Comparing Price and Non-price Approaches to Urban Water Conservation

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ABSTRACT

Urban water conservation is typically achieved through prescriptive regulations, including the rationing of water for particular uses and requirements for the installation of particular technologies. A significant shift has occurred in pollution control regulations toward market-based policies in recent decades. We offer an analysis of the relative merits of market-based and prescriptive approaches to water conservation, where prices have rarely been used to allocate scarce supplies. The analysis emphasizes the emerging theoretical and empirical evidence that using prices to manage water demand is more cost-effective than implementing non-price conservation programs, similar to results for pollution control in earlier decades. Price-based approaches also have advantages in terms of monitoring and enforcement. In terms of predictability and equity, neither policy instrument has an inherent advantage over the other. As in any policy context, political considerations are important.

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1. Introduction

Cities, towns, and villages around the world struggle to manage water resources in the face of population increases, consumer demand for water-intensive services, and increasing costs (including environmental costs) of developing new supplies. In this paper, we provide an economic perspective on reducing urban water demand through pricing and non-price conservation policies. We compare price and non-price approaches to water conservation along five dimensions: the ability of policies to achieve water conservation goals, cost-effectiveness, distributional equity, monitoring and enforcement, and political feasibility.

The worst drought on record continues to unfold in the American southeast, affecting major cities such as Atlanta, Georgia, and Raleigh, North Carolina. In the arid Western U.S., the Colorado River system faces the worst drought on record, lasting (thus far) from 1999 to 2008 and leaving Lake Mead (the source of more than 90% of Las Vegas's water) about half empty.

Municipal water consumption comprises only about 12% of total freshwater withdrawals in the United States; and agricultural irrigation, the single largest water use, comprises just over one-third of all withdrawals (Hutson *et al*. 2004). While analysis suggests that re-allocating water from agriculture to cities would be efficient in many regions, in the current legal and political setting, large-scale transfers of water rights from agriculture to cities are relatively uncommon (Brewer *et al*. 2007, Brown 2006, Howe 1997). Thus, cities often must reduce water consumption during acute shortages due to drought, or in the long run due to constraints on their ability to increase supply.

The efficient water price is the long-run marginal cost (LRMC) of its supply. LRMC reflects the full economic cost of water supply – the cost of transmission, treatment and distribution; some portion of the capital cost of reservoirs and treatment systems, both those in existence and those future facilities necessitated by current patterns of use; and the opportunity cost in both use and non-use value of water for other potential purposes. Many analysts have noted that water prices, for many urban as well as agricultural uses, lie well below LRMC (Sibly 2006, Timmins 2003, Hanemann 1997), with significant welfare consequences (Renzetti 1992, Russell and Shin 1996). In the short run, without price increases acting as a signal, water consumption proceeds during periods of scarcity at a faster-than efficient pace. Water conservation takes place only under "moral suasion or direct regulation" (Howe 1997). In contrast, if water prices rose as reservoir levels fell during periods of limited rainfall, consumers would respond by using less water, reducing or eliminating uses according to households' particular preferences. In the long run, inefficient prices alter land-use patterns, industrial location decisions, and other important factors. The sum of all these individual decisions affects the sustainability of local and regional water resources.

Implementation of efficient water prices would be challenging, to say the least. Some of the opportunity costs of urban water supply are exceedingly difficult to quantify. What is the value of a gallon of water left instream to support endangered species habitat, for example? While economists have developed a variety of useful methods for estimating such values, the expectation that every water supplier will develop full individual measures of the LRMC of water supply is unrealistic. If LRMC represents an ultimate water pricing goal, there are smaller, less ambitious steps toward efficiency that can be accomplished more readily.

Even with inefficient prices, injecting better price signals into the processes of water use and allocation can result in important improvements. For example, given a particular public goal, such as the conservation of a particular quantity of water or percentage of current consumption, various policies can be employed, some more costly than others. Choosing the least costly method of achieving some water-provision goal is characterized in economic terms as cost-effective water management. Even if the water conservation goal is, itself, inefficient, society can benefit from the minimization of costs to achieve it.

We focus on this issue of policy instrument choice for water conservation, summarizing research from the economics literature, including both our own work on this issue and that of other economists. Given the strong theoretical cost advantages of market-based approaches to water conservation over conventional alternatives, and the emerging empirical evidence for the potential cost savings from moving to market-based approaches to conservation, the time is ripe for a discussion of the relative strengths and weaknesses of these policy instruments.

2. Cost-effectiveness of water conservation policies

Decades of theoretical and empirical economic analysis suggest that market-based environmental policies are more cost-effective than conventional policies, often characterized as command-and-control (CAC) or prescriptive approaches. Market-based regulations encourage behavior through market signals rather than through explicit directives regarding conservation levels or methods. These policy instruments, if well-designed and implemented, encourage firms and households to undertake conservation efforts that are in their own interests and collectively meet policy goals. CAC approaches, in contrast, allow little flexibility in the means of achieving goals and often require households and/or firms to undertake similar shares of a conservation burden regardless of cost.

In the area of pollution control, the cost-effectiveness advantage of market-based approaches over CAC policies has been demonstrated theoretically (Pigou 1920, Crocker 1966, Dales 1968, Montgomery 1972, Baumol and Oates 1988) and empirically (Keohane 2007, Teitenberg 2006). Perhaps the best-known application of these principles to environmental regulation is the U.S. SO_2 trading program, established under Title IV of the Clean Air Act Amendments of 1990, which has produced cost savings on the order of $1 billion annually (Stavins 2003). Dozens of other market-based policies have been applied to air and water pollution control, fisheries management, and other environmental problems in industrialized and developing countries (Kolstad and Freeman 2007, Stavins 2003, Sterner 2003, Panayotou 1998).

Economists' attention has only recently turned to examining the potential economic gains from adopting market-based approaches to water conservation, rather than CAC approaches. Whereas the gains from market-based approaches to pollution control depend critically on heterogeneity in marginal abatement costs across firms (Newell and Stavins 2003), the cost savings from market-based approaches to water conservation derive largely from heterogeneity in households' marginal benefits from water consumption (Mansur and Olmstead 2007). This is because current CAC approaches to water conservation are essentially rationing policies. This makes the application similar to other cases in which rationing has been replaced with price-based allocation, such as traffic congestion on roadways (Parry and Bento 2002) and at airports (Pels and Verhof 2004). Recent studies demonstrate how raising prices, rather than implementing non-price policies, can substantially reduce the economic cost of achieving water consumption reductions (Collinge 1994; Krause *et al*. 2003; Brennan *et al*. 2007).

In order to illustrate the basic economics, we can examine one typical CAC approach to water conservation – a citywide required demand reduction achieved by uniformly restricting outdoor uses. Figure 1 portrays two households with the same indoor demand curves, but different preferences with respect to outdoor demand. The difference in slopes of the three demand curves is associated with differences in elasticity – the percentage change in demand prompted by a one percent price increase. (For all but one specific class of demand function, price elasticity varies along the demand curve, thus while we can speak broadly about comparisons across demand curves, there may be points on a relatively steep demand curve at which price elasticity exceeds that on some parts of a flat demand curve.) Here we assume that indoor demand (frame C in Figure 1), the steepest curve, is inelastic, because indoor uses are less easily reduced in response to price changes, reflecting the basic needs met by indoor water use. For outdoor demand, there is a relatively elastic household (Panel A), and a somewhat less elastic household (Panel B). The more elastic household is more likely to reduce outdoor demand in response to a price increase – perhaps because it has weaker preferences for outdoor consumption (e.g., in the short run, it would rather allow the lawn to turn brown than pay a higher water bill to keep it green).

Unregulated, with price set at $\overline{P}$, both households consume Q_C units of water indoors, the less elastic household consumes Q_B^{unreg} outdoors, and the more elastic household consumes Q_A^{unreg} outdoors. Outdoor reduction mandated under a CAC approach (which leaves indoor use unchanged, and reduces outdoor uses to Q_B^{reg} and Q_A^{reg}) creates a "shadow price" for outdoor consumption (λ) that is higher under the current marginal price ($\overline{P}$) for household B than for household A, because household B is willing to pay more for an additional unit of water than household A. If instead the water supplier charges price P^*, that achieves the same aggregate level of water conservation as the prescriptive approach, consumers would realize all potential gains from substitution within and across households, erasing the shaded deadweight loss (DWL) triangles. Consumption moves to Q_C^* indoors for both types of households, and to Q_A^* and Q_B^* outdoors. The savings from the market-based approach are driven by two factors: (1) the ability of households facing higher prices rather than quantity restrictions to decide which uses to reduce according to their own preferences; and (2) allowing heterogeneous responses to the regulation across households, resulting in substitution of scarce water from those households who value it less, to those who value it more.

How large are the losses from non-price demand management approaches when examined empirically? We know of only three cases in which the welfare losses from prescriptive water conservation policies have been estimated. Timmins (2003) compared a mandatory low-flow appliance regulation with a modest water price increase, using aggregate consumption data from 13 groundwater-dependent California cities. Under all but the least realistic of assumptions, he found prices to be more cost-effective than technology standards in reducing groundwater aquifer lift-height in the long run.

Another study of 11 urban areas in the United States and Canada compared residential outdoor watering restrictions with drought pricing (Mansur and Olmstead 2007). For the same level of aggregate demand reduction as implied by a two-day-per-week outdoor watering restriction, the establishment of a market-clearing drought price in these cities would result in welfare gains of approximately $81 per household per summer drought. This represents about one-quarter of the average household's total annual water bill in the study.

Using a different approach, Brennan *et al*. (2007) constructed a household production model to estimate the welfare cost of urban outdoor water restrictions in Perth, Australia, and arrived at similar conclusions. The household welfare costs of a two-day-per-week sprinkling restriction are just under $100 per household per season, and the costs of a complete outdoor watering ban range from $347-$870 per household per season.

Based on both economic theory and empirical estimates, the inescapable conclusion is that using price increases to reduce demand, allowing households, industrial facilities, and other consumers to adjust their end-uses of water is more cost-effective than implementing non-price demand management programs.

3. Predictability in Achieving Water Conservation Goals

3.1 Effects of Price on Water Demand

If policymakers are to use prices to manage demand, the key variable of interest is the price elasticity of water demand. Because an increase in the price of water leads consumers to demand less of it, all else equal, price elasticity is a negative number. (Elasticity figures may also be reported in absolute value, and the negative sign is then implicit. We use the more conventional negative sign in this paper.) An important benchmark in elasticity is –1.0; this figure divides demand curves into the categories of elastic and inelastic.

There is a critical distinction between "inelastic demand" and demand which is "unresponsive to price". If demand is truly unresponsive to price, price elasticity is equal to zero, and the demand curve is a vertical line – the same quantity of water will be demanded at any price. This may be true in theory for a subsistence quantity of drinking water, but it has not been observed for water demand more broadly in fifty years of empirical economic analysis.

That said, water demand in the residential sector is sensitive to price, but demand is inelastic at current prices. In a meta-analysis of 124 estimates generated between 1963 and

1993, accounting for the precision of estimates, Espey *et al*. (1997) obtained an average price elasticity of –0.51, a short-run median estimate of –0.38, and a long-run median estimate of –0.64. Likewise, Dalhuisen *et al*. (2003) obtained a mean price elasticity of -0.41 in a meta-analysis of almost 300 price elasticity studies, 1963-1998. And a recent, comprehensive study of water demand in eleven urban areas in the United States and Canada found that the price elasticity of water demand was approximately –0.33 (Olmstead *et al*. 2007). The price elasticity of residential demand varies substantially across place and time, but on average, in the United States, a 10% increase in the marginal price of water in the urban residential sector can be expected to diminish demand by about three to four percent in the short run. This is similar to empirical estimates of the price elasticity of residential energy demand (Bohi and Zimmerman 1984, Bernstein and Griffin 2005).

There are some important caveats worth mentioning. First, elasticities vary along a demand curve, and any estimate represents an elasticity at a specific price, in particular, actual (current) prices. Were prices to approach the efficient levels discussed earlier, water demand would likely be much more sensitive to price increases.

Second, consumers are relatively more sensitive to water prices in the long run than they are in the short run, because over longer time periods, capital investments are not fixed. For example, households might change appliance stocks, retrofit water-using fixtures, or alter landscaping from lawns to drought-tolerant plants; firms can be expected to change water-consuming technologies, increase recycling, or relocate to areas in which water is more plentiful. In the long run, a 10% price increase can be expected to decrease demand by about six percent.

Third, price elasticities vary with many other factors. In the residential sector, high-income households tend to be much less sensitive to water price increases than low-income households. Also, price elasticity may increase by 30 percent or more when price information is posted on water bills (Gaudin 2006). And price elasticity may be higher under increasing-block prices (in which the marginal volumetric water price increases with consumption) than under uniform volumetric prices (Olmstead *et al*. 2007). Price elasticities must be interpreted in the context in which they have been derived.

3.2 Effects of Non-price Conservation Programs on Water Demand

Historically, water suppliers have relied on non-price conservation programs to induce demand reductions during shortages. We consider the effects of such non-price programs in three categories: (1) required or voluntary adoption of water-conserving technologies; (2) mandatory water use restrictions; and (3) mixed non-price conservation programs.

3.2.1 Required or Voluntary Adoption of Water-Conserving Technologies

Many urban water utilities have experimented with required or voluntary adoption of low-flow technologies. (Since the 1992 Energy Policy Act, U.S. law has required the installation of low-flow toilets and showerheads in all new residential construction, but some cities have also mandated or encouraged retrofitting.) When water savings from these programs have been estimated, they have often been smaller than expected, due to behavioral changes that partially offset the benefit of greater technical efficiency. For example, households with low-flow showerheads may take longer showers than they would without these fixtures (Mayer *et al*. 1998). The necessity of the “double flush” was a notorious difficulty with early models of low-flow toilets. In a recent demonstration of similar compensating behavior, randomly-selected households had their top-loading clotheswashers replaced with more water efficient, front-loading washers. In this field trial, the average front-loading household increased clotheswashing by 5.6 percent, perhaps due to the cost savings associated with the appliances' increased efficiency (Davis 2006).

Several engineering studies have observed a small number of households in a single region to estimate the water savings associated with low-flow fixtures. But most of these studies used intrusive data collection mechanisms, attaching equipment to faucets and other fixtures in homes (Brown and Caldwell 1984). Study participants were aware they were being monitored as they used water, which may have led to confounding behavioral changes.

One comprehensive study that was not characterized by this monitoring problem indicates that households fully constructed or retrofitted with low-flow toilets used about 20 percent less water than households with no low-flow toilets. The equivalent savings reported for low-flow showerheads was 9 percent (Mayer *et al*. 1998). Careful studies of low-flow showerhead retrofit programs in the East Bay Municipal Utility District, California, and Tampa, Florida estimate water savings of 1.7 and 3.6 gallons per capita per day (gpcpd), respectively (Aher *et al*. 1991; Anderson *et al*. 1993). In contrast, showerhead replacement had no statistically significant effect in Boulder, Colorado (Aquacraft 1996). Savings reported for low-flow toilet installation and rebate programs range from 6.1 gpcpd in Tampa, Florida to 10.6 gpcpd in Seattle, Washington (U.S. General Accounting Office 2000). Renwick and Green (2000) estimate no significant effect of ultra low-flush toilet rebates in Santa Barbara, California.

It is not surprising that studies of the water savings induced by such policies vary widely, from zero to significant water savings – the scope and nature of policies vary widely, as well. More important than the raw water savings induced by these programs, however, is the cost per gallon saved, in comparison with alternative policies. The costs of toilet retrofit policies implemented in U.S. cities range from less than $100,000 to replace 1,226 toilets in Phoenix, Arizona to $290 million for 1.3 million toilets in New York City (U.S. General Accounting Office 2000). These can be expensive programs, but in most cases no analysis is done to estimate the magnitude of price increases that would have induced demand reductions equivalent to those observed with technology standards. Only with such information can price and non-price demand management programs be compared as policy options on the basis of cost.

3.2.2 Mandatory Water-Use Restrictions

Non-price management tools also include utility implementation of mandatory water use restrictions, much like the traditional command-and-control approach to pollution regulation. These include restrictions on the total quantity of water that can be used, as well as restrictions on particular water uses, usually outdoors, such as lawn-watering and car-washing. Empirical evidence regarding the effects of these programs is mixed. Summer 1996 water consumption restrictions in Corpus Christi, Texas, including prohibitions on landscape irrigation and car-washing, did not prompt statistically significant water savings in the residential sector (Schultz *et al*. 1997). However, a longer-term program in Pasadena, California resulted in aggregate water savings (Kiefer *et al*. 1993), as did a program of mandatory water use restrictions in Santa Barbara, California (Renwick and Green 2000).

3.2.3 Mixed Non-Price Conservation Programs

Water utilities often implement a variety of non-price conservation programs simultaneously, making it difficult to determine the effects of individual policies. One analysis of the effect of conservation programs on aggregate water district consumption in California found small but significant reductions in total water use attributable to landscape education programs and watering restrictions, but no effect due to non-landscape conservation education programs, low-flow fixture distribution, or the presentation of drought and conservation information on customer bills (Corral 1997). Another study of southern California cities found that the number of conservation programs in place in a city had a small negative impact on total residential water demand (Michelsen *et al*. 1998). An aggregate demand study in California found that public information campaigns, retrofit subsidies, water rationing, and water use restrictions had negative and statistically significant impacts on average monthly residential water use, and the more stringent policies had stronger effects than voluntary policies and education programs (Renwick and Green 2000).

3.2.4. Summing up the predictability comparison

Predictability of the effects of a water conservation policy may be of considerable importance to water suppliers, although in most cases the objective of water conservation policies is water savings, without any specific target in mind. In this case, an estimate of the reduction expected from policy implementation is necessary, but precision is less important.

If certainty is required, economic theory would suggest that the quantity restrictions typical of traditional, prescriptive approaches to water demand management would be preferred to price increases, particularly if water suppliers could be sure of near-total compliance, or at least be able to adjust their water savings target upward to account for a reliable estimate of the noncompliance rate (Weitzman 1973). But suppliers generally cannot rely on substantial compliance with quantity-based restrictions. In a comprehensive study of drought management policies among 85 urban water utilities during a prolonged drought in Southern California, analysts reported that 40 agencies adopted mandatory quantity restrictions, but also found that more than half of the customers violated the restrictions (Dixon *et al*. 1996). Such non-binding quantity constraints are common, but how are utilities to predict the water savings achievable through quantity restrictions when less than half of consumers typically comply? In the same study, about three-quarters of participating urban water agencies implemented type-of-use restrictions (most of them mandatory). Few penalties were reported, and enforcement was weak, again raising questions regarding compliance. With such low rates of compliance with traditional quantity-based regulations, neither price nor non-price demand management programs have an advantage in terms of predicting water demand reductions.

4. Equity and Distributional Considerations

The main distributional concern with a market-based approach to urban water management arises from the central feature of a market – allocation of a scarce good by willingness to pay (WTP). Under some conditions, WTP may be considered an unjust allocation criterion. Think, for example, about the negative reaction to selling food and water to the highest bidder in the aftermath of a natural disaster. This sense that there are some goods and services that should not be distributed by markets in particular contexts is behind the practice of rationing during wartime. A portion of water in residential consumption is used for basic needs, such as drinking and bathing. "Lifeline" rates and other accommodations ensuring that water bills are not unduly burdensome for low-income households are common. Thus, policymakers considering market-based approaches to water management must be concerned about equity in policy design.

What does the empirical evidence tell us about the equity implications of water pricing as a conservation tool? Agthe and Billings (1987) found that low-income households exhibited a larger demand response to price increases in Tucson, Arizona, but the study did not compare the distributional effects of price and non-price approaches. Renwick and Archibald (1998) found that low-income households in two Southern California communities were more price-responsive than high-income households, reflecting water expenditures' larger share of the household budget. Thus, if water demand management occurs solely through price increases, low-income households will contribute a greater fraction of the cities' aggregate water savings than high-income households. This is not surprising to economists – price elasticity tends to decline with the fraction of household income spent on a particular good.

Importantly, the distributional implications of non-price policies vary by type. For example, requiring particular landscape irrigation technologies results in demand reduction mainly among higher-income households (Renwick and Archibald 1998).

Mansur and Olmstead (2007) examined the distributional impacts of various demand management policies, and found that raising prices to reduce consumption would cause a greater consumption reduction for low-income than for high-income households. (If we return to Figure 1 and assume that households of type A are low-income and type B are high-income, we can see why this happens.)

The fact that price-based approaches are regressive in *water consumption* does not mean they are necessarily regressive in *cost*. Likewise, the fact that non-price programs are progressive in water consumption does not mean they are progressive in cost. The impact of non-price programs on distributional equity depends largely on how a non-price program is financed. And progressive price-based approaches to water demand management can be designed by returning utility profits (from higher prices) in the form of rebates. In the case of residential water users, this could occur through the utility billing process.

Drought pricing, like LRMC pricing, would cause utilities to earn substantial short-run profits (Mansur and Olmstead 2007). These profits would have to be returned to consumers in some form, as regulated utilities usually are required to earn zero or very low profits. Profits could be re-allocated based upon income, in order to achieve equity goals. Any rebate scheme that is not tied to current consumption can retain the strong economic-incentive benefits of drought pricing, without imposing excessive burdens on low-income households, relative to traditional approaches.

5. Monitoring and Enforcement

Price-based approaches to water demand management hold a substantial advantage over non-price approaches in regard to administrative costs for monitoring and enforcement. Non-price demand management policies require that water suppliers monitor and enforce restrictions on particular fixtures, appliances, and other technologies that customers use indoors and out, the particular days of the week or times of day that customers use water for specific purposes, and in some cases, the quantity used for each purpose.

The great difficulty in monitoring and enforcing these types of command-and-control approaches is one reason for the prevalence of outdoor watering restrictions – outdoor uses are usually visible, and it is relatively easy to cruise residential streets searching for violators. Overall, monitoring and enforcement problems explain the low rates of compliance with many non-price demand management programs. Where low-flow fixtures are encouraged or required, they are often replaced with their higher-flow alternatives if consumers are dissatisfied with performance.

In contrast, non-compliance in the case of pricing requires that households consume water "off meter," since water consumption is metered and billed volumetrically in most U.S. cities. Of course, higher prices generate incentives not only for conservation, but also for avoidance. However, at prevailing prices and even with substantial price increases, the monitoring and enforcement requirements of price changes are likely to be far less significant than those of a comparable non-price approach.

6. Political Considerations

Water demand management through non-price techniques is the overwhelmingly dominant paradigm in cities around the world. Raising prices, particularly for what people perceive to be a “public service” (though water is supplied by both public and private entities), can be politically difficult. After a two-year drought in the late 1970s, the city of Tucson, Arizona was the first U.S. city to adopt marginal-cost water prices, which involved a substantial price increase. One year later, the entire Tucson city council was voted out of office due to the water rate increase (Hall 2000). Just as few elected officials relish the prospect of raising taxes, few want to increase water rates.

Ironically, non-price programs are more expensive to society than water price increases, once the real costs of programs and associated welfare losses are considered. A parallel can be drawn in this case to market-based approaches to environmental pollution control, including taxes and tradable permit systems. Cost-effectiveness has only recently been accepted as an important criterion for the selection of policies to control pollution (Keohane *et al*. 1998). Despite empirical evidence regarding their higher costs, political constituencies that prefer non-price approaches have succeeded in preventing management through prices. Some of this resistance to using prices may be due to misinformation, since most policymakers and water customers are not aware of the cost-effectiveness advantage of the price-based approach. For example, a common misconception in this regard is that price elasticity is “too low to make a difference”.

Non-price demand management techniques can create political liabilities in the form of water utility budget deficits. Non-price conservation programs are costly. In addition, if these policies actually reduce demand, water utility revenues decline. During prolonged droughts, these combined effects can result in the necessity for substantial price increases following "successful" non-price conservation programs, simply to prevent water utilities from unsustainable financial losses. This occurred in 1991 in southern California. During a prolonged drought, Los Angeles water consumers responded to the Department of Water and Power's request for voluntary water use reductions. Total use and total revenues fell by more than 20 percent. As a result, the Department requested a rate increase to cover its growing losses (Hall 2000). In contrast, given urban price elasticities common in the United States, price increases will increase water suppliers' total revenues. The extra per-unit revenues from a price increase outweighs lost revenue from the decreased demand.

The costs of inefficient water pricing and the relative cost advantages of price over non-price water demand management programs are clear. But like other subsidies, low water prices (on a day-to-day basis, as well as during periods of drought) are popular and politically difficult to change. Some communities may be willing to continue to bear excessive costs from inefficient water pricing, in exchange for the political popularity of low prices. In other cases, rate-setting officials may be constrained by law, unable to increase water prices by a percentage that exceeds some statutory maximum. In these cases, the tradeoffs involved should be measured and made explicit to water customers.

7. Conclusions

Using prices to manage water demand is more cost-effective than implementing non-price conservation programs. The gains from using prices as an incentive for conservation come from allowing households to respond to increased water prices in the manner of their choice, rather than by installing a particular technology or reducing particular uses, as prescribed by non-price approaches. Price-based approaches also have important advantages in terms of monitoring and enforcement.

In terms of predictability, neither policy instrument has an inherent advantage over the other. Likewise, neither policy instrument has a natural advantage in terms of equity. Under price-based approaches, low-income households are likely to contribute a greater share of a city's aggregate water consumption reduction than they do under certain types of non-price demand management policies. But progressive price-based approaches to water demand management can be developed by returning some utility profits due to higher prices in the form of consumer rebates. Such rebates will not significantly dampen the effects of price increases on water demand, as long as rebates are not tied to current water consumption.

Raising water prices (like the elimination of any subsidy) is politically difficult, but there may be political capital to be earned by elected officials who can demonstrate the cost-effectiveness advantages of the price-based approach. At a minimum, communities choosing politically popular low water prices over cost-effectiveness should quantify this tradeoff and make it explicit. Where water rate-setting officials are constrained by law from raising water prices, during droughts or in general, a discussion of the real costs of these constraints would be useful.

We are reminded of the debate, beginning in the late 1980s, over market-based approaches to pollution control. While some opponents of environmental taxes and tradable permit systems still resist these approaches, policymakers have succeeded in implementing them in many cases, achieving impressive pollution reductions at great cost savings over more prescriptive approaches. A similar shift in the area of water conservation, where the principles are essentially the same, is long overdue.

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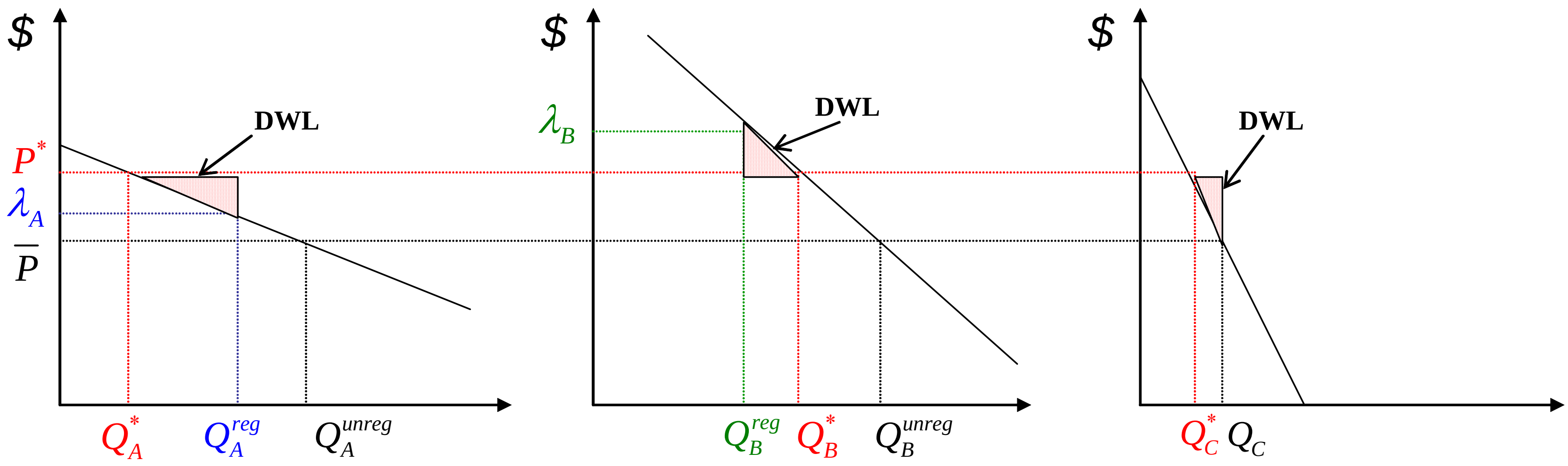
Figure 1. Welfare Losses from Outdoor Consumption Restrictions with Heterogeneous Outdoor Demand



A
Relatively Elastic
Outdoor Demand

B
Somewhat Less Elastic
Outdoor Demand

C
Inelastic
Indoor Demand

(Where P^* is the market-clearing price for $Q_A^{reg} + Q_B^{reg} + Q_C = Q_A^* + Q_B^* + Q_C^*$).

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