Optimal Allocation of Index Insurance Intervals for Commodities

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association (SAEA) Annual Meeting, Atlanta, Georgia, January 31-February 3, 2015.

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Abstract

The objective of this research is to incorporate the relationship between forage yields and rainfall levels to find optimal weights on insurance intervals using Pasture, Rangeland, and Forage Rainfall Index (PRF-RI) insurance. Unlike earlier models, actuarial fairness of the insurance product is assumed. Historical rainfall index and hay yield data are used to calculate returns and generate an efficient frontier using Markowitz Portfolio Theory.

Analysis of several counties in South Dakota demonstrates that the May-June and July-August intervals are important months for managing forage production risk. Sensitivity analysis included changing coverage levels, productivity factors, and the subsidy level. It is demonstrated that a producer enrolling in PRF-RI would earn higher returns per acre with lower risk compared to not using the subsidized insurance. Without the premium subsidy the mean returns from the optimal portfolio are lower, but the risk reduction remains.

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It is important for agricultural producers to manage the risks they face during production. There are many risk management tools administered by the United States Department of Agriculture's Risk Management Agency (RMA). In 2010 RMA insured 256 million acres of farm land with 1.14 million policies worth $77.9 billion in crop value (RMA). Traditional insurance coverage is dependent on losses that occur after a certain event. A crop producer would receive an indemnity payment only if the insured yield was less than the coverage yield for that year.

Traditional insurance has disadvantages of moral hazard and adverse selection. The issue of moral hazard arises after producers purchase traditional insurance; they may have little incentive to incur costs to prevent low yields. Adverse selection is using information about the degree of risk by the policyholder to their benefit. This can result in higher indemnity payments and would cause insurance premiums to go up in the future. Makki and Somwaru (2001), through empirical analysis, show that high-risk farmers are more likely to select a higher coverage level because of higher benefits and will be under-charged for coverage while low-risk farmers will be over-charged for insurance because of adverse selection.

Index based insurance products rely on measuring a variable that is highly correlated with the production of the crop. Because these products do not require farm level data they can be superior to traditional insurance. Most crop insurance policies pay indemnities based on yield and revenue. For many forages yield data are not readily available because of its bulk as a commodity and of the tendency for forage producers to use forage and not sell it. While data on yields of hay and other forages can be difficult to obtain, weather based index insurance does not require yield and revenue data. Thus, it can be a risk management tool for producers. Unlike traditional insurance products, index insurance products are not prone to the common insurance problems of moral hazard and adverse selection (Barnett 2004).

Basis risk, the difference between an index level and farm level yield, is one of the major concerns for index based insurance. It is highly improbable that an index would perfectly correlate with the farm level yield. Thus, there could be times when a producer could get an indemnity payment without a yield loss. Similarly, a producer may not receive an indemnity payment with a yield loss. According to Miranda and Farrin (2012), “Basis risk is the most serious obstacle to the effectiveness of index insurance as a general risk management tool”. Smith and Watts (2009) argue that the weather index insurance provided by RMA is imperfect as “it allows a farmer to game the product to maximize expected subsidies by insuring in intervals which the rainfall index exhibits the most volatile behavior, regardless of whether rainfall in those periods has any direct link to crop yields or forage growth”.

There are different types of insurance available for row crops but fewer for pastureland. Pastureland encompasses native rangelands, improved pasture because of practices of seeding, irrigation and use of fertilizers, and hay crops. Common features of pastureland are perennial forage production and ad-hoc to continuous harvesting either by haying or grazing livestock. Thus, pastureland is rarely harvested at a single time of the year like row crops such as corn, soybeans and wheat. To date, insurance products targeted to pastureland have neither been as prevalent nor as widely adopted when compared to other crops.

One of the weather index based risk management tools administered by RMA is the Pasture, Rangeland and Forage (PRF) insurance. PRF has been analyzed empirically for its potential to increase land values (Ifft, Wu, and Kuethe, 2014). Potential adverse selection has also been addressed for PRF (Nadolnyak and Vedenov, 2013).

Federal Crop Insurance Corporation (FCIC) launched the Pasture, Rangeland and Forage Index Pilot Program in 2007 with both rainfall and vegetation indexes. It was initially launched for six states but was expanded to other states including South Dakota (RMA). PRF with the rainfall index was first available in South Dakota for the 2013 crop year. South Dakota has 44 million acres of land in farms, and pasture and grazing accounts for 23 million acres of land use (NASS). PRF-RI may be a useful tool for producers to protect them from the risk of droughts. However, only two million acres were insured under PRF-RI in 2013.

The goal of the PRF-RI product is for farmers to have a risk management tool to insure against losses due to low rainfall. Animal production is dependent on forage quality and quantity. Low yields and poor quality of forages could cause financial losses to farmers. However, with insurance producers can expect an indemnity payment when yield losses occur. PRF-RI depends on the historical relationship between rainfall and forage production. The research objective is to find an optimal portfolio of insurance intervals that are highly correlated with rainfall. Such a portfolio would provide indemnity payments during the months of low rainfall that could offset the cost of buying forage. This will be achieved through the following specific objectives:

- Using portfolio theory to create an efficient portfolio frontier,
- Comparing different portfolios to determine the portfolio with the highest return that meets the risk preference of producers', and
- Determining costs and benefits of portfolio application to the producer versus not enrolling in the PRF-RI program and insuring all intervals equally.

Background on Pasture, Rangeland and Forage Insurance

PRF-RI coverage details are outlined in the “PRF Fact Sheet”, the “Rainfall Index Plan Common Policy”, and the “Pasture, Rangeland, Forage Crop Provisions” available from the Risk Management Agency (RMA) website (www.rma.usda.gov). In states with PRF-RI available, the area is divided into 12 by 12 mile grids. PRF uses rainfall data provided by the National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA) (RMA). Producers can select among eleven index intervals with each index interval containing a two month period: January-February, February-March, March-April, April-May, May-June, June-July, July-August, August-September, September-October, October-November, and November-December. Producers have to select coverage in a minimum of two intervals that do not overlap. Thus, a producer can only purchase a maximum of six intervals.

In South Dakota the maximum grazing land portion that can be insured in each index interval is 70 percent and the minimum is 10 percent. Different states can have different maximum or minimum levels of land that can be insured. In addition, the insured also selects a specific coverage level and a productivity factor. A productivity factor allows the insured them to individualize coverage based on productivity of crops, and it ranges from 60 through 150 percent (RMA). The insured can select a coverage level between 70 and 90 percent as desired to cover against losses. Indemnities are paid when the value of the index in a given interval falls below the trigger grid index.

The dollar amount of protection is based on the productivity factor and the coverage level. The dollar amount of protection equals the product of the county base value, the productivity factor and the coverage level. The county base is determined by FCIC and different counties may have different base values. The premium rate varies by county and depends on coverage levels and index intervals. The federal subsidy depends on the coverage level selected by the insured. The higher the coverage level, the lower the subsidy percentage.

For example, the county base value in 2013 for haying in Brookings County, South Dakota is \$204.23 per acre. The premium rate for the 90 percent coverage level is .2129 for January and February (RMA). The subsidy level for the 90 percent coverage level is 51 percent. If the producer selects the maximum productivity factor of 150% and a coverage level of 90 percent, the dollar amount of protection per acre would be \$275.71. The total cost of the premium would be \$59 per acre. With the premium subsidy the total cost to the producer is \$29 per acre for insuring the January and February interval. The producer would receive an indemnity payment if the final index value is below the trigger grid index.

The final grid index is determined using NOAA precipitation data and the trigger grid index is the product of the expected grid index and the coverage level. The expected grid index is the mean of NOAA's historical precipitation data. The trigger grid index for previous example would equal:

$$\text{Trigger grid index} = 100 * .90 \text{ or } 90.$$

The payment calculator factor would be the difference between the trigger and final grid index divided by the trigger grid index. The total indemnity payment would be the product of the payment calculation factor and the total policy protection level. For example, if the final grid index is 80, the payment calculator factor would equal:

$$\text{Payment calculator factor} = (90 - 80) / 90 \text{ or } 0.1111,$$

and the total indemnity payment would equal

Indemnity payment = 0.111 * 275.71 or $30.60.

Thus, with low rainfall an indemnity payment would exceed the cost of the insurance.

Methodology

Preliminary analysis shows that hay yields are highly correlated with rainfall totals. A way to purchase insurance may be to use Markowitz portfolio theory to find an optimal portfolio on the efficient frontier. Assuming each index interval and forage are assets; an efficient frontier can be created. The efficient frontier has the highest possible expected rate of return given a fixed level of standard deviation. Similar empirical applications can be found in Barkley, Peterson, and Shroyer (2010); Nalley, et al. (2009); and Popp and Rudstrom (2000). It is important to incorporate net returns from forage production and use its correlation with indemnity payments triggered during low rainfall. The return from the portfolio would offset losses caused by low forage production and provide indemnity payments to buy replacement forage.

The goal of this research is to use the historical index data from six different intervals to calculate net returns and incorporate returns from forage production to model PRF-RI using modern portfolio theory. Every insured producer can have different portfolio weightings based on their risk preference and local production data. However, because localized forage data are not readily available, county level hay data are used from 1948 to 2012. The literature suggests using Monte-Carlo simulation to calculate indemnity payments to find the portfolios. Because the historical rainfall data are available for South Dakota counties, it will be used to calculate a minimum variance portfolio, an equally weighted portfolio and a portfolio that will maximize returns. Comparing these portfolios will provide insight as to which months are more important to insure. Simulation and Econometrics to Analyze Risk (Simetar) and Excel will be used to find different portfolios. Oracle Crystal Ball will be used to find the efficient frontiers. Sensitivity analysis will be performed using different coverage levels, productivity factors and subsidy assumptions. The result from the sensitivity analysis can be used to confirm the robustness of the model.

A Markowitz portfolio application requires historical returns of assets to calculate an efficient frontier. It is assumed the annual indemnity payments less premiums are the net returns for each interval. Forage is incorporated into the model by calculating hay returns using hay yields and prices. Ideally farm level hay yield and revenue data would be used to calculate hay returns because a correlation between hay returns and index intervals would result in indemnity payments during periods with shortages of hay. Because farm level data are not available, it is assumed that a producer would require a five year average county level hay yield for feed needs. If the yield is below the five year average a producer would have a shortage and need to buy additional hay. If the yield is greater than the five year average the producer would have surplus forage to sell.

Because PRF-RI is based on precipitation and its relationship with yield, one assumption is that other production factors are constant. Another assumption is that the only relevant cost associated with growing hay is the cost of insurance for risk management. The portfolio application will be carried out for five different counties in South Dakota. The five counties selected are Brookings County, Campbell County, Tripp County, Butte County and Hughes County (Figure 1). The counties are located on the North, South, East, West and center of South Dakota.

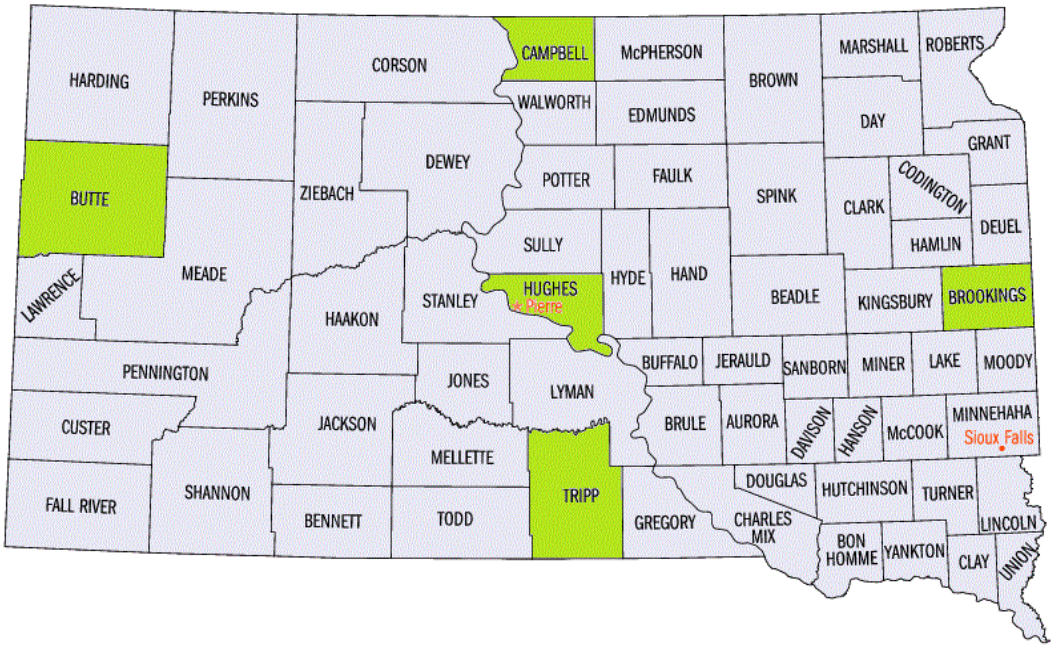

Figure 1. County Map of South Dakota

The results from different counties can be compared to show any variation in optimal weights from different regions. To find the efficient frontier the net returns from hay production and index intervals are calculated. Rainfall and hay yield has a correlation of 0.89 in South Dakota. Figure 2 shows the relationship between rainfall and hay yield in South Dakota.

Calculating Returns from Hay Production

To calculate returns from hay the historical hay price and yield data from USDA NASS are used. The rainfall index data are available from 1948 to 2012, so county-level hay data from 1948 to 2012 are used. Hay yield data at the county level are not available from 1976 to 1995, so the hay yield during that time period will be calculated using oats yield as a proxy. Oats data were used because it can be used as livestock feed, and because of its high correlation with hay yield. Hay yield and oats yield has a correlation of 0.86 at the state level in South Dakota. Figure 3 shows the long-run relationship between hay yield and oats yield in South Dakota.

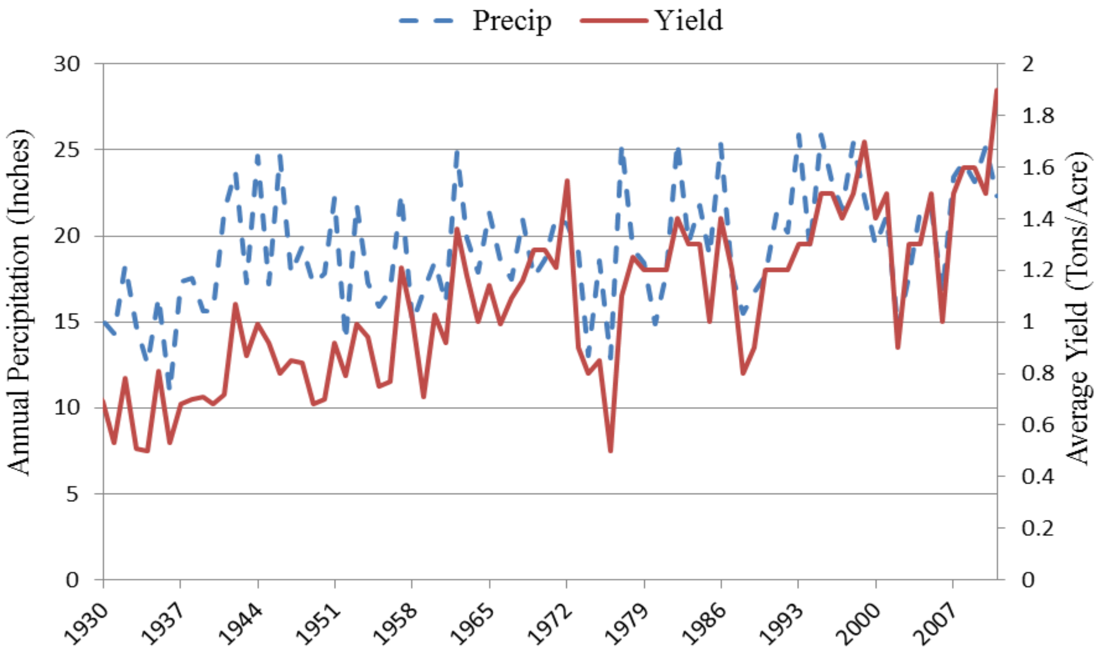

Figure 2. Hay Yield and Rainfall 1930 to 2012

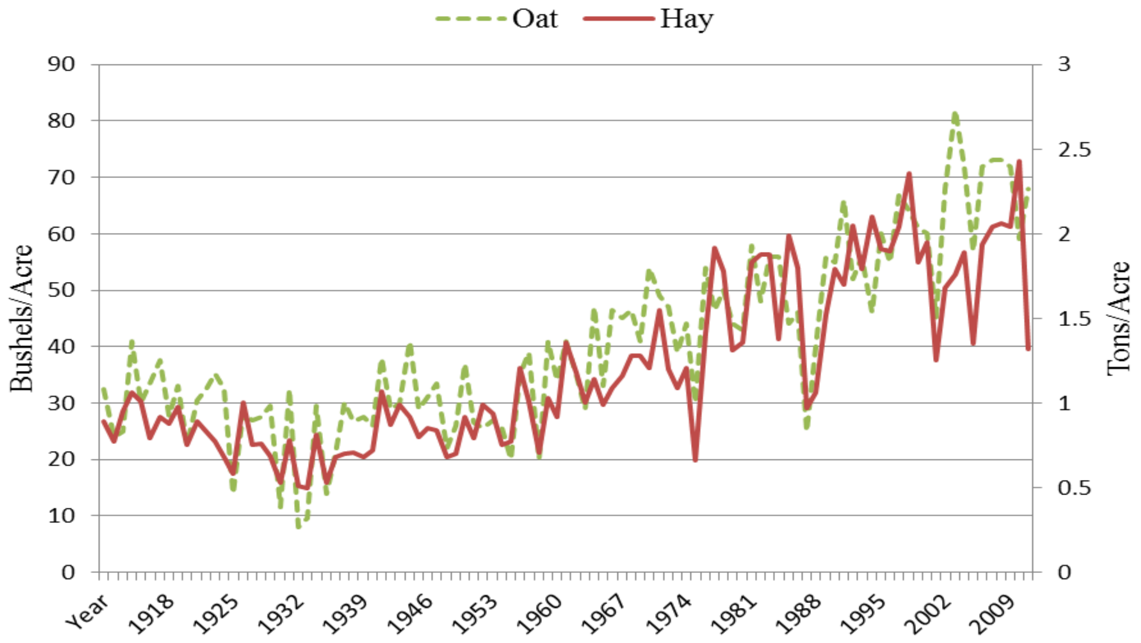

Figure 3. South Dakota Oat and Hay Yield

Hay yield from 1976 to 1994 was forecasted using the oats yield observed during the same period:

$$HayY_t = \alpha + \beta * OatsY_t.$$

The sample period in the regression used to estimate the hay yield was from 1924 to 2008, resulting in observed and proxies for hay yields denoted as Y_t. Assuming a producer would require a five year average hay yield to calculate hay returns, the hay yield deviation (YD_t) from the five year average is calculated as:

$$YD_t = Y_t – 1/5 * (Y_{t-1} + Y_{t-2} + Y_{t-3} + Y_{t-4} + Y_{t-5}).$$

The percent yield deviation ($\%YD_t$) is calculated as:

$$\%YD_t = \{ Y_t / [1/5 * (Y_{t-1} + Y_{t-2}+Y_{t-3}+Y_{t-4}+Y_{t-5})] \} * 100.$$

Calculating the five year moving average also de-trends the yield data. A producer is assumed to sell any surplus hay and buy any shortage of hay annually. If the percent yield deviation is between 90 to 100% of the five year average, the producer does not buy or sell any hay. If the percent yield deviation is greater than 100%, the producer sells any surplus (in tons). The producer buys hay to replace any percent yield deviation less than 90% to be consistent with a producer that would select 90% coverage level in the base model. The surplus or shortage rule is:

$$\text{if } \%YD_t > 100\% \text{ then}$$

$$\text{Yield Surplus}_t = \%YD_t – 100\%, \text{ and}$$

$$\text{if } \%YD_t < 90\% \text{ then}$$

$$\text{Yield Shortage}_t = 90\% - \%YD_{t,} \text{ and}$$

$$\text{Yield Surplus}_t/\text{Shortage}_t = 0, \text{ otherwise.}$$

Yield deviations are then calculated in terms of their 2012 values, which is the product of Yield Surplus/Shortage and the 2012 hay yield as:

$$YD12_t = \text{Yield Surplus}_t/\text{Shortage}_t * 2012 \text{ Hay Yield.}$$

The trend-adjusted yield deviations are then multiplied by the average price received that year inflated to 2012 dollars using the Producer Price Index (PPI) for Farm Commodities (BLS) to obtain hay returns:

$$\text{Hay Returns}_t = YD12_t * \text{Price}12_t.$$

The average hay prices from 1949 to 2012 are inflated to 2012 dollars to remove price inflation effects from the hay returns data. Net returns from hay production will be positive during surplus years and negative during shortage years. During a hay shortage, a producer would require the average hay yield, so they would want to buy hay causing a steep increase in price. However, during surplus years only the supply will increase and demand would not change because producers would have enough hay locally and the excess supply would cause the price to decline. Figure 4 shows the actual hay price and the inflated hay price from year 1949 to 2012.

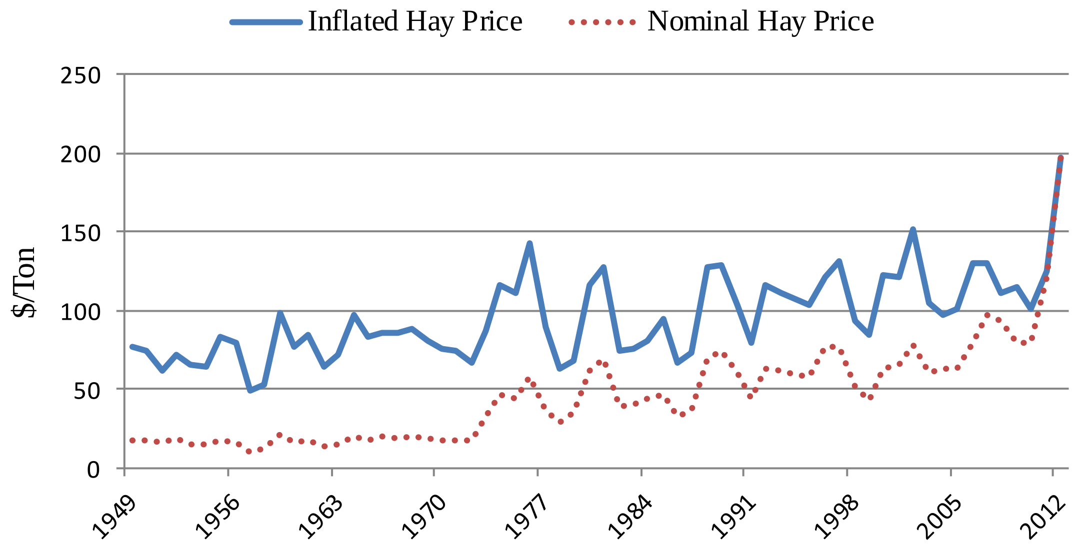

Figure 4. South Dakota Nominal and Inflated Hay Prices

Calculating Net Returns from Index Intervals

Indemnity payments are calculated using the method described in the PRF-RI basic provisions. Rainfall index data are used from the RMA decision support tool. Data are available for 11 different index intervals. To focus the model, only the intervals of January-February, March-April, May-June, July-August, September-October, and November-December are used as they cover a calendar year. Indemnity payments depend on the dollar amount of protection per acre calculated as:

Amount of Protection = Productivity factor * Coverage level * County Base Value.

In the base model, a productivity factor of 150% and a coverage level of 90% are used. The subsidy associated with the 90% coverage level is 51%. Indemnity payments are triggered if the rainfall index falls below the selected coverage level, and the producer would receive an indemnity payment based on the payment factor:

$$\text{Payment Factor} = (\text{Coverage level} - \text{Final grid index}) / \text{Coverage level},$$

giving the following:

$$\text{Indemnity Payment} = \text{Payment factor} * \text{Amount of Protection}.$$

Premium rates are provided by RMA and are used to calculate the total premium per acre for PRF-RI. Table 1 shows the premium rates in 2013 for the five selected South Dakota counties, calculates as:

$$\text{Premium per Acre} = \text{Premium rate} * \text{Amount of Protection}.$$

Table 1. 2013 Premium Rates at the 90% Coverage Level for Selected Counties ($/acre)

Intervals	Brookings	Hughes	Campbell	Butte	Tripp
Jan-Feb	$ 0.2129	$ 0.2418	$ 0.2427	$ 0.1730	$ 0.2499
Feb-Mar	$ 0.1589	$ 0.1639	$ 0.2437	$ 0.1437	$ 0.1501
May-Jun	$ 0.1276	$ 0.1351	$ 0.1233	$ 0.1549	$ 0.1184
Jul-Aug	$ 0.1220	$ 0.1194	$ 0.1668	$ 0.1329	$ 0.1300
Sep-Oct	$ 0.1746	$ 0.2220	$ 0.2665	$ 0.2332	$ 0.1922
Nov-Dec	$ 0.2459	$ 0.2675	$ 0.2659	$ 0.1783	$ 0.2607

Because the federal government provides a subsidy of 51% at the 90% coverage level, the premium after the subsidy is what the insured would pay for PRF-RI:

$$\text{Premium after Subsidy} = \text{Premium per Acre} * (1 - .51).$$

The net return to the insured is from any indemnity payment and after the premium outlay for that interval for a particular year, calculated as:

$$\text{Net return} = \text{Total Indemnity Payments} - \text{Premium after Subsidy}.$$

Net returns for the index intervals start out negative because of the premium paid for the insurance. The index interval will only be positive if the interval receives less rainfall than the selected coverage level, with indemnity payments exceeding the premium. Once the net return for different intervals and hay are calculated, Markowitz portfolio theory is applied to determine the efficient frontier of index intervals with hay. The returns are then used to calculate the mean return, standard deviation and covariance for all the assets. The total variance of the portfolio equals:

$$\sigma_p^2 = \begin{bmatrix} W_1 & W_2 & W_3 & W_4 & W_5 & W_6 & W_7 \end{bmatrix} \begin{bmatrix} \sigma_{1,1}^2 & \sigma_{1,2} & \sigma_{1,3} & \sigma_{1,4} & \sigma_{1,5} & \sigma_{1,6} & \sigma_{1,7} \\ \sigma_{2,1} & \sigma_{2,2}^2 & \sigma_{2,3} & \sigma_{2,4} & \sigma_{2,5} & \sigma_{2,6} & \sigma_{2,7} \\ \sigma_{3,1} & \sigma_{3,2} & \sigma_{3,3}^2 & \sigma_{3,4} & \sigma_{3,5} & \sigma_{3,6} & \sigma_{3,7} \\ \sigma_{4,1} & \sigma_{4,2} & \sigma_{4,3} & \sigma_{4,4}^2 & \sigma_{4,5} & \sigma_{4,6} & \sigma_{4,7} \\ \sigma_{5,1} & \sigma_{5,2} & \sigma_{5,3} & \sigma_{5,4} & \sigma_{5,5}^2 & \sigma_{5,6} & \sigma_{5,7} \\ \sigma_{6,1} & \sigma_{6,2} & \sigma_{6,3} & \sigma_{6,4} & \sigma_{6,5} & \sigma_{6,6}^2 & \sigma_{6,7} \\ \sigma_{7,1} & \sigma_{7,2} & \sigma_{7,3} & \sigma_{7,4} & \sigma_{7,5} & \sigma_{7,6} & \sigma_{7,7}^2 \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ W_3 \\ W_4 \\ W_5 \\ W_6 \\ W_7 \end{bmatrix},$$

where W_I = Portfolio Weights,

$\sigma_{i,j}^2$ = Variance, and

$\sigma_{i,j}$ = Covariance.

PRF-RI in South Dakota allows producers to insure a maximum of 70 percent of eligible acres in a given interval and a minimum of 10 percent in a given interval. Imposing the minimum of 10% increases the complexity of the model. The producer uses the land to grow hay and to allocate it across different intervals for insurance protection. Thus, the total weight of the portfolio would equal two with hay returns being one and the sum of index interval weights being one. The goal is to minimize the standard deviation subject to the following constraints:

i. the weight of an interval should be less than or equal to 70%,
ii. the weight of hay returns should equal one, and
iii. the sum of the weight of hay returns and interval should equal two.

The mean return and standard deviation from the portfolio without insurance is compared against the portfolio of equally weighted intervals, the minimum variance portfolio and the portfolio with the maximum return. Excel solver was used to solve the liner programming problem of calculating the portfolio variance for different portfolios.

Data

Rainfall index interval data for all counties in South Dakota are available from RMA from 1948 to present. County level hay data are available from National Agriculture Statistics Service (NASS). Since the hay data are not available from 1976 to 1994, county level oats yield data are used as a proxy for hay yield. Oats yield are also available through NASS. Premium rates for index intervals for different counties are also available through the RMA. Hay prices were inflated using PPI from the Bureau of Labor Statistics (BLS).

Results

Hughes County was selected as the representative county. What follows is the portfolio analysis for Hughes County in South Dakota. The results were calculated using a base model with a coverage level of 90% and a productivity factor of 150. The subsidy level associated with 90% coverage level was 51%. The results are compared against a portfolio with equal weightings, a portfolio with the maximum return and a portfolio of forage production without PRF-RI. Table 2 contains the premium rates for Hughes County.

Table 2. Premiums for Hughes County ($/Acre)

Grid 28921	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
Premium	66.67	45.19	37.25	32.92	61.21	73.75
After Subsidy	32.67	22.14	18.25	16.13	29.99	36.14

Table 3 provides the summary statistics of returns from index intervals and hay. The November-December interval has the highest mean return of $27.65 per acre with a standard deviation of 77.24. The January-February interval has the highest standard deviation of 78.04 with a mean return of $23.98 per acre. Hay has a mean return of $6.09 per acre and a standard deviation of 22.38 in Hughes County.

Table 3. Summary Statistics for Hughes County (per acre)

	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Hay Returns
Mean	$ 23.98	$ 15.66	$ 13.51	$ 15.18	$ 25.32	$ 27.65	$ 6.09
StDev	$ 78.04	$ 57.91	$ 50.19	$ 46.08	$ 77.35	$ 77.24	$ 22.38
CV	325.39	369.74	371.54	303.56	305.53	279.33	367.57
Min	$ (32.67)	$ (22.14)	$ (18.25)	$ (16.13)	$ (29.99)	$ (36.14)	$ (56.85)
Max	$ 238.75	$ 159.21	$ 188.84	$ 187.28	$ 243.27	$ 219.97	$ 58.59

Table 4 provides summary statistics for portfolio weights, mean returns to portfolio selection and the respective standard deviation for each portfolio. A producer would have to allocate 35% of acres in the May-June interval and 33% of acres in the July-August interval to achieve a minimum variance portfolio. Doing so, a producer would be able to achieve a mean return of $22.31 per acre with a standard deviation of 21.57.

Table 4. Summary Statistics for Portfolio Returns for Hughes County: 1949 to 2012.

Grid 28921 (Hughes)	Hay Sales	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec	Return ($/acre)	StDev ($/acre)
Min Variance	1.00	0.09	0.16	0.37	0.34	0.00	0.04	22.31	21.87
Max Return	1.00	0.00	0.00	0.00	0.00	0.30	0.70	35.87	64.31
Equal Weight	1.00	0.17	0.17	0.17	0.17	0.17	0.17	26.71	29.23

A producer seeking to achieve maximum returns from enrolling in PRF-RI would have to allocate 70% of acres in the November-December interval and 30% of acres in the September-October interval. The maximum return portfolio has a mean return of $35.87 per acre with a standard deviation of 64.31. An equal allocation of acres across all intervals has a mean return of $26.71 per acre with a standard deviation of 29.23. A producer enrolling in PRF-RI would earn 266.27% more compared to a producer not enrolling. Not only would the return increase but the standard deviation would also decrease by 3.66%. Figure 5 presents the estimated efficient frontier for Hughes County.

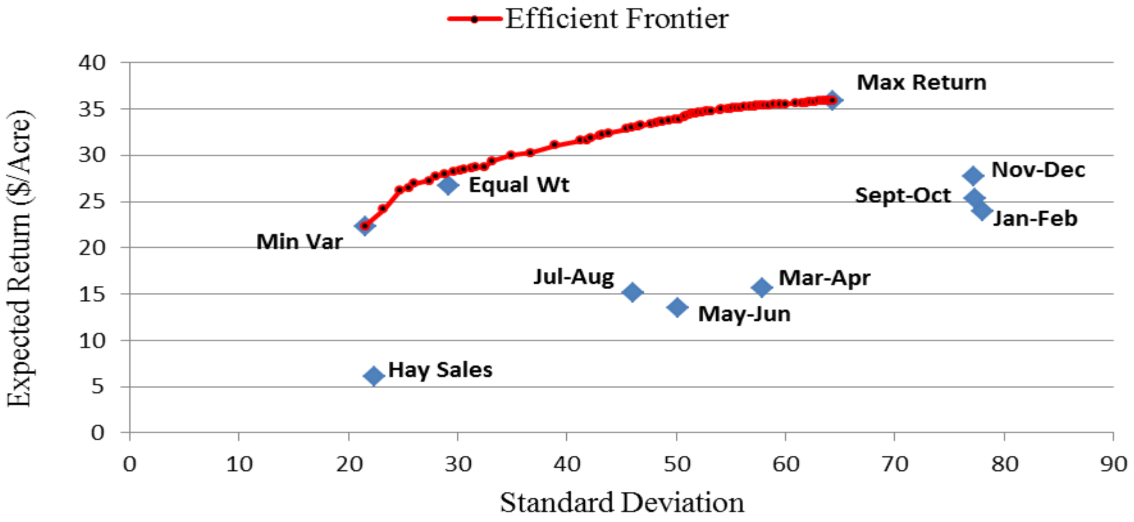

Figure 5. Efficient Frontier for Hughes County

Summary

By incorporating forage returns, portfolio theory can be used to find efficient allocations of insurance intervals for PRF-RI. The lack of local forage data meant that a proxy for yields was necessary. However, the outcomes are consistent with the desire of the potential insured parties to have payments that offset expected forage risk. The efficient portfolios have lower risk and/or higher returns compared to isolated choices of intervals. In the long run a minimum variance portfolio of index intervals provides higher returns and lower risk for a producer in Hughes County. Without the premium subsidy the mean returns from the minimum variance portfolio are lower. The subsidy can be evaluated further. The subsidy level and general application of the subsidy is subject to debate (see Smith and Glauber, 2012).

References

Barkley, A., H.H. Peterson, and J. Shroyer. “Wheat Variety Selection to Maximize Returns and Minimize Risk: An Application of Portfolio Theory.” *Journal of Agricultural and Applied Economics* 42(2010): 39-55.

Barnett, B.J. “Agricultural Index Insurance Products: Strengths and Limitations.” Agricultural Outlook Forum 32971, United States Department of Agriculture, 2004.

Ifft, J., S. Wu, and T. Kuethe. “The Impact of Pasture Insurance on Farmland Values.” *Agricultural and Resource Economics Review* 43(2014): 390-405.

Makki, S., and A. Somwaru. “Evidence of Adverse Selection in Crop Insurance Markets.” *The Journal of Risk and Insurance* 68(2001): 685-708.

Miranda, M.J., and K. Farrin. “Index Insurance for Developing Countries.” *Applied Economic Perspectives and Policy* 34(2012): 391-427.

Nadolnyak, D. and D. Vedenov. “Information Value of Climate Forecasts for Rainfall Index Insurance for Pasture, Rangeland,and Forage in the Southeast United States.” *Journal of Agricultural and Applied Economics* 45(2013): 109-124.

Nalley, L.L., A. Barkley, B. Watkins, and J. Hignight. “Enhanching Farm Profitabiltiy through Portfolio Analysis: The Case of Spatial Rice Variety Selection.” *Journal of Agricultural and Applied Economics* 41(2009): 641-652.

Popp, M., and M. Rudstrom. “Crop Enterprise Diversification and Specialty Crops.” *Agriculture Finance Review* 60(2000): 85-98.

Smith, V.H., and J.W. Glauber. “Agricultural Insurance in Developed Countries:Where Have We Been and Where Are We Going?” *Applied Economic Perspectives and Policy* 34(2012): 363-390.

Smith, V.H., and M. Watts. “Index Based Agricultural in Developing Countries: Feasibility, Scalability and Sustainability.” Monograph published electronically by the Bill and Melinda Gates Foundation, 2009.