Interactive comment on "Definition of efficient scarcity-based water pricing policies through stochastic programming" by H. Macian-Sorribes et al.

Anonymous Referee #2

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Answers to the Anonymous Referee #2 General Comments

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1. **REVIEW COMMENT**

   The authors have published several related papers in this area in recent years, and it is not entirely clear to me how they are distinguishing this work from their earlier work. I understand that previous papers, or at least Pulido-Velazquez et al. 2013, used an assumption of perfect hydrologic foresight, which certainly represents a limitation, but is the elimination of this assumption the primary difference between that paper and this one? Please elaborate.

   AUTHOR'S RESPONSE

   The new approach uses a stochastic programming procedure instead of a simulation or a deterministic optimization. Previous works relied on simulation or deterministic optimization to design the *a priori* pricing policies, both of them subjected to imperfections that hinder its optimality. We considered stochastic optimization as the best procedure to define an optimal pricing policy, since deterministic optimization is hindered by the perfect foreknowledge of future inflows (which is an unrealistic assumption that makes its results unattainable in real life) while simulation does not offer optimal results (as its goal is to follow certain a priori operating rules that can be non-optimal). Furthermore, we propose a different approach for deriving the a priori pricing function based on the MROC-state time series.

   The author's changes in manuscript due to this comment have been made jointly with the 1st referee detail comment 10.

AUTHOR'S CHANGES IN MANUSCRIPT (p 784 / line 17) additions in underlined italics, eliminations in crossed-out italics

"~~*The differences between this*~~*Unlike the* method ~~*and the one*~~ proposed in Pulido-Velazquez et al. (2013)*, this one uses* ~~*consist basically of: (1) using*~~ a stochastic programming approach instead ~~*a*~~ *of* deterministic programming or ~~*a*~~ simulation ~~one; and (2) obtaining pricing policies via statistical analysis and system state sorting according to the MROC values. The use of stochastic programming methodologies implies that the MROC state relationship obtained reflects an optimal but realistic situation, instead of a non optimal situation (simulation) or an unrealistic optimal one (deterministic optimization). In addition, the method proposed in this paper to obtain pricing policies avoids trial and error procedures, whose time requirements are hard to estimate~~. *It also employs a different method to derive the pricing policies based on the MROC and state time series.*"

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2. REVIEW COMMENT

While I understand the idea of marginal cost pricing in theory, I have many questions regarding how it would be implemented in practice. Estimates of marginal (or market) prices are notoriously poor in many contexts, and the same is likely to be the case here, so how does the system respond to a poor estimate? If prices are set too low and demand outstrips supply, what happens? Is there a cap on supply, and if so, how and on whom is it enforced? If prices are set too high, there is no physical limitation, but there could be significant economic losses. Given that most of the demand is agricultural, and therefore likely to be very elastic, it would seem that small errors in the estimated prices could give rise to very large discrepancies between the amounts of water demanded (at the MROC) and those estimated. How would this be managed?

AUTHOR'S RESPONSE

We agree this is a key issue. The response of the system to a wrong price estimate would be an unbalance between resources and demands; this unbalance already happens with the current management of the system during water scarcity periods, in which demand surpasses supply. If this occurs in the implementation of the measures, the pricing policy would need to be corrected (in an adaptive approach). Actually, we conceive this pricing policy as a first preliminary estimate of an efficient policy, to be further refined, discussed and negotiated.

If the demand outstrips the supply, then water could be restricted according to certain priorities now established by law or other procedure to be defined in advance.

Financial compensations could be paid in case that pricing policies are set too high. In fact, part of the revenues generated by the pricing policy could be used to increase the accuracy of the demand curves and thus of the pricing policies, as well as to invest in increasing water security and deal with potential equity issues. An explanation about that has been added to section 4.

The accuracy in the estimated demand curves is certainly important in the reliability of the simulated performance of a pricing policy. We found that agricultural demand curves have often both elastic and inelastic reaches, which vary across the price interval, with lower discrepancies in more inelastic parts. In any case, given the strong influence of the demand

curves in the results, demand curves should be properly estimated and tested.
The author's changes in manuscript due to this comment have been made jointly with the 1st referee general comment 4.

AUTHOR'S CHANGES IN MANUSCRIPT (p 784 / line 17) additions in underlined italics, eliminations in crossed-out italics

"*Given the uncertainties associated to the inputs of the model, the predictions concerning the pricing policy performance are uncertain. The most important source of uncertainty is the demand curves, since they directly affect the MROC values and the reliability of the simulated performance of a pricing policy. Given the strong influence of the demand curves in the results, demand curves should be properly estimated and tested.*

If water prices are poorly estimated, the result will be an unbalance between resources and demands: this unbalance already happens with the current management of the system during water scarcity periods, in which demand surpasses supply. In that case, the pricing policy should be corrected in an adaptive approach. In cases demand overtook supply due to price being lower than required, water supplies would need to be curtailed according to certain priorities determined either by negotiation or by law, in order to rematch demand and supply. On the other hand, if prices are set too high, financial compensations should be paid to the affected users. In order to avoid those situations, part of the revenues generated by the pricing policy should be employed to increase the accuracy of the estimated demand curves. Furthermore, they may be invested in water security increase or deal with equity issues."

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3. REVIEW COMMENT

Along similar lines, one of the largest obstacles to implementing some form of water market is the concern over high prices that would limit some activities' (i.e. agricultural) consumption of water. In order for this MROC pricing approach to be used, the obstacle of rising prices would have already been overcome, yet there would still be huge information requirements on the part of the administering water agency if it were going to accurately estimate the MROC month-after-month and year-after-year. Given that concerns over higher prices would have been overcome, why not just implement a market instead of the MROC pricing approach, it would certainly be more efficient given that the users would make decisions based on their own valuations, and probably easier to administer? I would like to better understand the circumstances under which the authors' feel that the MROC approach is preferable to a market, as these are not clear to me.

AUTHOR'S RESPONSE

Water market will be certainly another approach to enhance economic efficiency in water allocation in the system. In Spain, formal (spot) water markets are allowed by law since 1999, but in practice, only in a few occasions they have been implemented, and never in this system. Factors like high transaction costs, farmers' reluctance to participate, low physical connectivity, etc., often prevent more transfers. While the experience and literature on water markets is more abundant, water pricing is one of the most underused tools for dealing with water scarcity relative to its potential. Despite its limitations,

drawbacks and barriers and issues for its implementation, water pricing offers some interesting features: contributes to match supply and demand, generates revenues for the administration (which could be then invested in increasing water supply security, or as a potential rebate to compensate economic losses for dealing with equity issues), and maintain customer choices (against command-and control policies). On the other hand, the river basin authority holds the formal control of the system, what I essential for addressing environmental requirements, third party effects, and so on.

AUTHOR'S CHANGES IN MANUSCRIPT (p 785 / line 4) additions in underlined italics, eliminations in crossed-out italics

"*Comparing pricing policies with water markets, both will be theoretically valid approaches for enhancing economic efficiency in water allocation in the system. In Spain, formal (spot) water markets are allowed by law since 1999; but in practice, only in a few occasions have them been operative, and never in this system (Palomo-Hierro et al., 2015). Factors like high transaction costs, farmers' reluctance to participate, low physical connectivity, etc., often prevent more transfers. While the experience and literature on water markets is more abundant, water pricing is clearly underused regarding its potential for dealing with water scarcity. Despite its limitations, drawbacks, barriers and issues for its implementation, water pricing offers some interesting features: contributes to match supply and demand, generates revenues, and maintain customer choices (against command-and control policies). On the other hand, the river basin authority holds the formal control of the system, what is essential for addressing environmental requirements, third party effects, and so on.*

~~*To gain social acceptability and policy equity, mechanisms of financial compensation can be implemented (e.g., Tilmant et al., 2009). Additional financial resources generated could be them be employed to compensate the users, or to develop adequate infrastructure to increase water security (for example, by financing desalination plant that reduce water scarcity). The main objective in the design of the pricing policies discussed here focuses on the use of water prices as economic instrument for an efficient management of the interaction between supply and demand. The role of pricing for cost recovery of water services (pricing as financial instruments) will require a complementary analysis.*~~"

Answers to the Anonymous Referee #2 Detail Comments

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1. **REVIEW COMMENT**

   I think that the orientation of the reservoirs in Figure 3 may be incorrect. Aren't the wide ends of the reservoir symbols supposed to be at the downstream side and the narrow ends at the upstream side?

AUTHOR'S RESPONSE

Both configurations are possible and often employed in different Decision Support Systems (DSS) for water resources management: one could be the reservoir viewed from the top, and the other, a top view of the dam shape. The reservoir orientation adopted in this paper correspond to the one employed by the AQUATOOL DSS shell, while others like MODSIM employ the configuration suggested by the reviewer.

AUTHOR'S CHANGES IN MANUSCRIPT additions in underlined italics, eliminations in crossed-out italics

No changes were made.

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2. **REVIEW COMMENT**

pg 785, line 6 has several typos

AUTHOR'S RESPONSE

The typos were corrected. However, the sentence in which they were found has been eliminated in response to other comments.

AUTHOR'S CHANGES IN MANUSCRIPT (p 785 / line 5) additions in underlined italics, eliminations in crossed-out italics

"~~Additional financial resources generated could be them be employed to compensate the users, or to develop adequate infrastructure to increase water security (for example, by financing desalination plant that reduce water scarcity).~~"