Water trading as a risk-management tool for farmers

new empirical evidence from the Australian water market

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3 August 2012

Water markets as a risk-management tool (1)

Most of the decisions taken by farmers are risky because of uncertainty on:

- future weather / **water availability**
- plant and animal diseases
- commodities and inputs prices
- future public policies

Water markets as a risk-management tool (2)

Farmers may undertake actions to manage the risk of water shortage, e.g.:

- increasing/decreasing the irrigated area/dryland area
- growing crops that are less sensitive to drought
- changing input mix
- investing in water-efficient technologies, building on-farm water storage
- carrying-over water
- **purchasing water on the market**

Water markets as a risk-management tool (3)

Farmers' decisions in terms of risk management depend on their risk preferences:

- farmers are found to be *risk-averse* in most situations: they are adversely affected by a high variance of returns
- they may also be averse to unexpectedly low returns: *downside-risk aversion*

Water markets as a risk-management tool (4)

Risk-averse farmers and farmers averse to downside risk are going to take actions to hedge against risk in order to

- decrease the *variance* of returns/profit (*moment of order 2*)
- decrease the probability of very low returns/profit (*skewness* or *moment of order 3*).

In this paper **we test if farmers with returns characterised by a higher variance and a lower skewness are more likely to purchase water allocations on the market**.

If yes, this will be evidence that (risk averse) farmers use water markets as a risk-management tool.

Contributions of this study

- to provide one of the first empirical tests of the use of water markets by farmers as a risk-management tool
- using data from the MDB, to identify other factors (than risk preferences) that could explain differences in behaviour across industries (broadacre, horticulture, dairy) and across farmers within industries:
  - water entitlements and allocations
  - water price, commodity prices
  - weather conditions (rainfall)
  - farm characteristics (farm size, farm financial capacity)
  - farmers' characteristics (age, education)
  - etc.

Data description

- Four rounds of the ABARES survey of irrigation farms (2006-07 to 2009-10)
- Study region: southern Murray Darling Basin (regions of Goulburn, Murrumbidgee and Murray)
- 1,449 observations overall covering three industries: broadacre (385 obs.), dairy (294) and horticulture (770)
- ABARES survey: financial information (revenues, costs) and total amount of water allocations purchased and sold on the market over the year
- Combined with other data: rainfall (Australian Water Availability Project); regional water prices (Waterfind Annual Water Market Reports)

Interesting features of the data

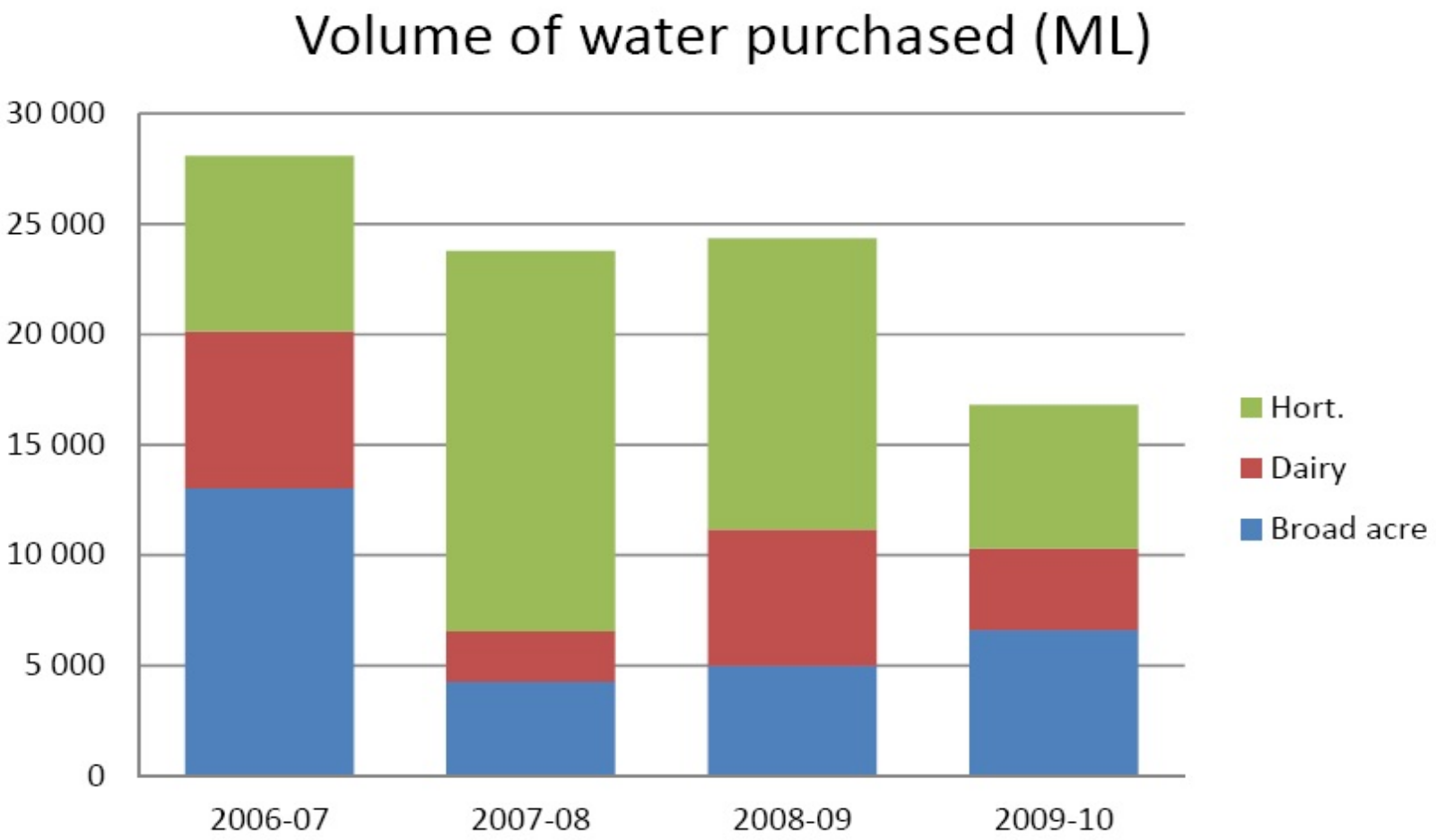
- MDB: one of the most active water markets
- A mature water market (in existence since late 1980s)
- Encompass periods of low and high rainfall
- Cover three industries facing different risks associated with water shortage
- (Rotating) panel: a number of farmers are followed over time

Simple statistics

Number of farmers who purchased water allocations (in sample)

	2006-07	2007-08	2008-09	2009-10
Broadacre	26	14	10	15
Dairy	26	19	30	19
Horticulture	67	165	85	50
% of total sample	31%	45%	38%	28%

Simple statistics (cont'd)



Methodology (1)

1. Estimation of the moments of the profit distribution (mean, variance and skewness)

2. Estimation of the effects of variance, skewness, rainfall, water price, commodities prices, farms and farmers' characteristics on the volume of water allocations purchased

Main hypothesis to be tested: a higher variance and a lower skewness increase the volume of water allocations purchased on the market.

Methodology (2)

Stage 1: Estimation of the moments of the profit distribution (variance and skewness)

- Profit: $\Pi = f(x;\beta) + \varepsilon$ with $E(\varepsilon) = 0$
- Expected profit: $E(\Pi) = E[f(x;\beta)]$
- First (centered) moment: $m_1 = E[\Pi - E(\Pi)] = \varepsilon$
- Second (centered) moment: $m_2 = E[(\Pi - E(\Pi))^2] = \varepsilon^2$
- Third (centered) moment: $m_3 = E[(\Pi - E(\Pi))^3] = \varepsilon^3$

This paper: Π is the observed profit and $f(x)$ is a (quadratic) function with x a vector of farms' production factors (labour, fertiliser, chemicals, seed etc.).

The set of parameters β are estimated using econometric techniques to get an estimate of ε.

Methodology (3)

Stage 2: The volume of water allocations purchased during the year is regressed on:

- the estimated mean of the profit distribution
- the estimated variance of the profit distribution
- the estimated skewness of the profit distribution
- rainfall
- water price and commodities prices
- farm's and farmers' characteristics.

Tobit models are estimated separately for the broadacre, horticulture (viticulture separate) and dairy industries.

Main results: factors influencing the volume of water allocations purchased

Variables	Broadacre	Dairy	Hort.	Viticulture
Estimated variance	(+)**	(+)***	(+)**	(+)***
Estimated skewness	(ns)	(-)**	(-)***	(-)***
Farm size	(ns)	(-)*	(ns)	(-)**
HS entitlements	(ns)	(-)*	(ns)	(-)**
Allocation (%)	(ns)	(ns)	(-)**	(-)***
Debt	(ns)	(-)**	(ns)	(ns)
Low education	(ns)	(-)**	(ns)	(ns)
Winter rainfall	(ns)	(-)**	(-)***	(ns)
Murrumbidgee region	(ns)	-	(-)***	(ns)
Murray region	(ns)	(-)**	(ns)	(ns)

ns: non-significant; *, **, ***: significance at the 10, 5 and 1 per cent level.

Main results: factors influencing the volume of water allocations sold

Variables	Broadacre	Dairy	Hort.	Viticulture
Estimated mean	(+)***	(ns)	(ns)	(+)*
Estimated variance	(-,ns)	(-,ns)	(-,ns)	(-,ns)
Estimated skewness	(+,ns)	(-,ns)	(-,ns)	(-,ns)
Farm size	(ns)	(+)**	(ns)	(ns)
Water price	(ns)	(+)***	(+)**	(ns)
HS entitlements	(ns)	(ns)	(+)**	(+)**
Allocation (%)	(ns)	(ns)	(+)***	(+)**
Low education	(ns)	(-)**	(ns)	(ns)
Winter rainfall	(ns)	(ns)	(-)**	(ns)
Murrumbidgee region	(ns)	-	(+)**	(ns)
Murray region	(-)*	(ns)	(ns)	(ns)

ns: non-significant; *, **, ***: significance at the 10, 5 and 1 per cent level.

Main results: summary

- farmers experiencing returns characterised by higher variance and lower skewness purchase more water allocations on the market (true for all three sectors)
- risk motives not so obvious for sellers
- a higher water price increases water sales in dairy and horticulture (no effect on water purchase)
- dairy farmers owning large farms purchase less and sell more water allocations

Main results: summary (cont'd)

- owning more HS water entitlements and receiving a higher percentage of water allocations decrease the volume of water purchased and increase the volume of water sold (stronger effects in horticulture and viticulture)
- dairy farmers with a higher level of debt purchase less water allocations
- dairy farmers with a lower education level are less likely to trade water allocations
- almost no effect of commodities prices
- less significance overall in broadacre industry

Conclusions - next steps

- empirical evidence that water markets are used by (risk averse) farmers as a risk-management tool
- water markets allow farmers to smooth out variations in profit and to reduce the risk of very low returns
- other water market products (e.g. options) might increase the use of water trade as a risk management strategy
- behaviour and motives of sellers still to be understood
- further insights probably gained from looking at intra-seasonal trade
- regional differences in farmers' behaviour?
- purchasing water on the market is only one strategy among a set of other strategies

Special thanks

- NCCARF for funding this project
- ABARES for providing the data and data support