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Reinterpreting King Solomon's problem: Malice and mechanism design

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ABSTRACT

I argue for an alternative interpretation of King Solomon's problem in terms of one of the two claimants being "malicious". A "malicious" claimant places no intrinsic value on the object but derives utility from depriving the rival claimant. This new interpretation permits a simpler solution than those considered in the literature; I derive a mechanism that induces truthful revelation where the equilibrium involves a single round of elimination of weakly dominated strategies, and no monetary transfers. I consider extensions which allow for the malicious claimant to also place some low but positive intrinsic valuation on the object; I also discuss the possibility of two-sided malice, and provide examples of several real-life contexts to which the mechanism or its extensions are applicable.

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1. Introduction

Following an insightful paper by Glazer and Ma (1989), a small game-theoretic literature has sprung up around economic interpretations of "King Solomon's problem". This literature includes Moore (1992), Perry and Reny (1999), Olszewski (2003), Bag and Sabourian (2005), Artemov (2006), Qin and Yang (2009), and Mihara (2011). Glazer and Ma recast the problem as one of allocating an indivisible object between two claimants with different valuations for the object. The mechanism designer does not know the identity of the high-valuation claimant, though he knows the magnitudes of both the high and the low valuations. While the subsequent literature on King Solomon's problem involved improvements in terms of weaker informational requirements, weaker solution concepts or generalizations to multi-player/multi-object cases, they preserved the essential interpretation of the problem as one of allocating an indivisible object to the person who values it the most. This interpretation has significant consequences. One of these is that this literature maintains that second-price sealed bid auctions (in which each player's dominant strategy is to bid her true valuation) results in an efficient allocation; the object goes to the highest-value bidder. However, the literature then specifies that the mechanism designer does not want the highest-value bidder to have to pay for the object *in equilibrium* and goes on to explore other solutions which do not involve monetary transfers in equilibrium. My paper differs from the literature in adopting a different interpretation of King Solomon's problem based on one-sided malice. Accordingly, the mechanism inducing truthful revelation changes (permitting a considerably simpler solution); and implications for the usefulness of sealed bid auctions also change.

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In this interpretation, of the two disputants, one (the "false mother") is motivated by malice. Her interest in disputing the "true mother's" claim stems not from any intrinsic value she places on the prize (the child) but on a utility she gains from depriving her rival claimant. To understand this interpretation, reconsider the biblical story. Two "mothers" – a true one and a false one – bring a dispute before King Solomon concerning a single child. Both claim to be the true mother. King Solomon proposes to cut the child in half and give one half to each woman. While the false mother agrees, the true mother reverses her statement and asks that the child be given to the other woman. Note that while the false mother will not obtain a child, or at least a live child, either in the case where she agrees with the true mother's claims or when the king cuts the child in half, she strictly prefers the latter case. The false mother's strict preference that the child be killed rather than given to the other woman reveals that she experiences a positive utility from depriving the "true" mother. This is the motive that I label "malice". In addition, the false mother's behavior also indicates that she does not value the child for its own sake, so that she places a negative, or at least a non-positive, valuation on the child itself. She is interested in claiming the child because her utility from malice exceeds any disutility she may incur in actually bringing up the child (assuming that legal restrictions prevent her from disposing of the child herself). My approach is not meant to deny the importance of the mechanisms highlighted in the traditional literature on King Solomon's problem; rather, my paper can be viewed as complementary to this literature, in that it considers a different interpretation based on malice.

As I show below, re-interpreting the problem in terms of one-sided malice has nontrivial implications. The malicious claimant's objective changes from obtaining the object to ensuring that her rival does not obtain it. Thus, for example, while in the literature either claimant would prefer to obtain the prize to the prize being retained by the mechanism designer (because of disagreement), this is no longer true for the malicious claimant in my model.

I extend my basic model to allow for cases where (i) the malicious claimant also places some positive, albeit low, valuation on the object for its own sake, and (ii) both claimants may bear each other malice. I also provide examples of real-life economic contexts to which the mechanism, or its extensions, are applicable. These include malicious patents filed by *non-practicing entities* (NPEs) – firms that file patents primarily to prevent rival firms from developing the patented product. Such firms may never develop the product themselves. Alternatively, firms may consider product development as a relatively minor objective of securing a patent (compared to the main one of harming competitors). The second example is of warring spouses who are separating and contesting rights to an asset on which they place different intrinsic valuations; one or both spouses may be motivated by malice, deriving pleasure from depriving the other spouse of the asset. A third example, related to the second, is about disputed land rights in extended families. In the first example, the mechanism designer's role is played by a patent authority; in the second and third, an arbitrator plays the designer's role.

My interest in modeling malice is also motivated by evidence on the importance of malice in decision-making. Beckman et al. (2002) find that malice and envy motivate over 50% of their subjects, who oppose Pareto improvements which make other people better off without ostensibly making them worse off. Other experimental evidence of spite (malice) and envy in economic decisions is provided by Bosman and van Winden (2002), Bosman et al. (2006), Albert and Mertins (2008), Zizzo and Oswald (2001), Abbink and Sadrieh (2008) and Abbink and Herrmann (2011), among others. For instance, Bosman and van Winden (2002) find that 21% of subjects destroy their own earnings (with almost all of these destroying 99 or 100%) when told that a portion of these earnings would later go to another subject (the power-to-take game). Zizzo and Oswald find, in the "money burning game" that two-thirds of players were willing to **pay** to destroy (burn) other players' money. Abbink and Herrmann (2011) find, in a one-shot "joy of destruction" game, that 10–25% of players destroy each other's endowments without any economic gain to themselves. Thus, if malice motivates at least some agents, as these experiments suggest, it would be interesting to work out the theoretical implications of this. This paper begins to explore the issue.

In Section 2 I first obtain a preliminary (negative) result concerning second price sealed bid auctions. I argue that when the mechanism designer's objective is to allocate the prize to the person with the greatest intrinsic valuation for it (as is likely when, for instance, the designer is child welfare or social services and the "prize" is a child), a second price sealed bid auction may not achieve this objective. I then obtain a simple mechanism that induces truthful revelation at no cost. This mechanism relies on a single round of elimination of dominated strategies, and the informational assumptions underlying it are weak. I assume that both claimants know their own valuations (and the malicious claimant knows the utility she will obtain from malice) but not each other's. However the true claimant is aware that her rival harbors malice and also that the rival places a nonpositive intrinsic value on the prize. The mechanism designer knows that one claimant has a positive valuation for the prize, while the other is malicious and does not value the prize for its own sake. However he knows neither the identity of the malicious claimant nor the magnitudes of the valuations or the extent of malice.[1] I also discuss a real-life example. In Section 3, I extend the basic mechanism of Section 2 to allow the malicious claimant to value the object for its own sake, and consider the possibility of two-sided malice. I also give examples of real-life contexts to which these extensions apply. Section 4 points out a parallel between the Myerson–Satterthwaite theorem and a condition I need for the extension where the malicious claimant also intrinsically values the object. Section 5 concludes with a discussion.

[1] In extensions of the basic model, some more information may be required; however it remains true that neither the designer nor the other claimant need to know the exact valuations or the exact extent of malice; and the designer never knows the identity of the malicious claimant ex ante.

2. The basic mechanism

Consider two risk-neutral claimants A and B contesting rightful "ownership" of a prize (a child). A is the "true" claimant (the rightful parent) and values the prize (child) at $V > 0$. B does not value the prize (child) for its own sake; her true valuation is $v \leq 0$. However she also derives a utility κ, where $0 < \kappa < \infty$, whenever A *does not get* the prize (child). The valuations V and v and the utility from malice κ are private information. However A knows that B is malicious and that B's true valuation for the prize (child) is nonpositive.

The mechanism designer knows that one of the two claimants is the true owner and values the prize (child) while the other is malicious, does not value the child for its own sake and is simply contesting to deprive the true claimant. However he does not know which is which.

Proposition 1. *Suppose the mechanism designer's objective is to allocate the prize (child) to the person who values it* ***for its own sake****. Then, even if the mechanism designer were willing to accept monetary transfers in equilibrium, a second price sealed bid auction may not achieve the desired objective.*

Proof. Suppose A and B participate in a second-price sealed bid auction for the prize (child). Now B's utility from obtaining the child is $v + \kappa$. Therefore it is a dominant strategy for her to bid $v + \kappa$, while A's dominant strategy is to bid her true valuation V. Now note that if $\kappa > V - v$, B wins the auction and obtains the child, paying V. Therefore the mechanism designer's objective may not be served. □

As an example of a context relevant to Proposition 1, social workers concerned with child welfare might prefer the child to be placed with the person or family who values the child the most for its own sake.

Next, I propose a mechanism that will result in A getting the prize (child) and that involves no monetary transfers in equilibrium. The solution concept is one round elimination of weakly dominated strategies, and the (unique) equilibrium that survives this elimination is a pure strategy Nash equilibrium.[2]

Definition. Define a mechanism Γ such that the designer asks the two disputants to simultaneously state "mine" or "hers" and

(i) If one says "mine" and the other says "hers" the designer awards the child (prize) to the one who says "mine".
(ii) If both say "hers" the mechanism designer retains the child (prize).
(iii) If both say "mine" the mechanism designer retains the child and executes[3] both disputants.

Proposition 2. *The mechanism Γ results in A getting the child (prize) at no cost in equilibrium.*

Proof. Noting that B obtains a utility from malice of κ whenever A does not get the child, and assuming that both A and B find the prospect of execution infinitely painful (with a utility of $-\infty$), the mechanism above results in the following payoff matrix:

B

A		Mine	Hers
	Mine	$(-\infty, \kappa - \infty)$	$(V, 0)$
	Hers	$(0, \kappa + v)$	$(0, \kappa)$

Note that B's malice is served even if she does not obtain the child herself, provided A does not get the child (as in the outcome "hers, hers" when the mechanism designer retains the child). Now since $\kappa < \infty$ and $v \leq 0$, saying "mine" is a (at least weakly, and strictly if $v < 0$) dominated strategy for B. By elimination of weakly dominated strategies, therefore, A expects B

[2] Iterated elimination of weakly dominated strategies has often been criticized since different answers may be arrived at by varying the order of elimination. This particular criticism however does not apply to one-round elimination of weakly dominated strategies, which is what is used here. Nonetheless, I also discuss how to weaken the solution concept to one round elimination of *strictly* dominated strategies, instead (in Remark 2). Note also that elimination, and even iterated elimination, of weakly dominated strategies has nevertheless been traditionally used in the literature on King Solomon's Problem (e.g. Olszewski, 2003; Bag and Sabourian, 2005; Mihara, 2011).

[3] Execution proxies for a very severe punishment. Later in this section, in Remark 1, we modify the mechanism for much smaller punishments (like fines).

to say "hers". Given $V > 0$, A says "mine". Therefore, the mechanism allocates the child to A and this equilibrium involves no monetary transfers. □

Remark 1. If the mechanism designer is aware of an upper bound on κ, say κ^*, then he can alter the mechanism above to imposing a fine of κ^* on both disputants if they both say "mine". The outcome will be the same. Note that κ^* need not be the smallest upper bound on κ. Moreover, neither A nor the mechanism designer needs to know either v or the true value of κ.[4] Call this modified mechanism Γ^*.

Remark 2. If the mechanism designer is aware of some positive $\underline{V}$ such that $\underline{V} < V$ (a strict lower bound on V) then the solution concept above can be weakened to one-round elimination of *strictly* dominated strategies by modifying the mechanism so that if both disputants say "hers" the designer retains the child but awards each of them payments of any $\varepsilon < \underline{V}$, where $\varepsilon > 0$. In the modified mechanism, saying "mine" is now a strictly dominated strategy for B, *even if* $v = 0$. By elimination of strictly dominated strategies, A says "mine" knowing that B will say "hers". Note that there are no monetary transfers in equilibrium.

2.1. An example: non-practicing entities

Consider two individuals, or firms, A and B, who must individually choose whether to apply for a patent. However, A and B differ in that only A means to actually develop a product subject to obtaining a patent. B is not interested in actually developing or marketing a product; her motive is to exclude A from doing so. That B is not interested in product development can be inferred from the actual behavior of non-practicing entities–sometimes also referred to as "patent trolls"; these firms do not in fact develop the products they patent (Fusco, 2012; Halt et al., 2013). Again, B's motive for securing the patent may conveniently be labeled as "malice" and its magnitude denoted by κ; malice here may have economic dimensions[5] in addition to potentially personal ones. "Intrinsic valuation" for the patent, here, is based on the motive for using the patent to develop and market a new product; this is $V > 0$ for A, but is totally absent as a motive for B, so that $\nu = 0$ (in Section 3 we will allow ν to be positive). Now the "mechanism designer"'s role is played by a patent authority, who knows that one of either A or B does not mean to actually develop the product, but, as usual, does not know the identity of the "malicious" applicant. The authority wants that the product actually be developed, and hence, would want to grant the patent to the individual whose intrinsic value for the patent is $V > 0$.

Now, the mechanism Γ^* can be used here. This would involve the patent authority imposing a fine κ^* if she receives applications from both candidates, and not granting either the patent. If only one applies, she grants the patent to the applicant at no charge. If neither applies, she does nothing. Mimicking the arguments of Proposition 2 and Remark 1, the equilibrium then results in only A applying, and getting the patent at no cost.

An alternative mechanism that the patent authority could use here (that I label Γ^{**}) would entail a slight modification to mechanism Γ^* such that if both candidates apply, she randomly allocates the patent, but a fine (which can also be seen as an exorbitant fee) of $F = \kappa^*/2$ must be paid by each applicant. (In the generalized case, Γ^{**} is identical to Γ^* with the difference that if both claimants say "mine" the designer randomly allocates the prize but charges both claimants $\kappa^*/2$.) As shown below, this mechanism achieves the same equilibrium outcome, but may sometimes be considered "fairer" in the sense that in the off-equilibrium case where both applicants apply for a patent, a patent is granted to one of them (as opposed to denying both patents under mechanism Γ^*). Also note that randomly allocating the patent in this event (under mechanism Γ^{**}) makes sense because ex ante, the patent authority cannot distinguish between the two applicants.

The payoff matrix is now

		B	
		Apply	**Don't Apply**
A	**Apply**	$((V-\kappa^*)/2, (\kappa-\kappa^*)/2)$	$(V, 0)$
	Don't Apply	$(0, \kappa)$	$(0, \kappa)$

[4] Implicitly, the rival claimant is at least as well informed as the designer. Therefore, if the designer knows that κ^* is an upper bound on κ, and imposes a fine of κ^* when both claimants say "mine", then A realizes that since the fine is an upper bound on B's malice, saying "mine" will be a dominated strategy for B. However, A does not need to know the exact extent of B's malice in order to understand this.

[5] Suppose A and B are multi-product firms; if A is unable to develop a new product because B has obtained a patent for it, this could affect A's profits to the extent that it becomes less able to compete with B in other markets, and exits.

Again, it is easy to see that applying is weakly dominated for B; by elimination of weakly dominated strategies, A applies and gets the patent.

3. Extensions and further examples

The mechanisms Γ, Γ^* and Γ^{**} considered in Section 2 have the restriction that v is assumed to be non-positive. In this section, I first cover the possibility that a malicious claimant may also have a positive (though relatively low) intrinsic valuation for the object ($0 < v < V$). Next, I allow for the possibility that both claimants may bear malice toward each other. I discuss examples where relevant.

3.1. The malicious claimant values the object: $V > v > 0$

Observation 1. *Suppose that, as in Remark 1, the mechanism designer knows κ^*, an upper bound on κ. If she also knows a lower bound on V, $\underline{V}$ (as in Remark 2) and an upper bound on v, v^*, then provided the interval $[v^*,\underline{V}]$ is non-empty,[6] she can design a mechanism identical to Γ^* with the difference that if both A and B say "hers", she offers them each a payment P such that $v^* < P < \underline{V}$ (call this mechanism Δ^*). Alternatively, she can offer a mechanism Δ^{**} identical to the generalized mechanism Γ^{**} with two differences, (i) offering the payment P, $v^* < P < \underline{V}$, when both say "hers", and (ii) setting the fine $F = \max[\kappa^*, v^*]$ (in the event that both say "mine"). Both these mechanisms result in A getting the prize after a single round of elimination of strictly dominated strategies.*

Proof. With the modified mechanism Δ^*, the payoff matrix becomes

		B	
		Mine	Hers
A	Mine	$(-\kappa^*, \kappa - \kappa^*)$	$(V, 0)$
	Hers	$(0, \kappa + v)$	$(P, \kappa + P)$

As $\kappa < \kappa^*$ and $v < v^* < P$, saying "mine" is a strictly dominated strategy for B, and knowing this, A says "mine" as $V > \underline{V} > P$, obtaining the prize.

With the mechanism Δ^{**}, the payoff matrix becomes

		B	
		Mine	Hers
A	Mine	$(V/2 - F, ((\kappa + v)/2 - F)$	$(V, 0)$
	Hers	$(0, \kappa + v)$	$(P, \kappa + P)$

Given that $F = \max[\kappa^*, v^*]$, it necessarily exceeds $(\kappa + v)/2$. Therefore B's expected payoff from the random allocation process becomes negative taking this fine into account; saying "mine" continues to be a strictly dominated strategy for B. It is therefore optimal for A to say "mine". □

Remark 3. Instead of making payments P to both A and B when both say "hers", the designer can also choose to do nothing in this event *and* change her strategy when only one claimant says "mine", giving the object to this claimant at a fee of P (the other claimant, who said "hers" does not pay anything). (When both say "mine", the procedure is as in Observation 1.) The mechanisms are equivalent to those just shown in the sense that saying "mine" will be dominated for B, and A will endup

[6] In Section 4 I will draw parallels between this particular condition and the Myerson–Satterthwaite theorem.

saying "mine" and obtaining the prize. The only difference would be that now, A would also pay a fee of P in equilibrium. However, this would still be better than holding an auction, because as shown in Proposition 1, an auction may not result in A obtaining the prize in the first place.

Remark 3 is interesting because it shows us a rather practical way in which the mechanism could be implemented in reality. Consider the patenting example of Section 2, but modify it such that now the malicious applicant, B, also places some small positive value $v < V$ on the patent for its own sake (perhaps now B also wants to develop the product, but on a smaller scale than A). Then the patent authority, by charging an application fee conditioned on the number of applications, granting a patent to the sole applicant if there is just one application, and following a random allocation process if there is more than one application for the same patent, could essentially implement a mechanism which ensures that the patent goes to A, who has the higher intrinsic valuation for it.

Other examples: warring spouses and extended family land disputes

Consider two spouses, A and B, who have decided to separate and are trying to decide who will get an asset (e.g., a house). It seems most realistic to assume that both spouses place some positive intrinsic value on the asset; however it is definitely possible that one spouse places a higher value on it. Possibly, this could be because this spouse is in greater economic need (while the other spouse has a well-paying job), or because of other factors (if the asset was a gift from A's parents, for example, A may place more sentimental value on it than B does). Let A's and B's respective intrinsic valuations be given by V and v, and assume without loss of generality that $V > v > 0$. Also, assume that B bears A malice (either due to past transgressions by A, or because this is B's nature) and obtains a malice utility of κ if A is deprived of the asset.

The mechanism designer's role is played by an arbitrator who knows that one of the disputants bears malice, but that one spouse has greater intrinsic valuation for the asset. The arbitrator however does not know the identity of this spouse. Now, it may be argued that the welfare implications here are nuanced. Keeping in mind that bad behavior by A in the past may have generated B's malice, is it necessarily better for A to get the asset just because A places more intrinsic value on it? Arguably, however, an arbitrator who does not even know which of the claimants bears malice is also unlikely to know whether the malice is due to innate ill nature or due to past transgressions by the other spouse. Accordingly, given informational limitations, it is reasonable for such an arbitrator to aim for an outcome where the spouse with the greater intrinsic value for the asset (V) obtains it. This arbitrator can then attain this objective by implementing either of the mechanisms Δ^* or Δ^{**}.

Another related example is the case where members of an extended family contest ownership of an ancestral house or an ancestral plot of land. Often, there is little love lost between the feuding relatives; so, apart from the intrinsic value which the disputants place on the asset, which may well be different (but which is nonetheless likely positive for all concerned), one or more disputants may feel happy if they are able to deprive the other party (malice). If an arbitrator is interested in the asset being allocated to the disputant that places the highest intrinsic value on it, he can therefore implement either mechanism Δ^* or Δ^{**}.

Therefore, while the mechanisms of Section 2 can be extended to the case where $v > 0$, this does come at an informational cost; as shown in Observation 1, the designer now needs extra information (on an upper bound for v) in addition to the information she was required to have in Remarks 1 and 2. Nonetheless, it remains true that neither the designer nor the other claimant need to know the exact valuations or the exact extent of malice; and the designer never knows the identity of the malicious claimant ex ante. Moreover, the solution concept is weakened to one-round elimination of *strictly* dominated strategies.

3.2. Two-sided malice, $V > v > 0$

We next consider the case where A also bears B malice, and gets a "malice utility" λ whenever B does not get the patent. Again, this malice may have some economic content to it. We make no assumption on the relative values of λ and κ, B's malice utility. We continue to assume that $V > v > 0$. Now, suppose the designer remains concerned about allocating the prize to the party with the greatest intrinsic value for it; she is not concerned about whether malice is or is not being served in the process.

Observation 2. *Suppose the mechanism designer knows an upper bound μ on the malice of the more malicious party (without knowing the identity of this party), $\mu > \max[\kappa, \lambda]$, and in addition knows a lower bound on V, $\underline{V}$ and an upper bound on v, v^*, then provided the interval $[v^*, \underline{V}]$ is non-empty, she can design a mechanism identical to Δ^* with the difference that she now imposes a fine of μ on A and B if both say "mine"(call this mechanism Φ^*). Alternatively, she can offer a mechanism Φ^{**} identical to Δ^{**} with the difference that if both say "mine", the fine is now set at $F^* = \max[\mu, v^*]$. In both cases, the equilibrium following a single round of elimination of strictly dominated strategies involves A getting the prize.*

Proof. Consider the first mechanism, Φ^*. With the proposed modifications, the payoff matrix is now

		B	
		Mine	**Hers**
A	**Mine**	$(\lambda-\mu, \kappa-\mu)$	$(\lambda+V, 0)$
	Hers	$(0, \kappa+v)$	$(\lambda+P, \kappa+P)$

Note that A obtains a malice utility of λ whenever B does not obtain the prize (irrespective of whether A herself obtains the prize or not). Since $\mu > \kappa$, and $v < v^* < P$, saying "mine" is strictly dominated for B; given $P < \underline{V} < V$, A then says "mine", obtaining the prize. Turning to the second mechanism, Φ^{**}, the payoff matrix after the proposed modifications is

	B	
	Mine	**Hers**
Mine	$((\lambda+V)/2-F^*, (\kappa+v)/2-F^*)$	$(\lambda+V, 0)$
Hers	$(0, \kappa+v)$	$(\lambda+P, \kappa+P)$

Since $F^* = \max[\mu, v^*]$, it is easy to see that it exceeds $(\kappa+v)/2$. Therefore saying "mine" continues to be a strictly dominated strategy for B. Knowing this, A says "mine" (given $V > \underline{V} > P$) and obtains the prize. □

Again, Remark 3 applies to the two-sided malice case as well; the designer may also choose to do nothing when both say "hers" and, in the event that only one claimant says "mine", give the object to that claimant for a fee P. Finally, note that our result about the second price auction continues to hold. Suppose A and B were given the right to bid for the prize in a second price sealed bid auction. If $\kappa - \lambda > V - v$, then with A bidding $\lambda + V$ and B bidding $\kappa + v$, B would win. The two-sided malice case may apply to any one of the three examples we have considered thus far–patent rivals, warring spouses, and extended family land disputes.

4. A Parallel

When the malicious party also places some positive intrinsic valuation on the object, a condition for the designer to be able to design a mechanism that allocates the object to the claimant with the higher intrinsic valuation was that the interval $[v^*, \underline{V}]$ be non-empty (please see Observation 1), i.e., we must have $v^* < \underline{V}$. Interestingly, there is a parallel between this and the conditions for inefficiency spelled out in the Myerson–Satterthwaite theorem. I elaborate on this parallel below.

In Myerson and Satterthwaite (1983), M–S consider efficient mechanisms for bilateral trading. They consider cases where neither the buyer's nor the seller's valuations are definitely known, but lie within known intervals. They show that if the two intervals overlap, there are no incentive-compatible mechanisms that guarantee efficient outcomes (where an "efficient outcome" is defined as the higher-valuation party getting the object). M–S do not consider malice.

The parallel to my model is the following. While the designer does not know A's or B's identity, he is in addition uninformed about their true intrinsic valuations. However, he knows the *upper limit* of the *lower* intrinsic valuation (v^*) as well as the *lower limit* of the *higher* intrinsic valuation ($\underline{V}$). It is then easy to see that if $\underline{V} < v^*$, then *from the designer's point of view*, conditions similar to the inefficiency condition of the M–S theorem would arise. My condition, that $v^* < \underline{V}$ is therefore equivalent to assuming that this inefficiency condition *does not* hold.

5. Discussion and conclusion

King Solomon's original solution did not involve a truthful revelation mechanism; rather, both mothers lied. Moreover, King Solomon did not keep his word (he gave the child to the woman who said the child was not hers). Therefore, economists have criticized this mechanism on the grounds that it relies on bounded rationality; if the women could foresee that King Solomon would act as he did, they would reverse their statements. The literature inspired by King Solomon's problem has accordingly looked for truthful revelation mechanisms which, moreover, do not involve monetary payments in equilibrium. This literature, however, does not allow for malice and instead envisions a high-valuation and a low-valuation bidder (or several bidders with heterogeneous valuations).

Interpreting the problem in terms of malice leads to rather different results from the literature. First, the literature has maintained that if monetary payments are permitted in equilibrium, a second-price sealed bid auction always delivers. Along similar lines, some of this literature involves second-price sealed bid auctions as *off-equilibrium* mechanisms (for example, Olszewski, 2003; Qin and Yang, 2009[7]) which help support an equilibrium where the optimal allocation is achieved at no cost. Implicit in the use of this off-equilibrium mechanism is the idea that second-price sealed bid auctions would result in the desired allocation. However, once malice is allowed for, this is no longer necessarily true, *if the mechanism designer wants the object to go to the person with the highest intrinsic valuation for it.* In the patent case, this would happen if the authorities wanted the patent to result in actual product development on a reasonable scale. In the warring spouse/feuding family members' case, this would happen if the arbitrator had no way of knowing if the malice were justified on ethical grounds, and accordingly preferred to allocate the asset to the party with the highest intrinsic valuation for it. This would be particularly true in the case of child custody, if the decision maker were concerned with child welfare or social services. Therefore, if the mechanism designer knows that one of the claimants is contesting out of malice, he should not *necessarily* have them participate in a second-price sealed bid auction, even if he does not mind collecting money from the winner in equilibrium.

Secondly, I find a mechanism that does induce truthful revelation in the model with malice, and allocates the object to the party with the higher intrinsic valuation for it. The mechanism designer must keep in mind that one of the claimants derives utility even in outcomes where she does not get the prize, provided the prize is not given to the other claimant. In fact, the malicious claimant may prefer the mechanism designer to keep the child rather than to take possession of it herself! The equilibrium involves one-round elimination of dominated strategies and is unique. I also look, in extensions, at cases of two-sided malice and cases where both claimants place positive, though different, intrinsic value on the object. My emphasis on modeling malice is consistent with evidence on the importance of malice in motivating some agents' decision-making.

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References

Abbink, K., Herrmann, B., 2011. The Moral Costs of nastiness. Economic Inquiry 49, 631–633.
Abbink, K., Sadrieh, A., 2008. The pleasure of being nasty. Economics Letters 105, 306–308.
Albert, M., Mertins, V., 2008. Participation and decision making: a three-person power-to-take experiment. Joint Discussion Paper Series in Economics Working Paper No. 05-2008.
Artemov, G., 2006. Imminent Nash implementation as a solution to King Solomon's dilemma. Economics Bulletin 4, 1–8.
Bag, P.K., Sabourian, H., 2005. Distributing awards efficiently: more on King Solomon's problem. Games and Economic Behavior 53, 43–58.
Beckman, S.R., Formby, J.P., James Smith, W., Zheng, B., 2002. Envy, malice and Pareto efficiency: an experimental examination. Social Choice and Welfare 19, 349–367.
Bosman, R., van Winden, F., 2002. Emotional hazard in a power-to-take experiment. Economic Journal 112, 146–169.
Bosman, R., Hennig-Schmidt, H., van Winden, F., 2006. Exploring group decision-making in a power-to-take experiment. Experimental Economics 9, 35–51.
Fusco, S., 2012. Markets and Patents Enforcement: A Comparative Investigation of Non-Practicing Entities in the U.S. and Europe. SSRN Working Paper.
Glazer, G., Ma, C.T.A., 1989. Efficient allocation of a "Prize" – King Solomon's dilemma. Games and Economic Behavior 1, 222–233.
Halt Jr., G.B., Fesnak, R., Donch, J.C., Stiles, A.R., 2013. Non practicing entities. In: Intellectual Property in Consumer Electronics, Software and Technology Startups. Springer, pp. 217–220.
Mihara, H.R., 2011. The second-price auction solves King Solomon's dilemma. Japanese Economic Review, http://dx.doi.org/10.1111/j.1468-5876.2011.00543.x.
Moore, J., 1992. Implementation, contracts and renegotiation in environments with complete information. In: Laffont, J.J. (Ed.), Advances in Economic Theory: Sixth World Congress, vol. 1. Cambridge University Press, Cambridge, pp. 182–282.
Myerson, R.B., Satterthwaite, M.A., 1983. Efficient mechanisms for bilateral trading. Journal of Economic Theory 29, 265–281.
Olszewski, W., 2003. A simple and general solution to King Solomon's problem. Games and Economic Behavior 42, 315–318.
Perry, M., Reny, P.J., 1999. A general solution to King Solomon's dilemma. Games and Economic Behavior 26, 279–285.
Qin, C.Z., Yang, C.L., 2009. Make a guess: a Robust Mechanism for King Solomon's dilemma. Economic Theory 39, 259–268.
Zizzo, D.J., Oswald, A.J., 2001. Are people willing to pay to reduce others' incomes? Annales d' Economie et de Statistique 63, 39–65.

[7] Perry and Reny (1999), in contrast, uses an all-pay auction in which the winner has the ex-post option to quit.