Transaction Risk versus Transaction Costs in Water Transfers

Water Resources Research, Vol. 29, No. 9, pp. 3103-3107, September, 1993

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ABSTRACT

Transaction cost has been a frequent topic in theoretical and practical discussions of water transfers. However, the risk or probability that a transfer effort will be unsuccessful should also have a significant effect on the decision by potential water purchasers to seek water transfers in lieu of seeking water by conventional means (source capacity expansion or water conservation). The importance of the uncertainty of transfer completion is examined analytically under a decision theory framework. Some implications of uncertain transaction completion for water transfer policy are discussed. In general, seeking water transfers becomes more attractive to potential water purchasers if the probability of a successful transfer is increased, if more of the transaction costs for water transfers are incurred after a transfer has been approved, and if the costs of delaying implementation of alternative water supplies are small.

INTRODUCTION

Much work has been done on the role of transaction costs on the feasibility and desirability of water transfers (Colby, 1990; MacDonnell, 1990; Brajer et al., 1989). These typically take a deterministic benefit-cost or neoclassical microeconomic perspective of the role of transaction costs in the desirability or market equilibrium of imperfect water markets. Such analysis has also been undertaken to explore the ability of transaction costs to substitute for consideration of third-party effects or externalities from water transfers (Colby, 1990). Other uses of deterministic transaction costs analysis have attempted to use transaction costs to explain the organization and operation of water-providing institutions (Nickum and Easter, 1991).

While this deterministic perspective is useful and interesting, it obscures the potential role of uncertainty in transaction outcome in assessing the desirability of seeking water transfers by potential water buyers and sellers. The uncertainty of water transfer approval can have several origins. First, in most cases, one or more State water or water-right regulators must approve a potential water transfer; their approval is by no means certain. Of 24 temporary water transfer applications to California's State Water Resources Control Board during the period 1981-1989, 6 (or almost 17 percent) were rejected or withdrawn (Gray, 1990). In Wyoming, between 1975 and 1984, over 20 percent of water transfer applications were denied (MacDonnell, 1990). Second, even where regulatory approval is likely, there may be court challenges to the transfer based on regulations or environmental impact. Third, the threat of controversy and expense from regulatory or court challenge of water transfers can dissuade political or administrative leaders of potential water buyers from continuing pursuit of water transfers. This third source of uncertainty can be particularly significant since it extends over a period of several years from the time when transfers are first being considered by an agency (well before potential water transfers are submitted for regulatory approval) until the time when a potential transfer has survived all likely legal challenges.

Even after regulatory and political approval for a water transfer, there are additional technical uncertainties involved in the physical delivery of legally transferred water. There are often unforeseen losses of transferred water due to conveyance requirements and spillage from reservoirs. The quantity of these losses are often substantial and difficult to estimate before the transfer has been completed (Lougee, 1991; Lund et al., 1992).

This paper contains a formal presentation of the importance of transaction risks for potential receivers of water transfers from a decision theory perspective. Further policy implications of the role of uncertainty in transaction completion are then discussed.

TRANSACTION RISK IN WATER TRANSFER EVALUATION

This problem can be formulated in decision theoretic terms. Should a water user seek to acquire additional water through water transfers or through the construction of additional water supply capacity (or additional water conservation efforts)? This decision entails some risk to the decision-maker. Seekers of water from different supply sources or through contractual arrangements can be expected to consider the costs, indirect costs, transactions costs, risks, and probabilities of successful transfer in selecting alternative water supply strategies and contractual arrangements. As such, their behavior would be similar to that of decision makers in other arenas considering transaction costs (Cheung, 1969).

Costs

For the purposes of this discussion, the ability to acquire additional water through capacity construction or water conservation is assumed to be certain, at a present expected value cost of C_C. However, the outcome of seeking water through transfers is often less certain. There is a probability P_s, that the sought-after water transfer will indeed be completed. If the attempted water transfer fails, then the water seeker must pursue the more certain (assumed certain in this case) source of water. The approach developed here would be conceptually similar, but more complicated and awkward, for the common case of multiple uncertain sources.

The transaction costs of the potential water transfer come in two parts, the transaction costs borne just to attempt the transfer (T_1) and the additional transaction costs borne to complete an approved transfer (T_2). The initial transaction costs (T_1) would include the expected value of the costs of technical and legal work needed to support a transfer which must be incurred before it is sure that a transfer will be successful. The transaction costs needed to complete an approved transfer (T_2) would include additional technical and legal work and any agreed-upon third party compensation needed to implement the transfer agreement once the transfer has been approved.

If a transfer is attempted, but fails, there are likely to be additional costs in adopting the conventional water supply alternative (C_D). This could include any increases (or decreases) in the real costs of construction, the increased cost of retrofitting water conservation into new construction rather than initially building to high water use efficiency standards, and other factors that change over time that would affect the cost of more conventional acquisition of additional water supply.

If the water transfer is implemented, there are usually additional costs beyond the purchase cost of water (C_w) for the construction or use of aqueducts and reservoirs needed to physically support the use of transferred water (C_s) (Lund et al., 1992). These costs (C_s) also could include the need to purchase additional water for instream flow uses or to compensate for conveyance losses and additional (or diminished) water treatment costs where the transferred water is of a different water quality than the alternative or existing water supply.

All costs in this paper are assumed to be in terms of present values, neglecting for the moment uncertainty in the times when costs would be incurred.

Expected Value Decisions to Seek Transfers

The choice to seek transferred water or not is illustrated by the decision tree in Figure 1. The incremental expected present value of choosing to transfer water can be expressed by Equation 1.

(1) $$TC_C - TC_T = C_C - [P_s(T_1 + T_2 + C_w + C_s) + (1-P_s)(T_1 + C_C + C_D)],$$

where TC_C = the total expected present value cost of conventional water supply expansion,

TC_T = the total expected present value cost of an equivalent amount of transferred water,

C_C = the expected present value cost of conventional water supply expansion,

P_s = the probability that a transfer effort will succeed in acquiring the water,

T_1 = the expected present value of transaction costs prior to approval of a transfer,

T_2 = the expected present value of additional transaction costs, given transfer success,

C_w = the direct expected present value cost of purchasing the water in a proposed transfer,

C_s = the expected present value cost of storage, conveyance, and treatment facilities needed to make use of transferred water, and

C_D = the expected present value cost of delaying development of a conventional water source, given transfer failure.

If $C_C \leq C_w + C_s$, then there are no circumstances under which the transferred water should be pursued (assuming the conventional supply availability is relatively certain).

Equation 1 can be made dimensionless if divided by the difference in deterministic cost (without transaction costs) between transfer and conventional water alternatives $\Delta C = (C_C - C_w - C_s)$. Where transfers without transaction costs are deterministically preferred, ΔC is positive. This yields:

(2) $$\frac{TC_C - TC_T}{\Delta C} = \frac{C_C}{\Delta C} + P_s \frac{-T_1 - T_2 - C_w - C_s}{\Delta C} - (1-P_s)\frac{T_1 + C_C + C_D}{\Delta C}, \text{ or}$$

(3) $$\frac{TC_C - TC_T}{\Delta C} = P_s - \frac{T_1}{\Delta C} - P_s \frac{T_2}{\Delta C} - (1-P_s)\frac{C_D}{\Delta C}.$$

These terms can be consolidated into a dimensionless equation:

(4) $\Delta\gamma = P_s - \tau_1 - P_s \tau_2 - (1-P_s)\gamma_D$,

where the Greek terms are dimensionless ratios of costs corresponding to the terms in Equation 3. This reduces the number of variables to consider from nine in Equation 1 to five in the Equation 4. Where $\Delta\gamma$ is positive and $C_C \geq C_w + C_s$, water transfers should be pursued, even in the dusk of uncertainty, assuming expected value decision-making. Note that for $\Delta\gamma > 0$, all other dimensionless ratios must have values less than one.

The dimensionless ratios in Equation 4 are readily interpretable. τ_1 is the initial transaction cost as a percent of the deterministic difference between conventional and transferred water without transaction costs. τ_2 is the after-approval transaction cost as a percent of the deterministic difference between conventional and transferred water without transaction costs. And γ_D is the expected cost of delay as a percent of the deterministic difference between conventional and transferred water without transaction costs.

Where $\Delta\gamma$ is zero, the expected value decision-maker is indifferent between the two alternatives. A curve of indifference can be found by modifying Equation 4, setting $\Delta\gamma$ to zero and some manipulation:

(5) $\tau_1 = P_s (1 - \tau_2 + \gamma_D) - \gamma_D$.

This is plotted in Figure 2, illustrating the conditions and parameter values where water transfer attempts are desirable for the potential water purchasing agency. The result demonstrates the importance of uncertainty in the final approval of the transfer and temporal distribution of transaction costs before and after transfer approval for the evaluation of potential water transfers by potential water purchasers.

The quantitative importance of this result is demonstrated numerically with a simple example, with no costs of delay. Assume that the probability of a transfer attempt being successful (P_s) is 0.5 and that post-approval transaction costs is ten percent of the deterministic difference in costs between transfer and conventional supplies ($\tau_2 = 0.1$). For this case, using Equation 5, the pre-approval transaction costs could amount to at most forty-five percent of the deterministic difference in costs between transfer and conventional supplies ($\tau_1 = 0.45$). For these conditions, potential purchasers making expected value decisions would be willing to pay only 55% of the total transaction costs that they would be willing to pay under conditions of certainty. If the value of τ_2 is left at 0.1 and P_s is increased to 0.8, then the maximum value of τ_1 for the transfer attempt being favored increases to 0.72, increasing total willingness to pay for transaction costs to 82% of their deterministic value. Any costs from delaying implementation of the backstop water supply would reduce the optimality of seeking water transfers under uncertainty.

Expected Utility Decisions to Seek Transfers

The foregoing analysis assumes a water purchaser's decision is based on a present expected monetary value criterion. In reality, most water agencies are likely to be somewhat risk averse. Formally incorporating risk aversion into this analysis would require introduction of utility functions. However, the expected value approach still has value in illustrating the importance of uncertainty in the evaluation, design, and institutional establishment of water transfers. For the case examined above, the introduction of risk aversion only makes water transfers less attractive than under expected monetary value analysis.

Interaction of Success Probability and Transaction Expenditures

The preceding analysis assumes that the probability of ultimate success for a proposed water transfer is independent of the resources the water seeker devotes to the effort. In many cases, the probability of ultimate success for a water transfer is likely to be related to the amount of legal and technical preparation (initial transaction cost T_1) devoted to the transfer and the compensation the water seeker is willing to pay to third parties (part of T_2). Functionally, consideration of the interaction of success probability with different transfer costs causes P_s to be replaced by $P_s(T_1, T_2)$.

This likely interaction of success probability with the resources devoted to the transfer leads to a subsidiary decision-making problem. How much should be spent in initial and final transaction costs, assuming that seeking a water transfer is desirable? Using an expected monetary value decision criterion, this is equivalent to maximizing the value of the choice to seek a water transfer.

The total cost of the choice to seek a water transfer, including interaction of success probability with transaction costs, is:

$$(6) \qquad TC_T = P_s(T_1, T_2)\,[T_1 + T_2 + C_w + C_s] + [1-P_s(T_1, T_2)][T_1 + C_C + C_D].$$

Minimizing this expected total cost can be achieved by setting the derivatives of Equation 6, with respect to T_1 and T_2, equal to zero. This provides two first-order conditions, where the asterisked variables are at their optimal levels:

$$(7) \qquad 1 = \frac{\partial P_s(T_1^*, T_2^*)}{\partial T_1}\,[C_C + C_D - T_2^* - C_w - C_s], \text{ and}$$

$$(8) \qquad P_s(T_1^*, T_2^*) = \frac{\partial P_s(T_1^*, T_2^*)}{\partial T_2}\,[C_C + C_D - T_2^* - C_w - C_s].$$

Dividing equation 8 by equation 7 yields:

$$(9) \qquad P_s(T_1^*, T_2^*) = \frac{\dfrac{\partial P_s(T_1^*, T_2^*)}{\partial T_2}}{\dfrac{\partial P_s(T_1^*, T_2^*)}{\partial T_1}} = \left.\frac{dT_1}{dT_2}\right|_{P_s^*} \leq 1,$$

giving the trade-off between initial and contingent transaction costs. Since the probability of a successful transfer is always less than or equal to one, the planner would always prefer transaction costs to be contingent on the successful completion of the transfer, $P_s(T_1^*, T_2^*)\, dT_2 = dT_1$. This effect is beyond any benefits of delaying transaction costs due to discounting.

Risk aversion for this problem of selecting investment levels for various types of transaction costs is likely to increase the investment in both types of transaction costs, T_1 and T_2, a bit beyond these levels. Little more can be said, given that the function $P_s(T_1, T_2)$ has an unknown and probably highly variable form (possibly discontinuous in reality), perhaps unique to each situation. Were this function known, the remainder of the decision analysis would be to employ the resulting T_1^*, T_2^*, and $P_s(T_1^*, T_2^*)$ in Equations 1 through 5 above in deciding whether to seek transferred water.

Staged Decision-Making

In reality, the uncertainty in approval for water transfers occurs in several stages, from early internal consideration in an agency through potential final court challenges after regulatory approval. The probability of ultimate success for a transfer will change through this course of consideration and litigation. The expected present value of costs is also likely to change throughout this course.

The above analysis considers only the early stages of consideration of water transfers. There are likely to be several stages of consideration of water transfers, perhaps each with its own transaction costs (whose amounts may also be uncertain). These legal and approval uncertainties may extend beyond the mere success of a transfer to include uncertainty in the amount of water that is ultimately legally available for transfer (Ellis and DuMars, 1978). Following legal or regulatory approval of a transfer, there are further uncertainties and costs regarding the deliverability and the delivered amount of legally transferred water, including the loss of water through the operation of the conveyance and storage systems needed to physically transfer transferred water (Lougee, 1991; Lund et al., 1992). Potential water purchasers are likely to reassess the desirability of continuing to pursue water transfers at each stage, with updated cost and probability estimates, including the neglect of already incurred sunk costs.

IMPLICATIONS

Transaction costs have long been studied as a major problem in the adoption of water transfers in the western United States. Some suggestions for reducing the transaction costs of water transfers include: increasing the scale of individual transfers, reducing opposition to transfers, more firmly assigning property rights, providing greater dissemination of information on water transfers and water market conditions (to lower search costs), and establishing water broker institutions (MacDonnell, 1990; Brajer et al., 1989). Some of these suggestions for decreasing transaction costs also would seem to increase the probability that water transfer attempts will be successful. Other suggestions for decreasing transaction costs, such as increasing the scales of transfers, might actually increase transaction risks.

Measures to Reduce Transaction Risk and Its Effects

One approach to reducing the impact of transaction risk is to increase the probability that an attempted transfer will be completed. Some particular measures that would tend to decrease transfer risks include: increasing the certainty that the transfer of water will not jeopardize the rights of the water-right holder (water seller), establishing firmer regulatory and legal guidelines for the management of third-party impacts, and establishing firmer regulatory and legal guidelines for the approval of water transfers. This is a fairly direct approach to reducing the effects of transaction risk.

The temporal distribution of transaction costs also can reduce or amplify the effects of uncertainty in transaction outcome. This is evident from inspection of Equation 1. Transaction costs incurred after approval of a transfer are preferred to costs incurred before transfer approval. Thus, purchasing parties should prefer to commit a larger amount of money for addressing potential third party impacts after the transfer has been completed than they are willing to spend on legal and technical work to eliminate third-party challenges to a proposed transfer. This is particularly true if such post-approval expenses further increase the probability of a transfer being approved and completed. There is a tendency to seek out transfer arrangements for which transaction costs tend to correlate well with favorable outcomes (e.g., transfer approval), particularly for risk averse purchasers of water. This agrees with Cheung's (1969) more general findings on the negotiation of contracts in the presence of risk and transaction costs. The effect of discounting future costs increases this preference for delaying transaction costs.

Ironically, some of these measures to reduce transfer risk could increase overall transfer costs for successful transfers. For example, establishing firmer, more certain standards for third-party impacts might increase the expected cost of managing third party impacts in some cases while reducing the ability of third parties to jeopardize transfers in other cases. The net effect could still be to increase the attractiveness of water transfers to water purchasers, particularly for risk averse parties.

The Role of Institutional Settings

The case of the recent California Drought Emergency Water Banks of 1991 and 1992 supports the role of decreased risk in increasing the success of water transfers. This water bank was sponsored by the State Department of Water Resources and accompanied by items of supporting State legislation (DWR, 1992). Water was purchased by the State and sold by the State to agricultural, urban, and environmental water users. Prices and terms were fixed by the State. While such an arrangement greatly reduced the negotiating and technical costs to the initial seller and ultimate buyer of the water, the water bank arrangement also appears to have greatly increased the perceived probability of successful transfer by all parties. By using the State as a banker and using emergency legislation to avoid concern with environmental impact reporting and loss of water rights from temporary sale of water, a deal could be sought with the State with a high certainty of outcome. The effects of increasing the probability of transfer success should not be overstated, in this case, however. The difference in costs between transferred water and alternatives was also seen as being very great during these drought years (Lund et al., 1992).

Other Applications for Transaction Risk

Uncertainty in the outcomes of negotiations and approval of transactions would seem to have a role in other areas of environmental economics. Are marketable pollution permits shunned a bit because they are seen as risky? Are negotiated solutions to externality problems shunned because the transaction costs and risks of such negotiations, including costs of delay, are seen as being greater than those of resolving these externalities by litigation or even simply accepting continuation of the externality?

CONCLUSIONS

Transaction risk and the temporal distribution of transaction costs should have an important impact on the desirability of water transfers from the perspective of prospective water buyers. In general the prospects for water transfers can be improved by:

• increasing the probability that water transfer attempts are successful, even where increasing the probability of a successful attempt increases transaction costs to a limited degree,

• loading transaction costs for water transfers after the time when transfers have been approved or completed (discounting gives further incentive for this), and

• minimizing the costs associated with delayed implementation of conventional water supply expansion and water conservation alternatives, which would be employed should a transfer attempt fail.

Recent State-sponsored water banking efforts in California seem to support the importance of reducing transaction risk as well as transaction cost in effecting water transfers in the western United States.

ACKNOWLEDGEMENTS

Mimi Jenkins and Morris Israel are thanked for their perceptive and useful comments on an earlier draft. The associate editor and two anonymous reviewers are thanked for their useful and thoughtful comments.

REFERENCES

Brajer, V., A.L. Church, R. Cummings, and P. Farah (1989), "The Strengths and Weaknesses of Water Markets as They Affect Water Scarcity and Sovereignty Interests in the West," *Natural Resources Journal*, Vol. 29, Spring, pp. 489-509.

Cheung, S.N.S. (1969), "Transaction Costs, Risk Aversion, and the Choice of Contractual Arrangements," *Journal of Law and Economics*, Vol. 12, No. 2, April, pp. 23-42.

Colby, B.G. (1990), "Transaction Costs and Efficiency in Western Water Allocation," *American Journal of Agricultural Economics*, December, pp. 1184-1192.

DWR (1992), *The 1991 Drought Water Bank*, California Department of Water Resources, Sacramento, CA, January.

Ellis, W.H. and C.T. DuMars (1978), "The Two-Tiered Market in Western Water," *Nebraska Law Review*, Vol. 57, No. 2, pp. 333-367.

Gray, Brian E. (1990), "Water Transfers in California: 1981-1989," in MacDonnell, Lawrence J.(Principal Investigator), *The Water Transfer Process As A Management Option for Meeting Changing Water Demands,* Volume II, USGS Grant Award No. 14-08-0001-G1538, Natural Resources Law Center, University of Colorado, Boulder.

Lougee, N.H., (1991), "Uncertainties in Planning Inter-Agency Water Supply Transfers," in J.L. Anderson (ed.), *Water Resources Planning and Management and Urban Water Resources*, ASCE, New York, pp. 601-604.

Lund, J.R., M. Israel, and R. Kanazawa (1992), *Recent California Water Transfers: Implications for Corps Facilities Nationwide*, U.S. Army Corps of Engineers Hydrologic Engineering Center, Davis, CA.

MacDonnell, L.J. (1990), *The Water Transfer Process as a Management Option for Meeting Changing Water Demands*, Volume I, USGS Grant Award No. 14-08-0001-G1538, University of Colorado, Boulder, CO.

Nickum, J.E. and K.W. Easter (1991), "The application of transaction cost economics to Asian-Pacific metropolitan water-use issues," Regional Development Dialogue, Vol. 12, No. 4, Winter, pp. 3-15.

Figure 1: Decision tree representing a simple transfer decision problem

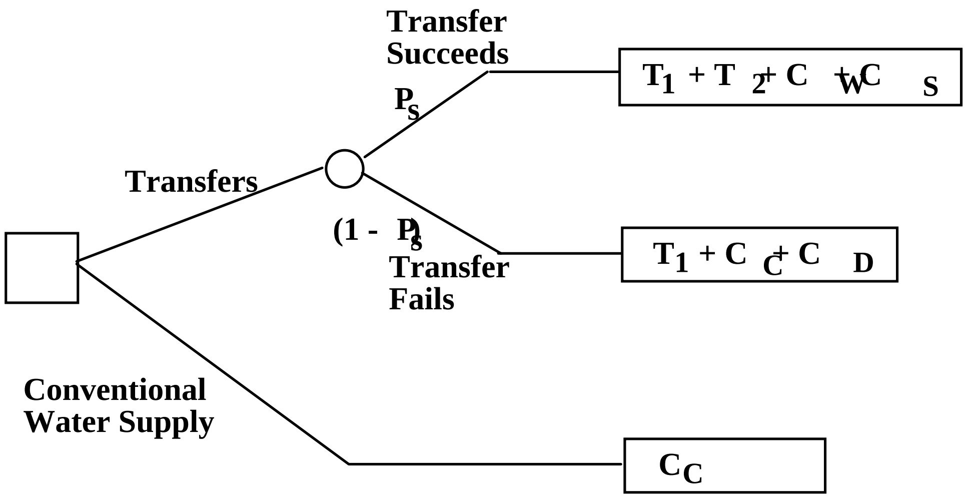

Figure 2: The dimensionless desirability of attempts at water transfers as a function of the probability of transfer success