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Third-party effects of water trading and potential policy responses*

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A key feature of water policy reform in Australia has been the separation of water access entitlements from land titles and the establishment of markets for water. However, the separation of water entitlements from land failed to account for a number of characteristics that were implicit in the joint right. This has given rise to a number of third party effects as water is traded in an incomplete market. This paper describes four third-party effects of water trade; reliability of supply, timeliness of delivery, storage and delivery charges, and water quality and examines policy responses to address these effects. The discussion draws on the concepts of exclusiveness and rivalry to determine the applicability of property rights and other solutions to the third-party effects of trade. It is likely that many of the third-party effects of trade discussed in this paper do not warrant policy intervention at the national or state level, but intervention at the local level may be warranted. The costs of addressing some third-party effects may outweigh the benefits. Where there are significant gains from trade, the existence of these third-party effects should not been seen as a reason to impede trade.

Key words: property rights, water trading, third-party effects.

1. Introduction

The focus of water policy in Australia over recent decades has changed from assisting ongoing resource development for consumptive use, to managing competing demands for a fully allocated resource. A turning point in Australia's water policy occurred in 1994, when the Council of Australian Governments (COAG) agreed to a water reform framework (COAG 1994).

A key feature of the 1994 reforms included the introduction of a cap on diverting water from the Murray–Darling Basin, the area with the largest agricultural water use in Australia. The objective of the cap is to achieve a

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balance between the economic and social benefits of water resource development and the provision of water for ecological purposes.

The cap on diversions and the provision of water for the environment have been accompanied by the separation of water access entitlements from land titles and the establishment of a market for water trade. In this context, trade allows water resources to move from uses that generate relatively low economic returns to those generating greater returns. Trade of water property rights can play a pivotal role in minimising the economic and social costs of obtaining additional water for the environment.

The National Water Initiative (2004) was designed to complement and extend the reform agenda commenced in 1994 and sought to further expand water trading (COAG 2004). However, trade has been constrained by a number of institutional issues and, to date, the volume of trade in permanent entitlements has been small (Goesch and Beare 2004).

The separation of water entitlements from land ownership is a necessary but not sufficient condition to ensure that a water market is complete. In the absence of fully defined property rights, trade has the potential to create adverse third-party effects that prevent the benefits of trade from being fully realised, or to have distributional effects that can have impacts on the wealth of other water users. Note that the existence of some third-party effects has been raised as a reason to impede trade (Goesch and Beare 2004).

The objectives in this paper are to identify key potential third-party effects of water trade under existing property rights structures in Australia and, where possible, to assess the relative significance of these effects. Examples are drawn from the southern Murray–Darling Basin system.

In the first section of this paper, water property rights, water use and trade are described. In the second section, a description is provided of four third-party effects of water trade that are related to reliability of supply, timeliness of delivery, storage and delivery charges, and water quality. Available policy instruments to address these effects are considered in the third section, drawing on a framework using the concepts of exclusiveness and rivalry (Randall 1983). The relative importance of each effect is discussed in the final section, to help policy makers determine whether potential reforms are worthwhile and to guide the prioritisation of reform efforts.

2. Water property rights and use

Irrigated agriculture contributes just over a quarter of the value of agricultural production in Australia, or around $A9.6 billion a year (Australian Bureau of Statistics 2004). The focus in this paper is on the southern Murray–Darling Basin region, located in the south-east of Australia and extending across the jurisdictional boundaries of Victoria, New South Wales, the Australian Capital Territory, and South Australia (see Figure 1). This region accounts for around 70 per cent of irrigated agriculture in Australia. It is characterised by the provision of large-scale public and private infrastructure to regulate water

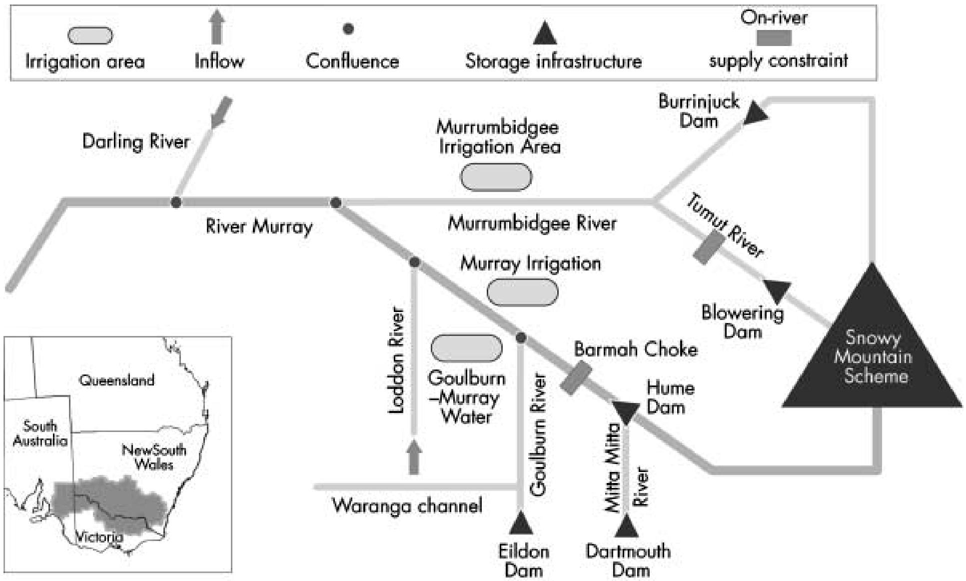

Figure 1 Schematic diagram of the southern Murray–Darling Basin.

delivery on a district basis to farms. The southern Murray–Darling Basin is hydrologically linked, enabling intraregional (within valley) and interregional (between valleys or states) water trading. It covers eight irrigation districts supplied by two main river systems: the River Murray and the Murrumbidgee River.

2.1 Trade in water entitlements and allocations

Most irrigators in the southern Murray–Darling Basin hold a nominal volumetric entitlement that is delivered as a share of an annual resource pool. The yield of the entitlement depends on the size of the resource pool that, in turn, depends on surface water run-off, storage capacity, and the way that storages are managed. Irrigators receive an annual volumetric allocation from these rights that they can call on, in full or in part, during the irrigation season.

Entitlement specifications and yields can differ between jurisdictions. South Australia and Victoria have the most conservative supply arrangements and nominal entitlements have a yield of around 95–100 per cent. In New South Wales around 10 per cent of entitlements are high security – similar to those in Victoria and South Australia. The remainder has a yield of around 80 per cent of entitlement. Further, there is a difference in the storage to allocation ratio in New South Wales and Victoria and, as a result, supply reliabilities can be affected significantly by climatic conditions.

Irrigators in the southern Murray–Darling Basin can trade both water entitlements ('permanent trade') and seasonal water allocations ('temporary trade'). Most trade occurs in seasonal allocations, and it is common for 10–20 per cent of allocations to be traded within an irrigation district in an irrigation

Box 1 Expansion of trade in the southern Murray–Darling Basin

Heaney *et al.* (2004) used a competitive partial equilibrium model of water markets in the southern Murray–Darling Basin to assess the economic impacts of water trade under freer administrative arrangements and alternative charging options for water delivery. This work suggests that removal of administrative impediments to trade will result in around 600 GL of additional trade in permanent water entitlements. This represents a relatively small share of total water use and partly reflects the large sunk investment in on- and off-farm infrastructure. Although water may become more mobile as these investments reach the end of their economic life, the demand for water for environmental purposes is likely to be an important driver of future trading patterns.

Peterson *et al.* (2004) used a computable general equilibrium model to estimate the regional impacts of expanding trade in the southern Murray–Darling Basin under a number of scenarios where water availability was reduced by 10, 20, and 30 per cent. With a 10 per cent reduction in water availability, total net water trade in the southern Murray–Darling Basin was found to be a relatively small proportion of total allocations, with only 2.3 per cent of allocations traded among regions. Similarly, under the same scenario, net water exports or imports from a region were a small percentage of total water allocations in that region. The Murrumbidgee region was projected to be the largest net exporter of water with around 4 per cent of allocations traded out of the region.

season (Peterson *et al.* 2004). Although trade in allocations has increased over recent years, trade in water entitlements remains small, at less than 1 per cent of diversions in 2001–2002. Low levels of interregional trade may be partly explained by administrative impediments such as trade quotas imposed by irrigation authorities that restrict out of district trade (Goesch 2001). There are also a number of physical and environmental factors that impede interregional trade (see Figure 1).

Two recent studies examined the effects of removing administrative impediments to trade in the southern Murray–Darling Basin (see Box 1). Both studies suggest that additional trade may be relatively small, even if impediments are removed.

2.2 Implicit water rights and trade

The development of irrigation in the southern Murray–Darling Basin created a link between access to water, infrastructure, and land. Prior to the cap on diversions being imposed, it was access to infrastructure rather than water resources that limited surface water use. The link between water, infrastructure, and land allowed the creation of water property rights that were largely implicit. These implicit rights included access to a location-specific pool of resources, storage facilities, and delivery channels, together with rights over the quantity and quality of return flows and conveyance losses (Goesch and Beare 2004).

Trade can alter the implicit rights attached to those entitlements. When a water entitlement that is defined at the point of delivery is traded, for example, the location from which it is sourced may change. This can have implications for the infrastructure used to store and transport this water; therefore, the specification of resource access rights, and hence, the water market is incomplete. Implicit changes in resource access rights arising from trade may not always affect other water users. Altering the location of storage and delivery infrastructure from where water is sourced, for example, will not affect other users if capacity constraints are not binding, but when and where these constraints are binding, trade can impose third-party effects. In general, utilities currently only approve trades if the trade is not likely to cause congestion.

3. Third-party effects of trade

Some of the key third-party effects of trade in entitlements and allocations in the southern Murray–Darling Basin are reviewed in this section.

3.1 Reliability of supply

The reliability of supply can be defined in terms of the probability that an entitlement holder will receive a volume of water in a given season – that is, the expected level of variation in physical water allocations that are realised from holding an entitlement. Supply reliability is determined by the natural variability of the resource pool and by the institutional arrangements that determine the share of that resource over which the entitlement is granted. The reliability of supply can also be affected by storage and conveyance losses, access to return flows, and the introduction of tradable water entitlements. The significance of factors affecting supply reliability varies across the southern Murray–Darling Basin. Importantly these factors are not currently explicitly specified in the irrigator's entitlements.[1]

In the southern Murray–Darling Basin, entitlements are defined at the point of delivery. The number of potential sources from which these delivery points can be supplied increases moving downstream as the effective catchment area increases with tributary inflows. Unless traded entitlements retain the features of the reliability of supply from the exporting catchment, net trade that spans one or more tributaries can affect the reliability of entitlement in both the source and the destination regions. If water is traded upstream of a tributary, a given pool of resources may be spread over a greater number of users, thus decreasing supply reliability for those users. At the same time, there is an increase in the share of resources that is potentially available to users below the tributary.

[1] Prior to the introduction of tradable entitlements, unused allocations from irrigators who did not exercise all or part of their entitlements were returned to the resource pool and reallocated. This increased the yield of the entitlement of active water users. The introduction of trade created an opportunity cost to irrigators who did not fully exercise their entitlements, which effectively led to an increase in the number of shareholders in the resource pool. Although not causing problems of efficiency, the distributional effects of this reallocation of resources induced by the potential for trade slowed the reform process.

Loss of water through evaporation and, in some circumstances, seepage, during storage and transport can reduce the availability of water for irrigation. For example, changing patterns of trade can alter the timing of required irrigation releases from the dam and, in turn, the period of time water is held in storage.

Conveyance can be either non-flow dependent or flow dependent and will differ within and between irrigation regions. Non-flow-dependent conveyance losses, such as those associated with saturating earthen channels, occur regardless of how much water is transported. Trade does not significantly alter non-flow-dependent losses. Conversely, flow-dependent losses vary depending on how much water is transported and may be affected by trade. They may occur, for example, if additional water caused the river to breach its banks.

Under traditional irrigation techniques, such as flood and furrow, irrigation run-off from farms is recycled via surface water run-off, drainage schemes, and accession to groundwater tables that eventually reach the river system. These flows are included in calculations of the volume of water that is allocated to downstream irrigators. However, irrigators presently hold an implicit right to the return flows in that they can trade or save water without considering the downstream effects on other water users associated with changes in water volume and quality. Water traded to an irrigator who employs more efficient on-farm water application techniques than the seller, for example, may lead to a reduction in water available to downstream users and thus affect the reliability of supply for some irrigators (see Appels *et al*. 2004). Under current institutional arrangements, reductions in the volume of return flows are simply absorbed as an additional diversion above the cap that may be at the expense of desired environmental flows.

3.2 Timeliness of delivery

The reliability of the delivery of an allocation is the timeliness of delivery of the water to the farm gate and depends on access to storage and delivery infrastructure. Congestion can occur in the river system as a result of the physical features of the river or within the irrigation system in near farm delivery infrastructure. Increasing marginal congestion costs are borne by irrigators and other water users through reduced timeliness of delivery on water orders. Water trade can have an effect on third-party access to infrastructure if, for example, water is traded from a scheme where channel capacity is rarely reached into a scheme where capacity is often reached. Under current institutional arrangements, this trade could reduce the reliability of delivery for all irrigators in the destination region.

Further costs will be imposed if, as commonly occurs, access to delivery capacity for irrigators within a district is rationed on the basis of historical allocation during times of congestion rather than on the basis of delivering to those who face the greatest marginal costs associated with a shortfall in deliveries. Trade into an irrigation area that worsens congestion can cause further inefficiency if access is not rationed according to costs. An irrigator on a local channel delivery system in the Goulburn–Murray Irrigation District, for example, is only permitted to trade water to the farm if there is sufficient capacity in the channel system for the delivery not to affect the timeliness of delivery of other irrigators on the channel. Trade that exacerbates channel constrictions at the Barmah Choke is currently prohibited. Although this may take account of the third-party effect of trade, non-market rationing does not ensure that the irrigators with the greatest net return gain access to the infrastructure. Congestion may also have environmental impacts if, for example, it impedes the delivery of water to meet environmental outcomes.

Water utilities avoid on-river constraints, to some extent, by using a number of rerouting mechanisms including moving water to downstream storages before the start of the irrigation season. Losses from these storages through evaporation and seepage are high and this, in turn, may have an effect on users' security of supply.

3.3 Storage and delivery charges

Trade in entitlements can result in a net trade of water permanently out of an irrigation district. If utility costs are apportioned to a smaller number of entitlements, charges for remaining irrigators may be higher. This may lead to their trading water out of the region and, ultimately, the utility may no longer provide irrigation water to the assets such as delivery channels, so the infrastructure may cease to be used. This is sometimes referred to as the 'stranded asset' problem.

It is important to distinguish between *ex ante* and *ex post* policies – in other words, whether the policy decision is made before or after utilities' infrastructure investment decisions. *Ex ante*, the requirement for undertaking and charging for an infrastructure investment (including infrastructure replacement) is for the total benefits of its creation and operation to be greater than the costs. *Ex post*, the infrastructure is a sunk asset that may have little or no salvage value and may not be replaced. It may be economic to operate that asset even if only covering variable costs. Inefficiency will arise if the charging rule does not allow for this possibility. Remaining debt on the infrastructure does not have economic efficiency implications although there may be equity issues.

If a utility *ex ante* allocates fixed and variable costs in an appropriate two-part charging scheme, such as part of a long-term contract with irrigators, the stranded assets problem seems to fall into the class of third-party effects where there are no deadweight social losses. These effects are sometimes known as a pecuniary externality. They are distinct from physical externalities, which occur when water transfer affects the quality or quantity of water use. Pecuniary externalities arise when the external effects are transmitted through higher charges. The stranding of assets that result from the exit of entitlements from an irrigation district can result in pecuniary externalities for the remaining irrigators. To the extent that these third-party effects do not create deadweight social losses, their removal does not improve economic efficiency (Katz and Shapiro 1994; Hanak 2003).

Where a utility adopts an inappropriate pricing model, such as one that allocates fixed costs to a variable charge, trade can have efficiency implications (Goesch 2001; Heaney *et al.* 2004). The average cost of delivery may rise in source regions, whereas in the destination region, average costs may fall. These artificial conditions of decreasing and increasing costs can distort the spatial pattern of trade and result in movement of water into lower returning activities.

3.4 Water quality

Changes in water quality because of trade arise through changes in the volume and quality of return flows, including run-off, drainage, and groundwater discharge and, to a lesser extent the movement of traded water through the river system. Water quality may be affected if water is traded to an area or industry that has different agronomic practices from the source area. If water is traded to a use that relies more heavily on agrochemicals that may reach waterways, for example, third-party costs may be imposed on downstream water users.

Water quality issues in the River Murray system include river salinity, and its effect on productive uses for water as well as river health. Much of the increase in salinity can be attributed to subterranean return flows through the mobilisation of saline groundwater to the river system, a consequence of high levels of groundwater recharge from excess irrigation water. Within the southern Murray–Darling Basin, there is considerable variation in the salinity of groundwater underlying irrigation areas. The highly location-specific nature of the underlying hydrology means that the third-party effects of trade on water quality depend on the source and the destination of the water traded.

Return flows can either improve or reduce water quality depending on the location of water use after trade, thus having either positive or negative effects on users not directly engaged in the trade. Within the southern Murray–Darling Basin system, for example, relatively fresh return flows from areas characterised by flood irrigation technologies can reduce the river salinity concentration. Conversely, return flows from irrigation areas located above high saline groundwater deposits can increase salinity in the River Murray.

The location-specific nature of these third-party effects is important for at least two reasons. First, trade may lead to improvements in water quality, and policy instruments that provide incentives to trade water to 'low impact' areas can generate positive environmental and economic outcomes. Second, as the effects of trade vary with the source and the destination of the trade, it is infeasible to fully internalise the effects of return flows on others through a system of private property rights. Potential policy initiatives for internalising the impacts of negative third-party effects will be discussed in more detail in the following section.

4. Policy options

Water entitlements are access rights to the stream of benefits (or costs) derived from using water for irrigation. The property right is a claim over some or all of the returns from water as a productive resource. Water trade is an instrument whereby irrigators can enhance the value of that right. Third-party effects from water trade arise if some of the benefits (or costs) of that action are not exclusive and not captured by the holder of the property right. The set of markets for this right is incomplete, and the true value of that asset will not be accurately reflected in its price.

4.1 The Randall framework

Developing effective policy instruments that will improve the management of natural resources requires an understanding of why the market is incomplete. Randall (1983) argued that the concepts of exclusiveness and rivalry represent the characteristics of goods and resources that matter in a public policy context. Randall's classification of goods is presented in Table 1, along with some illustrative examples.

Under an exclusive property right, an individual bears all the benefits and liabilities associated with consuming or producing a good or service. An exclusive property right is complete if it conveys all the costs and liabilities of either production or consumption. If a property right does not convey sole rights and liabilities, it is non-exclusive. If access to this right is restricted to a subset of individuals, such as a club, it is hyperexclusive; the limiting cases are monopoly or monopsony access.

A good or service is rival if its consumption or production by one individual has an impact on the consumption or production of others. Consumption and production of non-rival goods does not alter the choice set or incentives faced by other producers and consumers. Congestible goods are non-rival up to some point but as consumption or production increases, delays begin to occur that impose costs.

Properties of exclusivity and rivalry can reflect the institutional arrangements that define property rights that exist over goods and services. Governments may grant resource access rights that are open, exclusive, or even hyperexclusive.

Table 1 Randall classification of goods based on exclusivity and rivalry

Category	Exclusive	Hyperexclusive	Non-exclusive
Rival	Water entitlement or allocation	Allocation of water resource pool between consumptive and environmental uses	In-stream conveyance losses
Non-rival	On-farm saving of evaporative losses		Improved water quality Ecosystem services
Congestible	Tradable infrastructure access right	Congestion charge by a delivery utility	Open access delivery channel

For example, water entitlements are exclusive in nature but access to the resource pool is capped by government – a form of hyperexclusion. The properties of exclusivity and rivalry may also be intrinsic to a commodity or service in that they limit the nature of the property right that can cost-effectively be placed over that good or service. For example, existence values are intrinsically non-rival and the costs of excluding individuals from the amenity benefits of natural resources is often prohibitive.

Beare and Newby (2005) note that exclusivity and rivalry can exist in both production and consumption of goods and services and that this can have implications for the design of an appropriate policy instrument. For example, unregulated emissions may generate non-exclusive damages in consumption and are non-rival in production in that one firm's emissions do not limit another's. User or beneficiary charges may not lead to an efficient solution to the problem because of the transactions costs of compulsory charges and the incentive for beneficiaries to under-invest in abatement. However, a cap on emissions, another form of hyperexclusion, creates rivalry in production, allowing the introduction of a tradable permit scheme.

Randall (1983) argues that the joint classification of exclusivity and rivalry characterise a good or service and determines the most efficient means of provision and trade. Beare and Newby (2005) observe that the policy options available to complete a market are largely determined by characteristics of exclusion and rivalry in the missing primary good or goods. The Randall classification provides a framework to examine policy instruments to address third-party effects of trade that can arise in incomplete water markets.

4.2 Reliability of supply

Water entitlements are not fully exclusive (even though they are rivals) because they are not defined according to the location from which they are sourced. Consequently, trade in water entitlements fails to account for storage and conveyance losses and return flows. The lack of exclusion gives rise to third-party effects on the reliability of supply of an entitlement. Trade in water entitlements that do not take into account jurisdictional differences in the reliability of supply specifications can also generate third-party impacts.

The third-party effects of trade on reliability of an entitlement can be addressed using a source-based, property rights solution, which adds a further component to the current water right. One option is to redefine the entitlement from the point of delivery to the source of extraction to make the conveyance loss exclusive. Alternatively, Beare *et al.* (2005) suggest that a system of administered exchange rates could be used to account for the differences in the yield of an entitlement. An exchange rate may be used, for example, to account for trade resulting in a 10 per cent increase in conveyance losses, by converting the volume purchased to 90 per cent of the volume sold. Where there were no conveyance losses, the exchange rate determined would result in no net change in demand for water from the system on average.

Exchange rates, however, can be difficult to specify correctly so that efficiency losses do not occur. Appropriate exchange rates would need to be location specific and sufficiently flexible (including being adjustable retrospectively) to allow for changes in factors affecting supply security, such as changes to water sharing plans and long term climate change.

Water trading has been shown to have an effect on the reliability of supply of third parties through changes in patterns of return flows that alter the quantity of water available for irrigation downstream (Heaney and Beare 2001). This problem arises because water property rights are currently defined in terms of water diversions rather than the volume of water that is consumed. Although these third-party effects are non-exclusive, they may be amenable to a property right solution if the transaction costs of defining and measuring return flows are not prohibitive. This solution will be particularly complex when accounting for changes in water quality, because a fraction of non-consumed water will return to the river system in an altered state, possibly generating downstream costs or benefits.

Trade in allocations, on the other hand, only affects supply reliability where there are differences in the conveyance losses between the source of supply and destination of the water after the trade. If the extra flow created by the trade does not result in water breeching the banks of the distribution network and the trade occurs when distribution networks are full (as is usually the case with trade during peak irrigation period) the potential for further loss is greatly diminished as the distribution network is usually fully saturated and evaporation losses are not altered as the surface area of the channel is unchanged. Overall, conveyance losses are likely to be small relative to overall releases from storages (see, for example, Pratt Water 2004).

4.3 Timeliness of delivery

Irrigation delivery channels are generally referred to as congestible goods because they exhibit non-rival characteristics for a limited number of users or levels of use. Rivalry sets in once this limit is exceeded, and intensifies as the number of users increases.

Because demand for delivery capacity is highly seasonal and subject to periods of expansion and contraction, it is seldom optimal to invest in delivery capacity to meet periods of peak demand. Although congestion does impose costs, it does not necessarily follow that there is a need to ration access to minimise congestion costs. Where all irrigators seeking access to delivery infrastructure face the same marginal cost of delay, delivering services on a 'first come, first served' basis will lead to optimal allocation. Where irrigators face different marginal costs associated with a delay, however, delivery services must be rationed in some way to ensure that those irrigators with the greatest net return gain access.

It may be possible to reduce congestion costs by allocating access rights to delivery infrastructure and by allowing trade in those rights, if the right to access water and delivery infrastructure were separated and made explicit. Alternatively, congestion charging may be used during periods of congestion when services are rival, and where irrigators face differing marginal costs of congestion. By increasing peak period access charges during congestion, those irrigators facing higher congestion costs will be most prepared to pay the extra charges. Congestion pricing will have no rationing effect during continual congestion and will result in economic rents accruing to the infrastructure supplier, signalling a possible need for increases in capacity.

Further, rationing access to delivery infrastructure will only lead to a more efficient allocation of resources once rivalry sets in. Tradable access rights or congestion charging will create an inefficient exclusivity (rent seeking) if imposed when access to the infrastructure is non-rival.

With small net trade (see Box 1), third-party effects are most likely to be limited to near farm delivery infrastructure where trade causes or exacerbates peak period congestion. Even then, trade may only cause problems during a relatively small number of peak demand days. Net trade into an irrigation area is more likely to exacerbate peak period congestion in systems with similar agricultural enterprises (for example, rice production) because the timing of demand for water is likely to be similar across the region. Areas characterised by large variation in agricultural production may be less likely to have peaks in water demand.

4.4 Storage and delivery charges

Problems related to storage and delivery charges were identified in Section 2 as potentially having both equity and efficiency aspects. The policy challenge posed by pecuniary externalities, similar to the challenge arising from agricultural trade liberalisation, is an equity issue (Hanak 2005). If governments wish to intervene, however, constraining trade arrangements is unlikely to be the most efficient and effective mechanism to use.

The efficiency aspect of the problem may have arisen for two reasons. The first reason for inefficiency could stem from missing options markets for access to storage and delivery infrastructure. Purchase of such options would be akin to joining a club. Club goods are a class of public goods that are exclusive in consumption but non-rivalrous, at least to the point of congestion. Creation of such markets *ex ante* would allow long-term contracts to be established such that the actions of club members (such as exit) may not harm other members of the club.

The second reason is inappropriate pricing regimes. This could be addressed *ex ante*, for example, through adopting a two-part charging scheme for allocating fixed and variable costs. *Ex post*, where the asset might not be replaced, this could be addressed through more flexible pricing agreements between the utility and the irrigator, such as marginal cost pricing. However, under current institutional arrangements, there are restrictions to utilities adopting such a regime.

When weighing up the benefits and costs of government intervention related to stranded assets (or for any other reason), it is important to consider the positive as well as negative third-party effects that can result from trade. Positive effects associated with permanent water trade include the alleviation of congestion and pressure on groundwater tables in the exporting district, and greater economies of scale in the importing region. If governments wish to assist affected irrigators, they should choose instruments that are targeted and that do not impose unnecessary cost on other parties.

Inappropriate intervention to address stranded asset concerns can reduce efficiency. Restrictions on trade are the most common example in Australia. The imposition of *ex post* exit fees, for example, can lock water into low-productivity enterprises and regions. There is opportunity for the utility to rationalise its delivery system with asset redundancy, for example, by decommissioning or 'mothballing' redundant infrastructure. Some parts of the local distribution network may no longer be needed because water is no longer diverted from the main distribution network to smaller feeder channels to the irrigator's farm. The utility could then reduce charges to reflect the new patterns of infrastructure use. There may also be opportunities for the utilities to negotiate exits with irrigators.

In the absence of trade constraints, the incidence of stranded assets will be highest in regions where the marginal value product of water is lowest (for example, where a significant proportion of water is used for lower value activities), or in areas facing environmental degradation problems (for example, rising saline water tables). Localised channel and diversion infrastructure have been the main utility assets affected by trade in entitlements in the Goulburn–Murray Irrigation District to date. The net exit of entitlements in Goulburn–Murray Water subdistricts has tended to be geographically concentrated, with some subdistricts frequently reaching their quota. This may, in part, reflect commodity prices and salinity (see, for example, Barr 1999). Other factors, such as the size of the farm, the age of the irrigator, and their off-farm income are also likely to be important influences.

If administrative constraints to trade were removed, modeling suggests small net exit from irrigation regions, indicating that the rise in costs to remaining irrigators will be correspondingly small (see Box 1). Even where some subdistricts lost a third of irrigators over the decade, utility charges would only increase by about $A11 per megalitre in nominal terms[2]. With allocations trading around $A67 per megalitre in 2004–2005 (during the 2002–2003 drought they reached $500 per megalitre), in the Goulburn–Murray region such increases in charges are unlikely to bridge the gap between utility charges and

[2] Goulburn–Murray Water allocates 220 000 megalitres of water to entitlements on 1260 properties (including stock and domestic supplies) in the Pyramid Hill subdistrict. Annual fixed and variable charges are approximately $A22 per megalitre (not including bulk water charges) plus an administration fee of $A100 per property, generating around $A4.96 million in revenue annually. If a third of entitlements and properties left the subdistrict, there would be a reduction in annual revenue of $A1.65 million. To recover this loss, from the remaining 840 irrigators, annual allocation charges would need to rise to $A33 per megalitre and the administration charge to $A150 per property.

the traded prices for allocations and are, therefore, unlikely to influence investment and production decisions of irrigators (Peterson *et al.* 2004).

Major infrastructure assets such as dam and diversion infrastructure are unlikely to be affected. The cost of major dam infrastructure is passed on through trade, and entitlements are traded to meet the water needs of the purchaser. Just as the seller has relied on major infrastructure to store and deliver the water allocated to the entitlement in the past, so too will the purchaser in the future, regardless of whether the trade is intradistrict or interdistrict, or whether the purchaser is an irrigator or an environmental manager.

4.5 Water quality

The effect of trade on water quality is intrinsically non-exclusive. For example, trade out of a high-impact area that reduces saline discharge to the river would benefit all downstream users. Further, because the benefits accruing to water users differ according to their location, high transaction costs may prevent downstream users from collaborating to encourage investment upstream to improve water quality. Both these factors limit the usefulness of property right solutions that can capture the benefits of trade between parties. As a consequence, policies need to be directed to those activities that are the source for abatement of pollution.

Water-use rights may be used to impose specific conditions of use on irrigators. These rights may be regulations that apply to the location and intensity of water use, for example, in high-impact zones. Limits may be placed on the type of soil that can be used for particular activities, and maximum water application rates and standards may be imposed on water use efficiency. Regulations can, however, be inflexible. Imposing a maximum application rate, for example, will prevent irrigators from applying additional water in dry years, even if the benefits vastly outweigh the social costs. The conditions of water use rights can include the use of flexible economic instruments including levies, subsidies, or exchange rates; for example, an irrigator might be required to purchase a salinity credit from a salt extraction scheme to offset the impact of saline drainage water discharge.

A form of water-use right is currently implemented in the Murrumbidgee Valley, where rice production is limited to areas of specific soil types, and where maximum water application rates are imposed. These use rights are effectively tied to the land. Use rights can also be applied specifically to deal with the change in third-party effects associated with use when water is traded. Where the transfer of water results in an increase in external costs, for example, it may be possible to impose a levy on the use of water traded into that region. The levy revenue could be used to provide an incentive to trade water from regions with high external costs to regions with lower external costs. This approach currently is used by Sunraysia District where differential charging is applied depending on the source and destination of the trade.

Because the effects of water use vary continuously according to location in the river system, a levy or subsidy must be source and destination specific. A system of exchange rates could also be used to deal with third-party effects, for example, if water trade between regions results in an increase in salinity downstream of the recipient region, an irrigator may be required to purchase water in excess of requirements. This additional water would be used as a dilution flow to offset the increased salinity arising from this trade (Beare and Heaney 2002; Goesch and Beare 2004).

From a producer's point of view, unregulated pollution is non-rival – that is, the discharge of pollution by one producer does not affect the ability other producers to pollute. It is possible, however, to make water quality rival by creating tradable use rights and establishing a market for pollution caused by water use that meets some 'target' level of pollution at least cost. A tradable salinity credit scheme could, for example, be used to control the level of saline emissions from an irrigation scheme. Salinity credits equivalent to the desired level of emissions from the scheme would be initially allocated to irrigators. Once allocated, these credits represent an asset that can be traded. Irrigators with a lower marginal cost of abatement will have an incentive to sell credits to irrigators with a higher marginal cost of abatement.

The effects of trade on River Murray water quality have been shown to be considerable, depending on the source and destination of the trade (Heaney and Beare 2001). Net trade into the highly saline regions of South Australia and Victoria, for example, imposes costs on downstream water users through higher salt concentration of water used for productive purposes and also affects the riverine environment more generally. In contrast, regional trade between irrigation areas with similar agronomic and hydrological characteristics may not warrant policy intervention.

5. Conclusions

The separation of water entitlements from land failed to account for the spatial characteristics of water supply, demand and use that were implicit in the joint right. Trade in water entitlements and allocations have therefore given rise to third-party effects. The existence of third-party effects has been cited as a reason to restrict or prohibit intra- and interregional trade in the southern Murray–Darling Basin.

Third-party effects on delivery reliability are likely to be relatively localised and small in terms of scale and cost, but nonetheless amenable to property right solutions. Other effects have the potential to be more substantial, such as some of the effects on the security of supply. Accounting for differences in entitlement specification between jurisdictions, for example, would generate considerable benefits if there were large volumes of water traded between states.

Although for the most part, these third-party effects can be addressed through the introduction of more completely specified water rights, the creation, implementation, and enforcement of property rights regimes is not costless. In some instances, the costs of property right solutions may be higher than the benefits they generate. The regionally specific nature of the third-party impacts of trade examined in this paper highlight the need to recognise regional characteristics of surface and groundwater systems, soil, and climate as well as investments in fixed infrastructure when considering policy interventions. Adding a further component to existing property rights to account for the water quality effects of water traded within the Goulburn–Broken region, for example, may generate costs that exceed the benefits. The same action attached to water used in the highly saline regions of South Australia, on the other hand, may generate considerable benefits and allow the benefits of trade to be fully realised. Similarly, if the costs imposed by water losses and trade restrictions as a result of the current management of capacity constraints such as the Barmah Choke are such that they warrant intervention, property rights or pricing regimes to ration access may be considered as appropriate policy interventions.

It is likely that many of the third-party effects of trade discussed in this paper do not warrant policy intervention at the national or state level. In some instances, effects are likely to be relatively minor although some may be significant at the local level. The costs of addressing some third-party effects may outweigh the benefits. Where there are significant gains from trade, the existence of these third-party effects should not be seen as a reason to impede trade. There are first-best policy instruments to address these effects at an appropriate scale.

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