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The impact of drought and water scarcity on irrigator farm exit intentions in the Murray–Darling Basin

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Drought and future water scarcity in the Murray–Darling Basin (MDB) will continue to restructure the irrigation industry in the coming decades. There has been little work conducted in Australia that has modelled farm exit or exit intention. ABARES farm survey data were used to model irrigators' farm exit intentions across the southern MDB from 2006 to 2013. In particular, we examined the hypotheses that drought and water scarcity positively impacted on farm exit intentions and that it is the poorest performing farms that intend to exit in times of drought. Results revealed that water scarcity impacts varied considerably. There was only weak evidence to suggest that irrigators' exit intentions were higher in times of drought, but there was stronger evidence to support the influence of a lagged water scarcity impact on farm exit intentions during periods of nondrought (e.g. intending to exit at times when the property market was less depressed). There was also strong evidence that poorer performing farms (measured by rates of return and higher debt over a certain level) were more likely to have exit intentions in drought periods, but not necessarily so in nondrought periods. Older age is the most consistent predictor of farm exit intentions across all industries, though it was most significant in drought periods.

Key words: ABARES farm survey, farmers, water allocations.

1. Introduction

Farm exit issues have concerned policymakers for decades. Over time, farm exits have been associated with technological innovation, national economic growth and the transfer of labour from rural to urban areas (Breustedt and Glauben 2007; Dong *et al.* 2010). Climate change is another factor that is predicted to increase the rate of farm exit over time in some areas, because of its effect on the severity and frequency of drought and changing rainfall patterns (CSIRO 2008; Barr 2009; Wheeler *et al.* 2013). However, in other areas, climate change may actually improve agricultural productivity and farm numbers, as a warmer climate and increased carbon dioxide can allow greater value-adding production than previously possible (e.g. greater investment in viticulture in Tasmania as a response to shortening harvest

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times and increased temperature in traditional production areas (Brown *et al.* 2016)).

The increasing frequency of drought and associated water restrictions may result in declining agricultural profitability especially for irrigated farms, leading to an increase in farm exits (Edwards *et al.* 2009). Australia is the driest inhabited continent on earth and experiences a high degree of climate variability. As such, drought is a recurring problem for Australia's dryland and irrigated farmers. Due to what is known as the Millennium Drought[1] , from 2001–2002 to 2009–2010, the River Murray experienced record low flows and irrigators in the Murray–Darling Basin (MDB) faced considerable stress in dealing with reduced water allocations, higher temperatures and lower rainfall, along with falling commodity prices (for some industries). The drought broke in 2010 with flooding across the MDB (Jiang and Grafton 2012; Wheeler 2014). The reduction in water allocations during the drought and increased environmental stress during the previous decade resulted in a number of government initiatives such as the small block irrigator exit package scheme and the buyback of water entitlements from willing irrigators, which led a large number of irrigators to exit irrigation, although overall there was not a concomitant reduction in irrigation production (Grafton 2010; Nauges *et al.* 2016).

Over the past few decades, state and federal Australian governments have implemented income smoothing policies and farm exit policies, to help farmers to cope with drought, alleviate hardship and to provide a financial incentive to exit. There has been an increasing emphasis on farmer self-reliance and risk management, although payments for exceptional circumstances have been continually made available to farmers in drought-declared areas (Botterill and Chapman 2009). There have been a range of exit packages: for example, farmers in an 'exceptional circumstances' area could apply for exit packages, and irrigators during the Millennium Drought could apply for 'small block' irrigator exit packages (Zuo *et al.* 2015a,b, 2016). The drought (and other drivers) led to significant government intervention in the MDB, including a new *Water Act 2007*, large-scale irrigation infrastructure investment, water entitlement buyback and a new Basin plan (Crase *et al.* 2012; Wittwer and Dixon 2013; Wheeler 2014). These policies raised questions about the impact of water buyback on farming communities. Members of rural communities tend to argue that net farm exit is associated with negative impacts on farming communities, as the loss of farmers leads to decreased community income, decreased education and health services, and continuing depopulation (e.g. see various submissions to The Senate Select Committee on the MDB Plan (2016)). Conversely, some economists support

[1] We define the Millennium Drought as the period 2001–2009, which was the longest uninterrupted series of years with below median rainfall in south-east Australia since 1900. For south-eastern MDB, the end of the drought occurred in early 2010 with a strong La Nina event bringing very high precipitation and large-scale flooding (van Dijk *et al.* 2013).

the view that farm turnover and exit is a necessary condition to allow other farmers to expand and agricultural productivity to grow and that many who exit are better off (e.g. McColl and Young 2006). Grafton *et al.* (2016) and Wheeler (2014) reviewed the water buyback literature and concluded that there was very limited evidence to suggest that large, significant negative economic impacts from water buybacks actually exist.

This study examines irrigators' intentions to leave the farm in the southern MDB using a highly detailed panel of irrigator surveys from 2006 to 2013. A better understanding of the empirical relationships between farms and irrigator characteristics, their farming strategies and exit choices will allow better informed and coherent exit policy decisions.

2. Farm exit literature

For policy and research purposes, it is useful to understand: a) how farm exits are changing over time; and b) the characteristics of irrigators' exiting. Farm adjustment policies are theoretically meant to help the least efficient leave the industry. However, Australian reviews of structural adjustment policies over time have found that those who leave the industry tend not to be the least efficient managers, but the farmers with a high capacity for adjustment (Botterill 2002).

2.1 Intentions vs actual exit

Firstly, it is important to point out the difference between planned farm behaviour (e.g. intention to exit in this study) and actual behaviour (e.g. actual exiting of the farm). Intention is the plan to undertake a certain action, though of course this plan may not be executed if the individual does not have complete control to perform the action (Ajzen 1991). It is likely that influences such as planning regulations, poor economy, location and farm productivity may also constrain farm exits. While the intention to undertake a certain action is not the same as actual implementation, it is likely to be the best possible indication. Australian studies of planned and actual farm behaviour are relatively rare, although Fielding *et al.* (2008) found a positive link between intentions and actual sustainable farm behaviour. Furthermore, Wheeler *et al.* (2013) compared irrigators' intentions on what they planned to do (e.g. in terms of crop changes, buy/sell/lease land, infrastructure upgrades, water trading) on their farm in the next five years with their actual behaviour on the farm on the past five years over a 14-year time period in the southern MDB and found that irrigators' intentions generally aligned with actual behaviour (albeit actual behaviour was slightly less than intended behaviour) in situations of average to full water allocations.

The following section provides a review of the farm exit literature. There have been more studies conducted on farm exit intentions than actual farm exit (most likely because of the difficulties in collecting data to study actual farm exit). For example, in our review, some of the studies on actual farm exit include: Kimhi and Bollman (1999); Kimhi (2000), Goetz and Debertin (2001), Vanclay (2003), Barr (2004, 2009, 2014) and Väre (2006), while the literature on farm exit intention includes: Pietola *et al.* (2003), Bragg and Dalton (2004), Pushkarskaya and Vedenov (2009), Rae and Zhang (2009), Dong *et al.* (2010), Möllers and Fritzsch (2010), Tiller *et al.* (2010) and Zuo *et al.* (2015a,b, 2016). There are no consistent differences of variable influence in the actual and intention farm exit literature; hence, below we summarise their findings as a whole.

2.2 Farm literature

Human capital theory is relevant to consider here with regard to farm exit issues and at what age farmers may choose to leave the industry. In broadest terms, human capital theory suggests that an individual's lifetime earnings are influenced by their stock of knowledge, habits, social and physical attributes (Becker 1993). The theory suggests that the marginal benefits of making later investments in farm knowledge decline with age (suggesting productivity subsequently decreases, increasing the probability of farm exit). As noted by Klevmarken and Quigley (1976), there are a number of factors that complicate this simple linear relationship in human capital theory. These include the following: i) depreciation of human capital (highly relevant for farmers working long hours over many years); ii) relationship of human capital investment with ability/age and experience; and iii) physical capital presence (a very important factor for farmers with large mortgages – which is more likely to occur at a younger age). Hence, these influences mean that the relationship is not necessarily linear.

The actual evidence from the farm exit (intention) literature supports the hypothesis that there is no clear relationship between farmer age and exit. For example, some studies find there is a nonlinear relationship between farm exit and farmer age, with younger and older farmers more likely to exit (Kimhi and Bollman 1999; Bragg and Dalton 2004; Tiller *et al.* 2010). By contrast, Zuo *et al.* (2015a,b, 2016), Pietola *et al.* (2003) and Väre (2006) found exit decreased with farmer age. In terms of other human capital variables, others have found a positive relationship between education and exit (Pushkarskaya and Vedenov 2009; Rae and Zhang 2009). Human capital theory suggests that education may be associated with greater knowledge and ability to identify alternatives to working on the farm, which supports the argument that it is those with greater adaptability that are leaving. However, Peel *et al.* (2016) suggest that farmers with greater intentions to leave farming in the MDB had worse well-being.

In terms of other farm physical characteristics, a negative relationship has been found between farm size and exit (Kimhi and Bollman 1999; Pietola *et al.* 2003; Rae and Zhang 2009; Tiller *et al.* 2010), while Möllers and Fritzsch (2010) found a positive relationship. Again, Möllers and Fritzsch

(2010) found a positive relationship between farm income and exit, while Pushkarskaya and Vedenov (2009) found it to be negative. Many have found that better economic performance and productivity is associated with lower exit rates (Bragg and Dalton 2004; Dong *et al.* 2010; Möllers and Fritzsch 2010; Tiller *et al.* 2010). Farm diversification was negatively associated with exit (Pushkarskaya and Vedenov 2009), while Bragg and Dalton (2004) found it to be positive. Off-farm employment may help stabilise farm household income and have a negative impact on farm exit (Kimhi and Bollman 1999; Kimhi 2000; Väre 2006; Möllers and Fritzsch 2010). Alternatively the transaction costs associated with having off-farm work implies it lowers the overall costs of exiting farming and may have a positive impact on farm exit (Goetz and Debertin 2001; Bragg and Dalton 2004; Rae and Zhang 2009; Tiller *et al.* 2010).

Despite the considerable attention in the American and European agricultural economics literature (as evidenced above), there has been little economic quantitative analysis in Australia or New Zealand. More attention has been paid to the topic by geographers, sociologists and political scientists (e.g. Higgins 2001; Botterill 2002, 2007; Vanclay 2003; Barr 2004, 2009, 2014), while economists have tended to focus upon structural adjustment policy issues associated with drought and low incomes (McColl and Young 2006; Botterill and Chapman 2009). Exceptions to this include Marsden Jacobs (2010) which investigated irrigators' stated sensitivity to permanent changes in water allocations as part of research into the MDB plan and Zuo *et al.* (2015a, b, 2016) which conducted an experiment with southern MDB irrigators in 2011 to model predicted exit from irrigation, given a range of water entitlement and exit package scenarios. Zuo *et al.* (2015a,b, 2016) also found that price elasticity estimates of exit package take-up across SA, Victoria and NSW were elastic. These were most elastic for water prices at \$4,000/ML for NSW, \$3,500/ML for VIC and \$3,000/ML for SA. At water prices above \$5,000/ML, half of all irrigators would seek to take-up an exit package. However, all these research studies were undertaken at one particular point in time; hence, there is limited understanding about how irrigators' intentions to leave the farm can change under differing situations and, in particular, how periods of drought impact intentions – both now and in the future.

Similarly, very few studies have considered the role that water scarcity has played in influencing farm exit. The exception to this includes Zuo *et al.* (2015a,b, 2016), which considered the role of water ownership, carry-over volume and climate change belief on stated preferences for exit packages across the MDB. The influence of drought on farm exit choices is therefore obviously an area that is underexplored. As Barr (2009) discusses, the pressure to sell the farm will be highest during times of crisis periods such as drought (due to difficulties in farming, increase in costs and debt, availability of exit packages). But, at the same time, the presence of drought makes it less attractive to leave farming because the property market is often depressed. Barr suggests it will be the worst performing farms that will feel the most pressure to leave during these times. This leads us to our two main hypotheses:

H1: In times of drought, irrigators' exit intention increases;

H1.1: Greater water scarcity increases irrigators' intentions to exit; and

H2: Farms experiencing greater financial stress (e.g. lower rates of return, higher debt, less farm net income) are more likely to have an intention to exit in times of drought.

Testing the above hypotheses will help us answer the question about whether the least efficient irrigators are intending to exit, and how drought and water scarcity impact on exit intentions. These conclusions (and our other results) will be valuable for governments when designing future farm exit packages.

3. Methodology

3.1 Location

Our area of study in Australia is the southern MDB comprising irrigation districts located in NSW, Victoria and SA. Historically irrigators in these districts have received an allocation of water, regulated by government and determined by factors including history of use, environmental conditions and quantities stored upstream. Unlike other areas in Australia, the southern MDB is hydrologically linked, allowing water trade to occur. The uncertainty of irrigation water availability has been one main reason for the adoption of water trading by irrigators (Zuo *et al.* 2016).

3.2 Data

The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) has collected seven annual surveys from irrigators across the MDB, with the years 2006–2007 to 2012–2013 available for analysis. ABARES surveys are collected via face-to-face interviews, with a wide variety of information available. The dataset is a rotating (unbalanced) panel, with some farms randomly dropped after three years. We used the southern MDB region only (n = 2840 observations), for the main reason that this region is hydrologically connected and it has the majority of irrigators within it. Farms are classified into an industry based on their largest cash receipts, namely horticulture, dairy or broadacre.

We relied on the farm exit intention question within the survey on whether the irrigator planned to retire or sell the farm in the next three years (which is obviously not farm actual exit behaviour).[2] It is possible that irrigators may have answered strategically in their responses, but given the format of ABARES surveys (e.g. conducted on farm), strategic bias is likely minimised.[3] But, as found by Wheeler *et al.* (2013), actual irrigator behaviour will differ from intended behaviour when conditions are significantly different from expected (e.g. in periods of drought or water scarcity).

Table 1 provides the rate of exit intention annually from 2006–2007 to 2012–2013 for irrigators in the southern MDB. The rate fluctuated between 8.3 and 13.1 per cent. During drought years, the exit intention rate appeared more volatile than during nondrought years, when the rate remained around 10 per cent. It is worth noting that our farm exit intention rate for southern MDB irrigators from ABARES' survey was almost twice the national average annual rate of exit from farming as estimated by Barr (2014), which is unsurprising given the difference between intentions and behaviour, and the fact the question asked for exit intentions over the next three years. Table 1 allows for a first test of H1. Although the average rate of exit intention during drought years (12.4 per cent) is higher than in nondrought years (11.4 per cent), it is not significantly higher. Further detailed analysis is required.

3.3 Regression analysis

The following equation was estimated for intentions to sell the farm:[4]

$$\text{Sell}_i^* = X_i\beta + \varepsilon_i, \tag{1}$$

where individual irrigators are indexed by i, Sell_i* is a latent variable ranging from $-\infty$ to ∞, X_i is a vector of independent variables including rainfall and water related variables, β is a vector of parameters to be estimated, and ε_i is a classical error term. The observed binary variable for plan to sell is 1 if $\text{Sell}_i^*>0$ and 0 if $\text{Sell}_i^*\leq 0$. Two distributions of ε are commonly assumed: ε is assumed to be distributed normally with Var (ε) = 1 - the binary probit model, and second, ε is assumed to be distributed logistically with Var (ε) = $\pi^2/3$ - the binary logit model.[5] Given the number of exit intention

[2] Although irrigators who sell their farms could choose to buy another farm and continue farming in another area or work as farm labourers, to the best of our knowledge and experience, this scenario was unlikely. Hence, we assume that the definition of farm exit intention in the current study indicates the intention to stop farming altogether.

[3] Our experience from personally interviewing hundreds of irrigators is that they would attempt to answer truthfully.

[4] We also specified the equation as a panel structure and estimated a random effects panel probit model. However, the data do not fit the model well. One possible reason is that the data set is severely unbalanced with more than half of the irrigators appearing only once, and hence, the unobserved error term is likely to be correlated with the independent variables, which violates the assumption of the random effects estimator. We are grateful to an anonymous reviewer for highlighting this point.

[5] The two approaches are similar in terms of comparing the marginal effects of regressors (Amemiya 1981).

Table 1 Farm exit intentions in the southern MDB from 2006–2007 to 2012–2013

	Drought years				Nondrought years		
	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013
No plan to exit in next 3 years (*n*)	473	457	397	344	351	330	181
Plan to exit in next 3 years (*n*)	56	69	36	47	41	39	19
Plan to exit in next 3 years (%)	10.6	13.1	8.3	12.0	10.5	10.6	9.5

Source: ABARES' survey statistics.

observations within our database was relatively small (hence classified as a rare event), this poses an issue for the modelling when the sample is split into industries, as the maximum-likelihood estimate (MLE) may be heavily biased (Gao and Shen 2007). Hence, we used a penalised maximum-likelihood estimation method for the binary logit model proposed by Firth (1993) to reduce potential bias.

Equation (1) was estimated for i) the whole sample, ii) subsamples by drought and nondrought years and iii) subsamples by industry (horticultural industry by drought and nondrought years, and broadacre and dairy industries for the whole period).[6] Seven models were estimated in total.

Detailed variable definitions and summary statistics of the dependent and explanatory variables are presented in Table 2. Correlations and variance inflation factors (VIFs) among the explanatory variables were checked to ensure serious multicollinearity was not present. In particular, we are interested in how exit intentions respond to drought conditions/water scarcity. Drought conditions in the models are represented by the time period involved and by spatial variation across the southern MDB in terms of rainfall and water allocations received. There were three rainfall choices: summer, winter and total rainfall. The dependent variable was most responsive to winter rainfall;[7] hence, this was used in the modelling.

The water variables used in the regression to model farm exit intention were as follows: winter seasonal rainfall; mean water allocations for the previous five years; water entitlement ownership (ML); selling water entitlements and regional water allocation and entitlement prices. The exogeneity of the water variables used in the regression need further

[6] The broadacre and dairy industries subsamples could not be estimated by drought/nondrought years because the penalized maximum-likelihood regression could not converge due to small sample sizes and the small number of farm exit intentions. Therefore, the drought and nondrought years for broadacre and dairy were combined and an interaction term included between drought and winter rainfall to test for water scarcity impacts.

[7] The link between winter rainfall and dam storage (and hence water allocations) is probably the key here as to why winter rainfall was one of the most responsive.

Table 2 Summary statistics

	Mean	Std.Dev.
Dependent Variable		
Exit intention, dummy (1 = yes intention to exit; 0 = otherwise)	0.10	0.30
Independent Variables		
Age (years)	55.13	10.75
Age (years squared)	3154	1200
Low education (no school or only primary school), dummy (1 = low education; 0 = otherwise)	0.34	0.47
Opening season irrigated area (Ha) in logarithm	3.46	1.82
Opening season dryland area (Ha) in logarithm	4.31	2.33
High security (HS) entitlements (ML) in logarithm	2.78	2.87
General/low security (GS/LS) entitlements (ML) in logarithm	3.31	3.19
Regional water allocation price in logarithm ($/ML)	4.99	1.32
Regional water entitlement (high security) price in logarithm ($/ML)	7.62	0.18
Mean allocation % for previous five years for high security	0.80	0.14
Mean allocation % for previous five years for general/low security	0.13	0.18
Sold water entitlement in the current season, dummy (1 = sold water; 0 = otherwise)	0.06	0.23
Total opening season farm debt ($ millions, CPI adjusted)	0.81	1.42
Total opening season farm debt-squared ($ millions, CPI adjusted)	2.66	17.51
Opening farm capital ($ millions, CPI adjusted)	3.97	5.50
Opening farm capital-squared ($ millions, CPI adjusted)	45.97	373.38
Total salary from off-farm work ($000s, CPI adjusted)	10.39	22.04
Rate of return (%)*	−1.10	9.46
Farm net income ($000s, CPI adjusted)	104.08	412.16
Distance to the closest town centre with at least 5000 population (km)	35.38	39.49
SEIFA relative advantage and disadvantage index of the statistical local area (SLA)† where the irrigator lives‡	937.99	31.53
Winter rainfall§ (mm)	217.06	130.55
Region dummy for Victoria Murray‡ (1 = Victoria Murray; 0 = otherwise)	0.18	0.38
Region dummy for NSW Murray‡ (1 = NSW Murray; 0 = otherwise	0.11	0.31
Region dummy for Victoria Goulburn‡ (1 = Victoria Goulburn; 0 = otherwise)	0.19	0.39

Notes: *Defined as (farm profit at full equity divided by total opening farm capital) times 100. †SEIFA = Socio-Economic Indexes for Areas, developed by the Australian Bureau of Statistics from the Population Census. The index of relative advantage and disadvantage a continuum of advantage (high values) to disadvantage (low values) which is derived from Population Census variables related to both advantage and disadvantage (e.g. household with low income and people with a tertiary education). From 2006–2007 to 2009–2010 seasons, we used SEIFA index from the 2006 Population Census and for 2010–2011 to 2012–2013 seasons, we used SEIFA index from the 2011 Population Census. ‡Reference regions were SA Murray and NSW Murrumbidgee. §Winter rainfall was obtained from the Australian Water Availability Project and was matched with each farm's location using Geographic Information System software via ABARES. Winter rainfall was defined as total rainfall from April to October in each year.

consideration. Firstly, winter seasonal rainfall and regional measures of prices are exogenous, as individual irrigator behaviour cannot influence or change this. Given the possibility of water allocations being a function of irrigator behaviour (i.e. how much irrigators' use their water productively, or carry it over for example), then it is possible that water allocations are not strictly exogenous. However, our measure of water allocations minimises any potential problem of endogeneity by using the mean of the previous five years of water allocations for the irrigator (as a percentage). The final water variable included was whether an irrigator had sold water entitlements, which could be endogenous as the more an irrigator considers leaving their farm, the more they sell water entitlements, and then the more they face production difficulties and hence intend to leave (Wheeler *et al.* 2014). However, the counter-argument to this is that many irrigators sell surplus water and use the revenue from water entitlement sales to reduce debt, reinvest and increase innovation and which thus helps them to stay viable and remain in production (Wheeler and Cheesman 2013).

A bivariate probit model was used to test whether selling water entitlements was endogenous with farm exit intention, using selling water allocations as an exclusion restriction.[8] Selling water allocations had a significant association with selling water entitlements, and selling water allocation is a seasonal decision, which should not determine the intention to exit, therefore making it a good candidate for the exclusion restriction. The result suggested that selling water entitlements was not endogenous with farm exit intention.

4. Results and discussion

The results for seven logit models using penalised maximum-likelihood estimation are presented in Table 3. The number of observations ranged from 438 to 2631, and all models have a significant overall Wald chi-square statistic. The McKelvey–Zavoina R^2 ranged from 0.32 to 0.44 among the models and was a reasonable fit (Table 3).[9]

Modelling results suggest that irrigators' exit intentions were associated with a range of variables, and differences exist among industries and between drought and nondrought years. Overall, higher winter rainfall is negatively associated with exit intention. However, the result became insignificant (though still negative) in the nondrought years. In the industry models, for

[8] We used a bivariate probit model for the entire sample (2631 observations) that had over 260 farmers intending to exit. Hence, the MLE was not biased due to rare events. Although Sukjin and Vytlacil (2013) demonstrated that having an exclusion restriction is sufficient but not necessary in models with common exogenous covariates that are present in both equations, the presence of an exclusion restriction could still help the model identification.

[9] McKelvey–Zavoina R^2 is best able to mimic the OLS R^2 among seven pseudo-R^2 available to binary probit and logistic models (Veall and Zimmermann 1994; Windmeijer 1995). The McKelvey–Zavoina R^2 of our models also compares favourably to other farm behaviour models.

Table 3 Probit regression results for farm exit intention (1 = exit intention) by industry and drought time period

	All years southern MDB	Drought southern MDB	Nondrought southern MDB	Horticulture		Broadacre	Dairy
				Drought	Nondrought		
Age	0.265***	0.304***	0.165	0.307***	0.069	0.183	0.254*
Age-squared	−0.002***	−0.002***	−0.001	−0.002***	0.0001	−0.001	−0.002
Low education	0.114	−0.008	0.345	−0.186	0.632**	0.587*	−0.013
Irrigated land	−0.087	−0.09	−0.073	−0.037	−0.244	−0.108	−0.201*
Dryland	−0.069	−0.045	−0.114	−0.041	0.052	−0.14	−0.192
High security water	0.003	−0.025	0.009	−0.098	0.023	0.107	0.063
General/low water	0.012	0.017	−0.013	−0.017	0.006	−0.01	0.125
Water allocation price	−0.003	−0.199	0.044	−0.508*	0.439	0.267	−1.055**
Water entitlement price	0.307	0.454	1.946	0.473	3.215	−1.669	−1.486
High security allocation %	−0.733	0.991	−2.877*	2.471*	−4.864*	−5.685*	1.104
Gen./low security allocation %	0.501	0.729	−0.11	−0.252	0.831	3.177	−2.828
Sold water entitlement	0.863***	0.850**	1.025***	0.939*	1.095**	0.848	0.979**
Farm debt	−0.229*	−0.396**	−0.097	−0.568**	−0.701*	−0.336	1.396**
Farm debt-squared	0.020**	0.025**	0.028	0.034**	0.103**	0.049	−0.358*
Farm capital	−0.042	−0.024	−0.038	−0.093	−0.031	0.0005	−0.203
Farm capital-squared	0.001	0.0004	0.001	0.003	−0.0004	0.0002	0.014
Off-farm income	0.005*	−0.002	0.018***	0.001	0.021***	0.011	−0.007
Rate of return	−0.025**	−0.034***	0.011	−0.022	0.027	−0.036	−0.039
Net farm income	−0.0002	0.0005	−0.001	−0.0001	−0.001	−0.0001	−0.001
Vic Murray	0.048	0.354	−0.633	0.268	0.005	−0.698	−1.981
NSW Murray	0.504**	0.781**	−0.086	0.884	0.427	−0.233	−0.118
Goulburn	−0.057	0.66	−1.110*	1.171	−1.307	−1.856**	−1.42
Distance to town	0.0002	0.004	−0.010*	0.008*	−0.011	−0.009	0.003

Table 3 (*Continued*)

	All years southern MDB	Drought southern MDB	Nondrought southern MDB	Horticulture		Broadacre	Dairy
				Drought	Nondrought		
SEIFA	−0.001	−0.001	0.003	−0.001	0.005	0.005	−0.005
Winter rainfall	−0.002*	−0.004**	−0.002	−0.004*	−0.002	–	–
Winter rain and nondrought interaction -	–	–	–	–	−0.001	0.002	
Winter rain and drought interaction	–	–	–	–	–	−0.011*	−0.01
Drought	0.005	–	–	–	–	1.849	5.208*
Broadacre	−0.651**	−0.877***	−0.485	–	–	–	–
Dairy	0.086	0.094	0.298	–	–	–	–
Constant	−12.073**	−14.024*	−22.664	−13.839	−31.836	2.373	8.388
Observations	2631	1715	916	906	438	679	608
McKelvey–Zavoina R^2	0.32	0.33	0.37	0.34	0.44	0.36	0.41
Wald chi-square statistics	180***	122***	76***	70***	52***	44**	44**

Notes: *$P < 0.1$; **$P < 0.05$; ***$P < 0.01$ indicate significance at the 10, 5 and 1% levels, respectively.

horticulture and broadacre industries, higher winter rainfall is associated with a lower probability of exit intention during drought years, but not in nondrought years. Winter rainfall was not significantly associated with exit intention in drought or nondrought years for the dairy industry. However, the drought year dummy in the dairy model was associated with a higher likelihood of exit intention.

Higher water entitlement ownership (of any security) did not appear to influence exit intentions in any of the industries. Higher water allocation prices reduced the probability of exit intentions for horticultural irrigators in drought years and for dairy irrigators overall. Greater water allocation percentage for high security water entitlement in the previous five years was negatively associated with overall and horticultural exit intentions in nondrought years. However, during drought years, horticultural irrigators' exit intentions were positively associated with greater water allocation percentages.

The final water variable assessed was the impact of selling water entitlements on exit intentions. The results indicated that if an irrigator had sold water entitlements in the current year, this increased exit intentions in both drought and nondrought years. The influence of selling water was only significant in the horticultural and dairy industries, which are more likely to own smaller amounts of high security water entitlements. Such a situation indicates that irrigators believe selling their irrigation water has potentially placed them on a trajectory where it may be difficult to keep farming in the future, if and when the next water shortage occurs, a situation discussed in Wheeler *et al*. (2014). This is also played out in the regional characteristics. The higher the level of pain, in terms of low water allocations irrigators have received in the past five years, the more likely the intention to leave the industry, particularly in horticultural industries which have the least capacity to adjust to lower water allocation levels. This is more likely to have occurred after 2010–2011 (nondrought years), being the period after many of these irrigators have permanently sold a lot of their buffer and surplus water.

In summary, there seems to be only very weak evidence supporting Hypothesis 1 that drought increases the probability of farm exit intention. There is evidence that reduced winter rainfall increases farm exit intention in times of drought, more so than in nondrought times. However, what is interesting is the influence of the past five-year mean seasonal water allocation. In times of nondrought (when the property market is obviously less depressed), it is those irrigators who have been in considerable stress regarding very low water allocations that are now more likely thinking of exiting. Hence, a lagged effect of water scarcity on farm exit intentions was found.

Financial variables that significantly influenced exit intention included the following: farm debt, off-farm income and rate of return. Absolute farm debt (farm debt-squared) is negatively (positively) associated with exit intentions in the southern MDB overall model, but this result was driven solely by the drought year time period (debt was insignificant in nondrought years as influencing exit intentions). This indicates that higher debt after a threshold point positively influenced exit intentions. However, debt was significant in both time periods for the horticultural model. For example, the turning point for horticultural industry debt was \$8.3 million and \$3.4 million in drought and nondrought years, respectively. In the dairy industry, the opposite is the case: exit intentions increase with absolute debt levels and then decrease with debt after a certain debt level (\$1.9 million calculated from Table 3's dairy model). No significant results were found for farm capital. In the overall southern MDB model, an increase in a farm's rate of return decreased farm exit intention, having the most impact in times of drought. Although some studies in the literature suggest that off-farm employment may help stabilise farm household income and have a negative impact on farm exit (e.g. Kimhi and Bollman 1999; Kimhi 2000; Väre 2006; Möllers and Fritzsch 2010), our result indicates there is a positive relationship between off-farm income and exit intentions, particularly during nondrought years. This supports the argument by some (i.e. Goetz and Debertin 2001) that the transaction costs associated with having off-farm work lowers the overall costs of exiting farming, and has a positive impact on farm exit intentions. These results provide evidence to support Hypothesis 2: that farms with lower rates of return (and debt over a certain level) are more likely to have exit intentions during periods of drought stress than in nondrought times.

Generally, the age results are very consistent across all models, indicating that the older the irrigator, the more likely they were considering exiting the farm. However, there was a quadratic relationship between age and exit intention. For example, the turning point was 83 years old in the overall southern MDB model and 80 years old in the southern MDB drought year model, as calculated by the coefficients of age and age-squared in Table 3.[10] Since the proportion of irrigators who are over 80 years old is small,[11] the conclusion that exit intention increases with age is applicable to most irrigators. Over recent years, the rate of exit of young farmers in Australia has been rising, and the rate of exit of older farmers has fallen. Such trends have resulted in an ageing farmer population (Barr 2009, 2014). Our mean irrigator age was 55, and there is going to be a continuing ageing of the farmer population in the short term.

Irrigators with lower education levels are more likely to think about exiting in the horticultural industry (in nondrought years only) and in the broadacre industry. Hence, unlike the results for irrigator age, which strongly supported human capital theory, the education results do not support this view, which suggested that higher education might be associated with greater farm exit

[10] The coefficients for age and age-squared are 0.2650 and −0.0016, respectively, in the overall model and are 0.3036 and −0.0019, respectively, in the drought period model, if four decimal points are kept in order to calculate the turning point more precisely.

[11] The 2011 Census of Population and Housing estimates that 2.48 per cent of farmers/farm managers are older than 80 years (ABS 2013).

intentions. Very weak evidence was found for the impact of irrigated and dryland farm area on exit intentions. Only dairy irrigators who owned more irrigated land were less likely to consider exiting.

Being further away from the closest town centre increases the probability of exit intentions during drought years for the horticultural industry. In nondrought years for the overall southern MDB model, being further away from the closest town centre reduces the probability of farm exit intentions. Finally, the overall southern MDB model suggests that NSW Murray irrigators have higher exit intentions than those in Murrumbidgee and SA Murray, particularly during drought years. Broadacre irrigators are less likely to have exit intentions than those in the horticultural or dairy industries, particularly during drought years.

5. Conclusions

This study modelled irrigator farm exit intentions across the southern MDB, between 2006–2007 and 2012–2013. In particular, we sought to understand how water scarcity impacted on exit intentions. Overall, although there was only weak evidence to support the hypothesis that periods of drought increased intentions to exit, there was stronger evidence to support the hypothesis that there is a lagged influence of water scarcity on irrigators' choices to leave the farm. Those who had experienced greater cuts to water allocations in the past five years were much more likely to consider leaving the farm in nondrought periods (when the property market was less depressed). Similarly, it was found that irrigators with the poorest performing enterprises were inclined (forced?) to consider exiting in periods of drought.

Ongoing research on farm exit can inform government policy on schemes such as irrigator exit small block schemes. It is important to note that our research found no significant relationship between irrigated and/or dryland farm area and exit intentions. This provides some support for changes made in 2009 to the Small Block Irrigator Exit Grant Package, but also brings into question the criteria by which exit assistance is designed generally. Initially, only irrigators owning up to 15 hectares of farmland were eligible for exit assistance, but the revised guidelines allowed irrigators owning up to 40 hectares of farmland to apply for the package. Given land size was not found to significantly influence exit intentions, relaxing the eligibility would likely have encouraged additional financially stressed irrigators to apply and the targeting of the program could be possibly improved as a result. Removing criteria based on land size altogether and replacing them with financial performance measures may have offered even more benefits to policymakers seeking to provide assistance to those most vulnerable.

The finding that irrigators earning lower rates of return, with considerably higher debt levels, were thinking about exiting the industry raises important questions about how public financial assistance (e.g. concessional loans) is conceptualised. While such financial assistance aims to make farm enterprises more resilient over time, it is unclear how such policy plays out in practice. More specifically, when exiting agriculture features heavily in the minds of individuals, there are at least some grounds for questioning the social gains from forestalling actions via public finance.

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