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Allocating Scarce Water

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1. Introduction

Water in Australia has become a scarce resource with the competing demand for its use by households, industry, irrigation and the environment running ahead of available supplies. Because of scarcity, allocating more water to one use, say gardens, means less is available for other uses, say the environment, and vice a versa. The efficient or most productive allocation of water among different potential uses requires that we equate the marginal social value of water across each use. Further, because of changes in the available supply of water associated with the extreme variability of rainfall, and because of market changes in the benefits of water in different uses, the efficient allocation of water will need to change over time. In some cases, in addition to efficiency, the allocation of limited water will be concerned with distributional or equity effects of different arrangements. This paper develops the case for, and describes the application of, a mix of competitive markets and government intervention for allocating and reallocating water. Markets and changing water prices can effectively allocate water among most commercial uses by households, industry and irrigation uses. In the case of an allocation for environmental flows to provide flora, fauna and amenity services of value to individuals, markets fail and direct government intervention is supported.

It is widely recognised that the current pattern of allocation of water from Australian rivers and underground aquifers is far from efficient (see for example, Davidson, 1967, Hall et al, 1994, Quiggin, 2000, Murray Darling Basin Commission, 2001, Goesch and Hanna, 2002), and for some cases water has been over-allocated (see for example, National Land and Water Resources Audit, 2001, Murray Darling Basin Commission, 2002, Young and McColl, 2003). A history of allocation of water largely according to the first-come-first-served mechanism means many current uses have relatively low values at the margin while higher marginal value uses are denied water. Demands for water for environmental

purposes have been relatively late claimants. National efficiency losses associated with current allocations of water have been recognised by governments at Commonwealth and State levels, with a big stimulus for significant economic policy changes stemming from the 1994 COAG meeting, and further initiatives were announced in August 2003. Key proposals include the separation of land rights and water rights, the development of markets for transferring water rights from low value to higher value uses, and explicit entitlements for water for the provision of environmental services. A number of independent inquiries by States and by water authorities also have been undertaken or are in progress (for example, Victorian Government, 2003). Although considerable progress in increasing the efficiency with which limited water resources are allocated has been made, much more remains to be done.

This paper provides an economic perspective on mechanisms for achieving a more efficient allocation of Australia's limited surface and underground water resources. Section 2 provides a benchmark ideal for allocation and investment outcomes, and it notes some background economic properties of water as they affect the choice of markets or of government direction as alternative allocative mechanisms. Issues in making markets work to allocate water among different commercial water uses are discussed in Section 3. Section 4 follows with a more specific and detailed market allocation model. Procedures for allocating water for the provision of environmental services so as to increase national efficiency are evaluated in Section 5. A final section provides some conclusions.

2. Economic Principles

Economic efficiency, or national productivity, is maximised by allocating water among the different uses so that the marginal social value of the last litre used in each different use is equalised. If, for example, the marginal social value in one use is relatively low, say $50 per megalitre for rice in Leeton, and it is relatively higher in another use, say $200 per megalitre for grapes in Griffith, society would gain by reallocating water from rice to grapes, and in this example reallocation would generate a social gain of $150 per megalitre. Since water is water, the marginal social benefits equation rule applies to limited water which could be allocated to households for showers and gardens, for industry, for irrigation of different crops, and for the provision of environmental flows to support wetlands and red gums.

The efficient pattern of allocation of water among the different water uses will vary over time. Reality is that there is considerable variation within years and across years in the available water supply associated with the high variability of rainfall in Australia. Changes in market product prices, technology, incomes and other circumstances cause the marginal return from water, and especially relative marginal returns across different water uses, to change over time. Changes in both the water supply and water demand functions require changes in the water allocation pattern if marginal social benefits across the different uses are to be equated.

The choice of water allocative mechanism and the allocation of water among different uses using the ideal equation of marginal social benefits rule can now be considered in the context of economic properties of different water uses. First, consider the simplest case of those water uses which have the private good properties of rival consumption and ease of exclusion, and where there are no market failures such as externalities. Here, as is the case for other products with private good properties such as food, white appliances, movie tickets and a portion of land sales, competitive markets successfully will allocate and reallocate water across many of the commercial uses of water by households, irrigators and industry. Under these favourable circumstances, the market price of water equals marginal private benefits, and marginal private benefits equal marginal social benefits, resulting in an efficient allocation of water. Further, buyers and sellers in their own self interest allocate and reallocate water by buying and selling water for different uses in response to changes in the market price.

Market price changes indicate changes in the relative scarcity of water. The flexible coordination role of price changes provides a robust mechanism for reallocating water from lower value uses to higher value uses as market demand and water supply conditions change over time. These desirable efficiency properties underlie the attraction of developing effective and competitive water markets as the mechanism to allocate much of Australia's water more efficiently.

Second, in a number of cases the use of water with private good properties also cause spillover or external costs on third parties which are not considered in the private market decisions. Examples include the pollution downstream caused by waste water from industry and households returned to rivers, bays and oceans, and some (but far from all) irrigation adds to water tables and salinity which increase

costs for downstream water users. Where there are external costs, marginal private benefits exceed marginal social benefits, by the marginal external cost. To the extent the external or pollution costs are ignored, too much water will be allocated to the polluting uses and too little to other uses. For these uses of water there is a set of necessary conditions, but not a set of sufficient conditions, for government intervention to improve the allocation of water resources. The policy intervention could take the form of pollution taxes (ideally set at the marginal external cost), regulations requiring waste water treatment or restrictions on irrigation crops that can be grown or on particular irrigation methods which can be used, or tradeable permits in the external cost products, such as salinity credits. Because the government intervention may be inappropriate, for example because government has insufficient knowledge about the magnitude of the externality costs, or because of difficulties in measuring the externality, or because the choice of the form of intervention and its magnitude is more the result of political lobbying than externality correction assessment by a socially benevolent government, there can be no guarantee that the chosen intervention will improve the efficiency of the water allocation.

A third and increasingly important difficult application of the equation of marginal benefits across different water uses criterion concerns some of the services provided by water allocated for environmental purposes. Most of the benefits of maintaining, restoring or increasing the survival of native flora and fauna and of river heritage have public good, as opposed to private good, properties. That is, the provided existence values and passing-on to-future-generation values which arise from protection of flora, fauna and river heritage have non-rival or simultaneous consumption properties, and once these environmental services are provided they are available to all citizens and it is impossible to deny non-payers the benefits of these environmental services. Importantly, with public goods, whether they are environmental services as here or other public goods such as defence, there is an incentive for individuals to free ride and to leave it to others to buy water for environmental services. Markets in these circumstances will allocate too little water for the production of environmental services with public good properties, and they will allocate too much to private good uses of water. There then is a compelling case for

government policy intervention to reallocate some water from commercial uses to environmental flows.

The effective water supply might be increased by a number of investment options. These include building more dams, recycling, desalination, using pipes to reduce evaporation and seepage in delivery systems, more maintenance to reduce wastage via leaks and breakdowns, and even diversion of river flows from east to west and from the north to the south. Economic efficiency requires that diversion of labour, capital and other resources from, say, investment in roads and industry, to expand the effective water supply pass a social benefit cost assessment. Only if the marginal social value of the additional water provided exceeds the marginal social cost of the investment would the investment be justified as a contribution to national efficiency.

3. Making Markets Work

In principle, as argued above, a competitive market for water is an effective and robust mechanism to efficiently allocate water among most uses of water by different household, industry and irrigation uses because these water uses have the private good properties of rival consumption and low costs of exclusion. Australia has started to move in this direction. However, more reforms are required to extend the water market to fully encompass water trade on a permanent as opposed to a temporary basis, across regions as well as within regions, and for transfers between the industry user groups as well as between different irrigators. Achievement of more comprehensive and more effective water markets to allocate limited supplies between the different users so as to equate marginal social benefits across the different uses requires attention to such issues as the specification of water rights, the initial allocation of water rights, recognition of external costs where relevant, charges for water delivery, and a low cost and transparent mechanism for transferring rights between buyers and sellers and for maintaining a public record of these transactions.

Users of water can make better decisions on the use of existing water rights and they can make better decisions on whether to buy or sell water rights if the water rights are explicitly, clearly and transparently defined, just as is the case for decisions about the use of land and other products. Workable water property rights should specify such things as the quantity and reliability of water supplied, any charges attached, the ability to buy and sell and any conditions on sale and

purchase, and these rights have the backing of an enforceable, workable and low cost legal framework.

With water, the variability of water supply, including variability within a year, across years and longer term trends, has to be built into water rights. One set of options to recognise the variability of water supplies would specify water rights as a share of dam release or as a share of net accretions to a reservoir. Another set of options would have multiple water rights with different degrees of reliability of supply, for example, a priority right with a high level of supply certainty coupled with a lower priority right specified as a share of the (much more variable) residual supply. There are other definitional options regarding, for example, the point of volume measurement, including at dam release or at the user's gate, and of gross or net use where the later allows a credit for returned water. The Productivity Commission (2003) describes a diverse range of water property right specifications in current use in Australia, USA, Chile, Mexico and South Africa. What is at least as important as the structure and form of the water right specification is that these details be transparent, unambiguous, clear and enforceable. Then, the allocation of risk is clear and decision makers can proceed to make informed long term investment, production and buy/sell decisions affecting the use of water.

An important issue in setting up an effective water market is the initial allocation of the water property rights. From the perspective of achieving an efficient allocation of water, competitive markets will in time achieve an efficient allocation from any starting point or initial allocation of rights (the Coase, 1960, theorem). But, the initial allocation has important distributional implications. A common strategy to achieve efficiency and at the same time to make no one worse off is to allocate water property rights to existing users of the water, or the grandfather model. Other options are for government to auction the rights, to offer them at random, or to allocate them on a first-come-first-served basis.

Where the current allocation of water for commercial uses in aggregate is considered an over- allocation, for example if more water is required for environmental flows, government has several options to reduce the allocation to a water market. It could, for example, purchase water rights on the market using taxpayer funds, or it could announce a schedule of contractions in the future water available per commercial water right. Again, efficiency can be achieved with

either option so long as government intentions are made explicit and they are followed.

A single independent and transparent registry of water rights would officially record ownership, and changes in ownership following sales and purchases. This could be a government authority, as for land, or a private authority, as for corporate shares. In either case, the register would have a legal basis. Information on prices and quantities of water rights traded would be available to the public. Market transfers could be for the water right per se, representing a permanent transfer of title. Or, the water available with an entitlement for a particular year or other short time interval could be bought and sold much as a temporary transfer. Various lease arrangements could be developed to allow for the transfer of water flows for several periods whilst not changing ownership of the water property right asset .

Several options are available for government policy intervention to correct for external costs where they arise. In the case of household and industry waste, typically the externality takes a single pollution point form and it is relatively easy to measure. Corrective interventions could take the form of taxes per unit of waste, regulations on allowable wastes, or tradeable permits for waste, all set with the aim of equating marginal costs of waste reduction with the marginal external cost of the waste. The policy challenge to correct for external costs is more difficult in the case of irrigation water usage external costs. External costs associated with the pollution effects of irrigation on water tables and salinity for example typically are of the non-point form and they are very difficult to measure. Here the feasible policy option may be restricted to taxes or regulations according to region, crop or irrigation practice where these earlier points in the pollution production process represent only a crude and indirect proxy measure of external costs. The associated distortions in using indirect pollution correcting policy interventions may mean it is better not to intervene in many cases.

A component of either the water property right or of the licence to use water would be a charge for the costs incurred in the delivery of water to each user. At a minimum, the delivery charges would include incremental or operating costs and an annualised cost for new investments. In terms of economic efficiency, past investment outlays are sunk costs which should be ignored, along with all the

ambiguous debate on different accounting options about how they might be measured.

The foregoing has left a number of options as to how in practice more efficient water markets might be developed. In the next section a specific option is presented to illustrate in more concrete terms what is being proposed. Other specific options are given in, for example, Randall (1981), Dudley and Musgrave (1988), Alaouze (1991), and Young and McColl (2002).

4. A Market Proposal

4.1 Description

This specific proposal has two sets of water rights, high security rights and lower priority rights specified as a share of the residual water flow after the high security rights have been met. Rights initially are allocated to current commercial users of water. A government registry of rights is developed. Each commercial user has to have a water use licence which includes a payment schedule for the costs of delivery of water, and any physical conditions and restrictions on the delivery of water. The licence also specifies any taxes, regulations or other conditions on the use of water for the purpose of restricting the external costs of water use. Design of the system requires meteorological, hydrological, biophysical, legal and economic information, and a politically acceptable and smooth changeover to the new system may be supported with social science information. An allocation of water rights for environmental flows, with these rights having equivalent market status as those for commercial water uses, also would be provided, with further discussion of the details being deferred to the following section.

A comprehensive market for water would bring farmers, foresters and other water users up-stream of the main water supplies into the market. A grandfathering system would ensure continuation of their rights on existing dams and forests. To the extent that new farm dams and other dams, forests and other major land use changes reduce the water flow into water reservoirs, and hence the availability of water for downstream households, industry, agriculture and the environment, these new uses would need to purchase water rights from the market in competition against the other uses for the limited water.

Water rights, which essentially represent rights for a homogeneous water product at the reservoir exit point, can be freely traded between households, industry,

agriculture and the environment. Those with the combination of a high willingness to pay and with limited flexibility in changing water consumption from year to year would hold and purchase the high security rights. Among these holders we might expect to find households, but perhaps not for all the water used for gardens and local parks, industry and irrigation of perennial crops. Those with a lower willingness to pay, and those with a greater flexibility to adjust water use, would hold and purchase the less reliable and also much lower price lower priority water rights. We might expect to find some, but far from all, of the irrigators of annual crops to hold the lower priority water rights.

An independent system of water use licences would be designed to reduce the effects of any external costs associated with particular water uses and to charge for costs of water delivery from the reservoir. Restrictions on water use, or taxes on water use, would be more severe for those water uses involving higher external costs. Restrictions or charges for externality costs, along with differences in water delivery charges, would vary according to location, and they may vary with the water use. In aggregate, these restrictions and charges are designed to signal the social opportunity cost of using water in different locations, for different purposes, and using different irrigation methods.

Governments have roles in addition to setting the legal basis of the water rights and use licences. These include the provision of technical information to help water users improve their productivity, and the provision of probabilistic data on the future availability of water from the high security and lower priority rights. After an introduction period and when the market matures, the market price of the water rights provides existing owners and potential buyers with a measure of the opportunity cost, or the marginal social value, of water in alternative uses.

In practice specific equity concerns may also need to be addressed. For example, government may choose to provide each household with a minimum water allocation to meet basic needs at low cost. However, additional water, say for very long showers and for garden watering, would face the market water price. Given the low elasticity of demand for basic household water use, and its small share of total Australian water consumption, the efficiency losses of such deliberate redistributive arrangement would be very small.

4.2 Operation

The water market will trade two sets of water products, water rights and annual (or even shorter period) water volumes. First, the value of water rights, being the value of an asset much like a share in a listed company, will be set at the discounted sum of the expected value of water prices over the current and future years, with the annual water prices being analogous to the flow of dividends provided by company shares. These asset values will be relatively constant over time as they average across wet and dry years and across good and poor product market outcomes. High security water rights will be much more valuable than the low priority water rights. Second, in any one period (say a year), market arbitrage will result in a common price per unit volume of water each period for water associated with both types of property rights. In wet years, and in times of low commodity prices, the water price will be relatively low. By contrast, in dry years, and in times of high commodity prices, the water price will be relatively high.

The distributional or equity implications of a water market system are as follows. Both buyers and sellers of water and of water rights gain from market trade. A seller of annual water or of a water right does so voluntarily only if the market price exceeds the value of the water in its current use. A buyer purchases only if the value of the water or the right purchased exceeds the market price. A potential equity concern is for residents in a region that becomes a mass seller of water, with the land changing over to a more land intensive form of production, for example from irrigated dairy to dry land beef. For the reasons noted above, the farmers are winners, and so are the buyers and regions acquiring the water, but there will be pressure to down-size other non-irrigation farm businesses and service suppliers in the water selling region. This type of structural change is no more than another example of an on-going characteristic of modern economies in which new technology, changes in commodity prices, and other changes to the economy require reallocations of economic activity to maintain and raise economic efficiency. Further, society already has in place a number of general structural adjustment and social security schemes to cushion the adverse effects of structural change on individuals.

Government purchases of water rights to increase the allocation of water to provide more environmental services would have similar distributional effects.

That is, the selling farmers gain, but others in the region may lose, and society gains from the increased environmental services exceed the extra taxes.

An effective water market provides both incentives and rewards for individuals and businesses to increase the efficiency of water use. In a static efficiency sense, water trades involve the reallocation of water from lower value uses to higher value uses. In the longer run, market price sets the opportunity cost of water in different uses. Further, changes in the availability of water, changes in technology, changes in product prices and so forth lead to changes in market prices and a continuing process of reallocations of water from low value to more valuable uses. A particular advantage of letting market forces reallocate water is that there then is no need for governments or "experts" to guess the most valuable uses of water. Rather, well informed individuals in households, industry and on farms who know most about their own preferences, constraints and opportunities make the decisions guided by market prices. Among other things, markets dispense with the need for such unfounded and often seriously wrong assertions that marginal values of water equate to gross value per megalitre of water.

Importantly, a market system for allocating water which explicitly and transparently reveals the marginal social value of water provides enhanced incentives for water users to improve dynamic efficiency and productivity. For example, higher water prices provide incentives and rewards for users to improve water use productivity by, for example, laser levelling land, using more water efficient irrigation systems, night watering, dual flush toilets, the choice of water efficient plant varieties, and other water saving technologies. Over the longer term, higher water prices signal the potential pay-off from research to find more water efficient varieties, irrigation systems, production methods, and washing machines. As we have learned from the experience of the OPEC oil price shocks in the 1970s and 1980s, and from microeconomic reform in Australia in the 1980s and 1990s, these dynamic efficiency gains from improved production technology may be more important than the static efficiency gains from reallocations to equate marginal social benefits in raising national productivity in the use of water.

An anticipated second round effect of higher water prices is the reduction in the external costs associated with irrigation (see, for example, Weinberg, et al., 1993). Higher water prices and the incentives to increase the efficiency of water use will reduce some of the water now lost into the water table, with associated reductions

in down stream external costs caused by water logging and salinity. As discussed above, because only crude ways currently are available for combating these external costs via regulations and taxes in the water use licence system, and because of the associated efficiency costs of these arrangements, this may be an important longer term efficiency gain**.**

5. Environmental Flows

Much of the current debate about the allocation of water is focussed on requirements for an allocation of water for environmental flows. The flows are not an end in themselves, but rather they are a means to support native flora, fauna, wetlands, fish and recreational amenity. We as individuals place values on these environmental services in much the same way as we place a value on land allocated to national parks, or more generally as we value food and clothing provided by irrigated agriculture and green gardens made possible with water. Again, just as more and more food, clothing and green gardens provides us with declining additional satisfaction or marginal value, we also have declining marginal values for more and more hectares of wetlands and red gum forests provided by larger and larger allocations of water for environmental flows. Given a limited quantity of water available to allocate between irrigated agriculture, household use and the environment, economic efficiency requires that we equate marginal benefits across the different uses, including for the environment.

While the market systems discussed in the previous two sections work well for allocating limited water among most commercial uses of water by households, industry and irrigators, they break down for some environmental services. This is because many of the services produced with environmental water flows, such as maintaining biodiversity of native flora and fauna for their existence or future option values rather than for actual direct visitation, have the public good properties of non-rival consumption and high costs of exclusion. With services with these public good type properties there is an incentive for individuals to free ride and to leave it to others to purchase water for the environment. As a result, markets allocate too little water for the environment. There then is a case for direct government intervention to ensure some water is allocated to the environment in order to raise national efficiency. Ideally, the quantity of water allocated for environmental flows would equate the marginal social valuation of the increase in biodiversity made possible by the last megalitre allocated to the

environment with the price of market water (which, as argued above, approximately equals the marginal social value of the last megalitre allocated to different commercial uses of water by households, industry and irrigation). Clearly it is not easy to prepare estimates for society's marginal value of the services provided by water allocated to the environment. However a logical framework for preparing the estimates is well known. The starting point is a hydrological and biological description of the effects of different allocations of water to the environment on native flora and flora. A recent Interim Report for the Murray-Darling Basin Commission (Cooperative Research Centre for Freshwater Ecology, 2003) is an interesting illustration of what is required. Even at this stage, a number of difficult questions arise. For example, water allocations to support pristine type flora and fauna would require infrequent large flows to mimic floods and extended periods of minimal or zero flows to mimic droughts. Further, replication of the pristine world would require considerable variability in the sequence and duration of floods and droughts. Alternatively, a strategy requiring regular flows year after year or across seasons for the environment, say to provide visual amenity and maybe for the control of algal blooms, would support a very different mix of flora and fauna. It is apparent that some judgement will be necessary in proposing a finite number of possible strategies on changes in the allocation of water to environmental flows, and then describing their incremental effects on flora and fauna, and on other measures of environmental services of value to society.

Then, given the biological descriptions of the changes in flora and fauna outcomes for different increases in the allocation of water to the environment, contingent valuation and choice modelling procedures would be used to obtain estimates of the marginal social values, or dollars, placed by members of society on the increases in flora and fauna provided by additional allocations of water to the environment. These valuation techniques are controversial, and they are expensive to apply properly, but they are now used in a wide mix of environmental studies (see for example, Portney, 1994, Hanemann, 1994, and Diamond and Hausman, 1994). The resulting valuation for the additional environmental services would be compared with the market price of water in deciding on whether to increase or decrease the water allocation for the environment.

Current government initiatives to increase the quantity of water allocated to the environment are ad hoc. For example, Murray Darling Basin Commission (2000) proposed specific volumetric allocations to the Murray river for the environment with no supporting arguments or documentation on just what additional flora, fauna and other environmental services would be gained, let alone any assessment of society's valuation on those additional services provided relative to the opportunity cost of water diverted from irrigation. Similar criticisms can be made of recent Victorian Government (2003) statements that X% of the flow of the Thomson and other rivers should be allocated to the environment. The August 2003 COAG intention to allocate $500 million for environmental flows also appears to be an arbitrary number. The quality of political debate on how much water to allocate to environmental flows, and on the form which these flows might take, would be supported by more explicit and formal analyses of the anticipated changes in flora and fauna outcomes, and of estimates of the monetary sums members of society place on these changed biological outcomes. In the absence of such studies we will be uncertain as to whether too much or too little of river flows have been allocated for the provision of environmental services.

An important implication of the economic efficiency model for allocating water for the environment is that the allocation will vary over time, both with changes in the aggregate available water supply and with changes in the relative values placed on alternative and competing uses of water. For example, for those periods when water supplies are short, as during extended drought periods, market water prices will be relatively high to ration water to the high value uses, including only high valued environment uses. By contrast, when water supplies are plentiful, the market water price will fall and more water would be allocated to the environment. The income elasticity of demand for environmental services likely is much higher than is the income elasticity of demand for food and fibre, including that produced with irrigation, suggesting that over time as we experience higher incomes economic efficiency will require that the share of water allocated to the environment should increase at the expense of water allocated to irrigation.

6. Conclusions

The over-riding guiding principle for the allocation of water among competing uses by households, industry, irrigation and the environment is to equate marginal

social benefits across the different uses. A mixture of competitive markets and of government intervention is proposed to efficiently allocate water. Most commercial uses of water by households, industry and irrigation have private good characteristics of rival consumption and low costs of exclusion. For these uses, private competitive markets in well defined and transparent water property rights, supported by a system of water use licences to regulate or tax external costs of water use and to charge for the costs of water delivery, will lead to static and dynamic economic efficiency. Many of the services provided by environmental flows involve public good characteristics of non-rival consumption and high costs of exclusion, and here some government intervention to increase the allocation of water to the environment is desirable. Determination of the additional quantity of water to allocate for environmental flows requires information on the increases in preservation of native flora and fauna and other environmental services the extra flows would provide. Then, estimates of the willingness of society to pay for the additional environmental services would be compared with the opportunity cost of water diverted from commercial uses.

Australian water policy, particularly in its intention, is moving along the proposed path, but much development of water markets and of procedures for valuing environmental water flows is required. Finally, the proposed institutional structure then provides an improved set of incentives for the development of and adoption of new technology to improve water efficiency.

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