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A DECISION ANALYSIS FRAMEWORK FOR VENDOR SELECTION IN CONSTRUCTION PROJECTS IN GREECE

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ABSTRACT. The aim of the present paper is to model the vendor selection process in construction projects in Greece. The applied approach involves a multicriteria rating technique used for calculating a normalized economic bid for the alternatives (i.e. vendors) by determining a proposed multiplier coefficient. This technique uses two stage compromise programming procurement criteria and weights according to the relevant legislative framework for government procurement to provide a multicriteria value score for each vendor. The application of the approach is demonstrated by an illustrative example concerning the procurement of earthmoving equipment (i.e. bulldozer). The primary advantage of this approach is that it incorporates a degree of subjectivity into the evaluation process in compliance with the existing legislative framework.

INTRODUCTION

The purchasing function is central to supply chain management operations. The critical processes of the purchasing function include supplier (vendor) selection, negotiation of supply contracts, monitoring supplier performance, and acting as an interface between an organization and its suppliers (Talluri & Sarkis, 2002). Within these core processes of purchasing, this paper narrows its scope to focus upon the supplier selection process based on the legislative framework concerning government procurement in Greece.

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While price has been traditionally considered as the single most important factor in evaluating suppliers, it has been agreed upon that the evaluation process needs to include other important factors such as quality, delivery and flexibility (Talluri & Sarkis, 2002). Moreover, suppliers should be selected on the basis of how well they meet a variety of specific requirements (criteria) that do not depend solely on price (Li, Fun & Hung, 1997). Given this evolving competitiveness in the business environment, the contribution of this research is two fold. First, it applies a multicriteria evaluation approach for supplier selection in earthmoving equipment procurement by considering various criteria in compliance with the relevant legislative framework in Greece. Secondly by eliminating subjectivity, the application of this approach serves as a monitoring and control mechanism for vendor evaluation. The relevant model and its application are demonstrated through an illustrative case example.

BACKGROUND

Vendor Selection Process

The vendor selection process is a stage of the procurement process, which is directly related to the other stages of the whole procedure. The general structure of a procurement procedure includes the following stages: defining the 'subject matter' of the contract, drawing up the technical specifications and the contractual parameters for the product/ work/service, selecting the right candidate and determining the best bid (European Commission, 2004).

Public and private procurement procedures have the same structure as they follow the same stages mentioned above. It is worth noting that public procurement funded by taxpayers' money is based on two main principles (European Commission, 2004): a) getting the best value for money and b) acting fairly.

Criteria in vendor screening and evaluation can be distinguished as quantitative (i.e. service level) and non quantitative (i.e. reputation of vendor) (Nima, Abdul-Kadir, Jaafar & Alghulami, 2002). A methodological framework is merely multicriteria and analyzed as a vector selection system and decision making. The importance to the total cost in terms of owners/perspective is analyzed in the work of Roodhooft and Konings (1997). Methodologies for vendor evaluation that are used for support and rapid construction (Nutt, 1996) can be categorized into conceptual, empirical, and modeling approaches. The conceptual research in this area focused mainly on the strategic importance of vendor evaluation and the trade-off between cost, quality, and delivery performance, while the empirical research focused on studying the relative importance of various vendor attributes (i.e. price, quality, and delivery performance) (Talluri & Narasimhan, 2003).

Public entities have the responsibility to get the best value for taxpayers' money for everything they procure. Best value for money means getting the best deal within the parameters set and not only the cheapest offer. It is worth noting that value for money does not exclude environmental considerations and relevant parameters can act as equal amongst the others for the award of the contract.

Acting fairly means compliance with the principles of the internal market, which form the basis for the legislative framework. The most important of these principles are the principle of equal treatment (i.e. all competitors/ tenders should have an equal opportunity to compete for the contract) and transparency (e.g. the obligation for contracting authorities to inform the tenders concerned why their tenders were rejected).

The preparatory stage of any procurement procedure is crucial, because any mistakes at this stage will adversely affect the end result, as all stages build upon each other and as a result the definition of the "subject matter" of the contract is very important. The "subject matter" of a contract deals with the basic description of the product, service or work that an entity wants to procure. This process of determination will generally result in a basic description of the product, service or work (i.e. specifications based on technical standards), but it can also take the form of a performance-based definition.

Technical specifications are essential because they determine the level of competition by describing the contract to the market and they provide measurable requirements against which tenders can be evaluated. In addition, they constitute the minimum compliance criteria. At the European level, according to procurement directives 2004/17/EC and 2004/18/EC, contracting authorities are allowed to choose between specifications based on technical standards or on performance-based requirements (European Commission, 2004).

Technical standards are useful in public procurement as they are clear and non-discriminatory. Moreover, the standardization process at the European level includes the participation of a wide range of stakeholders, such as national authorities, environmental organizations, consumer associations, and industry. It is worth noting that European standards organizations are promoting environmental considerations, e.g. European Committee for Standardization (CEN) has a special environmental helpdesk and the European Commission itself is also committed to "greening" technical standards through the integration of environmental aspects into European standardization (European Commission, 2004).

In Greece, national legislation on procurement refers only to public procurement compatible with Community law. The existing legislative framework offers possibilities to integrate environmental considerations into public (i.e. government) purchases, notably when defining the technical specifications, the selection criteria and the award criteria of a contract (e.g. Directive 93/96-14/4/1993 and Presidential Decree 370/1995, Presidential Decree 394/1996; for more on the legislative framework in Greece [see Karanastasis, 1998]).

Selection criteria focus on the ability of the tenders (the offers) to perform the contract. Selection criteria are categorized into exclusion criteria, financial capacity criteria and technical capacity criteria.

The exclusion criteria deal with circumstances in which a tender can find itself that normally cause contracting authorities not to do any business with it (e.g. if the tender is bankrupt, has committed serious professional misconduct or has not paid taxes or social security contributions). In some particular cases, it may even be mandatory to exclude tenders (see Article 54 of Directive 2004/17/EC and Article 45 of Directive for criminal cases, Directives 2004/17/EC and 2004/ 18/EC for repeated breach of environmental law).

Awarding the contract (i.e. the last stage in the procurement procedure), the contracting authority evaluates the quality of the tenders and compares concurrently the prices. For the evaluation of the quality of tenders, predetermined award criteria, published in advance, are used in order to come to a final decision about the best tender. Under the public procurement directives, there are two options (European Commission, 2004): one can either compare offers on the basis of lowest price alone, or may choose to award the contract to the "economically most advantageous" tender (i.e. other award criteria including the price will be taken into account).

When the criterion of the "economically most advantageous tender" is used, environmental criteria can also be used as one of the sub-criteria included. An indicative list of various sub-criteria used for determining the most economically advantageous tender include quality, price, environmental characteristics, running costs, cost-effectiveness, after-sales service and technical assistance, delivery date and delivery period, and period of completion.

The above different sub-criteria are important because the best offer (i.e. the most economically advantageous tender) will be determined on the basis of them with the aid of techniques for comparing and weighting them. The specification and publication of criteria and relative weighting given to each of these criteria is the responsibility of contracting authorities. The different criteria that will determine will need to be formulated in such a way that: a) they relate to the "subject matter" of the contract (as described in the technical specifications) and b) they allow the assessment of tenders (See also recital 46 of Directive 2004/18/EC and recital 55 of Directive 2004/18/EC).

Vendor Evaluation Methodologies

The research on developing models for vendor evaluation has ranged from simple weighted techniques to more advanced methodologies. The more advanced methodologies have ranged from multi-criteria evaluation techniques to more complex mathematical programming and statistical methods such as mixed integer programming, multi-objective programming, data envelopment analysis, analytical hierarchy process and principal component analysis (see also Talluri and Narasimhan, 2003). The model developed here is an extension of a multicriteria decision support system developed by Manoliadis and Tsolas (2005) to a two stage decision- support model. In the first stage the vendors that are not suitable according to law are eliminated; moreover, environmental standards are scrutinized. In the second stage the most preferable vendor is selected through a multicriteria decision-analysis technique. One of the points of the methodology that needs further improvement is the weight of the criteria involved in the decision- theory process.

Some of the simple techniques for vendor evaluation include categorical, weighted point, and cost-ratio approaches. In the categorical method, the buyer rates each vendor as being preferred, unsatisfactory, or neutral on all equally weighted attributes considered in the evaluation process. The weighted point method assigns weights in an objective manner to each attribute and evaluates the sum-product of the weights and assigns scores for each alternative by standardizing all the attribute units. The cost ratio method is based on cost accounting systems and evaluates the cost of each factor as a percentage of total purchases for the vendor (Talluri & Narasimhan, 2003).

METHODS

For most projects, there are a multitude of potential vendors that differ in quality and other aspects that are difficult to assess at the time of contracting. In addition, many projects have outcomes that are difficult to measure or verify by outside parties. As a result, mechanisms that require verifiability of outcome, such as incentive contracting, only provide limited benefits in vendor selection and in some cases are ineffective or counterproductive. This paper presents an alternative mechanism for selecting high-quality vendors using a 2-stage contract. A similar approach in mechanisms for selecting IT vendors is presented in the work of Nutt (1996) and Snir and Hitt (2004). So, the proposed method consists of two stages. The paper presents a theoretical analytical framework to guide the vendor selection process and provides an illustrative case study application. The methodology for ranking vendors uses compromise programming (see Zeleny, 1982). In the first stage the vendors that do not fulfill the exclusive criteria of law are eliminated and the remaining vendors are examined in the second stage. When ranking a number of vendors, it would be advantageous to rank the vendors using several different weighting and balancing scenarios. By performing the assessment using multiple interactions for several weighting factors, the user can evaluate the robustness of individual vendors; the most preferable vendor is selected through a multicriteria decision-analysis technique. The concept behind the proposed approach is the existing national legislative framework on procurement in Greece concerning the evaluation of bids.

The choice of the winning bid is in principle simple: the best value for money, most economically advantageous offer that responds to all the requirements of the bid package is awarded the contract. Factors other than price to be used in the award criteria should be expressed, to the extent practicable, quantitatively.

Award criteria except for economic criteria (i.e. price, methods of payment, cost of installation, operation and maintenance) include technical specifications and quality criteria (i.e. compliance to the buyer's criteria) and technical support criteria (i.e. warranty, after sales service and support, experience and specialization of supplier, delivery time). Technical specifications and quality criteria are assigned a weight up to 80% and technical support criteria a weight up to 30%; the sum of both weights should be 100%. Each sub-criterion of both the above categories is assigned a weight by the buyer; the sum of all weights should be 100%.

Once the criteria have been rank-ordered, points should be assigned to each criterion. One hundred points are assigned to a criterion if there is full compliance. The points can be increased up to 120 if the offer exceeds the minimum value of the criterion and it can be decreased by up to 80 if the offer does not fulfill the minimum requirements of the criterion. In order to introduce subjectivity into the procedure, we propose the following formula for deriving the range of the multiplier coefficient from 80-120 for each criterion.

$$B=100+20(2/2^{n}-1) \qquad (1)$$

Where:

B = criteria value points ranging from 80 to 120 as stated above
and n = the optimum value / offer value of the criterion.

For example, if the optimum value equals to offer value (n=1) then B=120.

The optimum value for each criterion is either predefined or the average of the set of all the offers. Subsequently, an overall weighted multiplier coefficient (OMC) is estimated as a weighted sum of pre-selected weights for each criterion and the multiplier coefficients for each criterion. Finally, each economic bid value is multiplied with the above coefficient and a normalized economic bid (NEB) value is derived according to which best candidate is selected.

CASE ILLUSTRATION

A set of four vendors is considered in the evaluation process. The vendor data concerning the procurement of a bulldozer are hypothetical. The operational unit (buyer) considered in this case is a division of a public organization. Management has considered product price, capacity, noise, consumption, delivery time, days for service and length of warranty as the most important factors in evaluating alternative vendors (Table 1).

TABLE 1
Vendor Data

Evaluation Criteria	Optimum value of criterion	Vendors			
		A	B	C	D
Price	-	118000 €	119000 €	120000 €	120000 €
Capacity	-	10tn/hr	9tn/hr	9tn/hr	10tn/hr
Noise	50db	50db	40db	50db	70db
Consumption	0.1lt/HP/hr	0.1lt/HP/hr	0.1lt/HP/hr	0.1lt/HP/hr	0.1lt/HP/hr
Lead time	3 months	3 months	2 months	2 months	2 months
Days required for service	2 days	1 day	2 days	3 days	3 days
Warranty	2yrs	1yrs	2yrs	3yrs	3yrs

All data in Table 1 can be taken from the offers; price is assumed to have been calculated using the total life cycle cost (TLCC) method principles. TLCC is a technique for comparing alternatives by measuring their cost effectiveness; the first step is to identify the cash flows of each alternative and the next step to compute and add their present values to arrive at a TLCC for each alternative (State of Wisconsin, 1997). The measure of cost effectiveness for comparing alternatives stems from equation (2):

$$TLCC = PV(I) + PV(R) + PV(M) + PV(E) - PV(S) \quad (2)$$

Where:

TLCC = the total life-cycle cost for each alternative,

PV = present value,
I = initial cost,
R = replacement cost,
M = annual maintenance and repair cost (i.e. the cost of regularly scheduled preventative maintenance and repairs),
E = annual energy costs, and
S = residual or salvage value.

In our analysis, the base point is the bid date and the study period is the useful life of the alternative (i.e. equal for all the alternatives). Therefore, no replacement costs are considered. Since consumption is the same for all alternatives (see Table 1), no energy costs are taken into account. Moreover, residual value (i.e. the value of the asset remaining at the end of the study period) is assumed to be the same for all alternatives. As a result, TLCC in our case is given by equation (3):

$$TLCC = PV(I) + PV(M) \quad (3)$$

Where:
TLCC = the total life-cycle cost for each alternative,
PV = present value,
I = initial cost, and
M = annual maintenance and repair cost (i.e. the cost of regularly scheduled preventative maintenance and repairs).

Price as appears in Table 1 is the sum of the initial cost (i.e. the procurement is funded from cash and therefore the present value is equivalent to the initial cost at the base point) and annual maintenance present value.

First Stage

If we examine vendors in the first stage according to exclusively legal criteria the D vendor will be excluded from the selection procedure because the noise of his equipment is over the limit of 70db that is imposed by the laws. The alternatives remaining are presented in Table 2.

TABLE 2
Vendor Data after the First Stage

Evaluation Criteria	Vendors		
	A	B	C
Price	118000 €	119000 €	120000 €
Capacity	10tn/hr	9tn/hr	9tn/hr
Noise	50db	40db	50db
Consumption	0.1lt/HP/hr	0.1lt/HP/hr	0.1lt/HP/hr
Lead time	3 months	2 months	2 months
Days for service	1 day	2 days	3 days
Warranty	2yrs	3yrs	2yrs

Second Stage

In the second stage the remaining three alternatives are evaluated by a set of criteria weights. Table 3 depicts the criteria weights determined by the buyer.

TABLE 3
Criteria Weights Determined by the Buyer

Evaluation Criteria	Criteria weights Determined by the Buyer
Capacity	0.20
Noise	0.10
Consumption	0.40
Lead time	0.06
Days for service	0.12
Warranty	0.12

The results of the transformed vendor data/calculation are presented in Table 4.

TABLE 4
Transformed Vendor Data/Calculation of Multiplier Coefficients

Evaluation Criteria	Vendors		
	A	B	C
Capacity[a]	100.95	99.49	99.49
Noise	100.00	103.18	100.00
Consumption	100.00	100.00	100.00

TABLE 4 (Continued)

Evaluation Criteria	Vendors		
	A	B	C
Lead time	100.00	94.80	94.80
Days required for service[b]	105.98	100.00	94.80
Warranty	105.85	100.00	91.71

Source: Table 2.
Notes:

[a] Capacity is a characteristic example used when there is not a predefined value and the transformed data value is calculated as follows:
Mean value = 10+9+9/3 = 9.33tn/hr
For vendor A, n is calculated as:
N = 10tn/hr / 9.33 tn/hr = 1.07
The transformed value is: $100+20(2/2^{0.933}-1)$
Since $2^{0.933} = 1.91$ the ratio $2/2^{0.933} = 2/1.91 = 1.047$ and
Therefore the transformed value becomes 100+20(1.047-1) = 100.94
For vendor B and C, n = 9/9.33 = 0.965
The transformed value is: $100+20(2/2^n -1) = 100+20(2/2^{0.965}-1) = 99.49$

[b] Days for service can be used when there is a predefined value as follows:
For the element vendor A (Days for service = 1 day) n = 2/1 = 2 and the transformed value is 105.98 according to equation (1) as follows:
$100+20(2/2^2 -1) = 110$.
And for vendor C (n = 2/3 = 0.667) the transformed value is:
$100+20(2/2^n -1) = 100+20(2/2^{0.667} -1) = 94.80$.
For Vendor B (n = 2/2 = 1) the transformed value is:
$100+20(2/2^n -1) = 100+20(1 -1) = 100+0 = 100$.

The criteria weights and the estimation of overall weighted multiplier coefficients are presented in Table 5.

TABLE 5
Criteria Weights and Overall Weighted Multiplier Coefficient (OMC) Estimation

Evaluation Criteria	Vendors' Criteria Weights		
	A	B	C
Capacity	20.19[a]	19.90	19.90
Noise	10.00	10.32	10.00
Consumption	40.00	40.00	40.00

TABLE 5 (Continued)

Evaluation Criteria	Vendors' Criteria Weights		
	A	B	C
Lead time	6.00	5.69	5.69
Days for service	12.62	12.00	11.38
Warranty	12.70	12.00	11.01
Overall multiplier coefficient (OMC)	101.51[b]	99.91	97.98

Sources: Tables 2 and 3.

[a]Capacity weight for vendor A = 100.95 x 0.20.

[b]Overall multiplier coefficient (OMC) for vendor A = 20.19+10+40+6+ 12.62+12.70.

The final bid is presented in Table 6. The normalized economic bid is calculated from the vendor's offer multiplied by the overall multiplier coefficient (see Table 1).

TABLE 6
Results of Vendor Evaluation/Calculation of Normalized Economic Bid

	Vendors		
	A	B	C
Price; economic bid in €	118,000	119,000	120,000
OMC	101.51	99.91	97.98
Normalized economic bid = economic bid OMC, in €	11,978,180[a]	11,889,290	11,757,600

Notes: [a] Normalized economic bid for vendor A = 118000 x 101.51 = 11978180 where 118000 is the vendor A's offer and 101.51 is the OMC for vendor A.

From Table 6 it is evident that vendor C will be selected since his normalized bid is the lowest, though one can see from Table 1 the non- normalized bid was the highest of all others. As can be seen from the implementation of this methodology, price is dominant but it is not used for weight calculation. The final decision is the comparison of the normalized economic bid, a procedure that is used often nowadays by Greece's procurement decision makers. The methodology aims to lessen the subjectivity of the final decision by basing on objective criteria values.

CONCLUSIONS

This paper proposes an approach to vendor selection by incorporating on one hand a degree of subjectivity into the evaluation process as it is outlined in the existing legislative framework. On the other hand the approach allows for comprehensive evaluation of vendor performance by calculating a normalized economic bid for each vendor with the aid of a proposed multiplier coefficient; moreover, it lessens concurrently the subjectivity of the final decision based upon objective criteria values.

The application of this method in a real world setting had some satisfactory results. However, it is worth noting that the identification of buyer targets is highly critical because of their impact on the calculation of the multiplier coefficient and the whole decision-making process. Therefore, managers must carefully evaluate and select the factors that best represent the organization's goals and objectives and should incorporate them into the various stages of the procurement process.

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