JOURNAL OF PUBLIC PROCUREMENT, VOLUME 13, ISSUE 2, 149-175 SUMMER 2013

"BEST VALUE FOR MONEY" IN PROCUREMENT

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ABSTRACT. A gradual change on how to evaluate successful procurement, in both the private and the public sector has occurred in recent years. Indeed, in so far as economic efficiency is concerned from a price-only criterion for measuring success, decisions have shifted to a multi-criteria approach where various dimensions of quality, as well as price, are considered. The most common way to express such a shift is to say that procurement should deliver "best value for money" (BVM). That is, to award the contract, both monetary and non-monetary components of an offer are to be considered. Whether in competitive bidding or negotiations, BVM is typically formalized by a scoring formula, namely a rule for assigning dimensionless numbers to different elements of an offer, often expressed in different units of measurement. The contract would then be awarded according to the total score obtained by a bid. The main goal of this paper is to present a critical overview of some main themes related to the notion of BVM, discussing few typical forms of scoring rules as a way to formalize the procurer's preferences.

INTRODUCTION

Effective procurement is an increasingly important, and attracting, issue for business companies as well as for the public sector of an economy. In so far as the former are concerned procurement plays a crucial, strategic role both in the upturn and in the downturn of the economic cycle. Indeed in the upturn, with rising revenues, effective procurement allows companies to further

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increase their profit margins and take better advantage of the expansionary trend of the economy. In the downturn it can mitigate profit reduction, by controlling costs while keeping quality at the desired level. As for the public sector instead, effective procurement can be a fundamental support to pursue fiscal, industrial and innovation policies by best employing the available financial resources. Given the meaningful presence of the public sector in many countries, effective procurement could be a crucial driver for the socio-economic development and growth of a state.

Effective procurement can depend upon numerous elements. For example, the recent UNCITRAL Model Law (UNCITRAL, 2011) sets the following main objectives: (a) Maximizing economy and efficiency in procurement; (b) Fostering and encouraging participation in procurement proceedings by suppliers and contractors regardless of nationality, thereby promoting international trade; (c) Promoting competition among suppliers and contractors for the supply of the subject matter of the procurement; (d) Providing for the fair, equal and equitable treatment of all suppliers and contractors; (e) Promoting the integrity of, and fairness and public confidence in, the procurement process; (f) Achieving transparency in the procedures relating to procurement.

Though at first only Uncitral Model Law's objective (a) would seem to be directly concerned with the right price-quality composition for successful procurement, it is clear that the other objectives would be indirectly related to it also. Therefore careful design and evaluation of the many relevant aspects of a procurement are crucial for its success. This is why in recent years the public sector developed a gradual change in emphasis for assessing procurement success, from a price only type-of-criterion for a specified quantity and quality, more towards the so called "best value for money" (BVM) criterion where the attractiveness of an offer is evaluated considering, jointly, the monetary and non-monetary components of a proposal (European Commission, 2004; Dimitri, Piga & Spagnolo, 2006; OECD, 2008; UNOPS, 2010).

Though present in many documents and papers, an important example of the shift towards a BVM criterion is the recent European Commission Communication (2011), proposing a new Directive for public procurement of works, goods and services. Indeed, at the very beginning of the document the Commission specifies that one of the two main goals of the proposal is to "increase the efficiency of public spending to ensure the best possible procurement outcomes in terms of value for money." With respect to the currently operating 2004 Procurement Directive (European Commission, 2004), perhaps more oriented towards supporting the development of a unique EU market, the above Communication represents an important step towards procurement efficiency and BVM. A further remarkable example is the United Nations Organization for Peace Building, Humanitarian and Development Operations (UNOPS, 2010) which sets BVM as one of its main goals and defines it as "the trade-off between price and performance that provides the greatest overall benefit under the specified selection criteria. Application of the best value for money principle in the procurement process means selection of the offer which presents the optimum combination of factors such as appropriate quality, service, life-cycle costs and other parameters to best meet the defined needs".

As above, such a gradual shift from a one-dimensional to a multi-dimensional decision problem, while allowing for a more thorough and complete evaluation of bidders' offers, introduced further elements of complexity in procurement design. Indeed, in a multi-criterion decision framework, the relative importance of the various components of an offer must be carefully screened since otherwise misrepresentation of the buyer's preferences could seriously hinder procurements' success (McDonald, 2008).

But what does pursuing BVM exactly mean (Italian Audit Authority for Public Contracts, 2011), what are its merits and limitations, how can it be translated operationally? The answer to the above questions is composite, articulate and deserves attention (Laffont & Tirole, 1993). Indeed, pursuing BVM requires careful procurement design and planning, as well as monitoring, in all three main procurement phases: that is "before" a procurement contract is awarded, "at" the time and "after" the contract is awarded. Before procurement takes place it is important for the buyer to foresee and design all the crucial subsequent steps. Which awarding criterion is best? Is it preferable to use an open or a restricted procedure? Is it best to negotiate with the potential suppliers or organize a competitive bidding? How should we proceed in case of complex projects and, even more so, when the procurement is seeking radically new solutions? Moreover, how should we introduce the appropriate incentive or penalty schemes to prevent contract breaching and performance failure by the supplier? How should the proposed quality level before awarding the contract be verified? And how should we monitor and enforce it while being executed? How should we allocate relevant risks? How can we avoid future and inefficient lock-in with a single supplier? Correct answers to these and other issues jointly contribute to the success of procurement activities.

Because of the multi-dimensional and complex nature of procurement, capturing and making operational the notion of BVM may not be an easy task. It is worth noticing, however, that as broad and encompassing a notion as it can be, excessive emphasis on BVM may turn out to be reductive for other purposes, in particular for the development of a country (Arrowsmith, 2010).

Based on the above considerations, the aim of this paper is to present a broad overview on some of the main issues underlying BVM in procurement: that is how to define the buyer's main goal and how to make it operational. Though, as we said, BVM can be delivered if a whole sequence of needed steps is appropriately taken care of, in this paper we chose to focus on the specific issue of translating a buyer's preferences into scoring rules. The paper is structured as follows. In section 2 we discuss the main procurer's goal and ways to formalize it. Given the buyer's goal Section 3 discusses the procurement outcome and how it may depend upon both the buyer's preferences and the supplier's technology, in a life cycle perspective. Section 4 concludes the paper.

A Procurer's Main Goal: "Best Value for Money"

Procurement is an area where theory and practice naturally meet. The interaction is both ways since daily procurement design can benefit from the more robust theoretical findings, while practice can fruitfully feed academic research with new problems, suggestions and intuitions.

An important example of such two way interaction is the fundamental element of any successful procurement, that is the appropriate specification of the procurer's goals. Above we introduced what's currently the most wide-spread way to express a main goal among institutions and professionals, namely that successful procurement should deliver BVM.

Because of its fundamental importance for procurement practice in this section, as well as in the next one, our focus will be on discussing at length how to specify and formalize the procurer's goal and related issues, such as the possible consequences of its misspecification and the expected outcome of a procurement transaction.

Setting the Procurer's Goal

Although pursuing BVM may be a very general statement, it does launch an important message – that price is rarely going to be the only criterion for the buyer to select the contractor. Indeed, typically, selection should take into account the two main dimensions of a procurement contract: price and quality, where quality is intended in a very broad sense, possibly taking many different forms in different procurements. In fact delivery time, degree of innovativeness, technical characteristics, physical robustness over a life span, color, curriculum vitae (CV) of individuals working for the contractor, time to complete relevant tasks, quantity, risks, are just a few examples of qualitative aspects that could be introduced into procurement specifications.

Whether a contractor is selected by competitive bidding or through forms of negotiated procedures, BVM can typically be captured by a scoring formula, that is a formula translating into a single number, normally a dimensionless score, the quality-price components of a tendered or negotiated offer.

From the point of view of the buyer this is nothing but a way to formalize his own preferences, over the quality-price space of alternatives, by introducing an objective function and its associated iso score (indifference) curves. When the procurer does so, it is because he's willing to trade-off quality for price, allowing for potential suppliers with different characteristics to compete on their best grounds. More specifically, the procurer may be indifferent, for example, between receiving a high-quality, accompanied by a high-price, offer and a low-quality with a low-price proposal.

Depending upon the buyer's needs, that is, his preferences, the scoring formula can take various forms (Che, 1993; Branco, 1997; Asker & Cantillon, 2008)]. In what follows we discuss three main families of such formulae, capturing a large part of possible preferences. However, prior to starting with the discussion we need to introduce some notation. Let $q = (q_1, \ldots, q_m)$ and $p = (p_1, \ldots, p_n)$ be, respectively, the m-dimensional vector of quality indexes and the n-dimensional vector of prices. In what follows, without losing much generality, to simplify the exposition unless differently specified, both vectors will have a single element -- that is they will be scalars. To further enhance the illustration of such scoring rules, in the Appendix we present some examples of formula effectively used by Consip, the Italian Procurement Agency.

Finally, it is important to point out that not all the relevant qualitative dimensions of a procurement can be easily captured in a formula, contracted upon and enforced. For example, an energy service contract specifying that temperature in the relevant rooms of a building must be kept between 20 and 22 degrees Celsius can be formalized in a scoring rule, for instance awarding x additional score points if the temperature is kept at 21 degrees and $2x$ points if kept at 22 degrees. However, in a procurement for cleaning services the requirement that rooms must be clean may be difficult to formalize in a contract and to enforce. Typically, non-contractible quality of this kind poses specific problems that need to be addressed case-by-case (Dimitri, Piga, & Spagnolo, 2006).

The Additive Scoring Rule (ASR)

In procurement practice, a widely adopted type of scoring rule is the following additive formula

$$S(q,p) = N(q) + M(p) \qquad (1)$$

where $S(q,p)$ is the total score obtained by a bidder, expressed as a function of the quality-price pair (q,p) proposed by bidders, with $0 \leq N(q) \leq S(q,p)$ increasing in the quality index q and $0 \leq M(p) \leq S(q,p)$ decreasing in the price p. Such properties typically generalize to scoring rules where q and p are vectors (see Appendix).

The quality index and the price normally have different units of measurement and a scoring rule harmonizes the two components of the offer, allowing for their comparison, by expressing both of them as pure numbers. For instance, if the buyer is procuring desktop computers then a quality index could be given by the screen size as measured in inches, or by other technical characteristics related for example to memory and speed. Clearly, in this case the monetary and non-monetary component of an offer would be expressed by different units of measurement. This would not be a problem if, for any given pair of offers, one pair always dominates the other, namely it would be preferable over both components. That is, if for any two offers $A = (q, p)$ and $A' = (q', p')$ it is $q > q'$ and $p < p'$ then ranking the proposals is immediate and requires no transformation into a scoring rule. However, though such ranking based on dominance could be possible there is of course no guarantee that it would always be the case, and this is why scoring rules are introduced.

However, it is useful to point out that assigning a score is by no means the only way for comparing alternative offers. Indeed, what is important for the procurer is to be able to express the two components in the same unit of measurement. For example, when possible for the procurer, harmonization could be performed by expressing both components in a currency (Dollars, Euros, etc.)

Therefore, $S(q, p)$ formalizes the goal of the buyer by translating his preferences into a formula. In particular, formula (1) expresses the idea that in the buyer's preferences the scores of the monetary and quality dimensions can substitute each other at the same rate. That is, the buyer is always willing to "trade" a unit of monetary score against a unit of non-monetary score, at any value of the two scores. More formally, the marginal rate of substitution between the two score components $\frac{dM(p)}{dN(q)} = -1$ is constant and the same, both along a single iso score curve as well as across different iso scores. It is noted that this does not typically mean that one unit of p "trades" with one unit of the quality index q. That is, the marginal rate of substitution between p and q would in general be different.

Indeed, fixing the total score at a certain level $S(q, p) = \bar{S}$, and assuming the function $M(p)$ to be invertible, the equation

$$p = M^{-1}(\bar{S} - N(q))$$

expresses the iso score (indifference) curves in the space (q, p), that is the set of pairs (q, p) providing the same score $\bar{S}$ to the procurer, namely the same level of satisfaction (welfare) as formalized by the number $\bar{S}$. As usual, the marginal rate of substitution between q and p is the slope of the iso score curves.

Suppose for example that in a competitive tendering procedure points are assigned to a price offer according to the following formula

$$M(p) = 80\frac{p_{min}}{p} \qquad (1a)$$

where p_{min} is the minimum price received by the procurer, that $0 \leq N(q) = 2q \leq 20$ and $\bar{S} = 70$. Then the equation

$$p = \frac{80p_{min}}{70 - 2q}$$

describes the set of pairs (q, p) providing the buyer with an overall score of $\bar{S} = 70$. Notice that, in this particular example, the exact form and position of an iso score curve is defined only after the procurer received all the offers, since it depends on the minimum submitted price.

When scores are assigned as in $(1a)$, and analogous considerations could be made for quality, bidders would not know when they submit their offers which score they will obtain with their price. This is because scores are based on relative, rather than absolute, price levels which cause strategic uncertainty making the scoring formula and related procurement potentially more exposed to collusive behavior. If instead, for example, rather than $(1a)$, the monetary component of an offer would be assigned the score

$$M(p) = 80\frac{(r - p)}{r} \qquad (1b)$$

where $0 \leq p \leq r$ is the reserve, maximum acceptable price for the procurer then, when submitting, bidders would know exactly the score associated to any price level they could offer.

For instance, if $r = 200$ and $p = 100$, then $M(p) = 40$. When buyers adopt a scoring formula such as $(1b)$, shape and position of the iso score curves are uniquely determined in the (q, p) space before offers are submitted. Often, formulae $(1a)$ and $(1b)$ rather than being expressed in terms of prices are expressed in terms of discounts $d = r - p$ with respect to a reserve price. Examples of both will be discussed in the Appendix.

To summarize, if the score assignment depends on all the offers submitted to the buyer then the strategic connotation of the procurement increases since bidders need to form expectations and conjectures on what their competitors will present in order to figure out what score they could obtain.

Finally, the following further point is also worth making. While formulae such as $(1a)$ always assign the maximum score reserved to the monetary component, scoring rules such as $(1b)$ do so only for particular values of the price, in the example when the submitted price is equal to zero.

Often, though not always, in procurement practice $S(q,p) \in [0,100]$ where $N(q) \in [0,y]$ and $M(p) \in [0,100-y]$, with $y \in [0,100]$. In the above example $y = 20$, because the maximum score that could be assigned to the price component of the offer is 80, obtained by the bidder who proposes the minimum price $p = p_{min}$.

Given the additive structure of the scoring rule, the form of $N(q)$ and $M(p)$ provide different incentives to the bidders for competing more on the monetary, rather than on the non-monetary, component of the offer and vice versa. In particular both the shape of $N(q)$ and $S(p)$ as well as the value of y would affect bidders' behavior in this sense.

More specifically, setting a high y would induce bidders to compete more on quality, rather than on price, presenting good quality proposals if they wish to have reasonable chances to win. Indeed, the value of y reflects the importance (weight) assigned by the procurer to quality versus price, according to his own preferences.

But also the form of $N(q)$ and $M(p)$ plays an important part in driving the competition. Indeed, consider again the two previous scoring rules concerning price.

$$M(p) = (100-y)\frac{p_{min}}{p}$$

and

$$\widetilde{M}(p) = (100-y)\frac{(r-p)}{r}$$

They can give rise to very different score assignment.

In fact, suppose for example that $r = 200$ and that in a competitive tendering it is $p_{min} = 100$. Then, a bidder offering $p = 180$ receives $M(p = 180) = (100-y)\frac{100}{180} = (100-y)\frac{5}{9}$ points according to the first scoring rule and $\widetilde{M}(p = 180) = (100 -$

$y)\frac{(200-180)}{200} = (100-y)\frac{1}{10}$ according to the second scoring rule, which is different from $(100-y)\frac{5}{9}$ unless $y = 100$. Finally, for completeness, it should be noted that different scoring rules may give rise to different bidding behavior and that proper comparison among formulae should also account for strategic reasoning. This point would be further discussed below.

The Multiplicative Scoring Rule (MSR)

Alternatively, if in the procurer's preferences price and quality scores would not replace each other at a constant rate, the scoring formula may be given by

$$S(q, p) = N(q)M(p) \tag{2}$$

formalizing the idea that now $N(q)$ and $M(p)$ while still substitutes, they are also partly complements since, assuming $N(q = 0) = 0$ and $M(p = r) = 0$, both of them would be needed to generate a positive score. That is, the procurer in this case is willing to trade points related to the monetary component with points assigned to quality, however at a rate of substitution between the two score components given by $\frac{dM(p)}{dN(q)} = -\frac{M(p)}{N(q)}$ which is no longer constant but varies along the iso score curves. This is when the procurer is more willing to replace monetary savings with quality if the price offer is particularly aggressive (low price), or more willing to forego quality in exchange of further savings if quality is high.

Finally, notice that the multiplicative rule could be transformed into an additive one by taking logarithms on both sides of (2).

The Leontieff Scoring Rule (LSR)

In case $N(q)$ and $M(p)$ are perfect complements, the scoring rule could be

$$S(q, p) = Min\,\{N(q), M(p)\} \tag{3}$$

formalizing the idea that the overall score, level of welfare, can increase only if both components of the scoring formula increase in the desired proportion. This would capture a procurer interested in a balanced competitive bidding outcome, where savings and quality are both requested. In this sense, one component cannot replace the other and the marginal rate of substitution between the two scores is either zero or infinite.

Assuming $M(p)$ to be invertible, in the (q, p) space the iso score curves have kinks at points $p = M^{-1}(N(q))$. Below we shall see that this is where choice is likely to be made by bidders for rather general forms of their profit functions.

Other types of Scoring Rules

For the sake of completeness, though uncommon in procurement practice, in this section we briefly mention two further types of scoring rules. The first one

$$S(q, p) = Max\ \{N(q), M(p)\} \qquad (4)$$

would further emphasize substitutability between $N(q)$ and $M(p)$, already inherent in (1), capturing the preferences of a procurer available to swap completely quality with price and vice versa. As we shall further elaborate below, such a buyer would induce bidders to fully exploit and focus on their strengths.

The other class of scoring rules,

$$S(q, p) = \ N(q)^{M(p)} \qquad (5a);$$

$$S(q, p) = \ M(p)^{N(q)} \qquad (5b)$$

may be seen as (logarithmic) reformulations of (2). Indeed, by defining

$$\overline{S}(q, p) = \log S(q, p)\,, \overline{N}(q) = \log N(q),\ \overline{M}(p) = \log M(p),$$

equations $(5a)$ and $(5b)$ become, respectively,

$$\bar{S}(q, p) = \overline{N}(q)M(p)\ (6a);\ \ \bar{S}(q, p) = \ N(q)\overline{M}(p) \qquad (6b)$$

The two scoring rules capture preferences where the positive effect of a quality, or price, offer is magnified (exponentially rather than multiplicatively) by the other component.

The Formation of Preferences

But how is the buyer forming his own preferences, that is according to which criteria do price and quality transform into scores?

When the item being procured is available on the market, it is natural for the buyer to take its market price as the benchmark for structuring his own preferences, then asking potential suppliers to improve upon the market conditions in a negotiated, or competitive tendering procedure. The procurer may certainly have different quality-price preferences from the ones prevailing in the market. However, for each quality level that he may be willing to accept, the buyer could not prefer to pay more than the market price. He would obviously wish to pay less but, if too much less, he should also be prepared not to receive any offer in case no potential supplier could cover the costs. To illustrate the point, take again the previous example and suppose that in a competitive tendering the quality level index is fixed by the buyer at $q = 2$, with the most efficient supplier having as cost function $C(q) = q^2$. Then, if the reserve (maximum) price is set at $r < 4$, no supplier could cover his own costs, to make non- negative profits in this competition. A low r may be set for example because the procurer could be the only buyer, in a dominant monopsonistic position. However, unless suppliers have an alternative way to compensate their losses they may not submit an offer. Yet, there could be circumstances when offers are made even in case of losses. Indeed bidders may wish to obtain the procurement contract to try surviving in the market, hoping to renegotiate more favorable terms while delivering the contract, or perhaps because costs for executing the contract are uncertain and optimistically estimated by the bidder to be lower than they turn out to be.

THE PROCUREMENT OUTCOME

Once the procurer's preferences and goal are defined and formalized by a scoring formula, we argued how the specific form of $N(q)$ and $M(p)$ provide different incentives for the potential suppliers, whether in a competitive tendering or negotiated procedure, to focus on the monetary component rather than on quality, or vice versa. For this reason, the final outcome of a procurement will not only depend upon the buyer's preferences but also on the potential suppliers' cost structure. Below we discuss this point.

Suppose, for example, that $C(q) = q^2$ is the cost function of a supplier for delivering quality q, with its profit function given by

$$\Pi(q, p) = p - C(q) = p - q^2 \quad (7)$$

While

$$S(q, p; k) = N(q) + M(p) = kq - p \; with \; k > 0 \quad (8)$$

The scoring formula (8) formalizes simple preferences, where a procurer considers k times the quality index as equivalent to p. So, for example, a bidder can obtain a total score of k points by either offering $q = 1$ and $p = 0$, or any price-quality combination such that $p = kq - k$. Hence, in general, the iso score curves $p = kq - \bar{S}$ are straight lines in the (q, p) space, with the overall score typically affecting their intercept but not their slope (Che, 1993; Branco, 1997; Asker & Cantillon, 2008). As a consequence, also the rate of substitution between q and p is the same, within and across different iso score curves. Then assuming bidders would not make losses the maximum score $S^*(k)$, that is, the optimal level of welfare the procurer could enjoy when interacting with this provider can be obtained by imposing the following zero-profit condition

$$\Pi(q, p) = p - q^2 = 0 \Rightarrow p = q^2 \quad (9)$$

and plugging (9) into (8). Then, solving

$$max_q S(q; k) = kq - q^2$$

We obtain that the optimal (for the procurer) quality level q^* would be given by $q^* = \frac{k}{2}$ and the best price p^* (still for the procurer) by $p^* = \frac{k^2}{4}$. This would give rise to the maximum, obtainable, score of

$$S^*(k) = \frac{k^2}{2} - \frac{k^2}{4} = \frac{k^2}{4}$$

expressed as a quadratic, increasing, function of the quality weight k.

Consider now a potential supplier with a different cost function, equal to $C(q) = q^3$. Hence, the maximum score the procurer could obtain solves the following problem

$$max_q S(q; k) = kq - q^3$$

giving rise to the optimal quality level $q^{**} = \sqrt{\frac{k}{3}}$, which in general differs from $\frac{k}{2}$. The highest score achievable by the buyer in this case would be

$$S^{**}(k) = 2\left(\frac{k}{3}\right)^{\frac{3}{2}}$$

Therefore, given the procurer's preferences the best possible welfare level that he can achieve depends also on the contractor's technology; that is, on his cost function. In particular, if $k < \frac{32}{27}$ then $S^{**}(k) > S^{*}(k)$ and vice versa. The underlying intuition is simple. In going from $C(q) = q^2$ to $C(q) = q^3$ the production technology becomes more efficient (costs are lower) for very low quality levels, $0 < q < 1$ and less efficient for high quality levels $q > 1$. Hence, the procurer's maximum score (welfare) could increase only if he assigns sufficiently low importance (low k) to quality. Indeed, if the buyer considers the non-monetary component important (high k) then a relatively less efficient supplier could provide high quality but only at relatively high costs, which would lower the buyer's total score.

More in general, if $C(q) = q^a$, with $a > 1$ it is immediate to see that the optimal quality would be given by $q(a) = (k/a)^{\frac{1}{a-1}}$ and the best possible score by $S(q(a)) = (a-1)(k/a)^{\frac{a}{a-1}}$. By the envelope theorem it is easy to check that $\frac{dS(q(a))}{da} = -q^a log q < 0$, for $q > 1$, which generalizes the previous considerations.

Analogously, suppose now the procurer's preferences would be different and equal to

$$S(q,p;k) = \begin{cases} \dfrac{N(q)}{M(p)} = \dfrac{kq}{p} & if \quad p \neq 0 \\ 0 & if\ q = 0 = p \end{cases}$$

a scoring rule formalizing a buyer particularly interested in inducing price competition. In fact, unlike the previous example, for such scoring rule the iso score curves would still be given by straight lines $p = \frac{kq}{\bar{S}}$, always going through the origin where now the score affects the slope, and not the vertical intercept of the lines. This is why with both $C(q) = q^2$ and $C(q) = q^3$, and more in general $C(q) = q^a$ with $a > 1$, the maximum score would be obtainable with a very low price as well as low quality.

Notice that the same conclusion may not hold for alternative cost functions. Indeed, if there would also be fixed costs and, for example, $C(q) = c + q^a$ still with $a > 1$ and where $c > 0$ is the fixed cost, then the score maximizing quality level would solve

$$\frac{d\left(\frac{kq}{(c+q^a)}\right)}{dq} = 0$$

leading to $q(a) = (\frac{c}{a-1})^{\frac{1}{a}}$, which is positive and sufficiently high as a gets close to 1 and, in this case, also the associated zero-profit price would be high.

Finally, suppose that

$$S(q,p;k) = Min\left\{kq, \frac{1}{p}\right\}$$

then, in the (q,p) space, iso score curves have kinks along the function $p = \frac{1}{kq}$, obtained by solving the equation $kq = \frac{1}{p}$. Thus, if the winning bidder has cost function $C(q) = q^2$, the total score is maximized, solving the equality $p = \frac{1}{kq} = q^2$, from which $q = (k)^{-\frac{1}{3}}$ and $p = (k)^{-\frac{2}{3}}$ so that the maximum achievable score is $S^{***}(k) = (k)^{\frac{2}{3}}$, typically different from $S^*(k) = \frac{k^2}{4}$ and, unlike the previous examples, concave in k.

For completeness, before proceeding, we conclude noticing that if

$$S(q,p;k) = Max\left\{kq, \frac{1}{p}\right\}$$

still with $C(q) = q^2$, the total score has no maximum since it is increasing in q and decreasing in p. Notice that the same conclusion would hold also with fixed costs $C(q) = c + q^2$.

To summarize, though very simple, the above examples illustrate that the outcome of a procurement transaction would in general depend both upon the buyer's preferences and the potential supplier's technology. Therefore, it is crucial for the procurer to clarify his own preferences and appropriately translate them into a scoring formula, for the bidders to present offers consistent with the buyer's desiderata. If this is not done then the procurer may face the risk of suffering serious welfare losses. Below we illustrate this point.

For example, suppose the procurer's "true" preferences are represented by $S(q,p;k) = 3q - p$ but that, by mistake, he misrepresents them as $\tilde{S}(q,p;k) = 2q - p$. Further, suppose the procurer would become aware of this mistake only after the transaction is made. Then, if $C(q) = q^2$ the highest possible score in the first case would be 2.25 while in the second case the highest possible score would be 1. Therefore, if the buyer is unaware that he effectively likes quality more than he thinks then, for instance, in a negotiated procedure he might act as a relatively "soft" bargainer than he could have been with the counterpart, potentially suffering a welfare loss that we may quantify with the difference in the maximum score $2.25 - 1 = 1{,}25$.

How could the loss of x points in the score be interpreted in this case? The scoring rule correctly representing the procurer's preferences provides an answer. Indeed, suppose again $S(q,p;k) = 3q - p$ is the true scoring rule. Hence, for example, considering the indifference curve related to $S(q,p;k) = 0$, it follows that $\frac{p}{q} = 3$, that is each "unit" of quality is worth on average 3 units of the monetary component of the offer. Therefore the monetary equivalent, for the buyer, to a loss of 1.25 points in the maximum score is precisely 1.25€, that is the monetary equivalent of a quality index level of $q = \frac{1.25}{3} = 0.43$.

With a non-linear scoring rule the interpretation of the monetary value of a score may be more articulated. Indeed, suppose now the scoring rule representing true preferences is $S(q,p;k) = \frac{3q}{p}$ when the procurer thinks it to be $S(q,p;k) = \frac{2q}{p}$. If $C(q) = q^2$ then, unlike the previous example with a linear scoring rule, in this case imposing the zero profit condition for the ratios $\frac{3q}{p}$ and $\frac{2q}{p}$ we obtain, respectively, $\frac{3}{q}$ and $\frac{2}{q}$, with their difference $\frac{1}{q}$ being always positive and increasing as q gets smaller. Fixing again the total score level $S(q,p;k) = \bar{S}$, the iso score curves are now given by $S(q,p;k) = p = \frac{kq}{\bar{S}}$ so that the marginal rate of substitution $\frac{k}{\bar{S}}$, namely the slope of the iso score, would vary across different iso score curves. As above, suppose that $k = 3$ represents the true preferences of the buyer for quality and fix $\bar{S} = 300$; then $\frac{p}{q} = \frac{1}{100}$. If instead $\bar{S} = 150$ then $\frac{p}{q} = \frac{1}{50}$, that is, the monetary value of a "unit of quality" index would be constant along the same iso score curve but different across alternative iso score lines. In particular, the higher the total score, the lower the monetary value of a point in the score.

In the previous section we discussed how the market price for a good or service could serve as reference to form the buyer's preferences and structure. However, even if a market price for setting up a scoring rule is available, the buyer is never completely informed about the production and delivery costs of a supplier, which could diverge even meaningfully from the market price, in particular when markets are imperfectly competitive. In this case, as in the previous example, the scoring rule adopted by the buyer could also serve as a mechanism to induce potential suppliers to bid as near as possible to their costs, for each given quality level.

But how close to their costs could the procurer expect suppliers to bid? Previously we discussed the maximum score (level of welfare) the procurer can obtain. However it is the bidders' strategic behavior, in a competitive bidding or negotiation, that will determine the final score.

Indeed, consider a competitive tendering where bidders' cost function are now given by $C(q;\theta) = \frac{\theta q^2}{2}$, where $\theta > 0$ is a cost parameter characterizing each firm. So, more efficient firms will have lower values of θ. Further, suppose still that $S(q,p;k) = kq - p$ and that $\Pi(q,p;\theta) = p - \frac{\theta q^2}{2}$ is a bidding firm profit function. Then, to gain an understanding on how firms could behave notice first that for any score level $\bar{S} = kq - p$ it would be optimal for a participant to submit a quality level maximizing its own profit, that is, solving the following problem

$$max_q = kq - \bar{S} - \frac{\theta q^2}{2}$$

that is

$$q = \frac{k}{\theta} \qquad (10)$$

which is increasing with k and decreasing in the cost parameter θ. As previously mentioned, it is also worth reminding that given the form of the scoring rule adopted by the procurer the optimal quality level, for both the score and the profit function, $q = \frac{k}{\theta}$ is independent of the score $\bar{S}$. This may not be the case with alternative scoring rules. For example, if $S(q, p; k) = \frac{kq}{p}$ then the optimal quality q for the supplier can be obtained by solving the problem

$$max_q = \frac{kq}{\bar{S}} - \frac{\theta q^2}{2}$$

leading to

$$q = \frac{k}{\bar{S}\theta} \qquad (10a)$$

which depends upon $\bar{S}$. Therefore, the quality offered would vary with the total score that a bidder wants to achieve. In the above example, the higher the score, the lower the quality level submitted because, in doing so, the bidder could decrease the price and raise the score.

Consider again $S(q, p; k) = kq - p$ and assume bidders to be informed about each other's value of θ. We model the competitive bidding as an auction game (Krishna, 2009), assuming initially that no bidder would want to run the risk of winning the auction, and make negative profits, to try putting competitive pressure on the opponents. In this case we can immediately see that the contest will indeed be won by the most efficient firm, the one with the lowest cost parameter $\theta = \theta_1$, offering a quality level as in (10) and a price p_1 slightly below

$$p_1 = \frac{k^2(2\theta_2 - \theta_1)}{2\theta_1\theta_2} \qquad (11)$$

with $\theta_1 < \theta_2$, where θ_2 is the second lowest cost parameter. Indeed, (11) represents the price at which the most efficient bidder can equalize the maximum score of the second most efficient bidder. In this case, the procurer would enjoy an overall score of about

$$S = \frac{k^2}{2\theta_2}$$

Indeed, under our informational assumptions the most efficient firm offering $q = \frac{k}{\theta_1}$ could win the competition by submitting a monetary component of the offer above his own zero profit price,

$$p = \frac{k^2}{2\theta_1}$$

which provides a total score of $\frac{k^2}{2\theta_1} > \frac{k^2}{2\theta_2}$. The strict inequality suggests that there is a margin, for the most efficient bidder, to win at more favorable conditions, that he could exploit by raising appropriately the monetary component of his offer. He could do so by submitting a price slightly below (11), to lower his score, and still win, enjoying a strictly positive profit.

If under the above informational assumptions this outcome sounds plausible it is important to point out that there could be other possibilities. For example, by making sure this would not lead to his winning the contract, the second most efficient bidder may still submit $q = \frac{k}{\theta_2}$ but offering a price to obtain a score S_2 such that $\frac{k^2}{2\theta_2} < S_2 < \frac{k^2}{2\theta_1}$, below the maximum possible score however above his own zero profit score. In this case, the most efficient firm could obtain a score S_1 by offering a price such that $\frac{k^2}{2\theta_2} < S_2 < S_1 < \frac{k^2}{2\theta_1}$ and still win, however now enjoying a lower profit. Which outcome would eventually prevail depends upon the degree of competitive pressure that less efficient bidders intend to put on the most efficient one. Clearly, the higher the degree of competition that would unfold the higher the total score, and so the larger the benefits for the procurer.

That firms know each other costs can be an acceptable assumption when they have been interacting in the same market for some time. Indeed market interaction would, if not completely at least partially, transfer information on each other's delivery abilities and related costs. However, in a number of circumstances it may be implausible to assume that bidders know each other cost structure and, in this case, it becomes more difficult to gain an understanding of plausible outcomes. If bidders compete genuinely, that is do not collude, then they would need to outguess the competitors' costs before deciding their own offer. Such bidders' conjectures can typically be formalized as probability distributions over the possible cost values of the competitors. This incomplete information analysis would then become technically and conceptually much more involved and give rise to bidding functions, namely profit maximizing equilibrium bids expressed as function of a bidder's own cost parameter.

Besides choosing the scoring rule, how can a buyer design the procurement to receive an offer as close as possible to the best possible one, which implies zero profit for the winning bidder? That is, how can the buyer extract as much surplus as possible from the winning bidder? Should the procurer know the bidders' cost function then it could appropriately design a competitive tendering procedure to do so? Suppose, to simplify, that quality (quantity) is fixed and specified by the procurement documents. Moreover, suppose the buyer knows that, among the participants, the lowest cost to deliver the contract would be c. Then, by organizing a lowest price sealed-bid competitive tendering procedure the procurer could introduce a reserve price $r = c + \varepsilon$, with $\varepsilon > 0$ small enough so that the most efficient participant will still find it profitable to participate and submit a price offer p such that $c < p < c + \varepsilon = r$ with which he could win the auction but, at the same time, transfer most of his surplus to the buyer.

However, as we discussed earlier, it is often difficult for the procurer to know the bidders' cost function, and consequently to gain reliable information on how to determine the reserve price r. This may be a problem since if r is too low then no bidder may want to submit a price offer as they may be unable to cover their costs, while if r is too high then the winner can obtain the contract at a price which is relatively larger than the lowest one that he could have paid.

When possible, r is fixed by estimating the average market price for that good, service, in the market. That is, r in this case represents the price the buyer pays in case he does not organize a procurement but purchases directly from the market. Indeed, spending more than the average market price would be a very inefficient way to procure. However, under certain conditions it may be more profitable for the buyer to set r even below the average market price. This is because if bidders (as well as the buyer) do not know each other costs a lower r

could induce their price offer to be more aggressive, since they would now be certain to compete only against the most efficient opponents, those with sufficiently low costs (Krishna, 2009).

Life Cycle Perspective

In the previous sections we discussed the reserve price r and its role, however without entering into further details on how it should be computed. A point of view that is increasingly gaining importance is that costs, as well as benefits, whenever possible should be calculated taking a life- cycle perspective. This is, again, particularly emphasized by the recent 2011 Communication of the European Commission [6]. That is, for example, when estimating the costs for the provision of goods-services, the analysis should account for the expected time duration of the relevant goods-services, and in any case the full profile of costs and benefits for the whole time length of the contract.

To illustrate the point consider the following example. Suppose an organization needs to change its IT system. To do so it organizes a competitive bidding procedure, receiving two proposals: project A and B. Both projects have an expected life time of Tyears (more in general T dates), meaning that within this time horizon they are not expected to have major technical problems, nor technical obsolescence will be a main issue. Further, to simplify the exposition without losing much generality, assume that the two systems have the same overall quality but their costs are as follows. System A has an initial cost of $c_I(A)$ euro and then a yearly maintenance cost of $m(A)$ euro, while system B initially costs $c_I(B)$ with a yearly maintenance cost of $m(B)$. Which of the two systems is preferable? What sources of cost should be considered? The answer would be easy if one system has both lower initial costs and lower maintenance costs, since being preferable in both components would dominate the competing project. But what if $c_I(A) > c_I(B)$ and $m(A) < m(B)$? Should system B be selected because of its lower initial cost or should maintenance costs be also considered, and if yes how? The standard approach to the issue is to consider both sources of expenditures, in a life-cycle perspective. More specifically, the life-cycle cost of system A could be computed as follows

$$c(A) = c_I(A) + \sum_{t=0}^{T-1} \delta^t m(A) = c_I(A) + m(A)\frac{(1-\delta^T)}{(1-\delta)}$$

and, analogously

$$c(B) = c_I(B) + \sum_{t=0}^{T-1} \delta^t m(B) = c_I(B) + m(B)\frac{(1-\delta^T)}{(1-\delta)}$$

where $0 < \delta = \frac{1}{1+i} < 1$ is the discount factor and $i \geq 0$ the discount rate. It is immediate to verify that project A would be less expensive, and so preferable, if

$$\frac{(1-\delta^T)}{(1-\delta)} > \frac{c_I(A) - c_I(B)}{m(B) - m(A)}$$

suggesting that, for given initial costs and discount factor, there always exist large enough values of $m(B)$ such that the inequality is satisfied. That is, even if project B would have lower initial costs its maintenance costs could more than counterbalance them favoring the adoption of project A. Similarly, for given initial and maintenance costs, project A can be preferable for a long enough time horizon T provided that the difference $m(B) - m(A)$ is sufficiently larger than $c_I(A) - c_I(B)$.

Finally the two extreme values of $\delta = 0$, formalizing full impatience, and $\delta = 1$, complete patience by the procurer are easier to deal with. Indeed, the former case would be a decision based only on initial costs, while the latter implies that preference of A over B is when

$$\frac{c_I(A) - c_I(B)}{T} < m(B) - m(A)$$

that is when the differential between maintenance costs is higher than the "average" difference between the initial costs. Hence, in this case, there would always exist a large enough T such that the inequality is satisfied.

An additional cost component that may require consideration when taking a life cycle perspective are the switching, migration, costs from a current system to a future one. Estimating such costs is not a simple task since, notably when the expected time duration of a system T is long enough, it may be very difficult to foresee which system could replace it in the future and at what costs. However, in the previous example, the initial degree of compatibility and openness with other standards of system A versus system B could already be an indicator of such source of cost.

Indeed, suppose now that switching to a different system may occur at any date $T > 0$, that $s(A)$ and $s(B)$ are the switching costs, $0 < p < 1$ and $0 < q < 1$ the probability of switching to a new system, respectively, for system A and system B, at any single date. Assuming the event of switching at time T is independent of switching at $T + 1$, for any T, then the expected life cycle costs of system A are now given by

$$c(A) = c_I(A) + \sum_{T=2}^{\infty} p(1-p)^{T-2}[\sum_{t=0}^{T-2} \delta^t m(A) + \delta^{T-1}(m(A) + s(A))]$$

and analogously for system B. Because of the higher number of parameters involved the decision now can be more articulated. In particular, everything else being the same, if for a project the probability and the cost of switching are sufficiently high then the alternative proposal may be favored.

CONCLUSIONS

The paper provides an overview of some of the main issues concerning the notion of "best value for money" in the context of procurement. The idea is typically made operational by introducing and evaluating monetary and non-monetary components in a procurement offer. This in turn introduces heterogeneous variables, with different units of measurement, which are then made comparable by associating dimensionless scores to each element of an offer. Proposals are then ranked on the basis of such scoring rules, which formalize the procurer's preferences over alternative monetary and non-monetary profiles of an offer. The work considers some main classes of preferences for the buyer, arguing that the final outcome of a procurement transaction, whether a competitive or negotiated procedure, depends both upon the buyer's preferences and the winning supplier's cost structure. Finally, following a recent European Communication proposal for a new Public Procurement Directive, we underline how monetary evaluations should incorporate a life cycle perspective--that is, consider the flow of relevant sums throughout the contract time length.

ACKNOWLEDGEMENTS

The author would like to thank The Maastricht School of Management for support to this research and for having hosted me. I would also like to thank the University of Siena for kindly allowing such collaboration. Insightful comments on a previous version of the paper by Wim Naudé, Khi Thai and anonymous referees are gratefully acknowledged.

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APPENDIX

To better illustrate use and nature of some of the additive formulae of the type (1) in what follows we consider some procurement competitive tendering procedures taken from the activity of Consip, the Italian procurement agency, which centralizes the procurement of a wide range of goods and services for the whole Italian public system.

The first example we present is a procurement for cleaning and gardening services, www.consip.it/on-line/Home/Gare/scheda832, published on 7th July 2012, where bidders could at most obtain a score of 100 points. The procurement included 13 lots. For each lot, the call specified the reserve price of each of the 15 technical sub-criteria, as well as their "economic score" expressed in terms of price discount from each reserve price. More specifically, the price p_i offered for the generic sub-criterion $i = 1,..,15$, with reserve price r_i and associated discount $d_i = r_i - p_i$, will obtain a score of

$$S_i(p_i) = S_{imax} \begin{cases} 0{,}9\left(\dfrac{d_i}{d_{iaver}}\right) & if\ d_i \leq d_{iaver} \\ 0{,}9 + (1 - 0{,}9)\left(\dfrac{d_i - d_{iaver}}{d_{imax} - d_{iaver}}\right) & if\ \ d_i > d_{iaver} \end{cases} \qquad (12)$$

where d_{iaver} is the average price discount for sub-criterion i received by the procurer, d_{imax} the maximum discount and S_i the maximum score a bidder could obtain with his price offer for sub-criterion i.

Then, if $p = (p_1, .., p_{15})$ is the vector of prices offered by a bidder, his economic score in each is given by

$$0 \leq S(p) = \sum_{i=1}^{13} S_i(p_i) \leq 40 \qquad (12a)$$

Formula (12) belongs to the same family as $(1a)$, because the score obtained by a bidder in the economic component of the offer is relative, that is determined also by the opponents' economic offers. The formula specifies that the full score S_{imax} could only be obtained by the bidder with the maximum discount d_{imax} and that for discounts no larger than the average the score could be at most 90% of S_{imax} . Because the score depends on everyone offer, it is not known at the time bidders submit their offers, but only after they are open by the procurer. Finally, $(12a)$ specifies that the weight assigned to the economic component of the offer is 40, hence lower than the weight of the qualitative component of the offer. Evidently, Consip was trying to spur more competition on quality, notably because some it was difficult to measure.

The second example we consider instead adopts a relatively more standard linear scoring formula, for the submitted prices, akin to $(1b)$ in the sense that when the economic component is submitted the bidder knows what score he will receive, independently of the other bidders' offers. The following competitive tendering for 20.000 lap tops, published on 28^{th} November 2011, http://www.consip.it/on-line/Home/Gare/scheda774.html was split into two lots. For each lot the maximum score was 100, with the weight of the economic component given by 65 while that of the qualitative part being 35. In this case, being quality more standardized the competition was addressed more towards price rather than quality. The score associated to the economic offer p was defined by the following formula

$$S(p) = 65\left(\frac{r-p}{r}\right)$$

that is exactly like $(1b)$. In this procurement p was the sum of the prices offered by a bidder for each technical component included in the call, while r the sum of the reserve values of each component.

As a third, and final, example we consider the following competitive tendering www.consip.it/on-line/Home/Gare/scheda780 to procure radiology devices, published on 7th December 2011. There were two types of devices which suggested the introduction of two lots. For both lots the highest obtainable score was 100, and the price component received a weight 50. The price scoring formula was basically the same for the two lots and given by

$$S(p) = 50\left[1 - \left(\frac{p}{r}\right)^n\right] \qquad (13)$$

where $n = 4$ for one lot and $n = 5$ for the other lot.

Formula (13) expresses the desire of Consip to mitigate price competition, as additional points could be gained by offering lower prices, but at decreasing rates. The higher the coefficient n the more bidders could gain many points with relatively small discounts with respect to the reserve price.