Options for water market reform

ABARES submission to the ACCC Murray-Darling Basin water markets inquiry

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About

This document summarises ABARES response to the ACCC Murray-Darling Basin water markets inquiry interim report (ACCC 2020). ABARES submission focuses primarily on issues of 'market architecture' as discussed in part V of the ACCC interim report, drawing heavily on past research undertaken by ABARES. In particular, the submission is focused on the definition of water property rights and water market rules (e.g., water sharing rules, carryover rules and inter-regional trade limits) within the connected southern-Murray-Darling Basin (sMDB). Some brief comments on trade processing and water market information issues (as discussed in section IV of the interim report) are also provided. Issues relating to water market integrity and governance are not considered.

This submission presents a range of water market reform options for further exploration. However, it does not offer a detailed assessment of the costs and benefits of these potential reforms nor does it provide any specific recommendations. In particular, this submission presents some longer-term reform ideas, many of which would involve substantial changes to existing arrangements and be likely to impose significant transition costs. While the submission is informed by past research, all of the options would require more detailed analysis and investigation before informed decisions could be taken on implementation.

Summary

Water markets have been a success, but challenges are beginning to emerge

Australian water markets are rightly viewed as one of the best examples of their kind in the world. For several decades now, water markets have played a vital role within the MDB acting to quickly and efficiently allocate scarce water resources between users particularly during droughts (see Kirby et al 2014, Hughes et al 2016). Water markets are also crucial in supporting adaptation to a range of ongoing structural changes in the MDB (see Gupta and Hughes 2018) including long-term reductions in water supply related to climate change (see Hughes 2019, Cai and Cowan 2013), large scale environmental reforms and transformational change within the irrigation sector (Gupta and Hughes 2018).

In assessing the performance of water markets, it is important to separate the operation of the market itself from these large structural trends. Reductions in water supply (due to drought, climate change and environmental water recovery) and increases in demand (due to expansions in horticulture) have contributed to large increases in water prices in the sMDB over the last decade (Hughes et al. 2019). Past ABARES research has found that these increases in water prices can be largely explained by measurable changes in water supply and demand (see Hughes et al. 2016, Gupta and Hughes 2018, Hughes 2019).

Large increases in water prices have no doubt played a part in user concerns around the operation of the water market. However, high water prices on their own do not necessarily indicate failure or inefficiency in the water market. Rather, price signals are central to the function of water markets and help encourage efficient allocation and use of scarce water resources. Further, high water prices also suggest that water property rights are well defined and that compliance efforts in the sMDB are broadly effective (Hughes et al. 2020).

Notwithstanding this, the structural changes experienced in the MDB over the last decade have placed water markets under significant pressure and revealed some legitimate weaknesses in existing market rules and processes. For example, recent droughts and shifts in irrigation activity have started to push inter-valley water trade in the sMDB to its physical and administrative limits, leading to frequent trade closures (see Gupta et al 2018). This has raised concerns both around the efficiency and equity impacts of trade closures, and potential third-party effects of high inter-regional trade volumes (e.g., due to increased river losses).

Attention has also been placed on water sharing and carryover rules within the MDB; with concerns over the complexity of current rules and their potential to create uncertainty over the volumes of water allocated to water right holders. While many of these concerns are not new ongoing structural changes (particularly changes in climate conditions) are increasing pressure for reform.

Water market reform decisions are complex

Water markets require the definition of property rights to water in the form of legal and accounting systems which specify: the volumes of water available, how these are to be shared amongst right holders and any limits on the trading or carryover of these volumes. Given the physical complexity of water supply networks (and the costs of implementing the necessary

rules and processes) water property rights always involve some degree of approximation. Within the MDB, water property rights reform has occurred more or less continuously since markets first emerged, with rules gradually becoming sophisticated as water has become scarcer and more valuable (Hughes et al. 2013, Hughes 2010).

Decisions to change water market rules involve difficult trade-offs between efficiency and equity. A key challenge in established markets such as the MDB, is that any rule changes could have potential welfare and equity effects on existing water right holders. In practice, the costs of mitigating or offsetting these welfare effects can make reform difficult even where there are clear efficiency gains. Reform decisions also require weighing the efficiency benefits of more precise systems against the potential implementation costs.

Market architecture: water sharing rules and carryover

Current carryover rules within the sMDB are less than ideal due to the annual water accounting framework (which leads to a range of inefficient carryover limits). Further carryover rules are inconsistent across the sMDB (particularly between NSW and Vic.). In addition, water sharing rules (which set user allocations as a function of water resource availability) are highly complex and can create unnecessary uncertainty for water right holders.

This submission outlines a range of potential reform options to water sharing and carryover rules in the sMDB. Collectively these reforms would take current water accounting systems closer the 'continuous accounting' and 'capacity sharing' style systems currently adopted in northern NSW and southern Queensland respectively (see Hughes and Goesch 2009, Hughes et al. 2013). These reforms aim to set water sharing and carryover rules which—as far as practical—reflect the physical constraints of the water supply system, and then allow users to trade or carryover water subject to those rules.

Some key potential reforms for exploration include:

- Refinement of water sharing plans to ensure water allocations are determined by well-defined and transparent functions of physical water availability (ideally in the form of simple percentage shares).
- Continuous (i.e., daily/weekly) water accounting with periodic reconciliations to ensure match user water accounts match physical water supplies.
- Carryover subject to user water account limits (and 'internal spills') as occurs in current capacity sharing / continuous accounting systems (and the removal of current annual carryover limits and 'spillable water accounts').

Collectively this approach could help to maximise user trade and carryover flexibility while minimising third-party effects (externalities). In addition, the closer alignment of water sharing rules with physical water systems helps to improve transparency and reduce uncertainty. The range of reforms presented in this submission, allow for significant flexibility to vary scope and timing of future changes. For example, an ambitious reform agenda could see the sMDB approach something resembling capacity sharing (as implemented in southern Queensland), while a more modest agenda could lead to an approach similar to that implemented in northern NSW under the label of 'continuous accounting'.

Market architecture: inter-valley water trade

Inter-valley water trade needs to respect physical constraints and losses associated with transfer of water between catchments (in-order to maximise gains from trade while minimising third-party effects). Current approaches to the management of inter-valley water trade in the sMDB are less than ideal as they don't fully reconcile river operations (i.e., hydrological constraints) with the regulation of water trade. The existing system of Inter-Valley Trade (IVT) accounts is an attempt to address this issue, but it remains imprecise and can result in both inefficient and inequitable outcomes.

Managing inter-regional water trade via a rules-based approach is difficult, as river operations decisions and water trade flows are highly inter-dependent. In electricity, this problem has been addressed though the development of 'smart markets'. Smart markets are automated computer-systems where physical constraints are combined with a user-based auction mechanism to determine optimal trade flows and prices. While there has been some theoretical research on applying this concept to water, there are significant practical barriers and few real-world examples.

In other countries (particularly the US) these issues have been addressed though more active centralised management of inter-valley water trade. This has included government 'water banks' which trade water between regions on behalf of end-users, taking into both account economic information (i.e., prevailing water prices in different regions) and hydrological (river operations) information.

This report outlines a possible hybrid approach, which would involve the development of an auction-based mechanism for inter-regional water trade into which users in each region could submit bids and offers to buy/sell water allocations. Then a centralised water board would make regular decisions on interregional trade flows drawing on their knowledge of river operations and data from the auction system. This approach could more tightly connect inter-regional trade flows with physical water transfers leading to improvements in efficiency and equity.

This report details some options for how this approach might be implemented, however further research would be required to fully develop this concept before it could be adopted in the sMDB.

Trade processing and market information

ABARES recently published a report on the measurement of water market prices within the MDB (Sanders et al. 2019). This report documents high levels of noise in the prices reported on state government water trade registers. This noise can arise for a variety of reasons including missing or inaccurate price reporting along with limited trade classification (e.g., failure to separate forward contracts from standard allocation trades). These problems are widely acknowledged and covered at length in the ACCC interim report, and ABARES is supportive of efforts to improve the quality of trade information recorded on government registers.

While ABARES is not a direct provider of water market price information (as this responsibility now primarily lies with the BOM) ABARES continues to play a role in informing the water market via its regular Water Market Outlook reports. This product makes use of ABARES Water Trade Model, taking into account assumptions on potential future water supply and demand (i.e., irrigation activity) conditions to present estimates of future water allocation prices. ABARES has also undertaken a number of longer-term assessments (see Gupta et al. 2018), which simulate potential future water prices in the sMDB taking into account structural changes (including growth in horticultural plantings, water recovery programs and changes in water supply / climate conditions). Both of these products offer useful information to market participants which could help to inform short-and long-run water market decisions. However, at present ABARES water market products are not integrated with any other market information systems and some participants may be unaware of them.

Finally, the market architecture reform options outlined above may have some implications for water trade processing systems in the MDB. In particular, the proposed auction-based mechanism for inter-valley water trading could require some form of centralised exchange.

1 Market architecture: water sharing and carryover rules

The below discussion draws heavily on past ABARES research, particularly Hughes et al. (2013) who provide a detailed assessment of the major water sharing and carryover rules within the MDB.

Much of this past research has focused on the concept of 'capacity sharing' as proposed by (Dudley and Musgrave 1988). For the purposes of this submission a capacity sharing approach to water property rights and markets includes the following key features:

- Water rights defined as percentage shares of system inflow and storage capacity
- Continuous (i.e., daily) water accounting with periodic reconciliations to ensure physical water supplies match user accounts
- User carryover subject to storage capacity (account) limits and 'internal spills'
- User level delivery capacity rights and delivery loss factors
- An open intra-region low-transaction cost market in water allocations

It is important here to draw a distinction between the theoretical concept of capacity sharing and the real-world implementation. In practice, real world systems always approximate the 'text-book' idea of capacity sharing to some extent. Some real-world systems have been formally labelled as capacity sharing (such as those in southern Queensland), while others which closely approximate capacity sharing have alternative labels (including because they differ slightly in approach or because they were developed without knowledge of the theoretical concept).

There is a significant body of evidence, including both modelling and real-world observation to establish capacity sharing as a 'best practice' approach to water property rights in storage-controlled water supply systems. The approach has been successfully implemented at the end-user level in southern QLD (in the St George and Macintyre Brook regions, Hughes and Goesch (2009)) and for state level water sharing between NSW and Vic. on the Murray river. The 'continuous accounting' systems in northern NSW (such as the Namoi, Macquarie and Border rivers) are similar in many respects. Further, there are many international examples of river systems where capacity sharing like arrangements have emerged (though few are labelled as such, see Hughes 2015).

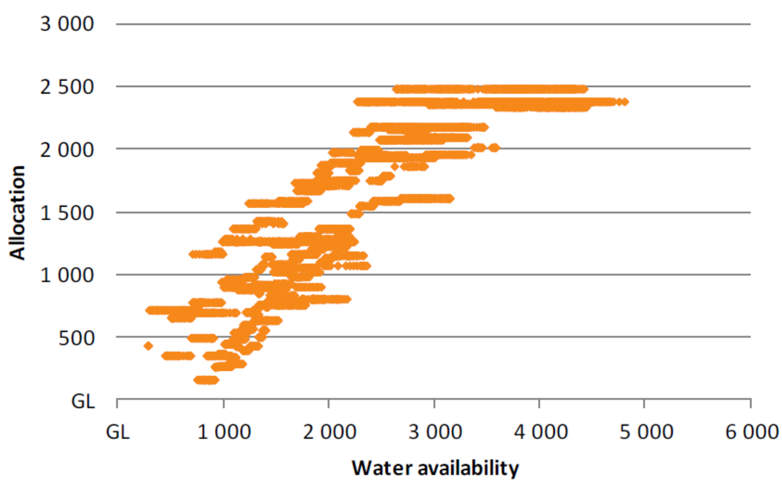
Below we provide some more detail on specific aspects of water sharing and carryover rules, in each case outlining a range of potential reform options.

1.1 Water sharing rules (inflow shares versus annual announced allocations)

Under current arrangements water entitlements are shares of an administratively determined 'consumptive pool'. With this approach users receive annual allocations determined by state government agencies in accordance with relevant water sharing plans. Past ABARES research has documented the limitations of this approach (Hughes et al. 2013). Given the complexity of water sharing plans rules, frequent rule changes, and discretionary input from water agencies, this system lacks transparency and creates additional uncertainty for water users (over and above uncertainty already faced due to climate variability).

Figure 1 (drawn from Hughes et al. 2013) provides an example showing how the allocations provided to NSW Murrumbidgee water rightsholders have historically varied for a given volume of physical water availability. While some of this variation reflects changes made to water sharing plans over this period, uncertainty can be created even under a fixed water sharing plans given the complex and 'fuzzy' nature of water sharing rules.

Figure 1: Murrumbidgee daily water availability versus allocations, 1995–96 to 2010–11



Source: Hughes et al. 2013

This lack of transparency has become a bigger issue over time as water supplies have become tighter and more variable. During recent droughts, some irrigator groups (particularly NSW general security holders) have grown increasingly frustrated with and suspicious of these processes in some cases blaming them for their low allocations (see NSW farmers 2018, ABC rural 2020).

Under a capacity sharing approach, water users receive a percentage share of system inflows (as recorded in official stream flow gauges). This closer connection between user allocations and physical water supply, helps to reduce uncertainty and improve transparency. In practice, system inflows can be defined as an aggregation of multiple inflow sources (i.e. dams and or tributaries), with various allowances for fixed environmental or human water needs, such that the approach can be applied in complex water supply systems (Hughes 2010)[1]. Inflow sharing also requires a system of periodic reconciliations to ensure total user water allocations continue to match physical water storage (see Hughes and Goesch 2009).

A key issue with making a transition to inflow shares are potential welfare effects (i.e., changes in entitlement reliability). However, such a shift is not unprecedented and has occurred

[1] In the context of the sMDB for example individual users on the Murray need not have explicit shares in storage capacity and inflows of specific dams (as is the case with state level water sharing arrangements, between NSW and Vic.). Rather end-users could have shares in the total available Murray inflow and storage capacity of their respective state.

successfully in other regions (such as St George, see Hughes and Goesch 2009). A more modest reform option is to keep current announced allocation systems in place but to undertake reform of water sharing plans to ensure water allocations are determined by simpler and more transparent functions of physical water availability. This could lead to an approach somewhere in between current systems and explicit inflow shares (similar to continuous accounting in northern NSW, see Hughes et al. 2013).

1.2 Priority water rights (high/low reliability)

Priority (high/low) water rights are a feature of most water markets in the MDB. However, under a pure capacity sharing approach no priority rights are defined. Economic modelling results (see Hughes 2015) show that in the presence of low transaction water allocation markets (as exist in the sMDB) priority water rights offer limited gains in efficiency relative to proportional sharing[2]. Priority water rights are a legacy of the pre-trade (and pre-carryover) era, where they played an important role in allocating water to higher value uses during droughts (Hughes 2015).

While the efficiency costs of priority rights are relatively small (Hughes 2015) they do have potential negative implications for some entitlement holders. In particular, low reliability holders are much more exposed to long-term changes in climate (including increased variability as well as likely reductions in average rainfall) and to adjustments to water sharing plan rules, whereas under a proportional sharing all users share equally in these risks. This issue helps to explain some of the concerns of NSW general security entitlement holders in recent times.

Given the small efficiency gains and the large potential adjustment costs (including the need to manage welfare effects) the removal of existing priority water rights may not be justified in the sMDB. Although, it is worth noting that removing priority rights from an established system is not unprecedented (for example this transition was successfully achieved in southern QLD, see Hughes and Goesch 2009).

1.3 'Continuous' water accounting

All sMDB regions employ an annual water accounting system. Under this approach user accounts are credited with new allocations periodically (usually fortnightly) while water use is deducted (and remaining unused or carryover water calculated) at the end of the financial year. This annual accounting system complicates the implementation of carryover, and results in a range of inefficient limits being placed on both carryover volumes and inter-regional water trade (see Hughes et al. 2013).

Under 'continuous' water accounting systems (similar to those in Northern NSW and southern QLD) water usage is deducted more frequently (i.e., daily or monthly) so that user accounts more closely reflect physical storage volumes. This approach removes the need for annual limits on carryover (such as those that currently apply in the NSW Murrumbidgee and the NSW Murray) and for the complex systems of 'spill risk declarations' as currently implemented in

[2] Welfare losses can occur where priority water rights exacerbate storage externalities (including internal spills see Hughes (2015). Further, while high reliability rights offer risk reduction benefits to their holders these can be more than offset by the risk increases imposed on low reliability holders (at least where users are unable to hold a mix of high and low reliability rights).

Victoria, while also allowing some inter-regional trade limits to be relaxed (such as the current NSW-VIC limit, see Hughes et al. 2013). A shift to continuous accounting could therefore offer gains in allocative efficiency (by removing some barriers on trade and carryover) while also offering improvements in transparency and simplicity for end users.

Continuous accounting has been implemented effectively in a wide range of water supply systems in northern NSW (and in the capacity sharing systems of southern QLD) and may be a feasible reform option in the sMDB over the medium term.

1.4 Carryover limits (storage capacity constraints and spills)

Water storage decisions involve a 'yield-reliability' trade-off: greater storage reserves help to reduce water supply (and price) variability but they also reduce long-run average water supply by increasing losses to dam spills and evaporation. As such carryover rules need to account for physical storage capacity constraints (and related spill losses) in order to prevent third-party impacts and achieve efficient storage outcomes.

At present there are two main competing methods for reflecting capacity constraints / spills within user carryover rules.

Under the first approach each user's water account has a maximum limit reflecting their share of total water storage (dam)[3]. This approach involves 'internal spills' whenever a user account reaches its maximum limit and excess inflow is reallocated to other users. These account limits are the most common way to internalise storage capacity constraints and are already used extensively for end users in NSW (both in the northern and southern MDB) and QLD and are also common internationally (see Hughes 2015).

In Victoria an alternative approach is adopted known as 'Spillable Water Accounts' (SWA). Under this system, users are subject to account deductions in the event that dam spills occur, such that users with higher account balances bear a higher proportion of the spill loss.

Hughes (2015) provides economic modelling comparing the performance of different approaches to storage capacity limits, including capacity sharing (account limits)[4], SWAs and

[3] In some cases, user account limits explicitly reflect a share of capacity in a specific dam, in other cases account limits may reflect a share in total storage capacity (across multiple dams and weirs). In these cases, the distribution of storage reserves across multiple dams may be managed centrally by river operators, subject to the constraint that the total balance matches user's account / carryover volumes (Hughes 2009).

[4] The system of capacity sharing modelled here assumes that storage capacity shares remain bundled to inflow shares (there is no secondary market in storage capacity / dam air-space). In the presence of efficient water allocation markets trading of storage capacity rights offers limited efficiency gain (Hughes 2015).

other variations including 'open access' storage (where carryover is unlimited) and a 'no carryover' (use-it-or-lose-it) approach. As would be expected, an open access approach leads to too-much water being stored because spill losses are not internalised. Further, a no-carryover approach leads to not enough being stored (given the 'use-it-or-lose-it' incentives). As a result, both approaches lead to large efficiency losses relative to either capacity sharing or spillable water accounts.

Overall, the modelling results find that capacity sharing generally performs best in terms of efficiency (Hughes 2015). The problem with SWAs, is that they do not fully internalise the cost of spills. As such, they tend to result in slightly above optimal storage volumes (too much carryover), while capacity sharing (due to internal spills effects) can lead to slightly below optimal storage (although still closer too optimal)[5]. While the differences in efficiency between capacity sharing and SWAs are small on average, there are some significant equity differences, with SWAs leading to lower welfare / profits for low reliability (i.e., broadacre) farmers, as the higher storage / higher reliability outcomes tend to favour horticultural users (see Hughes 2015).

Overall, there is strong evidence to suggest (both from modelling and real-world observation) that a capacity sharing (account limit / internal spill) approach to carryover can achieve near ideal efficiency outcomes in most water supply systems.

While the modelled efficiency differences between capacity sharing and SWA are small, there may be still be benefits from replacing the current SWA rules in northern Victoria with something closer to the capacity sharing / continuous sharing approaches adopted in NSW and QLD. Firstly, past experience in Victoria (during 2011 and 2012) has shown that when SWA is poorly implemented it can lead to an open access outcome resulting in large welfare losses (Hughes et al 2013)[6]. Further, differences in carryover rules between connected regions in the sMDB can affect inter-regional trading patterns (in particular, the more generous SWA rules are likely to encourage more water to be traded into Victoria from NSW in wet years) which in turn necessitates inefficient trade limits (i.e., the current NSW to Vic. trade limit).

1.5 Storage evaporation losses

In northern Victoria water users face a 5% deduction on carryover balances (applied at the end of the financial year), which is intended to reflect evaporation losses associated with holding water in dams. In NSW systems carryover balances generally do not face any evaporation loss deductions. In practice, the application of losses on an annual basis is problematic because it

[5] In theory an optimal outcome can be achieved under capacity sharing in the case where water market are perfectly competitive (with zero transaction costs) in which case internal spills would never occur, as users would always trade water out of their accounts prior to a spill.

[6] While some rule changes have occurred since these events, the potential for open access like outcomes is still a possibility if spill risk decelerations are incorrect (if an unanticipated spill occurs after a low spill risk deceleration has been made, see Hughes et al 2013).

creates an incentive for users to temporally trade water between regions in order to avoid the deductions (see Hughes et al 2013).

Modelling results (Hughes 2015) suggest that including deductions for storage (evaporation) losses offers limited gains in efficiency under a capacity sharing (account limit) carryover system[7]. However, loss deductions are important under SWAs. Under SWAs, if evaporation losses are socialised this can exacerbate over-storage and lead to welfare losses (Hughes 2015). This result helps to explain the current approaches to evaporation losses in the sMDB where storage loss deductions are applied in Vic. and not in NSW.

Where evaporation losses are deducted from user water accounts they should be applied on a more continuous (i.e. daily) basis (as for example occurs in St George, see Hughes and Goesch 2009). In practice, decision to include evaporation loss deductions or not will need to take into account the local context including the size of the losses and the prevailing carryover rules.

1.6 Delivery losses

At present, most regions in the MDB do not apply losses on the delivery of water from the source to end users. This socialisation of losses can lead to externalities particularly in regions where there are large differences in the rates of loss.

The inclusion of loss factors (exchange rates) to account for delivery losses (between the source / dam and point of use within a given catchment) is complicated by the fact that river and irrigation system losses are often highly non-linear functions of flow (Hughes 2010). In many cases, marginal losses (associated with a single user water order) may be negligible despite high average losses.

There are some examples of systems imposing delivery loss factors to reflect differences in average losses between a set of defined water use zones (at varying distances from the water source / dam (Hughes and Goesch 2009). These average loss factors serve mostly to influence longer-term decisions: for example, to discourage new irrigation development in higher average loss regions (within the same catchment).

Once again, a key challenge with introducing delivery loss factors are potential welfare effects. To avoid these effects users in higher loss zones, would need to be compensated by receiving a larger endowment of water entitlements (this was the approach adopted in Southern Queensland, see Hughes and Goesch 2009).

To date delivery loss factors have been subject to limited theoretical study and there a few real-world examples. At present, the inability to accurately measure losses in most cases makes practical implementation of loss factors / zones very difficult. There may be specific situations where loss factors could be considered: where average loss rates are known to vary dramatically in different parts of a catchment (on a consistent basis) and /or there is a genuine concern around long-term changes in irrigation development within the catchment (shifts toward higher

[7] In some model scenarios inclusion of evaporation loss deductions under capacity sharing actually lowers efficiency (Hughes 2015). Given capacity sharing generally leads to slightly below optimal storage volumes (due to internal spill effects) the inclusion of loss deductions can push user storage reserves further below optimal levels.

loss zones). As such, adoption of delivery loss factors would be best considered on a case-by-case (region-by-region) basis.

1.7 Delivery constraints

A related issue are short-term delivery capacity constraints between the water source and end user within a given catchment or trading zone (inter-catchment / zone constraints are discussed later).

Traditionally, delivery rights have been implicit within water entitlements: users expect to always be able to take delivery of allocations in their account, and river operators are expected to facilitate this irrespective of prevailing conditions. However, under some conditions it may not be feasible to satisfy all water orders in the short-term (or at least the losses required to achieve this may be excessive). These 'deliverability' issues appear to be a growing problem in the sMDB (due both to shifts in climate and in the distribution of irrigation activity).

Given the growing risk of water delivery shortfalls, there could be grounds to consider some form of user 'delivery' or 'water use' rights in the sMDB. In the event of a delivery shortfall there is a need to ration the available water in the affected region (the existing allocation market is ineffective in these cases as any purchased allocations cannot be delivered).

Under a delivery right approach, each water user would hold a share in the local water delivery supply volume (and these shares could be traded). The total available delivery volume could be varied by water agencies on a daily / weekly basis depending on river operations issues.

Under most conditions, total user water orders (in a given location / irrigation area) would be well below this upper limit. However, in peak conditions (e.g. during a summer heatwave) when river delivery constraints are binding, potential user water orders may exceed the total delivery limit (for that irrigation area / time period). In these cases, each user's orders would be constrained to be less than their share of the total limit. Trade in delivery volume shares would then enable the scarce local water supplies to be rationed to the highest value uses (within that irrigation area / time period).

While, there is an efficiency case for a system of delivery rights, there again would be potential welfare effects associated with their introduction. In particular, water users in regions where limits are likely to be binding may be adversely affected (unless otherwise compensated), while water users in other regions may benefit from a reduction in socialised losses (compared with a system where no delivery constraints are imposed).

2 Market architecture: inter-valley water trading

2.1 The current approach (IVT limits)

Currently within the sMDB users are permitted to trade water allocations between valleys subject to set of predefined rules. These rules include limits on how much water can be traded between each region and (less commonly) loss factors or exchange rates. The approach to inter-regional water trade in the sMDB (with high volumes of inter-regional user level allocation trading) is relatively unique by international standards. For contrast, in the western US inter-regional trade at the user level is often limited to very small numbers of water entitlement trades each of which are subject to approvals on a case-by-case basis[8].

The problem with a rule-based approach, is that setting fixed trading rules is very hard in practice. A key issue is that delivery losses and constraints depend on aggregate river flows (often in complex non-linear ways). This means that it is not possible to pre-define an optimal set of trading rules: the ideal trading rules will depend on the aggregate volume of trade and the aggregate volume of trade will depend on the trading rules[9].

In Australia, this problem is addressed through the central decision making by river operators. While the sMDB approach is often viewed (both by users and researchers) as 'trade subject to pre-defined rules' it is in practice a mix of rules and centralised decision making (with central decision making taking over when IVT account limits are binding).

IVT accounts record net trade volumes between regions based on user level allocation trades, such that IVT balances reflect physical water 'owed' from one valley to another. Where possible, river operators then arrange physical transfers of water between regions (known as IVT 'callouts') which then move these IVT accounts back towards zero. User level allocation trade is suspended whenever IVT account balances increase above pre-defined limits. When IVT limits bind, inter-regional trade volumes are effectively determined by river operators (based on the amount of water they decide to physically transfer between regions).

While some constraints on interregional trade will always be necessary the current system is rather blunt leading to less than ideal efficiency and equity outcomes.

Firstly, IVT trade closures create a game of "who can process their trade the fastest" as users rush to exploit differences in prices before trade is suspended. This is both inequitable, as it

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[8] In the US stricter limits are applied to inter-valley trading due largely to concern over third-party effects (Hughes 2015). In some cases, centralised arrangements (such as 'water banks') have emerged to support larger volumes of inter-regional trading these are detailed later in this section.

[9] The same problems also exist in within-valley water markets. The presence of non-rivalry (shared storage capacity) and non-linear evaporation loss functions means that rules-based markets cannot theoretically achieve an optimal outcome (there are always some small externalities). However, modelling results shows that with well-defined rules (approaching capacity sharing) decentralised markets can still achieve very close to optimal outcomes.

tends to concentrate the gains from trade in the hands of a small number of users, and wasteful as it leads to unnecessary effort being placed on tracking IVT account balances.

Second, it is not clear that the current system is arriving on the most efficient volume of inter-regional trade: that is there is potential for either too much or too little trade to be occurring at different times. For example, when trade limits are open, users can quickly accumulate large volumes of inter-valley trade, which then needs to be delivered by river operators (via IVT callouts) at a later date. However, given the time delays involved, river operators can find themselves in a difficult position where there is pressure to satisfy large volumes of prior water trade at a point in time when delivery constraints / losses are highly unfavourable. Conversely, there is potential for IVT limits to be binding at a point in time when conditions are actually favourable for inter-regional transfers.

At present, the governance processes and objectives of river operators do not appear to have evolved over time to account for their increasingly important and difficult role in determining inter-regional trade volumes. For example, currently river operators do not appear to take into account economic considerations (such as the differences in prices between regions) when deciding on inter-regional transfers (IVT callouts). Even if these factors were to be considered, the information currently available to river operators is limited (current prices are not enough to infer full water demand / willingness-to-pay schedules). Further, there is also limited information communicated to end-users to help them anticipate likely future river operations decisions and therefore future trade flows and prices. Finally, the current system offers only binary trade closures (trade is open or closed) and doesn't allow for 'exchange rates' / loss factors.

The current approach is clearly adapted to past conditions: when trade volumes were smaller, and limits were rarely binding. However, with recent shifts in water demand and supply there is now higher pressure for inter-regional trade, which is motivating the need to consider a change in approach.

2.2 Electricity style 'smart markets'

One alternative is the concept of water 'smart markets' similar to those implemented for electricity in many parts of the world (including the National Electricity Market). Smart markets are generally based on a computerised model of the physical system (e.g., the electricity transmission network, or water supply system) into which a periodic auction mechanism is embedded. End-users can then lodge bids/offers to buy/sell electricity or water. Optimisation algorithms are then used to find the optimal trade outcomes: which maximise the benefits of trade subject to the physical constraints.

Smart markets have some obvious theoretical advantages in that they overcome the simultaneity problem that confound rule-based markets. There has been some theoretical research considering how the smart market concept could be applied to water over the last decade (Raffensperger and Milke 2017). However, to the best of our knowledge there are few if any examples of working smart markets for water in real world river systems.

A key problem with adapting smart markets to water is that it is much harder to represent river systems (even heavily regulated ones like the sMDB) in computer models compared with electricity networks. In practice, river modelling and river operations decisions tend to involve a significant human component given the many uncertainties involved. For this and other reasons[10], it seems unlikely that a computerised water market would be viable in the sMDB at least in the short to medium term.

2.3 US style centralised 'water banks'

In the western United States (US) there are few pre-defined inter-regional water trading rules. Instead trades are assessed on a case-by-case basis to determine if they remain within network and legal constraints (Hughes 2015). In the US this process can be rather slow and costly. As a result, most water trades occur at a local level. Despite this some states such as California have managed to get water to where it is needed by taking a more centralised approach to trade (see Hanak and Stryjewski 2012).

One particular approach are so-called 'water banks'. Here a government agency enters the water market as an intermediary, typically during periods of drought. The water bank then seeks to buy water in regions with low prices and sell into regions with high prices. In theory, a central water bank of this kind is in a position to simultaneously assess both river operation constraints and the economic benefits from trading (by examining differences in prices between regions). This approach has been adopted successfully in California since the 1990s (see Hanak and Stryjewski 2012).

2.4 A hybrid approach

The core principal of smart markets is that information on user preferences should be combined simultaneously with physical constraints to determine optimal trade outcomes. While an automated smart market may not be practical, a similar result could potentially be achieved by providing all of this information to a central agency (i.e., human committee / board) which could then make periodic trade decisions.

As with the smart market concept, the approach would involve an auction mechanism, where water users in each region could make bids/offers to buy/sell water on the interregional water market (potentially over a single computerised water exchange)[11]. The central water trade board would then need to periodically (e.g., monthly) make decisions both over the net volumes of water to be traded / transferred between regions (similar to the current IVT 'callout' decisions) and any loss factors / exchange rates to apply. The board would include river operators but could also add a broader range of stakeholders / experts (such as economists and environmental and irrigator representatives).

[10] Water markets involve a number of physical complexities not present in electricity including: extensive long-term storage, significant delivery lags, highly variable and uncontrollable inflows, imprecise measurement of surface water volumes / flows (and limited measurement of surface-groundwater connectivity).

[11] Note this proposal would apply an auction mechanism only to inter-valley water trading. All within region water property rights / markets would remain as described in the previous section (i.e., rules-based user level markets). In theory the smart market concept could be extended beyond inter-valley water trade to cover within-valley trade and carryover (replacing traditional property rights systems entirely), however this approach seems unlikely in the foreseeable future and is not considered further in this report.

The board would be supplied with information on the volumes of water that could be feasibly transferred between regions over the period (e.g. a month), the potential losses and any other relevant operational impacts. This information could be combined with auction bids/offers to generate potential trade scenarios. The job of the board would then be to select from these scenarios (and in effect set trade volumes and exchange rates to apply for that period). The process would mirror that produced by computerised smart market (and could potentially be supported by economic / hydrological modelling) but would still involve an element of human discretion. In addition to allowing for hydrological uncertainties, human decision making could allow a broader range of values to be considered including environmental impacts of trade.

This proposed water trade board would need be subject to transparency / probity controls (as is already the case for state water allocation decisions). Decisions taken by the board must remain private until they are executed to avoid insider trading. The board would also need to provide as much information as possible about potential future trade volumes, to help users form reasonable expectations over future water supplies and prices (this could include future outlooks for trade similar to those published for allocations already by state water agencies).

Under this approach interregional water allocation trading would occur more in line with physical water transfers (unlike the existing IVT system where physical transfers may occur much later). For example, the volume of trade between two regions might be announced and processed at the start of the month (based on a commitment to physically transfer that volume over the rest of the month)[12]. Then (as with any smart market) water could be transferred to the highest bidders (from the lowest offers) until the announced trade volume is met.

The above approach may seem a radical departure for current arrangements, however the differences may not be as dramatic as they first appear. As discussed, under the current system inter-regional trade flows are effectively controlled centrally (by river operators) whenever IVT limits are binding. The above approach just makes this central control more explicit. Further, the auction mechanism provides the central decision makers with more information, helping trade decisions to find a near optimal balance between gains from trade and operational issues, and also offering more flexibility including the potential to apply loss factors reflecting prevailing seasonal conditions (without having to set fixed exchange rates).

[12] Linking inter-regional allocation trade with physical transfers may mean that opportunities to trade allocation could be limited at certain times of the year (particularly early in the season when IVT 'callouts' are rare). However, this would not constrain water use for users in downstream / water importing regions in the short-term except in cases of extreme (and unlikely) water shortage (where total short-run water demands exceed total unused allocation available). Further, these short-term constraints on water trade need not lead to short-term differences in prices between zones, at least where there is an expectation that sufficient inter-regional trade volumes will be available later in the water year.

2.5 Other reform options

While the centralised 'human water smart market' approach outlined above is a promising medium to long-term reform option, there are some other more minor changes which could be considered in the short-term. Collectively these changes would result in a system somewhere in-between current arrangements and the 'hybrid approach' outlined above[13].

Firstly, the role of river operators in effectively determining interregional trade flows (whenever IVT limits are binding) could be better clarified. This would involve setting some more precise objectives, which ideally encourage river operators to take into account both operational issues and economic information (such as differences in prices between zones). This would also involve better communication to help water users form expectations over potential future trade flows and water prices.

Next, the existing system of IVT limits could potentially be removed by implementing a form of 'tagged allocation trading'[14]. With this approach inter-regional allocation trade volumes would remain 'tagged' in the source (seller) region within an IVT style holding account. There would be no limits on total IVT account balances, however users in the 'destination' (buyer) region could not use any purchased water (it would not be transferred to their account) until a physical delivery (i.e., IVT 'callout' as determined by river operators) could be made or at least planned (at which point the water would be transferred from the IVT holding account into buyer accounts). Under this approach, river operators would be responsible for determining inter-regional trade flows at all times (similar to the hybrid approach above, although still without the flexibility offered by an auction mechanism[15]).

Importantly these transfers could occur in a proportional way to ensure all users can share equally in the gains from trade. For example, if buyers had accumulated a total of 200GL of trade in an IVT account, and river operators are able to process 50GL of trade in a given month then all buyers would have 25% of their purchased allocations transferred to their account (with the remaining 75% left in the IVT account).

Volumes of water remaining in IVT holding accounts would need to be subject to the storage capacity constraints (and spill losses) prevailing in the source region. This might mean that tagged allocation trades involve both a purchase of water (allocation) and a matching volume of storage capacity / account space (which is released back to the seller when the water is physically transferred).

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[13] The key difference being that this approach does not involve an auction mechanism. The absence of an auction mechanism limits the amount of information and flexibility available to central decision makers.

[14] Note that this proposal is distinct from current systems of 'tagged entitlement trading' present in the sMDB. In the presence of low transaction cost inter-regional allocation trading, tagged entitlement trading serves little purpose (further as noted in the ACCC interim report these tagged entitlement trades can create loopholes allowing users to by-pass allocation trade limits).

[15] For example, the auction mechanism would give central managers the flexibility to set exchange rates / loss factors 'on-the-fly' to match prevailing conditions (rather than having to fix them ex-ante). These loss factors can then be applied to the auction system bids/offers to find welfare maximising trading opportunities.

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