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Revenue Risk Estimation for Wheat Growers in Western Australia

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Background

- Western Australia (WA) wheat yields have shown a high variance. From 2006 to 2010, the average shire wheat yield varied between 0.92 t/ha to 2.03 t/ha.
- Yield variations are due to the randomness of growing conditions such as weather, pests and disease and the limited scope and high cost of mitigating adverse conditions.
- It has been found that Australian farmers are risk averse in response to the yield volatility.
- Therefore, accurate estimation of the yield distribution is of interest of farmers and policy makers.
- In the literature, yield distribution has been assessed as a precursor to risk management. A number of distributions have been tested to identify the best crop yield distribution, such as Just and Weninger (1999) and Sherrick et al. (2004)

Do these results apply to wheat yield distribution in Western Australia ?

Methodology

There are three steps to estimate wheat revenue risk.

- First, detrend historical wheat yield.
- Second, formally measures the goodness-of-fit candidate distributions.
- Third, estimates the yield risk and the revenue risk.

This work assesses the wheat yield distribution and estimates the yield risk and revenue risk in the shire level. Both graphical evidence and statistical evidence are provided to select the best distribution.

Methodology

--Detrend

Deterministic trend model is applied to each shire. The polynomial time function is defined as(1):

$$y_t = \beta_0 + \beta_1 time + \beta_2 time^2 + \beta_3 time^3 + \beta_4 time^4 + \beta_5 time^5 + \varepsilon_t \qquad \varepsilon_t \sim N(0, \sigma^2)$$

- *time = 1,2,…,82*, starting at 1 in year 1929 and ending at 82 in year 2010.
- ε_t is assumed to be independently identically distributed with 0 mean and σ^2 variance.
- The order of the polynomial trend is chosen based on the *F*-statistic

Methodology

--Goodness-of-Fit

Anderson-Darling (AD) test is used to measures the distance between each sample point in the empirical CDF and the fitted probability at the point. Distribution has lower AD statistics fits the yield better. The AD test is defined as (2):

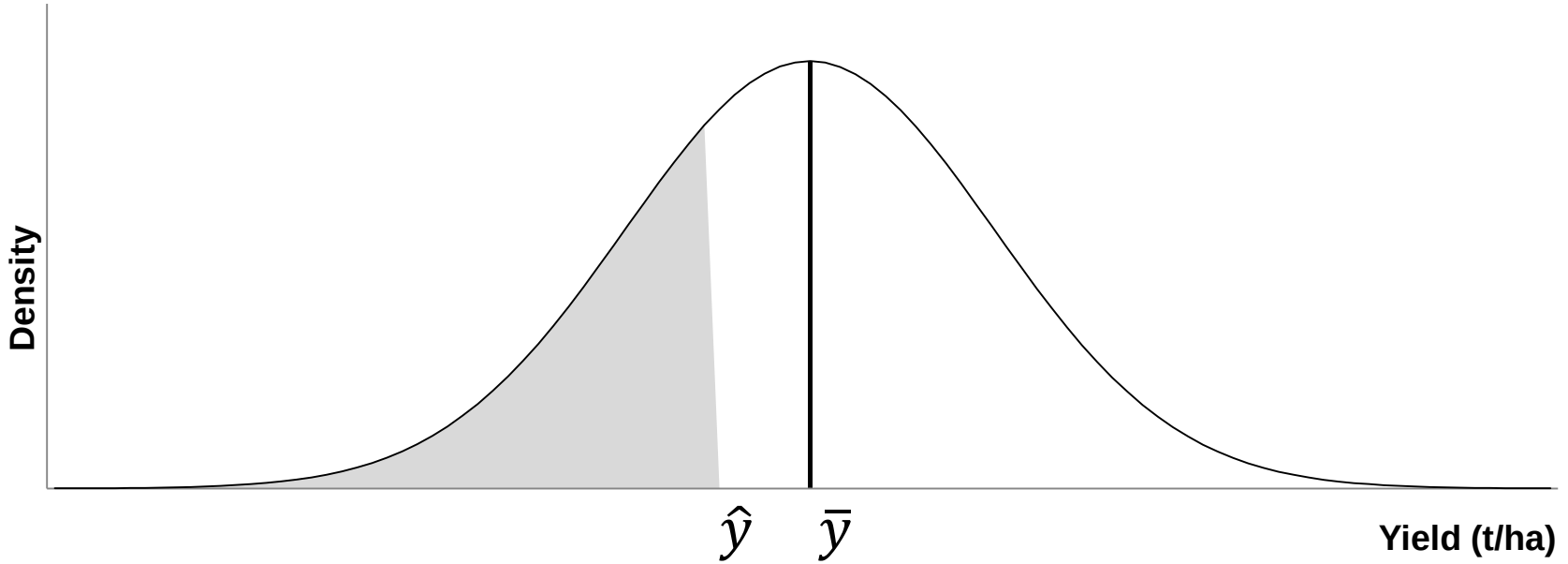
$$AD_n = n \int_{-\infty}^{\infty} \left[F_n(y) - \hat{F}_n(y)\right]^2 \Psi(y)\hat{f}(y)dx$$

- $\Psi(y)$ is the weight function: $\Psi(y) = \frac{1}{\hat{F}_n(y)[1-\hat{F}_n(y)]}$
- $\hat{f}(y)$ is the PDF of the fitted distribution
- $F_n(y)$ is the fitted cumulative cumulative distribution
- n is the size of the sample

Methodology

---Yield Risk

Yield risk is defined as the expected yield value below expected yield, which is defined as the average yield of previous years. Yield risk exposure is given by the gray area to the left of expected yield:



$\bar{y}$ is the full sample average yield.

$\hat{y}$ is the average yield of previous 4 years.

Methodology

---Yield Risk and Revenue Risk

- Yield risk exposure equals to the integration from 0 to $\hat{y}$ (3):

$$E(Y) = \int_0^{\hat{y}} (\hat{y} - y) f(y) dy$$

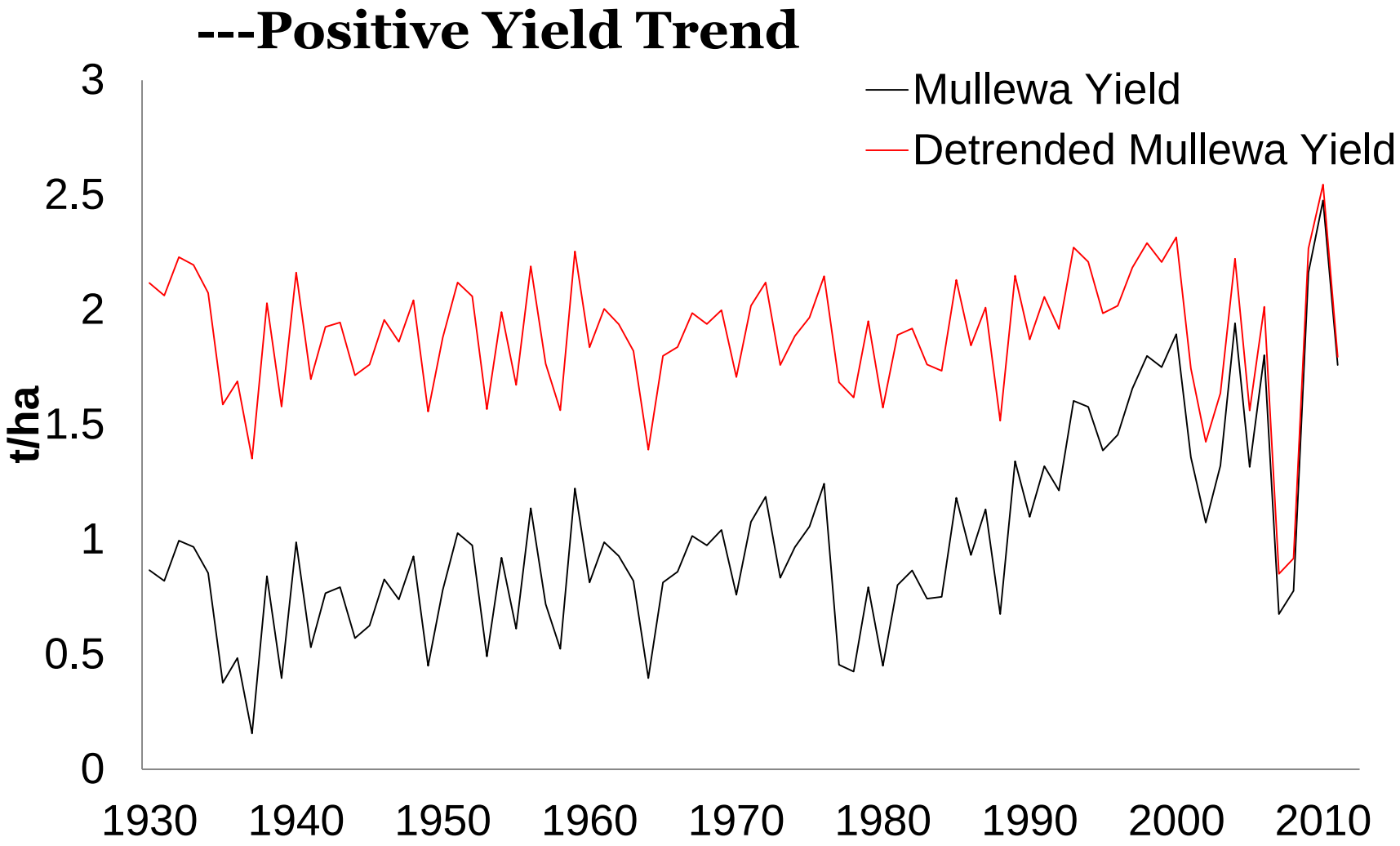
where y is actual wheat yield, $\hat{y}$ is the expected yield, $f(y)$ is the probability density.

- Revenue risk is calculated by the expected yield and the hedged price at the beginning of the season (May) (4):

$$E(R) = p_h \int_0^{\hat{y}} (\hat{y} - y) f(y) dy$$

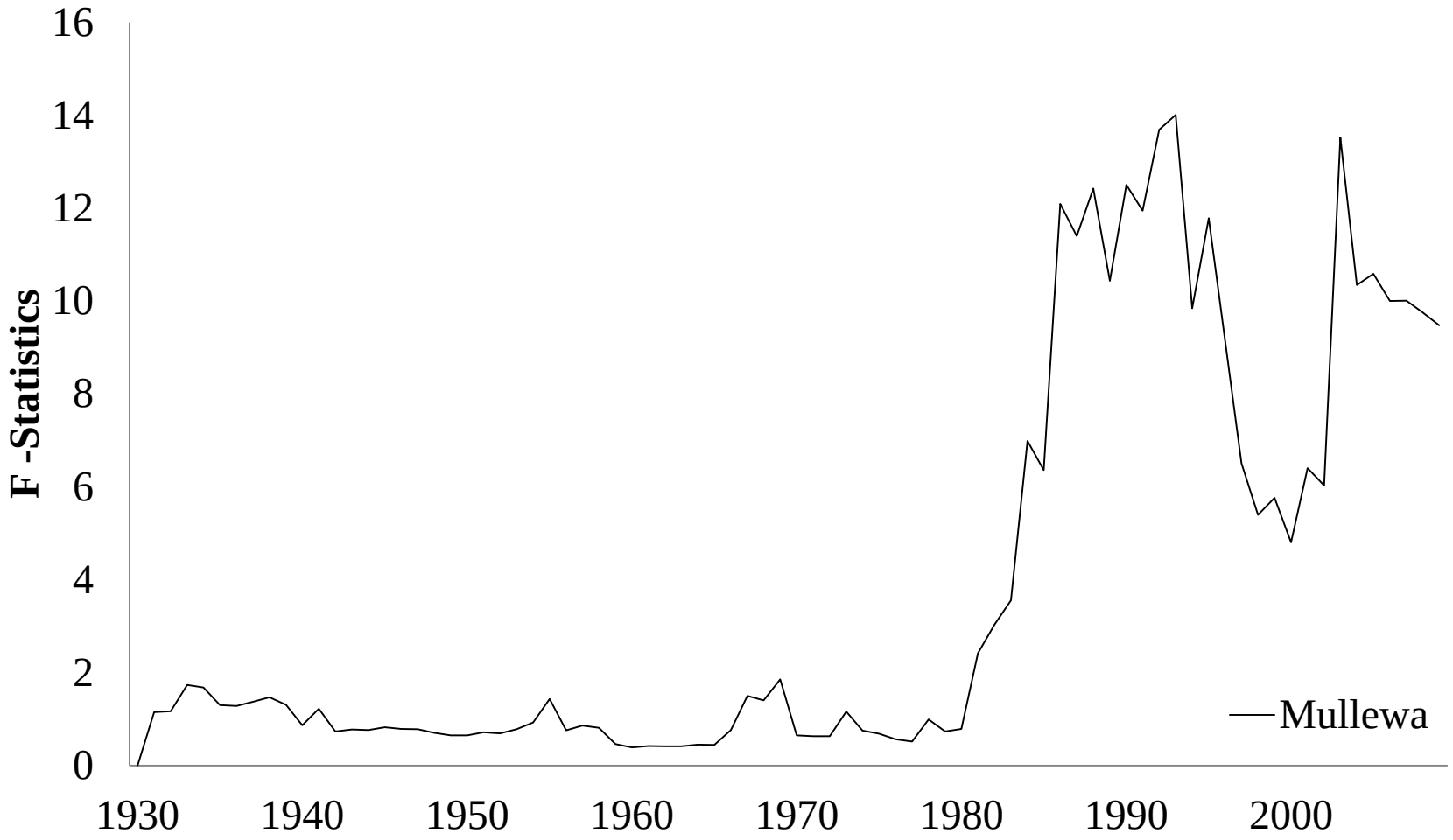
p_h is the price of WA wheat futures contract at May.

Data


---Positive Yield Trend
Mullewa Yield
Detrended Mullewa Yield
t/ha
3
2.5
2
1.5
1
0.5
0
1930
1940
1950
1960
1970
1980
1990
2000
2010

Data

---Structure Break of Wheat Yield

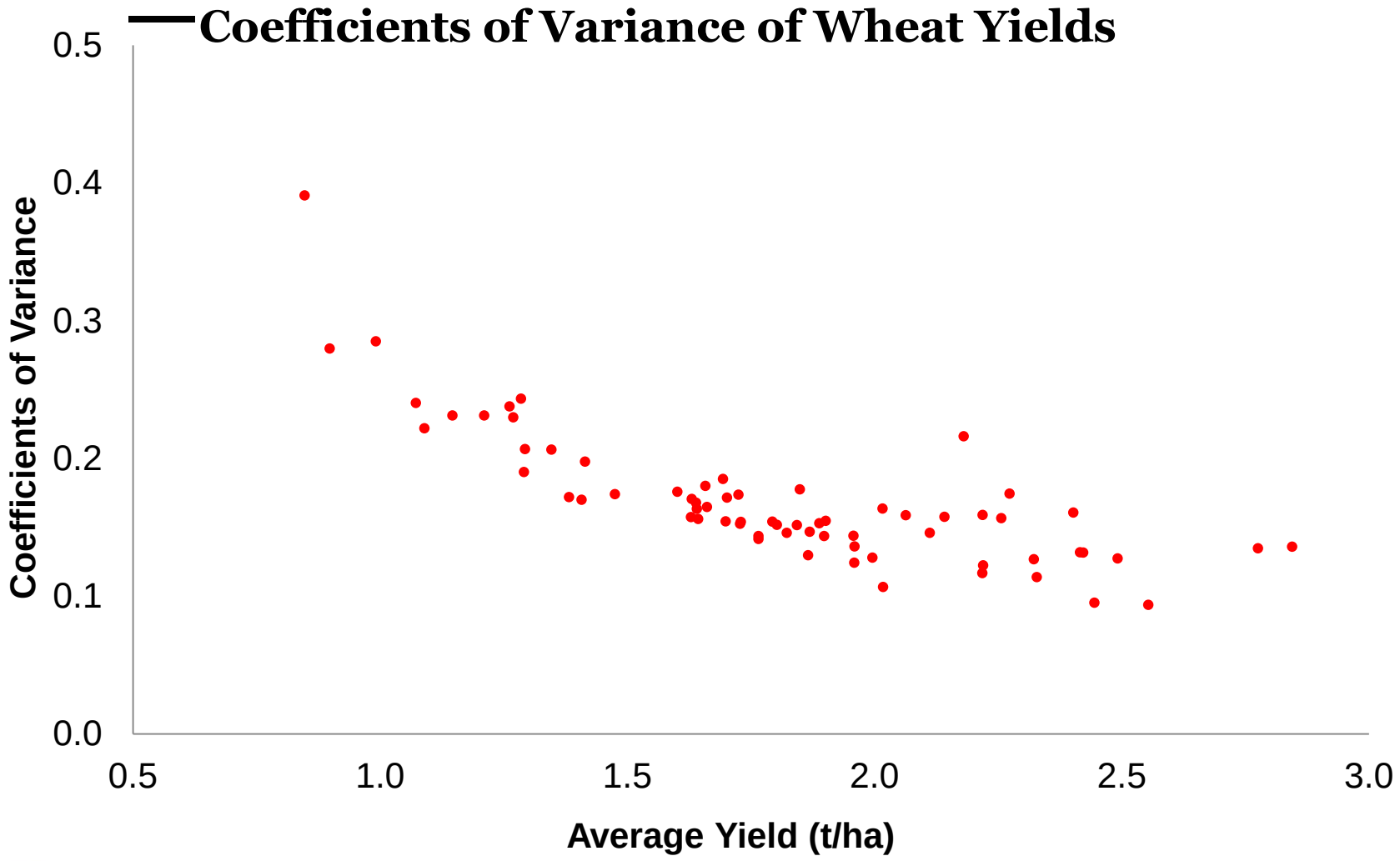


Data

—Detrended Yields Summaries

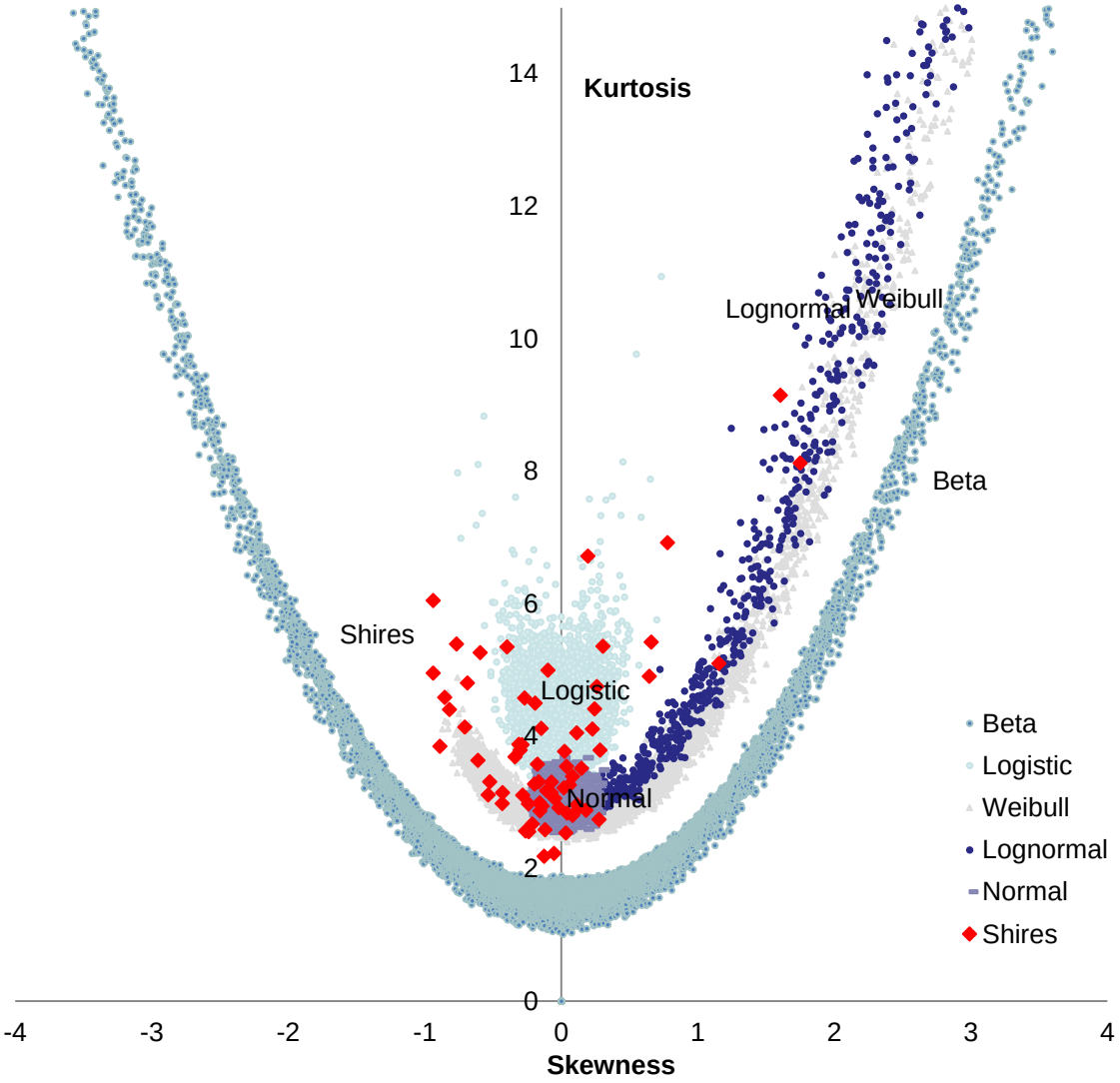
Shire	Mean	Standard Deviation	Skewness	Kurtosis	Coefficient of Variance
Mean	1.805	0.288	-0.081	3.928	0.169
Std	0.477	0.045	0.503	1.333	0.048
Min	0.847	0.215	-0.939	2.187	0.094
Max	2.845	0.471	1.751	9.149	0.391

Data


Coefficients of Variance of Wheat Yields
Coefficients of Variance
0.5
0.4
0.3
0.2
0.1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Average Yield (t/ha)

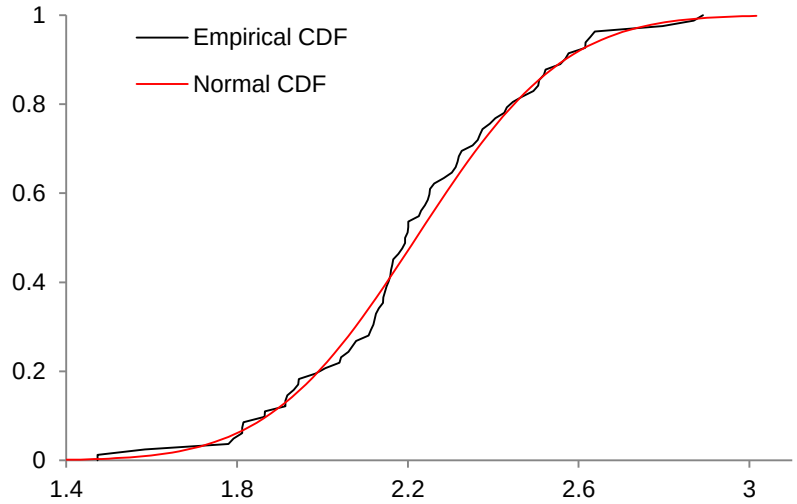
Results

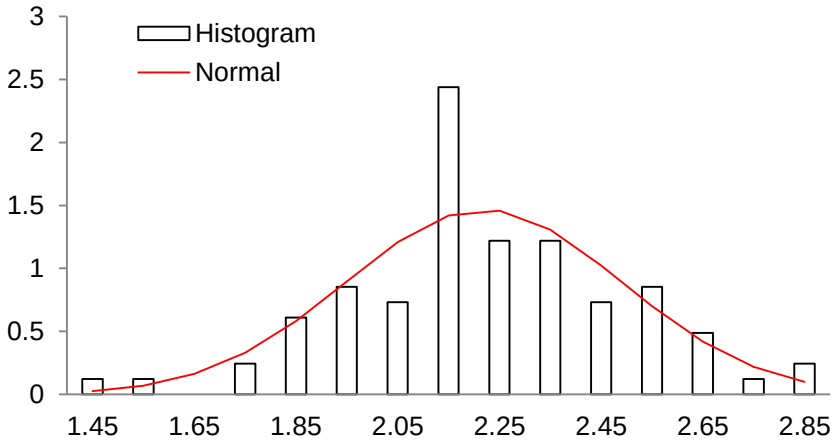
—Moment Ratio Diagrams of Shires 1929-2010

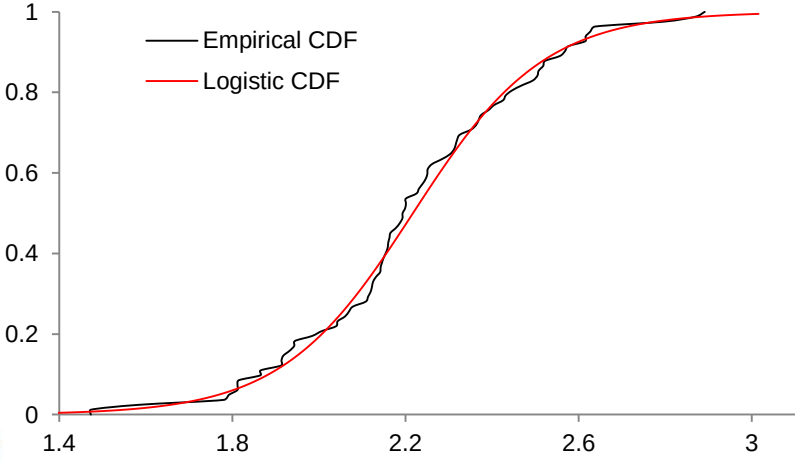


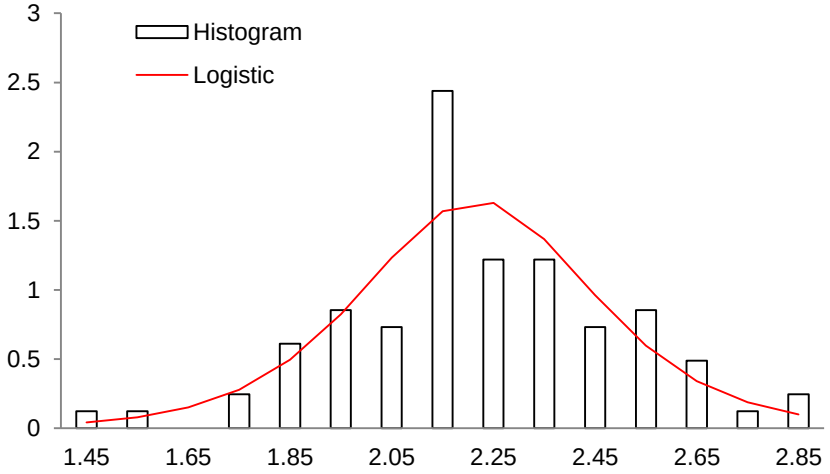
Results—

CDF , PDF and empirical distributions of Wheat yields in Albany









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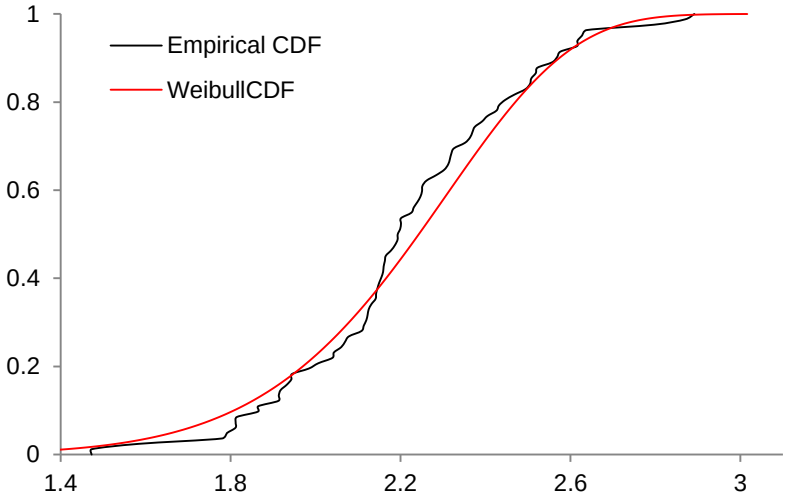
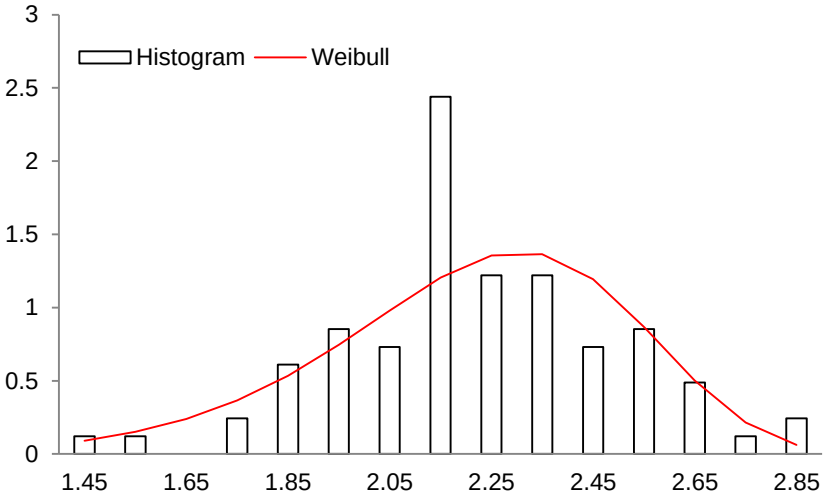
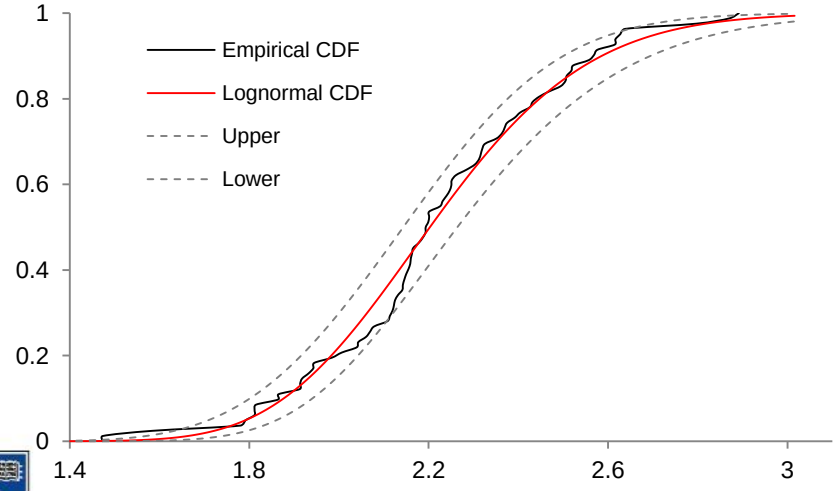
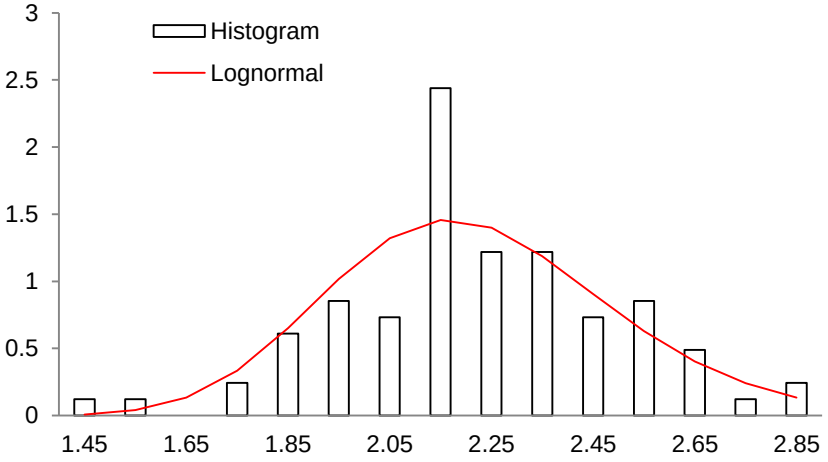
CDF , PDF and empirical distributions of Wheat yields in Albany









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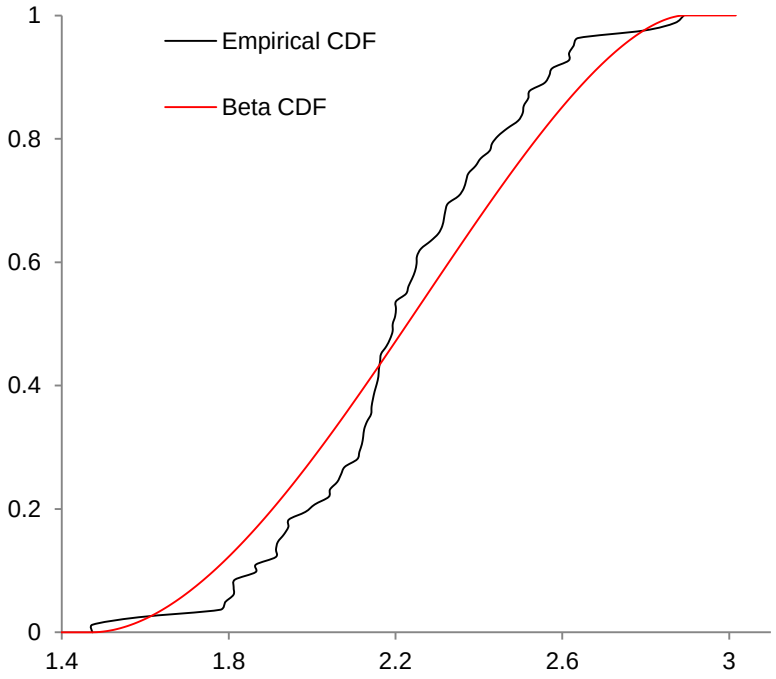

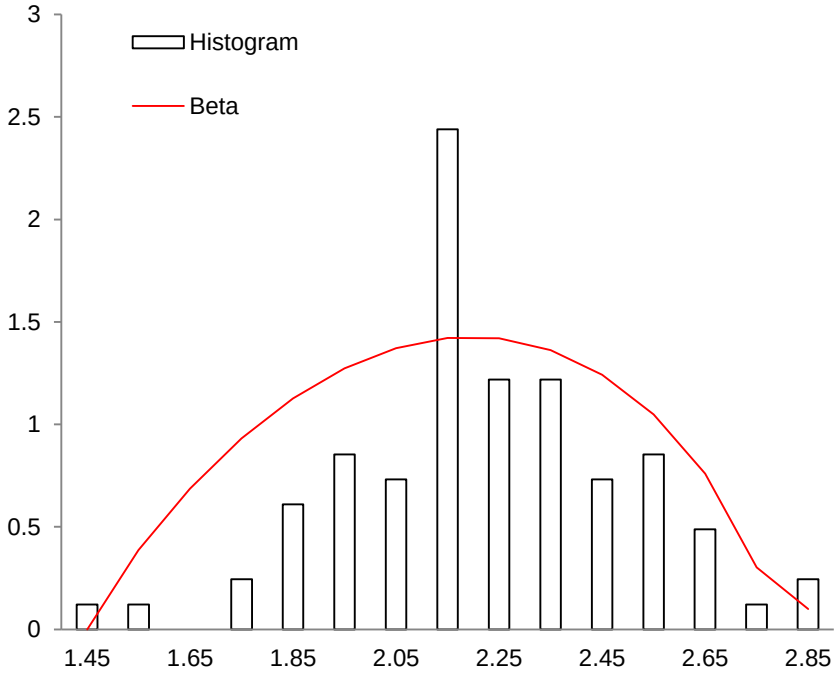

Results

—AD Test Measures Goodness-of-Fit

Rank	Normal	Logistic	Weibull	Lognormal	Beta
1st	47	0	21	0	0
2nd	21	0	47	0	0
3rd		68	0	0	0
4th	0	0	0	0	68
5th	0	0	0	68	0

Results

—Summary of Expected Yield Loss

Yield Risk				
	Normal		Weibull	
Average	0.097(t/ha)	5.46%	0.109(t/ha)	6.15%
Std. Dev.	0.052	3.20%	0.054	3.27%
Min.	0.010	0.53%	0.023	1.16%
Max.	0.246	15.77%	0.255	15.82%
Revenue Risk				
Average	20.943(AUD/ha)	5.46%	23.678(AUD/ha)	6.15%
Std. Dev.	11.329	3.20%	11.770	3.27%
Min.	2.163	0.53%	4.974	1.16%
Max.	53.396	15.77%	55.343	15.82%

Conclusions

- This work has evaluated the wheat yield distribution in WA and applied the result to estimate yield risk and revenue risk.
- Normal distribution outperforms than Logistic, Lognormal, Weibull and Beta distribution.
- Taking 2010 as an example, farmers in WA are facing revenue risk of more than 5.47% of the benchmark revenue, and about half of their operating surplus in 2009.
- Future research should consider more candidate distributions and apply this procedure into other crops.

Acknowledgement

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Thank you!