Econ Theory (2009) 39:259–268
DOI 10.1007/s00199-007-0304-x

RESEARCH ARTICLE

Make a guess: a robust mechanism for King Solomon's dilemma

Cheng-Zhong Qin · Chun-Lei Yang

Received: 9 February 2007 / Accepted: 12 October 2007 / Published online: 30 October 2007

Abstract We introduce endogenous fees for participating in second-price auction which we use for a two-stage mechanism to solve King Solomon's dilemma. They are positive for all agents. They are nonetheless shown to maintain the agents' incentives for truthful bidding and guarantee participation by the highest-value agent. This feature of the endogenous fees is powerful enough for the efficient outcome to uniquely result from one round elimination of *weakly* dominated strategies, followed by at most four rounds of iterative elimination of *strictly* dominated stage-strategies. We provide an extension to cases with n agents and k identical prizes.

Keywords King Solomon's dilemma · Mechanism design · Vickrey auction · Dekel-Fudenberg procedure · Iterative conditional dominance · Information robustness

JEL Classification C72 · D82

1 Introduction

King Solomon's dilemma refers to a story of the wisdom of King Solomon (I Kings 3: 16–28). In this story, two women appear before King Solomon seeking for judgment,

We thank Gary Charness, Harrison Cheng, Jeffrey Ely, Rod Garratt, Mamoru Kaneko, Xiao Luo, Albert Ma, and Steven Morris for helpful discussions. We also thank an anonymous referee for comments that have helped to improve the paper.

C.-Z. Qin (✉)
Department of Economics, University of California, Santa Barbara, CA 93106-9210, USA
e-mail: qin@econ.ucsb.edu

C.-L. Yang
RCHSS, Academia Sinica, Taipei, Taiwan
e-mail: cly@gate.sinica.edu.tw

both claiming to be the mother of a child. The problem is that, though the women know exactly whose baby the child is, King Solomon does not. Compounding the task is also his desire to give the child to its true mother at no cost to her. King Solomon's solution, which consisted in threatening to cut the baby in two, is not foolproof: What would he have done if the impostor had the presence of mind to scream like a real mother?

Without the requirement that no payment is made at solution, the standard Vickrey (sealed-bid second-price) auction can solve the problem. It is the no-payment feature that makes it a challenging problem to deal with. Assuming complete information about each other's values among the agents, Glazer and Ma (1989) offer a simple and elegant multi-stage mechanism that implements the efficient outcome of King Solomon's dilemma via a unique subgame-perfect equilibrium.[1] A simplification of their mechanism is provided by Moore (1992).

There have been several papers dealing with King Solomon's dilemma with general information conditions. The mechanism in Yang (1991, 1997) applies a less transparent equilibrium refinement that makes it difficult to apply. The mechanism in Olszewski (2003) solves King Solomon's dilemma under the most general information conditions as in the present paper. Olszewski shows that the efficient outcome is implementable through two rounds of elimination of *weakly* dominated strategies. His mechanism employs a random variable with a support equal to the real line to determine in part the winner and winning price of a modified second-price auction (Olszewski 2003, Remark 2, p. 317). The large support of the random variable complicates the mechanism.[2]

In comparison, Perry and Reny (1999) present a mechanism which is a second-price all-pay auction with a free winner-exit option. Their mechanism implements the efficient outcome in four rounds of iterative elimination of *weakly* dominated strategies. Their solution requires the assumption that neither agent rules out the true value of the other agent and that the low-value agent places a finite upper bound on the other agent's value (conditions (iii) and (iv) in Perry and Reny 1999, p. 281). The first part of the assumption is tantamount to requiring that each agent be able to identify the right range to cover the other's true value. The rules of the mechanism are very simple, but the path of reasoning towards the solution through four rounds of elimination of weakly dominated strategies is quite involved.[3]

In this paper, we provide a mechanism that solves the King Solomon dilemma under all information conditions that are compatible with the nature of the problem: Among the agents, the only common knowledge is they know who has the highest value (i.e., who is the most deserving agent to get the object), besides knowing their own values. Our mechanism is a two-stage game under which the efficient outcome is the only

[1] They start with the additional assumption that King Solomon knows the values too, but discuss in an Appendix a modification of their mechanism to remove this assumption. They also provide several economic applications of King Solomon's dilemma.

[2] For extensions of the mechanisms in Glazer and Ma (1989) and Olszewski (2003) to cases with multi agents and prizes, the reader is referred to Bag and Sabourian (2005). Artemove (2006) considers a mechanism which requires the addition of a time dimension to agents preferences. Adding a time dimension expands the outcome space. His mechanism provides an imminent Nash implementation of the efficient outcome under complete information without the use of money.

[3] A similar observation was also made in Olszewski (2003, p. 316).

one that survives the process of one round elimination of *weakly* dominated strategies followed by at most four rounds of iterative elimination of *strictly* dominated stage-strategies. The iterative process we apply is known as *iterative conditional dominance* (see Fudenberg and Tirole 1991, pp. 1128–1129).[4] The results can be generalized to cases with n agents and $1 < k < n$ identical prizes.

It is worth mentioning that there is no subsidy from the designer to the agents throughout the two stages of our mechanism. Consequently, our mechanism is ex ante collusion-proof. Our mechanism is, however, not interim collusion-proof, because the agents have incentives to collude in the second-price auction it uses. In comparison, the Olszewski's (2003) mechanism requires the designer to subsidize the agents for bidding. It follows that his mechanism is not ex ante collusion-proof, because both agents gain from colluding on the basis of ex ante payoffs due to the subsidy scheme.

1.1 An intuitive account of the solution

Given the nature of the problem, King Solomon wishes to allocate the good to the more deserving agent at no cost to her. Because bidding one's true value is weakly dominant, it is natural to consider a second-price auction as the mechanism to achieve that goal. A second-price auction alone, however, does not solve King Solomon's problem, as it involves payment from the winner to the auctioneer. In addition, it is not at all harmful to the less deserving agent to participate in the auction; hence, it leaves her with no good reason not to participate. The next natural step is then to design entry fees for participating in a second-price auction such that (i) they maintain incentives for truthful bidding; (ii) they yield a positive fee so as to deter participation by the less deserving agent; and (iii) they yield a small enough fee to guarantee participation by the more deserving agent. In this paper, we show by construction the existence of such entry fees.

The agents in our mechanism first decide individually whether or not to claim the good (the baby in King Solomon's dilemma). The good is naturally allocated when at most one of the agents claims. When both agents claim, however, they will subsequently participate in a second-price auction with entry fees. In a simple form, each agent simultaneously makes a guess about the other's bid and pays as the entry fee a fraction of the difference between the two. In this form, the optimality of an agent's guess is independent of both her own bid and the other agent's guess. It follows that the incentive structure of the second-price auction is unaltered by the entry fees. Furthermore, conditional on truthful bidding by both, the agents' optimal guesses are determined without any interdependence.[5]

Consequently, one round elimination of strictly dominated stage-strategies within the second stage would result in the optimal guess for each agent. As long as there is

[4] Our process of one round elimination of weakly dominated strategies followed by iterative elimination of strictly dominated stage-strategies is like the Dekel–Fudenberg procedure extended to conditional dominance. With the information settings as in Glazer and Ma (1989), the process is a direct application of the original Dekel–Fudenberg procedure. In any case, it is a weaker solution concept than iterated weak dominance (see Dekel and Fudenberg 1990).

[5] That is, given truthful bidding, the agents' optimal guesses are solutions to their individual decision problems with given beliefs.

some uncertainty about each other's true values, the resulting entry fee for each agent is positive. The entry fee for the more deserving agent is nonetheless small enough to guarantee a positive expected payoff to win the auction even by setting her own value as a guess of the less deserving agent's actual bid. This in turn implies that it is strictly dominant for her to claim, which leaves not claiming as the only optimal choice for the impostor. Hence, two subsequent rounds of iterative elimination of strictly dominated stage-strategies within the first stage would make the efficient outcome the only one that survives the overall process.

However, in the extreme case in which the impostor's belief is degenerate to a single-point mass, she can press her expected entry fee down to zero by correctly guessing the more deserving agent's bid, which may spoil the above solution. To deal with this case, we construct an entry fee for each agent in an extended form, with which the agent has to find a proper value within the spread of the opponent's bid and guess in order to minimize her entry fee. The agents do not all pay the "extended fees". Rather, at random one agent is selected to pay the extended fee while the other pays the simple fee as before. The agents are informed of the selection before they bid and guess, so that they can condition their bids and guesses on who pays the extended fee. Like her simple fee, the extended fee of an agent is independent of her own bid. It follows that the incentive structure of the second-price auction is again unaltered with the presence of the extended fees. Conditional on truthful bidding by both, one round elimination of strictly dominated stage-strategies within the second stage would result in the optimal "simple guess" for each agent, as in the case with simple fees only. Since the "extended guess" of an agent depends only on the other agent's bid and simple guess, one subsequent round of iterative elimination of strictly dominated stage-strategies would then result in the optimal extended guess for each agent.

The optimal simple guess of each agent is always different from her own value. Thus, no agent can avoid a positive expected entry fee, even when she is also informed of the other agent's value so that she can correctly guess the latter's actual bid. Nonetheless, the expected entry fee for the more deserving agent is still small enough to guarantee a positive expected payoff to win the auction even by setting her own value as both her simple and extended guesses. Consequently, it is strictly dominant for the deserving agent to claim, which leaves not claiming as the only optimal choice for the impostor in the first stage. It follows that two subsequent rounds of elimination of strictly dominated stage-strategies in the first stage would make the efficient outcome the only one surviving the overall process.

The rest of the paper is organized as follows. Section 2 introduces the basic settings of the problem and the basic structure of our mechanism. Section 3 presents our solution with simple participation fees, while Section 4 presents our solution with extended participation fees and an extension to n-person k-prize cases. Section 5 concludes.

2 Basic structure of the mechanism

There are two agents, $i = 1, 2$, and one indivisible good which will be allocated at no cost to the agent who values it most. The following information and objective functions are assumed throughout the paper:

I: It is commonly known to the agents that their values are non-negative and distinct; each knows both what her own value is and whether her value is the highest.[6]
II: Each agent is an expected utility maximizer.

Condition **II** is standard. It implies that each agent when facing uncertainty about the other's valuation will form a (subjective) belief about the other's belief, and so forth to base her own decision on. However, these (subjective) beliefs must not contradict information condition **I**.

Condition **I** summarizes the very information characteristics pertaining to King Solomon's dilemma. Let $F_1(\cdot|v_1)$ and $F_2(\cdot|v_2)$ be (subjective) posterior beliefs for agent 1 and agent 2, respectively. Then, condition **I** implies that for any realization of nature's choice that results in agents' values $v_i, v_j \in [0, \infty)$ with $v_i > v_j$,

- $F_j((v_j, \infty)|v_j) = F_i([0, v_i)|v_i) = 1$.

Notice that Condition **I** is identical with the combination of conditions (i) and (ii) in Perry and Reny (1999, p. 280).[7]

The basic structure of our mechanism can be described by the following two-stage game:

Claim stage	Agents decide whether to claim the good. Allocate the good to whoever is the sole claimant and game ends; allocate the good randomly if no one claims and game ends; go to the Contest Stage if both claim.
Contest stage	Agents bid and guess each other's bids. Charge agents entry fees as specified below, allocate the good using the 2nd-price auction, and game ends.

Let v_i denote agent i's value of the good. Let b_1 and b_2 denote the agents' bids and g_1 and g_2 their guesses. If agent i gets the good without entering the contest stage, her payoff will be v_i. If the contest takes place, her payoff will be $v_i - b_j - f_i$ if she wins and $-f_i$ if she loses, where f_i is i's entry fee. Agent i's payoff is zero in all other cases. A major part of the mechanism is the specification of the agents' entry fees, which we present in the next two sections.

[6] This precludes the possibility to have a tie in agents' valuations, a feature which is specific to King Solomon's dilemma.

[7] Let $\mathcal{T} = (T_i, \hat{\theta}_i, \hat{\pi}_i)_{i=1}^n$ be a belief-closed type space as considered in Bergemann and Morris (2005), which is a subset of the universal space in the sense of Mertens and Zamir (1985). In this formulation, elements of T_i are types of player i. Each type $t_i \in T_i$ incudes both a description of i's payoff type $\hat{\theta}_i(t_i) \in \Theta_i$ and a description of his beliefs about types of the other agents $\hat{\pi}_i(t_i) \in \Delta(T_{-i})$. In the context of King Solomon's Dilemma, Θ_i is the set of i's possible values from possessing the good. In this case, given $t_i \in T_i$ and $t_j \in T_j$, $\hat{\theta}_i(t_i) > \hat{\theta}_j(t_j)$ implies under our Condition **I** that $\hat{\pi}_i(t_i)$ assigns probability 1 to the subset of j's types t_j such that $\hat{\theta}_j(t_j) < \hat{\theta}_i(t_i)$, while $\hat{\pi}_j(t_j)$ assigns probability 1 to the subset of i's types t_i having $\hat{\theta}_i(t_i) > \hat{\theta}_j(t_j)$. Given this general specification of a type space, a Bayesian game can be formally defined with agent i's pure strategies mapping each of her type into an action. For expositional simplicity, we will omit formal notation as much as possible.

3 Solution with simple entry fees

The entry fee f_i for agent i depends on both her guess of agent j's bid and the latter's actual bid. Formally, given bid-guess pairs (b_1, g_1) and (b_2, g_2), f_i is determined by

$$f_i = \delta |g_i - b_j|, \tag{1}$$

where $\delta \in (0, 1)$ is a constant. Notice that f_i does not depend on i's own bid. It implies that the entry fees do not change the incentive structure of the second-price auction.

We say that the mechanism *solves* King Solomon's dilemma if the efficient allocation is the *only one* that survives the process of one round elimination of *weakly* dominated strategies, followed by iterative elimination of *strictly* dominated stage-strategies.

It turns out that the mechanism with the simple entry fees in (1) solves King Solomon's dilemma under Conditions **I**, **II**, and the following additional condition. In this case, the solution is uniquely obtained from one round elimination of weakly dominated strategies followed by only three rounds of iterative elimination of strictly dominated stage-strategies.

III: The low-value agent is uncertain about the true value of the high-value agent.

Condition **III** implies that the low-value agent cannot perfectly guess the high-value agent's bid even if the latter bids truthfully. We have

Proposition 1 *Assume Conditions* **I**, **II**, *and* **III** *are satisfied. Then, the mechanism with entry fees in* (1) *solves King Solomon's dilemma.*

Proof Let v_1 and v_2 denote the values of agent 1 and agent 2, respectively. Assume agent 1 is the high-value agent (i.e., $v_1 > v_2$). By (1), the entry fee for each agent does not depend on her own bid. Hence, the incentive to truthfully bid in second-price auction is unaltered. This shows that one round elimination of weakly dominated strategies removes all the strategies without truthful bidding for each agent.

With truthful bidding, $b_j = v_j$ for $j = 1, 2$. By (1) and Assumption I, agent 2's entry fee with her guess g_2 and agent 1's value v_1 is $\delta|g_2 - v_1|$. By Condition **III**, she believes agent 1's bid is randomly distributed according to the non-degenerate distribution $F_2(\cdot|v_2)$. Hence, her expected entry fee is

$$\int_0^\infty \delta |g_2 - v_1| \mathrm{d}F_2(v_1|v_2) > 0.$$

Since agent 2 can never win the auction, the preceding analysis of her expected entry fee together with II implies that her expected payoff from attending the contest stage is negative. On the the other hand, by (1) and assumption I, agent 1's entry fee with her guess $g_1 = v_1$ and agent 2's value v_2 is $\delta(v_1 - v_2)$. However, agent 1 gains $(v_1 - v_2)$

from the auction. Thus, the expected net gain with the suboptimal guess $g_1 = v_1$ is

$$\int_0^\infty (1-\delta)|v_1 - v_2| \mathrm{d}F_1(v_2|v_1) > 0.$$

Thus, by II, her expected payoff from attending the contest stage is positive.

The preceding analysis implies that given the elimination of weakly dominated strategies, one round of elimination of strictly dominated stage-strategies within the second stage results in agents' optimal guesses. Claiming the good will then be strictly dominant for agent 1, which in turn leaves agent 2 with not claiming as the only optimal choice. Hence, two subsequent rounds of elimination of strictly dominated stage-strategies within the first stage uniquely result in the efficient outcome. □

Notice that the solution puts no restrictions on the agents' subjective beliefs other than the compatibility with information Conditions **I** and **III**. Nonetheless, Condition **III** is restrictive because it requires that the low-value agent be uncertain about the true value of the high-value agent. In what follows we show that a slight modification of our simple participation fees can solve the dilemma without this requirement.

4 Solution with extended fees and its extension

At the beginning of the contest, a lottery with two equally probable states is drawn. The state of the lottery is made known to the agents before they bid and guess. The agents thus can condition their choices on the lottery state. In each lottery state, one agent pays an extended fee and the other pays a simple entry fee as introduced in the previous section. Let (b_i, g_i^e) and (b_j, g_j^s) be the bid-guess pairs by agent i and agent j in the lottery state in which i pays the extended fee and j pays the simple one.[8] Think of g_i^e as i's extended guess and g_j^s as j's simple guess. The extended and simple entry fees are determined by

$$f_i^e = \delta\Big[\lambda|g_i^e - b_j| + (1-\lambda)(g_i^e - g_j^s)_+\Big] \tag{2}$$

for agent i and

$$f_j^s = \delta|g_j^s - b_i| \tag{3}$$

for agent j, where $\delta, \lambda \in (0, 1)$ are constants and for $x \in \Re$, $x_+ = x$ when $x > 0$ and $x_+ = 0$ when $x \leq 0$.

Notice that agent i's optimal extended guess depends on agent j's simple guess of her bid b_i as well as on agent j's bid b_j. This feature turns out to be powerful enough for the mechanism to solve the King Solomon's dilemma without information condition **III**.

[8] We use superscripts e and s to indicate whether an agent pays the extended fee or the simple fee in a given lottery state.

Proposition 2 *Assume Conditions* **I** *and* **II** *are satisfied. Then, the mechanism with extended and simple entry fees in* (2) *and* (3) *solves King Solomon's Dilemma.*

Proof Let v_1 and v_2 be the values of agent 1 and agent 2, respectively. Assume agent 1 is the high-value agent (i.e., $v_1 > v_2$). Notice first that truthful bidding is still weakly dominant for the reason that neither the simple nor the extended fee for each agent depends on her own bid. As in the case with simple fees only, one round elimination of weakly dominated strategies removes all the strategies without truthful bidding for each agent.

Agent 1's optimal simple guess must be $g_1^s = v_1 - x$ for some $x > 0$ due to the common knowledge of agent 1 being the high-value agent. Consequently, agent 2's extended entry fee is

$$\delta\Big[\lambda|g_2^e - v_1| + (1-\lambda)[g_2^e - (v_1 - x)]_+\Big]. \tag{4}$$

When $g_2^e \le v_1 - x$, $|g_2^e - v_1| > 0$; when $g_2^e > v_1 - x$, $[g_2^e - (v_1 - x)]_+ > 0$. This shows that the extended fee in (4) is positive for any extended guess g_2^e of agent 2. Since agent 2 pays the extended fee with probability 1/2, her expected payoff from the contest stage is negative.

On the other hand, agent 2's optimal simple guess must be $g_2^s = v_2 + y$ for some $y > 0$ due to the common knowledge of agent 1 being the high-value agent. Notice $v_1 > v_2$ and $y > 0$ imply $(v_1 - v_2 - y)_+ < (v_1 - v_2)$. Thus, by (2), agent 1's extended fee with $g_1^e = v_1$ satisfies $f_1^e < \delta(v_1 - v_2)$. By (3), her simple fee with $g_1^s = v_1$ satisfies $f_1^s = \delta(v_1 - v_2)$. It follows that her expected entry fee over the lottery states is less than $\delta(v_1 - v_2)$. She gains $(v_1 - v_2)$ from the auction. Consequently, her expected payoff from the contest stage is positive. Putting together we have shown that, given the elimination of weakly dominated strategies, two rounds of iterative elimination of strictly dominated stage-strategies within the second stage result in optimal guesses. Claiming the good will then be strictly dominant for agent 1, which in turn leaves it strictly optimal for agent 2 not to claim. Hence, two subsequent rounds of iterative elimination of strictly dominated stage-strategies within the first stage uniquely result in the efficient outcome. This completes the proof for the case with agent 1 as the high-value agent. The case with agent 2 as the high-value agent can be proved analogously. □

The bid-guess messages of our mechanism induce the agents to self-select under general information conditions. The mechanism does not require any subsidy from the designer to the participants, and so the highest achievable expected payoff for the high-value agent coincides with her value of the good. Thus, knowing her value and knowing she is the high-value agent, she has no ex ante incentives to collude with the other agent, because collusion cannot help her to achieve a higher expected payoff than what she can achieve individually.

4.1 An extension to n-person k-prize cases

The mechanism for the 2-person case generalizes to the case with n agents and one prize as follows. Each agent simultaneously chooses between claiming the good and not claiming it. When nobody claims, the good is randomly allocated among them with equal probability at no cost to anyone. When exactly one agent claims, she gets the good at no cost to anyone. When two or more agents claim, they enter a contest stage and those who did not make that choice exit at no cost.

Let m denote the number of agents who claimed the good. Assume without loss of generality they are agents $i = 1, 2, \ldots, m$. A lottery with m equally probable states is drawn before these agents decide on their bid-guess choices, so they can condition their choices on the state of the lottery. In each lottery state, one agent pays an extended fee while all other ones pay simple fees.

Let (b_i, g_i) with $g_i = (g_i^e, g_i^s)$ denote agent i's bid-guess pair, where b_i is her bid, g_i^e is her guess of the highest bid by the agents other than herself when she pays the extended fee, and g_i^s is her guess of the highest bid when she pays the simple fee. Given the other participating agents' bid-guess pairs (b_j, g_j), $j \neq i$, let j_i be the agent whose bid is the highest of those submitted by agents other than agent i.

Let $\delta, \lambda \in (0, 1)$ be fixed. The simple fee for agent i to pay is given by

$$f_i^s = \delta |g_i^s - b_{j_i}|. \quad (5)$$

The extended fee for i to pay, however, is given by

$$f_i^e = \delta \Big[\lambda |g_i^e - b_{j_i}| + (1 - \lambda)(g_i^e - g_{j_i}^s)_+ \Big]. \quad (6)$$

The mechanism with the simple and extended entry fees in (5) and (6) solves the King Solomon's dilemma for the n-person 1-prize case under the n-person analogs of Assumptions **I** and **II**. The proof parallels the proof in the 2-person case.

When there are $1 < k < n$ homogenous prizes, we extend information Assumption (I) to:

I$'$: It is common knowledge to the agents that the kth and $k+1$th highest of their values for the good are distinct, and that each knows both her own value and whether her value is one of the k highest.

We can then extend the preceding mechanism by first replacing the second-price auction with a $k+1$th price auction to determine who the k winners are, in case more than k of them decide to enter the contest stage. Next, when paying the simple fee, we require an agent to make a simple guess about the kth highest bid of the other agents; we require her to also guess the kth highest bidder's simple guess when she pays the extended fee. It is straightforward to show that this extended mechanism solves the n-person k-prize King Solomon's dilemma.

5 Conclusion

Make a guess about your opponent's bid and pay for incorrectly guessing! It turns out that this addition to the second-price auction is sufficient to make the agents self-select, so that the true mother gets to keep her baby at no cost (i.e., the high-value agent wins the good at no cost). The efficient outcome can also be implemented if the agents' decisions other than bidding are made sequentially. For instance, the claim stage can be sequential with arbitrary ordering of the agents' moves. For the contest stage, the guessing part can take the following sequential form. First, the agent who pays the extended fee announces her guess. Then, observing the first mover's guess, the other agent announces her guess. The bids are then revealed, the good gets allocated, and payment and fees are collected.

The parameters $\delta, \lambda \in (0, 1)$ provide the designer with some additional room for manipulating the relative scales of the entry fees to make any inadvertent entry into the contest by the impostor costly.

The mechanism is robust in the sense that the same mechanism solves the problem under all information conditions compatible with King Solomon's dilemma. This is a much stronger notion of robustness than that discussed in Bergemann and Morris (2005), where different mechanisms may be needed for different information conditions to guarantee an efficient implementation.

References

Artemov, G.: Imminent Nash implementation as a solution to King Solomon's dilemma. Econ Bull **4**, 1–8 (2006)

Bag, P.K., Sabourian, H.: Distributing awards efficiently: more on King Solomon's problem. Games Econ Behav **53**, 43–58 (2005)

Bergemann, D., Morris, S.: Robust mechanism design. Econometrica **73**, 1771–1813 (2005)

Dekel, E., Fudenberg, D.: Rational behavior with uncertain payoffs. J Econ Theory **52**, 243–267 (1990)

Fudenberg, D., Tirole, J.: Game Theory. New York: MIT (1990)

Glazer, J., Ma, A.: Efficient allocation of a 'prize'–King Solomon's dilemma. Games Econ Behav **1**, 222–233 (1989)

Mertens, J.F., Zamir, S.: Formulation of Bayesian analysis for games of incomplete information. Int J Game Theory **14**, 1–29 (1985)

Moore, J.: Implementation in environments with complete information. In: Jean-Jacques Laffont (ed.): Advances in Economic Theory: Sixth World Congress, pp. 182–282. Cambridge: Cambridge University Press (1992)

Olszewski, W.: A simple and general solution to King Solomon's dilemma. Games Econ Behav **42**, 315–318 (2003)

Perry, M., Reny, P.J.: A general solution to King Solomon's dilemma. Games Econ Behav **26**, 279–285 (1999)

Yang, C.-L.: Robust weak dominance implementation solving the King Solomon's dilemma. University of Dortmund, Mimeo (1991)

Yang, C.-L.: Efficient allocation of an indivisible good—A mechanism design problem under uncertainty. In: Picot A., Schlicht E. (eds.) Perspectives on Contract Theory, pp. 263–272. Berlin: Springer (1997)