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An Economic Balance Sheet approach to quantify the risks affecting broadacre grain farmland value in Western Australia

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Abstract: The primary aim of this research is to propose a framework to quantify the myriad of agricultural risks to which broadacre grain farmers are exposed. The framework is an economic balance sheet, as the current accounting approaches do not attempt to quantify the agricultural risks and integrate these into an accounting framework. In order to meet this aim, the proposed research will answer these broad research questions:

a. What agricultural risks are broadacre grain farmers in Western Australia exposed?

b. What quantitative techniques, including the evaluation and selection of appropriate risk measures to reflect the risks in (a), can be used to determine the main drivers of land value for grain farms?

c. What quantitative frameworks can be developed to monetise the drivers of land value for grain farms in Western Australia, so that they may be appropriately reflected in a balance sheet?

Grain is the largest agricultural sector in Western Australia. It is also the fourth largest export industry in Western Australia, contributing more than AUD4 billion to the state's economy (Department of Primary Industries and Regional Development, 2023a). The Australian Bureau of Agricultural and Resource Economics and Sciences' (ABARES) report on the financial performance of farms from 2017/18 to 2019/20 (Martin & Topp, 2020) indicates the important contribution of the value of broadacre farmland to the high net asset values.

We need to understand the farmers' primary objectives, as a risk can only arise if there is a chance that the farmers' objectives will not be met. As such, any event that is certain to occur is not a risk. The clear theme from previous research is that it is the profiteering motive is the primary objective. The financial balance sheet and changes in the balance sheet that flow through the income statement influences the decisions of the key stakeholders. Under a revaluation accounting basis, the significant driver of the change in fair value is the market's pricing of the risk of farmland. For the purposes of this research, using the Tail Value at Risk perspective, farm risk is therefore defined as:

The probability and extent to which the farmers' profit objective is not met.

The tool that this research proposes to integrate the fair value of farmland including natural capital is an Economic Balance Sheet (EBS). An EBS would show the value of farmland at a time 't' and 't+1' as follows:

Economic Balance Sheet @ t	**Economic Balance Sheet @ t+1**
Market consistent value assets @ t: Market consistent value farmland @ t	Market consistent value assets @ t+1: Market consistent value farmland @ t+1
- Market consistent value liabilities @ t	- Market consistent value liabilities @ t+1
= Available economic capital @ t	= Available economic capital @ t+1
- Required economic capital @ t	- Required economic capital @ t+1
= Free capital @ t	= Free capital @ t+1

The uncertainty in the market consistent values is quantified in monetary terms in the required economic capital (REC). And the uncertainty is essentially the reflection of the risks to the farmland value. We recommend TailVaR to calculate REC as it is a coherent risk measure that is already accepted within Banking (Basel IV).

The next step in this ongoing Doctoral research is to apply the EBS to actual farm data in Western Australia, as shown in the summary treated data. I will provide preliminary modelling results when presenting this paper at the conference at the end of the year.

Keywords: *farm risks; International Financial Reporting Standards; economic balance sheet; machine learning; TailVaR*

1. INTRODUCTION

1.1. Broadacre grain farmers' risks

Grain is the largest agricultural sector in Western Australia. It is also the fourth largest export industry in Western Australia, contributing more than AUD4 billion to the state's economy (Department of Primary Industries and Regional Development, 2023a). Before any discussion can be made about the risks that Broadacre grain farmers face, we need to understand the farmers' primary objectives. The reason being that a risk can only arise if there is a chance that the farmers' objectives will not be met. As such, any event that is certain to occur is not a risk.

There are indeed a myriad of objectives, such as:

- Profiteering motive, whether considered as gross yield, gross margins, return on capital, accounting profit, or some other similar metric (Sumpsi, Amador, & Romero, 1997), (Kallas, Serra, & Gil, 2009), (Mandryk, Reidsma, Kanellopoulos, Groot, & van Ittersum, 2014)
- Sustainability of farming operations, such as soil quality, or variability in climate (Kallas et al., 2009), (Mandryk et al., 2014)
- Social aspects, such as generational transfer of farms to children, or the desire to have more manageable workload (Sumpsi et al., 1997), (Kallas et al., 2009), (Mandryk et al., 2014)

The clear theme from previous research, however, is that it is the profiteering motive that is the primary objective. For the purposes of this research, using the Tail Value at Risk perspective, farm risk is therefore defined as:

The probability and extent to which the farmers' profit objective is not met.

1.1.1. Production risks

The definition of production risk for this research adjusts that of Curtis et al (Curtis, Darragh, Heath, Laurie, & McRobert, 2019) to incorporate the definition of 'farm risk' above to be:

The probability and extent to which the expected on-farm production is not met

'Production risks' cover the main environmental risks. The ABARES 2019 report (Chancellor, Zhao, Randall, Lawson, & Hoang, 2019) showed the significant impact that the risk factors of rainfall and temperature, in particular, could have on the changes to broadacre farmland value. This is supported by other researchers such as (Chavas, 2019; Frascarelli, Del Sarto, & Mastandrea, 2021; Srivastav, Dhyani, Ranjan, Madhav, & Sillanpaa, 2021).

As weather is such a significant driver of land value (Chancellor et al., 2019), it requires us to consider the potential impact on farmers due to climate change. Table 2.2.1. below show the CSIRO and Bureau of Meteorology climactic projections for only the RCP4.5 scenario for 2030 (CSIRO and Bureau of Meteorology, 2015):

Table 1.1.2. RCP4.5. 2030 scenario for Southern Australia super cluster relative to 1986-2005

Climactic variable	10th Percentile	Median	90th Percentile
Temperature	+0.5 DegC	+0.8 DegC	+1 DegC
Annual rainfall	-9%	-4%	+2%

A prominent risk to crop health is that of diseases. The Department of Primary Industries and Regional Development in Western Australia noted that a number of the crop diseases are becoming increasingly resistant to fungicides (Department of Primary Industries and Regional Development, 2023b).

The wedded risk to crop health is naturally that of pests. The Department of Primary Industries and Regional Development estimates that more than a quarter of the world's stored grains is lost to pests (Department of Primary Industries and Regional Development, 2019).

A major contributor to the poorer mortality, morbidity and mental health of Australian farmers as compared to the non-farming community is their remoteness. This has a direct impact on the availability and nearness of appropriate medical help, as discussed by Brew et al (Brew, Inder, Allen, Thomas, & Kelly, 2016), Hull et al (Hull, Gunn, Smith, Jones, & Dollman, 2022) and Skaczkowski et al (Skaczkowski et al., 2023).

Another major contributor is farmers attitude to healthcare in general. Skaczkowski et al (Skaczkowski et al., 2023) split this factor into two themes: the perceived negative stigma associated needing healthcare and the lower importance allocated to healthcare (as covered by many other researchers such as Hull et al (Hull et al., 2022), Allan et al (Allan, Ball, & Alston, 2008) and Vayro et al (Vayro, Brownlow, Ireland, & March, 2020)).

1.1.2. Market risks

The definition of market risk adjusts the original work done by Keogh (Keogh, 2012) to incorporate the definition of ‘farm risk’ above to be:

The probability and extent to which the prices producers will receive for their commodities are lower than expected and/or the prices that producers will pay for their production inputs are greater than expected

Approximately 80% of Western Australia’s grain yield is exported (Department of Primary Industries and Regional Development, 2023a), which indicates that the primary exposure is to global grain prices. This exposes the Western Australian grain farmers to external, international influences on the global prices, such as the price of oil and external natural disasters, as suggested by Santeramo and Lamonica (Santeramo & Lamonaca, 2019).

Capital includes physical capital such as farm machinery. The price of this is the replacement cost of buying new or renting the equipment. This should also encompass the service costs of maintaining the physical machinery in good operational order and the current interest rate on refinancing.

For labour, the ABARES’ report identifies the input costs of both hired human capital and the owners of the production capital, as expanded by other researchers (Sheng & Jackson, 2015).

Materials includes the primary biological input being the market price of the seed. It also includes the prices of fertilizers, chemicals and other treatments to protect and enhance the crop yield. Finally, it includes daily costs of running the farm operation, such as electricity and fuel. (Sheng & Jackson, 2015)

The valuation of land is the main focus of this research.

1.1.3. Institutional risks

The definition of institutional risk for this research adjusts that of Curtis et al (Curtis et al., 2019) to incorporate the definition of ‘farm risk’ above to be:

The exposure to adverse events external to either production or market factors

The clear primary driver of institutional risks is that of government policy, as pointed out by both Curtis et al and Harwood et al ((Curtis et al., 2019), (Harwood, 1999)).

1.2. Aims and objectives

The primary aim of this research is to propose a framework to quantify the myriad of agricultural risks to which broadacre grain farmers are exposed. The framework is an economic balance sheet, as the current accounting approaches do not attempt to quantify the agricultural risks and integrate these into an accounting framework. In order to meet this aim, the proposed research will answer these broad research questions:

a. What agricultural risks are broadacre grain farmers in Western Australia exposed?

b. What quantitative techniques, including the evaluation and selection of appropriate risk measures to reflect the risks in (a), can be used to determine the main drivers of land value for grain farms?

c. What quantitative frameworks can be developed to monetise the drivers of land value for grain farms in Western Australia, so that they may be appropriately reflected in a balance sheet?

1.3. Significance

The Australian Bureau of Agricultural and Resource Economics and Sciences’ (ABARES) report on the financial performance of farms from 2017/18 to 2019/20 (Martin & Topp, 2020) indicates the important contribution of the value of broadacre farmland to the high net asset values. The significance of the value of farmland is supported by the research of Onel, Kropp and Moss (Onel, Kropp, & Moss, 2018) who found that the value of farmland represented over 80% of agricultural assets in the United States of America in 2015.

The financial balance sheet and changes in the balance sheet that flow through the income statement influences the decisions of the key stakeholders. Under a revaluation accounting basis, significant drivers of the change in fair value is the market’s pricing of the risk of farmland.

The primary purpose of this research is therefore to provide useful financial information for the most invested stakeholders so that they can optimise their decision making.

2. FARMLAND VALUATION TECHNIQUES

The common language used by most key stakeholders- farmers, banks, insurers, tax authorities- globally when crystalising ‘land value’ for the balance sheet is the International Financial Reporting Standards (IFRS, www.ifrs.org). In Australia, IFRS is interpreted locally in the standards set by the Australian Accounting Standards Board (AASB, www.aasb.gov.au). AASB 13 (Australian Accounting Standards Board, 2015a) (Australian Accounting Standards Board, 2015b) defines ‘fair value’ as “the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date.” For this research, the asset is the grain farmland. It is also usual to assume that the market participants are knowledgeable, willing participants trading at arm’s length without any conflict of interest in making a fair trade.

‘Knowledge’ is a key criterion behind a fair value as rational decision makers can make sub-optimal decisions with incomplete information. The assumption of ‘knowledgeable’ is particularly contentious with regards to farmland. There is likely to be significant informational asymmetries between the seller of the land, who should have a deep understanding of the current and future crop yield potential and their management of the natural resources, and the buyer, whose primary information sources are likely to be external observations and sources, such as a general understanding of weather patterns and soil quality in the area (external sources such as the Bureau of Meteorology and Department of Primary Industries and Regional Development (Western Australia) (Schoknecht, 2002)). The significance of the informational asymmetries effect is exacerbated when considering the myriad and, in many cases, potentially extreme risks to farm profits, as discussed above. These risks would therefore be key in any investigation of farmland value.

AASB116 (Australian Accounting Standards Board, 2015b) (Australian Accounting Standards Board, 2015c) also states that the land revaluation changes should flow through the income statement appropriately, and recognises that land revaluation gains can also occur. Revaluation changes reflected through an income statement is a significant driver of business decisions and ties directly back to profiteering motive and the risks to this.

Traditional farmland valuation methods involves a professional valuer applying the broad techniques of comparisons between similar farms, a cost based approach or discounted cash flows (Crane, 2019). We would prefer a method of attributing the farmland value that removes as much subjectivity and bias that a human valuer would naturally inject. As such, statistical measures of value attribution are preferable, as highlighted by (Renigier-Bilozor, Janowski, & Walacik, 2019) (Gruzauskas, Krisciunas, Calneryte, & Navickas, 2020) with real estate valuations and (Bruce, 2006) on environmental impact.

3. METHODOLOGY

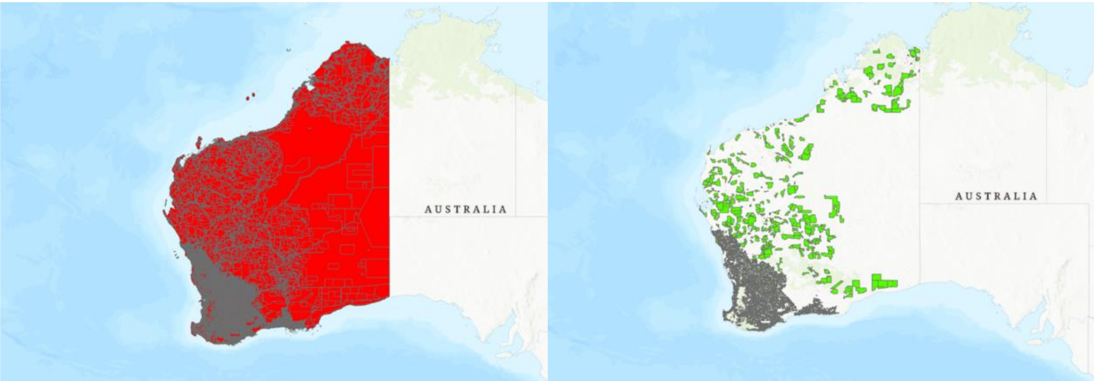
Literature sourcing: Google Scholar, ProQuest, Scopus and Web of Science.

Data sources: Landgate, CoreLogic, Bureau of Meteorology, Reserve Bank of Australia

Software: R, ARCGIS, QGIS, EXCEL

3.1. Summary of Western Australian farmland data

The raw, untreated spatial data from Landgate consists of 1 899 823 records (rows), shown in the left map. After considerable treatment, there are 130 031 unique records in the right map.



Figures 1.5.1.: Esri, USGS. “World Topographic Map”. Scale 1: 18 837 514. Provided with ArcGIS Pro.

Summary statistics on the treated data from the right map are as follows:

Table 1.5.1.: Summary statistics for the sales value per square metre for complete cadastre data

Mean	2,875.39
Median	5.20

Mode	80.00
Standard Deviation	160,439.87
Skewness	176.44
Kurtosis	40,976.61
Minimum	-
25th Percentile	0.68
75th Percentile	84.08
Maximum	45,325,203.25

3.2. Economic Balance Sheet (EBS)

The tool that this research proposes to integrate the fair value of farmland including natural capital is an Economic Balance Sheet (EBS). An EBS would show the value of farmland at a time ‘t’ and ‘t+1’ as follows:

Economic Balance Sheet @ t	**Economic Balance Sheet @ t+1**
Market consistent value assets @ t: Market consistent value farmland @ t	Market consistent value assets @ t+1: Market consistent value farmland @ t+1
- Market consistent value liabilities @ t	- Market consistent value liabilities @ t+1
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- Required economic capital @ t	- Required economic capital @ t+1
= Free capital @ t	= Free capital @ t+1

Market consistent valuation is an overarching recognition that the ideal value for inclusion in a balance sheet is a market price (Bacinello, Chen, Sehner, & Millossovich, 2021). If, however, the asset or liability does not have such a market, such as farmland, then an alternative valuation mechanism needs to be used. The market consistent value of assets can comply with the Australian Accounting Standards Board (AASB) concept of ‘fair value’. This therefore aligns with Australian financial accounting.

3.2.1. Discounted Cash-Flows (DCF)

The starting point for the market consistent value of farmland aligns quite closely with one of the current valuation methodologies, i.e. discounted cash-flows (Crane, 2019), which is a specific application of traditional property valuation techniques (Adams, Booth, & MacGregor, 1999):

$$NPV_t = \sum_{k=t}^{\infty}(Yield\ Income_k - Yield\ Expenses_k - Farm\ management\ Expenses_k) \times e^{Risk\ discount\ rate_k} \quad (\mathbf{1})$$

Two key departures from the traditional discounted cash-flow approach are: variables should reflect best estimates; and the risk discount rate is replaced by the risk-free rate.

3.2.2. Required Economic Capital (REC)

The uncertainty in the best estimates is quantified in monetary terms in the required economic capital. And the uncertainty is essentially the reflection of the risks to the farmland value. The required economic capital (REC) calculation requires an appropriate risk measurement choice, which should be coherent (Artzner, Delbaen, Eber, & Heath, 1999). We will use TailVaR as a coherent risk measure that is already accepted within the Banking community in Basel IV:

$$TailVaR_{\alpha,t}(Available\ economic\ capital_t) = -E_P[Available\ economic\ capital_t\ |Available\ economic\ capital_t \leq -VaR_{\alpha,t}(Available\ economic\ capital_t)] \quad (\mathbf{2})$$

The main risk factors affecting the farmland value need to be determined. This researcher suggests Machine Learning techniques, starting with shrinkage estimators such a LASSO (Least Absolute Shrinkage and Selection

Operator) regression. LASSO shrinks the explanatory variables through minimising the following cost function Cλ(β) (Hagiwara, 2016):

$$C_\lambda(\beta) = ||y - R \times \beta||^2 + \lambda \times ||\beta|| \quad (\mathbf{3})$$

Where y is the dependent variable and R are the explanatory variables representing the risk factors as discussed above; β is the sensitivity of y to R; and λ is the LASSO tuning parameter.

The required economic capital requires is a multivariate joint distribution of the key risk factors. Copulas may be used to derive joint distributions from the marginal impacts of individual risk factors:

$$J(r1, r2) = C[F(r1), F(r2)] \quad (\mathbf{4})$$

Where J represents the joint cumulative distribution function of two key risk factors, r1 and r2, e.g. temperature and rainfall, affecting farmland value; F represents the marginal cumulative distribution function for each risk; and C represents the chosen copula.

3.2.3. Cost of holding Required Economic Capital (REC)

The required economic capital should theoretically be held as capital to withstand the severe impact of the risks crystalising. This comes as a cost to the farmer as that capital cannot be employed elsewhere. The cost to the farmer is:

$$Cost_t = \sum_{k=t}^{\infty} Required\ economic\ capital_t \times (e^{Cost\ of\ capital\ rate} - 1) \times e^{-Risk-free\ rate_t \times (k+1)} (\mathbf{5})$$

3.2.4. Market consistent value of farmland

As any farmer would have to post the same capital to withstand the adverse impact of the risks, the market consistent value of the farmland is then:

$$Market\ consistent\ value\ of\ farmland_t = NPV_t - Cost_t \quad (\mathbf{6})$$

4. CONCLUSIONS AND RECOMMENDATIONS

This paper has discussed the myriad risks faced by farmers. It has then focused on the impact of these risks on the single biggest asset on a farmer's balance sheet. The research then proposes that an Economic Balance Sheet (EBS) is the most informative mechanism to show the quantitative impact of these risk exposures, with the added benefit that it complies with Australian Accounting Standards Board (AASB) reporting standards. The next step in this ongoing Doctoral research is to apply the EBS to actual farm data in Western Australia, as shown in the summary treated data. I will provide preliminary modelling results when presenting this paper at the conference at the end of the year.

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