Factors affecting the use of forage index insurance

Empirical evidence from Alberta and Saskatchewan, Canada

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Abstract

Purpose – The purpose of this paper is to examine factors affecting the use of forage index insurance. Forage is a difficult crop to insure, and index insurance may be well suited for forage insurance and has been implemented in several countries, including Canada, the USA and France. Despite being a promising risk management tool, forage index insurance participation rates in Canada, and other countries are low relative to crop insurance participation rates for grain and oilseed producers.

Design/methodology/approach – A survey was conducted with 87 beef and cattle producers from Alberta and Saskatchewan, Canada. A probit regression model was used, and a number of variables were included to examine the use of forage index insurance.

Findings – In total, 6 of 11 variables in the model are found to be statistically significant in explaining forage producers' use of forage index insurance. Results suggest that producers who maintain lower feed reserves are more likely to purchase forage index insurance. Also, producers with higher levels of knowledge of crop insurance and a more positive attitude toward forage insurance are more likely to use forage index insurance. Furthermore, producers are more likely to use forage index insurance if they perceive drought and weather risk as being of greater importance, and if they are younger. The importance of the variable forage index insurance premium price was statistically insignificant. This could be due to the effect of subsidization, reducing the importance of price for the decision to purchase. Similarly, the use of other subsidized risk management policies, including a whole-farm margin policy (e.g. the government program and AgriStability), did not reduce forage index insurance use. A possible explanation for this is that the subsidization of the policies may make it profitable to purchase both, despite the overlapping coverage.

Practical implications – These results may be useful for policy makers interested in increasing forage index insurance participation rates, as forage index insurance participation rates have historically been low relative to grain and oilseed producers.

Originality/value – This study is believed to be one of the first studies regarding the use of forage index insurance by forage producers. Producers can be exposed to catastrophic risks such as drought or other extreme weather events, and forage index insurance may be an effective means to manage these risks. Index insurance determines payments using an index that is correlated to producers' actual yields. A downside of this method is basis risk, which is the mismatch between the insured index and the producer's actual yield. Research has focused on basis risk and developing improved methods to reduce basis risk. However, less research has investigated the other important factors that may contribute to forage index insurance use.

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Keywords Agricultural insurance, Crop insurance, Index insurance, Forage index insurance, Forage insurance, Willingness to purchase

Paper type Research paper

1. Introduction

Forage is an important source of feed for the beef and dairy industry, and pasture and rangeland make up the largest proportion of agricultural land in North America (McCartney, 2011; Sanderson *et al.*, 2012). Beef producers and dairy producers face many risks, including feed production risk and feed price risk. In Canada, the largest concentration of beef producers is in the western provinces of Alberta and Saskatchewan. Feed production risk in Alberta and Saskatchewan is often due to droughts that are prevalent in both provinces. Extended droughts can severely damage forage and are not uncommon (Maybank *et al.*, 1995). In addition to production risk, producers face considerable feed price risk, in which farmers can face financial loss. Feed price variability is related to supply, and during production shortages replacing feed may become more expensive. A catastrophic event such as a prolonged drought can cause large farm losses due to increased feed cost. For example, Western Canadian producers experienced a decade-long drought in the 1930s that decimated forage production, and have experienced several severe droughts since (Khandekar, 2004). Similarly, in the USA over the past century, multiple severe droughts have destroyed forage and other crops (Woodhouse and Overpeck, 1998).

In the past, some forage losses have been covered by *ad hoc* government disaster payments. For example, in Canada in 2002 after a severe drought limited feed availability for beef and dairy producers in Alberta and Saskatchewan, the government paid $355m in disaster payments (Klein and Le Roy, 2010), far more than previous assistance. A more efficient and cost-effective way of handling large farm losses may be through risk management and a well-functioning insurance program. However, crop insurance participation rates for grains and oilseed producers are generally high, around 70–80 percent, but forage index insurance participation is much more limited at approximately 20 percent. As a result, forage producers may be exposed to large farm losses due to low insurance participation rates.

For many reasons, forage is a difficult crop to insure (De Leeuw *et al.*, 2014), including that it is primarily used on-farm and often little or no documentation exists regarding producers production history. Index insurance may be an appropriate solution for forage insurance, and there are index insurance policies available in several countries, including Canada, the USA and France, among others. Index insurance is designed to approximate producers' crop yield (e.g. forage yield). Common indices include weighted growing season precipitation indices and satellite vegetation indices. Index insurance suffers from basis risk, which is the mismatch between the insured index and the farmer's actual production. Research has focused on identifying and reducing the level of basis risk for forage index insurance policies (Yu *et al.*, 2019; Maples *et al.*, 2016), which has been cited as the largest drawback of index insurance (Smith and Watts, 2009), however, other factors may contribute to low participation rates. Producers may have a different risk management environment regarding forage production compared to other farm activities, and these differences have largely not been examined.

The purpose of this paper is to examine factors affecting the use of forage index insurance among forage producers. This information may help policy makers increase participation rates for forage index insurance, and as a result, strengthen current risk management approaches, which may reduce future reliance on *ad hoc* disaster payments. This study is believed to be one of the first risk management studies regarding the use of forage index insurance. Forage producers can be exposed to catastrophic risks such as prolonged drought or other extreme weather events, and forage index insurance may be an effective means to manage these risks.

This study is organized as follows. Section 2 provides background on forage production and a brief overview of how forage producers manage risk through risk reduction and insurance. Some of the challenges associated with forage insurance and the currently available forage index insurance for some Canadian provinces, the USA and France are discussed. Furthermore, forage index insurance use is discussed. Sections 3 and 4 include data and methodology, respectively. Section 5 discusses and summarizes empirical results, and Section 6 provides a summary of the paper, including a brief overview of results.

2. Forage production background

Forage production occurs on approximately 70 percent of the worlds' agricultural land (Food and Agriculture Organization of the United Nations, 2019) and is an important feed supply for the worlds beef and dairy industry. World demand for beef and dairy products has been rising steadily over the past few decades, and as global population and incomes rise, global beef demand will likely increase (Bruinsma, 2017) putting more pressure on the importance of forage resources.

In Canada, forage production uses 44 percent of the agricultural land with the majority of production situated in Western Canada. The provinces of Alberta and Saskatchewan account for over half of Canada's forage production, most of which is used for cattle grazing. Approximately 76 percent of Canada's forage land is dedicated to native and improved pasture for grazing (McCartney, 2011). The beef sector in Alberta and Saskatchewan represents a large portion of Canada's beef cattle and livestock production, representing approximately 80 percent of Canada's beef producers. One of the main reasons for this concentration of Canada's beef production is the availability of land for forage production. Forage production is a primary concern for Alberta and Saskatchewan beef producers as it is an important feed source. For beef and dairy producers in Canada, approximately 90 percent of forage is produced for on-farm use (McCartney, 2011). Forage is also an important resource in the USA and Europe, for example, the USA and France have abundant forage resources with approximately 67 and 50 percent of their total agricultural land suited for forage and rangeland, respectively (Sanderson *et al.*, 2012; Bella *et al.*, 2004). In many countries, forage index insurance is available to provide forage producers with a risk management tool to help manage risk, however, the use of forage index insurance is relatively low. There are many different types of forage production and different insurance policies that are designed to fit producers' needs.

2.1 Types of forage production

Different forage production types include green feed, hay, native pasture and improved pasture. Green feed or silage is produced from annual plants such as fodder corn harvested for feed. Hay is produced from perennial plants or perennial plant mixtures, and is harvested for multiple cuts each year and overwintered. Native pasture and improved pasture are grassland types, which are used for grazing. Improved pastures are planted with alfalfa or other perennial plants, and native pastures are merely wild grassland. Forage index insurance is generally used by producers with improved pastures or native pasture rangeland.

2.2 Forage insurance challenges

Forage is a particularly difficult crop to insure for five main reasons. First, cattle are continuously grazing on native and improved pastures. Continuous grazing makes the measurement of forage loss difficult for insurance purposes. Second, low forage quality can be of concern, in addition to low yield quantity (yield loss). Low-quality forage must be mixed with grains or high-quality feed to meet livestock needs. Third, most forage is grown for on-farm use, which means there are few or no records of historical yield. Fourth, insurance can have issues such as moral hazard and adverse selection (Miranda, 1991). For forage production, moral hazard may present itself by altered management practices that increase the likelihood of a forage insurance claim. An example of a moral hazard situation for forage producers could be to keep cattle grazing late in the season to lower feed costs while causing more forage winter-kill, and triggering an insurance payment to the producer. Adverse selection occurs when the producer has more information about their own risk than does the insurance provider (Goodwin, 2001). This information asymmetry can lead to a mispricing of premiums, in which the lowest risk producers subsidize the highest risk producers, and so the lowest risk producers may decide to not insure. Fifth, administering forage insurance could be costly because of the previous reasons outlined, specifically the lack of transparent yield accounting (Dismukes *et al.*, 1995).

2.3 Forage index insurance for native pasture and improved pasture

Forage index insurance may overcome some of the challenges associated with the measurement of forage yield loss because indemnities are index based and do not require yield loss measurement. Also, index insurance is believed to have much less adverse selection and moral hazard problems than traditional indemnity crop insurance (Miranda and Farrin, 2012). Additionally, index insurance is relatively inexpensive to administer as yield loss measurement is not required (Hazell and Hess, 2010). However, the major drawback of index-based insurance is basis risk (Clarke *et al.*, 2012; Elabed *et al.*, 2013; Woodard and Garcia, 2008; Smith and Watts, 2009). Basis risk is the risk that the index differs from the on-farm yield. Basis risk in the worst scenario for a producer could result in a large on-farm loss that is not observed by the index (Norton *et al.*, 2015) (e.g. the farmer does not receive an insurance payment).

In Canada, forage index insurance is provided by government-affiliated corporations and is available in several provinces for native pasture and improved pasture. In the province of Alberta two variations of forage index insurance are available, a precipitation index insurance called Moisture Deficiency Insurance (MDI), and a satellite index insurance called Satellite Yield Insurance (SAT). MDI protects producers from precipitation deficits during the growing season. The index is derived from precipitation measurements collected from the nearest weather station to the insured farm. Alternatively, producers can select up to three nearby weather stations from an authorized network and weight their precipitation values to best represent their farm experience (Roznik *et al.*, 2019). Producers can select coverage levels up to 85 percent of historical precipitation normals (Alberta Financial Services Corporation, 2019; Vroege *et al.*, 2019).

The SAT program operates using a remote sensing index called the forage production index (FPI), which is used as a proxy for forage yield. The FPI is derived from the normalized difference vegetation index (NDVI) and *in situ* forage measurements. The NDVI values are derived from surface reflectance information collected by satellite remote sensing platforms. These values are collected on a 1×1 km gridded surface that extends over Alberta's forage growing regions. These gridded cells are aggregated to the township level, and premiums are priced relative to historical FPI normals. For MDI and SAT different weighting and season length options are available to provide producers with policy flexibility. In Saskatchewan, a precipitation index insurance is available called Forage Rainfall Insurance (FRI). FRI is similar to the MDI policy in Alberta and provides similar flexibility to producers by offering growing season time interval weighting. FRI also adds a precipitation cap component, in which if precipitation in a given month exceeds a predefined threshold, it is not included in the trigger (Saskatchewan Crop Insurance Corporation, 2019). The precipitation cap limits the weight assigned to each growing season month used in the index calculation.

In the USA, forage index insurance is offered under the Pasture, Rangeland and Forage (PRF-RI) program, which first became available in 2007. The PRF-RI program operates using an interpolated gridded precipitation index that triggers payments if the accumulated precipitation in the grid cell in which the producer is located is below the insurable average

(Risk Management Agency, 2019; Vandeveer *et al.*, 2013). These grid cells are 0.25×0.25 degrees in size, which translates to about 27×21 km^2 grids in the central USA (Vroege *et al.*, 2019), and the insurance premiums are priced using the historical observations of the specific grid cell. The index is composed of accumulated precipitation that is split into two month periods, and producers select the weighting of these periods to best suit their forage risk (Carlson *et al.*, 2017). Producers choose their desired coverage level, and they also have the option to scale coverage using a productivity factor. Producers can increase or decrease the base coverage value by selecting a productivity factor ranging from 60 to 150 percent of the base insurable coverage (Maples *et al.*, 2016). This helps tailor coverage for a wider range of producers who may have different management intensities or forage types.

In France, a satellite remote sensing forage index insurance is available that uses a biophysical parameter index called the FPI, which measures the fraction of ground covered by forage called fCover (Roumiguié *et al.*, 2015). Satellite surface reflectance information is collected at a 300×300 m resolution grid and then aggregated to a larger municipal area, from which base premium rates are then derived. Other countries have implemented forage index insurance and for a more in depth review of forage index insurance see Vroege *et al.* (2019).

NDVI or similar satellite indexes may be promising for forage index insurance. These indexes may capture the dynamic effects of weather on crop yield and are measured at the farm location, including in areas of the world with poor meteorological infrastructure. However, there are mixed findings in the literature as to if NDVI is an appropriate replacement for weather-based index insurance. NDVI may require region-specific information to improve the relationship between the derived index and crop yield, and caution should be taken for future insurance designs (Turvey and Mclaurin, 2012).

2.4 Factors affecting the use of crop insurance

Research and development of forage index insurance is ongoing, and fewer studies have investigated forage index insurance use compared to traditional crop insurance. The existing research on crop insurance use may be useful for identifying factors affecting forage index insurance use. Crop insurance farmer participation rates have grown significantly in the past several decades, and examining this increase may be useful for increasing forage index insurance use. For example, participation in the US Federal Crop Insurance Program increased dramatically, from less than 25 percent of insurable acres enrolled in the early 1990s to 80 percent of insurable acres enrolled by 2003. This sharp increase is attributed to policy decisions, increased subsidization, insurance design adjustments and new crop insurance offerings (Glauber, 2013; Sherrick *et al.*, 2004). Several studies have examined the factors affecting crop insurance use, and reviews include Goodwin and Smith (1995), Knight and Coble (1997) and Gardner and Kramer (1986). Several factors have been found to influence crop insurance use, including age, farm debt, farm size, farm diversification, education and risk reduction (Sherrick *et al.*, 2004; Smith and Baquet, 1996). Weather index-based insurance use may be different than traditional crop insurance use in several ways, and there has been some research investigating these differences.

2.5 Factors affecting the use of index insurance

Similar to traditional crop insurance, the decision to purchase index insurance often begins with the self-assessment of risk and self-determination of the probability of loss. When purchasing weather index insurance, weather risk assessment is important for the decision. Hill *et al.* (2013) found that farmers in Ethiopia had a greater willingness to purchase index-based insurance if they had a higher perceived chance of experiencing loss. Basis risk was also found to have a negative effect on producer's willingness to purchase index insurance. Additionally, producers who had higher education and wealth were more likely to purchase index insurance. Index insurance use is normally thought of as negatively correlated with price, because if the price of the insurance falls or it is subsidized, more producers are likely to use the insurance (Clarke, 2016). Cole *et al.* (2013) in an empirical study conducted in India confirmed that willingness to purchase index insurance is negatively affected by increasing prices. Producer's wealth position may also affect the use of index insurance. In Malawi, wealth position has been linked to an increased desire to purchase index insurance (Giné and Yang, 2009). Additionally, high levels of insurance knowledge and more positive attitudes toward insurance were found to be very important factors affecting the use of index insurance (Cole *et al.*, 2013; Lin *et al.*, 2015). In India Cole *et al.* (2014) examined the dynamic factors of index insurance and found that within a small region (e.g. village) the number and dollar value of insurance payouts highly increase the probability that households purchase crop insurance the following year. This effect was consistent for households that had previously purchased index insurance and households that had not previously purchased index insurance. This suggests that insurance experience may be an important factor affecting index insurance use, including experience gained through peers. For forage index insurance in France, producers with larger feed storage capacity and low average stocking rates were found to have less incentive to purchase forage index insurance (Mosnier, 2015).

2.6 Forage index insurance use framework

A forage producer's decision to purchase forage index insurance is similar to a producer's choice to purchase traditional crop insurance. The main difference is that the forage index values are used instead of the producer's actual yields. Following from Maples *et al.* (2016) and Coble *et al.* (1996) we assume the producer will maximize the expected utility of wealth when choosing to purchase forage index insurance. Also, the producer chooses the insured coverage level and for some policies, the productivity factor. Higher selected coverage levels will result in higher premiums and a higher expected payout frequency. The risk averse forage producer's expected utility function is as follows:

$$\max_{\substack{A \in 0,1 \\ 70 \leq \delta \leq 90 \\ 60 \leq \varphi \leq 150}} EU(\pi) = \iint U(\pi) f(\Theta)\, dI\, dY, \quad (1)$$

where EU is the expected utility, π the forage profit, $U(\pi)$ the utility from forage profit plus expected benefit from enrolling in forage index insurance and $f(\Theta)$ the joint density of the forage index and the yield. Profit is defined as follows:

$$\pi = P(Y) + A\{k[\max(\delta - I, 0)] - c(\delta, \varphi) + s(\delta, \varphi)\} - \mathrm{r}'\mathrm{z},$$

where π is the forage profit, P the price for each unit of forage, Y the forage yield, A the a discrete choice variable that equals 1 if the producer is enrolled in forage index insurance and 0 if not, δ the coverage level choice ranging from 70 to 90 percent, φ the productivity factor adjustment ranging from 60 to 150 percent of the index value, k the value of the indemnity payment per acre, c the cost of the insurance premium, s the value of the subsidy, r the vector of other input costs, z the vector of other inputs. The joint density of the forage index and forage yield is a function of Θ, defined as:

$$\Theta = (I, Y),$$

where I is the forage index, and Y the forage yield. Basis risk is reflected in the joint distribution of Θ, which contains the relationship between the index and the forage yields.

The indemnity k is based on the coverage level δ, and the productivity factor φ, as follows:

$$k = B\delta\varphi,$$

where the value of the indemnity k per acre is defined relative to the base rate B, which for the PRF-RI program is based on the historical rainfall observed in a grid cell, or for the Canadian policies, MDI and FRI, are based on historical observations at the nearest weather station or multiple weather stations. For the Alberta SAT insurance, the base rate is defined relative to the grid cell aggregated to the township where the farm is located.

For the risk averse producer, the U(π) is a function of multiple exogenous parameters, including moments of π and the producers risk preferences. For the risk averse producer, the first and second derivatives of the utility function with respect to profit are positive and negative, as follows:

$$U'(\pi) > 0, \; U''(\pi) < 0.$$

Factors affecting producers' use of forage index insurance and their risk environment are the focus of this paper. The choice to use forage index insurance is part of a larger farm management system, and many factors may influence producers use of forage index insurance (Ritten *et al.*, 2010; Mosnier, 2015). Many producer attributes and characteristics may describe the use of forage index insurance including producer attitudes and price importance, weather risk perceived by the producer, use of other risk management programs, risk reduction and socio-demographics.

2.7 Producer attitudes and price importance
Producers with more knowledge of crop insurance and a positive attitude toward forage insurance may have a preference for risk reduction through purchasing insurance. Furthermore, producers who are more price sensitive may purchase less forage index insurance.

2.8 Weather risk perceived by the producer
Producers who perceive weather risks as being more important and those who are more concerned with drought may be more likely to purchase forage index insurance. For forage, drought is often considered to be the main weather risk in Alberta and Saskatchewan.

2.9 Use of other risk management programs
Producers may use other insurance policies or farm programs to reduce farm risk. Depending on the importance of forage production for farm revenue, enrolling in these programs may reduce the producers' level of risk regarding forage production, and therefore, reduce the expected benefit of using forage index insurance. In Canada, forage index insurance is provided to producers as part of a larger suite of government supported risk management programs. Forage producers have access to AgriStability and AgriInvest, which are farm stabilization policies that operate using actual farm accounting records (Agriculture and Agri-Food Canada, 2019a, b). Producers may use these programs with forage index insurance, but there may be some overlap of risk coverage, and forage producers may use these programs as substitutes for forage index insurance or as complementary programs.

2.10 On farm risk reduction
Producers' purchase of forage insurance may be affected by their level of on-farm risk reduction, such as maintaining forage reserves or having off-farm income. Forage production can be risky as producers manage pasture health in adverse weather conditions to preserve

adequate feed stores for their cattle herds. There are also other risk-reducing activities that producers can use, including crop and livestock diversification, savings, price risk management, carrying less debt and various other methods. These management methods may not be enough to limit agriculture production risk due to the relatively high weather risk faced by producers. However, some weather risks such as drought may be offset by use of the above risk reduction approaches, though the cost may be high (Harwood *et al.*, 1999).

2.11 Socio-demographics

The socio-demographics of a producer may affect their risk preferences and risk environment. For example, older producers may have less risk (e.g. less debt) than younger producers, so may be less likely to purchase insurance. Also, higher levels of education may increase the use of forage index insurance, as producers who have more education may better understand forage index insurance, and feel more comfortable purchasing it. Education may play an important role in index-based insurance use as it is a more complex insurance design from a consumer standpoint than traditional crop insurance.

3. Data

A questionnaire was administered in conjunction with the Alberta Beef Producers and the Saskatchewan Cattlemen's Association. In total, 47 responses were collected from Saskatchewan, and 40 responses were collected from Alberta. Survey respondents were forage and livestock producers who almost exclusively raised beef cattle. The questionnaire was designed to collect primary data to aid in developing and improving risk management tools for forage producers. The survey questions were broken into four sections: risk management and insurance, general farm practices and specific farm operations, demographic characteristics and forage insurance. Section 1, risk management and insurance, asked producers about their on-farm risk reduction, their knowledge and attitude toward agriculture insurance, their risk assessment and their past weather disasters. Section 2, general farm practices and specific farm operations, elicited information regarding producers' farm size and risk level, management practices, crop and livestock mix and government risk management program use. Section 3, demographics, asked questions about producer socio-demographics, including age, gender, province, household size and income. Section 4, forage insurance, was composed of questions relating to the use of forage index insurance, quality concerns, index insurance policy preferences and producer specific management questions. The questionnaire was conducted both online and in person. A total of 87 completed responses were compiled, and 30 of these responses were collected in person. The majority of questions were designed on a one to five Likert scale, and some questions were binary (1, 0), including the dependent variable. The respondents are representative of forage producers from the main growing regions of Alberta and Saskatchewan and include producers with mixed farm operations (i.e. beef production and field crop production), and producers who exclusively raise beef cattle and grow/manage forage.

4. Methodology

4.1 Eliciting insurance program use

In an attempt to examine which factors affect forage index insurance use, it is useful to adopt an empirical model framework. A framework can be developed in which producers state whether they either purchase or do not purchase insurance. This is a common method in many econometric studies that use farm-level data for determining the use of crop insurance (Coble *et al.*, 1996; Smith and Baquet, 1996).

4.2 Binomial probit regression model

When analyzing a binary dependent variable, it is common to use a discrete choice model (Greene and Hensher, 2010). In the most basic form, a linear probability model can be used to predict the probability of observing an outcome with a binomial choice, for instance, the use of forage index insurance (Yes = 1 and No = 0). However, there are problems associated with the linear probability model. Most importantly, the probability is not required to be between 0 and 1, which can lead to predicted values of greater than one and less than zero, both of which are theoretically incorrect. Also, the linear probability model can lead to heteroskedasticity issues that may result in inefficient estimates and unreliable significance levels. Because of the weaknesses associated with the linear probability model, the literature supports using a probit model as it overcomes both of the weaknesses of the linear probability model (Greene, 2003; Liao, 1994). As seen in the second equation, the latent variable y^* is an unobserved index variable representing the propensity for the event to occur. When this latent variable is greater than 0 an event $y = 1$ is observed, and if this latent variable is less than or equal to 0 then the event did not occur, and $y = 0$ is observed. A latent regression determines this outcome. The outcome of the binary choice model is determined from the value of the unobserved latent variable shown in the third equation:

$$y^* = y' x_i + \varepsilon_i, \tag{2}$$

$$y = \begin{cases} 1 & \text{if } y^* > 0 \\ 0 & \text{otherwise} \end{cases}. \tag{3}$$

The model assigns a probability distribution specification to the error term. For the model to be theoretically correct, the probability must be constrained between 0 and 1:

$$\begin{aligned} \text{Prob}(y_i = 1|x_i) &= \text{Prob}\left(y_i^* > 0|x_i\right) \\ &= \text{Prob}(y' x_i + \varepsilon_i > 0) \\ &= \text{Prob}(\varepsilon_i > -y' x_i). \end{aligned} \tag{4}$$

The literature supports using a probit link function (Greene, 2003; Liao, 1994), and when a probit link is adopted, the model is referred to as a probit model. The probit link distribution is based on a cumulative normal distribution Φ and is displayed in the fifth equation. To use the probit link function, $x_i|y_i$ is assumed to be a Bernoulli random variable as displayed in the sixth equation. Where F in the sixth equation denotes the cumulative distribution function for ε_i, which in the case of probit is replaced by the cumulative normal distribution Φ:

$$f(\varepsilon_i) = \frac{\exp\left(-\varepsilon_i^2/2\right)}{\sqrt{2\pi}}, \tag{5}$$

$$\begin{aligned} \text{Prob}(y_i = 1|x_i) &= \text{Prob}\left(y_i^* > 0|x_i\right) \\ &= \text{Prob}(\varepsilon_i > -y' x_i) \\ &= \int_{-y' x_i}^{\infty} f(\varepsilon_i) d\varepsilon_i \\ &= 1 - \text{F}(-y' x_i). \end{aligned} \tag{6}$$

4.3 Marginal effects

Probit coefficients magnitudes are not commonly interpreted. Instead, marginal effects are interpreted. Marginal effects are more useful than the probit coefficients because similar model results can be directly compared (For instance, another common link function is the logit link). Logit results and probit results can be directly compared using marginal effects. The marginal effects for continuous variables are calculated, holding all other independent variables constant at their means, as shown in the seventh equation. Marginal effects for binary variables are calculated using a stepwise approach outlined in the eighth equation where $\overline{x}_d$ represents the remaining independent variables held at their means:

$$\frac{\partial \text{Prob}(y=1)}{\partial x_i} = \Phi(y'x_i)y\,, \qquad (7)$$

$$[\text{Prob}(y_i = 1 | \overline{x}_d, d_i = 1)] - [\text{Prob}(y_i = 0 | \overline{x}_d, d_i = 0)]\,. \qquad (8)$$

5. Results

5.1 Dependent variable

Table I describes the variables in the "use of forage index insurance" probit regression analysis shown in Table II. Additionally, the scale of each variable is displayed. Survey results indicate that 39 percent of producers use or intend to use forage index insurance, and

Table I. Description of variables and survey response scores for use of forage index insurance binomial probit model

Variables	Scale of variables
Dependent variable	
Use of forage index insurance?	1 = Yes, 0 = No
Independent variables	
Producer attitudes and price importance	
Knowledge level regarding crop insurance	1 = Very low, …, 5 = Very high
Attitude toward forage insurance	1 = Very negative, …, 5 = Very positive
Forage insurance price importance	1 = Not important, …, 5 = Very important
Weather risk perceived by producer	
Producer perceived weather risk	1 = Much lower, …, 5 = Much higher
Perceived importance of drought risk by producer	1 = Not important, …, 5 = Very important
Use of risk management programs	
AgriStability use	1 = Never, …, 5 = Very often
AgriInvest use	1 = Never, …, 5 = Very often
Risk reduction	
Maintain inventory	1 = Never, …, 5 = Very often
Off-farm income	1 = Yes, 0 = No
Socio-demographics	
Age	1 = Under 25 2 = 26–40 3 = 41–55 4 = 56–70 5 = 71 and older
Education	1 = Some high school 2 = High school graduate 3 = Some college or other 4 = Undergraduate degree 5 = Post-graduate

Note: $n = 87$

Variables	Estimates	SE
Producer attitudes and price importance		
Knowledge level regarding crop insurance[a]	0.511**	0.204
Attitudes toward forage insurance[a]	0.534***	0.203
Forage insurance price importance by producer	−0.234	0.203
Weather risk perceived by producer		
Producer perceived weather risk[b]	1.109***	0.337
Perceived importance of drought risk by producer[b]	0.888***	0.293
Use of risk management programs		
AgriStability use	−0.173	0.119
AgriInvest use	0.143	0.128
Risk reduction		
Maintain inventory	−0.380*	0.222
Off farm income	−0.559	0.464
Socio-demographics		
Age	−0.459*	0.235
Education	0.196	0.235

Notes: $n = 87$. Pseudo R^2 – McFadden R^2: 0.4493; Predicted correct: 81.61 percent. Dependent variable: "use of forage index insurance" (1 = Yes, 0 = No). Forage index insurance includes coverage for improved pasture and native pasture grasslands. [a]Correlation of knowledge and attitude is 0.1142; [b]Correlation of perceived weather risk and drought risk is 0.0930. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Table II. Estimates of the binomial probit model: use of forage index insurance

61 percent do not. Table III shows descriptive statistics of the dependent and independent variables used in the analysis including the mean, standard deviation, minimum value, 25 and 75 percentiles, and the maximum value.

5.2 Independent variables and goodness of fit

The binary probit regression model "use of forage index insurance" is estimated with a total of 11 independent variables categorized into five groups, and Table II displays the results.

Variables	Mean	SD	Min.	Pctl. (25)	Pctl. (75)	Max.
Dependent variable						
Use of forage index insurance?	0.391	0.491	0	0	1	1
Independent variables						
Knowledge level regarding crop insurance	2.793	1.112	1	2	3	5
Attitude toward forage insurance	3.034	1.083	1	2	4	5
Forage insurance price importance[a]	4.161	0.729	3	4	5	5
Producer perceived weather risk	3.172	0.735	1	3	4	5
Perceived importance of drought risk by producer	4.241	1.023	1	4	5	5
AgriStability use	3.023	1.656	1	1	5	5
AgriInvest use	3.908	1.507	1	3	5	5
Maintain inventory[b]	3.908	1.007	1	3	5	5
Off farm income[c]	0.276	0.450	0	0	1	1
Age	3.276	0.802	2	3	4	5
Education	2.920	0.838	1	2	3	5

Notes: $n = 87$. Dependent variable: "use of forage index insurance" (1 = Yes, 0 = No). Pctl. is percentile. [a]Refers to premium price importance per acre; [b]refers to maintaining additional levels of feed inventory; [c]binary variable (1 = Yes, 0 = No), all other independent variables are on a one to five scale

Table III. Descriptive statistics for binomial probit model variables

The five groups are producer attitudes and price importance, weather risk perceived by the producer, use of risk management programs, risk reduction and socio-demographics. The model shows a goodness of fit measure of 0.4493 for the McFadden R^2. Additionally, the percent predicted correct goodness of fit measurement is 81.61 percent. Of the 11 variables, 6 are significant at the 10 percent level or better. As indicated by the goodness of fit measures, the model has an acceptable fit. Additionally, marginal effects are shown in Table IV for interpretation.

5.3 Producer attitudes and importance of price

This group is composed of three independent variables: knowledge of forage insurance, attitude toward forage insurance and forage insurance price importance by the producer (Table II). Two of three variables are significant at the 5 percent significance level or better. Knowledge of crop insurance, as well as attitude toward forage insurance, is positively related to the use of forage index insurance. Knowledge of crop insurance has a positive coefficient (0.511) significant at the 5 percent level, and attitude toward forage insurance has a positive sign (0.534) significant at the 1 percent level. These results are similar to findings in India by Clarke *et al.* (2012), as well as in China by Lin *et al.* (2015). Similar to Cole *et al.* (2014), the effects of knowledge and attitude may suggest that insurance experience may be important, as knowledge and attitude likely are related to experience gained from crop insurance use and from peers use of crop insurance. Also, the importance of price variable has a negative relationship with the use of forage index insurance, as shown by the negative coefficient (−0.234). However, the importance of price variable was not found to be statistically significant. A possible explanation for this is that the producers' price sensitivity may be diminished due to the effects of subsidization.

Table IV. Marginal effects for the binomial probit model: use of forage index insurance

Variables	df/dx	SE
Producer attitudes and price importance		
Knowledge level regarding crop insurance[a, b]	0.1622*	0.0634
Attitudes toward forage insurance	0.1698**	0.0647
Forage insurance price importance by producer	−0.0743	0.0799
Weather risk perceived by producer		
Producer perceived weather risk	0.3522***	0.1034
Perceived importance of drought risk by producer	0.2822***	0.0840
Use of risk management programs		
AgriStability use	−0.0548	0.0373
AgriInvest use	0.0454	0.0407
Risk reduction		
Maintain inventory	−0.1206*	0.0708
Off-farm income	−0.1612	0.1186
Socio-demographics		
Age	−0.1460*	0.0787
Education	0.0623	0.0757

Notes: $n = 87$. Pseudo R^2 – McFadden R^2: 0.4493. Predicted correct: 81.61 percent. Dependent variable: "use of forage index insurance" (1 = Yes, 0 = No). Forage index insurance includes coverage for improved pasture and native pasture grasslands. [a]Interpretation: a one unit increase from the mean in "knowledge level regarding crop insurance" results in a 16.22 percent greater chance of using forage index insurance; [b]marginal effects are calculated at the variable's mean. $*p < 0.1$; $**p < 0.05$; $***p < 0.01$

5.4 Weather risk perceived by producer

The weather risk perceived by producer group has two independent variables, and both variables are significant at the 1 percent level or better (Table II). Producer perceived weather risk is found to positively impact the use of forage index insurance. Producers use more forage index insurance as their self-assessed weather risk increases. This relationship is shown by the positive coefficient (1.109) that is significant at the 1 percent level. Perceived importance of drought risk is also found to be positively related to the use of forage index insurance. The coefficient (0.888) is positive and significant at the 1 percent level. These results are supported by other studies such as Hill *et al.* (2013) in which the likelihood of loss perceived by the producer is found to positively affect the use of index insurance.

5.5 Use of risk management programs

The use of risk management programs group has two independent variables, and neither is significant at the 10 percent level or better. Though neither variables are significant in affecting forage index insurance use, AgriStability has a negative coefficient (−0.173), and AgriInvest has a positive coefficient (0.143). Both AgriStability and AgriInvest are government-sponsored risk management programs. Forage index insurance, AgriStability and AgriInvest are each subsidized programs, and this may affect their use. For example, if AgriStability, which is a whole farm type margin insurance, and forage index insurance are purchased, a possible outcome is a double indemnity. If unsubsidized then the risk-reducing value of the insurance may be less than the premium paid and producers may then purchase less of AgriStability or forage index insurance. Since these policies are subsidized, this effect may be reduced, or producers may purchase both policies, depending on the level of subsidy.

5.6 Risk reduction

The risk reduction category includes two independent variables, maintain inventory and off-farm income. The degree in which producers maintain inventory (−0.173) is found to be significant at the 10 percent level. Producers may use forage inventory reserves as a substitute for forage index insurance. This result is consistent with findings from Mosnier (2015). Producers with large feed stores may reduce the severity of forage production losses on-farm revenue by providing feed reserves during times of scarce supply. Off-farm income was not found to be significant at the 10 percent level, but the coefficient is negative. Further analysis is needed to determine the off-farm income effect on the use of forage index insurance. Both empirical studies and theoretical research have indicated that using various methods of risk reduction negatively affects the use of index insurance (Clarke, 2016; Mosnier, 2015).

5.7 Socio-demographics

Age and education make up the two independent variables in the group called socio-demographics. Age is found to be significant at the 10 percent level, or better, and education is not found to be significant. As indicated by the sign (−0.512), age is negatively related to the use of forage index insurance, as age increases forage index insurance use decreases. Education shows a positive coefficient (0.196), but it is not significant.

6. Summary and implications of the study

Forage index insurance participation rates are low relative to that of crop insurance for non-forage crops. Forage producers face risk in both production and prices, and while many of these risks can be reduced on farm, catastrophic risks may be difficult to reduce without forage insurance and other risk management approaches. Large events such as prolonged droughts can be costly for government to manage on an *ad hoc* basis. An effective means to deal with these large risks may involve producers reducing risk by participating in insurance programs such as forage index insurance. Forage is a difficult crop to insure, and index insurance may be well suited for forage. Forage index insurance is available in several countries such as Canada, the USA and France, and researchers are investigating its use in other areas (Vroege *et al.*, 2019). Index insurance determines payments using an index that is correlated to producers' actual yields and a downside of this method is basis risk, which is the mismatch between the insured index and the producer's actual yield (e.g. the producer may have a loss, but the index does not trigger a payment to the producer). Research has focused on basis risk and developing improved methods to reduce basis risk (Yu *et al.*, 2019; Maples *et al.*, 2016), however, less research has investigated other important factors that may contribute to forage index insurance use. Producers may have a different risk management environment regarding forage production compared to other farm activities, and these differences had largely not been examined.

The objective of this study was to examine factors affecting the use of forage index insurance. This analysis was an effort to provide policy makers with information regarding forage producers' use of forage index insurance. A survey was administered in cooperation with the Alberta Beef Producers and the Saskatchewan Cattlemen's Association. The questionnaire was conducted both online and in person, and a total of 87 responses were used for this analysis. In total, 47 responses were collected from Saskatchewan producers and 40 from Alberta producers. Survey respondents were forage and livestock producers and almost exclusively raised beef cattle, except for a small number of dairy producers. A binomial probit model was used for the empirical analysis.

In the estimated binomial probit model "use of forage index insurance," 6 of 11 variables were found to be significant at the 10 percent level or better. Forage producers with higher levels of crop insurance knowledge and a more positive attitude toward forage insurance were found to use forage index insurance more often than other producers. Furthermore, producers who rated drought as being of greater importance and who perceive that their overall weather risk is higher are more likely to use forage index insurance. Age was found to be an important factor in determining forage index insurance use, as younger producers were found to use forage index insurance more often. Also, producers who maintain higher inventory levels of forage were found to use less forage index insurance. For forage production, in times of drought or other extreme events, production losses are generally widespread and can affect a large geographic region. Producers may replace feed by purchasing forage from other producers or switching livestock feed type. As a result, local forage replacement prices may rise and increase the severity of forage loss to livestock producers revenue. Producers may reduce some of this effect by maintaining feed reserves, which can be used in times of short supply. The importance of the forage index insurance premium price variable was statistically insignificant. This could be due to the effect of subsidization, reducing the importance of price for the decision to purchase. Similarly, the use of other subsidized risk management policies, including a whole-farm margin policy (e.g. the government program, AgriStability), did not reduce forage index insurance use. A possible explanation for this is that the subsidization of the policies may make it profitable to purchase both, despite the overlapping coverage.

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