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The economics of water: environment and development. Introduction to the special issue

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Introduction

This special issue collects research initially reported at two very different fora. The first was the 'International Symposium on Water Resource Management—Efficiency, Equity and Policy'. This conference was held in Cyprus, and was jointly organized by the University of Cyprus and University College London. It brought together many of the world's leading water resource economists.[2] The second was the 6th Conference of the International Water and Resource Economics Consortium, held in Waikola, Hawaii. The consortium is a group of some 60 economists from the US, Europe, and elsewhere.

The Cyprus Papers

The first four papers in the special issue set out the principles and problems of water management. It commences with an introductory paper by Charles W. Howe, a world-renowned writer in this field, detailing the

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special problems of arid countries regarding water management. The paper expounds on these issues theoretically, then follows with brief case studies that illustrate important problems and exhibit innovative economic and managerial approaches to the solution of these problems. The three papers that follow are case studies illustrating these general principles, from a range of different countries: France, Cyprus, and Mexico. These case studies provide illustrations of some of the most important problems associated with water management and regulation.

Howe's paper is a survey of the economics of water, and focuses on the identification of social welfare enhancing opportunities from conjunctive management of surface and groundwater. Although these opportunities were well known for many years, very few systems of explicit conjunctive management are found both in developing and developed countries. Not all groundwater systems, however, involve intimate connection with surface supplies. Howe adopts Gisser's (1983) taxonomy of the three major types of groundwater systems, notes the major problems found in each (depletion, contamination, salt water intrusion), presents brief case studies illustrative of these problems and critically reviews steps that have been taken to mitigate those problems.

In general, the need for the management of groundwater resources arises due to the absence of appropriate institutional/property rights settings, where groundwater systems become open access resources subject to the creation of important contemporary and inter-temporal externalities. The survey produces a number of very informative conclusions for policy makers. First, it identifies many opportunities for resource and investment savings from implementing integrated surface water–groundwater management. Second, it proposes regulation of the economic and demographic development of arid regions dependent on non-rechargeable groundwater based on criteria relating only to the very long term. Thirdly it concludes that urban–agricultural demand competition for limited groundwater need not result in perceived crises for either sector if water markets or market-like institutions are available to mediate the competition.

Understanding and analysing the effects of water prices on water demand is a crucial contribution to water management policy; however, the estimation of agricultural and urban water demand is not a straightforward task. The next two papers tackle this task; Bontemps and Coutoure focus on irrigation water demand and Hajispyrou, Koundouri, and Pashardes focus on residential water demand.

The absence of observations on water consumption has induced the use of mathematical programming, rather than parametric estimation approaches, for the estimation of derived water demand curves. However, a major criticism of these approaches is that they use pre-specified functions that do not represent accurately the underlying biological and physical processes of growth. Bontemps and Coutoure propose a two-stage methodology to estimate irrigation water demand based on the evaluation of the farmer's maximum willingness to pay for the marginal unit of water. Demand is generated using a sequential-decision behaviour model and a non-parametric estimation procedure. The approach—

coupling mathematical programming and non-parametric estimation—is general and can be used when the underlying phenomena and related functional relationships are not known with certainty and cannot be estimated parametrically due to the lack of data.

The proposed methodology is used for the estimation of water irrigation demand in the southwest of France. Results show that irrigation water demand is inelastic for low prices and becomes elastic at a threshold price. The threshold price depends on weather conditions and varies between 0.27 F/m^3 for wet years to 1.57 F/m^3 for dry years. These results strongly support the hypothesis that irrigation water conservation policies need to account for climatic variations.

As in the estimation of irrigation water demand, opinions vary widely concerning the appropriate methodology for estimating residential water demand. The paper by Hajispyrou, Koundouri, and Pashardes considers demand for residential water in the context of a theoretical framework consistent with fundamental principles of consumer behaviour. The novelty of their approach is in the exploitation of the cost and indirect utility functions underlying the consumer theory framework to derive a general demand model, which enables evaluation of the welfare implications of alternative water pricing policies. This is particularly important, given the significance attached to equity and the strong political objections to water price reform.

The model is applied to individual household data drawn from the Cyprus Family Expenditure Survey to estimate the price and income elasticities of residential demand for water and evaluate the welfare effects associated with potential changes in the current water pricing system. In particular, the effects of switching from the current regionally heterogeneous increasing block water pricing system to a regionally homogeneous uniform pricing one are investigated. The current system is progressive but found to be inefficient in the sense that it introduces gross price distortions resulting in deadweight loss. Regional differences are found to introduce a substantial price heterogeneity that cannot be justified by either efficiency or equity criteria. Moreover, the paper's empirical analysis suggests that the price elasticity of demand for water ranges between (−0.4) for households in the lowest and (−0.8) for households in the highest 10 per cent of the income distribution. This implies that, for residential water use, price can play a role in the context of a demand management scheme designed to tackle the growing fresh water problems in Cyprus. Such an approach, however, should take into account the distributional impact of alternative price regimes.

Many countries are currently facing the pressing need to reform, not only their pricing policies, but also their public water sector as a whole due to the low efficiency of the existing water and sewerage companies. Private sector participation is a popular solution to these inefficiency problems. However, the relevant literature is non-conclusive with regard to the effect on efficiency of a change from public to private operations. Anwandter focuses on the empirical determination of whether reforms implemented in Mexico (that is administrative decentralization, the separation of regulatory and operations functions, and the introduction of the

'new water law') have helped to reduce the technical inefficiency in the water sector.

Based on the inputs and outputs of a sample of 110 utilities and comparing only firms with a similar input mix, he finds that the inefficiency of the public water utilities does not depend so much on the type of ownership. Instead it depends on the lack of competitive pressures in a monopoly, on the principal–agent problem between the managers of the water companies and the owner (the public), and on the political, and not autonomous, regulation of the water companies. Inefficiency is measured by Data Envelopment Analysis (DAE), which proves to be particularly adequate to measure efficiency in the water sector. This involves using the Debreu–Farrell radial efficiency measure, which defines the minimum proportion by which all the inputs of a firm may be reduced, while still producing a given amount of output. Anwandter suggests that the adoption of DEA methodology by national regulation together with the publication of comparative efficiency values could reduce the information asymmetry between the public managers and the local users, who in a decentralized system could then exert pressure to increase efficiency.

The Hawaii Papers

The next paper, by Kaiser and Roumasset, develops a unique method for valuing the watershed benefits of a tropical forest, which does not use contingent valuation or other survey methods that have often come under criticism for their lack of an underlying theoretical structure. The authors compute the value of a conservation project in the Ko'olau Watershed on Oahu, Hawaii in maintaining recharge of groundwater as between 1.4–2.6 billion dollars, depending on the discount rate. Such indirect valuation exercises may be important especially in the developing countries where standard benefit–cost analyses of development projects is hampered by the non-existence of markets for most environmental goods and services. Moreover, survey techniques used on subjects who are often poor and disenfranchized, and do not participate in the market, are likely to produce a higher degree of distortion in the results.

In their framework, a social planner maximizes consumer plus from production of water through recharge and desalination, the latter being a backstop resource. Recharge is a function of the stock of forest, which can be maintained through conservation investments. This Hotelling type dynamic model yields an equilibrium condition for the extraction of water at any instant in time. The authors then apply this model to the Pearl Harbor Aquifer—the major source of groundwater in Hawaii. They estimate that about 45 per cent of the recharge comes from the Ko'olaus. The model computes a steady state in which the recharge is exactly equal to the rate of withdrawal of water. Beyond this point, additional water is drawn through desalination.

The present value of the groundwater resource is the discounted sum of the scarcity rent in each period, times the optimal water consumption in each period. When the contribution of the Ko'olau attributable to maintenance of good forest quality is withdrawn (31 per cent of recharge), the switch to higher cost desalination occurs much earlier, thereby reducing

net benefits from the project. The difference between these two values yields an estimate of the economic contribution of the forest. These values, however, do not measure the other non-timber benefits of the forest, only its contribution to aquifer recharge.

The transboundary angle to water management is addressed by Fernandez who looks at the effects of trade liberalization along the US–Mexico border on wastewater pollution. Her work examines how cooperation between the two countries that share an international border will affect pollution and unemployment in a bi-national watershed. Secondly, she studies factors that are significant in eliciting transboundary cooperation in pollution control. Her methods can be widely used in empirical modelling of strategic behaviour relating to the use of transboundary resources such as water, fisheries, acid rain, and so on.

In her set-up, the two countries use water for production but are negatively impacted through accumulation of pollution in the common waterway. Mexico has an added benefit from water because it is used to produce cotton for export to the US under NAFTA. The two countries play a non-cooperative game in which they choose the amount of treated and untreated emissions. The resulting Markov perfect equilibrium is simulated using numerical data. Cost and demand data from both countries is used. Valuation of pollution damages is done through epidemiological survey of residents in a set of non-sewered and non-electrified residential areas. Public health damages are separated by whether they are caused by the water stock (drinking water quality) and flow (recreational fishing and swimming). Non-cooperation yields a high concentration of emissions. However, somewhat counter-intuitively, trade liberalization decreases pollution because it increases the opportunity cost of water, thereby making treatment economical. Cooperation with trade liberalization produces the lowest concentration of pollution. Between the two countries, Mexico benefits more from cooperation and trade because of its role as an exporter to the US. A fixed proportion production function allows for computation of employment levels in Mexico under the cooperative and trading regimes.

The paper then performs statistical analysis to examine how the Border Environmental Cooperation Commission (BECC)—a bilateral institution responsible for undertaking environmental improvement projects in the border area—selects from project proposals. BECC is assumed to maximize the sum of net benefits accruing to the two countries. The author finds several key determinants of project approval by the BECC. For example, wastewater projects are more likely to be funded relative to solid waste, water treatment, and recycling activities. Transboundary projects are also likely to be funded since they provide benefits to both countries. Employment potential and relaxation of budgetary constraints also increase the likelihood of a project being approved. There seems to be bias towards approving more projects proposed by the US and this may be because in the past more projects were approved for Mexico.

Another aspect of water management covered in this issue is the role of transactions costs in the formation of water markets. Most economists agree that the allocation of water through market mechanisms will increase efficiency, reduce over-use and its environmental impacts such as

waterlogging and salinity. However, water markets are more of an exception than the rule and as Carey, Sunding, and Zilberman point out, it is important to consider the role of transactions costs on trading behaviour. Most water markets, unlike other commodities, have no centralized trading location and no publicly posted market prices.

They propose a 'network' model of water trading in which farmers can trade within a network ('internal trade') at zero cost while trading across networks involves a fixed transactions cost. Gains from trade are realized if the value of marginal products across farms is different. Thus trades within and between networks are affected by the cost of conducting the transactions. An added twist in the model is a productivity shock, which changes the value of marginal product of water for farms. These shocks may affect individual farms within the same network differentially. Some interesting results are obtained. For example, the net gains from trade are larger for large networks because they can trade within themselves and economize on the transactions costs of trading. Moreover, large networks can insulate themselves from productivity shocks through internal trading. These results are obtained numerically for various ranges of transactions costs.

The model is applied to water markets in the Westlands Water District in California's Central Valley, the main agricultural region of the state. The District has about 800 farms. The frequency of trades is significantly affected by the initial water allocation and also by a priority rationing system. However, the majority of trades (about two-thirds) occurring in the Westlands District are within networks of farms, often run by a common management agency. The study performs non-parametric tests on trade data to support the hypothesis that in the spring season when farmers have more lead time to make trades and they have advance information on their water needs (low transactions costs) market trades are more likely. They also find evidence that average size of market trades (across networks) is higher than for internal trades. The data also suggest that although large networks do more trades at the network level, they trade less at the farm level. Thus the bigger the network, the more it minimizes costs by reallocating water internally, and they often use one or two 'representative' farms to conduct outside network trades. They also found that networks tended to engage in long-term trading relationships suggesting that this behaviour may be suggestive of high transactions costs of investing in new trading relationships.

The paper provides very useful insights into the role of transactions costs in water trading that may be an important lesson for policy makers in developing countries who are looking at removing impediments to the formation of water markets. For example, it may be useful to initiate pilot scale water trading experiments in regions with a high proportion of formal and informal networks.

As seen in the above paper, the assumption of perfect information may not be very plausible in the case of water management. This theme is picked up by Osgood, who looks at the provision of weather information for increasing efficiency of water use in irrigated agriculture. Weather data have public good characteristics and are often overlooked by policy

makers in their preoccupation with water markets and 'getting the prices right'. More specifically, Osgood looks at the California Irrigation Management Information System (CIMIS), a publicly provided weather information system provided through popular media, extension services, as well as through the web. This allows farmers to compute evapotranspiration requirements for crops and determine how much water to use on a daily basis.

In order to examine if weather information has private or public good characteristics, the two are modelled as two different techniques of production and farmers have a choice of adoption. In California, farmers using pressurized low-precision systems reported an average reduction in water use of about 15 per cent under CIMIS. Those using non-pressurized systems reported a reduction of only 5 per cent. Statewide savings were of the order of 132 cubic meters of water annually. Because of the complementarity between the level of water-saving technology and the weather system, adoption of the new technology increased under CIMIS. Thus improved public good provision led to increased adoption. It was calculated that the same amount of water savings could be generated if a tax of 75 per cent was imposed on current water prices. The deadweight loss from the tax would be about ten times the cost of the public good.

Some general lessons that can be gleaned from this approach relate to the characteristics of a publicly provided weather information system for water use. Such information should be made available to a large group of farmers at low marginal cost. Extension services may be required to teach farmers how to optimally use the information. Osgood discusses the Mexican weather information system in detail to relate the California experience to a developing country environment.

Water markets in the Murray–Darling River Basin in Australia is the subject of the paper by Bjornland and McKay. The Basin's water resources which supply water to three states—New South Wales, Victoria, and South Australia—are overused and a cap on withdrawals has been in effect since 1997. Experiments with water trading, albeit on a small scale, were started in 1987. They find that the trades were often between lower valued users and higher valued users, with the latter buying water to expand production or to switch to higher valued crops. They also found that proceeds from water sales were used both for debt reduction by households and for making capital investments. They also noted positive environmental impacts as water is traded out of high to low salinity soils. However, trading has also altered dilution flows and increased river salinity levels. Price dispersion was widespread in the early years of trading but has reduced because of the better distribution of price information in a mature market.

In conclusion, the papers in this volume deal with a range of critical issues relating to water, environment and development. For researchers and policy makers in a developing country setting, these papers provide both methodological and policy insights. The methodologies presented here are innovative in applying economic theory to a number of critical environmental issues relating to water. The experience with water markets will enable policy makers to learn from diverse settings and apply locally

relevant approaches to institutional reform in water. The adoption of these ideas and methods in research and policy analysis is critical to reducing the inefficiency and environmental problems associated with water use in developing countries.

References

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