Location, Location, Location: the spatial influences on water entitlement selling in the southern Murray-Darling Basin

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Outline

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Abstract (100 words)

This research illustrates the importance of spatial characteristics on irrigators' water entitlement sale decisions. Irrigator locations were geocoded and spatial characteristics were linked to recent survey data covering farm, farmer and water trade characteristics (n=1,462) in the southern Murray-Darling Basin. A key finding was that the closer irrigators were to the River Murray's terminus to the sea (i.e. closeness to key environmental issues from low flows), the more likely they were to sell permanent water. There was also evidence of a farmer network effect, with higher likelihood of water sales occurring in areas where more neighbours had sold permanent water.

Keywords: Water entitlements, Murray-Darling Basin, Irrigators, Spatial effects

1 Introduction

Droughts and over-allocation of resources have led to the depletion of water resources worldwide; and nowhere more so than in Australia's Murray-Darling Basin (MDB). Given the importance of the MDB in Australia, the Millennium drought triggered a $3.1 billion water buy-back program (*Water for the Future*) to buy back water entitlements from willing irrigators to restore certain deteriorated environmental sites (Parliament of Australia 2010). There have been a variety of political questions raised about why irrigators might sell their water, and the corresponding regional impact. The issue still triggers much unrest in rural communities.

Previous economic research on irrigators' reasons to sell water to the government is relatively limited and has primarily tested socio-economic and farm specific data and left the incorporation of various other potential determinants for future research (e.g. Isé & Sunding 1998; Wheeler et al. 2012).

One such determinant that deserves additional research is spatial aspects. Spatial economics studies the relationship between space/distances and economic behaviour, and this study investigates the impact on water selling behaviour and helps to answer what some of the impacts on regional communities may be.

2 Methodology

2.1 Data

Two datasets of irrigator surveys in the southern MDB were used: 2010 (n=942) and 2011 (n=534) (see Wheeler et al. 2012 for further details). The survey data included farmer, farm and location information, which allowed for spatial analysis in GIS.

Secondary spatial data were also collected (Table 1). Spatial data were chosen that offer the smallest resolution, and those closest to the survey years. However, not every dataset needed for the analysis was available for the years relevant to the surveys. Nevertheless, since some factors have a rather permanent character, i.e. features tend to remain unchanged over a certain period of time; it does not reduce the feasibility of the analysis. According to FAO (1985) permanent features include, for example, soil texture.

Table 1: Variable description and data sources

Variable	Details
Dependent variable:	
Entitlement sale	1=irrigator sold water entitlements to government for environmental purposes; 0=otherwise; for each survey year respectively
Independent spatial variables:	
Net rainfall	Rainfall minus evapotranspiration at the irrigators' location, averaged for previous 5 years, 2005/06-2009/10 and 2006/07-2010/11 respectively (mean annual, mm/d)
Soil texture	Index of soil texture in the soil layer 1: 1=sands, 2=sandy loams, 3=loams, 4=clay loams/light clays, 5=clays (mean for the irrigators' 30km buffer zone)
Dryland salinity	1=Irrigators' 30km buffer zone is affected by dryland salinity risk/hazard; 0=otherwise
Groundwater salinity	1=Irrigators' 30km buffer zone is affected by saline groundwater (> 3000 mg/l TDS); 0=otherwise; composite dataset (1994-2009)
Surface-water salinity	Mean salinity level (EC) per river valley (using the salinity station that is closest to the irrigator) for the previous farming season
Regional population change	Percentage of regional population change averaged for previous 5 years, 2005-2009 and 2006-2010 respectively (SA2)
Distance to cities	Distance to cities/rural centres with population >5000 (km)
Neighbours sold	Number of neighbours sold water entitlements to the government since 2008 (SA2)
Distance to downstream area	Distance to River Murray mouth (km)
IIO charges	Irrigation Infrastructure Operator (IIO) charges: Total annual irrigator bills (variable and fixed charges) per ML in natural log; 250 ML of entitlement with delivery of 100% allocation (CIT: averages for pumping pressures, MI: weighted according to the ownership of GS or HS water), 0=private irrigator only
Water entitlement price	Mean HS prices water entitlements ($/ML, natural log) per river valley of the previous 5 years, 2005/06-2009/10 and 2006/07-2010/11 respectively
Age	Age (years)
Age squared	Age (years, squared)
Low education	1=highest education level is Year 10 or below; 0=otherwise
Farm plan	1=has a whole farm plan; 0=otherwise
Government agency	1=information source is government agencies; 0=otherwise
Water entitlement	Sum HS water entitlements (ML, natural log) before sale to the government (in NSW including GS entitlements)
Groundwater entitlements	Sum volumetric groundwater entitlements (ML, natural log)
Annual crops	Percentage of area in annual crops per irrigated area, for each survey year respectively
Operating surplus	Net farm operating surplus ($, natural log)
Children	Number of children

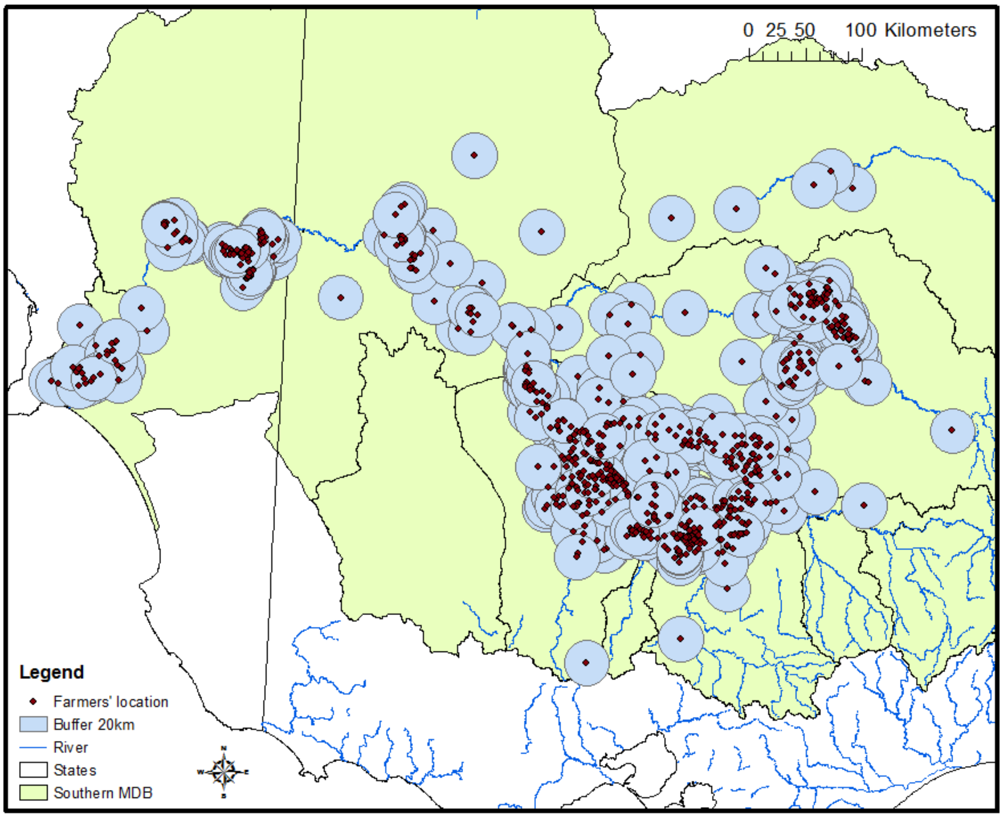
Allocation trade	1=Irrigator is a net seller of allocation water; 0=otherwise, for 2010 survey; 1 = was a net seller in 2009/10 and has sold allocation water in 2010/11, for 2011 survey
Entitlement sale private market	1=sold water entitlements in the private market prior 2008 for 2010 survey and prior 2009 for 2011 survey; 0=otherwise
Allocation percent	Mean end-of-season allocations to high- and low-security entitlements for the previous 5 years, 2005/06-2009/10 and 2006/07-2010/11 respectively, weighted by individual ownership of high and low/general water entitlements
Gender	1=male; 0=otherwise
Successor	1=has successor; 0=otherwise
Employees	Number of FTE farm employees
Farm size	Farm size (ha)
Horticulture	Percentage of area in horticulture (including viticulture) from irrigation ha,
Off-farm income	Percentage of household income from off-farm work
Debt	Farm debt to equity ratio (for 2011 survey debt to land value ratio)
Productivity change	Likert scale of productivity change in the last 5 years: 1=strongly decreasing to 5=strongly increasing
Health	Farmer Health: Likert scale: 1=poor, 2=fair, 3=good, 4=very good and 5=excellent
Organic	1=Certified organic produce grower; 0=otherwise
Diverse	Index of how many farming activities the farm earns income from (crop types, one crop=1, two crops=2 etc.)
Risktype	Likert scale: from 1=totally unwilling to take risks to 5=completely willing to take risks
Carryover	Carryover water saved (ML, natural log) from the previous season
Survey year	1=survey year 2010; 0=otherwise

2.2 Geocoding and GIS-analysis

Farm locations were geocoded using ArcGIS 10.1 and analysed using GISs' geoprocessing tools. Specific spatial information regarding the farmers' location and/or neighbourhood was extracted on the basis of the irrigators' locations in ABS' Statistical Local Area 2 (SA2 level) and 30km buffer zones (minimising the obstacle of inaccurate geocoded locations from postcode level data). A 30km buffer zone was chosen to calculate biophysical data statistics, and SA2 was chosen for community-based data (e.g. neighbourhood interaction, socio-economics).

Figure 1 illustrates the southern MDB and coded irrigator locations.

Figure 1: Southern MDB and irrigators' locations



2.3 Data analysis

A binary probit regression model of water selling was estimated, expressed as follows according to Greene (2003):

$y^* = x\beta + \varepsilon$ *(1)*

$$\varepsilon \sim N(0,1)$$

$y = \begin{cases} 1 \; if \; y^* > 0 \\ 0 \; if \; y^* \leq 0 \end{cases}$ *(2)*

where y^* is the latent dependent variable that relates to the binary variable y (1 = the irrigator has sold water entitlement to the government; 0 otherwise) according to equation (2), x is a vector of independent variables (see Table 1), β is a conformable parameter vector and ε is the error term.

3 Results

The reduced form results (where variables are significant at least at the 10% significance level) are summarised in Table 2.

Table 2: Results of the probit model of water entitlements sold

	Coefficient	Robust SE
Spatial variables		
Net rainfall	5.38**	2.25
Dryland salinity (dummy)	0.31***	0.11
Surface-water salinity	0.0**	0.00
Regional population change	-0.04**	0.02
Neighbours sold	0.01**	0.00
Downstream distance	-0.0***	0.00
Survey variables		
Age	-0.18**	0.08
Age squared	2.65**	1.14
Low education level	0.27*	0.14
Farm plan	0.37***	0.13
Government agency	-0.40*	0.23
Water entitlement owned	0.24***	0.05
Allocation trade	0.29***	0.11
Allocation%	-0.01***	0.00
Farm size	-0.0**	0.00
Risktype	0.08*	0.04
Carryover	-0.04*	0.02
Survey year	0.28*	0.17
Constant	-12.32**	4.13
Number of observations	1,364	
Wald chi^2 (18)	103.82	
Pseudo R^2	0.13	
McFadden's R^2	0.13	
McKelvey and Zavoina's R^2	0.27	
Percentage predicted correctly	0.89	

*Notes: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$*

The probit model is estimated using a pooled cross-section dataset. The model had reasonable prediction and had no serious multicollinearity issues (tested with VIFs and correlation analysis) and was estimated with clustered robust standard errors.

Firstly, the model results confirm relationships between water entitlement selling and farm and farmers' socio-economic characteristics, such as water entitlement ownership, age and education as suggested by previous studies (e.g., Wheeler et al. 2012).

Results showed that irrigators located in poorer resource areas, specifically irrigators that are affected by dry-land salinity and higher levels of surface-water salinity are more likely to sell water entitlements. Also, a key finding is that the closer that irrigators are to the ‘arse end of the system’ as it has often been called: namely the terminus of the River Murray that faces considerable environmental problems from a lack of flows, then the more likely they are willing to sell their water to government for environmental purposes. In other words, SA irrigators are more likely than Victorian irrigators who correspondingly are more likely than NSW irrigators to sell water.

Further, evidence of network impacts on selling water is found. Networks have been shown to be an important influence on much human behaviour: and our results suggest it in water selling behaviour as well. In the past: selling water has been very much a controversial decision for irrigators to undertake; in the 1980s irrigators were often ostracized from the pub if they sold permanent water from their area. We found evidence that, holding other influences constant, irrigators in areas where more neighbours have sold water makes it more likely that they sell their water, hence indicating a potential social acceptance to do so. We also found that irrigators’ located in regions that have been suffering a decline (i.e. population decline) were more likely to sell their water. Although it was also found that the further away irrigators were from a town they were more likely to sell their water, this result was not significant in the reduced form model.

4 Conclusion and significance

This research is important in contributing to the understanding of irrigators’ water sale decisions, to provide ongoing information for relevant water programs and reforms. Understanding irrigators’ behaviour and the determinants of market participation is a crucial factor to secure an overall success of maximising water sales and minimising transaction costs. The better the understanding of what determines market adoption behaviour and failure, the better market instruments can be designed to meet environmental requirements.

This research suggests that environmental factors, which signify long-term productive issues such as salinity and water scarcity (downstream variable impact), do seem to play a part in the spatial distribution of traded water. The results support the claim that the presence of water markets in Australia provide a very important adaptive tool for farm management. While further advances within markets and greater adoption in Australia is warranted from a policy perspective, it is obvious that further research in farm management strategies to deal with poor environmental factors is also needed. In addition, this research shows that early general distrust of irrigators regarding the water buy-back program could be alleviated through neighbours’ influence on selling decisions.

This research can be used by the government to refine the planning of the last stages of the water purchase program to meet environmental needs. Accordingly, the study can indicate regions of high or less likelihood of selling suggesting where the government could either promote water selling because water purchase are needed in a specific catchment area, or promote farmer support programs to provide for potential farm exits.

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