Australian Government
Department of Agriculture
ABARES

The drivers of Australian broad-acre farmland value

An experimental analysis from 1975 to 2018



Will Chancellor, Shiji Zhao, Lucy Randall, Kenton Lawson & Khanh Hoang

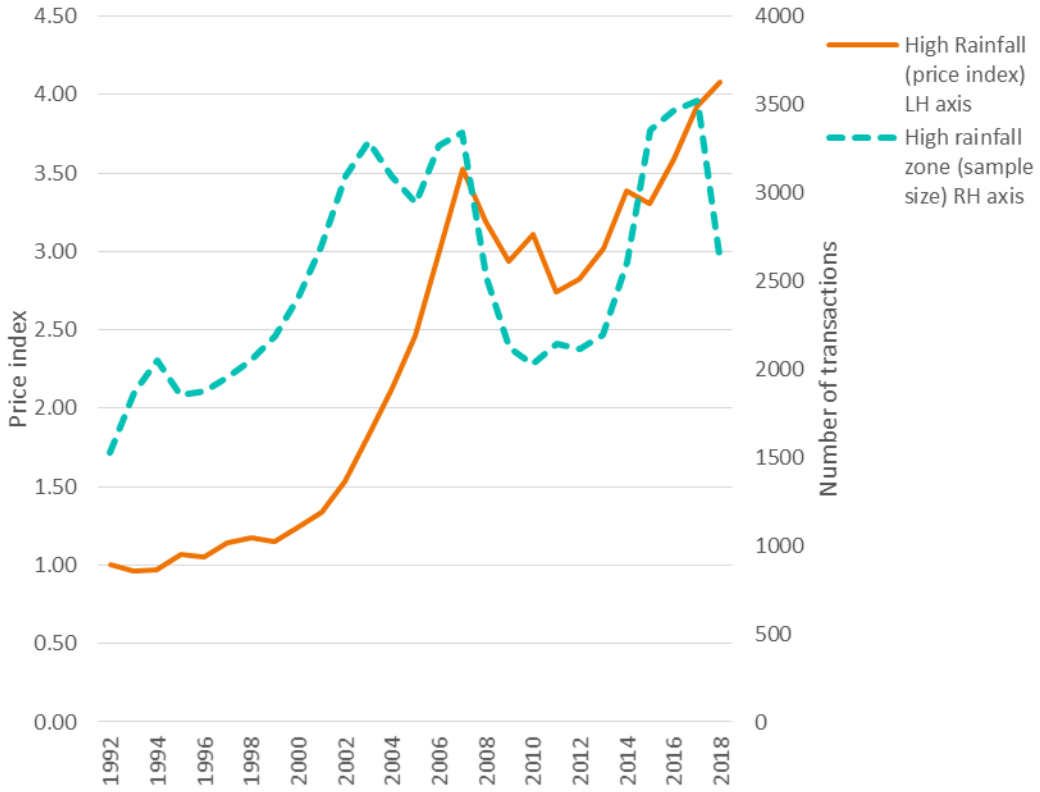
Australian Bureau of Agricultural and Resource Economics and Sciences

Working paper
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Motivation

- Drivers of farmland unknown (lack of evidence / anecdotal)
- Farmland value unknown for most farmers (comparisons often made to neighbouring sales)
- Viability of many farms relies on land value (i.e. for equity or wealth accumulation)
- Some concern of land bubble (as recently the case in Sydney and Melbourne residential property markets). Yet, banking sector more optimistic…
- Opportunity to inform policy makers

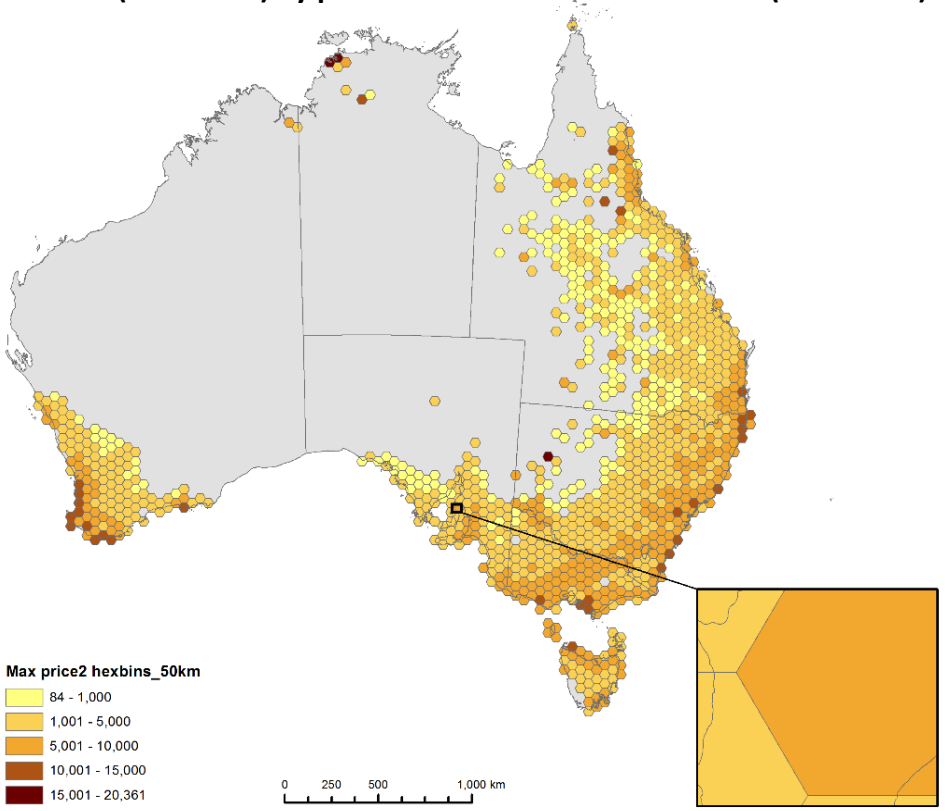
High rainfall zone (price index v number of transactions, 1992 to 2018 – clean dataset.



Some background

- Previous land value studies in Australia (and overseas)
  - Often restricted to local region over short time period due to data limitations
  - Different studies control for different features (probably due to data availability). These include: parcel size, land features, land quality, crop yield, climate variables, infrastructure, liveability, recreational amenities, soil erosion… etc.
- Lessons from real-estate studies
  - Hedonic models, use of quantile regression and stratification
  - spatial dependence issue (due to data limitations)

Price per hectare (maximum) by parcel in clean dataset 1975-2018 (as hexbins)



Raw data overview

- Administrative records (state level) from 1900 to 2019
  349,217 unique properties and 700,424 property transactions

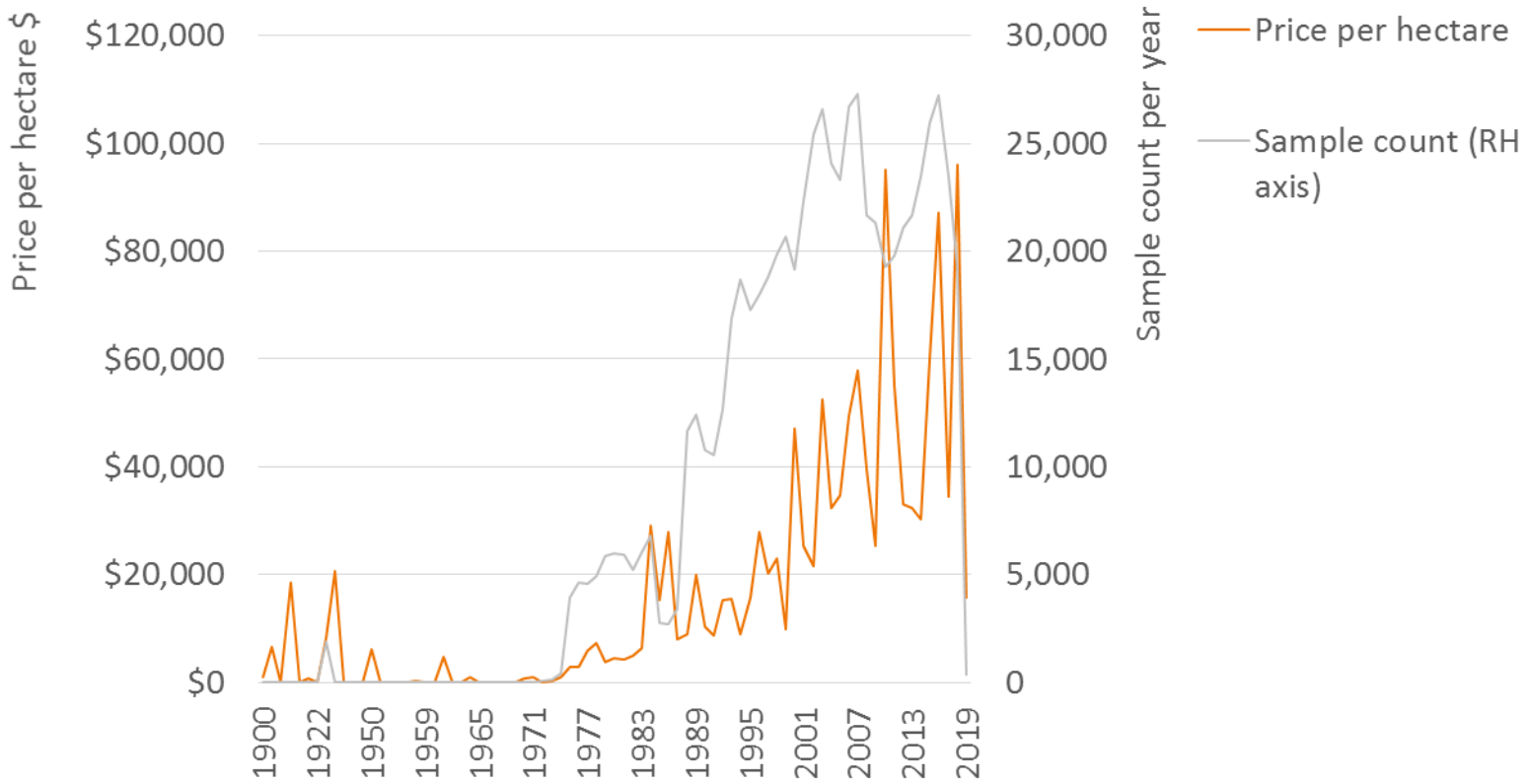
- Loosely defined as ‘agricultural transactions’

Number	Data field	Definition
1	Property ID	Unique record key within the core database for the property.
2	Real Property Description	The legal parcel(s) description of the property, depending on the scheme adopted for each state.
3	Lot Number	Lot Number component of the parcel's description. NSW, VIC, QLD, WA, SA, TAS, NT only
4	Full Property Address	Property Address
5	Property Type	CoreLogic identified category for the property such as House, Unit, Flats, Land, Business i.e. House, Unit, Flats, Business, Commercial, Community, Farm, Land, Storage Unit
6	Property Type Minor	Corelogic minor category for properties such as Multi Storey, Duplex, One story/Lowset, etc.
7	Primary Land Use	The Primary Land Use of the property such as single Unit Dwelling, House etc.
8	Latitude	The geographical latitude of the property.
9	Longitude	The geographical longitude of the property.
10	Bedrooms	The most recently recorded bedrooms count.
11	Bathrooms	The most recently recorded count of bathrooms for the property (inclusive of ensuites).
12	Land Area	Total size of the parcel/s in square metres.
13	Transfer ID	Unique record key within the core database for the transfer
14	Contract Date	Contract date of transfer which indicates the date on which the sale price was contractually committed between a vendor and a purchaser.
15	Transaction Date	Contract Date for states were VG Contract Date is provided include NSW, VIC, QLD, WA, TAS, ACT only
16	Contract Price	A proxy Contract Date with Settlement Date substituted for states where no VG Contract Date is provided. Allows for ordering transfers by the time that the transfer occurred.
17	Multi Sale	Sale price of transfer indicating the consideration for the property changing ownership (if available)

Data problems

- Excessively high and excessive low price per hectare
- Excessively small farm size (in hectares)
- Non-broadacre farms according to CoreLogic identifier labels.
- Multi-sale transactions

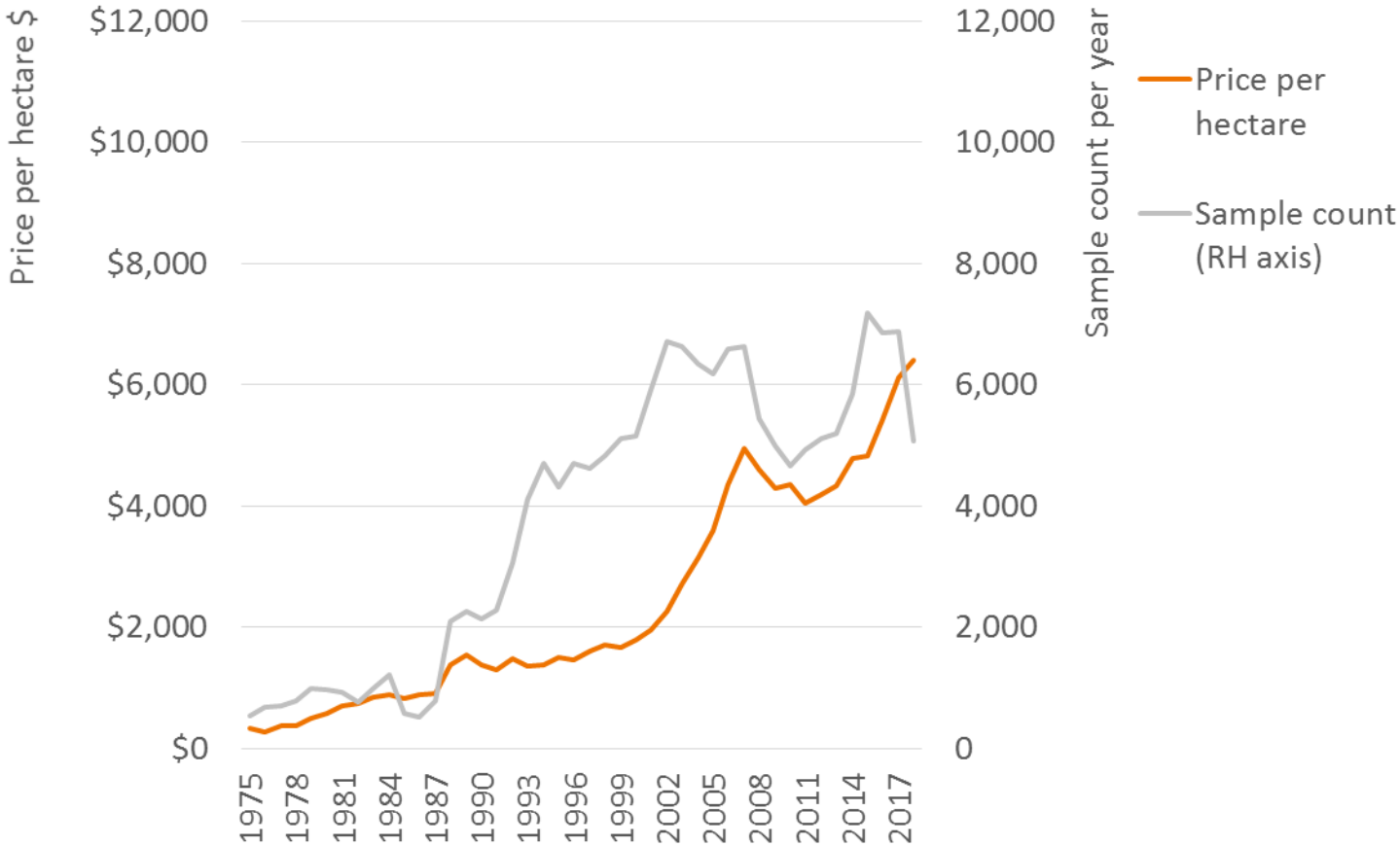
Pre-data cleaning, average price per hectare and sample count



Cleaning and scoping the data

- Price per hectare
  - $0 transactions (e.g. between family members)
- Broad-acre scope
  - Remove hobby farms (pre-defined)
  - Dairy
  - Irrigated etc.
- Quantile extremes
  - Remove very small properties
  - Price per hectare extremes

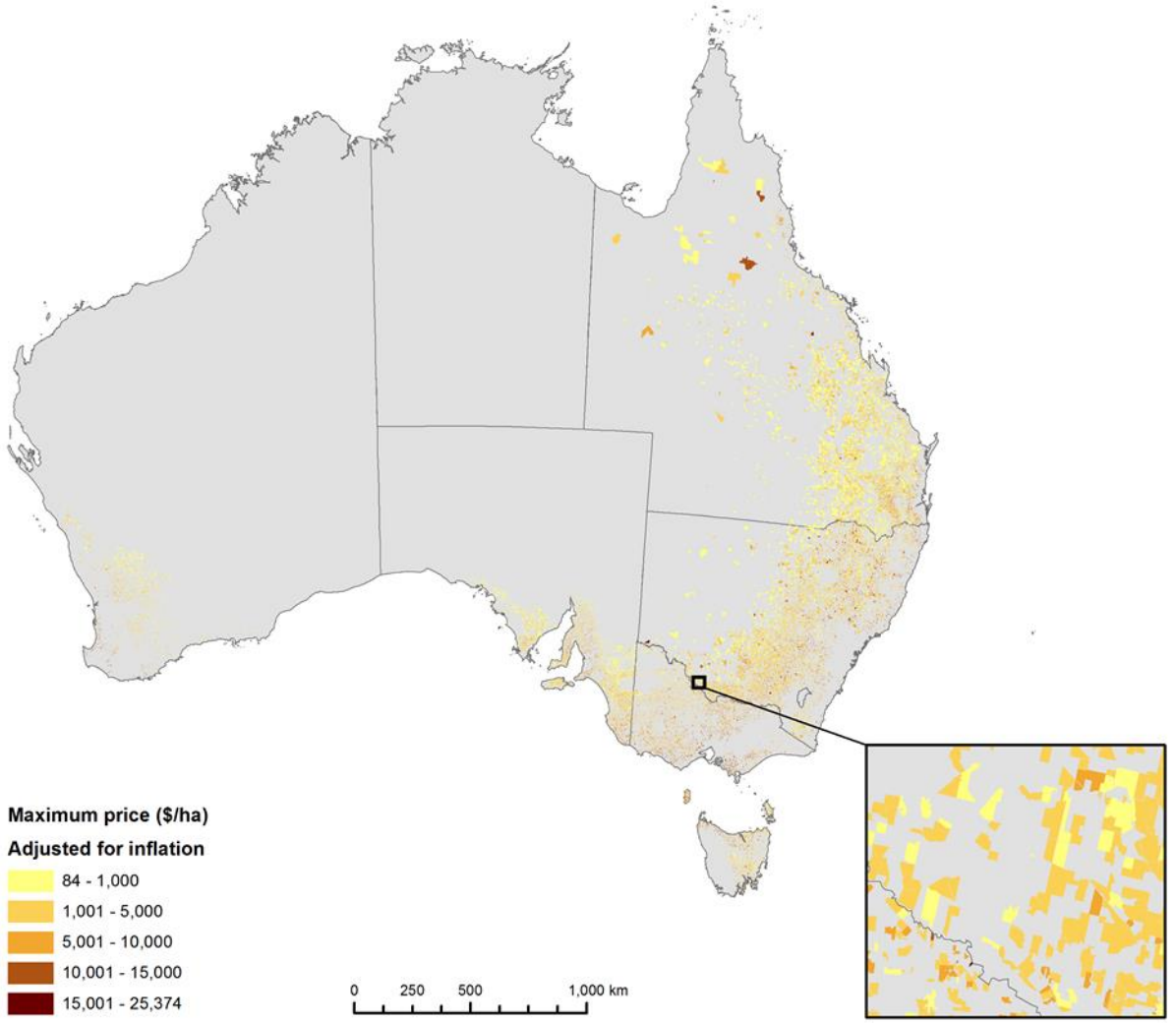
Post-data cleaning, average price per hectare versus sample size



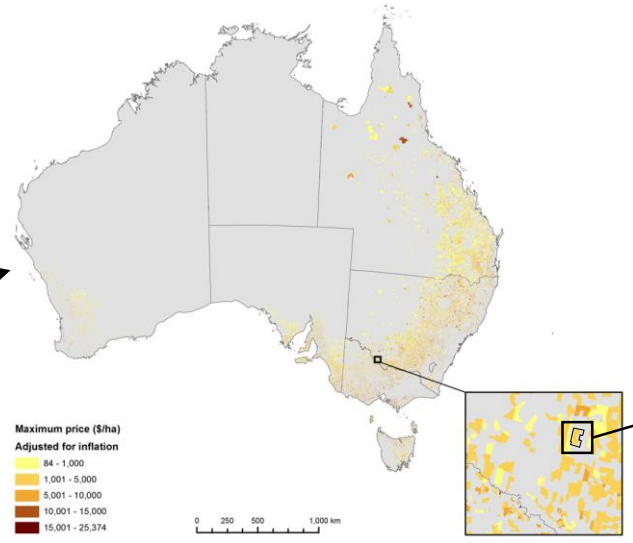
Spatial transformation and variable construction

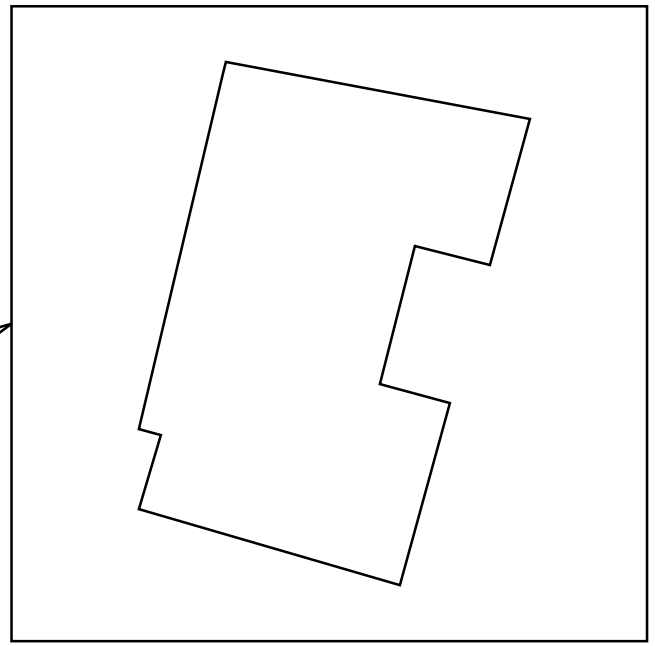
- Data transformation
  - Key component of this work
  - Unique data availability
  - Spatial parcel boundaries derived for each property
- Spatial boundaries enable linkages
  - Farm specific attributes
  - Scientific datasets

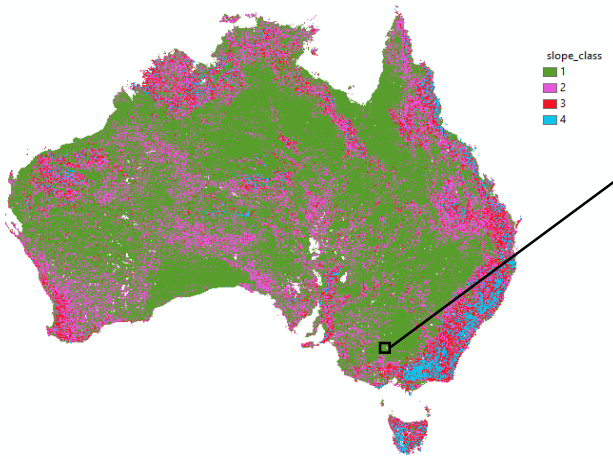
Price per hectare (maximum) by parcel in clean dataset 1975-2018



Practical Example of spatial variable join (land slope example)



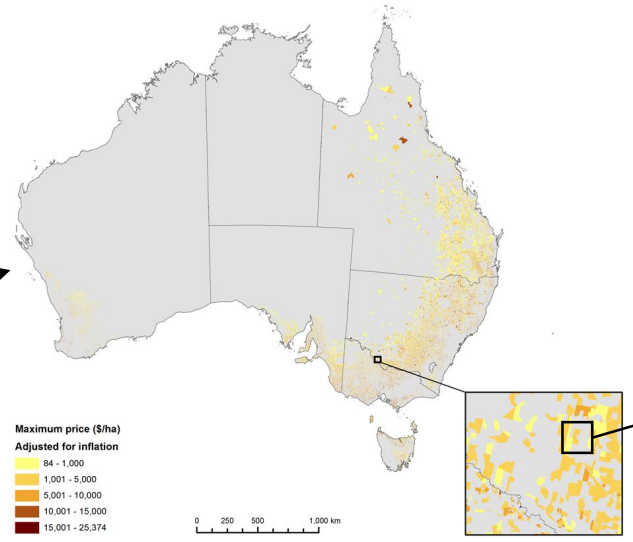


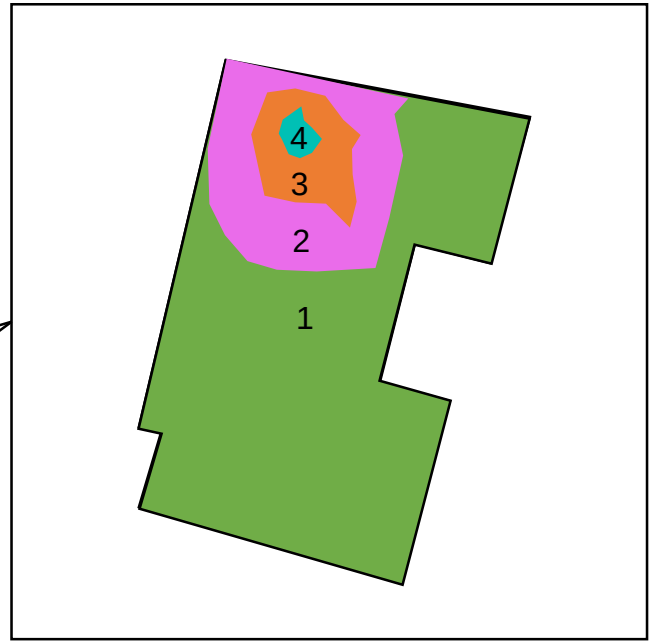


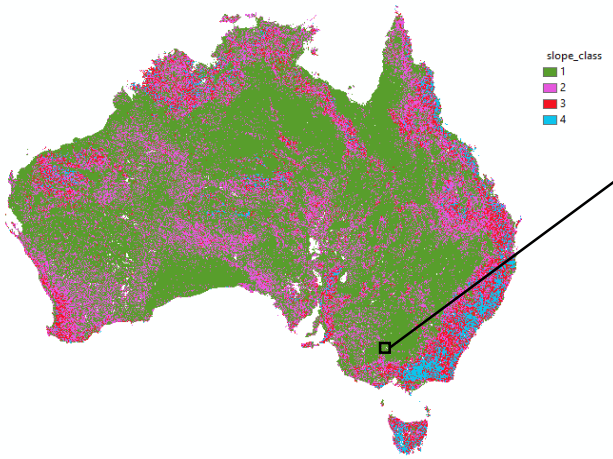
Land topography attributes for specific farmland parcel

Land slope class	Land topography	Percentage of land parcel
1	Flat	
2	Undulating	
3	Hilly	
4	Steep	

Practical Example of spatial variable join (land slope example)





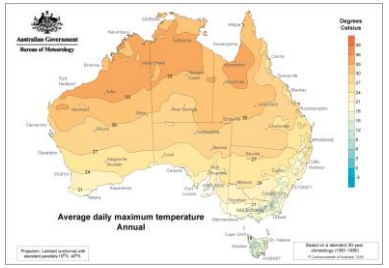


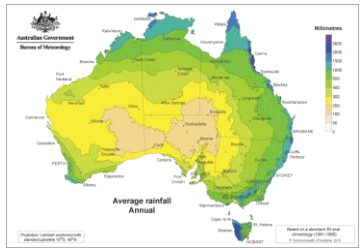
Land topography attributes for specific farmland parcel

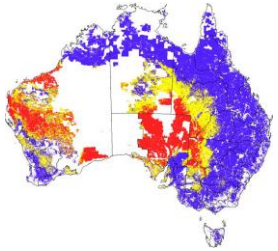
Land slope class	Land topography	Percentage of land parcel
1	Flat	68.4%
2	Undulating	22.2%
3	Hilly	6.8%
4	Steep	2.6%

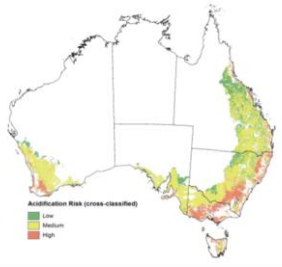
Similar rules apply for:

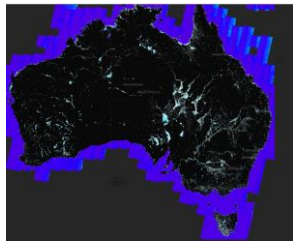
- Temperature
- Rainfall
- Soil Erosion risk
- Soil acidification risk
- Water cover
- Land use
- Tree cover/land clearing
- Distance/cost to towns and cities
- Buildings

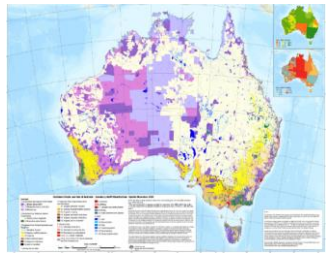


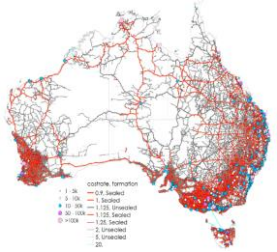


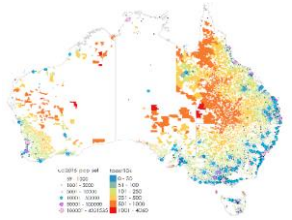


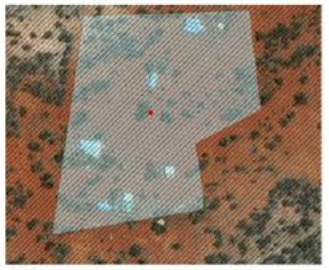








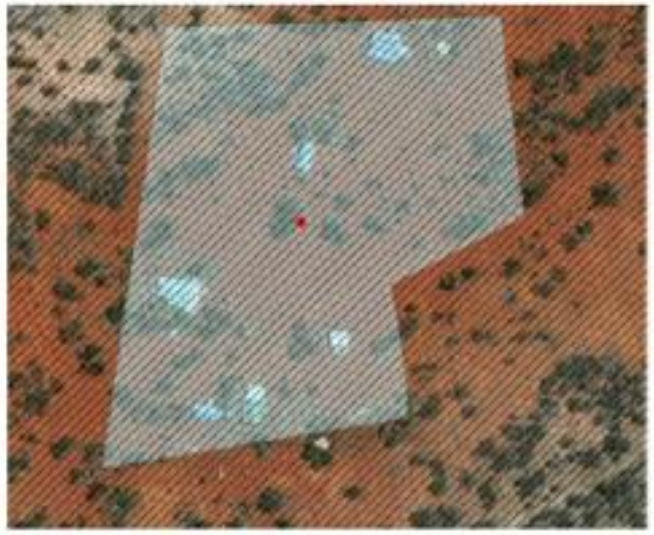




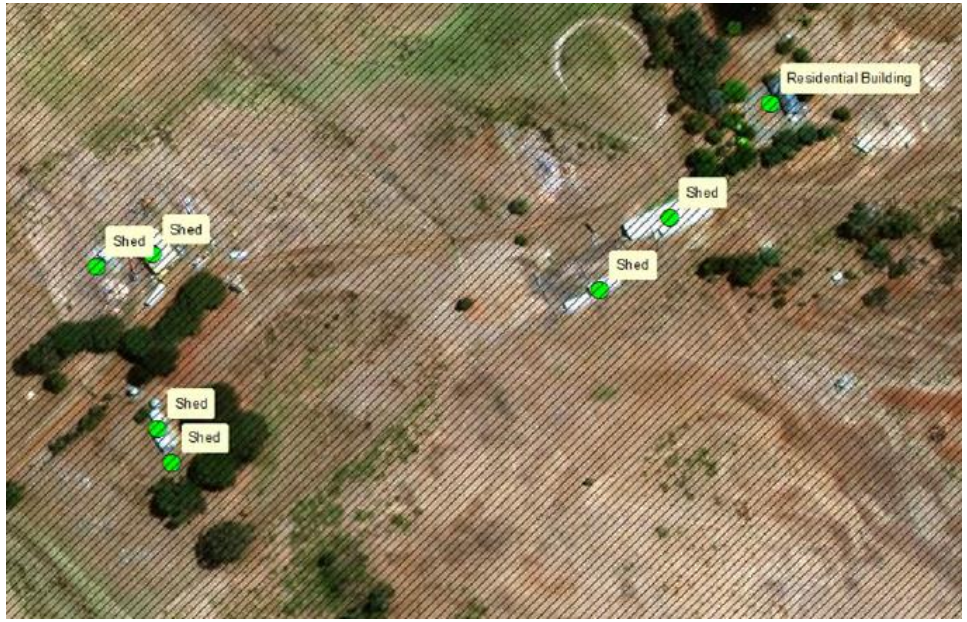
Some practical issues

- National buildings data
  - National data up to date, but not useful for number of buildings
- State level data
  - Unavailable for Western Australia and Northern Territory
  - Level of detail differs by state (e.g. building type)

Example of building cover data in national dataset



Example of building cover data in state dataset



Spatial variables

Explanatory variable	Description	Expected relationship to dependent variable
Building points		Positive, greater fixed capital investment likely to increase farmland value
Transport cost to small town (population 1,000) Transport cost to large town (population 100,000)	Distance from property to small town, accounting for quality/type of roads and infrastructure. Distance from property to large town, accounting for quality/type of roads and infrastructure.	Negative – an increase in the distance / cost to a small or large town suggests the property is more remote and has less access to infrastructure and services. This is likely to reduce land value.
Land clearing	Evidence of land clearing (negative) or revegetation (positive) between 1988 and 2018)	Unknown, potential to be positive or negative depending on region and farm type
Land slope (flat) Land slope (undulating) Land slope (Hilly) Land slope (Steep)	Percentage of land parcel that is flat Percentage of land parcel that is undulating Percentage of land parcel that is hilly Percentage of land parcel that is Steep	Unknown – flatter land is expected to be a positive attribute for land value, whereas hilly or steep land is likely to be negative. However gradient may be irrelevant for some production types.
Rainfall Jan-Mar Rainfall Apr-Jun Rainfall Jul-Sep Rainfall Oct-Dec	Average rainfall assigned to farm by quarter	Positive – Farmland with high average rainfall is likely to be positive for value due to the benefits for most agricultural production systems.
Maximum temperature Jan-Mar Maximum temperature Apr-Jun Maximum temperature Jul-Sep Maximum temperature Oct-Dec	Average maximum temperature assigned to farm	Negative – Areas with high average maximum temperatures are expected to demand lower prices, as this is unfavourable for most broad-acre production activities.
Minimum temperature Jan-Mar Minimum temperature Apr-Jun Minimum temperature Jul-Sep Minimum temperature Oct-Dec	Average minimum temperature assigned to farm	Unknown – the effect of average minimum temperature on broad-acre production is unclear, yet this may be positively related to value due to reduced frost risk which is unfavourable for some crop production systems.
Water cover 20% Water cover 5% Water cover 1.5%	Percentage of transacted farmland with water cover	Unknown – low levels of water cover are expected to be positive, however excessive water cover may be negative due to increased flood risk.
Cropping	Dummy variable assigned where land used for cropping exceeds 50 hectares	Positive/unknown – may indicate more valuable farmland
Grazing	Dummy variable assigned where land used for grazing exceeds 50 hectares	Negative/unknown – may indicate less valuable farmland
Mines sites	Dummy variable assigned where mine site identified on farmland	Unknown. Some anecdotal information suggests a positive relationship
Wind power	Dummy where wind turbines present on farmland	Positive – fixed investment may increase farmland value
Buildings	Dummy where buildings/infrastructure are present	Positive – fixed investment may increase farmland value
Soil Acid high Soil Carbon high Wind erosion high Water erosion high	Acidification risk high Soil carbon potential high Wind erosion risk high Water erosion risk high	Negative Negative Negative Negative

Non-spatial ‘general variables’

Data type	Explanatory variable	Description	Expected relationship to dependent variable
Administrative	Number of bedrooms	Number of bedrooms if house is present on transacted property	Positive – presence of house likely to increase land value. Larger house is expected to increase this further.
	Number of bathrooms	Number of bathrooms if house is present on transacted property	
Administrative	Hectares	Land size for transacted property	Negative – small farms generally expected to have higher value on ‘per hectare’ basis. As size increases, price per hectare is likely to decline.
	Multi-sale	Flag to indicate property parcels sold as grouping	Negative – expected that the sale of grouped property prices is done so at discounted rate
Macro	Productivity	State level experimental productivity estimates assigned as indicator of technology	Positive – productivity improvement may lead to improvements in land management and investment in fixed infrastructure through improved technology and farming practices.
	Rural debt	National level (RBA)	Positive – Increases in debt may be an indication of increased demand for agricultural land and increase availability of lending.

Method

National level model (OLS component)

$$log(Y) = \beta_0 + \beta_1 log(X)_1 + \beta_2 XD_1 + \beta_3 CT_1 \ldots + \beta_x log(X)_x + \beta_x XD_x + \beta_x CT_x + \epsilon$$

ABARES agricultural zones (high rainfall, wheat sheep, pastoral) model (OLS component)

$$R(log(Y)) = R(\beta_0 + \beta_1 log(X)_1 + \beta_2 XD_1 + \beta_3 CT_1 \ldots + \beta_x log(X)_x + \beta_x XD_x + \beta_x CT_x) + \epsilon$$

Where
Y : *price per hectare (dependent variable)*
β : *coefficients*
X: *Explanatory variables (e.g. average rainfall)*
XD: *Dummy explanatory variables (e.g. multi-sale flag)*
CT: *Control variables (e.g. time)*
ϵ: *Error term*
R: *Strata for ABARES zone*

Method

- To test relationship between price per hectare and explanatory variables by size category

Quantile function (to construct new variable that assigns properties to one of three categories based on respective size in hectares)

$$(-\infty, x_{[p1]}], (x_{[p1]}, x_{[p2]}], \dots, (x_{[pm-2]}, x_{[pm-1]}], (x_{[pm-1]}, +\infty)$$

Numbered, respectively, $1, 2, \dots, m$, based on the m quantiles given by the $p_k th$ percentiles, where $pk = 100\ k/m$ for $k = 1, 2, \dots, m-1$.

- Practically achieved using state function 'xtile' in (Ryan, P. 2014)

Size quantile model (OLS component)

$$q.S(log(Y)) = q.S(\beta_0 + \beta_1 log(X)_1 + \beta_2 XD_1 + \beta_3 CT_1 \dots + \beta_x log(X)_x + \beta_x XD_x + \beta_x CT_1) + \epsilon$$

- Practically, three separate robust OLS regressions are run for farms within each size quantile (small, medium, large).

Method

Simultaneous quantile regression (price categories)

$$[(Q_{.10}(log(Y)) = \beta_{0.Q_{.10}} + \beta_{1.Q_{.10}} log(X)_{1.Q_{.10}} + \beta_{2.Q_{.10}} XD_{1.Q_{.10}} + \beta_{3.Q_{.10}} CT_{1.Q_{.10}} \ldots + \beta_{x.Q_{.10}} log(X)_{x.Q_{.10}} + \beta_{x.Q_{.10}} XD_{x.Q_{.10}} + \beta_{x.Q_{.10}} CT_{x.Q_{.10}} + \epsilon)$$

$$\text{^}(Q_{.50}(log(Y)) = \beta_{0.Q_{.50}} + \beta_{1.Q_{.50}} log(X)_{1.Q_{.50}} + \beta_{2.Q_{.50}} XD_{1.Q_{.50}} + \beta_{3.Q_{.50}} CT_{1.Q_{.50}} \ldots + \beta_{x.Q_{.50}} log(X)_{x.Q_{.50}} + \beta_{x.Q_{.50}} XD_{x.Q_{.50}} + \beta_{x.Q_{.50}} CT_{x.Q_{.50}} + \epsilon)$$

$$\text{^}(Q_{.90}(log(Y)) = \beta_{0.Q_{.90}} + \beta_{1.Q_{.90}} log(X)_{1.Q_{.90}} + \beta_{2.Q_{.90}} XD_{1.Q_{.90}} + \beta_{3.Q_{.90}} CT_{1.Q_{.90}} \ldots + \beta_{x.Q_{.90}} log(X)_{x.Q_{.90}} + \beta_{x.Q_{.90}} XD_{x.Q_{.90}} + \beta_{x.Q_{.90}} CT_{x.Q_{.90}} + \epsilon)]$$

- Practically, using sqreg in stata, to test variation between inexpensive, moderate and expensive farmland.
- Bootstrapping (20 iterations)

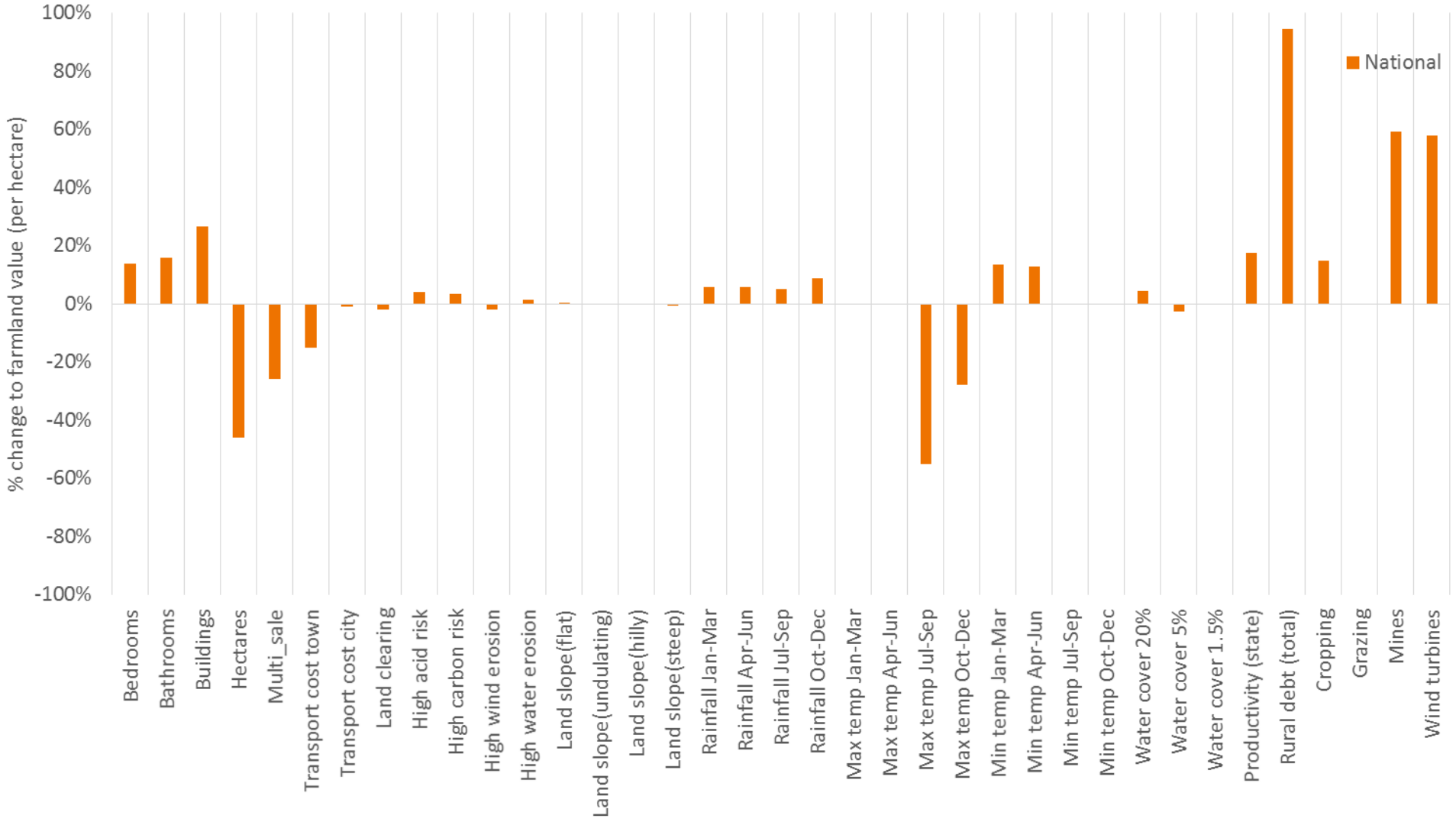
Results

- National
- ABARES zones
  - High rainfall
  - Wheat-sheep
  - Pastoral
- Size quantiles (using robust regression with constructed quantiles)
- Price per hectare quantiles (using simultaneous quantile regression)

- Insignificant co-efficient results $where\ P > |t| => .05$ are omitted
- Time dummy omitted

- Log form, percentage change in the co-efficient results in a corresponding change in the dependent variable (price per hectares)

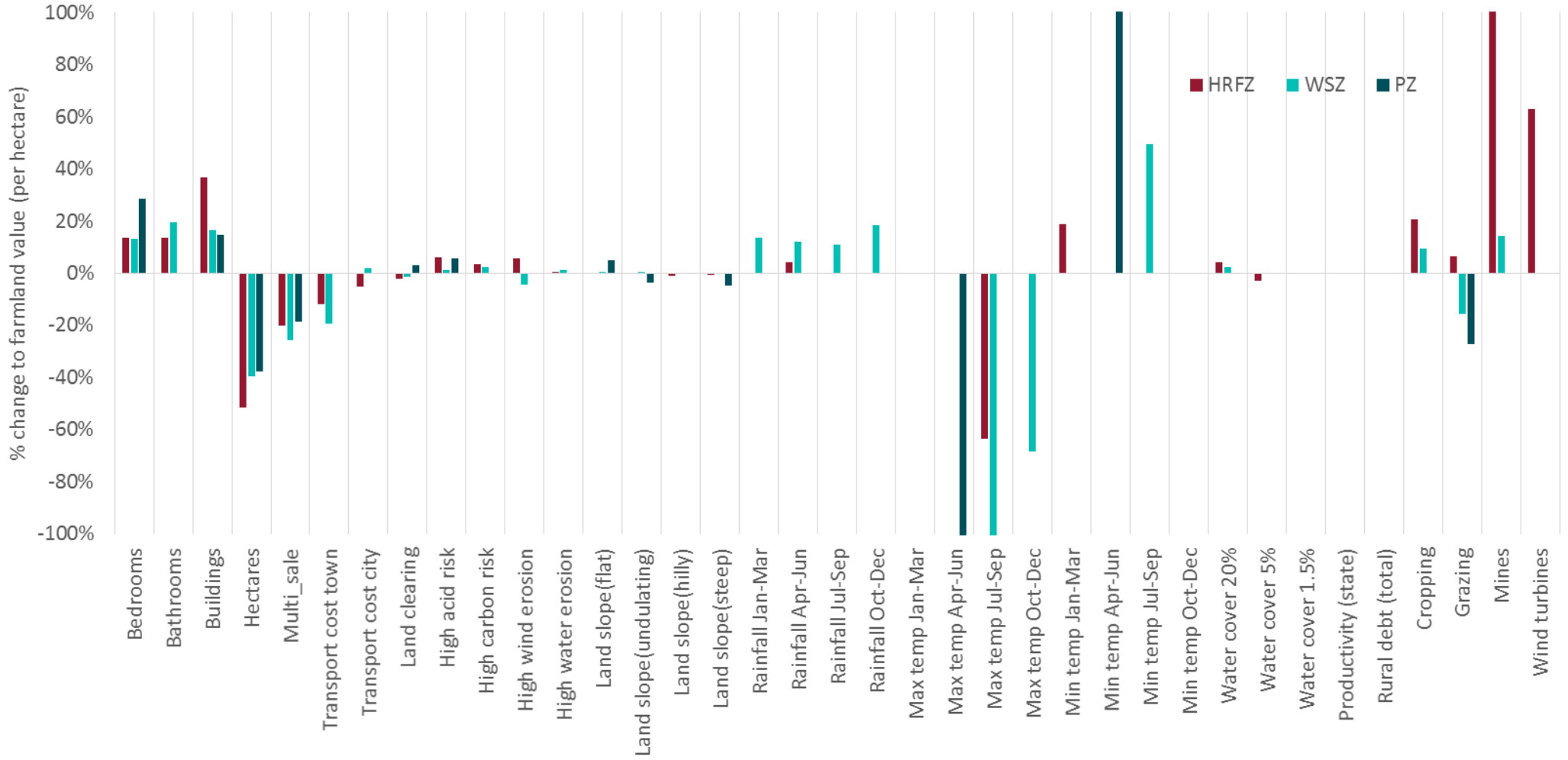
Broad-acre land value drivers - national



Source: Authors estimates

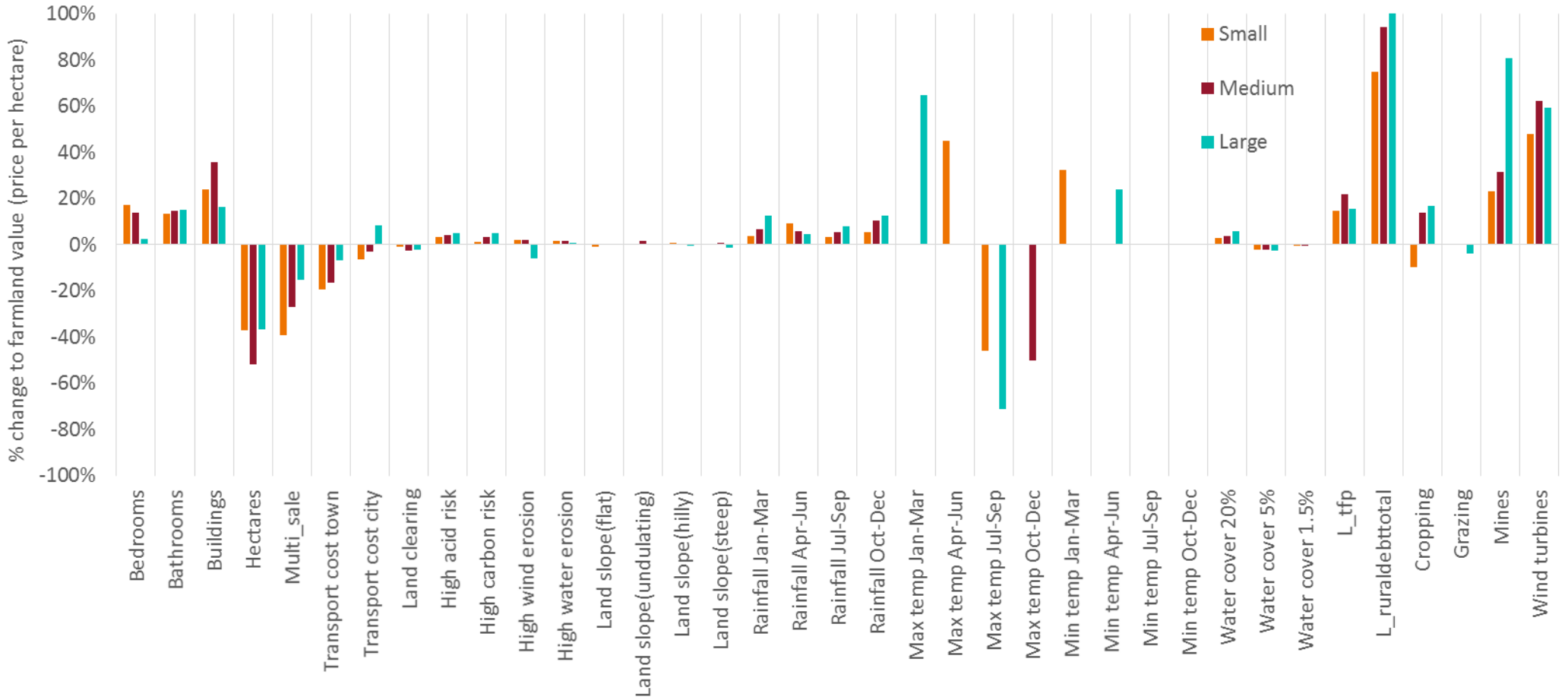
Note: (R^2=.67), observations=166,994,

Broad-acre land value drivers – ABARES agricultural zones



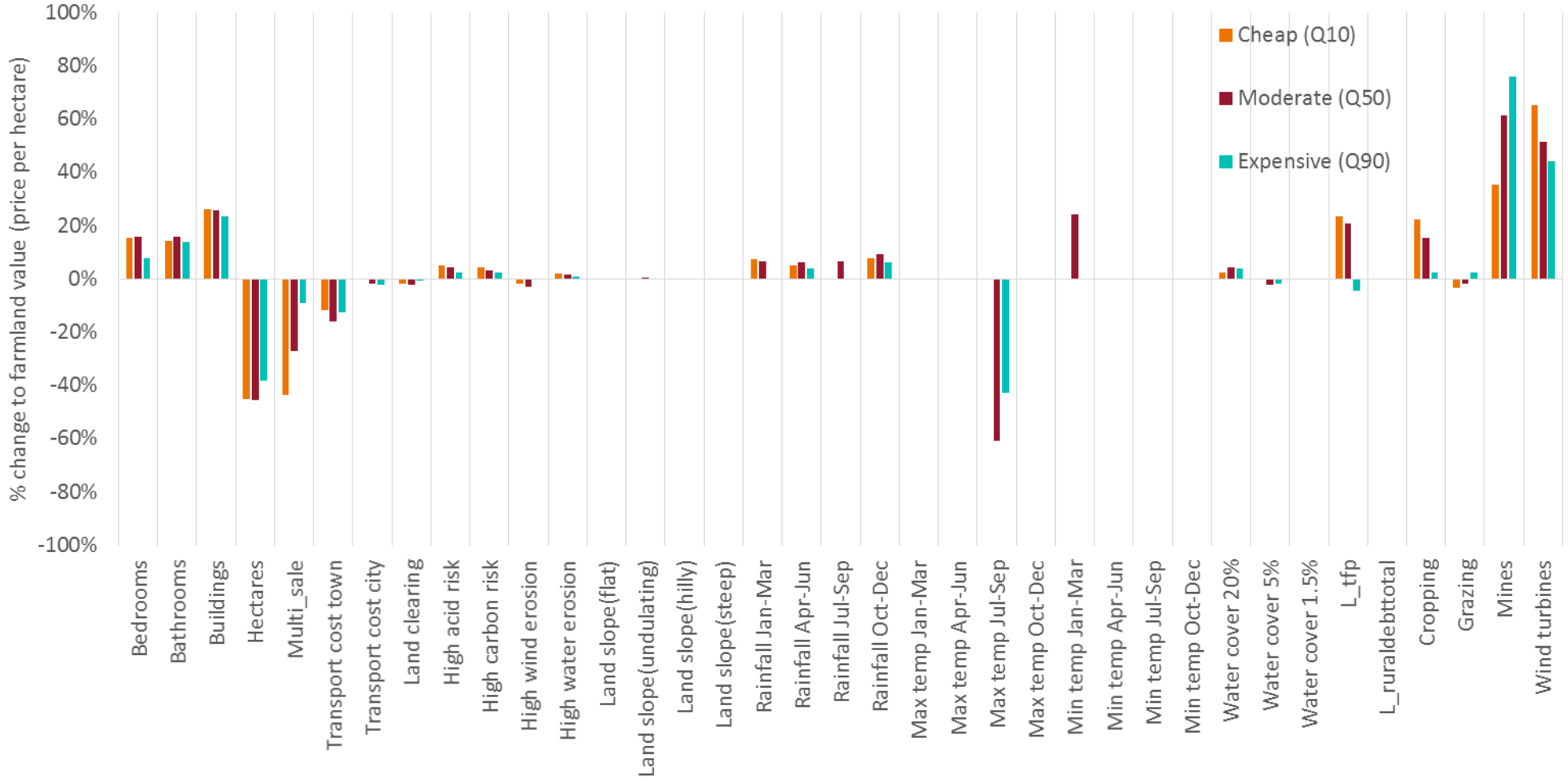
Source: Authors estimates
Note: High rainfall zone (R^2=.65), observations=105,061; Wheat Sheep zone (R^2=.64), observations= 85,423; Pastoral zone (R^2=.6581), observations=2,376

Broad-acre land value drivers – National – by size quantiles



Source: Authors estimates
Note: National small (R^2=.58), observations=55,665; National medium (R^2=.51), observations=55,664;

Broad-acre land value drivers – National – by price per hectare quantiles



Source: Authors estimates
*Note: Cheap (.10) (PR^2=.42); Moderate (PR^2=.43), Expensive (PR^2=.39), Number of observations=166,994**

Summary of results

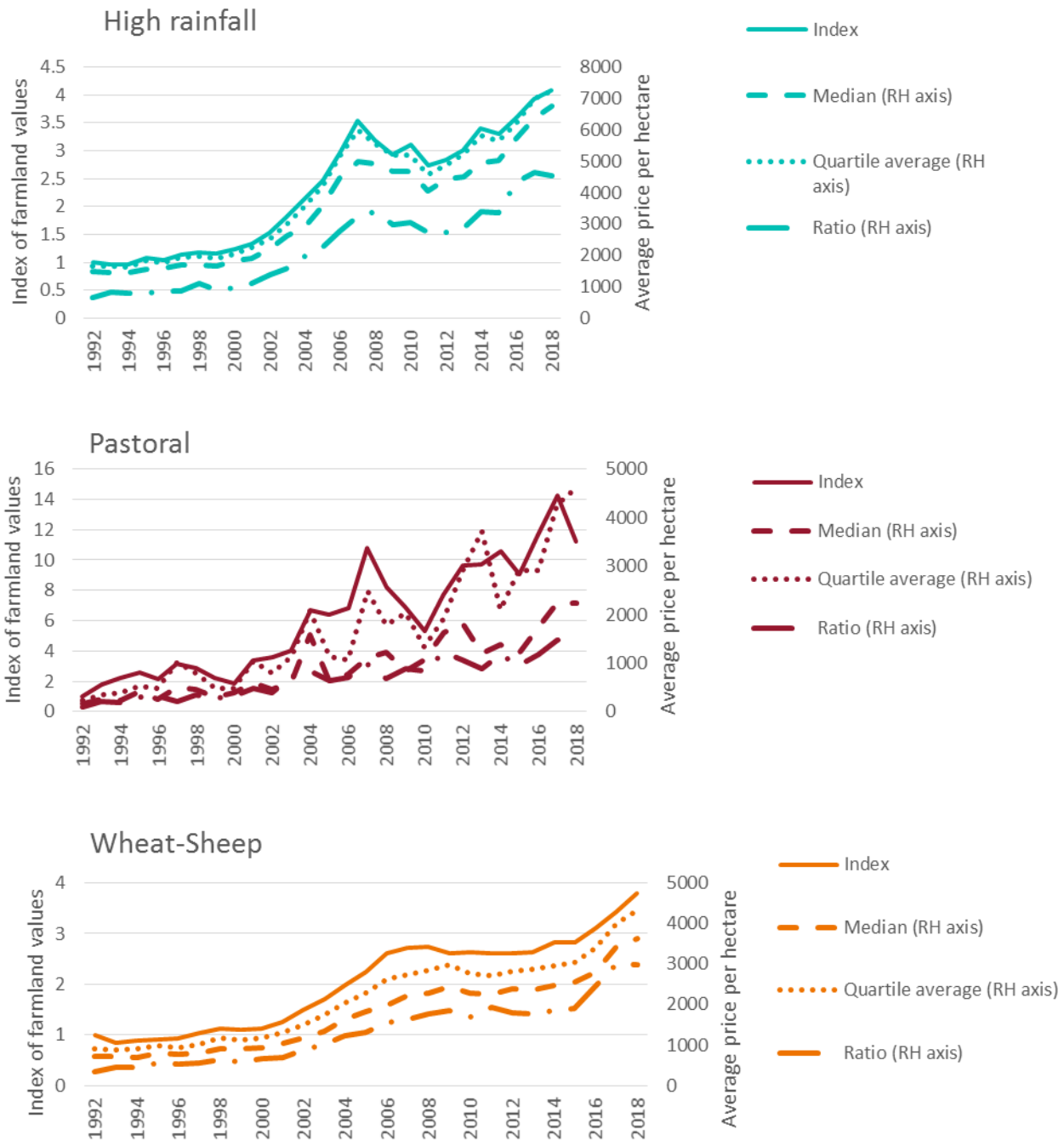
- Positive drivers
  - The presence of a house on the farm is a positive driver in all models
  - Similarly, building points are positive
  - Higher rainfall tends to be a positive driver of land value
  - The presence of a mine site or wind turbines is positively correlated with farmland value
  - TFP and rural debt (generic variables)

- Negative drivers
  - Land size (larger properties demand lower prices on a ‘per hectare’ basis)
  - Multi-sale (land parcels ‘grouped’ for sale demand lower prices)
  - Distance and transport cost to towns indicates a negative correlation with farmland value
  - High average maximum temperature tends to be a negative driver

- Unusual / mixed results
  - Soil conditions (e.g. acidification tends to be positively correlated with land value)
  - Land clearing (small negative), suggesting only minor improvement in land value with tree clearing
  - Land slope, flatter land appears to be only slightly positive in main cropping zone (wheat-sheep)

Future research

- Currently…generate indexes of farmland value based on administrative transactions
- Generate hedonic estimates of farmland value based on models in this study
- Experiment with biophysical modelling to determine optimal land areas based on hedonic factors
- Link to *farmpredict* to run simulations (e.g. the effect of drought on farmland values, relationship between profit and farm value)



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Link to published working paper



abares.gov.au/productivity