection problem suffers from two major shortcomings. First, the level of the selection is not exactly defined (evaluation of the active players of the market and making a list of them or the tender phase and evaluation of received proposals?). Second, the selection criteria of each level are not separately determined for different sources (the criteria for invitation to a tender or the criteria for bid winner selection?). Accordingly, this study investigates an integrated system that encompasses all aspects and requirements of source selection by focusing on the major client companies. Therefore, the objective of this text was to answer to the following questions:

1. What are the main selection criteria of the key service/goods providers for the housing construction clients in Iran?
2. What is the main evidence for criteria evaluation to select each of the above sources?
3. Which assessment model is the most appropriate method for source selection at each level?

However, in the following sections, the construction industry and also the importance, procedures and criteria of the source selection phase in the projects of this industry are reviewed based on previous research. In the next sections, the methodology of the current investigation are described. Finally, the findings of the study are presented.

2. Outsourcing in the Construction Industry

There are universal motives for outsourcing, including globalization, increasing complexity and emerging markets [23]. The construction industry constitutes a considerable portion of the national economy all over the world [24], and outsourcing plays a significant role in it. The construction industry involves hundreds of companies in a wide range of services, and their evaluation process should cover competitive capabilities and managerial aspects [16]. The source selection problem can be analyzed through the project contract strategy viewpoint. For instance, [25] has proposed the partnership as the most appropriate delivery method for lean construction. However, in the case of selection, the outsourcing method for the project as the output of the make-or-buy analysis, the source selection problem will arise. It should be noted that within the wide range of stakeholders of a project, the key sources with which the client of the construction project usually concludes a contract are the construction consultant, the construction contractor and the construction supplier [26–31]. In the buying process of construction projects, these parties, which act as the source and are known as the seller, can be defined as follows (Figure 1):

I. Construction General Contractor, who may also be called Constructor [32], is the second party in a construction contract with the client and refers to the person who undertakes the executive phase of the project by the preparation of required resources including machinery, materials and human resources [33–35].
II. Construction Consultant, who may also be called the Designer [34], Engineer [32] or Architect, is the party in a construction contract with the client and means a person who acts on behalf of the client and undertakes the vast responsibilities of designing, estimating and monitoring the execution phase, interpreting contract documents and inspecting the improvements and payments [35,36].
III. Construction Supplier, who may also be called the Manufacturer [35] or Vendor [37,38], produces or prepares materials and equipment off-site for the project that are used, installed or erected on the site [39]. Suppliers may also be engaged either by the contractor or directly by the client [34].

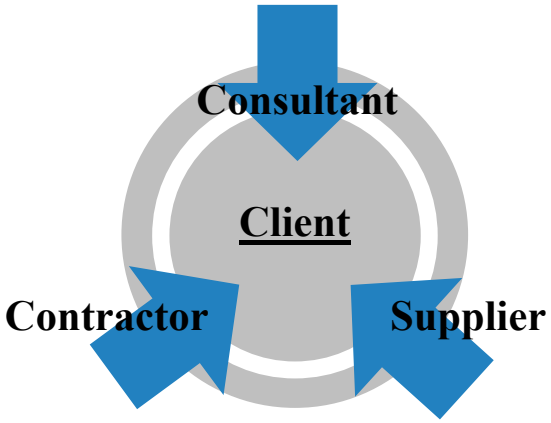

Figure 1. Key sources of a housing construction project.

In the following sections, source selection studies of outsourcing have been reviewed in three fundamental categories of source evaluation, which can be considered the main steps of source selection (Figure 2).

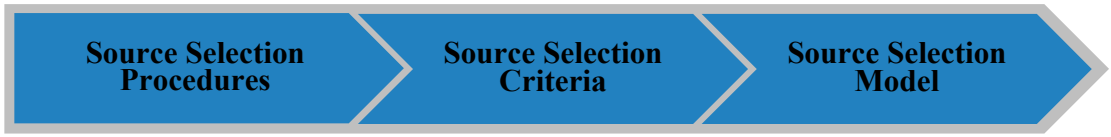

Figure 2. Main steps in source selection.

2.1. Procedures of Source Selection

Different countries have developed specific and strict laws and regulations of procurement in the governmental sector for purchasing services or goods [6] especially in construction works, where the public sector is a considerable client [21].

Some countries and organizations may establish a multi-tier system to select a source. For instance, in Taiwan, it is common to consider a two-stage process, which includes prequalification of potential contractors and then selection of the winner through a hard bid [7]. In the UK, although public organizations significantly modify prepared appendices of regulations, they still follow strict procedures [21]. Contractor assignment in the governmental sector of Saudi Arabia is done in a two-step process. Firstly, contractors prequalify in a public department (Contractor Classification Agency of Ministry of Municipal and Rural Affairs) by considering technical, financial, and managerial capabilities; then, in the second stage, the contractor is selected through bidding [40]. Governmental organizations in Japan enforce bidders to be evaluated before entering the tendering process [41]. This evaluation process, called Unified Qualifications Screening, requires source registration, tax payments, financial statements and company resume. Documents required for tender are business conditions, location of company and tax statements. In India, public organizations follow a three-stage procedure: screening by registration information; scoring and selecting three top bidders by three criteria of similar experiences, resources and financial situation; and finally selection of the lowest bidder price [42]. In Poland, public entities have to select the source in compliance with related laws [43].

Ref [16] considers three major levels for acquiring a supplier source: main selection criteria, subset selection criteria and determination of each order quantity. Other research studies argue that contractor selection consists of three phases, which include research to create a long list without prejudice (no more than 12), prequalification to create a short list and tenders for carrying out the assignment [44]. Ref [45] states that the adequate number of shortlisted contractors in design–build projects is approximately 3 to 5 sources. Although some researches implicitly differentiate between qualification stages and final selection of the contractor, these steps are not clearly distinct [46]. However, there are some studies that define the procedure of source selection in the procurement effort. Ref [23] explains the contractor section process in Taiwan, which consists of basic qualification to a long list (more than four bidders), preliminary short-listing and final selection. Ref [47] proposes five stages—packaging, invitation, prequalification, short-listing, and bid evaluation—for contractor selection. In addition, [48], has stated that there are four steps to select the contractor in a design–build contract as follows:

1. Long list of interested contractors;
2. Short list of contractors to interview;
3. The contractors who will tender;
4. The final choice of the contractor by competition or negotiation.

The long list of potential bidders is always one of the organizational assets of major companies and is held as a data bank and updated regularly [48].

Likewise, [23] defines a nine-step process to tender: 1. Review Scope for Outsourcing and Requirements. 2. Identify Potential Service Providers. This stage is focused on developing the long list by reviewing the organizational factors such as IT capabilities, human resources, facilities, infrastructures, technical and management capabilities, quality systems and reputation. 3. Produce Request for Information

(RFI) and Shortlist. In this stage, a request for information (RFI) will be sent to each company present in the long list to investigate the interest in tendering and further assessment. Here, no exact criteria are mentioned to reduce the long list to a short one through an RFI process. 4. Prepare and Issue the Request for Quotation (RFQ), 5. Assess the Tenders. Received information will be assessed in a multi-disciplinary team, which consists of different specialties like logistics, procurement, finance and human resources. 6. Select Contract and Assess Risk. 7. Determine Contract. 8. Implement Contract. 9. Manage Ongoing Relationship.

Moreover, [49] defines 10 steps for the selection process of outsourcing: 1. Review the scope for outsourcing; 2. Identify the type of service required; 3. Identify potential service providers (A long list of 20 to 30 companies); 4. Produce RFI and short list; 5. Prepare and issue RFP; 6. Tender evaluation and comparison; 7. Contractor selection and risk assessment; 8. Contract determination; 9. Mobilize and implement; 10. Manage the ongoing relationship.

2.2. Source Selection Criteria

Source selection as a multi-criteria decision making problem is related to both quantitative and qualitative criteria such as cost, quality, technical and management capabilities, health, safety and environment (HSE) and reputation. Nevertheless, according to research, generally, 70 percent of the qualification weight is dedicated to price only [50]. Reviewing the literature [51–53] shows that considering the price is not adequate in the contractor selection process, and taking into account other qualitative and quantitative criteria is necessary [54]. Ref [55] reports a multi-criteria approach to contractor selection in which the criteria include technical ability, health and safety, reputation, management capability and bid amount (cost). The selection criteria may include past performance, past experience and financial stability [56]. Ref [57], focuses on a specific criterion in selecting contractors, which is the "management performance" at the prequalification stage. Some studies consider experience, reputation and capability to be the most important criteria [57]. The summary of the source selection criteria in the previous research is shown in the Table 1.

Table 1. Source selection criteria per sources based on the selected references in the literature.

Reference	Source	Country/Context	Selection Criteria
[21]	Contractor	Invitation to a Tender	current regional location/financial conditions/technical expertise/managerial capabilities/size of previous contracts
[58]	Contractor	-	financial soundness/technical ability/management capability/health and safety/reputation
[47]	Contractor	Prequalification and bid process	financial soundness/technical ability/managerial capability/safety and reputation
[59]	Contractor	Hong Kong	financial/technical/managerial
[60]	Consultant	Architect selection in Hong Kong	background of firm/past performance/capacity to accomplish the work/project approach
[61]	Supervision Engineers	China	education/comprehensive practical experience/ability of organizing/working attitudes/professional ethics/ability in using a foreign language/ability in using the computer
[62]	Contractor	-	financial capacity/past performance/related experience/manpower/machinery/HSE/quality systems/capacity/claims record

Table 1. *Cont.*

Reference	Source	Country/Context	Selection Criteria
[63]	Contractor	Public–private partnerships	price/experience/technical approach/management approach/qualification/schedule/past performance/financial capability/responsiveness to the RFP/legal status
[34]	Supplier	-	logistical performance/commercial structure/production
[64]	Contractor	-	financial/management and technical ability/experience/historical/resources/quality/ health and safety
[65]	Sub-Contractor	Palestine	adherence to requirements/time schedule/commitment to the provided prices/reputation/specialty in certain type/quality standards/sufficient equipment/labor monitoring/provide the necessary equipment/qualified craftsmen and laborers
[66]	Supplier	-	cost/quality and services/assurance of supply/payment/terms and past performance
[67]	Consultant	Architect	working knowledge/education/ability to revise project's quality and achieving determined goals/creativity/ability to satisfy client's and project manager's requirements/ability to work with clients, consultants and community/culture and communication skills/responsibility and ability in detailing of the project
[23]	Supplier	Tendering process	technology/quality/function/management/ commercial terms/past achievements in contract performance/price/financial plans
[68]	Contractor	-	technical/financial/managerial capacity/experience/ reputation and occupational health and safety
[69]	Supplier	-	price/receiving discount for specific purchase/possibility of selecting the way to pay the order/same quality of products in the multi-stage orders/variety of the products/low number of defective parts in the deliver orders/exchange of defective parts/possibility of ordering products in desired volume/delivery of products according to order/delivery of products according to schedule/possibility of rapid delivery of order in emergency cases/possibility of producing product according to buyers demand/providing technical consultation/possibility of delivery of order in desired location/having different representatives all around the country/reputation of company in the market/cooperation experience with manufacturer/great history of company in the market/great history of company to produce the desired product/market share/considering environmental issues/domestic certifications/international certifications

Table 1. *Cont.*

Reference	Source	Country/Context	Selection Criteria
[70]	Contractor	Palestine	Financial evaluation of the bid/Completeness of bid document/Past performances in similar projects/Staff skills and experience/Contractor's reputation/Quality of work/Contractor site management/Bid understanding/Plant and equipment resources/Health and safety performance
[71]	Contractor	Saudi Arabia	experience/financial capabilities/reputation/capacity/manpower/ organization/HSE/past performance/quality systems
[72]	Architect	Key project management (PM) competencies	Effective cost control/ability to progress monitoring/knowledge of standard specifications/understanding project phases/effective in managing different persons/project time management skill
[34]	Contractor	Poland	legal authorizations/knowledge and experience/technical capability/personnel and financial points
[3]	Contractor	-	financial stability/experience/past performance/technical/capacity/resources/ quality and safety
[46]	Contractor	-	financial capability/past performance/contractor's past experience/contractor's resources/current workload/safety performance
[73]	Contractor	Prequalification	financial/managerial/technical/reputation
[74]	Contractor	-	price/experience/equipment/technical ability/financial stability/scheduling, quality/organizational factors/policies/certifications/security/factors pertaining to customer/factors pertaining to contractor/past function
[2]	Supplier	Heavy equipment, Indonesia	price and sales according to market dynamics/trading permits: producers, vendors, agents, recondition services, financing services, and importers/ equipment registration
[75]	Contractor	CO_2 emissions bid evaluation	technology/tender price/HSE
[76]	Supplier	For wall, cladding and roofing materials	cost/quality/delivery/payment method/geographical location/supplier profile/buyer-supplier relations/ecological characteristics/supplier capacity/technical acceptable materials
[77]	Supplier	-	primary performance/flexibility/enterprise capacity/R&D/green abilities
[78]	Contractor	-	past relationship/financial statements/bid price/quality of past performance of the contractor/organization chart/work experience/HSE/claims and legal issues/documented program of risk management/machinery and equipment appropriate to the project/accuracy of the documents in the technical proposal, sufficient knowledge of the site/labor/time
[20]	Contractor	Bid evaluation	technical/managerial/financial/personnel/ experience/past performance/HSE

Table 1. *Cont.*

Reference	Source	Country/Context	Selection Criteria
[79]	Contractor	India	company's attributes/experience record/past performance of the contractor/financial capability of the contractor/performance potential of the contractor/ project-specific criteria
[16]	Supplier	-	time/price/quality competence/delivery ability/production facilities and location/management and organization/and performance history
[80]	EPC Contractor	Iran	Experience/conducting similar projects/legal and political affairs/technicality and production include skills and technology/project management/available equipment and human resources/record of cooperation/volume of investment/ financial affairs
[81]	Supplier	-	design/GHG pollution/delivery and flexibility/responsiveness and communication/ financial condition/the offered price/environmental management system
[50]	Sub-Contractor	-	on-time delivery of materials/failure to complete contract due to financial problems subcontractor's difficulty in reimbursement/reputation/tender price/dealing with the critical activities during the construction stage
[8]	Contractor	Green Construction Projects	firm characteristics/commitment to sustainability/experience in similar projects/relation with the client/reputation/bid price/proposed time/technical bid/proposed project management plan/environmental
[82]	Contractor	Bid Evaluation	financial stability/technical capability/management ability/experience/health and safety/organizational performance
[83]	Sub-Contractor	Bid Evaluation	estimated tender price/reputation/acknowledgement certificates from government agencies/the qualification of staff/financial status/delivery/duration/health and safety record/management/production and capacity
[2]	Contractor	Public–private partnership projects, Bid level	three groups of criteria namely value for money/financial feasibility/ sustainable innovation
[2]	Supplier	Air handling unit system, Russia	price of product/warranty period/delivery lead time/conformity with the specifications/quality of communication with the supplier/quality of maintenance and spare parts service/conformity with energy performance of buildings directives for green production, design and supply/efficiency level of motors

2.3. Source Qualification Models

There are dozens of proposed methods in the literature to calculate points of sources, which include multi-criteria decision-making (MCDM), multi-attribute analysis (MAA), multi-attribute utility theory (MAUT), multiple regression (MR), cluster analysis (CA), bespoke approaches (BA), fuzzy set theory (FST) and multivariate discriminate analysis (MDA) [47,55,79,84–91]. Simple additive weighting

(SAW) as a powerful approach to the Multi-Criteria Decision Support Method (MCDM) [92,93] was surveyed by researchers in order to source the selection problem [94–96]. The analytical hierarchy process (AHP) method has also been applied frequently in the literature [7,46,71,97–99]. Moreover, Ref [78,100] focus on risk considerations in source selection, and BWM (best, worst method) has been applied to select international engineering, procurement, construction (EPC) contractors in the energy sector of Iran [80]. Furthermore, other methods that are not generally related to traditional selection criteria have been proposed by researchers, like the logistic regression (LR) model, which is based on performance forecasting of the contractor, or the credit model, which is a cash-flow-based model [101,102]. Ref [16] categorizes significant methods of supplier evaluation as data envelopment analysis (DEA), expert systems and artificial intelligence, AHP and analytical networking process (ANP), mathematical programming, multi-attribute utility theory (MAUT), outranking, categorical method, scoring method, simulation, total cost of ownership (TCO), taguchi loss function method and dimensional analysis.

3. Research Methodology

In the first phase of this study and based on the literature review, face-to-face semi-structured interviews were conducted to recognize the principal alternatives of three core issues: 1. Procedures of source selection, 2. Source selection criteria and 3. Source qualification models, which are discussed in the previous sub-sections in the context of Iranian housing megaprojects. The semi-structured interview is non-standard, not based on a hypothesis and changeable depending on the orientation of discussions [103] and is a strong tool to extract information from another person [104,105]. Interviewees were 8 experts with more than 10 years' experience in source selection activities in public and private sectors. Content analysis by theme coding of gathered data of interviews shows two entirely different main categories of levels of evaluation and procedures of evaluation, which will be discussed further in the next section (Table 2).

Table 2. The content analysis of interviews.

Theme	Main Categories	Subcategories/Levels	No. (and Percentage) of Appearing in Transcripts
Develop an integrated system for the source selection problem	Levels of evaluation	1. Development of Long List	23 (31%)
		2. Preparation of Short List	27 (36%)
		3. Selection of the Most Appropriate Source	25 (33%)
	Procedures of evaluation	1. Source identification method	25 (28%)
		2. Criteria Definition	33 (37%)
		3. Evaluation Arrangement	16 (18%)
		4. Development of Assessment Model	15 (17%)

Subsequently and in the second phase, open-question questionnaires were used and distributed among experts to acquire two sets of data: first, detailed alternatives and definitions of two of the above main categories and second, supplementary data, which include a minimum number of evaluators, a minimum number of competitive corporations in each level for three key sources in housing projects and the organizational unit or department, which should be responsible for evaluations (Table 3). In total, 65 questionnaires were distributed among experts with more than 5 years of work experience in and out of client corporations; 43 completed ones were returned and analyzed (Table 4).

Table 3. Minimum number of evaluators, Minimum number of available sources in each level and responsible/administrative unit.

Level of Source Selection	Seller Type	Minimum Number of Evaluators		Minimum Number of Competitive Outputs		Responsible and Administrative Unit
		Mean (μ)	Std.dev. (σ)	Mean (μ)	Std.dev. (σ)	
Development of Long List	Contractor	6	1.90	25	3.00	PMO
	Consultant	6	1.50	12	2.40	
	Supplier	4	1.80	10	2.30	
Preparation of Short List	Contractor	8	1.70	10	2.60	Project Manager and Board of Directors
	Consultant	7	1.50	4	3.40	
	Supplier	4	1.50	8	2.90	
Selection of the Most Appropriate Source	Contractor	8	1.40	N.A	N.A	Expert Committee and CEO
	Consultant	8	1.50	N.A	N.A	
	Supplier	3	1.20	N.A	N.A	

Table 4. Summary of gathered data of received questionnaires.

Categories	Subcategories/Levels	Characteristics/Alternatives	Number (Percentage) of Appearing in Responses
Levels of evaluation	1. Development of Long List	• Organizational asset	8 (23.53%)
		• Update regularly	13 (38.24%)
		• Prequalification level	13 (38.24%)
	2. Preparation of Short List	• Project-oriented	12 (14.29%)
		• Based on available lists	9 (10.71%)
		• List of potential bidders	34 (40.48%)
		• Done by project applicant sector	21 (25.00%)
		• Qualification level	8 (9.52%)
	3. Selection of the Most Appropriate Source	• Related to tender process	13 (14.94%)
		• Process of RFP	28 (32.18%)
		• Technical and financial proposals	9 (10.34%)
		• Done by expert committee	29 (33.33%)
		• Evaluation Level	8 (9.20%)
Procedures of evaluation	1. Source identification method	• Search	25 (17.24%)
		• Advertisement	23 (15.86%)
		• Available lists of other organizations	35 (24.14%)
		• Correspondence/Contact	11 (7.59%)
		• Screening	33 (22.76%)
		• Scoring	18 (12.41%)
	2. Criteria Definition	• Criteria Determination	10 (23.26%)
		• Criteria Weighting	9 (20.93%)
		• Proofing Evidence/Documents	24 (55.81%)
	3. Evaluation Arrangement	• Independent Evaluators	25 (51.02%)
		• Expert Judgment	13 (26.53%)
		• Specialized Team	11 (22.45%)
	4. Development of Assessment Model	• AHP	27 (32.14%)
		• SAW	24 (28.57%)
		• EJ	33 (39.29%)

In the third phase and based on the two-round Delphi method with 5 panelists (selected among 43 samples from the previous phase) with more than 10 years of experience in the construction industry, holding at least a bachelor degree and above 35 years old, four core problems, namely source selection method, criteria definition (supported by input data of Table 5), evaluation arrangement and assessment model were investigated in three identified levels, for three main sources of buying, which include construction general contractor, consultant and supplier. Moreover, to measure the agreement of the Delphi panel, Kendall's coefficient of concordance (W in Equation (1)) was used, which is a quantity range between 0 for no overall attitude of agreement and 1 for perfect unanimity. The Delphi method is a scientific analysis that is an effective method of recognizing variables and dimensions of complex

problems by converging the opinions of a given panel [106]. The range of samples in this method, which is very efficient and popular in business research, is 3 to 171 panelists in two rounds [107].

$$W = \frac{12S}{m^2(n^3 - n)} \quad (1)$$

$$S = \sum_{i=1}^{n} \left(R_i - \overline{R}\right)^2 \quad (2)$$

$$\overline{R} = \frac{1}{n}\sum_{i=1}^{n} R_i \quad (3)$$

$$R_i = \sum_{j=1}^{m} r_{i,j} \ (object\ i\ ranked\ r_{i,j}\ by\ judge\ number\ j\ for\ in\ total\ n\ objects\ and\ m\ judges) \quad (4)$$

Table 5. Principal source selection criteria presented to the Delphi panel as input.

NO.	Criteria	Generic Proofing Evidence or Documents Based on the Results (Past Performance) and Enablers (Current Capabilities)	References
1	Price	Cost of past completed projects in the past 5 years, Cost overruns, Current Proposed Price	[16,50,55,63,64,74,75,78]
2	Quality	Quality performance of previous works, Quality confirmation of former clients, Quality control, policy, Assurance systems	[3,16,62,63,71,74,78,108]
3	Technical	Record of failures, Design capabilities, Executive technics, Innovated method, Drawings and technical documents	[3,6,8,16,20,21,50,55,58,59,63,64,68, 73–75,78–80,82]
4	Management	Performance, procedures and standards of project management capabilities, Organizational structure	[8,16,20,21,55,57–59,63,64,68,71,73, 74,78–80,82,108]
5	HSE	Safety performance, Accountability, Injury and illness	[3,20,46,55,58,62,64,68,71,75,78,82]
6	Reputation	Length of time in business, Client satisfaction, Company image, Relationship	[3,8,50,55,58,64,68,73,74]
7	Experiences	Number, Size and type of projects in the past 5 years, Experience in the region	[3,6,8,16,20,21,46,56,62–64,68,71, 74,78–80,82,108]
8	Financial	Credit rating, Turnover, Bank confirmation, Debit ratio, Liquidity, Profitability, Bonding	[3,6,8,20,21,46,50,56,58,59,62–64, 68,71,73,74,78–80,82]
9	Time	Time of past completed projects in the past 5 years, Time overruns, Current Proposed Time	[16,50,63,74,78]
10	Manpower	Number, Quality and Experience of staff	[3,6,8,20,46,62,64,71,78,80,108]
11	Legal	Claims and litigation, Shareholders	[6,62–64,78,80]
12	Capacity	Current work load	[3,46,62,71]
13	Machinery	Plant and equipment	[3,8,16,46,62,64,74,78]

4. Discussion

Megaprojects, including residential complexes, home mass production and high-rise buildings, are common and are some of the remarkable solutions to the shortage of housing especially in both public and private sectors of developing countries like Iran. Due to this notable role of housing construction in an urban economy, successful fulfilling of these projects has vast economic and social effects, and one of the key parameters in this regard is the selection of appropriate key stakeholders of contractors, consultants and suppliers, as previously mentioned. However, in the following three subsections and based on the gathered data, the gathering process of which was described earlier, an integrated comprehensive model is proposed to tackle the problem of source selection in the context of housing projects of the construction industry.

4.1. Levels of Evaluation

In major client companies, especially in the public sector, there are strict and predefined procedures for contracting and purchasing goods and services. Reviewing these methods shows that it is significant to distinguish between three main levels in the pre-contract phase of the contractor selection problem:

1. Development of the long list (prospective sources): in this stage, the client side tries to develop a list of all potential corporations that can sell goods and services without considering a specific project. Obviously, this list is one of the assets of the organization, which should be updated regularly and, based on an arranged survey and precise criteria, be kept in a data bank. This stage is mainly done by the headquarters of corporations. To achieve consistent terminology, this stage is called the prequalification level.
2. Preparation of the short list (screened sources): referring to a particular project, by considering the characteristics of a given project on one hand and checking the capabilities of existing sources of the long list on the other hand, a short list of potential bidders is selected. This stage should be done by the project applicant sector or subsidiary company and under the supervision/approval of senior managers of the organization. This process may also be defined under a limited tendering procedure. This stage is called the qualification level.
3. Selection of the most appropriate source (selected source): in the tender process, technical and financial proposals of potential bidders are received through an RFP procedure. Selection of the source as the bid winner and the second party of the contract by evaluating different suggestions is the final step of outsourcing, which is normally followed by a scrutinized process. Responsibility for this stage is usually delegated to an expert committee and under the supervision/approval of senior managers of the organization or subsidiary company. This stage is called the evaluation level. It is also very important to separate technical evaluations from commercial ones in this step.

Therefore, client organizations in the construction industry must consider a source-selection system that includes all three above-mentioned levels of selection. (Figure 3). It is worth mentioning that, in the case of negotiation or single source selection, due to the lack of competition, there is neither a selection process nor a proposal evaluation at the third level.

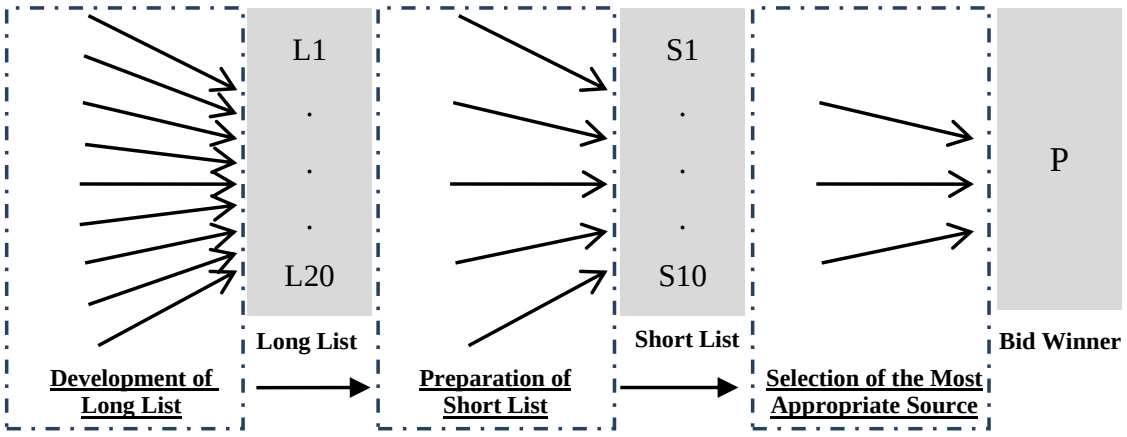

Figure 3. Hierarchal levels of source selection in the construction industry.

4.2. Procedures of Evaluation

Based on the collected data, in each of the defined levels, four main steps, which are stated below, must be followed, and proportionate approaches should be adopted. Indeed, any assessment attempt should comprise some logical steps which are organized here to the source selection problem.

4.2.1. Source Identification Method

Identification of prospect sources through one of the following methods is possible and is divided into two basic categories.

- No historical data are available in the organization.

If there are no previous activities in the organization to develop a list of possible sources in a specific field, one of the following choices should inevitably be considered:

- Search. The primary method for gathering and updating information about sources is to investigate available companies active in various fields and disciplines.
- Advertisement. Sources can also be identified by sending advertisements to professional and specialist newspapers or web pages. Such procedures are compulsory by law in some public organizations.
- Available lists of other organizations (e.g., lists of surety companies, associations or public entities).
- Similar available lists.

If the lists of sources in the organization are available but not up to date, besides the above ways, these lists should be subject to improvement processes by applying the following:

- Correspondence/Contact. Direct contact with companies to request information about them is a conventional way to acquire proper information.
- Screening. In the case of available lists of sources and their information in the organization, screening of companies by the elimination of thoroughly unrelated sources is a method to achieve a preliminary list of companies.
- Scoring. Following the above-defined screening process, it is possible to improve the list by using engineering judgment by primarily prioritizing the available options by scoring the available companies.

4.2.2. Criteria Definition

However, subsequent to the determination of the method of receiving and primarily listing companies, the second step is to specify the selection criteria, their weights and related evidence:

- Criteria Determination. As source selection is a multi-criteria decision-making process, it is essential to determine and define specific criteria to be used to designate satisfaction with each option versus the intended criterion.
- Criteria Weighting. Clearly, all defined criteria are not equal in terms of importance, so their weight in the calculations should be specified.
- Evidence. To obtain a reliable and objective basis to assign the points, related documents must be defined exactly. Evidence should provide a basis on which all evaluators have the same judgment and impression.

4.2.3. Evaluation Arrangement

In the next step, it should be determined how to score corporations and how to score based on the received documents by a panel of evaluators. This panel should consist of approximately 6 to 10 evaluators who are experts and experienced in source selection. Based on the gathered data, the following are common practices:

- Independent Evaluators. In this method, evaluators score companies based on different criteria completely separately and autonomously.
- Expert Judgment (Consensus). In this method, evaluators score criteria based on negotiation until they make a unanimous decision.
- Specialized Team (Voting). In this method, evaluators score companies based on a preliminary discussion on various options and then reach a decision based on maximum votes.

4.2.4. Development of Assessment Model

Finally, after determining each criterion's score, a moderator should sum up all scores by predetermined methods. Based on the experts' opinion, the following techniques are the most appropriate models to evaluate the sources in housing construction in Iran.

- Analytical hierarchy process (AHP). In this method, all sources for each criterion are compared pair-wise, and a ranking list of sources is provided. It should be mentioned that choosing this method affects previously made decisions and compels the panel to follow the laws of this method.
- Linear model of simple additive weighting (SAW). In this method, each source satisfaction against each criterion is calculated by applying their weights.
- Engineering judgment (EJ). If the nature of the work and its complexity necessitates that the review and the decision should be made by a panel, the responsibility for overall scoring and ranking will be dedicated to an engineering expert panel that is capable of taking into account all the parameters.

4.3. Proposed Integrated System of the Source Selection

Procurement management, which is defined as the process of administration of goods and services preparation includes the procedures of buying or acquiring in the pre-contract and post-contract activities. These processes of purchasing products, services or results from the outside of the project organization and its team are some of the major responsibilities of project-oriented organizations, especially in the public sector. Therefore, purchasing processes of a project are unique and should be well-planned in an organizational established system that integrates all purchasing aspects at different levels and supports each project exclusively. As discussed above, the selection of the sources, including the general contractor, the consultant or the supplier, e.g., in the major client companies of the housing sector, can be arranged on three levels by considering distinct iterative procedures for each level. In the following tables, the proposed structure as the output of the Delphi method is presented for the three above-mentioned sources (Tables 6–11).

Table 6. Criteria development of Construction General Contractor and their weights.

Levels	Criteria Definition				
	No.	Main Criteria	Evidence	Weight of Criterion	Kendall's Coefficient (W)
Development of Long List	1	Management	Organizational charts, systems and procedures	19.85	0.809
	2	HSE	Safety performance	32.12	0.726
	3	Reputation	Length of time in business	33.33	0.894
	4	Experiences	Contracts of the previous 5 years, Experience in the region	14.70	0.858
Preparation of Short List	1	Financial	Turnover of the past 10 years, Bank confirmation, Bonding	29.74	0.789
	2	Manpower	Number, Quality and Experience of staff	16.05	0.825
	3	Legal	Records of previous claims	11.11	0.822
	4	Machinery	Plant and equipment	43.11	0.741
Most Appropriate Source *	1	Price	Comparison with other proposed prices **	13.99	0.899
	2	Quality	Quality control, policy, assurance systems	19.26	0.711
	3	Technical	Drawings and technical documents	18.92	0.738
	4	Time	Comparison with other proposed times **	23.80	0.913
	5	Capacity	Checking current workload	13.90	0.881
	6	HSE ***	HSE plan	10.13	0.881

* In this stage, to avoid probable collusion, it must be checked whether there is a common shareholder among the bidders. ** This item has been proposed in the Delphi process. *** This item, in addition to reviewing at the first stage, must be evaluated further in this stage.

Table 7. Proposed procedures of evaluation of Construction General Contractor.

Categories	Long List	Kendall's Coefficient (W)	Short List	Kendall's Coefficient (W)	Tendering	Kendall's Coefficient (W)
Identification Method	Available lists/Search	0.762	Long list	0.892	Short list	0.792
Evaluation Arrangement	Independent Evaluators	0.799	Specialized Team	0.792	Specialized Team	0.893
Assessment Model	Engineering Judgment	0.842	SAW	0.898	AHP	0.865

Table 8. Criteria development of Construction Consultant and their weights.

Levels	Criteria Definition				
	No.	Main Criteria	Evidence	Weight of Criterion	Kendall's Coefficient (W)
Development of Long List	1	Quality	Quality performance of previous work	43.31	0.916
	2	Management	Design management systems	30.93	0.700
	3	Reputation	Client satisfaction, Company image	25.76	0.914
Preparation of Short List	1	Experiences	Number, Size and type of projects in the past 5 years	32.87	0.913
	2	Time	Time of past completed projects in the past 5 years	44.80	0.711
	3	Legal	Claims and litigation, Shareholders	22.33	0.876
Most Appropriate Source	1	Price	Comparison with other proposed prices *	27.71	0.871
	2	Technical	Design capabilities, Executive techniques, Innovated method, BIM	26.66	0.719
	3	Manpower	Number, Quality and Experience of staff	25.22	0.766
	4	Capacity	Checking current workload	20.41	0.731

* This item has been proposed in the Delphi process.

Table 9. Proposed procedures of evaluation of Construction Consultant.

Categories	Long List	Kendall's Coefficient (W)	Short List	Kendall's Coefficient (W)	Tendering	Kendall's Coefficient (W)
Identification Method	Advertisement	0.876	<Long list>	0.886	<Short list>	0.810
Evaluation Arrangement	Independent Evaluators	0.780	Independent Evaluators	0.792	Expert Judgment	0.759
Assessment Model	SAW	0.870	AHP	0.753	EJ	0.854

Table 10. Criteria development of Construction Supplier(s) and their weights.

Levels	Criteria Definition				
	No.	Main Criteria	Evidence	Weight of Criterion	Kendall's Coefficient (W)
Development of Long List	1	Reputation	Length of time in business, Client satisfaction	18.36	0.722
	2	Experiences	Number, Size and type of projects in the past 5 years, Experience in the region	33.16	0.910
	3	Financial	Credit rating, Debit ratio	31.98	0.684
	4	Machinery	List of plant and equipment	16.51	0.899
Preparation of Short List	1	Management	Production management systems	12.14	0.718
	2	Manpower	Number, Quality and Experience of staff	28.12	0.850
	3	Legal	Records of litigation, Shareholders	34.53	0.901
	4	Capacity	Checking current work load	25.21	0.787
Most Appropriate Source	1	Price	Comparison with other available prices *	29.10	0.817
	2	Quality	Quality confirmation of former clients, Quality control, policy, assurance systems	18.36	0.904
	3	Technical	Design capabilities, Innovated method, Technical documents	26.22	0.805
	4	Time	Comparison with other proposed times *	26.32	0.885

* This item has been proposed in the Delphi process.

Table 11. Proposed procedures of evaluation of Construction Supplier(s).

Categories	Long List	Kendall's Coefficient (W)	Short List	Kendall's Coefficient (W)	Tendering	Kendall's Coefficient (W)
Identification Method	Advertisement/Available lists	0.819	<Long list>	0.887	<Short list>	0.724
Evaluation Arrangement	Independent Evaluators	0.839	Independent Evaluators	0.741	Specialized Team	0.710
Assessment Model	AHP	0.823	SAW	0.919	EJ	0.899

Since most project-oriented organizations seek to take the advantage of outsourcing, the major client companies in the housing sector continuously face different levels of procurement processes. Therefore, the establishment of an organizational purchase system of services and goods is essential for project success and business development. This system should be managed dynamically and must be updated regularly. The main characteristics and features of the proposed system are illustrated in Table 12. Accordingly, this system is primarily divided into three main service/goods sellers for three different organizational levels. Source selection criteria for each seller has been organized in a conic method, which becomes more precise from the long list to the tendering phase. Therefore,

using this approach, there are no replicated criteria in different phases of source assessment, which can be considered a common fault in the company's evaluation. After providing the long list of prospective sources, this list will as input for short listing, and the outcomes of this stage will apply to tendering. The other issue is the minimum number of the assessment panel, which is composed of the approved evaluators who should scrutinize the received documents of the sources. Eventually, based on the predefined criteria, the assessment of each phase will be done by the related evaluation arrangement and the assessment model.

Table 12. Summary of the proposed integrated organizational system for the source selection.

Source	Level of Selection	Selection Criteria	Evidence	Identification Method	Evaluation Arrangement (Min Number of Evaluators)	Assessment Model
Construction General Contractor	Long List	Management HSE Reputation Experiences	Organizational charts, systems and procedures Safety performance Length of time in business Contracts of previous 5 years, Experience in the region	Available lists/Search	Independent Evaluators (6)	Engineering Judgment
	Short List	Financial Manpower Legal Machinery	Turnover of past 10 years, Bank confirmation, Bonding Number, quality and experience of staff Records of previous claims Plant and equipment	<Long list>	Specialized Team (8)	SAW
	Tendering	Price Quality Technical Time Capacity HSE	Comparison with other proposed prices Quality control, policy, assurance systems Drawings and technical documents Comparison with other proposed times Checking current workload HSE plan	<Short list>	Specialized Team (8)	AHP
Construction Consultant	Long List	Quality Management Reputation	Quality performance of previous works Design management systems Client satisfaction, Company image	Advertisement	Independent Evaluators (6)	SAW
	Short List	Experiences Time Legal	Number, size and type of projects in the past 5 years Time of past completed projects in the past 5 years Claims and litigation, Shareholders	<Long list>	Independent Evaluators (7)	AHP
	Tendering	Price Technical Manpower Capacity	Comparison with other proposed prices Design capabilities, Executive techniques, Innovated method, BIM Number, Quality and Experience of staff Checking current work load	<Short list>	Expert Judgment (8)	EJ
Construction Supplier	Long List	Reputation Experiences Financial Machinery	Length of time in business, Client satisfaction Number, Size and type of projects in the past 5 years, Experience in the region Credit rating, Debit ratio List of plant and equipment	Advertisement/Available lists	Independent Evaluators (4)	AHP
	Short List	Management Manpower Legal Capacity	Production management systems Number, Quality and Experience of staff Records of litigation, Shareholders Checking current workload	<Long list>	Independent Evaluators (4)	SAW
	Tendering	Price Quality Technical Time	Comparison with other available prices Quality confirmation of former clients, Quality control, policy, assurance systems Design capabilities, Innovated method, Technical documents Comparison with other proposed times	<Short list>	Specialized Team (3)	EJ

5. Conclusions

Selection of a source is the strategic core of the procurement management process and, alongside the legal aspects and risks of the contract, has a notable impact on achieving project objectives. This problem has been surveyed in many research studies and has been debated by the legal authorities of different countries to improve the outsourcing processes of public entities. Unfortunately, the level of source selection, e.g., contractor, is ignored in many studies, and a great number of them proposed the selection at the tender level and therefore focused on bid procedures. However, in the real world, major regular structured clients face multiple levels of decision making and organize them into established systems. In this study, by gathering related information from previous research and then acquiring implicit knowledge of experts in this regard, an integrated organizational system of housing project source selection has been proposed that features three different levels, four distinct procedures and three key sources. Therefore, the proposed integrated organizational system for source selection consists of the following three key axes (A, B and C) as a three-dimensional matrix: A. levels (the long list, the short list and the most appropriate source), B. procedures (source identification method, criteria definition, evaluation arrangement and development of assessment model) and C. sources (construction general contractor, construction consultant and construction supplier(s)).

Therefore, the organizations that predominantly act as a client and those that often enter into construction contracts as the buyer side of the deal, especially in the housing sector of the construction industry, must develop a dynamic system to address prospective sources selection activities. It is strongly recommended that such a system is established as an independent unit directly under the top management board because the outcomes of this unit have a remarkable effect on the project objectives besides that the process of their tasks can lead to corruption in the organization. Furthermore, the discussed system can be created as a part of a strategic project management office (SPMO) to handle the source selection problem and consequently conclude the related contract.

It is worth noting that at least two other factors (albeit less important) are also significant in the case of the supplier selection process, which can be studied in future research: first, the special field of the business and subjects of transaction e.g., the type of the equipment and material, and second, the size of the contract, which may be small, medium, large or even very large.

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