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Revenue volatility faced by Australian wheat farmers

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This paper uses variance decomposition modelling to explore how wheat revenue volatility in Australia has changed spatially and temporally. The components of revenue variance are the variances and covariances of wheat prices, the area of wheat harvested and the yield of wheat. The key finding is that the volatility of wheat revenue (detrended) has more than doubled in every main wheat-growing State in Australia over the last 15 years or so Changes in wheat areas are mostly a minor source of revenue variance. The principal cause of volatility is yield changes with price changes increasing slightly in absolute importance when compared to their adjacent previous period. Greater downside yield risk is often the principal cause of the increased yield variance. The implications are that revenue variance, and especially downside revenue risk, has posed major problems for wheat-dominant farm businesses over the last 15 years or so. How Australia's wheat producers have managed this greater volatility of wheat revenue is likely to have greatly affected the viability of their farm businesses.

Keywords: risk, wheat production, variance decomposition, wheat farming

Introduction

Wheat is Australia's main agricultural crop. Often around 13 million hectares are planted annually resulting in production that can range from 10 to 26 million tonnes. Australia's exports of wheat range from 7 million to 18 million tonnes annually and the international price of wheat over the last 25

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years has ranged from 110 US$/t to over 360 US$/t. As Australia's main dryland crop, wheat production is the main source of revenue for many of Australia's broadacre farm businesses. A farm's or region's wheat revenue is the multiplicative outcome of wheat price, wheat area and wheat yield.

Wheat prices follow the price pattern of a storable commodity; prolonged periods of relatively low to moderate prices interspersed with price spikes (Williams and Wright 1991). In the longer periods of lower prices marked price volatility is relatively uncommon and extremely low prices are rare. In these periods, hedging against pronounced downside risk is rarely a management priority for wheat producers. Historical evidence that illustrates the low probability of marked downside risk comes from the operation of Australia's Guaranteed Minimum Price Scheme for wheat that was in place in from 1978-80 until 1988-9. When this scheme operated, very rarely was its lower bound support mechanism ever invoked, indicating a low probability of extremely low wheat prices.

However, as a storable commodity, when per capita wheat stocks are low, for whatever reason, then any subsequent large reduction in production typically triggers a price spike (Williams and Wright 1991, Kingwell 2000). These brief but large spikes, in combination with longer periods of moderate prices, cause the long run distribution of wheat prices to be leftwards skewed.

The responsibility for managing price risk in wheat production is now the responsibility of each individual wheat producer in Australia Deregulation of wheat export marketing in Australia in July 2008 (Productivity Commission 2010; McCorriston and MacLaren 2007) has shifted the responsibility for managing wheat price risk on to growers and away from the Australian Wheat Board. Individual wheat growers now need to manage their price risk through employing a grain marketing firm and agreeing to use a marketing strategy with associated price risk management choices. As at May 2010, 28 firms were accredited to export wheat in bulk from Australia.

Accompanying price risk is yield risk. Wheat yields and dryland agriculture in general in Australia are often acknowledged to be risky (Mauldon and Schapper 1974; Anderson and White 1991; Makeham and Malcolm 1993; Productivity Commission 2005; Rayner *et al.* 2010). Australian dryland farming experiences volatile seasons (Hennessy *et al.* 1999; Power *et al.* 1999; Alexander *et al.* 2007) overlain recently with posited impacts of global warming (Kokic *et al.* 2005; Howden and Jones 2004). Pests, diseases, weeds and damaging weather events further affect wheat yield risk. The main wheat-growing regions across Australia display different historical yield trends and yield variation (Stephens and Lyons 1998; Beeston *et al.* 2005) and projected climate change is posited to affect different regions differently (Pittock 2003; Howden and Jones 2001, 2004; Kokic *et al*. 2005). O'Meagher (2005) points out that Australia has the highest rainfall variability and run-off of any continent, with the variability generally increasing inland. Wheat-growing typically occurs in low rainfall regions and it is known that locations that experience the greatest rainfall variability tend to be those with the lowest mean rainfall. More generally, the Productivity Commission (1995) observes that Australian agriculture, over the three decades preceding 2005, displayed the highest level of volatility in year-to-year output growth of all industries in Australia (more than two and a half times higher than the average for all industries).

The remaining ingredient in wheat revenue variation is the variation in the wheat area sown and harvested. Since the demise of the Reserve Price Scheme for wool in 1991, dryland farm resources have tended to switch away from wool and sheep production into cropping (Rayner *et al*. 2010). As an indicator of the magnitude of the shift away from wool production, in 2008–2009 the number of sheep and lambs in Australia was 71.6 million head, the lowest number since 1905. New crop varieties, herbicide technologies, new tillage technologies and improvements in the size and capability of cropping gear have facilitated the switch toward cropping in dryland farming systems. Furthermore, the labour-intensive nature of sheep production and difficulties in attracting and retaining skilled sheep labour and the vagaries of prolonged drought have provided further disincentives to sheep production.

Given all these changes in cropping dominance, yield movements and price variation it appears timely to re-examine the nature of the variability of returns from wheat production in Australia. Decomposing this variability can reveal the relative importance of the key components of revenue variance. Although such variability, and farm income variability in general, have long been topics of interest to agricultural economists in Australia (e.g. Harris *et al.* 1974; Mauldon and Schapper 1974; IAC 1978; Quiggin and Anderson 1979) and underpinned much policy discussion about price stabilization, crop insurance, drought and natural disaster policies; little empirical investigation of revenue variability has occurred in recent decades. Hence, it seems timely to re-visit this issue to measure the components of wheat revenue variation faced by Australian farmers.

So this paper comprises three sections. The first outlines the methodology to decompose wheat revenue variation and the various datasets used and assumptions employed. The second presents the modelling results, highlighting spatial and temporal findings. A final section discusses ways in which governments and farmers have or could respond to the variance components.

I. Revenue Variance Decomposition

Revenue from wheat production has three components:

$$R = P.A.Y \tag{1}$$

where revenue (R) is the product of the price received for wheat harvested (P), the area harvested (A) and the grain yield (Y). The typical units for these components are R ($), P ($/tonne), A (hectares) and Y (tonnes per hectare).

If each component is independent then

$E[P.A.Y] = \overline{P}.\overline{A}.\overline{Y}$ and following Goodman (1960) $Var[P.A.Y] = E[(P.A.Y - \overline{P}.\overline{A}.\overline{Y})^2]$

$$Var[P.A.Y] = (\overline{P}.\overline{A}.\overline{Y})^2 (G[P] + G[A] + G[Y] + G[P].G[A] + G[P].G[Y] + G[A].G[Y] + G[P].G[A].G[Y])$$

where $G[P]$, $G[A]$ and $G[Y]$ are the squared coefficients of variation. For example,

$$G[P] = \frac{var[P]}{\overline{P}^2}$$

However, *P*, *A* and *Y* are unlikely to be independent and so, following Goodman (1962), the formula for the product variance becomes an extremely complex 28 term equation (Peiser 1984). This means that there are 28 components to the variance of wheat revenue and so interpreting findings can be problematic. Although the variance equation can be approximated, thereby lessening the number of terms, nonetheless this requires invoking a range of assumptions upon which the accuracy of the approximation rests.

Accordingly, to facilitate the task of revenue decomposition, a log transformation is possible. This is feasible as revenue and its key components cannot be negative (*P*, *A* and *Y* each must be greater than or equal to zero). So, following Blank *et al* (1997), a log transformation of equation (1) gives:

$ln(R) = ln(P) + ln(A) + ln(Y)$ where

$E[ln(R)] = E[ln(P)] + E[ln(A)] + E[ln(Y)]$ and

$$Var[ln(R)] = Var[ln(P)] + Var[ln(A)] + Var[ln(Y)] - 2Cov[ln(P),ln(A)] - - 2Cov[ln(P),ln(Y)] - 2Cov[ln(A),ln(Y)] \qquad (2)$$

As pointed out by Blank *et al* (1997) the advantage of this transformation is that it generates only six terms for variance decomposition; the first three terms are direct effects of the variance of each main random variable (*P*, *A* and *Y*) and the last three terms are interpretable indirect effects or covariance effects.

To apply equation (2) to datasets requires first accounting for trend effects. .Time series data containing an underlying trend (e.g. price inflation, technology progress) cause the variance of the random variable to increase with the level of that random variable, giving rise to non-stationarity that invalidates variance estimation. Hence, prior to the log transformation, the revenue components (P, A and Y) at each location were trend corrected. A simple linear time trend for wheat yields was applied and in all cases proved statistically significant. A simple linear trend and 7-year moving average were applied to wheat areas.

An important issue for wheat prices is that they are subject to general price inflation, as mostly shown in the exponential fitted trend to nominal wheat prices in Appendix one. However, there is also an acknowledged long-run decline in real prices of wheat due to the impacts of technical progress and the passing on to wheat consumers of some of the economic gains of productivity improvement (Alston *et al.* 2009). Hence to detrend nominal wheat prices requires representing both the inflationary trend and the long-run decline in real prices (Aadland 2005). Accordingly in this study nominal wheat prices are detrended for both effects, with final prices expressed in 2009 dollar terms. Charts displaying raw data and temporal trends are given in Appendix one.

Although a linear time trend can apply to the wheat area in each State, due to agricultural expansion and the gradual intensification of cropping, there are additional structural changes in the wheat area, mostly due to the relative profitability of cropping versus sheep and cattle production, that are better captured by moving averages of the wheat area. For example, a 7-year moving average trend tends to capture these gradual but important structural shifts better than a simple linear trend.

After detrending the price, yield and area data, the direct and cross effects of the revenue components were then expressed as a percentage of the total direct effects. This procedure results in the sum of the first three percentages (price, area and yield) all being positive and summing to 100, while the remaining three percentages (the various covariances) take either sign (positive or negative) and associated value.

Historical datasets for wheat production in each major wheat-producing state of Australia were obtained from the Australian Bureau of Statistics. These datasets were supplemented with the most recent estimates of wheat production and wheat prices for the production year 2009. The States included were New South Wales (NSW), Queensland (QLD), Victoria (VIC), South Australia (SA) and Western Australia (WA) and the time period of analysis was 1955 to 2008, although yield, area and nominal price data and temporal trends for the period 1920 to 2009 are displayed in Appendix One. Because reliable datasets for cost inflation in Australia are not available for years previous to

1948, and because of the structural impact of World War Two and the Korean War (1951 to 1953) on commodity prices, the period of analysis was restricted to 1955 onwards.

Wheat yields were calculated from production and area data. Price data came from various ABARE Commodity Statistics reports and from the Australian Bureau of Statistics and various Year Books for Western Australia. Wheat prices were based on nominal prices in principal markets which were in most years were export markets. A uniform set of free-on-board wheat prices was used. Although differences in wheat prices between Australian States are likely, finding reliable and consistent time series data for each State for the study period proved problematic. Hence, a single Australia-wide dataset for wheat prices was used. This means that the variance in wheat prices experienced by each State is identical in this analysis, although covariance effects will differ and be specific to each State.

2. Results of Revenue Variance Decomposition

Changes in the variance of wheat revenue for each Australian State, as denoted by the left hand side of equation 2, are listed in Table 1. Different structural periods and two representations of the time trend in wheat area (linear and 7-year moving average) are reported.

The structural periods include firstly, the period after the collapse and subsequent cessation of the Minimum Reserve Price Scheme for wool in 1991. Its demise triggered a string of years of depressed prices for wool that encouraged a switch of farm resources away from wool production and into crop production (Crooks and Levantis 2010). Cereal production increasingly relied on minimum tillage techniques, herbicide technologies and nitrogenous fertilisers. Statutory marketing deregulation, microeconomic reform, gradual erosion of public sector agricultural R&D and a greater role for agribusiness occurred in this period.

The period 1973 to 1991 commenced with the lifting of quotas on wheat production in Australia and ended with the demise of the Minimum Reserve Price Scheme for wool, after a wool price boom in the late 1980s. During this period, crop and pasture rotations began to include grain legumes and oilseeds and much larger cropping gear facilitated crop production. Large investments in R&D and State agency extension services were prevalent. Major policy reforms included the floating of the Australian dollar and reduced protectionism for manufacturing and agricultural industries. This period also included a resources boom in the 1970s and serious inflation with several years of very high interest rates in the 1980s that greatly affected the viability of debt-laden crop-dominant farms (Ripley and Kingwell 1984; Tucker *et al.* 1990; Beare *et al.* 1990).

The period from 1955 to 1972 followed the Korean War (1951 to 1953) wool boom and the post-WWII commodity boom. The period ended with the imposition of wheat quotas in 1971 and 1972. In this period, cropping gradually became subject to greater mechanisation yet remained strongly part of rotational farming based on improved pastures and superphosphate applications. Expansion of farming, particularly in Western Australia and Queensland, and enlargement of government advisory and marketing services for farmers also characterised these years.

The wheat revenue variances for these different periods and different Australian States are listed in Table 1. When either a linear or 7 year moving average trend applies to wheat areas, the consistent finding is that the most recent period records by far the highest levels of wheat revenue variance. This finding applies in all Sates, but is especially evident for NSW, QLD and VIC. The wheat revenue variance experienced in the most recent period (i.e. 1992 to 2009 or 1992 to 2006) is typically greater than the revenue variance experienced in its adjacent period or across the entire study period (1955 to 2009 or 1955 to 2006),

Table 1: Wheat revenue variance for key Australian States in different periods; with different detrending of wheat area

	Wheat revenue variance (linear area trend)		Wheat revenue variance (7-year moving average area trend)	
NSW				
	1992 to 2009	0.40	1992 to 2006	0.20
	1973 to 1991	0.13	1973 to 1991	0.09
	1955 to 1972	0.15	1955 to 1972	0.10
	1955 to 2009	0.23	1955 to 2006	0.13
WA				
	1992 to 2009	0.10	1992 to 2006	0.09
	1973 to 1991	0.07	1973 to 1991	0.06
	1955 to 1972	0.07	1955 to 1972	0.04
	1955 to 2009	0.10	1955 to 2006	0.09
SA				
	1992 to 2009	0.20	1992 to 2006	0.12
	1973 to 1991	0.08	1973 to 1991	0.08
	1955 to 1972	0.11	1955 to 1972	0.07
	1955 to 2009	0.15	1955 to 2006	0.11
QLD				
	1992 to 2009	0.17	1992 to 2006	0.19
	1973 to 1991	0.09	1973 to 1991	0.09
	1955 to 1972	0.11	1955 to 1972	0.07
	1955 to 2009	0.11	1955 to 2006	0.11
VIC				
	1992 to 2009	0.38	1992 to 2006	0.19
	1973 to 1991	0.14	1973 to 1991	0.11
	1955 to 1972	0.15	1955 to 1972	0.07
	1955 to 2009	0.22	1955 to 2006	0.13

To better understand how wheat farming in each State has been affected by revenue volatility requires knowledge of which components of revenue variation have changed the most, and in what direction. Accordingly, Tables 2 and 3 present results of the decomposition of the variance of wheat revenue for different time periods in the various Australian States.

Table 2: Wheat revenue components for each Australian State over 15-year periods: with a linear time trend applying to wheat area.

	Variance			Covariance		
	area	yield	price	area,yield	yield,price	price,area
	%	%	%	%	%	%
NSW						
1992 to 2009	16.75	70.01	13.25	0.77	-6.08	-5.59
1973 to 1991	35.81	42.66	21.53	0.22	-3.10	2.33
1955 to 1972	26.92	41.71	31.37	4.45	1.50	-4.71
1955 to 2009	21.93	51.42	26.65	2.08	-2.50	-2.36
WA						
1992 to 2009	4.52	46.85	48.63	6.27	-7.66	-6.44
1973 to 1991	23.93	31.64	44.43	-15.58	-3.88	11.05
1955 to 1972	7.13	21.94	70.93	-2.00	14.29	-10.36
1955 to 2009	11.48	28.19	60.33	-4.27	-4.50	6.09
SA						
1992 to 2009	9.03	64.30	26.67	-7.10	0.36	-5.57
1973 to 1991	9.33	63.97	26.69	5.00	4.35	2.95
1955 to 1972	15.85	39.43	44.72	3.12	8.34	-11.55
1955 to 2009	11.37	48.46	40.16	-0.45	0.31	-2.92
VIC						
1992 to 2009	19.55	64.69	15.76	-13.56	2.59	-8.31
1973 to 1991	28.73	54.10	17.16	1.43	0.46	7.23
1955 to 1972	38.35	22.18	39.48	-1.91	6.34	-15.39
1955 to 2009	24.13	47.41	28.45	-5.14	3.48	-2.54
QLD						
1992 to 2009	31.04	45.03	23.92	22.35	-12.39	-6.04
1973 to 1991	16.75	65.31	17.94	16.79	1.68	1.51
1955 to 1972	8.38	61.83	29.79	5.00	20.46	-7.94
1955 to 2009	20.20	49.19	30.61	14.76	4.19	1.33

The values in Tables 2 and 3 are estimates of the contributions of the direct variance terms and the covariance terms from equation (2), as a percentage of the sum of the three direct variance terms when either a linear or moving average trend in wheat area applies. The columns Var(ln(P)), Var(ln(A)), and Var(ln(Y)) are the direct variance contribution of price, area and yield, respectively. The next three terms Cov(ln(P),ln(A)), Cov(ln(P),ln(Y)), and Cov(ln(A), ln(Y)) refer to the various covariance terms between price , area and yield. Tables 2 and 3 use a slightly different final time period, due to the different data requirements of the trend calculation of wheat area.

Table 3: Wheat revenue components for each Australian State over different structural periods: with a moving average time trend applying to wheat area.

	Variance			Covariance		
	area	yield	price	area,yield	yield,price	price,area
	%	%	%	%	%	%
NSW						
1992 to 2006	4.86	80.34	14.79	12.74	-1.17	-2.26
1973 to 1991	5.28	62.95	31.77	6.84	-7.62	-0.63
1955 to 1972	12.40	50.00	37.60	7.55	5.33	-0.21
1955 to 2006	6.38	58.66	34.97	8.99	0.72	-0.46
WA						
1992 to 2006	5.48	53.23	41.29	8.64	-5.65	-5.59
1973 to 1991	6.64	38.83	54.53	-2.13	-4.76	2.79
1955 to 1972	4.15	22.64	73.20	0.55	14.75	2.31
1955 to 2006	3.95	31.71	64.35	2.17	-4.22	0.26
SA						
1992 to 2006	1.34	73.63	25.03	-1.62	9.44	0.44
1973 to 1991	4.71	67.24	28.05	5.31	4.58	1.06
1955 to 1972	4.84	44.59	50.58	4.93	9.43	1.69
1955 to 2006	2.93	53.32	43.74	2.14	2.81	1.53
VIC						
1992 to 2006	1.43	83.12	15.45	3.13	6.07	-0.40
1973 to 1991	6.64	70.88	22.48	5.83	0.61	0.97
1955 to 1972	18.37	29.36	52.27	1.03	8.39	1.03
1955 to 2006	6.05	58.57	35.38	3.19	5.01	1.13
QLD						
1992 to 2006	39.96	42.71	17.33	29.00	-13.72	-10.47
1973 to 1991	23.35	60.13	16.52	23.41	1.54	-0.09
1955 to 1972	10.32	60.52	29.16	11.93	20.02	-1.21
1955 to 2006	21.89	49.21	28.90	20.27	4.23	-3.06

The results in Tables 2 and 3 reveal that in the key wheat producing States of NSW and WA, the most recent period from 1992 to 2009 (or 1992 to 2006), compared to previous periods, is characterised by a pronounced lift in the contribution of yield variance to revenue variance. Only in QLD does wheat yield variance make a lesser contribution to revenue variance in the most current period.

In the key wheat producing States, the contribution of area variance to revenue variance is often the least important direct component, especially when the 7-year moving average trend applies to wheat areas. Again QLD is a notable exception where the direct effect of area variance and the covariance effect of area and yield play important roles in affecting revenue variance. It appears that the area planted to wheat in QLD, especially in the period 1992 to 2009 (or 2006) is especially sensitive to yield prospects.

To be expected, when the 7-year moving average trend (see Table 3) rather than the linear trend (see Table 2) applies to wheat areas, then the contribution of the variance in detrended wheat areas to revenue variance is much reduced. The moving trend more accurately reflects the medium term structural trends that affect areas sown to wheat. Often it is the relative profitabilities of cereals, oilseeds, wool, sheepmeat or cattle that gradually affect resources devoted to cropping. Farmers usually make incremental changes in the resource mix of their farms (Kingwell 2006) and need prolonged or sizeable shifts in relative profitability before embarking on substantial changes in their enterprise mix (Just *et al.* 1990).

Although the price spike for wheat in mid 2007 into 2008 is captured in the dataset, nonetheless price variance in the current period (1992 to 2009), relative to yield variance, has played a lesser role in contributing to revenue variance. Yield variance is by far the main source of revenue variability, usually followed by price and area variance. Although much media attention globally accompanied the 2007 price spike, by historical comparison such price variation is not unique. However, the dataset does not include data for 2010 when another price spike emerged. Hence, price variance currently is likely to play a larger role in affecting current revenue variance than is suggested by the analysis presented here.

The emergence of these price spikes is attributable to several causes (Westhoff 2009; Irwin and Good 2009; von Braun. and Torero 2009). Globally, physical stocks of wheat have changed little since the mid-1980s, despite a large increase in the world’s population (Figure 1), so the per capita availability of wheat stocks has fallen over time which makes wheat markets more vulnerable to price spikes such as occurred in 2007 and 2010. Westhoff (2008) observed that “World grain stocks have been declining, as consumption has exceeded production in most recent years. Stocks have now dropped to levels where it is harder to satisfy demand by continuing to draw down stocks”. (p.7)

Yield variance, being the principal cause of the enhanced variance in current wheat revenue, plays an even more important spatial role in affecting revenue variance than the State data indicate. To illustrate this, consider the disaggregated data for WA in Figure 2. The coefficient of variation in detrended wheat yield for the period 1975-2009 is compared to that for 1940-1974.

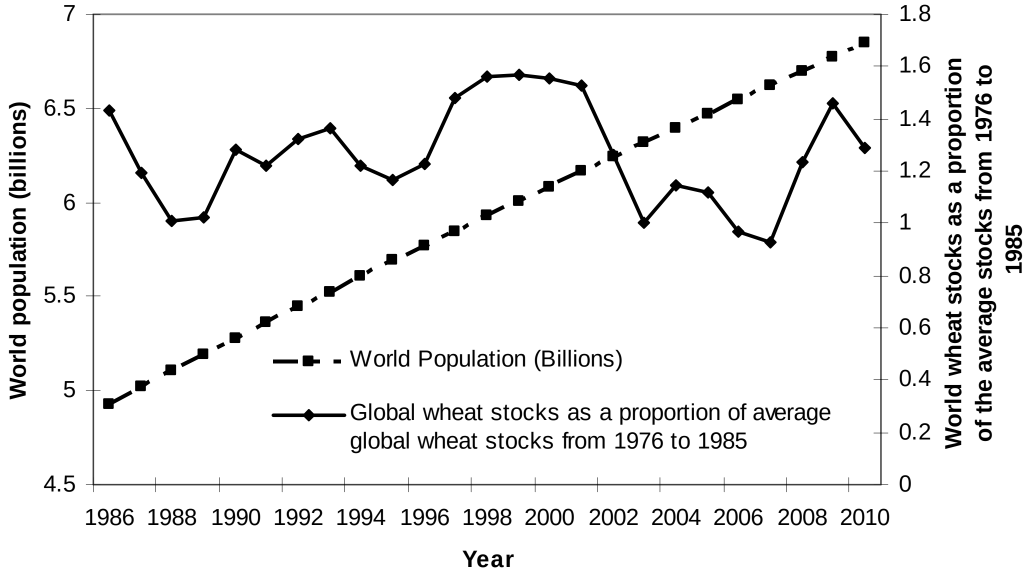

Figure 1. Changes in the world's population and global wheat stocks from 1986 (as a proportion of average global wheat stocks from 1976 to 1985)
Data sources: World Bank (2010) and USDA (2010)

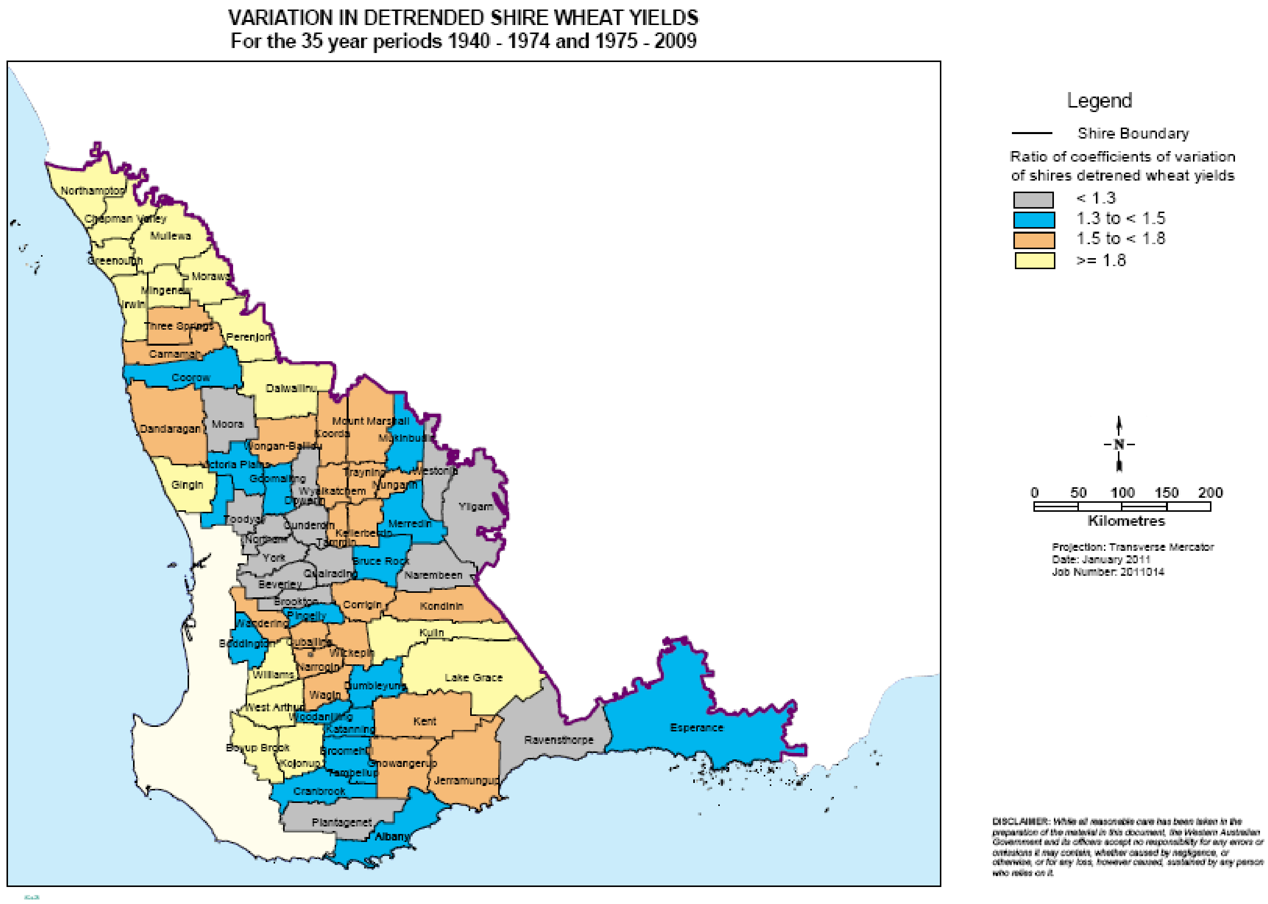

Figure 2. The spatial pattern of the ratio of coefficients of variation of detrended shire wheat yields in WA for the periods 1975-2009 versus 1940-1974

The ratio of the coefficients of variation in all wheat-growing shires of WA (see Figure 2) has increased, and in some regions of WA, as indicated by the yellow shading, yield variance has hugely increased. The yellow-shaded shires in the north and east regions are major centres of wheat production in WA; indicating that the primary enterprise of wheat growing has become more risky in these regions. It is this greater volatility in grain yield (particularly downside yield risk) in the last decade or so that has challenged the prosperity of wheat-farming in these parts of WA and the same finding is likely to apply to shires in many other parts of Australia.

To illustrate the yield variance (particularly downside risk) over the last 15 years or so; the detrended yields of 4 shires from the north-east, east, south-east and central wheatbelt of WA are displayed in Figure 3. Typically it is the more frequent very adverse seasons (indicated by data points shaded red in Figure 3) that are the principal cause of the increase in the yield variance since 1999 in these shires. However, as shown in the State-level yield data in appendix one, the increase in yield variance is also partially attributable to the incidence of a few very high-yielding production years; so it is often the combination of a few very favourable years and several very adverse years that has raised yield variance.

In an early study of decomposition of revenue variance in Australian agricultural industries, Harris *et al* (1974) found that quantity variance was by far the major contributor to wheat revenue variance. These authors lumped area and yield effects together, and used detrended data, although they did not outline their method of detrending. In each period, 1949 to 1972 and 1960 to 1972, they found that 97 per cent and 3 per cent of the revenue variance was attributable to quantity and price variance respectively. By contrast in the current study for the similar periods, and in other periods, price variance is found to be much more important as a component of revenue variance. The implications of Harris *et al*'s findings were that price risk was almost unimportant in the wheat industry. The results in the current study, however, suggest this is not the case and certainly the practical experience of farmers over the last several years suggests that managing price risk is particularly important.

Harris *et al* also found a very strong negative covariance effect for wheat price and quantity. However, for the similar period in each State, this current study found mostly small positive covariance effects.

3. Implications for Farmers and Governments

The revenue variance in the most recent period, 1992 to 2009 (or 2006), is often double that in the preceding period. Moreover, the revenue volatility associated with wheat production in each Australian State over the last 15 years is much greater than that recorded over the entire study period 1955 to 2009.

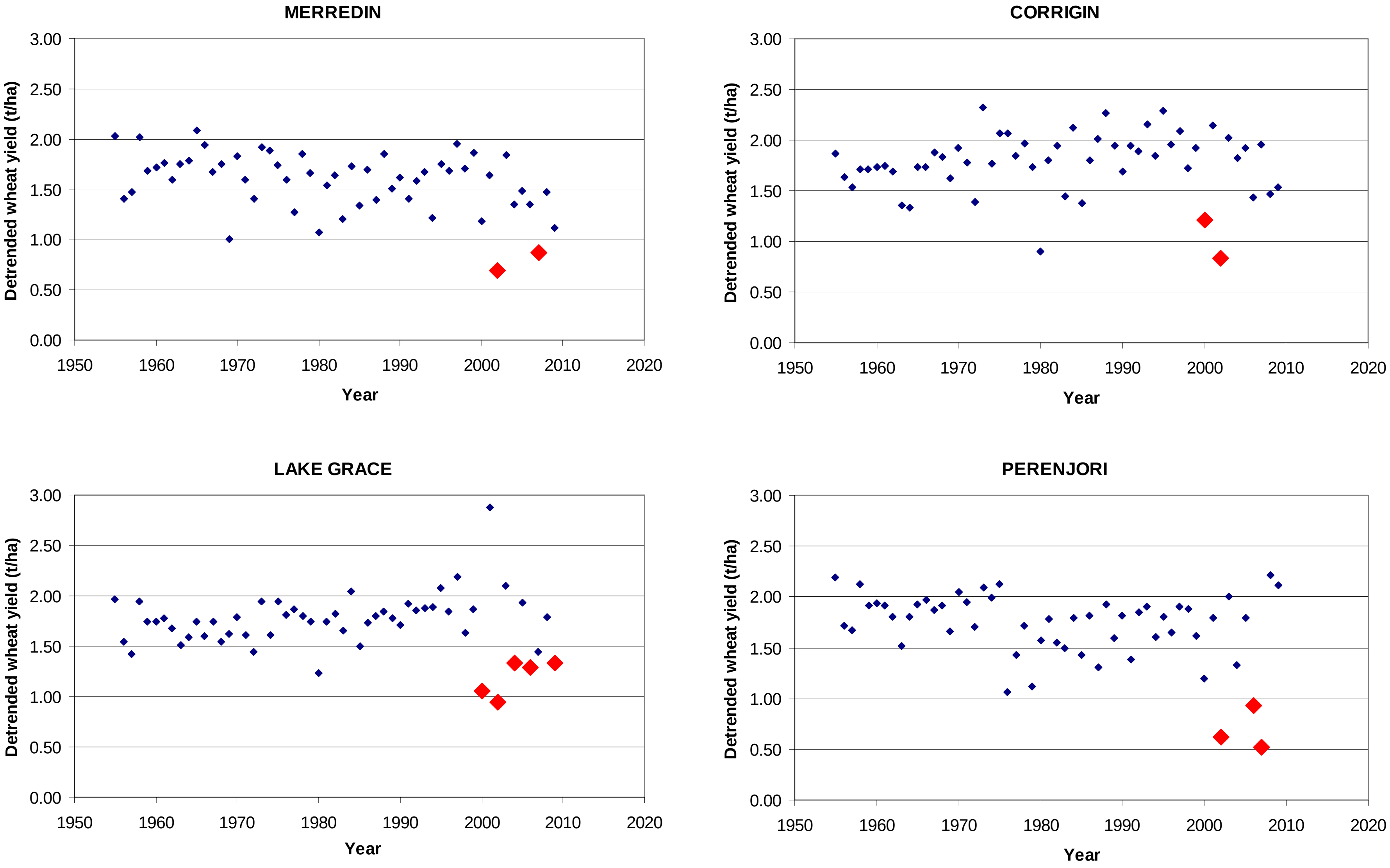

Figure 3. Detrended wheat yields of 4 shires in WA for the period 1955 to 2009. Source: D. Stephens, *pers. comm*.
The data points in red are very low-yielding years since 1999.

Farm survey evidence during the last decade suggests that the nature of this more recent volatility has tested many farm businesses reliant on wheat production. Since 2000, farm debt on Australian grain farms has increased on average by 107 per cent (Crooks and Levantis 2010). These same authors report that "… in response to greater variability in average farm cash income in recent years, high and very high intensity grains producing farms have increased working capital debt more than other cropping intensity groups." (p. 20). Martin *et al* (2010) reported on the financial performance of Australia's broadacre industries and found that over the last 19 years, average farm business profit was positive in only five of those years.

In spite of the raft of technological advances that have aided wheat production (new varieties, tillage and herbicide technologies, bulk-handling and communication improvements) nonetheless revenue variability has increased greatly. Where farmers have lacked appropriate risk management strategies then ultimately their farm viability has worsened, sometimes rapidly.

When examining the current and likely future structure of crop-dominant farming systems in Australia, Kingwell (2002) observed that: ".. a switch into more cropping means a more capital-intensive business with greater demands for working capital. With such a business structure a few poor seasons, especially if coupled with poor prices, can rapidly cripple a farm business. Hence, although farms are likely to maintain a diversity of crops (cereals, pulses and oilseeds), and although climate forecasting may improve to facilitate crop and livestock management, nonetheless managing enterprise and business risk will be increasingly important." (p. 10). Similarly, Sadras *et al* (2003) showed that dryland high input crop dominant businesses in Australia faced increased financial risk as farm input costs rose.

Farmers' responses to the increase in wheat revenue variance are a range of short-term seasonal actions as well as longer term structural choices. Short term actions, particularly in unfolding adverse production years, include:

(i) reductions in personal and household expenses.

(ii) reductions in some costs of production (e.g. avoiding or lessening expenditures on the least productive, least responsive or most risky paddocks; lowering inputs of lime, superphosphate; limiting areas sown to more risky crops (certain grain legumes) or not sowing crops requiring expensive inputs (e.g canola)).

(iii) deferring capital expenditures (e.g. machinery replacement.) or scheduled maintenance, where defensible.

(iv) greater use of own labour rather than hired labour.

(v) negotiating prices to be paid for farm inputs, farm services and personal expenses.

Medium and longer term actions of farmers include:
(i) selling up and moving out of farming.
(ii) examining what enterprise mix or business arrangements might best ensure the longer term viability of the farm business.
(iii) sale of non-performing or surplus assets, both farm and off-farm assets.
(iv) negotiating longer terms for finance contracts and loans for plant, vehicles and land purchases.
(v) negotiating with lessors on rent payments and their timing to improve cashflow.
(vi) selling some land to lessen debt, if a sufficiently attractive price can be achieved.
(vii) seeking off-farm contract, part-time or seasonal work.
(viii) diversifying income sources and seeking government funding assistance, where available.

Farmers who currently experience grave financial problems as a result of the impacts on their farm businesses of the greater variance in wheat revenue may wish for government assistance. However, since 2007 most tiers of government have been preoccupied with responding to the global financial crisis and its ramifications. After committing funds to stimulate economic activity, most governments now see that during economic recovery their priorities include tighter control of their expenditures. Accordingly, apart from aiding farmers and rural communities affected by floods in 2011, there is likely to be little special largess to farmers from the treasuries of State and Federal governments. It is more likely that governments' responses to farmers affected by increased revenue variance will be in the form of on-going or highly targeted activity such as:
(i) supporting rural financial counselling and debt mediation services and maintaining community and mental health services in rural districts under stress.
(ii) supporting regional infrastructure projects that provide employment opportunities for farm and rural workers and their equipment.
(iii) assisting the re-training of farmers and rural workers to gain formal accreditation for their prior learning and skill sets that are applicable in other sectors (e.g. mining, materials and handling).
(iv) continuing to co-fund agricultural R&D and biosecurity services to lift and secure the productivity and profitability of farming systems that need to operate against the backdrop of more frequent adverse production years.
(v) maintaining support for extension and education services to ensure farmers are aware of both the risks in agriculture and the appropriate risk management tools and strategies.
(vi) encouraging and supporting innovation infrastructure to enhance the profitability of farming and its supply chains.

Although mindful of how revenue variation can affect wheat farmers, governments in Australia in general have acted in ways that have resulted in broadacre farmers receiving, by international comparison, low levels of assistance (Anderson 2009). Unlike the situation in North America, governments have resisted supporting crop insurance programs. The Industries Assistance Commission (1996) recommended against any government-supported crop insurance program. These findings were later supported by other studies (Ernst and Young 2000; Multi Peril Crop Insurance Task Force 2003; Hertzler 2005).

Governments have tended to encourage self-reliance among farmers; whilst recognizing the occasional political imperative or opportunity provided by hardship stemming from environmental adversity. By illustration, in 1992 the Federal and State governments agreed on a national drought policy based on principles of self-reliance and risk management (Botterill 2005). However, within a few years the science-based exceptional circumstances declaration process, a key aspect of the policy, increasingly became politicized (White *et al.* 2005). Nonetheless, the current financial imperatives for many governments will force them to lessen their exposure to assisting wheat farmers affected by adversity.

In general, gradually through de-regulation, microeconomic reform and the weakening of the political power of the rural lobby, Federal and State governments have progressively limited the assistance provided to wheat growers facing increased revenue risk. Whether the impacts of this greater risk eventually constitute a structural problem in the wheat industry that forces additional actions by governments, time will tell.

Conclusions

The decomposition of wheat revenue variance in the main wheat-growing regions of Australia reveals that the volatility of wheat revenue (detrended) has more than doubled in every main wheat-growing State in Australia over the last 15 years or so Changes in wheat areas are mostly a minor source of revenue variance. The principal cause of volatility is yield changes, although price changes have increased in absolute (but not percentage) importance when compared to their adjacent previous period.

Increased downside yield risk, in combination with a few high-yielding years, is the principal cause of the increased yield variance. The implications are that revenue variance, and especially downside revenue risk, has posed major problems for wheat-dominant farm businesses over the last 15 years or so. Supporting this finding are farm survey results that show farm indebtedness is growing and farm business profit more rarely is positive. It appears that the rewards and penalties surrounding risk management by Australia’s wheat producers have been substantial over the last decade or so.

The compounding effects of the downsides of the revenue risk faced by wheat growers over the last 15 years or so make the next handful of seasons crucial in affecting the business survival of a sizeable proportion of Australian wheat growers. More importantly, if the next decade displays the same adversity as the last then Australia's wheat industry faces very serious structural problems.

Given the current financial constraints imposed on all tiers of government in Australia, it is unlikely that wheat farmers can expect much financial relief from government. If structural adjustment does occur then government actions will only likely slightly mollify the size and extent of that adjustment.

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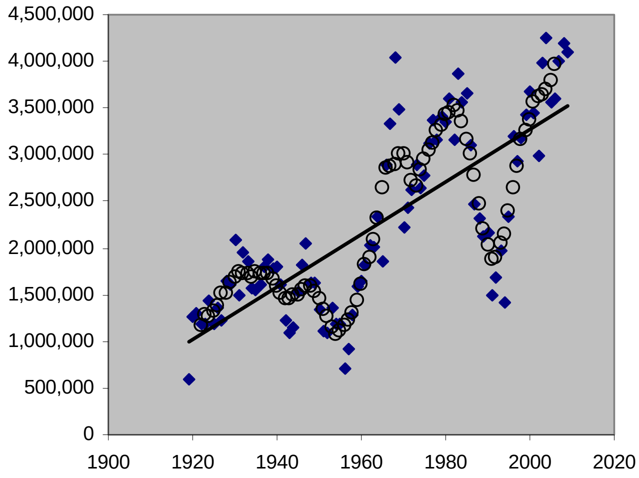
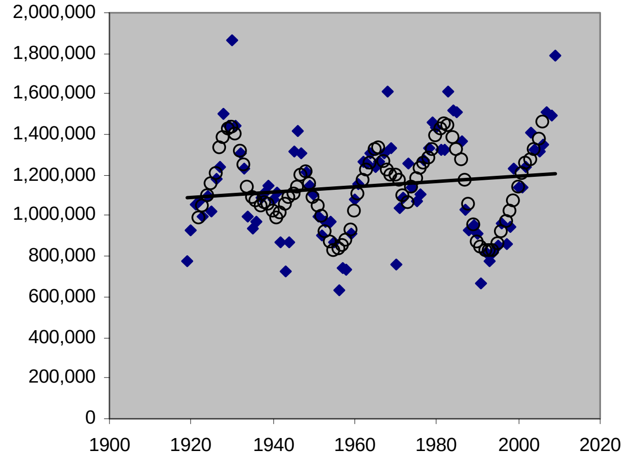
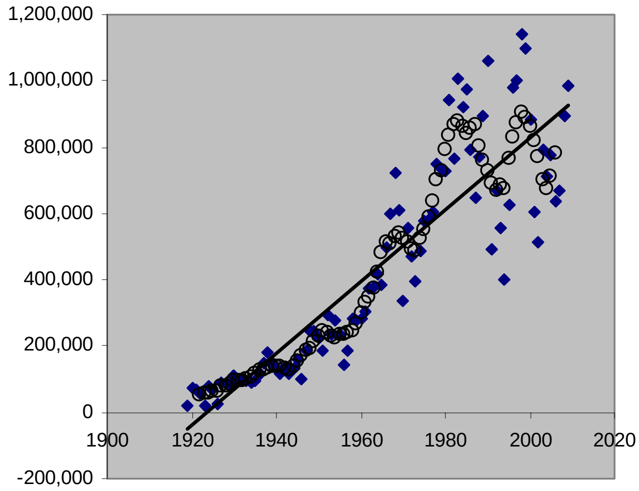
Appendix One; Area, Yield and Price data and trends of Australian main wheat-growing States



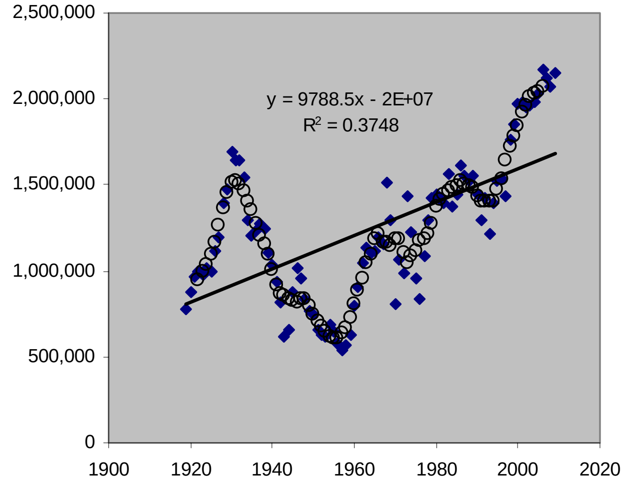
NSW Wheat Area: linear and 7 year moving average trend



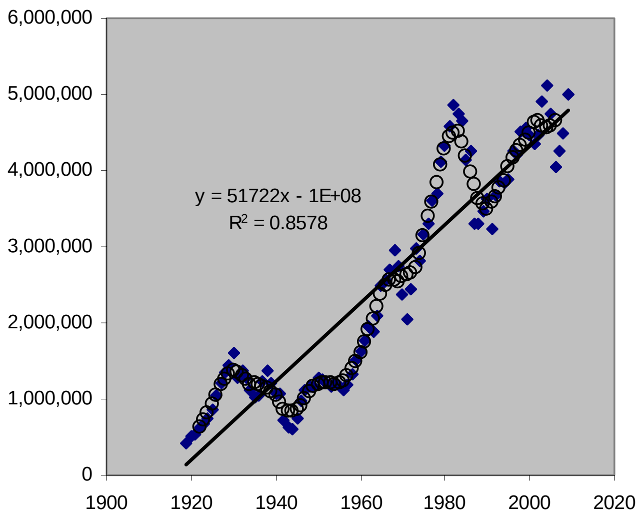
VIC Wheat Area: linear and 7 year moving average trend



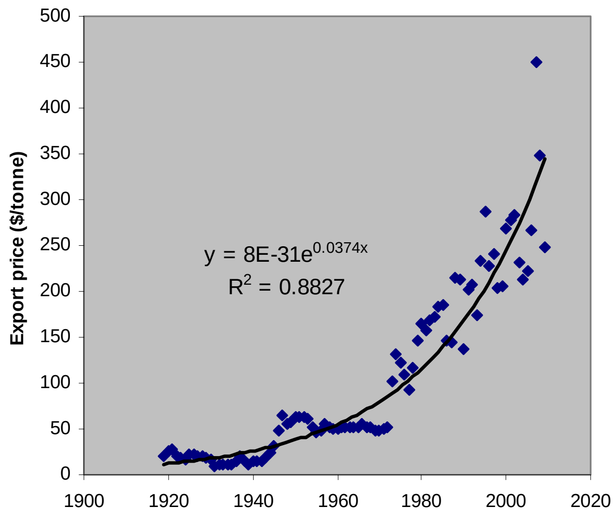
QLD Wheat Area: linear and 7 year moving average trend



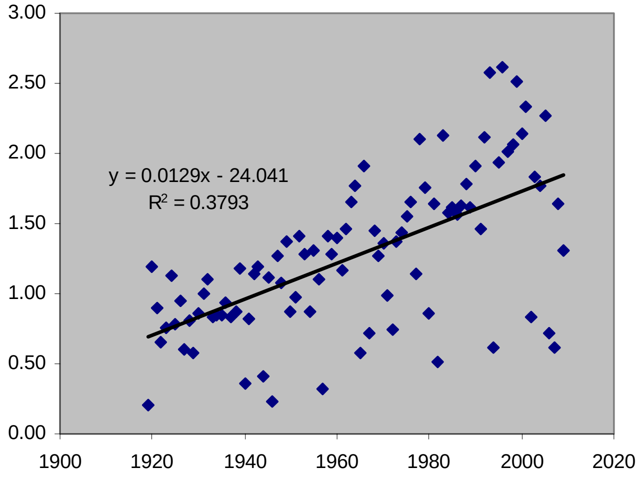
SA Wheat Area: linear and 7 year moving average trend



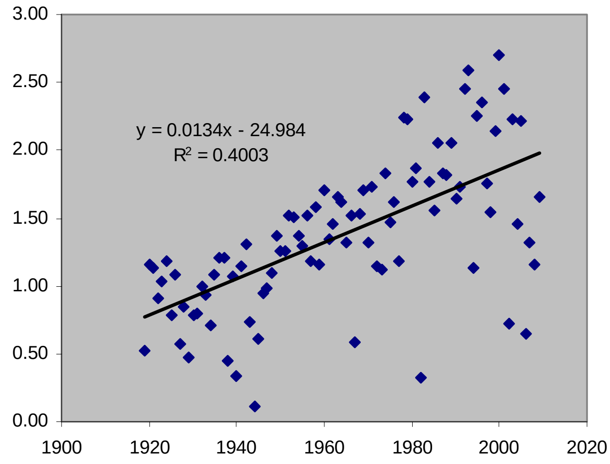
WA Wheat Area: linear and 7 year moving average trend



Export wheat prices and exponential trend



NSW wheat yield (t/ha) and: linear trend



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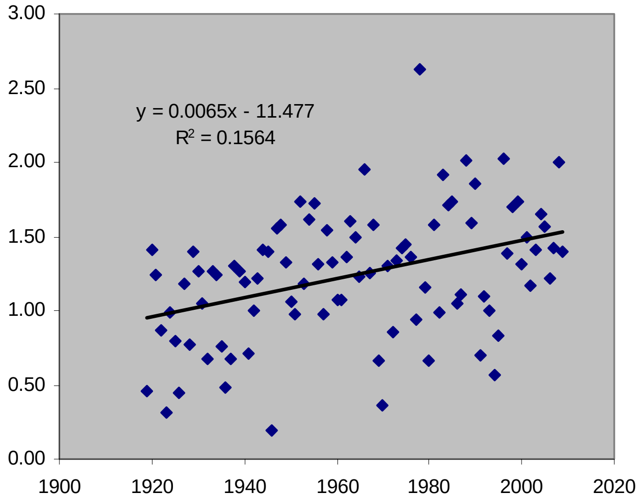

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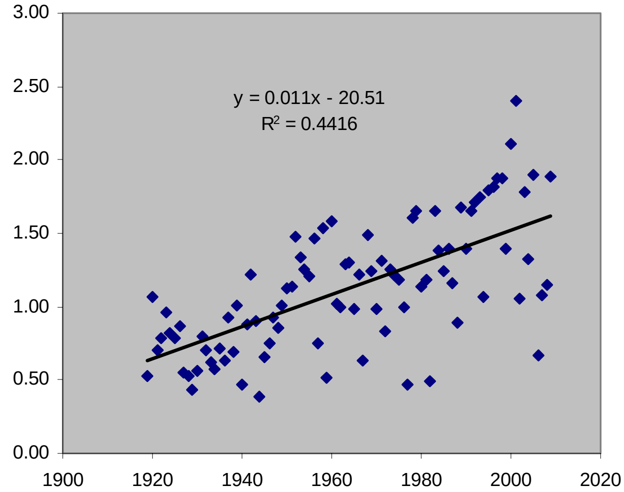

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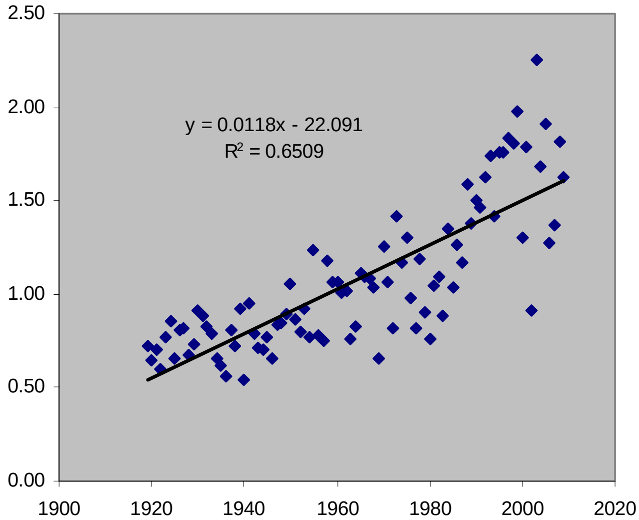

WA wheat yield (t/ha) and: linear trend