Area Yield Crop Insurance:
Effectiveness of an Australian simulation

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Abstract

Area Yield Insurance (AYI) differentiates itself from the other more popular yield insurance schemes in its ability to reduce administrative costs, and decrease both adverse selection and moral hazard. These basic characteristics make AYI a candidate for considering a yield insurance scheme within Australia. This study simulates AYI indemnities and premium rates for five shires separated into two groups, based on geographical location. Through a set of coverage levels and farm yield variability, risk reduction and certainty equivalent measures are found. Adequacy of these measures are addressed though sensitivity analysis across a wide range of variables. Basis risk issues are confronted and brought to the forefront through correlation analysis of both across-shire and farm-shire yields. Results provide positive notions towards effectiveness in yield protection for Australian producers, however under the immobilizing assumption of government or external support.

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1. Introduction

The wide scope of literature relating to crop insurance, both from a yield and revenue perspective, deal with a multitude of considerations and variables which allow for near endless variations of sensitivity analysis. Within this field the reference to sensitivity analysis does not end at choice of variables such as coverage level or risk averseness, but rather ventures into the manipulation of data estimation techniques and estimations of expected utility or producer demand. A basic acquaintance with the subject matter reveals various uncharted areas and further opportunities for study. A great deal of existing literature has explored many of these highly significant nooks and crannies, however one may quickly find that the study of crop insurance is limited in regards to applications within different territories, countries and continents.

This study aims to expand the number of yield insurance applications throughout various regions. Specifically taking Area Yield Insurance (AYI) for wheat under consideration. Previous studies include applications in China, Peru, Mali, and Mongolia to name a few of the less popular regions of study. Naturally the US represents the majority of existing studies, followed by Canada and various EU nations. Australia has limited, yet not non-existent, literature relating to crop insurance schemes. A near uniform conclusion is drawn on the major obstacle facing an Australian implementation- lack of producer demand. In Australia producer demand has been linked to yield variability and levels of coverage in the form of a positive correlation (Fraser, 1992). Producer demand is typically referenced as a combination of the following components: size of farm, perceived yield risk, leverage ratio, and importance attributed to risk management (Sherrick et al 2004a). AYI has an Achilles heel, which unfortunately targets the insured producer. This weakness is regarded to as basis risk, which represents the situation when an insured producers yield falls below the shire level trigger value yet the overall shire yield remains above the trigger value. Such an event results in no indemnity payout for the insured producer. Naturally the opposite situation is also possible and probable (Halcrow, 1949). The implications on producer demand are clear, with unclear solutions.

This research study considers 5 shires in Australia packaged into 2 groups (3 laying in close proximity within Western Australia, and 2 in Queensland). A certain degree of sensitivity analysis is performed on the 112 year data sets made available by Dr. Andries Potgieter from the University of Queensland. However the myriad of data estimation variations are not considered, but rather the most popular or "justified" option is chosen for the purpose of the study. The aim in most direct terms is to measure the effectiveness of AYI in Australian shires- hence measuring the correlation of farm yield to shire yields. Furthermore expected utility levels are calculated to provide an indication of AYI effectiveness taking premium rates into consideration and allowing for some indication of potential AYI demand.

AYI was chosen under several considerations. First and foremost the cost cutting capability was viewed as vital to the potential implementation of AYI in

Australia. This statement applies globally, as all crop insurance schemes are expensive and are unable to break even without government assistance. Such assistance, in the form of subsidies, is the core source of controversy surrounding crop insurance. Although increased subsidies for various coverage levels of crop insurance have spurred demand, it appears the increase in demand relates to an exponential increase in government subsidies. A less costly approach to simulating demand has been proposed in the form of differed tax reserves for farmers (Makki et al, 2001). Many of the sky rocketing costs, and constant prevalence of indemnity payouts over premium charges, are attributed to lack of diversification, moral hazard, adverse selection, and catastrophic event management. AYI superiority over previous schemes (MPCI) is ability to near eliminate moral hazard and basis risk. Risk diversification is not an issue inherently solved by AYI (as is the case with the previous two) however can be solved through financial markets or a global re-insurer. This will be discussed in greater detail under conclusions and further considerations.

The rest of the paper is organized as follows: Section 2 goes into a detailed discussion on the relevant literature focusing on AYI, yet including relevant points from alternative insurance schemes. Section 3 provides information regarding data used and the relevant descriptive statistics. Section 4 discusses methodology and the limits and constraints it entails. Sections 5 and 6 will display the results and their implications on the implementation of AYI in Australia. Finally Section 7 provides concluding remarks and further study points.

2. Literature Review (attached after front cover page).

Area yield insurance in Australia does not exist as such at the moment, although a variety of other indexed and non-indexed insurance products have entered the market. For this reason there is a lack of literature on the application of such a scheme in Australia, however the extensiveness of research within the US provides very many useful lessons for the potential implementation of such a scheme in Australia as this paper proposes. Throughout the text, unless otherwise noted, the studies reference US data sets. Area yield insurance was first proposed for the US in 1949 by Halcrow as an alternative insurance technique which lowers exposure to moral hazard and adverse selection and also reduces administrative/transaction costs. Moral hazard is reduced both in ex-ante and ex-post (Mahul 1999b). It is an insurance product based on an index which represents a specified area rather than individual farms. It was first implemented (tested) on soy beans by the USDA (United States Department of Agriculture), and later on formally and commercially available through a product called the Group Risk Plan (GRP) (Barnett et al 2005). The GRP was further expanded to include another product by the name of Group Risk Income Plan (GRIP), which instead of dealing with yields dealt with variations in annual income/revenue. There has been some discussion on the preference of revenue insurance over yield and vice versa. In 2004 61% of US soybean farmers insured revenue over yield insurance, further analysis on this statistic was performed using a subjective approach by Shaik, Coble, Knight, Baquet, and Patrick. The study found that those farmers expecting lower yields and price most often choose revenue insurance over yield. There is no one explanation, however one is that simply producers may receive higher indemnities if prices fluctuate during the contractual time (Shaik et al 2008). However the emergence of climate variability affecting crop yields and playing a larger role in total risk may increase demand for yield insurance over the coming years. General characteristics influencing choice of revenue or yield include but are not limited to farmer risk profile, income, and insurance cost (Makki et al, 2001a). Putting aside the choice of GRP or GRIP both have experienced success and over a period of 4 years (2002-2006) their percentage of FCIP (Federal Crop Insurance Program) liability has risen from just 3% to 14% (Deng et al, 2008).

Although there is a myriad of variables and factors to take into account when simulating such a program in Australia the most important point to take away from the US model is the incredibly high level of subsidization. Much of the research, although focusing on specific areas of insurance and design relate to this point and attempt to lower costs or at the least provide insight into the potential of lowering government involvement. Hence above all the viability of AYI in Australia is greatly subject to the availability of government subsidies. Government involvement displays an indication of market failure within crop insurance, since by the definition of insurance and risk pooling, risks should be sufficiently diversified and uncorrelated to function properly. Unfortunately this does not appear to be the case for crop insurance which is affected by many correlated variables such as weather. A recent study however has shown that if risk pooling is achieved by spreading risks over large distances it eliminates positive correlations (Wang et al 2003). More specifically this study yields very optimistic results if coverage levels have a standard deviation below the mean yield in a specified county. Needless to say this not only has the prospect of lowering government subsidies but give rise to a private crop insurance market. When considering a private insurance market other tools are at the disposal of insurers including crop diversification, and engaging in international reinsurance markets (Wang et al 2003). On top of these tools the US government offers a great deal of support to private insurers through subsidies and allocating shares of underwriting gains and losses.

Due to past attempts and, at this stage, the realized inherent tendency to market failure of insurance companies the government plays a sizable role in the existence of area yield insurance, and also the vast majority of all agriculture insurance schemes. Much of the current participation of producers in crop insurance is directly related to steadily increasing government subsidies per acre through premium subsidization. The efforts have been successful with insured acres in 1998 amounting to 182 million and in 2003 amounting to 217 million acres, however one must consider the levels of government intervention and their sustainability (Glauber, 2004). The following graphic represents the relationship between government subsidies and participation rates.

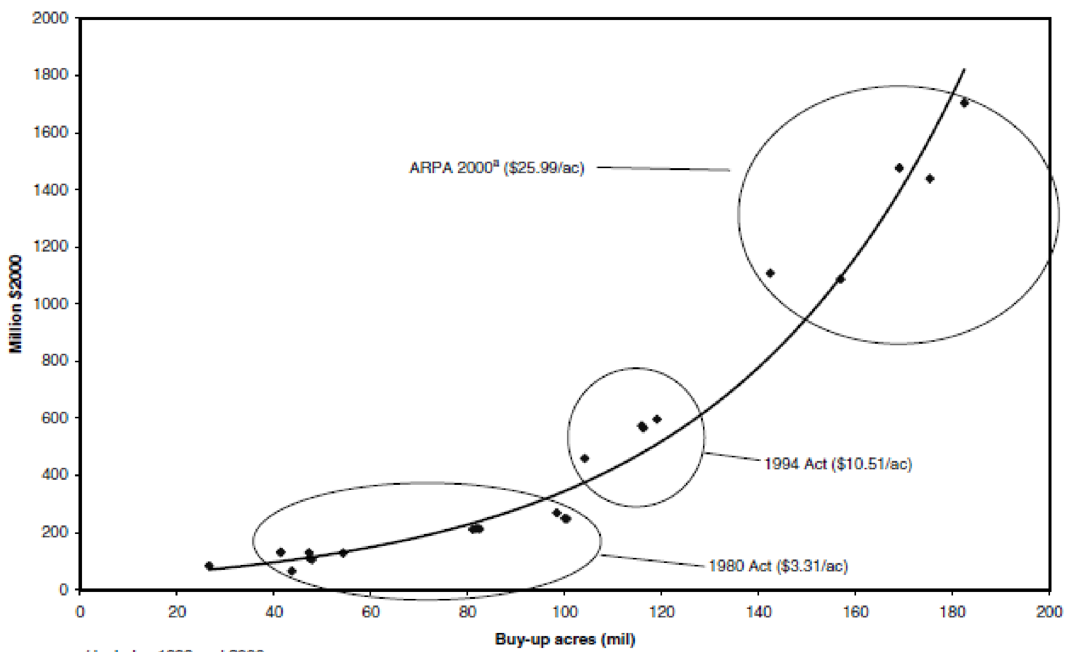

Figure 1: Relationship between Government Subsidies and Participation Rates Source: Glauber (2004).

Figure 1 calls into question if participation rates are dependent on levels of government subsidies and more interestingly if the necessity for government subsidization is exponentially increasing with uptake/"buy-up"(Glauber, 2004). Subsidies directly affect the premiums paid by producers, hence a closer look of premium rates and producer demand elasticity must be undertaken. One can speculate that in all cases the premium desired by insurance companies is higher than the premium producers are willing to pay. The government solution is subsidization, which can be astronomical as is seen in the study of implementation of AYI in Portugal (Alentijo dry region) where 79.5-80.5% of the premium would have to be paid by government (Serrao et al, 2000). Of course the willingness to pay (WTP) is influenced by the risk aversion of producers, which can be controversial in valuation methods. Considering willingness to pay Fraser (1992) refers to a survey taken in 1988 (by Patrick, G.F.) in which Australian farmers with yield variability state their willingness to pay (WTP) for insurance at or even beyond the actuarial cost. This however invites our previous point on how far off would the insurance companies desired premium be from that figure, not to mention bias of surveys to overestimate WTP for a hypothetical scenario. The study promotes the previous statement of WTP and adds that WTP is positively correlated to yield variability and levels of coverage, which will be discussed in greater detail further on (Fraser, 1992).

With the possibility of infinitely large premiums government assistance would not be necessary, but the point at which premiums begin to equal (in some cases pass) indemnity payout farmer interest drops rapidly. The usual break even ratio of indemnities versus premiums is established at 0.95 by the US government, however as (Miranda 1991) expressed the ratio is centered around 2.05. Such a disparity between the two values explains governments strong presence. In the years 1980-1988 the US government spent 4.2 billion dollars and covered a staggering 80% of indemnities (Miranda 1991). Higher premiums have a disastrous effect on the success of an insurance product through lowered number of participants and increased adverse selection. Furthermore government plays another essential role in the process through legislature. The Agriculture Risk Protection Act 2000 brought up issues regarding federal sale of insurance contracts to farmers directly, essentially bypassing the agent. This further raised issues on agents making excess profits and sale commissions (Phil Z, 2000). This is easily understood from the years 1981 -90 where indemnities exceeded total premiums by 2.3 billion, while simultaneously private agents and insurance companies receive underwriting gains of 102$ million dollars (Glauber, 2004). Further concerns were raised that Freedom to E-File Legislation promoted federal sale of insurance contracts (Phil Z 2000). An important aspect which must not be omitted from the discussion is coverage of disasters and catastrophic events, covered by US government CAT coverage. Along-side the subsidization for insurance products, there are additional expenses of covering such events worth over 15$ billion in the last 20 years (Glauber et al, 2002). The coverage for disastrous events is meant to be absorbed by the private insurance market, however all the current literature suggests such a goal is far off. Primarily attempts were made to link crop insurance to CAT (or other support) programs (Dismukes et al, 2005)., Nonetheless within this potential framework AYI offers itself as the worthy transfer system for large scale events (Paulson et al, 2008). A study on Indiana corn production risks shows that AYI disaster relief considerably cuts costs for government, however proves to be inefficient in risk coverage for areas with “diverse yield conditions” (Vandeveer et al, 1994). A concern however centers on the amount of tax payer dollars producers receive and how much is "lost" to the private insurance industry facilitating the transfer of tax payer dollars. A possible alternative is area disaster assistance programs (as opposed to individual), which would not necessarily be offered through private insurers, a benefit of such a disaster relief is that it demonstrates many of the benefits found in AYI (Williams et al, 1993). Finally combining disaster relief and commercialized (to some degree) crop insurance is difficult because producers prefer classic disaster assistance due to the simple fact that they do not need to pay for it.

In order to develop a private insurance market successfully one must look at the reasons for government intervention and subsidies. As mention before, the common thought is that information asymmetries are the cause of market failure hence the need for government support. However this theory has come under some fire due it being acknowledged primarily on a theoretical basis rather than empirical. The alternative view point believes that the core cause of market failure is due to one of the foundational concepts of AYI, systemic risk(Miranda et al,1997). Miranda and Glauber (1997) show the significance by offering a simple example of how a drought not only affects farms within a predetermined area but rather a much wider geographical area, hence essentially eliminating any diversification opportunities by the insurer. Such diversification opportunities, or rather lack of, cause added risk to the portfolios of insurers; the study finds that crop insurers are prone to portfolio risks 10 times greater than insurers for more classic risks (Miranda et al, 1997). If systemic risk is indeed the cause of market failure it interestingly provides some options. Under the asymmetric information belief the firm can either suffer actuarial losses or increase premiums resulting in lowered participation, neither offer a beneficial solution. However dealing with systemic risks offers several possibilities such as reinsurance(global, national) or exchange traded area yield options, however neither can fully cover the risks without government assistance (Miranda et al, 1997). The following graphic expresses the authors reasoning behind this statement.

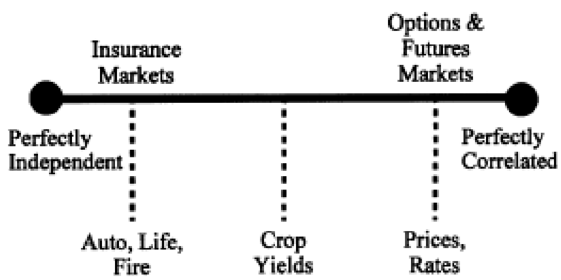

Figure 2: Correlation, Risk and Insurance
Source: Miranda et al, 1997.

The FCIC in the US has acted as a reinsurer to some degree, especially after the implementation of the SRA (Standard Reinsurance Agreement). There is limited potential for a private reinsurer to take significant interest in AYI due to, once again, the difficulty of diversifying systemic risk. However through increased company exposure and potential gains through underwriting due to newer SRA legislature private insurance involvement is predicted to rise (Glauber, 2004). The options market offers a degree of potential, but would only function effectively in highly concentrated areas where sufficient liquidity can be achieved (Miranda et al, 1997). The availability of options and bonds, especially for use in catastrophic disasters with risk spread across wide areas, are a direct result of the private insurance industries inability to deal with risks which are highly correlated (Mahul, 2001a). At the moment they appear to be the best viable solution for dealing with systemic risks.

The use of financial markets to transfer systemic risks from the private insurer has been discussed briefly in literature, focusing on the use of futures. A proposed scheme presents a model in which the insurer sells a AYI contract to producers and then uses the financial markets for handling system risks through use of a portfolio composed of contracts. Martial et al show that through a derivation of the price for such contracts a mixture of price futures, crop yield futures and zero coupon bonds can diminish the systemic risk component faced by insurers. The model rejects the practicality of reinsurance and hedging systemic risk from potential differences in year to year yields. Limitations include the incompleteness of a market for such future contracts due to limited liquidity. Pooling errors occur due to inadequate portfolio size and the assumption of "ideal market conditions" (Martial et al, 2003). This model is expanded on by Martial and Cordier in 2005 with a specific look a farm crop insurance emphasizing the need for insurance companies to access financial markets and futures contracts which temporarily were available by the Chicago Board of Trade from 1995-2000 (Martial et al, 2005). A more in-depth study has found that under the assumptions of unbiased market and a positive beta a short position on a future should be proportional to β (Mahul et al, 2000). In this example it is found that options and futures can provide risk protection on par with individual insurance and that there is "perfect systemic risk coverage related to futures contracts", hence reaffirming previous statements on the potential of financial markets (Mahul et al, 2000). In terms of options there are a variety available to producers in order to hedge against risks such as call options on water levels and temperature based options (Barnett 2000).

The GRP has gone through many alterations throughout the years, mainly regarding the change of allowed coverage (proportion of expected yield/revenue- Dismukes et al, 2005) and scale measures. One such example in when in 1994 farmers were allowed to insure for up to a 95% coverage level. This illustrates an important implication for the research, especially when designing an area yield program. The most successful AYI products have shown flexibility and an ability to adapt to changes in market and climate. Although there is has been a significant amount of discussion surrounding the method of distinguishing an "area", do to simplicity and cost effectiveness the US GRP has opted to use counties as the identified yield zone. Unlike Canada which has the option of continually re-drawing the boundary lines within its area yield program. A study by Wang (1998) states that the use of so called zones with homogenous attributes result in improved risk management and cost effectiveness over simply dividing by county. This was further reinforced by Ramaswani (2004) by deriving through use of models that clusters (specified zones) result in higher systemic risk while use of counties, or other aggregated areas, result in lower systemic risks and higher idiosyncratic risks (Ramaswani et al 2004). Although GRP areas are defined by counties, eligible counties are chosen on climate similarity and soil similarity (taking data availability as given). The importance of homogenous soil type is also mentioned in Barnett et al (2005). Miranda (1991) develops this further by stating the more homogenous climate and soil is in a specified area the more closely Beta (β) will amassed around 1. Beta (β) describes the correlation between an individual's yield and the expected area yield, this value is discussed in further detail in the calculation of premiums and indemnities. Miranda (1991) goes on to say that assuming that all farmers β is greater than 0.5 area yield insurance is risk reducing. This results is influenced by critical yield level (Miranda 1991). An interesting figure to consider is individual farm beta's relative to a national level, the results show that national yield variations have strong influence on individual yields with the majority centered at β (2.0-2.5) (Mahul et al, 2000).

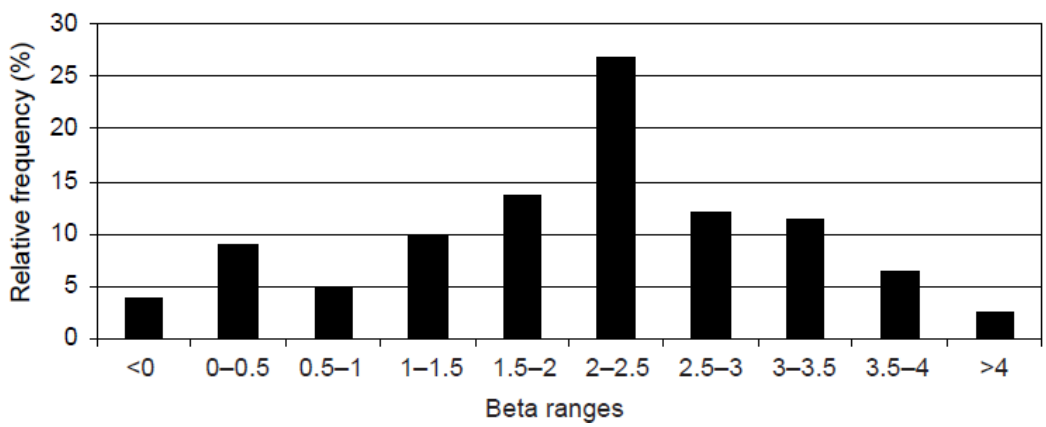

Figure 3: Farm relative to national yield Beta distribution
Source: Mahul et al, 2000.

A paper by Ramaswani et al (2004) suggest that merely stating that β depends on soil and climate calls into question the producers influence, since the models thus far treat yield and β as a stochastic variable (no producer control). Their paper speculates that β is also derived from technologies used by individuals, implying producer choice (Ramaswani et al 2004). Hence they elaborate on Miranda's statement of soil and climate, by adding factors such as management methods, farming expertise and assets as factors influencing β (Ramaswani et al 2004). Both β and critical yield are vital in any analysis of area yield insurance, and special attention will be paid to these variables throughout the design of this paper.

There has been some criticism of area yield insurance in that it is not an insurance product in the classical sense. It may or may not compensate a farmer for losses, depending on how the farmers losses are related to the indexed area. Mahul describes it in some cases as a put or call option, depending on the farmers relation to area yield. If β positive the contract behaves as a put option and if the β coefficient is negative the contract behaves as a call option, naturally a negative β is extremely uncommon (Mahul 1999b). Benefits of GRP vary from levels of risk averseness to choice of coverage level and budget. Scale and coverage levels can reduce basis risk, specifically scale is used as a solution to imperfect correlation of farm to area yield - first formally discussed by Miranda. GRP farmers can scale up to 150% (90-150%) (Mahul 1999b).

Data collection is based on historical county/area data, or in some cases crop growth simulators. In some cases simulators provide similar risk coverage to historical indexes, especially when levels of risk aversion are assumed to be low (Deng et al, 2008). The same applies in heterogeneous settings (as opposed to AYI preferred homogenous settings), (Deng et al, 2006). As to specifics of data collected most frequently an aggregation of acreage from harvested or planted acres is used (Barnett et al 2005). This varies from study to study, and some studies do not mention such a distinction. When confronted with the lack of individual farm yields, Miranda's specification can be used to simulate such data. When using time series data, as is used in AYI application and analysis, one must apply unit root tests for stationary points such as the Phillip-Perron test which was opted for by Zheng et al in their analysis of AYI viability in China. Roots tests are significant for the process of rejected false units from time series data (Zheng 2011). The majority of data is collected from NASS (National Agricultural Statistics Service) in the form of county yield data, while others opt for other forms of data collection to avoid certain forms of bias (Barnett et al 2005). Considering the expansion of AYI and other indexed insurance products the verification of yield data for particular crops, such as hay, maybe difficult due to the lack of sale certificates or book keeping (Barnett, 2004). According to a study conducted by Hourigan when comparing Area Yield Insurance, specifically GRP in the US, to traditional individual yield insurance the GRP choice resulted in 60% "variation coefficient" in revenue then with other insurance models. This result is enforced by studies conducted by Smith, Chournard and Baquet, further demonstrating improved risk protection with area yield insurance. The study on China resulted in preferable results for MPCI, however the authors note that in their case the significantly lower premium rate of AYI gave it the "competitive edge"- especially in regards to the indicator percentage risk reduction per premium. (Zheng 2011).

In current literature there is an imbalance with benefits of MPCI (multi-peril crop insurance) and AYI, with no decisively clear weight on the benefit of AYI. Many of risks associated with one do not apply to the other, for example one of the major issues with MPCI demand is the high elasticity (sensitivity to price) in low loss risk farms in turn having a negative effective on adverse selection, while AYI to a large degree completely eliminates the issues arising from adverse selection (Goodwin, 1993). AYI demand is characterized by the size of the farm, perceived yield risk, importance attributed to risk management, and leverage ratio (Sherrick et al, 2004a). General characteristics of insurance products that spark demand include choice of yield or revenue, affects demand, coverage level choices, and most significantly flexibility in terms of insured acreage (Sherrick et al, 2003). However Sherrick (2003) finds that higher premiums, which decrease demand, are synonymous with increased flexibility due to the resulting decrease in deterrence of moral hazard and adverse selection. A study by Makki and Somwaru (2001) reiterates the general characteristics of demand and proposes that increased variety of insurance products (such as total farm insurance vs. “crop for crop”) and the implementations of deferred tax reserves for farmers may play a role in simulating demand (Makki et al, 2001b). The knowledge of both the existence and strength of certain characteristics on demand should not be taken lightly when implementing an AYI in Australia because its attractiveness to producers is a necessity.

Risk associated with Area-Yield Insurance

Basis risk plays a major issue in area yield insurance, although Barnette et al 2005 would disagree as to its significance. Basis risk influences the selection of area, the method used to forecast yields, indemnity pay out rules, and protection (coverage/scale) levels (Barnett et al 2005). As one can see almost every nook and cranny of area yield insurance is influenced by basis risk. As mentioned earlier, the issue under consideration is not its existence but rather its degree of influence over the viability of area yield insurance. This topic is taken under examination by Barnett, Black, Hu, and Skees in their 2005 study of the competitiveness of area yield insurance. They found that for the midwest region the GRP program is not affected by tremendous amounts of basis risk, more importantly it is not necessarily more affected by basis risk than MPCI. They argue that MPCI also encounters basis risk through the unreliability of farmer provided information (disinformation for farmers benefit) and hence indemnities may be paid out when not necessary (Barnett et al 2005). This issue brings to light the major issues plaguing not only MPCI but many other traditional insurance products, namely adverse selection and moral hazard. Moral hazard is manifested in a variety of ways under standard insurance contracts, such lowered maintenance and lowered application of newly purchased inputs such as machinery (Shaik et al, 2000). However in some cases more hazard is applicable to both MPCI and AYI for example common practice of riskier production techniques to induce covered losses, this was seen in Kansas wheat farmers who decreased use of chemicals (yield maximization tool) after engaging in crop insurance (Smith et al, 1996). Issues of adverse selection plague MPCI due predominantly to information asymmetries which are too costly to eliminate. Under a certain perception a form of adverse selection does exist within AYI where high risk producers are favored over low risk producers hence forming an externality on low risk producers who would essentially be “subsidizing” the program (Turvey et al, 1995). Under MPCI when looking at the cost of adverse selection for cotton farmers in US, it was found that adverse selection cost (solely based coverage) choice amounts to 73,274,705 dollars (Shaik et al, 2002). When comparing the two the general notion is that AYI crop insurance out performs MPCI in homogenous zones, while MPCI does better in heterogeneous zones. Few studies have compared various indexed insurance products in a heterogeneous setting. A study by Deng et al (2006) finds that AYI out performs *cooling degree day* and simulated crop yield prediction models (DSSAT). It must be noted that in a heterogeneous setting MPCI outperformed all indexed products; it has also been found that demand for MPCI is greater among risk averse farmers, in wheat and grain sorghum, requiring larger AYI premiums subsidies for competitiveness. (Williams et al, 1993).

To control the aspect of basis risk (Barnett et al 2005) proposes the use of basis risk riders, which would protect farmers taking part in the policy from idiosyncratic occurrences- which are usually ignored by area-yield insurance contracts. The number one way of combating basis risk (besides area selection etc) is to increase the risk protection (from a farmers perspective) by choosing an area yield product when there is high correlation between individual yield and area yield (Miranda 1991). Another option, although not viable from an insurers perspective, is to limit the scale of the index hence having a more accurate and small "area" of similar (if not identical) risk correlation (Alabed et al, 2013). In nearly all indemnity calculating equations this relationship is represented by Beta (β). Furthermore Miranda 1991 states that an increase in yield variance of the producer increases the level of risk protection offered by aggregate yield insurance plan. A very recent approach to dealing with basis risk is multi-scale indexed insurance which completely eliminates "false positives" (indemnities paid when no loss occurs) and greatly reduces "false negatives" (Elabed et al, 2013). This was achieved through a dual trigger mechanism one on a very low level which must also coincide with a larger geographical area index (Elabed et al, 2013).

Risks arising from yield variation can be most effectively divided into 2 groups, idiosyncratic risk and systemic risk. More importantly the distinction between systemic and idiosyncratic risk (farm influenced) raises important issues regarding policy choice and also policy mix. Miranda equation famously decomposed the irregularity between farm yield and expected yield into the two risk groups, where systemic risk is measured as β multiplied by area yield deviation from expected yield, and ε represents idiosyncratic risks. This decomposition is used frequently throughout literature and further studies (Miranda 1991).

Systemic risks are considered to be covered most efficiently by an area yield insurance scheme, such as GRP, while idiosyncratic risks are managed on the individual basis or through other types of insurance. So called "wrap-around policies" have been considered for GRP in which the government handles systemic risks and private insurers cover individual idiosyncratic risks- providing an attractive risk mitigation mix. Such a combination of government and insurance markets has great potential as expressed by Huang, and further may lead to the strengthening and resilience of the insurance industry. Mahul goes on to state that the optimal area (aggregate) insurance exists if farm specific (idiosyncratic risks) are non-transferable, and those should be hedged on the producer level (Mahul 1999a). Further risks that should be mitigated at the producer level include price risks, which are often not dealt with under AYI. Using futures and options mixed with AYI allow for greater risk reduction on all fronts, and aids AYI to deal with yield and other systems risks (Wang HH et al 1998). This 1998 study explores further by stating that the observed negative correlation between price and yield creates a situation in which AYI is not effective for 100% coverage yield insurance. This peers into the discussion on optimal trigger values/restrictions and insured acreage restrictions. Expanding on futures and options a 2003 study shows how the use/non-use of replacement pricing (RP) for valuation of indemnities (referencing pre-planted and realized harvest future prices) effects optimal mix of futures and insurance types. The results show that using RP futures and revenue insurance provide superior management, while without RP yield insurance is preferred (Wang et al, 2003).

"Optimal" Area Yield Insurance

Much of the discussion surrounding an optimum area yield plan is centered around optimal coverage and scale versus full or predetermined coverage (Miranda 1991). These topics directly relate to basis risk, therefore to properly understand these topics a measures of risk reduction through AYI must be achieved. Miranda first successfully mathematically described this relationship in risk reduction and farm area correlations using variances and co-variances. A more recent study of AYI in China has improved upon this equation by using "risk reduction percentage per premium" instead of simply percentage risk reduction when defining their empirical model (Zhang et al 2011). Under area yield insurance the most important factors are optimal coverage levels and a high critical yield level (Miranda 1991). All study results, as stated before, depend on critical yield levels. Under Miranda (1991) the soy industry with critical yield of 88.5% the full coverage option results is fair premium rates. Some cases show that the removal of pre-determined critical yield values not only have the potential to decrease premium costs but increases performance of AYI especially when comparing it to individual crop yield insurance products (Wang HH 1998). However fair premium rates are not the only side of the issue one must consider. Coverage and scale are of great significance, and are affected by premiums. Premiums affect coverage choices due to the subsidization of premiums, this is due to producers not only focusing on risk coverage but also "capturing" as much of the subsidy residing in premiums as possible (Deng et al, 2008). This was also observed by Wang et al (2003) stating that proportional subsidization based on coverage levels leads to inept risk management and instead efficient subsidy gain maximization. When comparing optimal coverage, individual yield coverage and area yield coverage the optimal coverage offers the best risk reduction% (39.1%, 30.8%, 22.4% respectively).The optimal coverage is not one set value, but varies with the level of critical yield (Miranda 1991). General themes are that in AYI with higher Beta (β) the optimal (average coverage level is 160%) coverage provides the highest risk protection while under higher yield variances individual yield protection offers higher protection. Such studies provide a great deal of insight into the most effective use of area yield insurance, however obstacles are put in place through lack of government support. Coverage levels of 160% and higher than normal critical yields are difficult if not impossible to rationalize to the government. This issue further enforces the argument for separating risks to idiosyncratic and systemic, with the government's involvement solely relating to systemic risks. When looking at the relationship of coverage levels and critical or trigger yields it was found that in many cases, especially Iowa corn producers, the manipulation of acreage covered has little economic gain and a restriction of 100% coverage is beneficial proposition (Wang HH 1998). The soundness of a 100%

coverage level is further enforced due to producers preference for 100% coverage, under risk averse assumptions, in the presence of climate related information and also in the lack, displaying the robustness and general applicability of 100% coverage levels (Nadolnyak et al, 2008). Partially due to the work of private insurers and government subsidization reward for higher coverage levels, a trend of rising coverage levels can be seen between 1998 and 2004. Coverage not only depends on available subsidies but naturally is the result of higher allowed percentages of coverage, and the price of insurance itself (Dismukes et al, 2005).

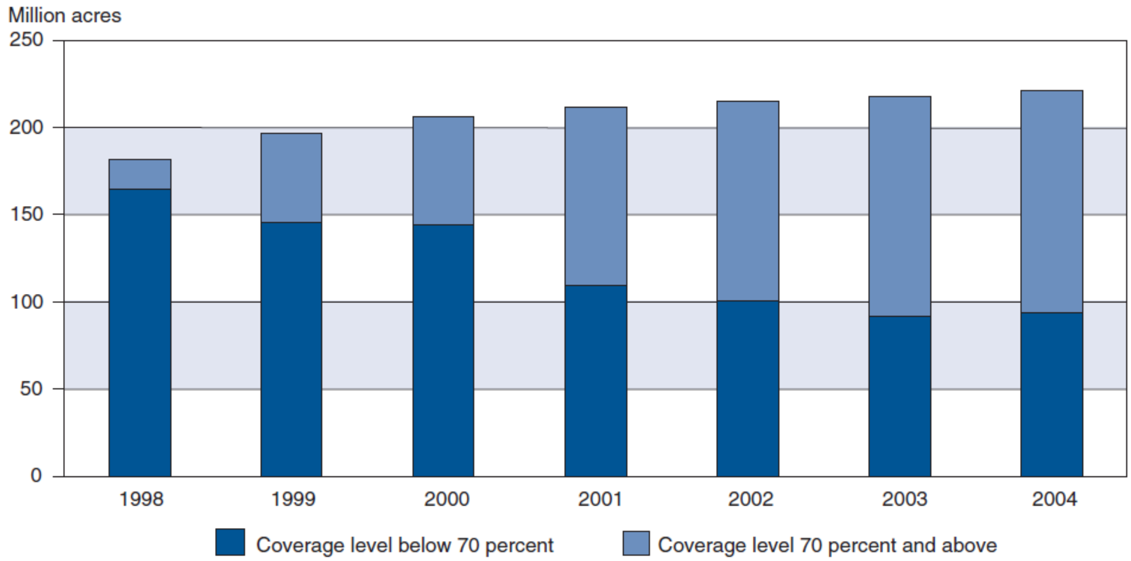

Figure 4: Rise of higher coverage levels from 1998 to 2004
Source: Dismukes et al, 2005

A study by Mahul (1999b) states that the optimal level of coverage is equal to β, if the premium is actuarially fair under the assumption of no constraints. This stance has been repeated through many further studies on the subject as accurate. The concept of no constraints reoccurs frequently within literature, and many state that current constraints thwart producers from receiving optimal protection (Deng et al, 2008). Furthermore optimum critical yield is directly related to the farmers utility function, more interestingly the farmers critical yield increases as the fixed (predetermined) coverage level decreases(ceteris paribus and constant absolute risk aversion) (Mahul 1999b). A study by Bourgeon and Chambers (Bourgeon et al 2003) discusses this issue however dismissing the assumption that the β coefficient is known to the insurer, essentially resulting in the asymmetric information model. The authors propose an interesting argument stating that even with private information if there is a choice of coverage levels adverse selection will exist because individuals with high β will opt for contracts designed for low β and hence take advantage of the system.

A study by Chambers and Quiggin (Chambers and Quiggin 2002), discuss the ideal area yield insurance in terms of optimal producer behavior. The primary assumption is that the producer behaves differently when he/she is enrolled in an area yield insurance scheme. Using the Arrow-Debreu state-contingent model, the authors model expected utility preferences, the stochastic production function, mean-variance preferences, and generalized expected utility preferences (Chambers and Quiggin 2002). Put simply the study attempts to find optimal production while under a given insurance contract. First it can be seen that unlike the risk neutral producer, the risk averse producer increases risky behavior when under the insurance contract, and more significantly resulting in change production patters to the degree that their idiosyncratic risks reflect their systemic risk (which is covered by the area yield insurance scheme) (Chambers and Quiggin 2002). The same was found in the simulation of AYI in Portugal. In this way the producer is able to benefit themselves by using the "income smoothing properties" of area yield insurance contracts. Thus an interesting issue regarding area-yield insurance is discovered: that although only targeting systemic risks idiosyncratic risks are nonetheless affected by AYI. Referencing back to the optimal insurance contract, Mahul implies that insurance premium should be proportional to expected indemnity and therefore should display "co-insurance" (Mahul 1999a). This enforces the common theory that for an ideal area insurance contract the scale and coverage levels should be selected by the producer (McCarty 1941). Furthermore when there are constraints imposed on coverage or scale, the constraint level on scale (coverage) has a direct effect on optimized coverage (scale) level (Deng et al, 2008).

A closer look at premiums, as stated before is of great benefit due to their influence on farmers and level of influence from distributions of yield which are discussed in the following section. For example many coverage level studies rely on premiums for their conclusions, a study by Mahul (2000) states that full insurance against an index is only optimal when the premium is actuarially fair. Premium values (insurance rating) are also influenced by neighboring counties, this issue is discussed by (Barnett et al 2005) and defined as spatial correlation. Spatial correlation can be a hint at the results from a study by Schurle (1996) which finds relationships between the number of acres a producer owns and yield variability. If in AYI there is high spatial correlation it shares similarity with a high acreage farm, interestingly the study finds that higher acreage (or spatial correlation) can lower potential premium rates by 15 to 37% (Schurle, 1996).

The concept of premium loading has recently been discussed extensively, especially on the factors that affect the amount or percentage of loading. Loading is influenced by private insurers desire to increase or create cash reserves for catastrophic events. Due to the popularity of this technique the FCIC moved to impose pre-determined reserve loading percentages of the premium (Barnet et al 2005). There is a relation between premium loading and basis risk (correlation of individual yield to area yield), as basis risk decreases the amount of loading also decreases. More specifically is has been observed that once individual to area yield correlation drops below 0.9 there is a visible rise in premium loading charges (Wang HH 1998).

A further major discussion point within premium rating and estimation is the role of so called "wedges," which describe the difference the premium cost and what the producer can expect in an indemnity payout. A positive wedge results in higher premiums compared to indemnity payout, and a negative wedge works vice versa. The recognition of wedges plays a significant role in the use of premium rating methods, more specifically it calls into question the use of actuarially fair premiums which become unrealistic with the introduction of positive wedges (Deng et al, 2007). The study makes a comparison of 3 premium ratings (actuarially fair premium rates, subsidized actual premium rates, and unsubsidized actual premium rates) with the following results,

		Actuarially Fair Premium Rates		Actual Unsubsidized Premium Rates		Actual Subsidized Premium Rates	
Crop	State/ CRD	*Coverage* (70%–90%)	*Scale* (90%–150%)	*Coverage* (70%–90%)	*Scale* (90%–150%)	*Coverage* (70%–90%)	*Scale* (90%–150%)
Cotton	GA/50	90%	112%	90%	113%	90%	118%
Cotton	GA/60	90%	113%	90%	130%	90%	138%
Cotton	GA/70	90%	118%	90%	114%	90%	150%
Cotton	GA/80	90%	120%	90%	119%	90%	125%
Cotton	SC/30	90%	130%	90%	126%	90%	150%
Cotton	SC/50	90%	133%	90%	105%	90%	150%
Soybean	SC/30	90%	125%	90%	112%	90%	134%
Soybean	SC/50	90%	90%	90%	90%	90%	90%

Figure 5: Optimal coverage & scale under alternative premium rates
Source: Deng et al, 2007.

from which one can see the change in optimal coverage and scale in respect to premium rating schemes. The optimal scale levels are clearly over 100% for the majority of crop, state and premium rating, which reinforces our previous discussion of Miranda's findings (Deng et al, 2007). The table provides valuable insight into the effects of various premium ratings, and show the importance of considering premium wedges. The study goes on to use actual subsidized premium rates for comparing AYI and MPCI. AYI proves to be a preferred choice even in a heterogeneous production factor area, in contrast to previous literature emphasizing the need for systemic risk maximization through choice of homogenous areas (Deng et al, 2007). Further discussion is necessary on optimal indemnity payouts, in which consideration must be placed on the success of "lump sum" indemnities versus indemnities proportional to underperformances in expected yield. The use of constrained efficient contracts allows for lump sum payments and also the previously mentioned proportional indemnities. The use of a lump sum indemnity is found to not be realistic or applicable in the real world particularly when trigger values are under a constraint (Vercammen, 2000). The paper by Vercammen provides insight into premium, trigger and indemnity relations when considering constrained efficient contracts. These findings include an inverse relationship between indemnity and yield trigger levels, and finally an increase in premium loading when indemnities are increased (Vercammen 2000).

Crop yield data estimation

Premium rates are closely related to crop yield distributions and are affected by a variety of factors and can vary from county to county. Issues have been raised on non-actuarially fair premium rates between counties simply due to one county experiencing a catastrophic event (Kevin 2004). The premium rates are based on yield rates, which as is known can have strong variability even in close vicinities. Premium rates play major role in the success of insurance contracts and are influenced by crop yield risk measurements, which in turn are influenced by yield distributions (Goodwin et al 1998). Hence crop yield distributions are a core issue in area yield insurance and the valuation methods impact insurance valuations (premiums) and risk assessments. Goodwin's paper speculates that a preferred technique to crop yield distributions estimates is a non-parametric approach, due to its ability to capture idiosyncrasies unique to certain areas and have a major impact on yield distribution. Furthermore non-parametric measures do without major assumptions, such as the unrealistic necessity for using an appropriate parametric type to describe the yield (Zhang, 2011). Through a policy simulation (Goodwin et al 1998) discovers that to improve actuarial performance of GRP contracts non-parametric premium rates should be used alongside alternative yield forecasting procedures. The study performed this using double exponential smoothing for forecasts and univariate time-series models (ARIMA). When estimating wheat and barley for the GRIP by the Government non-parametric methods are used (Goodwin et al 1998). Two years later in a paper revisiting nonparametric kernel estimators Ker and Goodwin expand the discussion by proposing benefits by specifying a conditional mean yield density at a given point in time and space through a "Spatio-temporal" process for yields (Ker et al, 2000). Another nonparametric estimator which uses joint modeling of yield data and discrete county data, proved to successfully increase an insurance companies' ability to acquire gains or losses from underwriting new contracts hence motivating its efficiency (Racine, et al 2006). This 2006 paper found that the new estimator when compared to the estimator proposed by Goodwin (1998), significantly outperform through higher efficiency,

Taking a look at Texas cotton production provides yet another insight, due to the irregularity of data in many counties. A study by Chen and Miranda (2006) orthodox parametric trend evaluation fails many counties creating inaccurate premium and rating values. A solution is presented through use of semi-parametric mixture distributions to analyze trends computed by a piecewise linear spline. The necessity for an alternative technique arises from the inaccurate results of parametric distributions evaluated: normal distribution, lognormal distribution and beta distribution (which was rejected by all counties). A mixture distribution model takes into account severe weather and crop failure by being "conditioned" by outside economic and environmental factors (Chen et al 2006). The results display a far more accurate portrayal of data and also resulted in higher premium values for the majority of counties undertaken, which has major implications on the current measurements of premiums and hence possible explanations for actuarial problems experienced in this area (Chen et al 2006).

Incorrect premium calculation has also been blamed for big government subsidies and issues with private insurance company returns. A paper on the accuracy of premium rates based on data from the University of Illinois Endowment Farms proposes the use of a complex (and hence expensive) premium calculation technique. Yield distribution estimates are calculated using parametric normal, Sua, Sub, Sba, and Sbb distributions, afterwards comparing newer parametric premium estimation versus the historical cost –loss estimation technique. The results show that using the later method results in large margins of error in premium rates, affecting much of the insurance products success (Ramirez et al, 2011). Although this study utilized individual farm yield data and was not conducted from an AYI perspective, but rather MPCI, it still provides valuable insight into more sophisticated estimation techniques and more importantly the accuracy of current premium values faced by producers.

Efforts to improve premium rates and actuarial soundness of AYI contracts include incorporating additional data, rather than only discussing yield distribution methods. A study by Nadolnyak et al (2008) promotes the use of climate forecasts in yield distribution and premium calculations. Specifically looking at the El Nino's effects on the southeast US a relation between yield distributions and different phases of the El Nino Southern Oscillation (ENSO), leading to more accurate premium and insurance ranking measures. Looking at different phases (El Nino, La Nina, and "calm" neutral phases) it is found that taking climate related influences under consideration improves the actuarial soundness of both individual and area based crop insurance contracts (Nadolnyak et al, 2008). Although this added information has no effect of producers choices of coverage it does improve risk management indirectly through rates. The incorporation of other data sets, such as climate data from El Nino, offers an alternative approach to calculating accurate premiums however specifically in regards to AYI one must be aware of issues with the effectiveness of using weather indexes on the aggregate farm level over the individual level. Tests have shown that area (or aggregate farm) insurance coverage is inferior in weather risk hedging effectiveness when compared to individual farm coverage (Heimfarth et al, 2012). However weather risks are a particular case, and weather indexed insurance is seen as the only appropriate option to handle such risks alongside the use of related weather derivatives in the financial markets (Mahul, 2001b). As with nearly all discussion of crop insurance contracts the region at hand plays a decisive role in the outcome of a study, for example in Kazakhstan AYI outperformed (marginally) weather indexed insurance in weather risk reduction (Breustedt et al, 2008).

Implementations in other countries

Recent introductions of AYI in new markets and countries has revolved around developing nations. One such study was on rice farmers in the northern valleys of Peru. According to the thesis by Christopher Rue, although focused on issues concerning developing nations, serious considerations need to be taken when calculating actuarially fair premiums and additional costs that may be implemented in a more realistic setting. One such cost which has a wider application is cost loading, which was mentioned earlier in regard to private insurers increasing cash reserves for catastrophic events. The study finds that for Peruvian rice farmers an actuarially fair premium results in 86.5% demand for the product, but when adding in cost loading and varying consumption minimum uptake drops dramatically, in some cases nearly by half (Rue 2011).

More significant for the study that this paper focuses on, Rue derives estimates for insurance demand based on coefficients of basis risk specific to individual farmers, which are acquired from farm yield data provided from the Peruvian government (Rue 2011). Specifically singling out Latin America as a potential area of growth for AYI a variety of issues come to light which, although to a lesser degree, also apply to implementation in developed western nations. These include the requirement of an independent data collection organization, reliable data monitoring technology, and financially secure indemnity payout companies (Wenner et al, 2003). Taking a brief look at AYI simulation in a western country from a study previously mentioned on the topic of Portuguese dry land AYI displays similar issues and shows the high need for government subsidies (Serrao et al, 2000).

Multi-scale indexed insurance was mentioned earlier as a tool to decimate basis risk faced by producers, and specifically aimed at small scale producers. This study by Elabed et al was performed on cotton farmers in Mali, who due to high yield fluctuation opted out of loans and more profitable and risky production. The standard 1 trigger indexed area yield insurance was not accepting by the community due to substantial basis risk due to volatile climate and variation from region to region. The driving factor behind lowered demand was basis risk and the ambiguity (or compound risk) associated with a single trigger product, this second risk was found to drive demand even lower and a stronger rate. This setting allowed for the potential success of multi-scale indexed insurance. The results were highly positive with false negative factor of basis risk falling from 70% to 35% and probability of false positives completely eliminated (Elabed et al, 2013). Through false positive elimination this program shows potential interest from insurers, while the remainder of basis risk reduction was shown to promote producers profitable activities, use of loans and joint liability loans, and lowering risk rationing where existing collateral is not a sufficient incentive to take up loans (Elabed et al, 2013).

Taking a look at Lichi production in Vietnams mountainous region displayed that the introduction of insurance did not have any effect on simulating production of the profitable Lichi, unlike in Mali were enticing farmers to engage in more profitable yet risky production was of great importance. An all-risk AYI contact was introduced to the lichi producers, this was due to desire for fraud limitation and also area yield performed successfully (Vandeveer, 2001). Interestingly although the program proved to reduce yield variability it did not influence income variability. A key issue from the study which applies to many developing countries is the accuracy of expected yield estimation, which can be challenging both in terms of data collection but also unforeseen production fluctuations and type of crop (production of lichi varies greatly by tree age, many tress reach their peak at 15 years while a tree reported high yields at age 200).

An interesting implementation outside the US is indexed live-stock insurance in Mongolia, based on counties. The use of AYI in other agricultural fields has been discussed and a viewed with potential, such an example is livestock. Due to high death rates Mongolia implemented an indexed-insurance with the help of the World Bank, although the study deviates from crop insurance it encounters many identical issues and more interestingly provides a framework for such implementation in a developed country. Indexed insurance was chosen due the reasons listed in previous example and also the extreme cost of monitoring in the immense expanse of Mongolian herders (Mahul et al, 2007). Several innovative steps were taken to maneuver around some of the major challenges. Firstly to handle severe losses an insurance provider pooling syndicate allowed for pooling of insurer revenues for reserves and spreading risk. Second banks were involved in providing low interest rate loans for insurance contract purchases, and finally a government sponsored "public awareness" campaign was launched to increase demand (Mahul et al, 2007). Furthermore when considering less developed nations, interested in AYI and other indexed products, prior to the introduction of a more complex and specialized scheme it is beneficial to first implement catastrophic risk coverage as a means of eliminating major and outlier risks (Skees, 2008). A 1991 study proposes a modifies AYI contract with link to financial markets so credit and risk markets are connected. Through this governments which may be unwilling or unable to fund crop insurance can transfer some weight to the financial markets, which would be able to handle covariate risks more effectively (Skees et al, 1999).

Finally implementation of crop insurance schemes can have effects that spill over domestic boundaries and have global economics effects. Such issues in detail are beyond the scope of AYI implementation, however none the less an awareness of potential global influences is important. Insurance products have been documented to effect production habits and patters, such as planting risker crops however also in some cases over production (Glauber, 2004). The importance of such distortions has been seen the past several years where Brazil filed a claim at the WTO (World Trade Organization) against the US for distorting its cotton production, directly influenced by new cotton crop insurance products (Glauber, 2004).

The expanse of literature on both AYI and various crop insurance products provides a solid framework on which to rely on during the implementation of AYI to a new environment. More importantly potential benefits of yet another analysis and implementation become clearly visible, particularly in several areas. Primarily the area of government involvement is stressed within the review, and one may draw the conclusion that without government subsidies crop insurance will not exist. However there are means of reducing its presence such as use of financial markets and broad cost reduction. Others include stimulation of farmer interest and potential benefits through the use of "ideal" or "optimal" coverage, scale and premium rates. However the discussion reveals there is no one ideal data distribution measurement or degree of government involvement but rather that it various from scenarios, just as there is no one universal taxation system. Furthermore almost comically there is no ideal for optimal insurance contracts in terms of coverage, scale and area. Rather it varies depending on a myriad of influencing characteristics ranging from producer behavior to environmental factors to government involvement and regulation. Crop insurance for those well versed in the field may imply a near contradiction, due to high degree of systemic risk and idiosyncratic risks associated with excessive monitoring costs. These are essentially the “founding” problems of crop insurance, however due to agricultures importance in economies and welfare a solution must be found. One should not lose hope and see a set of guidelines rather than rules come into sight which could regulate the construction of crop insurance products. In this way although the research presented in this paper has a primary focus of AYI it will most definitely has implications for the entire agriculture insurance market. As implied these issues are universal in their influence on the industry, and significant topics such as government involvement can be broken down into a process for identifying risk groups through (possibly) the use of financial instruments by which they can be separated and dealt with in the most efficient manner. Over universal suggestions which currently exist are boundary designation in area products, preference for non-parametric or mixed distribution models, table market for reinsurance and financing, basis risk reduction, cost reduction, and the necessity for widespread demand. Australia shares characteristics of undeveloped countries in the lack of interest for crop insurance, however it displays a unique opportunity for study in that it already has an established crop insurance market (although limited). The size/global significance of the agriculture market predicts great insights into insurance, exponentially higher than those already gathered from implementation in less developed nations. Furthermore the existence of efficient data collection organizations and a strong academia not only inspires confidence in the research at hand but for further discussion and ultimately a successful aggregate indexed crop insurance scheme.

References for literature review found in Appendix C

3. Data

As mentioned in the introduction 5 Australian shires were selected for the purposes of this study. Beverly, Koorda and Dumbleyung are the shires within close proximity of each other in the state of Western Australia. Koorda stands of out from the group due to its northern location and being in a relatively more arid region. Emerald and Wambo also share the fact that they are in close proximity and are located near the east coast of Queensland. The producers considered in each shire are concerned with wheat production, over a span of 112 years (1901-2012). Since the crop yields are annual, this study is not able to differentiate between seasonal crop yields (winter yield for example). Such specification is useful, as yields vary from season to season based on various factors already under considering within this study, such as differences in rainfall affects yields (Fontana et al, 2007).

Yield data simulation has made impressive progress over recent years both in accuracy and length of predicted time period. For example a technique used on a basis of season rainfall is GCM (General Circulation Model) which improves upon previous techniques both in accuracy and length of "lead time" (Hansen et al, 2004). Further innovations include use of advanced satellite imagery, as performed over Queensland, by capturing "reflectance" over large areas with the use of Moderate Resolution Imaging Spectroradiometer (MRIS) (Potgieter et al, 2011).

The correlation of wheat yields between the selected shires offer a glimpse at how AYI is affected by various environmental factors and, more importantly, the possibility of risk diversification between insured shires. Using shire level data the correlations between shires display the following results.

Table 1 – Yield correlation among shires presented alongside respective distance in Km

	Beverly	Dumbleyung	**Emerald**	Koorda	**Wambo**
Beverly	**1.00000**	**153.46 Km**	**3,206.60 Km**	**155.98 Km**	**3,360.82 Km**
Dumbleyung	**0.37428**	**1.00000**	**3,166.5 Km**	**276.36 Km**	**3,284.77 Km**
Emerald	**-0.02876**	**0.01938**	**1.00000**	**3,130.5 Km**	**511.55 Km**
Koorda	**0.46507**	**0.31595**	**-0.09078**	**1.00000**	**3,301.72 Km**
Wambo	**0.05081**	**0.05355**	**0.43212**	**0.12913**	**1.00000**

Alongside the results for inter-shire correlation the graph offers the distance of shires in kilometers as one of the characteristics, which accounts for the variation. The myriad of causes for the correlations seen above is spoken of throughout this paper. As could be expected distance does not account for all the variations, this is seen simply by noting that the lowest distance in kilometers does not represent the highest level of inter-shire correlation., the same as true of most distant shires.

Both Emerald and Wambo are located in Queensland, and have for this reason been set in Bold. Interestingly these two shires do not share the closest correlation found between the shires, which is found between Beverly and Koorda (correlation coefficient of 0.46507). One must keep in mind that not only agro-climatic factors should be considered but also the "shape" or historical designation of county boundaries. In an effort to expand on this, it is important to understand Australian shire designation, in which agro climatic factors do not decide upon shire boundaries. More importantly shires throughout Australia (including the ones under study) have wide rectangular shapes, which inherently have a high likelihood of combining different climate patterns (ie variation in rainfall) and soil qualities. Not all weather patterns have been clearly defined and timed, hence certain variables affecting correlations between shires may be unobservable from an empirical standpoint, such as the effects of the El Nino effects on Australian producers (Potgieter et al, 2005). Clearly such an understanding is vital when discussing reasons for high or low shire yield correlations. As can be found in the literature review, a form of AYI in Canada allows for flexible shire/county designation in regards to yield insurance. From an AYI perspective, the ideal is to work with highly homogenous pools within a highly heterogeneous ocean composed of the individual pools (Ramaswani et al, 2004). Permitting greater risk diversification for a national insurer. Furthermore the potential lack of homogeneity within shires results in a strong influence of basis risk. One may say that these two issues along with need for government co-funding are the major obstacles facing AYI implementation in Australia. For example in 2012, according to the US congressional research service, the US government paid 62% of the premium charges faced by farmers (Knutson, 2013). A figure that would be politically unfeasible for Australia when considering the introduction of a crop insurance scheme.

Although the highest correlation is not present between Emerald and Wambo, they clearly have significantly lower correlations between the remaining shires from Western Australia. Emerald displays negative correlations with respect to Beverly and Koorda (-0.02876, -0.09078 respectively). Correlations of shires in Western Australia have intuitive results in that they share relatively high correlations amongst each other. For this reason the correlation results are intuitive and express confidence in the subsequent analysis.

Due to the lack of sufficient historical data on yields of producers within Australia, agro climatic simulation of shire yields was opted for. Sufficient is defined as at least 100 years of yield data necessary for a rigorous and robust statistical analysis. Throughout the analysis the number of simulated farms has been equal or greater than 1000 simulations. For the simulation of variance reduction among farms, 10,000 farms where simulated and 20 randomly selected farms were chosen per shire. The following section discusses this process in greater detail.

4. Methodology

In order to achieve farm level yields, Mirandas specification is used as a tool for farm level yield simulation (Miranda 1991). Mirandas specification takes both systemic risks and idiosyncratic shocks under consideration, where a beta value represents basis risk. Farm yield levels are produced at 10,000 hypothetical farms for a 0.02 degree of farm level yield divergence from area yield. Different levels of divergence are used as a form a sensitivity analysis and in an effort to produce realistic results. As previously mentioned, users of AYI are prone to basis risk, which has a positive relationship with the degree of divergence measure used in simulating farm yields. In an effort to prevent encountering negative or zero value individual farm yields a function is introduced in so that if through the simulation a zero value is achieved it is replaced with the minimum value for area yield, within an interval of -/+ 0.5 yield- representing either a higher or lower level of yield from the specified area yield minimum. Hypothetically a farm could receive an annual yield of zero, however this is highly unrealistic. More importantly the reason for the replacement of such values is due to issues they create among large data sets when trying to calculate certain values, such as expected utility.

Farm level yields are not readily available. Therefore, the simulation method as per Coble and Dismukes (2008) is performed, which in turn is based on Miranda's (1991) specification of farm yields:

$$Y_f = \mu_f + \beta_f(Y - \mu) + \varepsilon_f \quad (1)$$

where Y_f is farm yield, Y is area yield; μ_f and μ are historical means of farm and area yields, respectively, and β_f is a measure of farm-to-shire yield deviation responsiveness. Finally, ε_f is idiosyncratic risk faced by a farm.

With regard to idiosyncratic shocks defined by ε_f in the above equation, followings Miranda's formulation Coble and Dismukes (2008) discuss the estimation of such an idiosyncratic risk by means of finding a minimum value of the difference between an "average effective premium rate" and the "simulated expected loss cost" subject to a specified standard deviation (Coble and Dismukes, 2008). The deviation of farm yields from shire yields throughout this paper is used by adjusting the value of what Coble and Dismukes (2008) referred to as average effective premium rate on a scale of 0.01 to 0.2; this value will be referred to as epsilon.

As per standard AYI design indemnities are triggered when average farm yield falls below a predetermined (or average) shire area yield trigger yield.

The value of indemnity payout out is given in terms of "units of yield" rather than monetary payout. Although not tightly conforming to a realistic payout it alleviates the burden of referencing wheat prices through out the years and digressing into any controversies, which surround the separate subject matter of price risk for producers. Furthermore, this setup allows for a clear depiction of how the insured area yield (adjusted with potential indemnity payouts) reflects non-insured area yield values. The indemnity payout is calculated as:

The indemnity payout is calculated as:

(2) $$I = \max\{0, \mu_Y C - Y\} \times \delta$$

where Y is observed area yield, μ_Y is its historical mean, and C is coverage level. Indemnity is calculated as a function of coverage level, while keeping the scale parameter, δ, constant at 100% (Barnett et al, 2005).. Throughout the relevant literature ideal coverage levels have been discussed to a much greater extent than scale, primarily due to its higher level of influence over the design of an AYI contract. For this reason a constant scale of 100% is chosen, while coverage levels range from 0-160% in an effort to encompass all coverage levels discussed throughout literature in both hypothetical terms and also in terms of those coverage levels already available under the existing products (such as the GRP- Group Risk Plan). It is important to note, that although a coverage level of 160% may maximize variance reduction of expected utility, the corresponding premium charge makes such a rate unfeasible. However Miranda in the 1991 paper found that for optimal coverage AYI the average coverage level was set at 160%, for Kentucky soybean producers (Miranda 1991). Furthermore premium rates are already subsidized, especially at lower coverage levels, resulting in high taxpayer expenses and the appropriate controversy in response. Taking the US individual revenue insurance for corn in Minnesota as an example, the subsidization % per each premium is as follows: 71% subsidy for 60% coverage, 66% for 75%, and 49% for 85% coverage (Thiesse, 2012).

The insured producers have a right to these payments if there is a breach of the trigger value and naturally if premium payments are made. Premium payments are calculated as:

(3) $$\pi = \frac{\mu_I}{\mu_Y C}$$

where $\mu_I = E(I)$ is expected indemnity, and π represents the actuarially fair premium rate charged.. The actuarially fair premium rate refers to the rate at which the premium paid is equal to the net value of expected payoffs (Barnett et al, 2005). From the perspective of the insurer this premium is charged equal to the expected indemnity payouts during a contractual year. Naturally this rate is not experienced in a real life implementation where administrative costs and premium loading add a significant cost the premium rate experienced by producers. Premium loading is often present in shires/counties where the correlation between farm yield and area yield is below 0.9 (Wang HH 1998). However the choice of actuarially fair premiums in the research work is consistent with previous studies made on crop insurance schemes and implementations.

The aforementioned designation between insured and non-insured area yield allows for the primary calculation performed within the research. The primary indicator of what effects AYI is a variable referred to throughout the text as Insurance Effectiveness (or yield variability reduction through insurance). Insurance effectiveness is calculated as:

$$\%\,\Delta\,\sigma^2 = \frac{\{\sigma_0^2 - \sigma_I^2\}}{\sigma_0^2} \tag{4}$$

where σ_0^2 is farm yield variance without insurance and σ_I^2 is farm yield variance with area insurance. The variance-reduced values, $\%\Delta\sigma^2$, are taken as a mean of 20 representative farms per shire at each coverage level 0-160%. Meaning that at coverage level of 0% there should be a reduction in yield level of zero, representing the status quo. To analyze benefits of area-yield insurance, the expected utility approach is implemented. Expected utility calculations reflect producer's preferences in the context of a tradeoff between mean returns and risk reduction, taking into account their risk-aversion, under the assumption of constant relative risk aversion (CRRA). Similar to Ubilava et al (2011) expected utility is calculated as:

$$\epsilon(U) = \begin{cases} \frac{\mathrm{y}_I^{(1-\theta)}}{1-\theta} \; if\ \theta \neq 1 \\ \ln(\mathrm{y}_I) \; if\ \theta = 1 \end{cases} \tag{5}$$

where θ is constant relative risk aversion coefficient, and y_I is farm yield with insurance. There are various forms of risk aversion to be considered, and even greater consideration given to the values for the risk aversion factor. Within economics and for studies such as the one at hand constant relative risk aversion (CRRA) is most often chosen as an adequate representation of risk aversion (Siegel and Hoban, 1982). The value of CRRA, which ranges from 0 up to 10, is a source of even greater controversy. However a CRRA value of 2 is referred to as the benchmark. This benchmark varies minimally in certain studies, such as CRRA of 1.92 among rural producers in Paraguay, however generally for the use in related studies 2 is viewed as an acceptable choice (Schechter 2007). In an effort to not only select previously used values for risk reduction a choice of 0-7 is taken in this study, allowing for greater robustness of results and comparison. It is interesting to note that a study by Deng et al (2008) has shown that under low risk aversion levels the use of simulated shire yield data results in highly similar results as historical risk reductions.

Based on the E(u) values acquired through the previous calculation Certainty Equivalents (CE) are calculated. Through the use of CE the results offer a more consistent range of values on which to draw conclusions and comparisons. Although the negative E(u) values received at high risk aversion levels are theoretically accurate, CE presents a more powerful tool for representing preferences and values of the producer. CE in its simplest definition describes the indifference values of the producer, more specifically its value represents the lowest payment a producer would be willing to accept (WTA) to avoid a certain negative outcome at various levels of risk (Ubilava et al, 2011). One must note the difference in such measures in using WTP or willingness to accept, how much would a producer be willing to accept for carrying a particular risk. These measures should not be confused in the context of this paper, with WTP used more often in a direct government policy implantation situation. The CE are calculated as follows:

$$CE = \begin{cases} [\epsilon(U)(1 - \theta)]^{\frac{1}{1-\theta}} \; if \; \theta \neq 1 \\ \mathrm{e}^{\epsilon(U)} \; if \; \theta = 1 \end{cases} \quad (6)$$

The functions given above used in simulation analysis, which is performed using econometric software R. For each shire a various sets of farm yield divergence (from area yield), coverage levels, and risk aversion levels are considered to perform sensitivity analysis. Within each shire and each representative farm, 10,000 farm iterations are performed, yielding the simulated indemnities and associated yield variance with and without adequate insurance product..

Finally the correlation between farm yield and shire yield is calculated. This step does not contribute an entirely new view on the viability of AYI in our representative shires, however it speaks more directly to sustainability of AYI in any particular shire. The greater the correlation the higher the expected utility will be per insured, due to a closer similarity in rises and falls of shire and farm yields. Through the farm yield simulation the divergence of farm to shire yield can be specified by the value of epsilon, for the purpose of the study a range of values from 0.01 to 0.2 are used. Amassing all the above measurements should offer a picture of the benefits and pitfalls of AYI in Australia, and also result as a sensitivity analysis for the overall results. Furthermore the comparison between various shires offers and opportunity to measure the amount systemic risk found throughout Australia and the resulting risk diversification tools available to the insuring organization.

5. Results

Initially a look is taken at the yield means of all shires combined for each year 1901-2012. This provides a basic reference point regarding the individual farm yield to such a mean yield on the scale of all shires considered. Although 5 shires do not provide a great deal of statistical power in the representation of Australia as a whole, it does display the starting relationship in one clear graphic depiction.

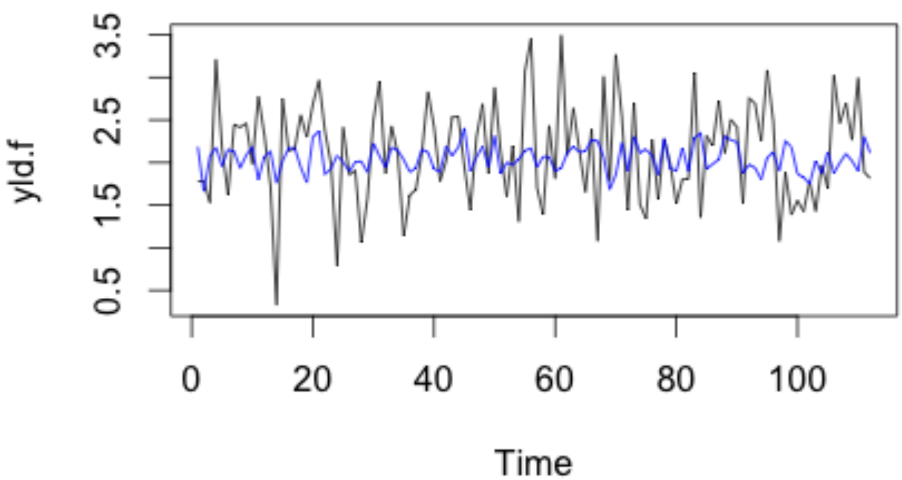

Figure 6 – Mean farm yields across all shires vs. Mean shire level yield of all shires

The graphic above displays shire yield through the 112 years of available yield, alongside the yield of an individual farm without insurance. As mentioned previously the divergence of farm yield to area yield is set at a degree of 0.1 within the Miranda equation. The blue line displays shire level yield while the dark line represents the individual farm. Simply from viewing the results one can see many opportunities where basis risk occurs. Naturally individual farm yield is far more volatile than the aggregated area yield.

The epsilon or divergence of farm to shire yield has an inverse relationship with the correlation of shire to farm yields. This relationship varies from shire to shire and as stated previously is a key consideration when interpreting the results. The following graphic displays the change in correlation (Y-Axis) as Epsilon values rise from 0.01 to 0.2 at intervals of 0.01.

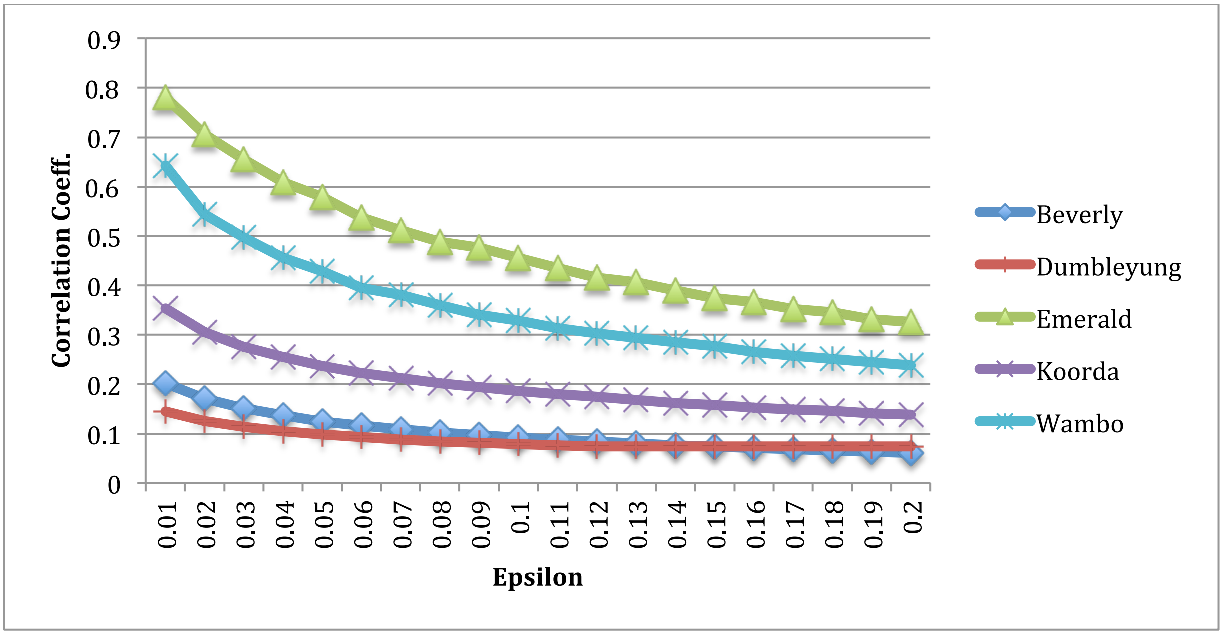

Figure 7– Effective of change in epsilon on the correlation coefficient of shire to farm level yields

The results paint a clear picture in regards to which shires have the highest correlation between farm and shire yield. Emerald displays the highest correlation at any epsilon value. Wambo and Koorda take 2nd and 3rd positions relative to Emerald, while Beverly and Dunbleyung intersect. This intersection displays that after the 0.15 epsilon value the Beverly correlation coefficient is lower than that of Dumbleyung. Finally there is a clear trend among all shires in the relationship between the rise in epsilon and correlation coefficient, with Dumbleyung and Beverly displaying less dramatic steepness of the decline in correlation with respect to the remaining shires. This simply implies that the correlation of farm and shire yield in Dumbleyung and Beverly is less sensitive to changes in epsilon, and due to their position on the bottom of the graph , have the lowest correlations. The correlation coefficient should have a clear relation to results on variance reduction (or insurance effectiveness) and certainty equivalent for the producer.

With the introduction of coverage levels (0-160%) we are able to display premium and our variance reduction values across a wide spectrum of coverage. Premium rates remain uniform, with extremely minor variations between shires. Premiums take rise at either 60, 70, 80, or 90%. Afterwards the level of growth slightly varies however at full coverage level all shires meet at a premium percentage of 0.375. In order for an insurance contract to be attractive to a holder the premiums should represent benefits in either variance reduction or CE maximization.

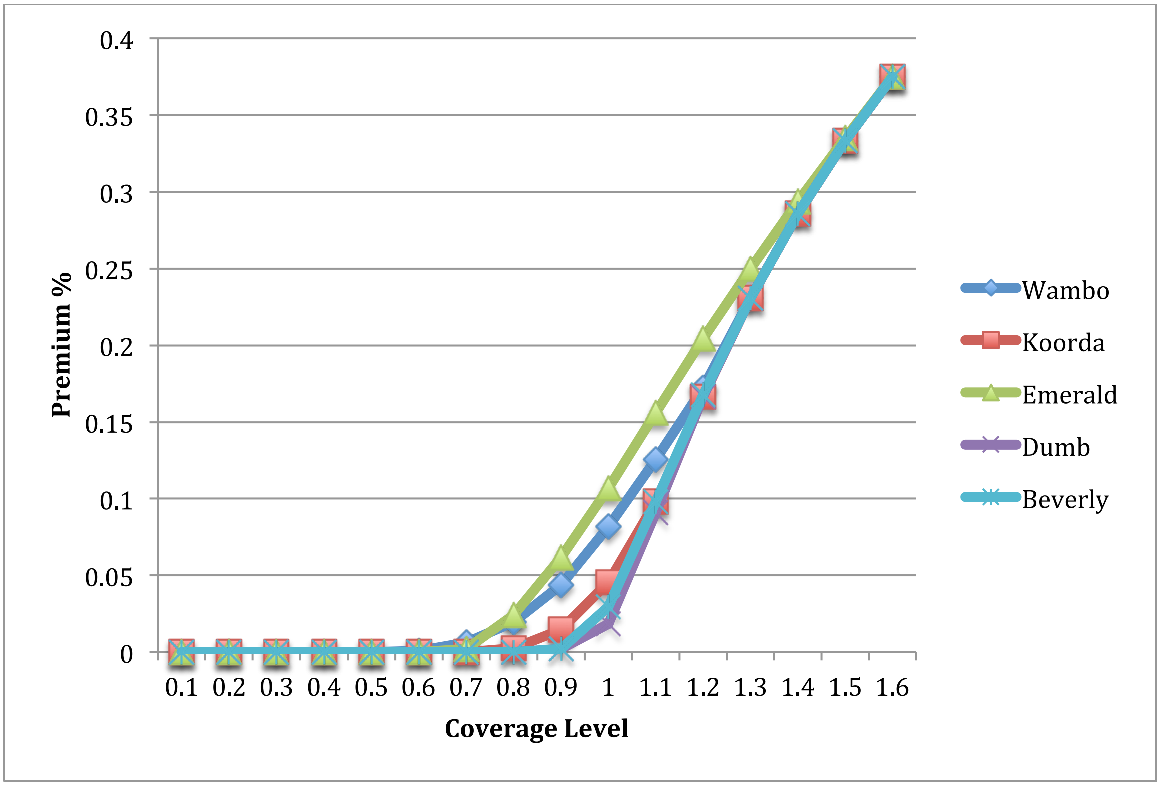

Figure 8 – Rise in premium rate over coverage levels 0-160% compared among shires

The results are sound in terms of a theoretical representation of premium rates, which the shire data has proven to move alongside with. At very low coverage levels there is no premium payment (as a percentage of yield), this interestingly extends for relatively large portion of coverage levels up to 60%. There are several reasons for this, which will be discussed in greater detail in the subsequent section, however in a basic sense at these levels of coverage the differences between shire and farm yield and negligible hence there is no actuarially fair necessity of high premiums (if any). Furthermore, at low coverage levels indemnity payouts are not triggered hence premium payments must be appropriately low.

The results seen above should be echoed by the results for the insurance effectiveness measure (or variance reduced through insurance). At lower coverage levels the indemnity payments will not be triggered and hence there will be no justification for an increase in premium. While at high indemnity payout periods (where variance reduction is greater) the premium costs rise. This can indeed be seen the following graphic.

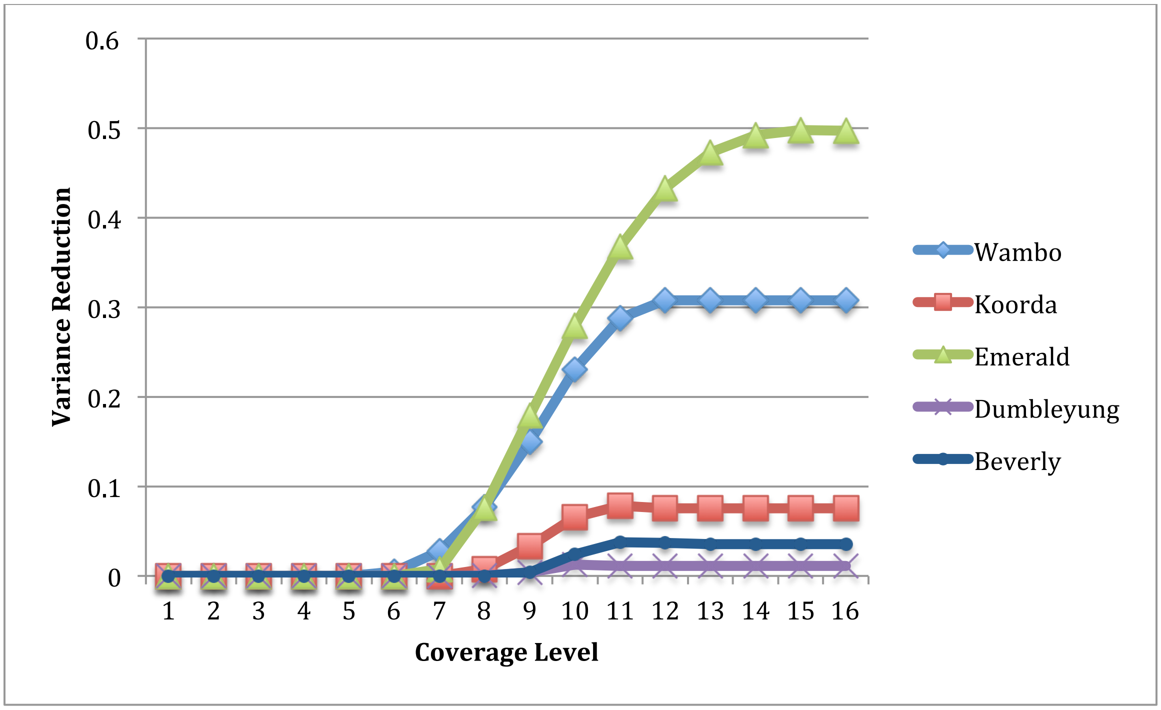

Figure 9– Variance reduction (insurance effectiveness) per coverage level among shires

Although the results do mirror the hypothesis based on premium rates, there is a visible change variance reduction initiated at 60% coverage, and the change in premium rate follows in accordance. This displays an important characteristic of the AYI scheme, in that even under low end coverage levels certain variance reduction benefits can be witnessed. More importantly this is particularly the case in the event of catastrophic losses due to a force majeure. The implication of this result is in line with the current design of crop insurance contracts in the US, and the efforts to replace CAT bonds for farmers with crop insurance incorporated with catastrophic risk protection (Paulson et al, 2008). For this reason the highest levels of subsidization are found among lower coverage levels GRP (Mahul 1991). AYI has been referred to as mechanism for delivering catastrophic event relief, performing more cost effectively and efficiently than other programs such as MPCI (Dismukes and Glauber, 2005). However there is an opposition from producers, due to the pressure for them to sign into an insurance contract for such relief compared to receiving this assistance free of charge previously.

Referencing the further levels of coverage an interesting relationship evolves, composed of a plateau near the end where further coverage levels only have minimal benefits in variance reduction. One must duly note that coverage levels of 160%, although useful in a study such as this are not economically meaningful nor financially or politically feasible. The certainty equivalent values for producers amongst alternative coverage levels should further emphasize why coverage levels beyond a certain point are no longer feasible, from a rational perspective. Another indicator, which is worth noting, is variance reduction percentage per premium (Zhang et al, 2011). Such a value is most useful when comparing various crop insurance schemes, for example MPCI (Multi Peril Crop Insurance) with AYI.

Referencing previous statements on AYI, one would hypothesize that MPCI would have lower variance reduction per premium then AYI would. However such a comparison is outside the scope of the research at hand.

However the changes in variance reduction based on the incremental increase of epsilon (decrease in correlation) are vital to understanding the true effectiveness of AYI in the selected shires. Intuitively and following the results presented thus far, greater degrees of correlation should result in greater variance reduction and insurance effectiveness. The following graphic verifies this statement and further solidifies the previous results. The coverage level is set at 90% and constant relative risk aversion is set to 2; which as stated before is considered the benchmark value.

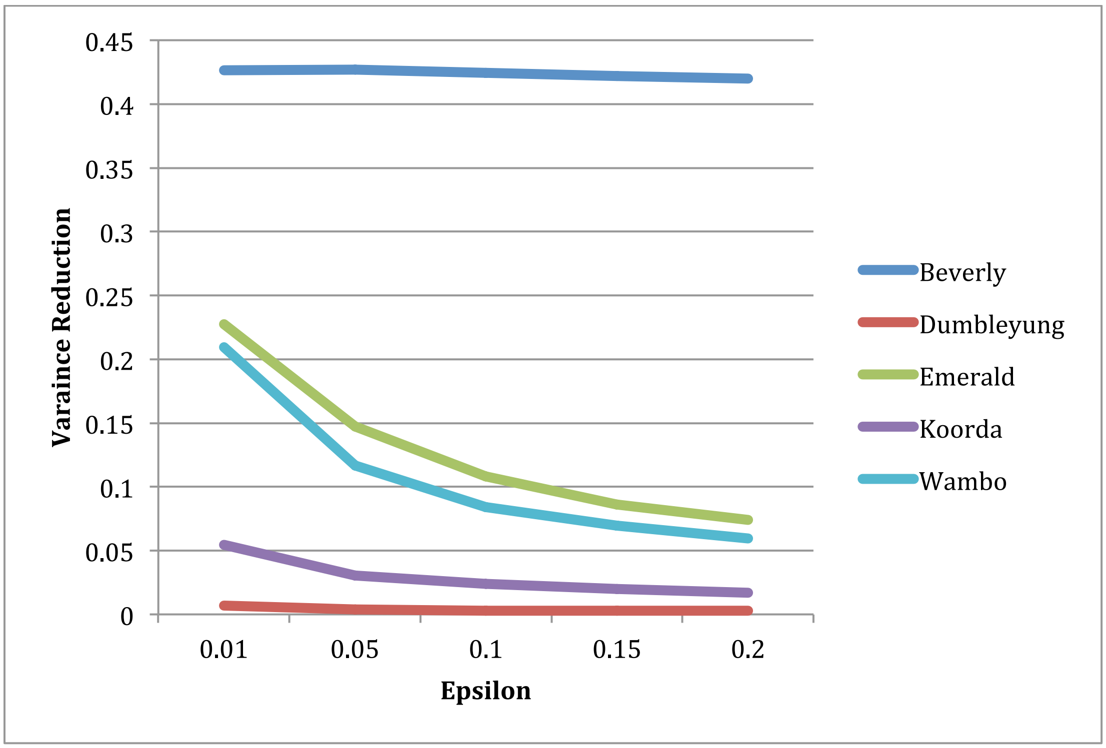

Figure 10- Variance reduction per Epsilon values .01-0.2 among all shires

The first noticeable results are that Beverly and Dumbleyung diverge from the three other shires. This result is consistent with the findings presented on the relation between correlation of shire to farm yields and movements in epsilon. Due to these two shires displaying low correlations and relatively low reactivity to changes in epsilon, the variance reduction relative to epsilon is minimal (however note that there is a decrease in variance reduction as epsilon increases). The remaining shires of Emerald, Wambo and Koorda display this reduced insurance effectiveness as a result of epsilon in a far clearer manner.

Certainty equivalent offers a clear indication of the highest payment a producer is WTP for avoidance of a risky scenario. It is closely related to the level of utility a producer can achieve at different coverage levels, constant relative risk aversion levels, and epsilon (or correlation) levels- the reason for this can be clearly seen in the methodology. The results generated in this study offer sensitivity analysis on all these fronts, allowing for a complex yet exceedingly informative look at the viability of AYI by Australian farmers. First one must note that factors such as risk aversion do not influence our variance reduction calculations and hence are not displayed within the paper, this fact further emphasizes the importance of conducting an certainty equivalent calculation for each shire.

The effect of epsilon on CE values is worth noting in its merits as a comparison to its effects on variance reduction. CE is however affected to a much greater degree by constant relative risk aversion than epsilon and hence the following results are gathered. These results are at 90% coverage level and constant relative risk aversion set to 2.

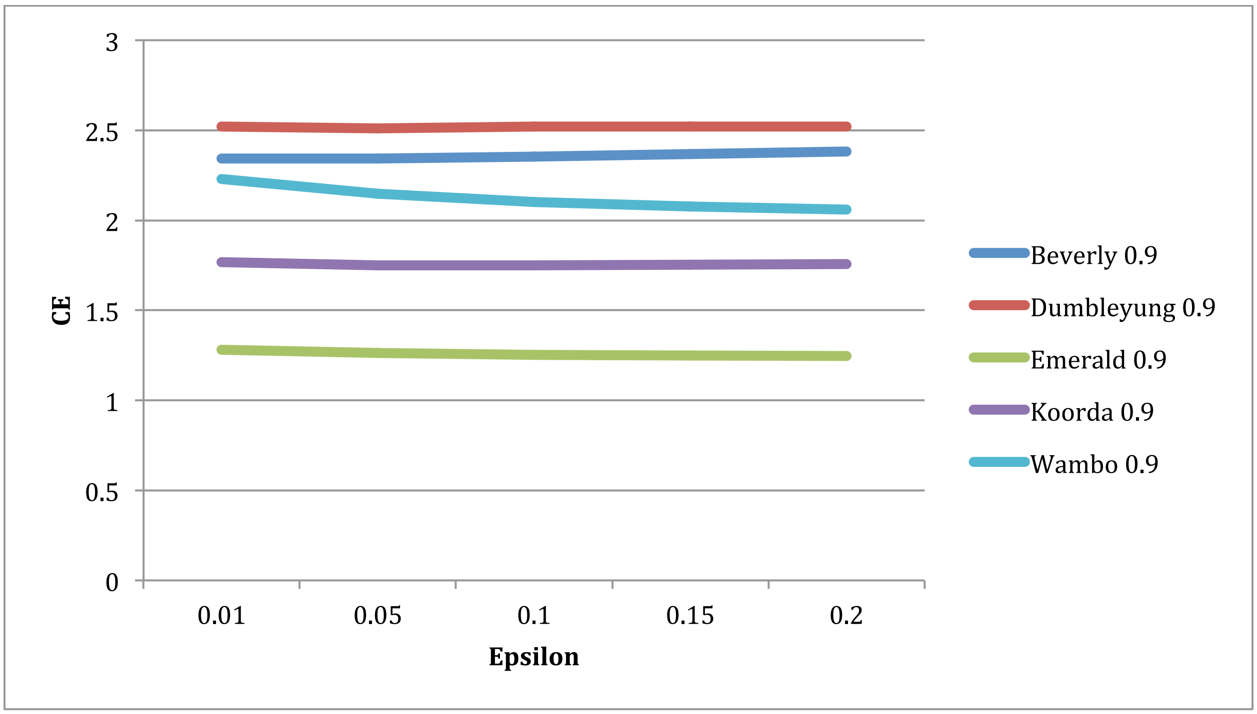

Figure 11 - Change in CE per Epsilon value among all shires

These results put forth the notion that correlation among farms to the shire yield is not the holy grail of AYI insurance, especially from the stand point of an insured producer. The shire of Beverly has a counter intuitive result of slightly higher certainty equivalent as the divergence of farm yield to shire yield becomes greater.

Having considered this significant difference between variance reduction measures and certainty equivalent , one must take a look at how certainty equivalent reacts to changes in coverage level among shires. In order to achieve meaningful graphical representation epsilon is set constant at 0.02 and constant relative risk aversion (CRRA) is set to 2.

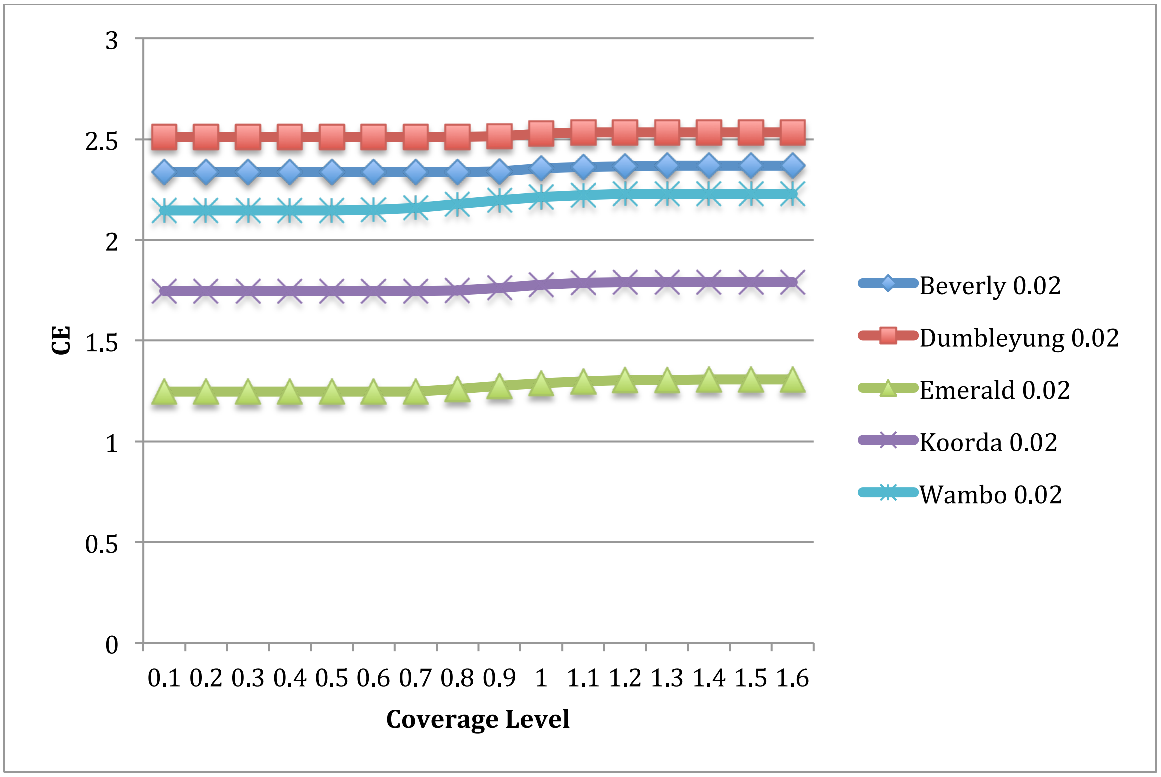

Figure 12 – Change in Certainty equivalent per coverage levels 0-160% among all shires

Although in the graphical format above the increase in CE appears minimal, it is due to the wide variation in initial CE values across the shires. In the appendix C the reader may find graphs of CE at all epsilon values and at constant relative risk aversion values ranging from 0-7. An interesting finding when considering relative risk aversion and its effect on CE in that changes in CRRA have a significant impact on the influence of coverage levels on rise in CE. Furthermore the significance of Epsilon (or correlation coefficient) is visible as risk aversion increases. This is shown through a general trend displaying that at higher levels of CRRA differences in epsilon become more and more irrelevant in certainty equivalent values across all coverage levels. However the point at which epsilon begins to exert significant less influence varies from each shire, with the exception of Dumbleyung where CE levels at CRRA 0-7 remains relatively constant. It this point it is important to remark on that no matter what the general trend is, all shires resemble low epsilon influence under CRRA of 2. This is interesting when taking into consideration that 2 is the benchmark risk aversion. Hence the findings suggest epsilon as a consideration under AYI is not always a highly significant factor when considering CE. This finding is also true of E(u) at CRRA, however E(u) displays a clearly greater degree of variation among different epsilon levels as CRRA rises. This is also true regarding the previous discussion on variance reduction, meaning that the lower the epsilon (or higher the correlation of shire to farm yield) the greater the risk reduction (especially at higher coverage levels). As can be seen below

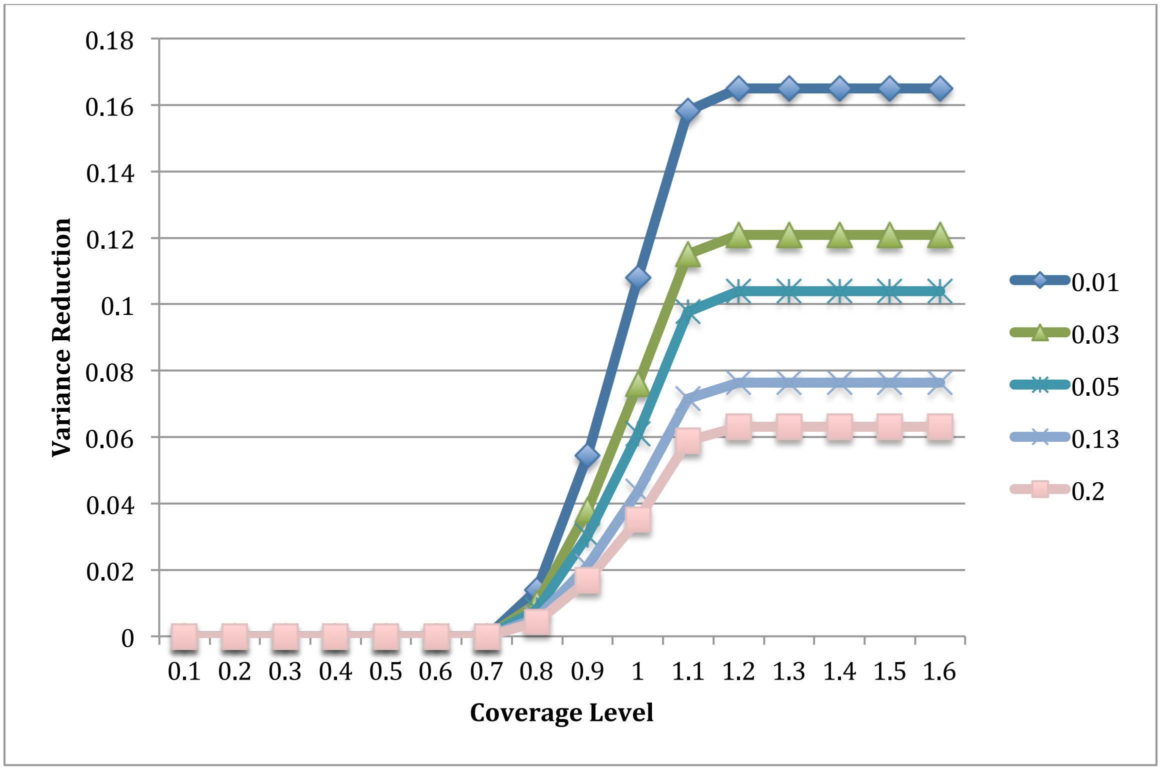

Figure 13 – Relationship between coverage level and variance reduction at epsilon values of 0.01, 0.03, 0.05, 013, and 0.2. At any CRRA

The relationship is clear is mimicked among all shires, with minor changes among low epsilon values coverage level difference among each other. The full range of epsilon values for all shires can be found in the CD appendix attached. Note that CRRA levels have no influence over the variance reduction measurement.

Taking a look at Koorda we see that at CRRA levels up to 5 there is a stark change in epsilons effect on certainty equivalent levels. For CRRA of 6 and 7 the results return to displaying a minimal difference in among different epsilons (similar to that found at CRRA of 2). Both these effects are clearly visible in the shire of Koorda found in Appendix B along with the relevant tables of values. The reader will find CE values for each coverage level, CRRA, and correlation coefficient (correlation coefficients are displayed for epsilons 0.01 to 0.02 as in graph [2]). A graph of this relationship is provided in the printed appendix B, while all over shires are found on the CD appendix attached.

The growth of certainty equivalent is strongest at the benchmark risk aversion level of 2, while under risk aversion of 7 the growth presents a much flatter growth rate. These observations are accurate in regards to all shires, as well as the finding that ideal (or fastest growth in CE) coverage is found in-between 70% and 100% coverage level, at either end of these coverage levels the graphs exhibit flat growth rate of CE, hence making premium payments under those levels a disutility to the producer.

Graphs 8 and 9 display the change in E(u) for the shire of Koorda. To display this relationship the choice of Koorda is sufficient due to all shires resembling highly similar relationships. As can been seen the highest growth occurs at CRRA yet epsilon exerts the greatest influence under CRRA of 7. Once again all shires can be found on the CD appendix attached.

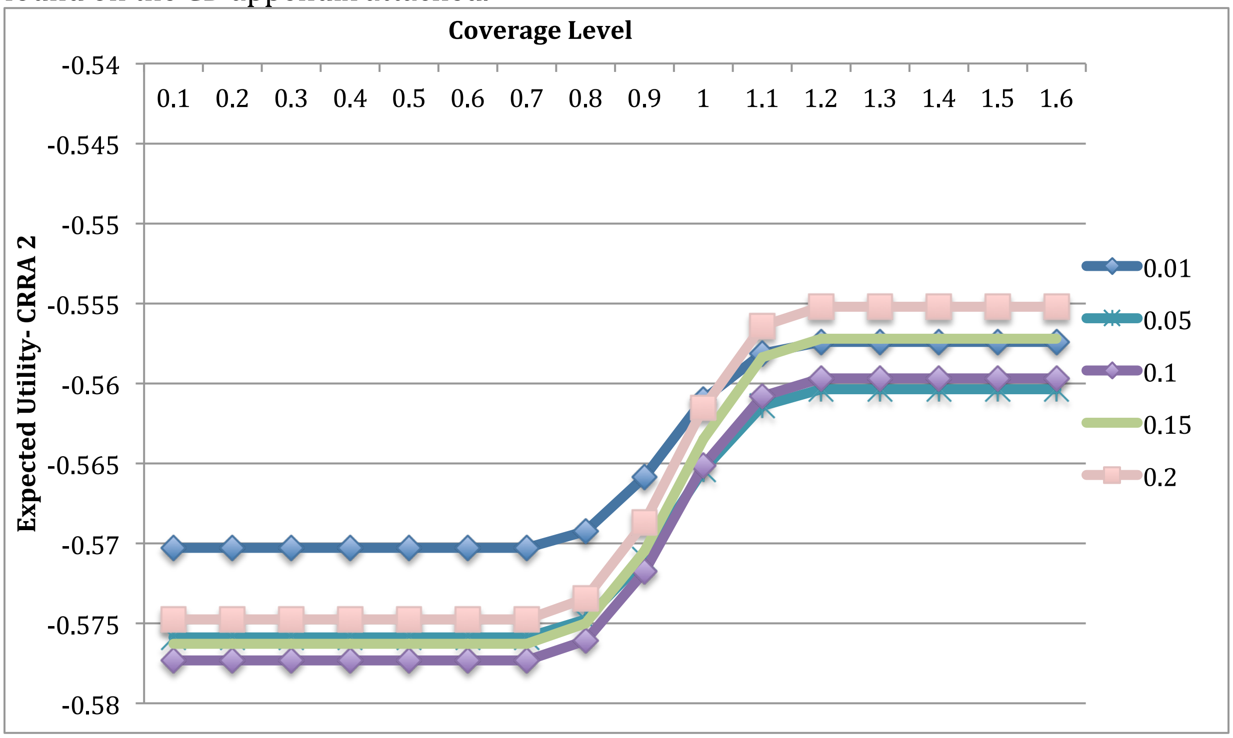

Figure 14– At CRRA 2 the change in CE per coverage level compared among different Epsilon Values: Koorda Shire

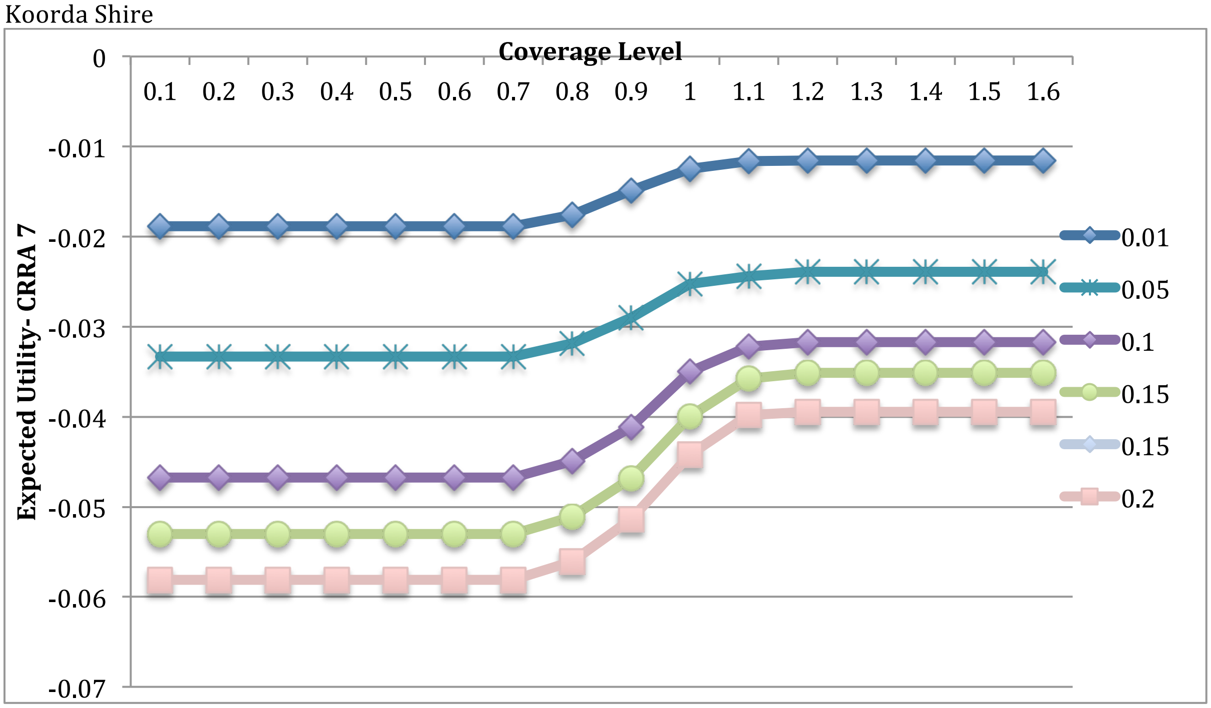

Figure 15 – At CRRA 7 the change in CE per coverage level compared among different Epsilon Values: Koorda Shire

Referencing CD appendix for any shire selected, one will notice a decreasing E(u) as CRRA rises. At first this may appear counterintuitive, however the right standpoint must first be established in order to properly understand the data results. What the E(u) are displaying is that for the same amount of risk (keeping variation constant) the individual producer is receiving less expected utility for each lower CRRA value.

Finally, in an effort to view the potential government involvement through subsidies, a descriptive ratio is of interest between indemnity and premium. Such a ratio results in a measure for the need of government subsidization. Unfortunately due to simulated nature of the results used within this study, such a ratio would hold no significance. The US government sets this ratio for crop insurance products at 0.95, while studies have shown the rate in the US is closer to 2.0 (Miranda 1991). Although in reality many more influencing factors exist for government subsidies, not just in equality between premium and indemnity rates.

6. Discussion

Being able to present rational and intuitive results for such core statistical analysis as farm and shire yield correlations and even insurance effectiveness measures, allows for a substantive theoretical analysis. More importantly, although the results are constrained by many variables and assumptions the degree of sensitivity analysis results in an opportunity to offer new insights and revelations into the Australian crop yield insurance market. From a general point of view the array of sensitivity analysis offers a highly informative chart or "map", if you will, of AYI influence and effectiveness among the areas of Australia under consideration. Naturally an clear opportunity arises for mapping out a greater range of regions within Australia following the same methodology.

The results for variance reduction among shires closely reflect the correlations each shire has between farm and shire yield. Dumbleyung presented the lowest correlation, and likewise displayed the lowest variance reduction over the entire coverage level spectrum. Although Dumbleyung surpasses Beverly correlations coefficient under a particularly greater rate of divergence (epsilon), it consistently has lower variance reduction than Beverly. On the other end of the spectrum Emerald not only distinguishes itself from the shires of Western Australia but even greatly outperforms its fellow shire Wambo in terms of variance reduction. Once again this result is a clear reflection of our primary graph displaying correlation coefficients of shires with respect to a rising epsilon value.

Taking only correlation into account one does not see the degree to which AYI effectiveness varies from the two major geographical locations. Under the variance reduction analysis this distinction is clearly visible with both Emerald and Wambo exhibiting far greater variance reduction and variance reduction growth rates. Furthermore these two shires have indemnities and premiums triggered at lower coverage levels than the shires of Queensland. However there does not appear to be a relation between the highest level of variance reduction achieved and coverage level where premiums and indemnities are triggered, not when referring to premiums an increase in premium rate is triggered.

Premium rates follow a relatively similar trend for all shires concerned, with the majority of deviations occurring under lower coverage levels (more accurately coverage levels at which premium rates rise) and gradually agglomerating at the highest coverage levels finalizing at a premium % of 0.375 for all shires. As stated previously Emerald and Wambo premium rates rise before the Queensland shires, with Emerald displaying the initial movement. Although this initial movement displays the trigger mechanism for indemnity payouts initiates earlier than the other shires, the premium growth is characterized by a slower rate of growth than both the Western Australian shires and Wambo. However one may argue that even variance reduction, and premium rates, is not the ideal indicator of the health of an AYI contract within a shire. Although certainty equivalent provides further insight, it is served the same fate as variance reduction measures in terms of the optimal indicator of the effectiveness of a contract. This indicator is the correlation of farm to shire yields, which effectively serves as a measurement of proneness to basis risk. If basis risk has a strong presence within a shire (low correlation) it makes the AYI contract a form a lottery ticket which may either place you in the winning group or the loosing group, irrespective of your actual losses incurred.

An integral aspect of AYI construction and analysis is shire selection and shire appropriateness. The indicator of such a measurement is variance reduction and correlation between shires- to some degree certainty equivalent naturally is also an important indicator. The differences between shires in variance reduction essentially come down to correlation and elimination of basis risk. The variables affecting these factors include everything from shire boundary selection and soil salinity levels. Under and implementation of AYI in Australia a careful study must be undertaken in an effort to explain which variables have the highest degree of influence on shire viability. More importantly, once such variables have been identified there is an opportunity to test the ability of manipulating these variables. However one must note that these variables influence systemic risk, and must be distinguished from farm level idiosyncratic risks. Such idiosyncratic risks are most effectively managed by a separate risk management scheme and not by AYI.

It is useful to interpret the variance reduction data based on differences between agro-climatic variables affecting each shire. Before delving into individual shire differences, two groups must first be analyzed from a broader perspective. This would not necessarily be feasible or essential, however due to the visible difference between the shires of Queensland and Western Australia such an analysis is indeed indispensable.

With regard to annual rainfall and likelihood to drought all shires are prone to similar risks. The northern most shires of Emerald and Koorda are faced with far greater heat levels and less rainfall. Taking temperature and annual rainfall under primary concern there appears to be a trend of harsher conditions resulting in greater variance reduction. Emerald lies in a region most highly prone to drought and high temperature, and displaying the highest degree of variance reduction. The shire of Koorda lies the furthest north of the Western Australian shires and enjoys greater variance reduction than Beverly or Dumbleyung. It is important to understand at this stage that the severity of yield loss is not necessarily a decisive factor in AYI but rather the degree to which farms move alongside shire yields in the event of yield losses. Taking a further look at the two spatially distant groups of shires there is an indication for preferred agro –climatic zones. The shires located near the coast of Queensland are located in subhumid to subtropical zones, while the Western Australian shires are located in the temperate to seasonally dry zones (Australian Bureau of Meteorology). This stark difference between the two sets of shires lends itself to be an accurate explanatory variable for the difference in variance reduction and yield correlations; furthermore yield volatility is also a significant influencing factor. As stated previously not only is the general region within the shire is located important, but even more so is any difference in climate zone within each shire. Such variation within a shire leads to poor correlation of farm and shire yields, in effect raising basis risk. The increase is climate variability and changes in climatic patters not only present a challenge for AYI but naturally an opportunity at reducing variability of returns for producers during the volatile conditions to come. By 2050 it is predicted that weather patterns while mutate to such a degree for wheat production on Australia wheat beat will require technologies and strategies for adaptation, AYI may be one of these strategies (Potgieter et al, 2013).

The differences observed among variance reduction and correlations between shires and also the two states not only give an opportunity to discuss differences between the two climatic regions but also give rise to diversification opportunities from the perspective of a national insurer offering AYI throughout Australian territories. Referring back to the correlations found between shires, we able to see degree of heterogeneity between regions and hence degree to which risks can be diversified away. Emerald offers itself as an attractive candidate for a risk diversification portfolio when combined with Western Australian shires, especially Beverly and Koorda with which Emerald has a negative correlation of -0.02876 and -0.09078 respectively. However both Emerald and Wambo have sufficiently low correlations to offer a certain degree of diversification when combined with the Western Australian shires.

If there was a very high degree of correlation between all shires a potential insurer could be assumed to encounter large systemic risks throughout Australia, hence hampering diversification efforts. Diversification of risk among groups of heterogeneous shires is essential to the functionality of a crop insurance scheme. Among homogenous shires risk diversification or "balancing out" is not possible. Building upon the assumption that a high degree of homogeneity is displayed among the shires a viable option would be to introduce a global insurer to the AYI scheme in Australia. Through a global insurer (or rather re-insurer) shire scale risks throughout Australia can be diversified, even with high levels of homogeneity throughout themselves, through diversifying throughout the world. Another option, although requiring significant infrastructure and market development, is the use of financial markets to spread risks among investors. Market instruments used would include trading area yield options, and have experienced a certain degree of success in the US while being traded on the Chicago Mercantile Exchange (CME)(Martial et al, 2003). However not only is the proper infrastructure necessary but also a high level of liquidity within the market is vital for such a risk management tool to be of use (Miranda and Glauber, 1997). Naturally the risks labeled as "diversifiable" globally Australia would be systemic risks within Australia, while idiosyncratic risks can be successfully managed locally. In the US there has been a great deal of discussion centered on private insurers managing idiosyncratic risks and government agencies (and funds) managing systemic risks.

Considering changes in Epsilon and correlation, more insight can be gathered from the variance reduction results generated. The results show that the sensitivity of correlation to changes in epsilon varies greatly from shire to shire. Those shires where an increase in epsilon resulted in a significant decrease in the value of the correlation coefficient, display a similar trend in terms of variance reduction. As epsilon rises (or correlation decreases) the effectiveness of insurance decreases proportionally. This further emphasizes the previous statements discussing correlation among farms within a shire. The shires of Beverly and Dumbleyung display minimal changes in insurance effectiveness over a range of epsilon values. However although minimal, the changes are in line with those found in Emerald, Wambo and Koorda.

Certainty equivalent analysis is far more complex and hence offers a much wider array of interpretations, which build upon those, made based on variance reduction. Under certainty equivalent calculation many more influencing variables are present, which include CRRA 0-7, Epsilon values .01-.2, and coverage levels 10-160%. As briefly discussed in the results section each variable has a unique relation with each other. Initially taking a look at CE over various coverage levels we see a healthy upward trend as coverage rises and after a certain point a slight decrease. This parabola (very light) displays a tendency for optimal coverage level, or utility maximizing coverage level. Unfortunately this initially difficult to see at a constant level of risk aversion, however as risk aversion rises the steepness of in the incline various. CRRA levels of 0 and 1 display nearly flat growth with respect to coverage level, while at CRRA of 2 there is a sharp rise in growth between 60-100%. This range of 60-100% is found in all counties and across all levels of CRRA, displaying that the coverage level range where the highest growth in CE occurs is within the 60-100% area, with the highest rate of growth centered around 80%. After 100% the CE values begin to plateau once again, meaning that at 100% coverage level certainty equivalent is maximized across all shires. This can most readily be seen in the appendix where all risk aversion values are displayed for each shire.

Furthermore taking a look at appendix B (and CD appendix for full range), a selection of epsilon values represent the various data series visible. Through this graphical representation there is an opportunity to see how epsilon is affects by both CRRA and rises in coverage level. The result is that epsilon relation to coverage level in regard to CE depends on the choice of risk aversion to a staggering degree. Also, in a more straightforward interpretation, epsilon values gain greater effect on CE as relative risk aversion and at the highest levels of CRRA epsilon values contribute less influence. This however is not the case in Dumbleyung, which indicates the shire has a lowered sensitivity to relative risk aversion values. In this case producers exhibiting various types of risk aversion will experience relatively stable CE values. However, as was mentioned previously, this is not the case under E(u) where there under CRRA of 7 a lower epsilon value (0.01) has a dramatically higher CE than at epsilon value of 0.2. While under a risk aversion value of 2 or lower, different epsilon values are far more homogenous. However it must be clearly noted that at lower CRRA levels the same relation exists meaning that lower epsilon results in greater CE, however the difference is much smaller.

The implications of this are straightforward in the sense that the viability of an AYI program achieve success in a shire greatly depends on the producers realized and certainty equivalent . Hence the situation in which it is maximized should be opted for upon shire selection. According the data a mix of risk aversion and epsilon sensitivity will dictate which coverage level range in most attractive, within the shires analyzed here the range appears to be uniform and representing the interval of 60-100% coverage as exhibiting the greatest growth rate. As noted by a figure in the results section, while holding CRRA and coverage level constant there is nearly no change in CE as a result of increasing epsilon.

Some care must be applied when considering a wide range of flexibility of coverage levels in an AYI scheme. The increased flexibility and availability of high coverage levels results in a decrease ability for the AYI to deter moral hazard and adverse selection. However compared to MPCI where low risk farmers pay a large premium for their more risky counter parts, AYI is able to almost entirely resolve issues concerned with moral hazard (Goodwin, 1993). While MPCI observes high degree of moral hazard behavior, such as decrease use of pesticides while insured (Smith et al, 1996). As seen throughout this paper there is a great degree of interdependence within the inner functioning's of crop insurance, hence one can already expect the chain re-action caused by highly flexible coverage levels. Through the higher risk of moral hazard and adverse selection premiums must rise in order to continue providing actuarially fair premiums, in this case the upward adjustment in premium rates benefits the insurer in maintaining a balance between indemnity payout and premiums received (Sherrick et al 2004a).

A further option in line with reducing insurer and subsidization costs is the limitation of basis risk. As mentioned through out the paper basis risk plays an integral role in AYI and is one of the major weaknesses attributed to AYI. Basis risk can affect both parties (insured and insurer) in that there can be "false positives" and "false negatives". The elimination of false positives, when insurer pays indemnity to a producer who did not experience losses, can be achieved through the use of a dual trigger mechanism (Elabed et al, 2013). The use of such a mechanism in the Australian implementation of AYI would require a sub shire grouping for which data would be available. Essentially an indemnity payoff would only be triggered if a trigger value were passed on both the shire and sub shire scale. Such a mechanism allows for more accurate payoffs, and lowered costs of the usurer through lowered probability of false positives.

7. Concluding Remarks

The simulation of AYI in 5 Australian shires discussed above displays a vast array of data analysis and calculation for various indicators and measurements. All these calculations build to produce an understanding of the environment an AYI insurance contract will face when entering Australia. Naturally the results do not intend to show how Australian producers should adjust to such a crop insurance scheme, but rather clearly define the dimensions within the contract that require flexibility and those which have the most influence over utilities for producers. Often throughout the writing a re-occurring statement is easily defined as reminding the reader that the core concern is correlation of farm yields with shire yields. Such variation or correlation is dependent on agro-climatic factors, which cannot be influenced by contract design or any short-term design change. The boundary selection of shires can have a positive effect on this issue, in an effort to make the county environmental factors more homogenous. A further step to take in order to decrease basis risk due to irregular correlations is as described above the dual trigger mechanism, which effectively makes an AYI contract into a dual area insurance contract composed of an area as in the original version and also a subarea- both of which must have critical yields triggered in order to result in an indemnity payout. This structure however is designed to eliminate basis risk losses faced by the insurer rather than the producer.

Taking the farm and shire yield correlations as given this paper looks at the possible adjustments and optimal coverage levels without aiming to primarily adjust correlations. For all shires concerned a coverage level of 100% is found to maximize certainty equivalent , and a high growth rate in CE is found to start at 60%. These coverage level preferences are irrespective of correlation and relative risk aversion. However under greater risk aversion the growth rate during the optimal coverage range slows, and correlations begin to exert greater importance with regard to CE maximization.

Variance reduction varies greatly between the two states in which the 5 shires are located. This is primarily due to yield correlations of farm and shire found with in each state. Queensland shires of Emerald and Wambo display a high degree of correlation and hence significantly higher variance reduction compared with the Western Australian shires of Koorda, Beverly and Dumbleyung. The final two WA shires listed display both the lowest shire-farm correlations and variance reduction. While Emerald not only enjoys significantly more variance reduction than WA shires but also the nearby Queensland shire of Wambo. The differences in correlation between shires, but as per the results more significantly between states can be attributed to various aspects. One such aspect may include homogeneity of technology used. Size of the shire in terms of number of farms also has a heavy weight in defining correlation. Most importantly however there should be a clear understanding that, whatever the cause (technology, climate, size) the homogeneity it is that uniformity which makes a shire the most applicable candidate for AYI.

Finally the correlation between shires is highly substantial in terms of AYI implementation. In this case minimal correlation is preferred, as it allows for greater risk diversification among insured shires. If a negative correlation were observed among all Queensland and Western Australian shires the need for risk mitigation tools would be minimized. Otherwise an insurer may need to look towards financial markets or a global insurer for further risk mitigations and diversification options. A necessity for such options may arise irrespective of the results, previous studious have found that severe droughts have wide implications for surrounding shires hence causing state level insurance to dissolve (Miranda and Glauber, 1997)

Further research on this topic may take many forms, and if considered in enough detail may appear to be endless. First off a more detailed study should be undertaken with regard to climatic and environmental factors affecting each shires, and how (and if) these patterns or zones change within the shires discussed in this study. Such environmental factors may include variability in rainfall, soil salinity and so on. Furthermore not only environmental factors need to be considered in great detail but also idiosyncratic effects on farmer production such as machinery, irrigation and use of pesticides should be analyzed for each shire (Ramaswami et al, 2004). Such detailed analysis gives a deeper understanding of our results for correlation of both far-shire and inter shire correlations. Naturally more Australian shires could be analyzed, or more regions analyzed for greater comparative power. Finally comparisons between different crop insurance programs (MPCI or GRIP) would generate a far deeper understanding of the Australian crop insurance market. If historical data, rather than simulated as in this study, could be used such calculations as indemnity/premium ratios for subsidy needs and variance reduction per premium could be calculated allowing for greater insight for both producers and agencies involved in insurance implementation.

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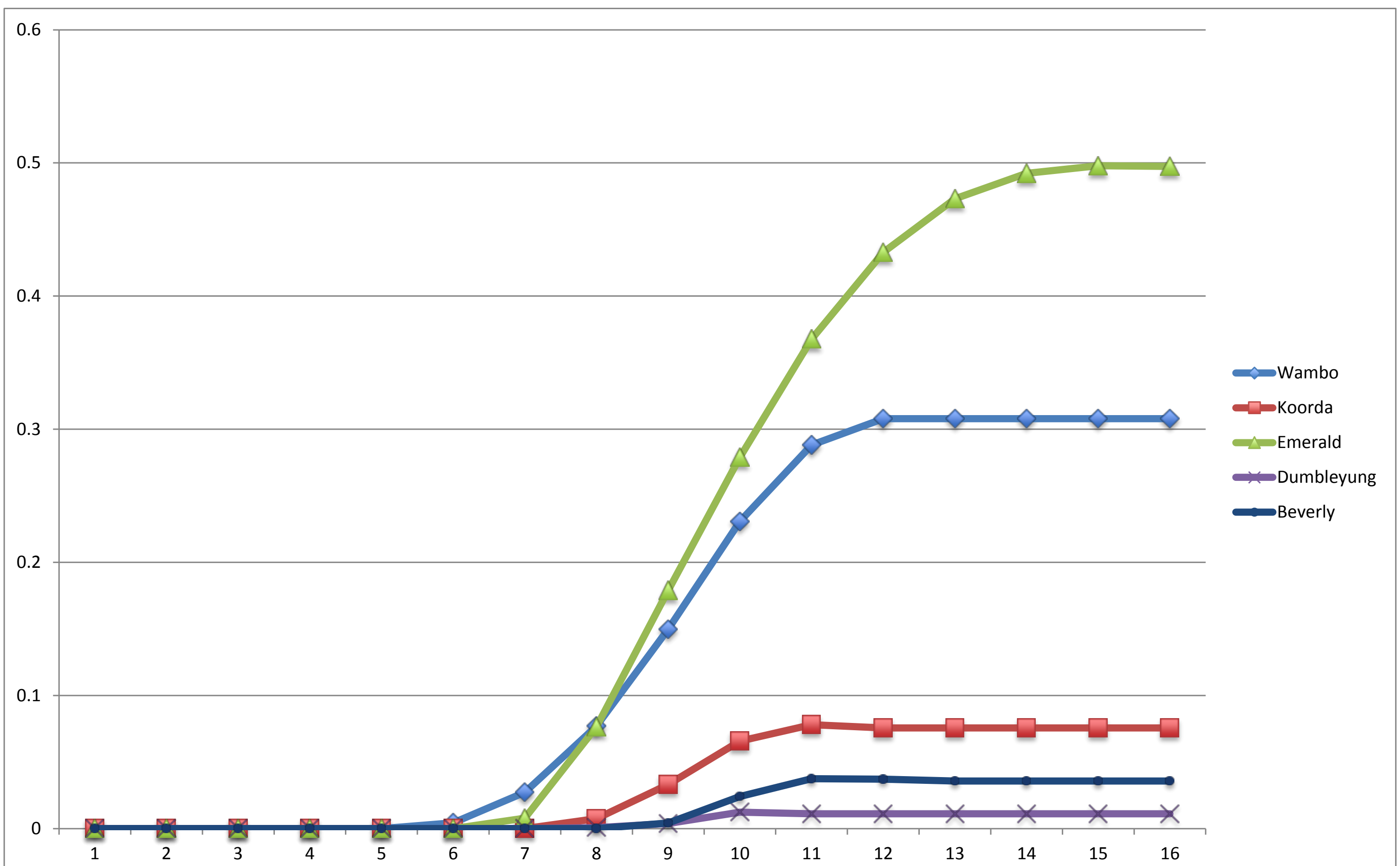
Appendix A: Shire Variance reduction mean values (graphical and table format)

Coverage Level	Wambo	Koorda	Emerald	Dumbleyung	Beverly
0.2	0	0	0	0	0
0.3	0	0	0	0	0
0.4	0	0	0	0	0
0.5	0	0	0	0	0
0.6	0.00445	0	0	0	0
0.7	0.02727	0	0.007888	0	0
0.8	0.07709	0.007517	0.076532	0.00070361	0
0.9	0.14983	0.033098	0.178987	0.00380329	0.004143
1	0.23074	0.065804	0.279045	0.01240681	0.024222
1.1	0.28809	0.078019	0.36765	0.01118539	0.03749
1.2	0.30784	0.075581	0.432907	0.01118539	0.037089
1.3	0.30798	0.075581	0.473075	0.01118539	0.035784
1.4	0.30798	0.075581	0.492174	0.01118539	0.035784
1.5	0.30798	0.075581	0.497938	0.01118539	0.035784
1.6	0.30798	0.075581	0.497324	0.01118539	0.035784



Appendix A: Beverly variance reduction and premium over 20 farms at coverage levels 10-160%

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0.004039533	0.00278513	0.00365668	0.00474534	0.00506427	0.00569921	0.00440167	0.00504204	0.00446759	0.00350509	0.00467991	0.00413249	0.0030952	0.00438337	0.00303595	0.00503226	0.00434574	0.0040247	0.00430754	0.00241349
10	0.019641035	0.02140274	0.02410321	0.02726684	0.02774637	0.02718053	0.02497936	0.02938636	0.02446849	0.02482888	0.02615098	0.02079547	0.02147149	0.0231877	0.02264717	0.02819761	0.0237154	0.02305995	0.02393473	0.02027282
11	0.030969157	0.03235643	0.03843687	0.04287539	0.04236727	0.03940582	0.03947045	0.04549686	0.04105234	0.0375954	0.04198495	0.02908656	0.03514997	0.033141	0.03765929	0.04280896	0.03531469	0.03753415	0.03634283	0.03075586
12	0.031435665	0.03128036	0.03982976	0.04374698	0.04377777	0.03733668	0.03979514	0.04760367	0.04286889	0.03346609	0.04350215	0.02670012	0.03300637	0.03071524	0.03724482	0.0426391	0.0346763	0.03795263	0.03560662	0.02858829
13	0.031716476	0.03030013	0.03851633	0.04298883	0.04277007	0.03572072	0.03817086	0.04772229	0.04221911	0.03059267	0.0424894	0.02503923	0.03061022	0.02860171	0.03610131	0.04153695	0.03247317	0.03783818	0.03423651	0.0260393
14	0.031716476	0.03030013	0.03851633	0.04298883	0.04277007	0.03572072	0.03817086	0.04772229	0.04221911	0.03059267	0.0424894	0.02503923	0.03061022	0.02860171	0.03610131	0.04153695	0.03247317	0.03783818	0.03423651	0.0260393
15	0.031716476	0.03030013	0.03851633	0.04298883	0.04277007	0.03572072	0.03817086	0.04772229	0.04221911	0.03059267	0.0424894	0.02503923	0.03061022	0.02860171	0.03610131	0.04153695	0.03247317	0.03783818	0.03423651	0.0260393
16	0.031716476	0.03030013	0.03851633	0.04298883	0.04277007	0.03572072	0.03817086	0.04772229	0.04221911	0.03059267	0.0424894	0.02503923	0.03061022	0.02860171	0.03610131	0.04153695	0.03247317	0.03783818	0.03423651	0.0260393

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0.002315442	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544	0.00231544
10	0.029753753	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375	0.02975375
11	0.097903018	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302	0.09790302
12	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804	0.16766804
13	0.230769231	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923
14	0.285714286	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429
15	0.333333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333
16	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375

Appendix A: Dumbleyung variance reduction and premium over 20 farms at coverage levels 10-160%

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0.000794692	0.00052136	0.00066638	0.0005928	0.00104293	0.00068152	0.00094506	0.00083548	0.00078716	0.00047541	0.00057814	0.00074835	0.00041153	0.00074838	0.00072177	0.00089692	0.00055635	0.00080539	0.00071438	0.00054817
9	0.003624026	0.00231958	0.00350933	0.00373961	0.00550669	0.00399788	0.00527725	0.00493039	0.0046393	0.00242553	0.00332352	0.00400338	0.00219899	0.00382274	0.00388176	0.00484467	0.00278813	0.00430664	0.00302244	0.00390402
10	0.011329538	0.00834032	0.01021145	0.01218686	0.0144076	0.01457528	0.01657239	0.02019737	0.01236439	0.01193223	0.01330876	0.01003471	0.00885243	0.01050084	0.01381968	0.01482556	0.00890268	0.01378157	0.00990087	0.01209175
11	0.008938791	0.00643177	0.00717193	0.01089521	0.01268451	0.01303794	0.01614927	0.02167778	0.01099617	0.01283649	0.01286451	0.00788338	0.00658492	0.00801778	0.01312147	0.01495863	0.00601623	0.01532023	0.00968406	0.00843671
12	0.008938791	0.00643177	0.00717193	0.01089521	0.01268451	0.01303794	0.01614927	0.02167778	0.01099617	0.01283649	0.01286451	0.00788338	0.00658492	0.00801778	0.01312147	0.01495863	0.00601623	0.01532023	0.00968406	0.00843671
13	0.008938791	0.00643177	0.00717193	0.01089521	0.01268451	0.01303794	0.01614927	0.02167778	0.01099617	0.01283649	0.01286451	0.00788338	0.00658492	0.00801778	0.01312147	0.01495863	0.00601623	0.01532023	0.00968406	0.00843671
14	0.008938791	0.00643177	0.00717193	0.01089521	0.01268451	0.01303794	0.01614927	0.02167778	0.01099617	0.01283649	0.01286451	0.00788338	0.00658492	0.00801778	0.01312147	0.01495863	0.00601623	0.01532023	0.00968406	0.00843671
15	0.008938791	0.00643177	0.00717193	0.01089521	0.01268451	0.01303794	0.01614927	0.02167778	0.01099617	0.01283649	0.01286451	0.00788338	0.00658492	0.00801778	0.01312147	0.01495863	0.00601623	0.01532023	0.00968406	0.00843671
16	0.008938791	0.00643177	0.00717193	0.01089521	0.01268451	0.01303794	0.01614927	0.02167778	0.01099617	0.01283649	0.01286451	0.00788338	0.00658492	0.00801778	0.01312147	0.01495863	0.00601623	0.01532023	0.00968406	0.00843671

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0.000250349	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035	0.00025035
9	0.002052761	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276	0.00205276
10	0.018327224	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722	0.01832722
11	0.090909091	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909	0.09090909
12	0.166666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667	0.16666667
13	0.230769231	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923
14	0.285714286	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429
15	0.333333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333
16	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375

Appendix A: Emerald variance reduction and premium over 20 farms at coverage levels 10-160%

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0.00756647	0.00860787	0.00723869	0.00814047	0.00750641	0.00833175	0.00811578	0.00826049	0.00755897	0.00702321	0.008101	0.0081226	0.00775343	0.00806642	0.00833314	0.0077851	0.00818722	0.00793818	0.0079	0.00722622
8	0.07467407	0.07574894	0.07472564	0.07564731	0.07560091	0.07906045	0.0788811	0.07744934	0.07507683	0.07559115	0.07811088	0.0773981	0.07528195	0.07727913	0.07704628	0.07463226	0.0774654	0.07499215	0.0767816	0.07919451
9	0.17691949	0.17602933	0.17820698	0.17652195	0.17944414	0.18286149	0.1802996	0.18194174	0.17775671	0.18069278	0.1823456	0.18043074	0.17567082	0.17823299	0.17773188	0.17525588	0.1823053	0.17399448	0.17757219	0.18553239
10	0.27830549	0.27507359	0.28043729	0.27522366	0.28018049	0.28486797	0.27857947	0.28321326	0.27769128	0.28141007	0.28139019	0.27977392	0.27708854	0.27844238	0.27469351	0.27422808	0.28446599	0.27160451	0.27769375	0.28652947
11	0.3690101	0.36366147	0.3706667	0.36370932	0.36911734	0.37566765	0.36382004	0.37166536	0.36903812	0.36973447	0.36873102	0.36872847	0.36652638	0.36746422	0.36067347	0.36232066	0.3721424	0.3585156	0.36660464	0.37519868
12	0.43681254	0.43009473	0.43619976	0.42839265	0.43517993	0.44276373	0.42412339	0.43735675	0.4390199	0.43346406	0.43174925	0.43545586	0.43224695	0.43157587	0.42477279	0.4265945	0.4364387	0.42255916	0.43182591	0.44151232
13	0.47702583	0.47135551	0.47645885	0.46938093	0.47609928	0.48356916	0.45946111	0.47890257	0.48287396	0.47170147	0.47017707	0.47815001	0.47262885	0.4717013	0.46424515	0.46663308	0.47396596	0.46306767	0.47140513	0.48270366
14	0.49631217	0.49147763	0.49518243	0.48979056	0.49591971	0.50299859	0.47495662	0.49943549	0.50342034	0.48836485	0.48938974	0.49929007	0.49188355	0.49093766	0.48393452	0.48493841	0.49044815	0.48274103	0.49055465	0.50149431
15	0.5024315	0.49834733	0.49974594	0.49603858	0.50244412	0.50891817	0.47883897	0.50809764	0.50830007	0.49269494	0.49600076	0.5063413	0.49679569	0.49736043	0.49004371	0.48958638	0.49494418	0.48932111	0.49682601	0.50568874
16	0.5020638	0.49815028	0.49870845	0.49551407	0.50176436	0.50792457	0.47745658	0.50820643	0.50698073	0.49127657	0.49545191	0.50667604	0.49590229	0.49703711	0.49003578	0.48842701	0.49438176	0.48920144	0.4962796	0.50505028

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098	0.00233098
8	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488	0.02441488
9	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493	0.06201493
10	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076	0.10675076
11	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395	0.1562395
12	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516	0.20463516
13	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347	0.25010347
14	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924	0.29359924
15	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003	0.33519003
16	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375

Appendix A: Koorda variance reduction and premium over 20 farms at coverage levels 10-160%

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0.00818344	0.00626102	0.00724398	0.00777593	0.00870959	0.00826983	0.00753626	0.00876699	0.00614008	0.00742857	0.0080151	0.00694158	0.00716406	0.00790874	0.0068549	0.00826837	0.00816328	0.00669902	0.00723309	0.00678231
9	0.03536648	0.03001627	0.03455407	0.03453699	0.0384507	0.03450947	0.03411906	0.03731062	0.03034794	0.03105924	0.03301732	0.03111133	0.03018931	0.03341563	0.02892787	0.03658384	0.03387221	0.03182803	0.03095934	0.03178429

Appendix A: Wambo variance reduction and premium over 20 farms at coverage levels 10-160%

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0.00492724	0.00389852	0.00523358	0.00483508	0.0049354	0.00454207	0.00437841	0.00417308	0.00413993	0.00429873	0.00411201	0.00384614	0.00421144	0.0044992	0.00478424	0.00434804	0.00487086	0.00462583	0.00394636	0.00432071
7	0.02922518	0.02622064	0.02744057	0.02870296	0.02746811	0.02801079	0.02714534	0.02558929	0.02686828	0.02684264	0.02646172	0.02494855	0.02602647	0.02743081	0.02856697	0.02716419	0.02853037	0.02843524	0.0258637	0.02849668
8	0.08151221	0.07420991	0.07621434	0.07804016	0.07622077	0.07934052	0.07805078	0.07358715	0.07637039	0.07762205	0.07600736	0.07350531	0.0731623	0.07874845	0.07947485	0.07635941	0.07988884	0.07828941	0.07525007	0.07987573
9	0.15857139	0.14438862	0.14971313	0.14827945	0.14707307	0.15485773	0.15153909	0.14392158	0.15160568	0.14939944	0.1461377	0.14580377	0.14402574	0.15332876	0.1532337	0.14724582	0.15345604	0.15192931	0.14733568	0.15476688
10	0.24262177	0.22421624	0.232341	0.22893312	0.22873989	0.23938424	0.23331908	0.22702309	0.2331385	0.22625827	0.22156799	0.22672834	0.22351168	0.23613697	0.23520162	0.22604537	0.23277754	0.23252102	0.22811918	0.2361701
11	0.30180006	0.28055709	0.28920705	0.28658851	0.28913404	0.29867333	0.2887693	0.28835677	0.28966664	0.28137425	0.27264715	0.28856318	0.27955374	0.29561473	0.29201303	0.28195967	0.2885373	0.2875231	0.28680976	0.29436059
12	0.32128645	0.30087046	0.31075496	0.3070878	0.31225593	0.31996791	0.30722048	0.31240142	0.30674276	0.30043672	0.28746065	0.31060216	0.29724889	0.3174843	0.31025502	0.30043433	0.30620407	0.30722398	0.3050241	0.31583286
13	0.32014355	0.30163031	0.31208972	0.30730815	0.31255416	0.31960322	0.30668844	0.31417295	0.30614236	0.30104398	0.28745292	0.31136045	0.29723942	0.31821942	0.309752	0.29987954	0.30623593	0.30750903	0.30331384	0.31733711
14	0.32014355	0.30163031	0.31208972	0.30730815	0.31255416	0.31960322	0.30668844	0.31417295	0.30614236	0.30104398	0.28745292	0.31136045	0.29723942	0.31821942	0.309752	0.29987954	0.30623593	0.30750903	0.30331384	0.31733711
15	0.32014355	0.30163031	0.31208972	0.30730815	0.31255416	0.31960322	0.30668844	0.31417295	0.30614236	0.30104398	0.28745292	0.31136045	0.29723942	0.31821942	0.309752	0.29987954	0.30623593	0.30750903	0.30331384	0.31733711
16	0.32014355	0.30163031	0.31208972	0.30730815	0.31255416	0.31960322	0.30668844	0.31417295	0.30614236	0.30104398	0.28745292	0.31136045	0.29723942	0.31821942	0.309752	0.29987954	0.30623593	0.30750903	0.30331384	0.31733711

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827	0.00102827
7	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191	0.00650191
8	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458	0.01983458
9	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375	0.04407375
10	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184	0.08176184
11	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137	0.12568137
12	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799	0.17251799
13	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923	0.23076923
14	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429	0.28571429
15	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333	0.33333333
16	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375

Appendix A.1 : Correlation Coefficient Farm-Shire at Epsilon 0.01-0.2

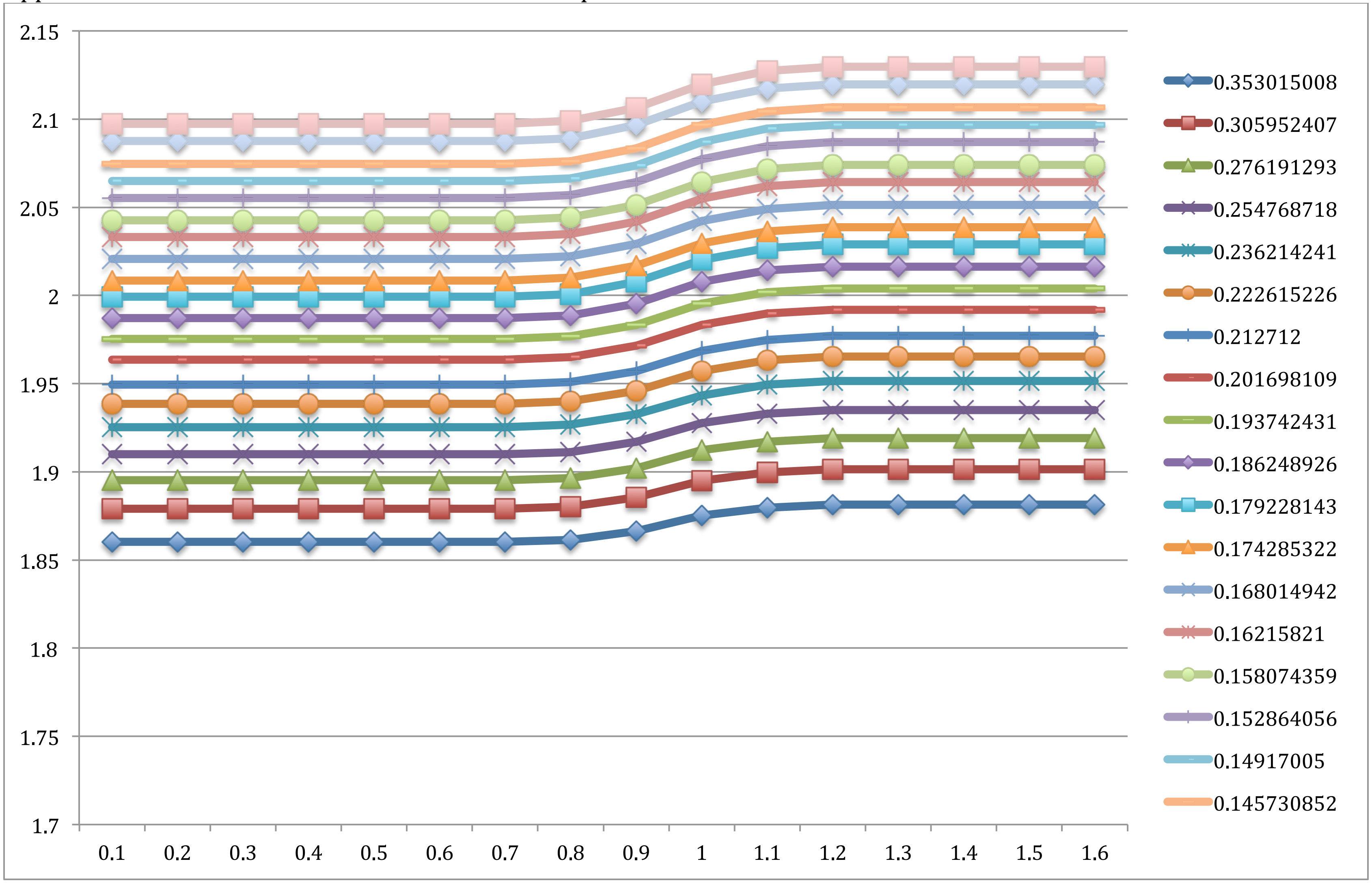
	Beverly	Dumbleyung	Emerald	Koorda	Wambo
0.01	0.20243543	0.145230921	0.78106653	0.35301501	0.64291828
0.02	0.17073412	0.125246382	0.70577803	0.30595241	0.54364976
0.03	0.15158561	0.11329371	0.65551893	0.27619129	0.49681758
0.04	0.13703282	0.104882948	0.60818645	0.25476872	0.45573764
0.05	0.12452427	0.098220785	0.57867956	0.23621424	0.42816796
0.06	0.1163152	0.09291716	0.53742109	0.22261523	0.3951591
0.07	0.10906039	0.087984712	0.5119093	0.212712	0.38032259
0.08	0.10245067	0.084424091	0.48829798	0.20169811	0.35964793
0.09	0.09635468	0.080971248	0.47698381	0.19374243	0.34081129
0.1	0.09184372	0.078150606	0.45545924	0.18624893	0.32914803
0.11	0.0876183	0.075898813	0.43529024	0.17922814	0.31313425
0.12	0.08366564	0.074048747	0.41619823	0.17428532	0.30327827
0.13	0.07994766	0.074048747	0.40716289	0.16801494	0.29388345
0.14	0.07654624	0.074048747	0.39017132	0.16215821	0.28506013
0.15	0.07395821	0.074048747	0.37433758	0.15807436	0.27670706
0.16	0.0708641	0.074048747	0.36676984	0.15286406	0.26487009
0.17	0.06791712	0.074048747	0.35234884	0.14917005	0.25756913
0.18	0.06565873	0.074048747	0.34540428	0.14573085	0.25080176
0.19	0.06348304	0.074048747	0.33202508	0.14129656	0.244287
0.2	0.06087919	0.074048747	0.32563018	0.13808612	0.23800683

Appendix B : Correlation Coefficient Farm-Shire for correlation coefficients at Epsilon 0.01-0.2 CRRA 0

	0.353015008	0.30595241	0.27619129	0.25476872	0.23621424	0.22261523	0.212712	0.20169811	0.19374243	0.18624893
0.1	1.860322974	1.87907839	1.89519135	1.90996668	1.92529649	1.93850929	1.94938981	1.96353326	1.97526553	1.98719702
0.2	1.860322974	1.87907839	1.89519135	1.90996668	1.92529649	1.93850929	1.94938981	1.96353326	1.97526553	1.98719702
0.3	1.860322974	1.87907839	1.89519135	1.90996668	1.92529649	1.93850929	1.94938981	1.96353326	1.97526553	1.98719702
0.4	1.860322974	1.87907839	1.89519135	1.90996668	1.92529649	1.93850929	1.94938981	1.96353326	1.97526553	1.98719702
0.5	1.860322974	1.87907839	1.89519135	1.90996668	1.92529649	1.93850929	1.94938981	1.96353326	1.97526553	1.98719702
0.6	1.860322974	1.87907839	1.89519135	1.90996668	1.92529649	1.93850929	1.94938981	1.96353326	1.97526553	1.98719702
0.7	1.860322974	1.87907839	1.89519135	1.90996668	1.92529649	1.93850929	1.94938981	1.96353326	1.97526553	1.98719702
0.8	1.861463017	1.88030803	1.89647553	1.91130247	1.92666357	1.93991962	1.95081391	1.96500618	1.97674842	1.98871274
0.9	1.866333259	1.88558145	1.902064	1.91712718	1.93268275	1.94607291	1.95711824	1.97157391	1.98344799	1.99552796
1	1.875132623	1.89505232	1.91220801	1.92753372	1.94337897	1.95711982	1.96862018	1.98343138	1.99551689	2.00780037
1.1	1.879536266	1.89978176	1.91718501	1.93288737	1.94932984	1.96339092	1.97493928	1.98969719	2.00185325	2.0142521
1.2	1.881338956	1.9015504	1.91911644	1.93495101	1.9514561	1.96550476	1.97703469	1.99176219	2.00395641	2.01645028
1.3	1.881338956	1.9015504	1.91911644	1.93495101	1.9514561	1.96550476	1.97703469	1.99176219	2.00395641	2.01645028
1.4	1.881338956	1.9015504	1.91911644	1.93495101	1.9514561	1.96550476	1.97703469	1.99176219	2.00395641	2.01645028
1.5	1.881338956	1.9015504	1.91911644	1.93495101	1.9514561	1.96550476	1.97703469	1.99176219	2.00395641	2.01645028
1.6	1.881338956	1.9015504	1.91911644	1.93495101	1.9514561	1.96550476	1.97703469	1.99176219	2.00395641	2.01645028

0.17922814	0.17428532	0.16801494	0.16215821	0.15807436	0.15286406	0.14917005	0.14573085	0.14129656	0.13808612
1.99930817	2.00845639	2.02072972	2.03316624	2.04263605	2.05528742	2.0648392	2.07452094	2.08750119	2.09734431
1.99930817	2.00845639	2.02072972	2.03316624	2.04263605	2.05528742	2.0648392	2.07452094	2.08750119	2.09734431
1.99930817	2.00845639	2.02072972	2.03316624	2.04263605	2.05528742	2.0648392	2.07452094	2.08750119	2.09734431
1.99930817	2.00845639	2.02072972	2.03316624	2.04263605	2.05528742	2.0648392	2.07452094	2.08750119	2.09734431
1.99930817	2.00845639	2.02072972	2.03316624	2.04263605	2.05528742	2.0648392	2.07452094	2.08750119	2.09734431
1.99930817	2.00845639	2.02072972	2.03316624	2.04263605	2.05528742	2.0648392	2.07452094	2.08750119	2.09734431
1.99930817	2.00845639	2.02072972	2.03316624	2.04263605	2.05528742	2.0648392	2.07452094	2.08750119	2.09734431
2.00084167	2.00999628	2.02229463	2.0347583	2.04424028	2.05689604	2.06647028	2.07615734	2.08915186	2.09900215
2.00774304	2.01694623	2.02940048	2.04199455	2.05148443	2.06420645	2.0738785	2.08359037	2.09665733	2.10651853
2.02018948	2.0295605	2.04215357	2.05483404	2.0644699	2.07738315	2.08710576	2.09687978	2.10996259	2.11984677
2.02684078	2.03638223	2.04916002	2.06206612	2.07179353	2.08477771	2.09452801	2.10431646	2.11742	2.12734918
2.02908102	2.03863602	2.05144519	2.06434197	2.07406953	2.08705782	2.09682569	2.1066488	2.1197968	2.12973357
2.02908102	2.03863602	2.05144519	2.06434197	2.07406953	2.08705782	2.09682569	2.1066488	2.1197968	2.12973357
2.02908102	2.03863602	2.05144519	2.06434197	2.07406953	2.08705782	2.09682569	2.1066488	2.1197968	2.12973357
2.02908102	2.03863602	2.05144519	2.06434197	2.07406953	2.08705782	2.09682569	2.1066488	2.1197968	2.12973357
2.02908102	2.03863602	2.05144519	2.06434197	2.07406953	2.08705782	2.09682569	2.1066488	2.1197968	2.12973357

Appendix B : Correlation Coefficient Farm-Shire at Epsilon 0.01-0.2 CRRA 0 GRAPH

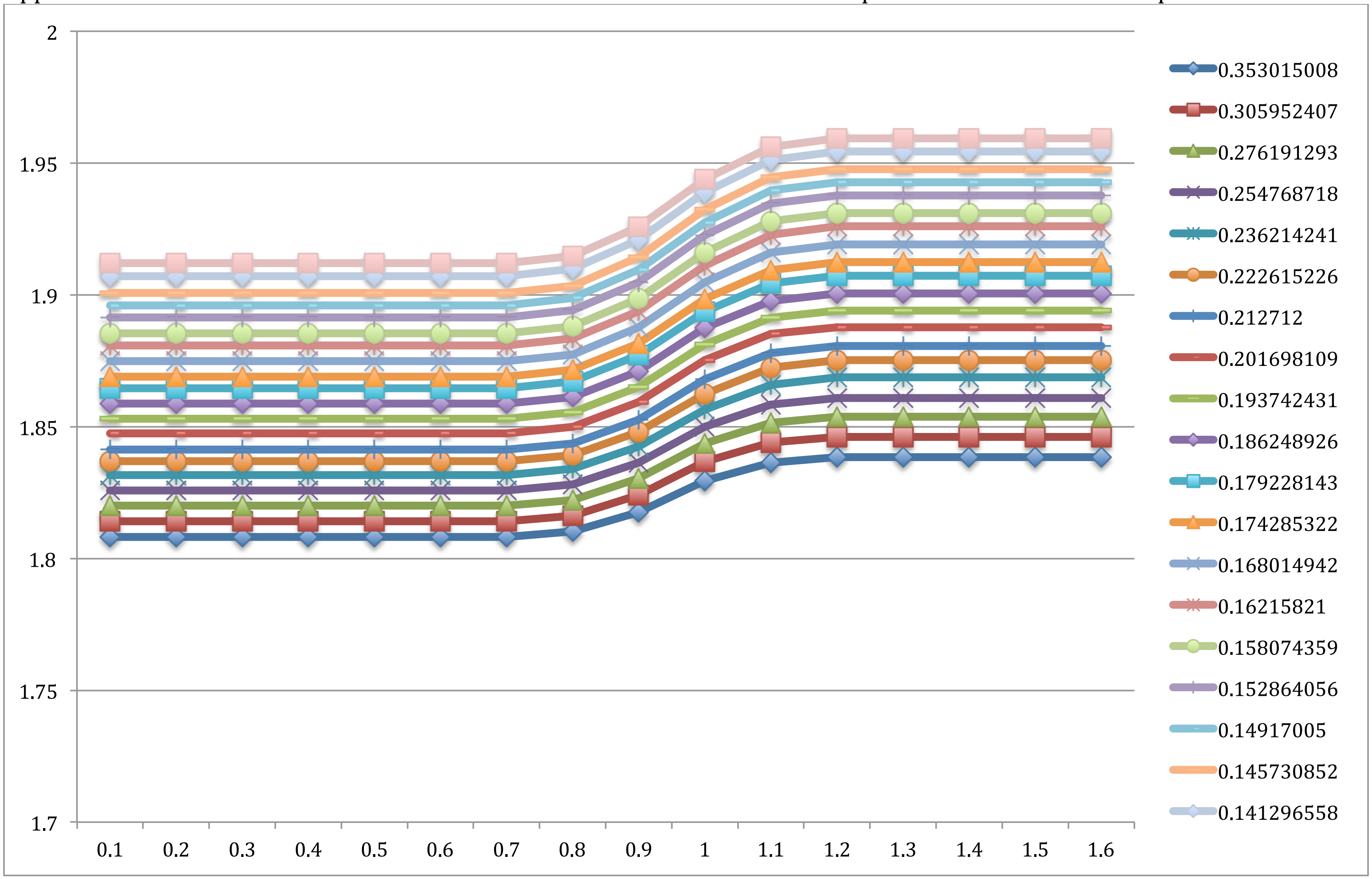


Appendix B : Correlation Coefficient Farm-Shire for correlation coefficients at Epsilon 0.01-0.2 CRRA 1

	0.353015008	0.30595241	0.27619129	0.25476872	0.23621424	0.22261523	0.212712	0.20169811	0.19374243	0.18624893
0.1	1.808171655	1.81413182	1.81997621	1.82573667	1.83165227	1.83684087	1.84125768	1.84747728	1.85301538	1.85872649
0.2	1.808171655	1.81413182	1.81997621	1.82573667	1.83165227	1.83684087	1.84125768	1.84747728	1.85301538	1.85872649
0.3	1.808171655	1.81413182	1.81997621	1.82573667	1.83165227	1.83684087	1.84125768	1.84747728	1.85301538	1.85872649
0.4	1.808171655	1.81413182	1.81997621	1.82573667	1.83165227	1.83684087	1.84125768	1.84747728	1.85301538	1.85872649
0.5	1.808171655	1.81413182	1.81997621	1.82573667	1.83165227	1.83684087	1.84125768	1.84747728	1.85301538	1.85872649
0.6	1.808171655	1.81413182	1.81997621	1.82573667	1.83165227	1.83684087	1.84125768	1.84747728	1.85301538	1.85872649
0.7	1.808171655	1.81413182	1.81997621	1.82573667	1.83165227	1.83684087	1.84125768	1.84747728	1.85301538	1.85872649
0.8	1.810222955	1.81629239	1.82220321	1.82801943	1.83396506	1.83921598	1.84365699	1.84997448	1.85553028	1.86129409
0.9	1.817614168	1.82407798	1.83035177	1.83639318	1.84255286	1.84796537	1.85266486	1.85944179	1.86519393	1.87113247
1	1.829424888	1.83669432	1.84370628	1.85000213	1.85653032	1.8624705	1.86792329	1.87523271	1.88126661	1.88748784
1.1	1.836303378	1.8440693	1.85146828	1.85834312	1.86592852	1.87246927	1.87797208	1.88515433	1.89132367	1.89775776
1.2	1.838430972	1.84613236	1.85376342	1.86089	1.86869144	1.87521161	1.88068181	1.88777652	1.89402988	1.90065567
1.3	1.838430972	1.84613236	1.85376342	1.86089	1.86869144	1.87521161	1.88068181	1.88777652	1.89402988	1.90065567
1.4	1.838430972	1.84613236	1.85376342	1.86089	1.86869144	1.87521161	1.88068181	1.88777652	1.89402988	1.90065567
1.5	1.838430972	1.84613236	1.85376342	1.86089	1.86869144	1.87521161	1.88068181	1.88777652	1.89402988	1.90065567
1.6	1.838430972	1.84613236	1.85376342	1.86089	1.86869144	1.87521161	1.88068181	1.88777652	1.89402988	1.90065567

0.17922814	0.17428532	0.16801494	0.16215821	0.15807436	0.15286406	0.14917005	0.14573085	0.14129656	0.13808612
1.86458916	1.86897257	1.87480162	1.88076118	1.88538243	1.89145686	1.89602311	1.90076574	1.90710683	1.91200083
1.86458916	1.86897257	1.87480162	1.88076118	1.88538243	1.89145686	1.89602311	1.90076574	1.90710683	1.91200083
1.86458916	1.86897257	1.87480162	1.88076118	1.88538243	1.89145686	1.89602311	1.90076574	1.90710683	1.91200083
1.86458916	1.86897257	1.87480162	1.88076118	1.88538243	1.89145686	1.89602311	1.90076574	1.90710683	1.91200083
1.86458916	1.86897257	1.87480162	1.88076118	1.88538243	1.89145686	1.89602311	1.90076574	1.90710683	1.91200083
1.86458916	1.86897257	1.87480162	1.88076118	1.88538243	1.89145686	1.89602311	1.90076574	1.90710683	1.91200083
1.86458916	1.86897257	1.87480162	1.88076118	1.88538243	1.89145686	1.89602311	1.90076574	1.90710683	1.91200083
1.86718098	1.87156921	1.87743985	1.88343983	1.88808134	1.89416189	1.89877092	1.90352418	1.90989896	1.9148044
1.87712913	1.88157757	1.88769592	1.89391588	1.89856765	1.90475756	1.90956625	1.9143737	1.92089528	1.92582077
1.8937055	1.89839034	1.90472386	1.91107869	1.9159919	1.9225455	1.92744015	1.93235986	1.93889501	1.94384303
1.9043628	1.90940377	1.91609513	1.92288554	1.92797623	1.93467435	1.93962534	1.94457483	1.95114259	1.95616901
1.90736374	1.91243498	1.91919514	1.92597182	1.93106273	1.93776951	1.94274789	1.94774928	1.954383	1.95941246
1.90736374	1.91243498	1.91919514	1.92597182	1.93106273	1.93776951	1.94274789	1.94774928	1.954383	1.95941246
1.90736374	1.91243498	1.91919514	1.92597182	1.93106273	1.93776951	1.94274789	1.94774928	1.954383	1.95941246
1.90736374	1.91243498	1.91919514	1.92597182	1.93106273	1.93776951	1.94274789	1.94774928	1.954383	1.95941246
1.90736374	1.91243498	1.91919514	1.92597182	1.93106273	1.93776951	1.94274789	1.94774928	1.954383	1.95941246

Appendix B : Correlation Coefficient Farm-Shire for correlation coefficients at Epsilon 0.01-0.2 CRRA 1 Graph



Appendix B : Correlation Coefficient Farm-Shire for correlation coefficients at Epsilon 0.01-0.2 CRRA 2

	0.353015008	0.30595241	0.27619129	0.25476872	0.23621424	0.22261523	0.212712	0.20169811	0.19374243	0.18624893
0.1	1.753510583	1.74650944	1.74236613	1.73955494	1.7364683	1.73402624	1.73239007	1.73146583	1.7316875	1.7321472
0.2	1.753510583	1.74650944	1.74236613	1.73955494	1.7364683	1.73402624	1.73239007	1.73146583	1.7316875	1.7321472
0.3	1.753510583	1.74650944	1.74236613	1.73955494	1.7364683	1.73402624	1.73239007	1.73146583	1.7316875	1.7321472
0.4	1.753510583	1.74650944	1.74236613	1.73955494	1.7364683	1.73402624	1.73239007	1.73146583	1.7316875	1.7321472
0.5	1.753510583	1.74650944	1.74236613	1.73955494	1.7364683	1.73402624	1.73239007	1.73146583	1.7316875	1.7321472
0.6	1.753510583	1.74650944	1.74236613	1.73955494	1.7364683	1.73402624	1.73239007	1.73146583	1.7316875	1.7321472
0.7	1.753510583	1.74650944	1.74236613	1.73955494	1.7364683	1.73402624	1.73239007	1.73146583	1.7316875	1.7321472
0.8	1.75675769	1.7498721	1.74578795	1.74300748	1.73991706	1.73754279	1.73593377	1.73517196	1.73541268	1.73593638
0.9	1.767290535	1.76068067	1.75695108	1.75427293	1.75131861	1.7490558	1.74783229	1.74779438	1.74827131	1.74900295
1	1.782480308	1.7768947	1.77382683	1.77126024	1.76867756	1.76713196	1.76706368	1.76773711	1.76851877	1.76959509
1.1	1.791722356	1.78672193	1.78408385	1.78218877	1.78124207	1.78070351	1.78061065	1.78094515	1.78188825	1.78323256
1.2	1.794100193	1.78891426	1.78650904	1.78500868	1.78462876	1.78403161	1.78385917	1.7839505	1.78504527	1.78671381
1.3	1.794100193	1.78891426	1.78650904	1.78500868	1.78462876	1.78403161	1.78385917	1.7839505	1.78504527	1.78671381
1.4	1.794100193	1.78891426	1.78650904	1.78500868	1.78462876	1.78403161	1.78385917	1.7839505	1.78504527	1.78671381
1.5	1.794100193	1.78891426	1.78650904	1.78500868	1.78462876	1.78403161	1.78385917	1.7839505	1.78504527	1.78671381
1.6	1.794100193	1.78891426	1.78650904	1.78500868	1.78462876	1.78403161	1.78385917	1.7839505	1.78504527	1.78671381

0.17922814	0.17428532	0.16801494	0.16215821	0.15807436	0.15286406	0.14917005	0.14573085	0.14129656	0.13808612
1.73282762	1.73327165	1.7337996	1.73450724	1.73526152	1.73609534	1.73669726	1.73758468	1.73878171	1.73991923
1.73282762	1.73327165	1.7337996	1.73450724	1.73526152	1.73609534	1.73669726	1.73758468	1.73878171	1.73991923
1.73282762	1.73327165	1.7337996	1.73450724	1.73526152	1.73609534	1.73669726	1.73758468	1.73878171	1.73991923
1.73282762	1.73327165	1.7337996	1.73450724	1.73526152	1.73609534	1.73669726	1.73758468	1.73878171	1.73991923
1.73282762	1.73327165	1.7337996	1.73450724	1.73526152	1.73609534	1.73669726	1.73758468	1.73878171	1.73991923
1.73282762	1.73327165	1.7337996	1.73450724	1.73526152	1.73609534	1.73669726	1.73758468	1.73878171	1.73991923
1.73282762	1.73327165	1.7337996	1.73450724	1.73526152	1.73609534	1.73669726	1.73758468	1.73878171	1.73991923
1.73663433	1.73706658	1.73764509	1.73839287	1.73916782	1.73999399	1.74065537	1.74155042	1.74279671	1.74393947
1.74979382	1.75025567	1.75116537	1.75221267	1.75296988	1.75390942	1.75488806	1.75585298	1.75731628	1.75845611
1.77057876	1.77129501	1.77244833	1.77362912	1.7747519	1.77623563	1.77729812	1.77839629	1.77979427	1.78088975
1.78481094	1.78612538	1.78780345	1.78963001	1.79098653	1.79263103	1.79371888	1.79479842	1.79614578	1.79729127
1.78847842	1.78983494	1.79161805	1.79340269	1.79473944	1.7963727	1.79747684	1.79860026	1.7999977	1.8011045
1.78847842	1.78983494	1.79161805	1.79340269	1.79473944	1.7963727	1.79747684	1.79860026	1.7999977	1.8011045
1.78847842	1.78983494	1.79161805	1.79340269	1.79473944	1.7963727	1.79747684	1.79860026	1.7999977	1.8011045
1.78847842	1.78983494	1.79161805	1.79340269	1.79473944	1.7963727	1.79747684	1.79860026	1.7999977	1.8011045
1.78847842	1.78983494	1.79161805	1.79340269	1.79473944	1.7963727	1.79747684	1.79860026	1.7999977	1.8011045

Appendix B : Correlation Coefficient Farm-Shire for correlation coefficients at Epsilon 0.01-0.2 CRRA 2 Graph

Appendix B : Correlation Coefficient Farm-Shire for correlation coefficients at Epsilon 0.01-0.2 CRRA 3

Appendix B : Correlation Coefficient Farm-Shire for correlation coefficients at Epsilon 0.01-0.2 CRRA 3 Graph

Appendix B : Correlation Coefficient Farm-Shire for correlation coefficients at Epsilon 0.01-0.2 CRRA 4

Appendix C: References- Literature Review

Barnett BJ (2000) The U.S. Federal Crop Insurance Program. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* **48**, 539-551.

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