RURAL ECONOMY

The Role of Economic Instruments to Resolve Water Quantity Problems

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Project Report 97-02

PROJECT REPORT

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Report to Environment Canada on the Project: Economic Instruments for Water Resource Allocation. Project Leader: T.S. Veeman, University of Alberta. Researchers: W.L. Adamowicz, University of Alberta, J.R. Church and T.M. Horbulyk, University of Calgary.

This research was funded by Environment Canada through the University-Based Research Program on Economic Instruments. The views expressed here are not necessarily those of Environment Canada, and any errors or omissions are the authors' alone. The authors acknowledge the valuable role played by colleagues Jeffrey R. Church and Terry S. Veeman in designing and executing many aspects of the research project upon which this paper is based. At the time of writing Horbulyk was Visiting Associate Professor in the Department of Agricultural and Resource Economics at the University of New England, Armidale, Australia, and *UNE's* research support is gratefully acknowledged.

The Role of Economic Instruments to Resolve Water Quantity Problems

If economic instruments are to play a role in the resolution of water quantity problems, then two important preliminary steps will be to assess what those problems are and to ascertain what scope there is for resolving them with policy reforms. The next section of the paper addresses these two issues. The following section reviews the importance of property rights and compensation to any broadly based policy reforms. Subsequent sections report on research into the use of water markets and water pricing to address problems associated with water quantity allocation. Three empirical studies are summarized that attempt to quantify the potential role to be played by these economic instruments in southern Alberta. Brief concluding comments follow.

The Nature of Emerging Water Quantity Problems and Solutions

There is not, in general, one water quantity problem, but an overlapping and inter-related set of water quantity problems.[1] For example, there are *surface* water supply shortages that, in various regions, may be acute, chronic or intermittent (i.e., problems related to the reliability of surface water supply). Consumptive users of water may experience these problems or, alternatively, instream flow uses may be the prime casualty. There are problems of *groundwater* supply that can appear as shortages, as increased costs of access, or as specific problems of diminishing aquifer storage capacity, saline intrusion, or land subsidence, to name a few. Problems of water quality, though not the focus of this paper, may be closely related, and in some instances are a symptom of the quantity allocation problems that are present. These water problems share a number of common causes and may be remedied by some, but not all, of the same policy responses.

Often water allocation problems are considered to be technical or natural issues arising from our inability to "capture" sufficient water for human use or from the impact of natural variability of water supplies. However, the consumption and allocation of water resources are dependent on the human institutions created for these functions. It is these institutional mechanisms that economists are concerned about. Water shortages, water quality problems and other water resource problems are often primarily problems of inefficient institutions rather than problems of inadequate technology.

By any definition of "economics," water quantity allocation is an "economics" problem. Although multidisciplinary approaches are to be encouraged, economics can help one to ask the right questions and can suggest some possible answers. Society's objective in such an exercise might focus on issues of economic efficiency—that is, gaining the highest and best use of the available water, including instream and non-consumptive uses, at least cost—but this is unlikely to be the sole objective. People may also have concerns about the fairness of the water policy reform process and of the outcomes attained. Governments will be concerned about their costs and ability to administer, enforce and monitor any policies that are proposed.

An economist can abstract from the specific stresses and hardship that accompany acute water shortages and can generalize that shortages merely reflect an excess of quantity demanded over quantity supplied at the going price. Since both quantity supplied and demanded are almost always responsive to economic incentives such as prices, subsidies and taxes, so too will shortages be responsive to these variables. The economist's perspective is likely to be that, technology and hydrology permitting, a shortage of water is merely a shortage of money or wealth. Unfortunately, it is a shortage all the same!

To deal with shortage, there is a long list of potential sources of new supply that could be developed. Historically, attention has been focused on increasing the capacity to divert and store surface water, such as with dams and diversions. Growing public protest over recent projects suggests that these may no longer be the least-cost sources of supply. Alternatives include investments in increased groundwater supply (including groundwater recharge schemes and preventing the loss of aquifer storage capacity), increases in system reliability, and purifying water that is saline or wastewater. Importantly, the pursuit of any of these options might be encouraged by increasing the marginal cost of water to those who consume it (or by increasing the marginal revenue to those who would supply it).

Another approach to alleviating water shortage is to reduce water demand. Water conservation and so-called "demand-side management" may be less costly means of balancing supplies with demand—and of gaining the highest return from the water used. Here the list of available options is also long and varied. It includes decreasing storage and distribution losses through improved system design and operation; decreasing water use through changes in crops and agronomic practices (including changes in the timing and method of irrigation application); and improving soil moisture retention. Once again, the rate of adoption of these approaches will be responsive to marginal costs or returns.

The current interest in various types of economic instruments to help resolve problems of water quantity allocation is based upon recognition that technical solutions exist and that solutions can be adopted more quickly when the "appropriate signals" can be provided by public policy and by market forces in general.[2] "Economic instruments" can include any of a wide range of schemes that bring market forces to bear on water quantity allocation decisions. Examples include tradable water entitlements or permits, water banking schemes, water pricing, and various storage authorizations that link, for example, surface and groundwater uses, or storage and diversion uses. These economic instruments can be defined and established in water law as part of a government's reform of existing water policy.

Prior to considering the specific contributions that any of these economic instruments might make to resolving water quantity problems, it is important to recognize that any reform of existing water policies might be seen by some people as redefining—indeed, as even confiscating—the rights and entitlements these people currently enjoy. The potential for legal and constitutional restrictions on water policy reform, or a potential requirement for specific financial compensation are important issues to be addressed by those who would consider such reforms.

Property Rights and Compensation as Potential Impediments to Water Policy Reform

Where a set of proposed water policy reforms affects landowners, water users and related third parties, the effects of regulatory change may be capitalized into the market value of the lands where the water could be used. When capital losses occur, there may be claims from landowners for public compensation. If compensation is not provided, there might be legal action to halt or reverse the policy changes.

In the United States, this "property rights" issue has received considerable legislative attention at the national and state levels in the early 1990s. There is every reason to think that the underlying public sentiments have also been noted by Canadian policy-makers. In the U.S., regulation-related capital losses by land owners can represent “regulatory takings” and, when they do, the Fifth Amendment to the U.S. Constitution requires that just compensation be paid to injured landowners. Importantly, U.S. constitutional compensation requirements do not seek to compensate, fully or even partially, all of those harmed financially by a regulatory change. (An interpretation of the U.S. “regulatory takings” clause is that the market valuation of any individual’s potential use of water and land resources after a policy change must not be less than that value before the change, or else a liability exists to set these valuations equal through compensation paid by government.) Even so, legal constraints of this type might well stand in the way of proposals to employ economic instruments.

In Canada, no similar legislative or constitutional requirements for compensation exist. All the same, there are numerous recent precedents for Canadian governments to provide compensation voluntarily, such as when eliminating rail freight subsidies under the Western Grains Transportation Act, or in buying back unusable fishing licences following the closure of specific fishing grounds. The new Alberta Water Act (a revision to the nearly 100 year old Alberta Water Resources Act) provides for compensation if a water licence is amended or cancelled, however, this same Act outlines a mechanism by which a portion of water transferred in a transaction may be held back by the government, without compensation. If Canadian governments feel an obligation to compensate for losses caused by regulatory change, and if the reduction of public deficits and debt is a high priority, might this preempt further reform of water policies for the foreseeable future?

Potentially many elements of a re-designed water policy, such as new provisions for instream flow uses or a new system of pricing, could cause water users’ capital values to decrease. At the same time, other elements of re-designed water policy could increase the value of a water permit, and if present, could act as “non-monetary compensation” or “compensation-in-kind” that partially or fully compensates for any decrease. Finally, other elements of a new policy could be calibrated so as to increase or decrease this capital value, *ceteris paribus*.

Fortunately for the policy reform agenda, there are numerous elements that can be included in a water policy reform proposal that have the potential to increase both capital values *and* the efficiency of water resource use. Examples include policies that promote and facilitate market transactions for tradable permits; policies that minimize the cost of obtaining regulatory approvals (especially for short-term trades); and policies that guarantee the longevity and restrict the size of the stock of permits in circulation. Similarly, charging (higher) volumetric prices for water access would lower capital values but these effects might be offset by appropriate social investments in system reliability or water quality, for example.

If policy makers are concerned about regulation-related capital losses then the policy makers' challenge is to construct and to implement a set of policy reforms that serves two purposes. One purpose is to improve the allocation of water quantity in a manner that serves society's objectives with respect to economic efficiency, social equity, and so on. The other objective is to ensure that set of changes does not decrease resource rents (and thus capital values) to landowners.

The Potential for Water Markets

The move to water markets as an allocative device is one attempt to employ the information that can be conveyed by price signals to improve upon the allocations that would otherwise be used. At their best, such market signals can indicate, on an up-to-the-minute basis, the relative (private and perhaps even social) values of water in a variety of uses, fully incorporating the knowledge and expectations of a wide range of industry participants.

There is considerable scope to learn about potential water markets by observing others. For example, one can observe other jurisdictions' experience with various water allocation methods. One can also draw on current practice in other related sectors of the economy (e.g., electricity distribution, natural gas distribution, individual transferable quotas in the fishery, and so on). In this way, one can identify at the outset many design parameters that might or might not be used in a reform of water policy. Thus, any comparative evaluation of various economic instruments will also need to pay attention to issues of instrument design.

In the case of tradable permits, water pricing, and so on, the questions to be asked in advance of policy reforms are similar. Where will the water be allocated under the proposed scheme? What benefits and costs will be incurred and what prices (if any) will be charged? Who will win and lose relative to the status quo, and by how much? Are there combinations of policy instruments that will have a more beneficial effect than any one instrument alone? The following section reviews recent research undertaken in Alberta to examine these issues.

The Value of Water Rights

Before embarking on an examination of the potential of water markets, it is necessary to understand the nature and the value of the "good", water rights. Water rights in Alberta are allocated on the basis of administrative apportionment (Veeman and Freeman, 1993). That is, the rights to certain quantities of water are based on licences that are priority dated. If one individual (or industry, municipality, or irrigation district) holds a licence dated earlier than another party, the former has priority over their full amount of water in times of shortages. This approach to water allocation is quite common in western North America and arose from the problems associated with riparian rights systems in these relatively arid regions. However, these licences are also commonly tied to specific parcels of land. Thus, the value of the water right is capitalized into the value of the land.

Royer (1995) examines the value of water rights in southern Alberta using a hedonic price analysis. He examines 230 land sales in 8 counties that included a mixture of parcels with and without water rights. The gross difference in the price of irrigated versus non-irrigated parcels was $342 per acre. However, this difference does not account for the fact that irrigated sites may be on higher quality soils and may have had more capital investment. Thus, a hedonic price analysis is performed. After taking into account the soil type differences, distance to major urban centres, and other factors that affect land value, the value of the water right is isolated. This value, for the transactions that took place in 1993, is approximately $190 per acre. The average value of an acre of land in this data series is $648, thus, the value of a water right constitutes about 30% of the value of the land.

Royer's results show that water rights have significant value in agriculture. Thus schemes that permit the transfer of water rights from one agricultural user to another may lead to considerable increases in efficiency if the historical allocation of licences does not allow the most highly-valued current uses. Royer attempts to examine the variability in water value over the region, but fails to find a significant difference among regions. This may be due to the fact that there is not enough variation in the land sales data to permit identification of a regional effect. Alternately, the lack of regional variation may be because the particular year in which the study was carried out was a period of growth in livestock prices. Thus many land purchase decisions were based on investment in cattle enterprises and thus were quite similar across the study area. Nevertheless, given the high value of water rights and some degree of heterogeneity among users, it is clear that some form of economic instrument would be an efficiency-enhancing allocation mechanism.

The Gains from Water Markets

While Royer's research examines the question of the value of water rights within agriculture, water transfers may be more likely to occur between agricultural and industrial or municipal sectors. Recent research undertaken at The University of Calgary examines the questions of impact, gains, and distribution of benefits from water markets with respect to the potential trade in water among rural and urban users in the South Saskatchewan River Basin of Alberta (Lo 1995, Lo and Horbulyk 1996). A mathematical (quadratic) programming approach is employed operating on the assumption that water trading outcomes under competitive market conditions would be equivalent to optimal outcomes imposed by a social planner operating with full information about resource valuations. Importantly, water is demanded for not only rural and urban uses, but for instream flow needs and to meet an interprovincial apportionment agreement with down-stream provinces. The model is a static representation of short-term behaviour, with water supply data selected to represent an acute drought with flows at the level that are exceeded historically with 90% frequency.

There are four sub-basins in the study region and four scenarios are presented that examine how water would be allocated as the scope of market trade is expanded in steps. In Scenario 1, no trade is allowed and the optimal allocations are constrained to replicate historical entitlements. In Scenario 2, trade is allowed between rural and urban users in a sub-basin, but no trade is permitted across sub-basins. In Scenario 3, trade is permitted among and within basins, but water used for instream flows and for interprovincial allocation continues to be sourced (exogenously) following historical practice. In Scenario 4, water procurement is also endogenized for instream flow needs and interprovincial apportionment, as if the agency responsible participated in the new market to ensure the least-cost source of supply. The model is calibrated using representative data on rural and urban water values that vary spatially across the study area.

The salient features of the results are that only about ten percent of the available supplies need be transferred from rural to urban users to achieve the optimal allocation in the drought conditions simulated. Static measures of aggregate consumer and producer welfare from participation in water markets increase by over 50% (a gain of over $500 million per season) in Scenario 4 (unrestricted trade) compared to the base case (no trade). Importantly, 90% of this gain is achieved with only modest reforms (Scenario 2) without a need to establish inter-(sub-)basin transfers.

The distribution of these resulting gains depends on the property rights specified as part of the policy reform package. In the case where water is not priced, but where the optimal solution is imposed (without compensation to those whose entitlements are lowered) the urban users (collectively) gain at the expense of rural users (collectively) although rural users in at least one sub-basin gain from this change. If the Crown were to charge the market-clearing prices in each sub-basin as a means of imposing the optimal solution (and to return these resource revenues to the Provincial Treasury), then urban users would still achieve some gain (in consumers' surplus) at the expense of rural users who would lose. Alternatively, if historical entitlements to water were enshrined in the policy reform, then rural and urban users could be allowed their historical annual water entitlements without any charge, and could be allowed to trade these entitlements among themselves. The welfare of both groups increases with trade (relative to the status quo) under such an outcome since all trades are voluntary movements of a commodity from lower to higher valued users. These examples show only a few possibilities for distributing the efficiency gains that are due to the achievement of efficient market allocations. Other distributions may be identified that favour each group to a greater or lesser degree.

Although the line of inquiry reported here is short term, it provides a modelling framework that could be calibrated to show long run outcomes as well. In the long run, one would expect agents to respond to higher water costs by substituting other water sources, technologies and crops, for example, and this would be shown in revised—more price elastic—demand and supply parameters. The equilibrium water prices (dual solution values to the model) and the magnitude of annual welfare outcomes would be expected to be lower once water users have time to make these other long run adjustments.

This line of inquiry also allows consideration of adjustments external to the model, such as revising the downstream apportionment agreements with other provinces, or revising the upstream authority to store surface water, such as for hydroelectric generation. Either event can be represented as relaxing a specific (spatial) supply constraint to reveal new water values in total, on average and at the margin.

One extension of this research has been proposed and implemented by Mahan (1996) wherein he incorporates a more diverse set of water users, including industrial users and hydroelectric generators. He also includes a richer description of non-consumptive uses and represents demand with less spatial aggregation than in the earlier work.

The Potential for Water Pricing

Another potential policy reform is the use of some form of water pricing as a quantity allocation device. Two distinctions become important at the outset: the purpose and the form of water pricing. Each will be discussed in turn.

First, when economic efficiency is an important objective of policy reform, pricing will be worth considering for its ability to apportion and to allocate water under scarcity. Some forms of pricing are capable of generating market information to the resource managers about the appropriateness of current capacity levels, and about the markets' valuation of proposed capacity expansions. It is important that pricing be evaluated not (solely) for its potential to generate revenue. Indeed, the allocative effects of water pricing could be achieved even if every dollar of the resource royalties collected under a new pricing scheme were returned to the water users, provided that the amounts returned to each specific user were not based on actual usage levels. For example, one might propose "patronage rebates" based on the volume of water each user is *entitled* to draw, whether or not that right is fully exercised. In this case the intended allocative effects could still be realized without having extracted any revenue, in aggregate, from the community of water users. Importantly, all users should face a positive price for the marginal unit of the scarce resource even in the presence of the rebate scheme.

There are many forms of pricing that one could contemplate, where there are potential efficiency gains from choosing or designing pricing schemes that match the specific circumstances of water demanders and suppliers in a region. For example, in general, water prices that are to influence use levels should be charged on a volumetric basis and not on a flat annual fee that is independent of usage. This implies that the effective implementation of such pricing schemes will be reliant on the Crown's ability to estimate or meter authorized water consumption, to collect associated fees and to enforce against unauthorized or unmetered withdrawals. If pricing schemes are to focus on total water *consumption* as distinct from total water *diversion*, there will also be a need to measure or estimate return flows to (surface) water courses.

There remains considerable latitude for implementing a variety of volumetric pricing schemes. For example, one might employ a single price per cubic metre for all water used (constant unit charge), or a price per cubic metre that rises or falls as monthly or annual consumption levels reach higher and higher levels (so-called increasing or decreasing block rates, respectively).

Two part pricing presents a water tariff or charge that includes some charge per cubic metre consumed plus some other charge that is independent of consumption, such as a fixed monthly or annual fee for a specific type or class of service. Such tariffs are common in municipal and residential water pricing. If this type of rate is to influence users' consumption levels then the per unit charge must be levied from the lowest expected levels of use, and not only after some significant threshold volume. Otherwise, some users will face a price of zero for their marginal uses.

Peak-load pricing, interruptible pricing and priority pricing are specific methods of practising price discrimination in the pricing of water. That is, different prices are charged (to the same or different users of the water) for various units they consume and these price differences are not solely due to differences in the cost of provision.

Pricing schemes and tradable water rights can be viewed as alternative or complementary approaches, each of which relies on an informed and effective regulatory authority if that approach is to be implemented successfully. In the case of trading, there is a need for the regulator to determine the amounts of water available for trade in any given month so that instream flow needs can be met and local shortages avoided. Whereas the regulator determines the available quantity, the market participants negotiate the prices at which water trades occur. A well-known problem with introducing a scheme of tradable water rights is how to deal with any pre-existing stock of under-utilized water licences (NERA, 1992). These would be expected to be offered for sale on the new markets, shifting in status from under-utilized to fully-utilized, making problems of water shortages grow worse not better. Various solutions include having the Crown purchase or confiscate some percentage of the outstanding stock, either immediately or as a "tax" on water trading transactions. Alternatively, regulators might need to make greater use of priority rationing rules and mechanisms that are historically defined for these water rights. In the case of water pricing schemes, the regulator also needs to set prices that are sufficiently high for the available water to be allocated efficiently without shortages developing—especially if pricing is introduced as a substitute for historical licences or quantity limits.

Hatch (1995) examines a water pricing innovation whereby the fees paid in advance by water users depend not only on the volumes of water to be consumed, but on the (guaranteed) probability of receiving those volumes even in the event of shortage.[3] Under this type of "priority pricing" the water authority charges a higher price in all periods to users who value a reliable or assured supply. These users are granted full or partial exemption from water rationing in periods of shortage. Since any rationing that ultimately occurs has been based on market participants' own valuations of service reliability, these schemes are capable of generating efficiency gains whenever there are systematic differences in the value of reliability among uses or users. Moreover, the market valuations that are observed provide valuable information about whether further investments in reliability of supply are warranted.

Variants on innovative water pricing are also explored by Peacey (1995). This work reviews a number of water pricing alternatives ranging from peak-load pricing through “interruptible pricing” to “priority pricing” and compares these alternatives to the use of spot markets as a water allocation mechanism. Each of these schemes differs in terms of the information that would be required by market regulators and market participants to exploit any potential efficiency gains. These gains derive from better allocation of a scarce water resource in times of shortage and also appear as more appropriate levels of investment in system reliability and capacity.

The Impact of Water Pricing and Rights Trading on Agriculture: A Case Study of Alberta’s Eastern Irrigation District

The largest user of water in Alberta is agriculture. In some years, irrigation users in Alberta make up a large proportion of the total water used in Canada. Historically, water resource developments have played a large role in the development of the communities and industries in regions like southern Alberta. It is relatively clear that these users may be significantly affected by changes in water institutions. Thus, a detailed case study of an irrigation district was performed to examined how it would be affected by water prices or by water demands from outside of the district (Viney, Veeman and Adamowicz, 1996). In southern Alberta, agricultural water rights are typically held by the irrigation district and not the individual farms. However, this study examines the changes that may occur if reallocation of water within a district is allowed.

Models of twelve representative farm types in the Eastern Irrigation District (EID) are constructed and aggregated to produce a model of the entire district. Income statements for the twelve representative farm types are first derived from typical farm revenue and expenditure scenarios. Linear programming is then used to determine the optimal output mix and productive value of irrigation water for each farm given a profit maximizing objective that is subject to agronomic constraints and changes in water availability. The resulting individual farm water demands are then discussed in terms of the potential for water reallocation given transferable water rights and water quantity reductions.

There is a considerable variability in the derived water values across the twelve farms types. Values of water range from $250 per acre foot to $8 per acre foot, depending on the enterprise mix. This illustrates that there is sufficient heterogeneity within the EID to accommodate a transferable rights system and to provide social gains. One of the most important requirements for the functioning of such a market is heterogeneity in demands among the users (NERA, 1992).

Based on the results of these farm budget water demand analyses, the introduction of transferable water rights will facilitate a proportional increase in the use of irrigation water for the production of high valued specialty crops relative to traditional pasture and cereal crop usage. However, increases in specialty crop production will be limited by the financial risk component of specialty crop farm investments and by an uncertain marketing potential.

With transferable rights and increasing water costs, the specialty crop producing farms will have the net income to purchase nearly all of the water that they apply from the traditional farms, everything else being equal. This conclusion is based on productive water values of approximately $100 to $350 per acre-foot for specialty crop farms and $10 to $68 per acre foot for traditional farms. Small irrigated pasture operations and traditional cereal crops producers will be the first to give up water in favour of dryland production in the event of water quantity reductions or in response to rising prices for water that induce sales of water rights. It is worth noting, however, that the demand curve for water is relatively inelastic and that very little transfer of water is initiated for any value less than $10 per acre foot.

Although specialty crop production generates a high productive water value, it also generates a very high financial risk. The risk-return trade-offs are not unreasonable given the capital market comparison, although the probability of observing larger negative returns will be a deterrent to expanded specialty crop production.

In summary, the analysis indicates that there is considerable potential for gains from water trade within the EID. The additional impact of trading with industry or municipalities would be a reduction in pasture operations and traditional cereal operations, although the willingness to pay for water from these non-farm users would have to be relatively high to attract significant water trades.

Conclusions

Economic instruments for water quantity problems have been largely unexplored in Canada, particularly in the agricultural sector. With increased demands for protection of instream flow needs, increased occurrence of water shortages and with intended movement toward efficient uses of resources, there appears to be great potential for the use of some forms of economic instruments.

Instrument choice will depend on the uncertainties that policy makers and resource managers are willing to take on. If water prices are chosen to aid in rationing water, the quantity response will be uncertain. A quantity instrument like tradable permits on the other hand will result in uncertain prices but will guarantee that quantity limits are maintained. However, allowing trade in quantity instruments may create shortages if there are "sleeper licences." For tradable permit schemes to function well there needs to be sufficient activity in the market and no significant market power. To this end, water banking schemes or other market intermediation may be valuable components of some new trading schemes.

There are also concerns about the distributional impact of tradable permit schemes. For example, communities may be severely affected if the water rights held by local farmers are purchased by individuals outside of the sector. These equity concerns have lead to the placement of constraints on trading schemes or the requirement for pre-trade approval processes in the U.S., for example. For the process to yield social gains, however, trades must take place and reallocations must be realized. If there are regulations restricting trades, or if trades are associated with "holdbacks" (removals of certain quantities of water to provide for instream flow protection each time a trade occurs) the potential gains from tradable water rights mechanisms will not be realized. The key will be to design the mechanism such that sufficient trading will occur, without having detrimental effects on third parties or environmental quality. There is a tradeoff between the degree to which the market alone is allowed to signal the scarcity value of water and the degree to which criteria such as environmental concerns, third party effects and equity concerns are addressed. It seems that an effective tradable rights scheme needs to be preceded by a river basin plan outlining minimum instream flow requirements and defining the amounts of water available for diversion and consumption.

Instrument choice also will be influenced by natural features of the water courses, but probably more importantly, it will be affected by the economic, political, and social aspects of the situation. In Alberta, proposed tradable water rights, for example, appear to be accepted reasonably well by the parties involved with the resource (Alberta Water Management Review Committee,1995). This is likely so because the allocation of tradable water rights is based on the separation of these rights from the current combined land and water rights in a way that does not harm many land owners. This is an analogous effect to the introduction of marketable pollution permit schemes that allocate rights based on historical pollution levels. The difference is, however, that water rights have always been associated with land and these values are already capitalized into the land values. Nevertheless, because this situation involves little immediate threat of capital loss compared to the status quo, it is accepted by the stakeholders.

Water prices are often proposed as an alternative instrument to tradable water rights. Water pricing, however, is plagued with the label of being a "tax grab." Thus, this instrument is often the source of considerable political debate and of conflict between stakeholders and the government. Even though royalty payment structures are common in oil, gas, coal and forestry sectors, similar payments for the use of water are commonly viewed as unacceptable by the agricultural community. This is an unfortunate situation given that novel pricing mechanisms may have a great deal to offer in terms of social gains from resource reallocation. It may be worth investigating some form of revenue-neutral institutional change that involves pricing and lump-sum redistribution. Such an approach would send the appropriate resource use signals while maintaining the revenue situation of the users. The practicality of such schemes, given transactions costs and other considerations, may be limited.

In the future there will probably be even more strain on water resources and water resource institutions. Increasing demands for improved water *quality* and increased instream flows are becoming evident in the political arena. Institutions that are responsive to such demands must be the goal of policy makers. While water basin planning may provide for some of these demands, decentralized mechanisms to address water quality issues should also be considered. Tradable right systems may offer some potential here, although the link between tradable quantity rights and water quality determinants is not well established. An additional policy concern should be to maintain the flexibility of our allocation institutions in a world with changing natural conditions. The forecasts of climate change and changing temperature and rainfall profiles suggest that the new institutions for reallocating water resources may be even more important in the future since then their additional role will be to facilitate water users' adaptation to a changing environment.

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Notes

[1] This and the following section draw on Horbulyk (1995a) and (1995b).

[2] One line of inquiry not reported here seeks to determine the conditions under which water market prices can provide such "appropriate signals." Ideally, market prices and user costs would convey valuable information upon which to base water reallocation and system expansion, for example, but some instream water uses (as non-rival "public goods") might not fit a model of market allocation.

[4] This research endogenizes the rationing process or rationing problem that can arise in any system that is subject to supply variability. This research investigates alternatives to the historical system of priority dates currently used in Alberta, and alternatives to proportional water rationing rules used in other jurisdictions.