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Theoretical and Applied Economics of Water Demand Management: All Dressed Up and Nowhere to Go

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ABSTRACT

Economists have advocated efficient use of water resources through the demand management tool of marginal cost (including opportunity cost) pricing policies for several decades, using increasingly sophisticated models to point out the welfare gains of this policies. More recently, water markets have become *de rigueur* in many articles, books and texts as a way to "automatically" include both delivery and opportunity costs.

A review of the experience in both the developed and developing world, however, suggests that the adoption of these policies has been infrequent at best, particularly for irrigated agriculture. The objective of this paper is to review existing demand management activities in many countries, including the U.S., and to try to provide some understanding of the failure of water management agencies to employ these tools.

Water subsidies for agricultural water are found in many developed countries, such as the United States, and widely among developing countries, even when water is in critically short supply. Most papers and reports describing the application of marginal cost pricing and/or water markets, the same few references appear over and over (Chile, Israel, and Australia, for example). Many authors suggest that the reason for the widespread absence of full marginal cost pricing and/or water markets lies in the rent seeking behavior of current beneficiaries and the inertia in water management systems.

While these barriers are important, technical and institutional difficulties also play a critical role, especially in irrigated agriculture. Based on examples from many countries, it is clear that water measurement at the user level does not exist and that it will be costly to implement and maintain, reducing the ability of managers to apply efficient pricing. Moreover, creating water (use) rights also requires some form of water control and measurement at the user level. For systems with many very small farmers, the problem is multiplied substantially. Institutional barriers also are difficult to overcome. Some of these barriers, such as reluctant administrations and powerful lobbies, reflect, at least in part, the kind of rent-seeking and inertia economists (and others) often point out. Some involve the economic reality of long-term leasehold interest and consequent large losses of investment value. Some are related to institutions other than those for water, such as insecure and/or fragmented land tenure. Still others are cultural and social, and represent a broad consensus of society, rather than specific beneficiary groups. The many examples of the institutional and technical difficulties suggest that as demand management increasingly becomes the rhetoric of water economists, and the water

management community in general, finding workable solutions to the those problems is absolutely essential if efficient water pricing and water markets are to be implemented.

Introduction

Many economic researchers and practitioners have written on the subject of optimal water allocations and water pricing. The criteria for economic efficiency are clear: supply equals demand or marginal costs equal marginal benefits equal price. Of course, various constraints can affect these conditions – for example, the existence of externalities, common property and public good characteristics, and economies of scope and scale. Still, there are volumes of scholarly books and articles which deal with these problems and basically reach the same conclusion. As a highly respected, University of Chicago-trained professor of mine once put it: economic efficiency (and therefore public welfare maximization) is achieved by equating at the margin in all directions.

The current literature in water economics focuses mainly on three issues: water markets, water pricing, and pollution. The latter topic is extremely critical without doubt. However, this paper will focus on quantity aspects of water allocation and only briefly touch on quality problems. The title of this paper suggests the following: Economists and economic analyses have proven themselves capable of identifying the benefits to individuals and societies which arise from the establishment of water markets and, in the absence of full markets, have estimated the appropriate tariffs on water which would achieve economics efficiency. Unfortunately, the long history of economic analysis is not accompanied by a similarly long history of the development of water markets or the application of optimal, economically efficient tariffs. This paper attempts to suggest reasons why the failure to implement these economic tools of demand management seems so ubiquitous. The author does not claim originality. Most of the observations have been made elsewhere. Yet, it seems that in a conference on Water Demand Management, attention should be focused to some degree on the obstacles to these effective economic policies.

For the most part, water demand management (quantity) issues focus on irrigation for several reasons. First, irrigation reflects an insufficient quantity of rainfall to produce viable crops, so that agricultural production depends on some kind of development activity. Second, once in place, irrigation usually consumes at least a majority – and most often a great majority – of the developed water. Third, agriculture is generally speaking the least valuable use of water; that is to say, the net value of crops is usually small relative to other uses (municipal, industrial) per unit of water consumed. Finally, agriculture is usually granted significant water subsidies in the form of little or no charges for water compared to other users. Thus, economic analyses of efficient water use and demand management usually target shifts of water use from low valued agriculture to higher valued uses.

Water Markets

Much of the "new water demand management economics" is focused on the development of water markets, for clear theoretical reasons, as Hutchins, R. L. Anderson, Gardner and Fullerton, and Charles W. Howe, et al. all pointed out early literature (1930-1970) on potential water markets in the West. Individuals and firms trading water based on its value and cost should reach a solution in which economic efficiency is achieved. No one will pay more than the value of additional water to him or her; no one will sell additional water for less than it costs him

or her. Water will be transferred at the margin from low valued uses to high valued uses automatically. Water sources will only be developed if the benefits of the additional water are greater than or equal to the costs of provision. Finally, any water transfer is accompanied by a "fair" compensation for the loss of the right to the seller – a "win-win" situation.

Many authors (Gardner and Fullerton; Anderson and Snyder; Wahl, 1986 and 1989; Easter and Hearne; to name just a few) have discussed the value of market transfers in allocating water resources, the economic costs inherent in the failure to allocate efficiently, and the impediments to free transfers. In much of the water market literature, the same examples appear: the American West, Chile, Spain, and East Asia (India and Bangladesh). The examples from the Western United States are relatively numerous. Some are based on transfers from low value to high value agricultural water users within a canal company (water user association) or other institutional entity. Some are based on exchanges between irrigators (usually represented by canal companies) and municipal or industrial users. Others involve sales of water to various types of users within a water management agency (such as the Northern Colorado Water Conservancy District). Still others represent water leasing arrangements in times of drought. In Chile, water sales from users and user organizations to municipal users are noted. Even though these examples demonstrate gains from trade and markets in water rights, the markets are often confined to relatively small areas and trading is limited.

Since markets seem so attractive as an allocation mechanism, why are there only a few examples of working water markets evidenced around the world? Failure to implement markets has most often been laid at the feet of rent seeking users and government administrators (see, for example, Anderson and Snyder). But is that a sufficient critique of how few water markets have developed or encouraged?

As many authors (including Reidinger, Schleyer, Cummings and Nercesiantz, Simpson and Berkoff – all found in Le Moigne, et al) point out, markets require several specific conditions to be effective. First, some form of water right must be allocated to individuals and/or organizations. Those "rights" must include the three attributes generally recognized in the economic literature: the right to use, the right to transfer, and the ability to exclude others. As a part of this institutional framework, recourse to recognized and consistent authority must be provided such that these rights may be defended. In addition, quantification and measurement are a necessary condition for rights to be assigned or transferred. Finally, for market to be efficient, consideration of external effects must be considered.

In almost all nations, water is regarded as a property of the State and the "right" to the water resource belongs to the government. Within the examples of water markets which have been presented in the literature, the form of the water right varies substantially, but in almost all cases, it is a "usufructory" right – that is, a "right" is granted to use a certain allocation of water, subject to a set of conditions (among which is the recognition of the State's ownership of water). These rights may be "appropriative" (such as found in the Western United States), where the amount and priority for diversion are granted by the State government (not the Federal government). One comment often heard is that most of the surface water in the Western US is "over-appropriated" – that is, the amount of water rights granted exceeds the average water production for the specified area. The priority serves to allocate water. During scarcity, higher

priority rights are able to divert water whereas lower priority rights are not. During periods of high water production, the lower priority rights can gain access. As a result, markets in water rights discount low priorities, as should be the case. In Chile, the allocated rights are distinguished in priority by general characteristics (classes). However, the government retains the right to withdraw or reallocate water rights in times of water scarcity. In other cases, water "rights" are stated in the form of delivery contracts or agreements (the water companies in the Western United States are an example). The certainty of the right (contract) depends upon the contract conditions, and transfers of water rights or contracts may be constrained by those conditions. A good discussion of this approach in the Western US can be found in Wahl (1989). In Morocco, the newly created River Basin Agencies are charged with providing authorizations for the use of surface and ground water. These authorizations, however, are granted for 5 to 20 years (renewable), and not freely transferable, so water markets would be only for temporary transfers, at best. Many countries follow similar patterns.

In many developing countries, water "rights" are regarded with at best suspicion. Many, if not most, countries view water provision and allocation as a state function. The "right" to use water is seldom granted, although most water managers (in Egypt, for example) see provision of water supply as a duty and failure to deliver the full measure of water as a potential disaster to be avoided if possible. In more developed countries, private or semi-private firms or agencies are granted a water right and a franchise to sell water to consumers. The Northern Colorado Conservancy District (NCCD) and the Société du Canal de Provence in Southern France (SCP) are examples. However, this type of allocation mechanism frequently creates a monopoly supplier and the government often sets limits on the "market" price which can be charged. These suppliers contract with buyers based on their offer price. These are clearly markets, but not the competitive markets of open trading among individual owners of water rights. It should be noted, however, that other existing sources of water may also limit pricing to close to competitive levels (see Spulber, for example, for a discussion of monopoly pricing with threats of entry). Clearly, so long as monopoly prices are not charged, there is a gain from the trade in water rights. In the SCP case, a range of purchase options, which include interruptability and priority delivery, are given to buyers. It should be noted that, at the current prices (ranging from about $0.30 to $0.50 per cubic meter) only about 40% of the available SCP agricultural water is sold (Keith). Note that "franchising" water distribution to private firms is being considered in many areas, such as in the Souss Massa basin in Morocco, where water from storage is being contracted to a firm for delivery to areas of groundwater exhaustion (Keith and Ouattar). A large portion of these "franchises" are found in municipal water supply.

The measurement of water allocations is also often impediments to broad water markets, especially in developing countries with many small farmers. Without a measure of the "right" and a measure of the amount of the sale, markets are not likely to flourish. For small systems with a large number of withdrawal points, measurements are very costly. There are cases of market-like exchanges in these systems, such as in Egypt's Fayoum region, in which water "turns" are exchanged although even there, there is little evidence of monetary transactions (Cardinelli, et al.). In most cases in which markets exist in these kinds of small farm systems, either the market is informal or the buying or selling agency is a water user association, rather than individuals. The WUA acts more or less as an agent of water users in negotiating water

transfers outside of the internal exchanges which might occur. Again, most of these "markets" exist within a small region or project.

The protection of third parties in market structures – at least with respect to quantity – is a function of the right itself. Some rights are granted with respect to consumptive use, some with respect to withdrawals or diversions. Since the latter normally involve return flows to surface or ground water, trades in rights must secure access to other rights holders. In either case, knowledge about the return flows is necessary before the water right can be firmly established, which requires measurement and studies. In many cases, this knowledge is lacking. There is a significant literature in the U.S. arguing that water markets do not protect third parties and may diminish, rather than improve, social welfare (Brown and Ingram and Mumme and Ingram, for example). Moreover, social values in many countries, including but not limited to Muslim countries, seem opposed to the granting of water rights. It is true that this "social" position is often espoused by the government water managers (perhaps fearful of losing control of a valuable political resource, which would certainly be rent-seeking), but my experience over 30 years of water research and policy analysis, anecdotal though it is, suggests that the mistrust of granting water rights is relatively widespread, probably due at least in part to non-transparency of government actions in water management and other arenas. Note, for example, that even where water markets seem relatively abundant in several Western US states, those states have denied water right owners the ability to trade or transfer out of the state boundaries in fear of losing some future potential economic development within the state.

Clearly, water markets do represent an alternative allocation method which can achieve economic efficiency. But most developing countries must be willing to change the way in which they view and manage water "ownership" before markets can immerge. Some options – such as tradable delivery contracts – may offer a way around mistrust of full water use rights, but limited rights also mean limited gains in efficient. In any event, without the institutional structures – technical (measurement) and legal (rights) – it is highly doubtful that water markets will assume a major role in water allocation, and that these markets will continue to be locally confined and relatively undeveloped. To repeat, water markets are the exception in the world, rather than the rule. Thus, I turn to the pricing of water by government, quasi-government, or private utilities.

Water Pricing

If the economic literature on water markets is large, the literature on optimal water pricing is enormous. Pricing at marginal cost – including opportunity cost – has been examined in many countries. The literature for the Western U.S. case spans many decades. Critiques of water pricing and subsidies in U.S. federal projects can be found in almost any academic journal related to natural resource management. Operations research models of optimal water allocations (and the optimal shadow prices of water) abound and a list of references from highly respected researchers is very long indeed, including such names as Charles W. Howe, B. Delworth Gardner, Robert A. Young, and Oscar R. Burt in the 1960s and 1970s up to Ariel Dinar, Yakov Tsur, David Zilberman in the last two decades, just to name a few. The record in optimal pricing – particularly for agriculture – is dismal.

"The Political Economy of Water Pricing Reforms," edited by Ariel Dinar (Dinar, ed.) reports work from many authors relative to the theory and practice of the implementation of optimal water pricing. In his first chapter, he presents his and others (Ahmed and various publications of the OECD in 1998 and 1999) examinations of water pricing throughout the world (Table 1). There seem to me to be two striking features of these comparisons: First, there are relatively few countries charging a volumetric delivery fee to agriculture which might be expected to approximate cost recovery. Those countries are, by and large, Northern European, with the addition of Israel and Tanzania. Their prices are generally between 0.10 and 0.50 per cubic meter.[1] The remainder (including the United States) appear likely to be below-cost charges (or no charges, which is the case in most North African and Middle Eastern countries), and range from $0.001 to $0.04 per cubic meter. The second observation, also in general, is that water tariffs for municipal and industrial users are significantly (orders of magnitude) higher than irrigation charges. Of course, delivered potable water would be expected to be more costly than irrigation water. However, there is also agreement that potable water charges, particularly in developing countries, also are below cost.

Dinar's book is an essential reference for anyone interested in the problems of implementing optimal water prices. While I don't wish to review the presentations (and they are better off read in the original) there seems to me to be a general agreement that water pricing reform is a complex issue, involving political and institutional, as well as technical, aspects. The impetus for reform appears to come from either a crisis (or near crisis) in the form of drought, growing demand far exceeding supply, physical and/or financial failure of the delivery system, or from outside forces (such as the World Bank or other donors). It should be noted that several pricing structures are discussed in this book, and none appear to be completely transparent. The success of reform depends on many factors, among which Dinar lists institutional constraints, political constraints and the development of support or opposition, and redistribution of wealth. These are, of course, inter-linked. Again, according to Dinar, successful reform requires careful

Country	Agriculture			Domestic		Industrial
	Fixed cost (ha or season	*Variable cost (cubic meter)*	*Fixed cost (household per yr or month)*	*Variable cost (cubic meter)*	*Fixed cost (plant per year or month)*	*Variable Cost (cubic meter)*
Algeria	3.79-7.59	.019-.022		0.57-.27		4.64
Australia	0.75-2.27	0.0195	9-162	.23-.54		7.82
Austria		.36-.98		0.85		
Belgium				2.06-2.47		
Botswana				.28-1.48		
Brazil	3.5	.004-.032		0.4		
Canada	6.62-36.7	.0017-.0019		.34-1.36		.17-1.52

[1] The reported cost for irrigation water in Turkey is $12.00 to $80.00 per cubic meter, which seems improbable.

Czech Republic				0.68		
Denmark		0.71		3.18		
Egypt				.07-.09		.12-.59
Finland				2.76		
France		.11-.39		.36-2.58		.36-2.16
Germany				2.69		1.02-3.70
Greece	92-210	.02-.08		1.14		
Hungary				0.82		
India	0.16-27.5		0.82	.0095-.08	5.49	.136-.29
Israel		.16-.26		0.36		0.26
Italy	21 - 78.2			.14-.82		
Japan	246			1.56		
Jordan		.01-.04		.27-1.03		.12-.35
Korea				0.27		
Lebanon			8.71			
Luxembourg				1.01		
Madagascar	6.25-11.3		.075-.25	.32-1.75		
Mexico	33-60					.08-.35
Namibia	53	.004-.028	1.54-4.28	.22-1.38		
Netherlands				3.16		.57-1.71
New Zealand	6.8-16.6		16 - 164	.31-.69		
Pakistan	1.5-5.8		.25-1.63	.06-.10		.38-.97
Portugal		.009-.019	4.46-1937	.15-.53	8.86-2705	1.19
Saudi Arabia				.04-1.07		
Spain	1.0-165	.0001-.028		.0004-.005		.0004-.005
Sudan	4.7-11.2		1.67-3.33	.08-.10	1.67-3.33	.08-.10
Switzerland		.33-1.96		1.29		
Syria	50		3.21	.11-.53		0.71
Taiwan	23-214			.25-.42		
Tanzania		.26-.40		.06-.24		.26-.40
Tunisia		.02-.08		.096-.53		0.58
Turkey		12.-80.				
Uganda				.38-.59		.72-1.35
UK			152-171	.0095-.025		
US		.01-.04				
Yemen		.02-1.45		.10-13.79		.10-13.7

Table 1. Water prices by selected countries (taken from Dinar)

planning, the existence of some institutional framework, a cadre of political support sufficient to achieve the reform, and most likely patience.

My own anecdotal evidence (as well as evidence from many other authors) suggests some additional cautions. First, where delivery systems are deteriorated due to failure of maintenance, it is highly unlikely that farmers will be willing to pay for water deliveries. In most of these cases, deliveries are uncertain at best, or completely absent. Setting a tariff equal to cost recovery is not likely to bring participation. A clear example is that of the Aral Sea Basin. Farmers in Kazakhstan, Uzbekistan and the Kyrgyz Republic are levied costs of which they pay 20 to 40 percent. Interestingly enough, the range of delivery of water is approximately the same percentages, since the water systems in those areas are mostly non-functional (or was at the end of the 20th Century). Thus, water pricing at even cost recovery levels will not likely succeed unless the system is operational.

As another example, in their chapter in Dinar's book, Diao and Roe report potential impacts of agricultural reform (as likely with the just concluded free trade agreement) in Morocco. Large losses are expected for farmers growing soft and hard wheat, particularly those who irrigate. Since water is priced far below cost (and often not priced at all in the case of groundwater), these losses appear as wealth and income losses to the farmers. A market for water rights would permit those farmers to substantially reduce these losses by selling water rights to growers of crops more profitable on the world market, such as citrus and vegetables. How far has the Moroccan government advanced in the 10 years since the "new" water law was passed allowing river basin water management agencies to provide appropriations of water and charge for both surface and ground water? Very little distance indeed. There is almost no discussion of water markets among water management agencies at the basin or national level, and to date water charges remain much below costs. Moreover, agricultural interests were able to negotiate a 15 to 20 year phasing-in period for agricultural reform in cereal grains. Clearly, change comes slowly in agriculture and seemingly even more slowly in water.

The Moroccan example also illustrates a second problem in water pricing reform. It is very difficult to develop support for the reduction in water subsidies to agriculture (or other sectors, for that matter), when trading partners provide those same subsidies. Given that the U.S. subsidizes water for irrigation of many cereals – rice and wheat, for example – the argument that the Moroccan government should implement water pricing reform can not be very appealing. Clearly, reducing water subsidies to Moroccan farmers will make them worse off – either reducing their income or reducing their competitive position, or both. No wonder that water pricing reform is a very slow process. Until developed nations begin to phase out water subsidies to agriculture, it will be very hard to convince developing nations to do so.

Another example is that of Egypt. First, water pricing is not accepted by most agricultural water users. Moreover, the system of delivery is such that water deliveries must be on a rotational basis (with the possible exception of the Fayoum example above). Measurement of water deliveries occurs at the secondary or tertiary canal level, and not at the farm level. A single rotation to a tertiary canal may serve hundreds of farmers. Water is delivered from the tertiary canals to local canals from which farmers pump or divert (although some farmers pump directly from the tertiary canals as well). The only technically feasible solution is to charge for

water delivery to water user associations based on the measurable delivery point. Thus, in order to manage demand using economic tools, the water user association would have to assess each farmer according to his or her water offtake. Clearly, monitoring that offtake is expensive, and it is quite possible that these transactions costs exceed the value of the conserved water. Further, the aggregation of land into larger farms poses social problems unless alternative employment opportunities exist (a so-called "balanced development" approach). In fact, in Egypt policies are in place to distribute population to the countryside (on 5 hectare plots) in order to reduce further urban growth.

Another technical problem is evident with small landholders in many countries (Egypt and Morocco, for example). Often, administrative processes for changing land titles are so cumbersome that recorded titles are not clear. In other cases, such as Morocco, dividing land into smaller and smaller parcels (generation by generation) is legally constrained by a minimum size regulation, so what titles exist are not registered to the current owner. One of the suggested benefits of increasing water prices is the inducement to employ modern water saving technologies (drip and sprinkler irrigation, for example). Small landholders are unlikely to have sufficient capital to participate in conversion, and, moreover, lending agencies are unlikely to treat land without clear title as collateral. Aggregation of small farms is also constrained without clear titles.

One of the primary issues in water management in Egypt is high-water using crops (such as rice or sugar cane). If high water-using crops are grown on a substantial portion of the canal, the number of rotations is increased. The volume of delivery to the tertiary canal, however, is not adjusted incrementally by volume. Facing the difficult task of monitoring off-takes, many have suggested placing a water surcharge on rice and sugar cane production (this has also been suggested more broadly in the literature as an alternative when volumetric pricing is not possible). These kinds of water demand management tools may be less than efficient themselves. First, the water demand effect is binary – either the tax is enough to dissuade the production of the crop or not. If the farmer decides to grow the crop, the amount of water use is basically unregulated by price. Secondly, it is quite possible that the crop is high value (or high profit) to the farmer, in which case either the tax is ineffective in controlling water use, or it can result in non-optimal farmer decisions. Maximizing "crop per drop" as an objective is not necessarily economically efficient. Maximizing net value per drop (as a residual claimant) may be.

Dinar points out that the issue of compensation is critical to finding support for demand management. Water subsidies which have arisen from low or no water price are captured in the value of other fixed assets (usually land) in the form of lease-hold interest. Increasing water prices reduces income and asset value of those fixed resources without compensation. The reduction in welfare will galvanize affected water users to oppose the increases in tariffs. The beauty of water rights markets is that compensation is automatic (and negotiated). As Dinar notes, informing the public and developing a base of support for tariff increases is essential.

Before concluding, Table 2 presents the past and projected water demand for the Middle Eastern countries, as developed by the ESCWA secretariat of the U.N. Domestic and industrial demands increase substantially, as might be expected from a region with growing populations.

However, the most striking numbers are the increases in agricultural demand. In a very water short region, with increasing high value pressure on water supplies, EVERY SINGLE COUNTRY projected a substantial increase in agricultural water use. Forecasts of increasing future agricultural water use can be found for almost every country listed today as extremely water short by the FAO (plus most other countries as well). These projections suggest to me that advocates of water demand management have a very difficult task ahead.

Country		**1990**			**2025**	
	Domestic	*Industrial*	*Agriculture*	*Domestic*	*Industrial*	*Agriculture*
Bahrain	86	17	120	230	73	271
Egypt	2,700	4,600	49,700	6,300	10.9	69,100
Iraq	3,800	1,450	45,200	4,750	3,560	66,000
Jordan	190	43	650	750	175	1,090
Kuwait	295	8	80	1,100	160	140
Lebanon	310	60	750	1,100	450	2,581
Oman	81	5	1,150	630	350	1,500
Qatar	76	9	109	230	50	205
Saudi Arabia	1,508	192	14,600	6,450	1,450	16,300
Syria	650	146	6,930	3,070	2,300	22,900
UAE	513	27	950	1,100	50	2,050
Palestine	78	7	140	800	70	420
Yemen	168	31	2,700	840	137	3,800

Table 2. Estimated water demand by country (millions of cubic meters) taken from United Nations.

Conclusions

Unfortunately, the conclusions which I draw from the literature and from my own observations are that, in spite of the benefits which result from economically managing water demand, the likelihood of massive use of the tools in the near future is not high in most countries. Water markets offer a first-best solution (assuming third party effects are controlled), but require recognition by governments of some form of water right and the ability to measure water exchanges reasonably accurately. Institutional changes such as the provision of water rights and markets are slow to develop unless some external force is applied. Water pricing reform is also problematic, in that losers are very likely to vigorously oppose it, particularly when the prices applied are not transparent. Although economists and water managers must look to water demand management as an allocation tool, given that water supply augmentation is become more limited, we should not expect the implementation of demand management to be easy or quick. Patient explanations, careful institutional change and development, and cognizance of the income and wealth distribution impacts will be necessary.

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