"The Impact of Personal Attitudes on Cereal Variety Adoption Decisions in Alberta"

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Abstract

The goal of this study was to help guide development efforts of a current breeding program underway in Saskatoon, Saskatchewan, aimed at producing new cold tolerant cereal varieties. In order to maximize the impact of research dollars and efficiently meet the needs of producers in the realm of technology provision, it is helpful to understand the types of producers who might use the new varieties. A survey was used, in Alberta, Canada, to obtain data on producer attitudes affecting adoption of new technology, particularly in adopting a future cold tolerant cereal variety. The survey was structured with demographic, attitudinal and stated choice questions. A conditional logit regression model was used to estimates the probability of adoption based on the survey responses. Principal component analysis was used to limit the number of variables in the regression. Willingness to pay calculations are then made based on the selected logit model. Frost tolerance is found to be the most desired trait over a decrease in degree days for the sample population. Certain producer characteristics (attitudes towards risk, for example) were found to impact on the estimated willingness to pay for frost tolerance and decreased days to maturity.

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The Impact of Personal Attitudes on Cereal Variety Adoption Decisions in Alberta

The Issue

The adoption of technology is extremely important in determining the future of food security, producer welfare, and general global stability. Competing demands such as those coming from population growth, and concerns about environmental health place great strains on agricultural production forcing it to rely on new technology for relief through advancement of production limits. Technological adoption in agriculture and other businesses has driven development by expanding the production possibilities of the adopter and allowing countries adopting specific technologies to gain comparative advantages in that area of focus. Examples include the discovery of Marquis wheat by Charles Saunders in 1904, the invention of 2,4-D herbicide in 1946, and development of large scale machinery that is currently used in grain production. For this reason governments as well as farmers have a vested interest in agricultural technology adoption and a need for information about the decision making process surrounding it.

Every producer in Alberta faces a limit as to what they can produce with the resources they control. This limit is caused by scarcity of those resources that are used for the purpose that the holder derives the highest possible benefit from. In agriculture benefit is represented by yield levels or premiums produced from the existing yield. Historically (pre-1940's), the best way to increase yields was to purchase more land, but this option became less feasible as land became more expensive due to its scarcity and demands from the growing population.. The rise in land prices lowered the marginal benefit of adding more land and opened the door for other viable options which produce

higher gains such as technology that increases yields or adds values like quality and risk reduction attributes to existing crops or livestock.

Currently a joint research effort by GE^{3}LS is being coordinated by Chris Barker and undertaken by Dr. Brian Fowler and Dr. Jim Unterschultz in Saskatoon, Saskatchewan and Edmonton, Alberta at the University of Saskatchewan and University of Alberta respectively to produce a variety of wheat that is as cold tolerant as rye. Despite a high variability in growing season length cold tolerant cereal grain technology has a high potential impact in Alberta. The combination of short growing seasons in northern Alberta, climate instability, and a need for rotational options raises the marginal benefit level for these varieties when compared to other technologies that may be adopted to increase productivity or value to the producer. For this reason it is important to understand the drivers behind technology adoption in order to efficiently produce and channel this new technology to capture the highest possible returns to all stakeholders from development efforts. The goal of this study is to aid in focusing this specific technology toward the attributes that producers want and need so that an efficient expansion of production possibilities along the correct expansion path may take place. The expected outcome will be higher returns to stakeholders including producers, researchers, and society in general through efficient allocation of research and final investment dollars. Another possible outcome may be insight into which method of channeling the new technology will maximize the likelihood of adoption.

Previous Work

Of the literature examined two articles that contained analysis based on survey data that differ enough to give a range of approaches are: "The Role of Husbands and Wives in Farm Technology Choice" by Zepeda and Castillo (1997), and "The Role of Education in Facilitating Risk-Taking and Innovation in Agriculture" by Knight, Weir and Woldehanna (2003). Both surveys targeted households but that is the extent of their similarities. Knight used data from the Ethiopian rural household survey (ERHS) which was randomly sampled from different districts in Ethiopia complemented by a purposefully designed one that surveyed the same households in fewer districts than the latter. The complementary survey focused on attitudes about risk and new technologies and included scales to gauge these attitudes. The Zepeda survey was administered to the whole population of married dairy farm operators in three regions of Wisconsin. Both the husband and wife were asked about farm income, decision making in the household, and demographics and the survey boasted a 58% completion rate. The differences in these survey methods may depend on the resources of the location they were administered in such as enumeration data. Both survey methods seemed to serve the purpose of relating demographic information to technology adoption decisions.

Rauniyar and Goode have done a study titled "Technology Adoption on Small Farms" on the adoption of high yielding varieties in Swaziland. This study provides valuable insight into adoption of cold tolerant varieties in Alberta because of the similarities exhibited. A survey was used to collect adoption data over time which was then analyzed with Principal Component Analysis (PCA) to break down different groups by adoption behavior. Three different relevant factors were isolated from this analysis

that gave a clear picture of which technologies and practices were related to one another and likely to be adopted contemporaneously. The outcome of this study may have an impact on agricultural extension policies towards adoption. However useful this study is to the situation in Alberta, there is a gap between the levels of agronomic technology being adopted that could possibly result in different behavioral patterns Similar methodology was used by Rehman *et al.* in "Identifying and understanding factors influencing the uptake of new technologies on dairy farms in SW England using the theory of reasoned action. PCA was used on attitudinal scales in a survey for use in a multiple regression analysis with regards to technology adoption on dairy farms in England. The ultimate goal of this study was to examine the role of social pressures in the determination of technology uptake.

Methods

Survey

A written survey with research ethics approval was used to collect information from participants for this research project (actual survey is available from the author on request). Information was collected by distributing the surveys in person at a local farmer information meeting in Stony Plain, Alberta, through a farm and ranch show in Edmonton, Alberta, and also by distributing them individually to farms in Southern Alberta around the town of Vulcan. Questions asked on the survey were categorized into four sections entitled *Technology and Your Farm, Frost Issues, About You,* and *Variety Choices*. Technology and your farm related to previous adoption decisions and involvement in producer groups. Attitude questions in this section covered attitudes about risk, and important attributes to both a new variety and farm technology in general. Next, Frost

issues explored the respondent's previous experience with frost related losses on their farms. The About You section followed with demographic questions and finally, in the Variety Choices portion respondents were asked to choose between hypothetical varieties with different cold tolerant traits and their own existing varieties. In all, sixteen hypothetical varieties were paired up against the existing varieties. In order to keep the length of the survey reasonable these questions were split in half and equally distributed in the form of two versions of the survey.

Principal Component Analysis (PCA)

The attitudinal questions within the survey had many individual questions, although they were not grouped specifically around a previously validated psychographic scale. The number of questions made their individual inclusion within regressions impossible. PCA analysis was used in order to decrease the number of variables used in the conditional logit regression model. PCA analysis simply groups variables or individual survey questions, to generate new variables that explain the variability within the set of questions. The explanatory power of the PCA depends on the suitability of question groups analyzed as well as the number of principle components generated. Each principal component generated from the set of questions places unique ratings on each individual question answered. Individual respondent's answers can then be grouped by the weighting factors generate aggregate scores that can be used as stand alone variables in the regression. For instance, in a set of individual questions about risk behavior, a new component could be created that weighs all individual questions favoring risky behavior highly but weights questions favoring conservative behavior very low. Individuals who

score high on this component are relatively risk seeking. The point of the PCA is to describe larger sets of variables in the regression through as few variables as possible.

Logit Regression

A logit regression model was chosen because of the binomial nature of the dependant variable. The only two possible outcomes were adoption or non adoption of the new hypothetical cold tolerant variety which made this model the natural choice. Other features of the logit model are the measure of a probability of adoption based on the independent variables used as well as the ability to include multiple choices made by each respondent.

The chosen method of analysis may fit this particular project quite well for the purposes it is intended for, however it does have shortcomings. The PCA, logit model and quantification of willingness to pay are all based on respondent questions to hypothetical questions and may suffer from 'hypothetical' bias. Another downfall is that the number of question combinations that could have been conceived for the PCA analysis was quite high in this survey and weren't all explored at length. This means that a more significant model that was not tested may exist. For the most part this model suited the study and provided useful information for the purposes intended.

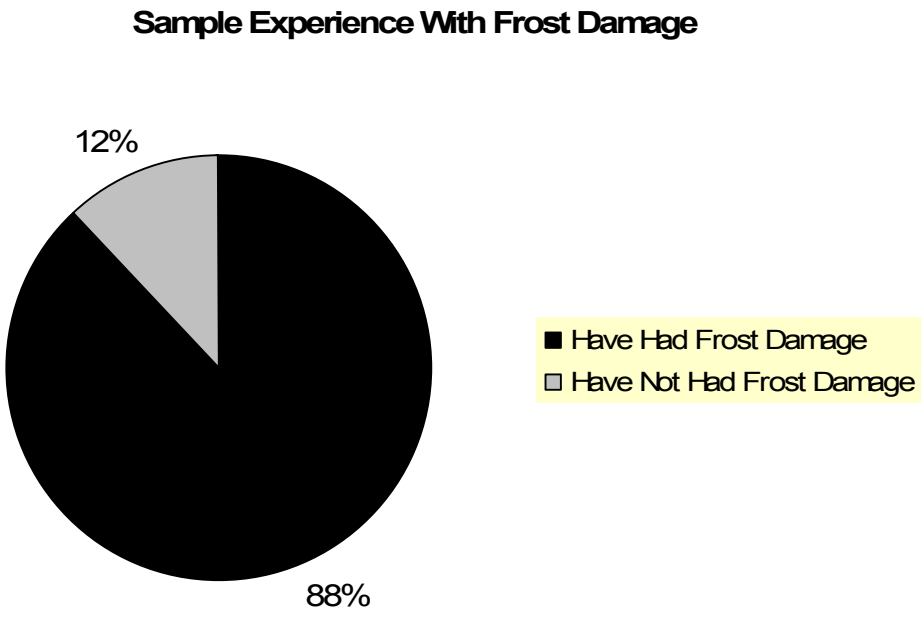
Results

It should be noted that although the survey sample was large enough to provide reasonable statistical significance some bias may exist due to the venues of distribution. The farm and ranch show exclusively showcases new equipment which tends to attract individuals who may have a higher income and hence the money to spend on this equipment. In fact, the average income from the sample was compared against the

Alberta average and found to be higher so some bias may exist in this area. It was not a large concern for this study because these producers may be the ones more likely to investigate new varieties targeted with specific traits but should be kept in mind.

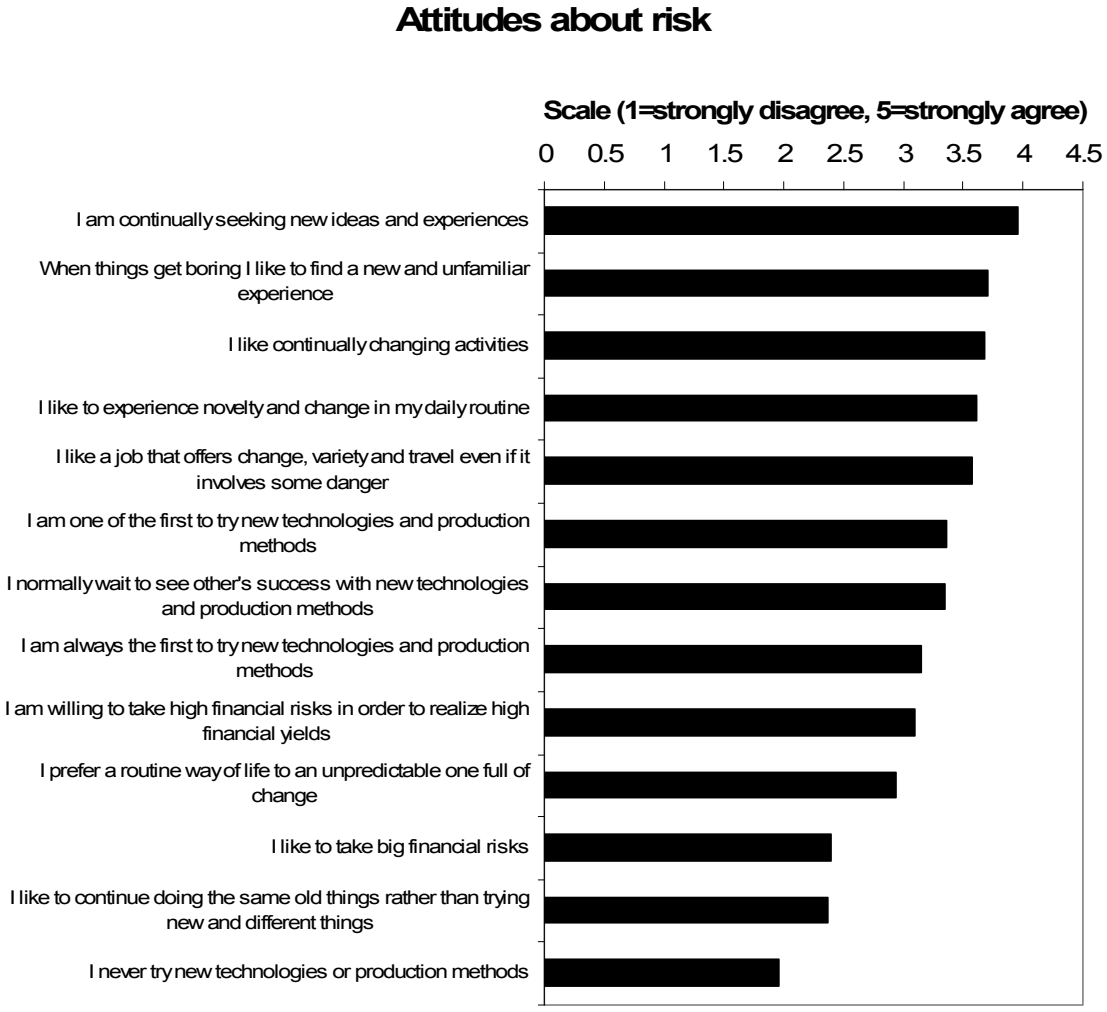
Frost Experience

The question of whether or not producers had experienced frost related damage to their crops on the survey revealed that 88% had in fact had losses due to frost. This was not too surprising since Alberta is prone to somewhat unpredictable weather caused by the Rocky Mountains and shorter growing season length. Another reason may be that winter wheat crops are susceptible to the colder winters and require snow cover for protection in the case of an extreme cold event. In any case the frequency of frost damage oddly enough did not appear to be a significant factor in predicting the adoption of cold tolerant varieties. The effect of this variable may have been encompassed by attitudes toward risk or another variable in the survey.

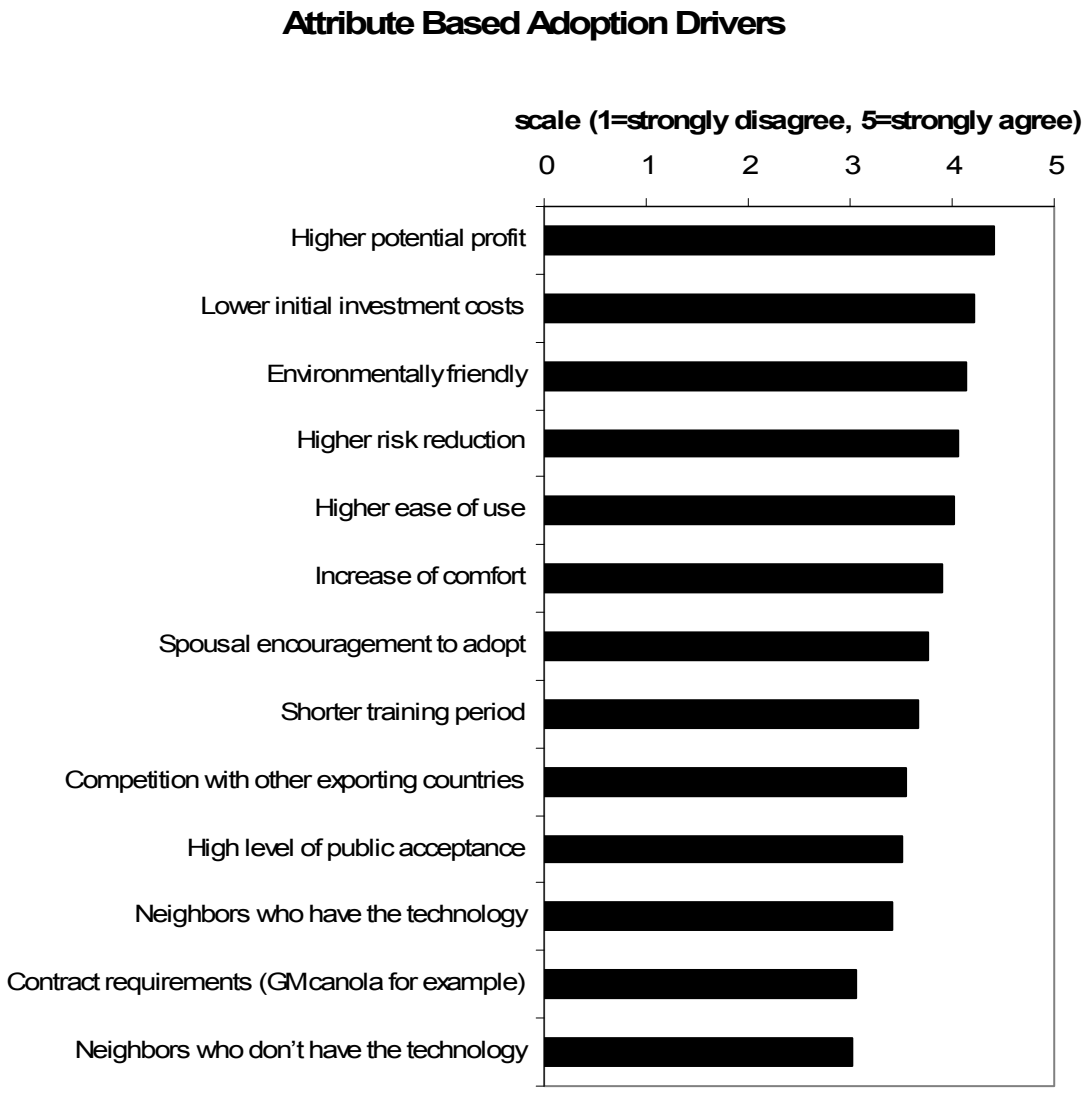


Attitudinal Response

The sample surveyed in this study showed some interesting characteristics. For the most part respondents were fairly risk loving, and liked to try new things. Contrary to this they also did not like taking large financial risks and generally wanted to wait and see the success that others had with the new technology before they tried it themselves. The results of the risk questions can be viewed in the following table expressed as averages for the entire sample.



The attribute based adoption driver attitude questions revealed the respondents hypothetical preferences for key attributes of a new cereal variety. Not surprisingly the top of the list included profit and costs. The environmental friendliness attribute was surprisingly third on the list followed by risk reduction properties. The least important attributes involved social pressure and genetic modification. The complete list can be seen below.



Discussion of PCA results

Five PCA variables were originally generated from the variables from five distinct categories where the questions were deemed appropriate to group together. These variables and a general description can be seen in the chart below followed by the specific factor loadings of PCA variables used in the regression.

Variable Name	Description	Includes
ADP	Adoption of previous technologies or practices	1,2,3, except 1d,e
Char	Variety attributes	4gijk
RA	Risk attributes	5all
NVARAT	New variety attributes	6
FI	Frost experience	7,8

From the principal component analysis sixteen questions on technology adoption were grouped into six factors. From the estimated factors two were used in the subsequent regressions. As you can see below factor ADP1 has relative large loadings on use of the internet, futures market, email and accounting software but not on use of environmental farm plans (EFP). Respondents receiving a high score in this category would be considered heavy technology users, especially computer related ones. ADP2 on the other hand has its largest weight on email usage but less machinery related, or risk reducing technologies such as futures, and GPS. High scoring respondents can be characterized as lighter technology users.

Factor loadings for PCA variables used in the final regression

	ADP1	ADP2
INTERNET	0.61259	0.57719
PRODGROUP	0.47171	0.12624
PUB	0.36154	0.36431
FUTURES	0.52837	-0.42405
INNOVAT	0.23466	-0.02674
EFP	0.2101	-0.22783
CROPINS	0.50197	-0.01519
CAIS	0.39821	-0.38906
EMAIL	0.55808	0.66451
ACCTGSOFT	0.55242	0.12723
WEATHERNET	0.53804	0.18276
GIS	0.51691	-0.24071
GPS	0.43135	-0.55073
HERBRES	0.56183	-0.28979
AUTOSTEER	0.15801	-0.75158

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	CHAR1	CHAR2
COSTS	0.13585	0.19883
PROFIT	0.53673	0.45329
RISKRED	0.5271	0.1888
EASEOFUSE	0.77568	-0.12895
TRAINING	0.67892	-0.31837
ENVIRO	0.73618	-0.21332
ACCEPTANCE	0.6639	-0.10955
COMFORT	0.79149	-0.13946
SPOUSAL	0.54218	-0.23397
NEIGHBORSHAVE	0.47126	0.11079
CONTRACT	0.19314	0.7635
COMPWEXP	0.36026	0.59314

The final PCA analysis used to condense variables in the model was done on the questions involving characteristics of a new technology that would be important when considering adoption. The factor loadings in CHAR1 concentrated on the relative ease of use and training, but also on the environmental attributes. The high scorers in this variable may be looking for something that had a low impact on their own physical and mental environment. The second characteristic variable, CHAR2 placed high importance on contract requirements and GM attributes. These could be respondents that already

grow GM crops and place a high importance on the nature of the possible contract for the new technology because of previous experience.

Another PCA was done on questions related to risk behavior, which revealed preferences for risk. Four components were identified. RA1, the first component, had high factor loadings on the risk loving, exciting lifestyle pursuing characteristics. The second component was the opposite. Respondents who scored high with the factors in RA2 were risk averse respondents who did not like change or an exciting lifestyle.

	RA1	RA2
ALWAYSFIRST	0.57298	0.22584
ONEOFFIRST	0.52902	-0.35473
WAITANDSEE	-0.34858	0.42804
NEVER	-0.14644	0.81903
WILLINGHIGH	0.62925	0.038966
LIKERISKS	0.63876	0.31122
SAMETHING	-0.22454	0.64569
LIKENOVCHANGE	0.50938	0.13109
LIKESCHANGE	0.64567	0.22126
SEEKING	0.7407	-0.0446
LIKESCHANGINGACT	0.66407	0.02119
UNBORING	0.61857	0.28145
ROUTINE	-0.2454	0.47146

Although five sets of principal components were estimated only the above were used in the logistic regression model. An organized description of the PCA variables used in the logistic regression model can be seen below.

Explanation of PCA Variables used in the model	
ADP1	Heavy technology users (Internet, Email, accounting software, weather net,) some weighting on ag technologies such as GIS and futures
ADP2	light technology users (Internet, E-mail) marks taken off for futures, auto steer, GPS…less ag technology
RA1	Risk loving, seeking an exciting lifestyle
RA2	Risk averse
CHAR1	Ease of use, comfort and the environment are very important
CHAR2	Contracts and GM attributes are important to this high scorer. GM users?

A PCA variable that may be worth mentioning is CHAR3, the third principal component in this category of questions. Although it placed a high importance on profit and cost in determining the score it created for the individual respondents, it was not used further because of low significance. This may be because of a low variability in the question options, or possibly that cost and profit were not as significant as hypothesized in determining the probability of adoption of a new technology. There may also be an underlying variable that is siphoning significance. For instance, risk aversion characteristics are closely related to decisions made about future profit and may confuse the results.

Principal component variables not used in the regression model were FI, and NVARAT. FI was based on the frost damage experienced and frequency of that damage. It is logical to assume that this variable may have some impact on the choice to adopt a variety that will avoid these problems. The risk variable RA1 may have captured some of the significance out of this variable as well because it may capture attitudes toward risk related to frost experience. Like CHAR but more specific, NVARAT was made of questions concerning attributes of a new variety that would be important when considering adoption. CHAR may have captured some of the significance away from this variable; however the questions were different enough that it may have had a lesser effect. Below is a description of some of the unused PCA variables.

Unused PCA variables worth mentioning

CHAR3	Care about profit and cost
FI1	Early frost experiencers
FI2	Late Frost
FI3	Frequent frost experiencers
nvarat1	Marketers-yield and short season important
nvarat2	Identity preservers

Discussion of PCA correlations

Some significant correlations exist between the different PCA variables used in the logistic model. The correlation table can be seen below (explanations of variables can be seen in the appendix). A strong negative relationship exists between risk aversion and heavy technology users which means that as risk aversion tendencies increases, the chance of current technology usage or in the past does as well.. Risk aversion has a similar relationship with respondents placing a high importance on ease of use, contract requirements and GM attributes. Likewise the risk lovers tended to be heavy technology users and not light ones. They also value ease of use, comfort, the environment, contracts, and GM as important attributes in the decision to adopt a new variety. Respondents valuing ease of use, the environment, contract requirements and GM tended to be higher technology users as well. It can be seen from the correlations that attitudes about risk are related to technology adoption decisions. Also, risky people place a higher importance on ease of use, environmental characteristics, contract requirements, and GM attributes in terms of adoption decisions.

	ADP1	ADP2	CHAR1	CHAR2	RA1	RA2
ADP1	1.00					
ADP2	0.00	1.00				
CHAR1	**0.13**	0.02	1.00			
CHAR2	**0.18**	**-0.07**	0.00	1.00		
RA1	**0.27**	**-0.14**	**0.13**	**0.20**	1.00	
RA2	**-0.50**	0.04	**-0.14**	**-0.32**	0.00	1.00

Bold=significant at 95% level or above

Logistic Regression Model

> "A logit regression, uses a *Binomial (or binary) logistic regression* is a form of regression which is used when the dependent is a dichotomy and the independents are of any type. When multiple classes of the dependent variable can be ranked, then *ordinal logistic regression* is preferred to multinomial logistic regression. Continuous variables are not used as dependents in logistic regression. Unlike logit regression, there can be only one dependent variable.
>
> Logistic regression can be used to predict a dependent variable on the basis of continuous and/or categorical independents and to determine the percent of variance in the dependent variable explained by the independents; to rank the relative importance of independents; to assess interaction effects; and to understand the impact of covariate control variables.
>
> Logistic regression applies maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of the dependent occurring or not). In this way, logistic regression estimates the probability of a certain event occurring. Note that logistic regression calculates changes in the log odds of the dependent, not changes in the dependent itself as OLS regression does." (http://www2.chass.ncsu.edu/garson/PA765/logistic.htm accessed June 13, 2007)

A number of conditional logit models were tested to see which variables were significant in predicting an individuals adoption likelihood before the final model was arrived at. The model selected used seed cost, frost tolerance, decreased days to maturity, and the PCA variables ADP1, ADP2, RA1, RA2, CHAR1, and CHAR2.as independent variables predicting the likelihood of adoption. Seed cost, decrease in days to maturity and frost tolerance were all significant beyond the 1% level ($p<0.01$). The regression output coefficients in the following table loosely indicate the utility that is derived from the specific attributes. For instance a positive sign on the coefficient would mean that the individual would have a higher probability of gaining utility by adopting technology with that attribute. Respondents generally gain utility from frost tolerance and a decrease in days to maturity but a negative utility is experienced from an increase

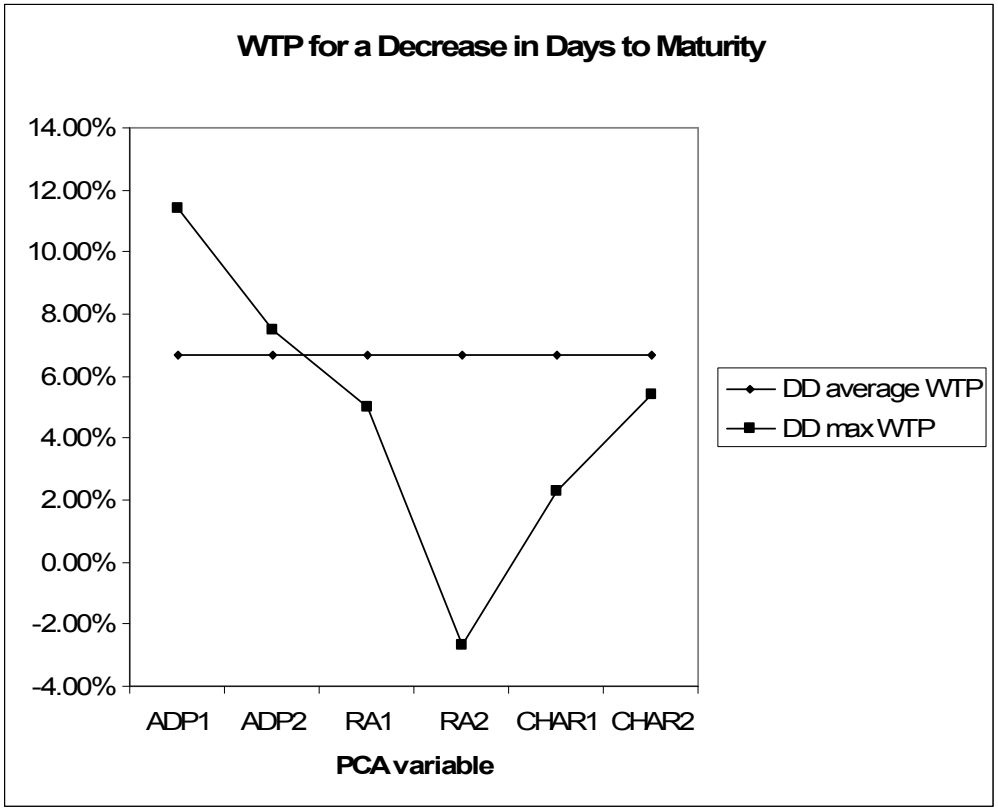
in seed cost (as would be expected from economic theory). The remaining variables in the model are interactions of significant PCA variables and these three attributes of the choice between new and existing varieties. The interactions suggest whether or not the attitude variable affects the respondent's interest in frost tolerance or decreased days to maturity or response to price.

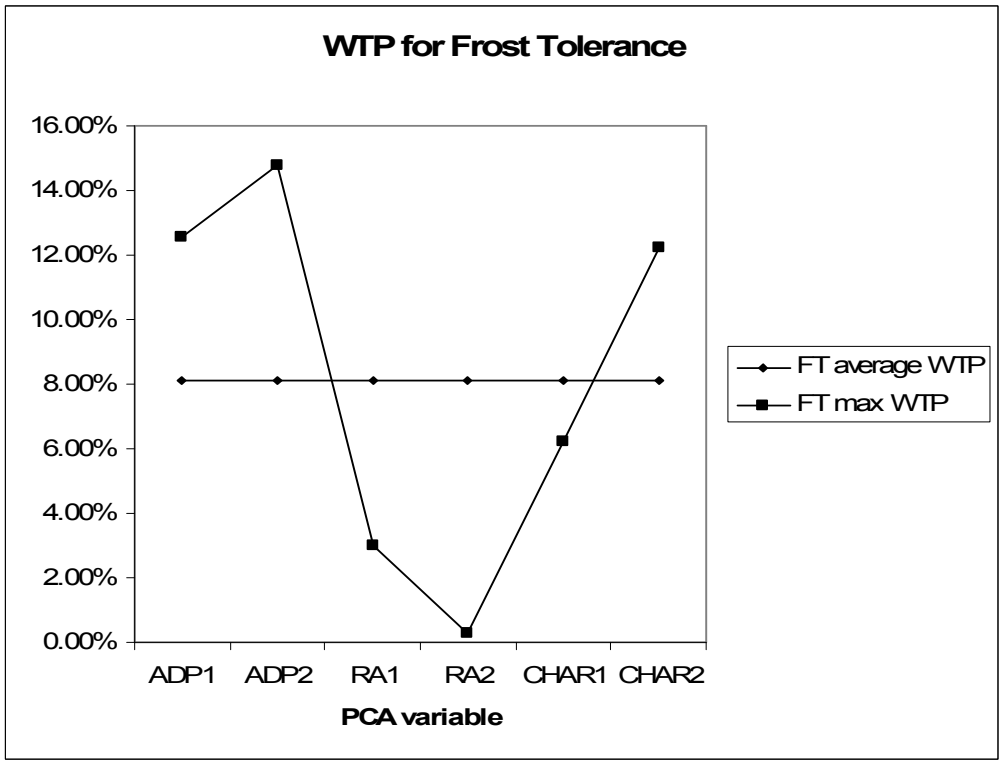
Parameter	Estimate	Standard Error	t-statistic	P-value
SC	-5.13046	0.720027	-7.12537	[.000]
FT	0.415592	0.058128	7.14959	[.000]
DD	0.346221	0.059757	5.79379	[.000]
SQ	-0.544135	0.311925	-1.74444	[.081]
ADP1FT	0.119998	0.060121	1.99594	[.046]
ADP1DD	0.124863	0.062923	1.98437	[.047]
ADP1SC	-1.16692	0.612961	-1.90374	[.057]
ADP2FT	0.223192	0.051175	4.36137	[.000]
ADP2DD	0.024094	0.050586	0.476293	[.634]
ADP2SC	-2.37772	0.508378	-4.67708	[.000]
RA1FT	-0.082777	0.056944	-1.45365	[.146]
RA1DD	-0.028332	0.059025	-0.479997	[.631]
RA1SC	1.465	0.599125	2.44524	[.014]
RA2FT	-0.083571	0.065691	-1.27218	[.203]
RA2DD	-0.100928	0.064481	-1.56525	[.118]
RA2SC	1.88816	0.652742	2.89265	[.004]
CHAR1FT	-0.044816	0.058685	-0.763678	[.445]
CHAR1DD	-0.106108	0.056453	-1.87959	[.060]
CHAR1SC	0.293964	0.589537	0.498636	[.618]
CHAR2FT	0.08616	0.052919	1.62816	[.103]
CHAR2DD	-0.028354	0.056978	-0.497632	[.619]
CHAR2SC	-0.885999	0.551918	-1.60531	[.108]

Willingness to Pay (WTP)

Willingness to pay was calculated for both the decrease in days to maturity and frost tolerance traits. This calculation was the sum of product of the regression coefficients and PCA outputs divided by the coefficient on seed costs or 'price' of the new technology. Mean levels of all explanatory variables were used to calculate an

average willingness to pay for each frost tolerance and decreased days to maturity. To find the maximum willingness to pay for each unique attribute of a new frost tolerant variety the maximum value of individual variables was included with the other values held constant. This resulted in a maximum WTP that could be compared with an average baseline for a particular attitude attribute. Below are graphs showing the mean and maximum WTP for each individual characteristic. For decreased days to maturity it was found that heavy technology users had the highest WTP. The lowest interest in decreased days to maturity was held by the risk averse individuals and their WTP was negative. This may be because of a resistance to switching to a new variety and change in general. Interest in paying for frost tolerance was fairly similar, with the exception that that light technology users had a higher WTP than heavy users.. Risk averse individuals also had a low WTP but not negative as with decreased days to maturity. Across all characteristics examined willingness to pay for the frost tolerance attribute was higher than decreased days to maturity.


WTP for a Decrease in Days to Maturity
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
-2.00%
-4.00%
ADP1
ADP2
RA1
RA2
CHAR1
CHAR2
PCA variable
DD average WTP
DD max WTP


WTP for Frost Tolerance
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
ADP1
ADP2
RA1
RA2
CHAR1
CHAR2
PCA variable
FT average WTP
FT max WTP

Conclusions and Implications

The information gleaned in this study has the possibility to narrow the focus of breeding efforts to benefit all stakeholders throughout the value chain. Information may be conveyed to researchers about traits to include in cold tolerant varieties that can be introduced through targeted channels increasing the chance of adoption with the ultimate benefits going to producers who would experience lower risk and society through the efficient expansion of the agricultural production frontier.

PCA analysis implied that there is significant variety in a number of attitudinal variables across the Alberta farming population. Principal component analysis identified differences around use of technology, attitudes towards risk and behavior in contracts. These characteristics were statistically important in explaining decision to select a new over an existing variety in a stated choice set of questions. Current heavy use of technology, risk seeking behavior and interest in contracts were all related to selection of new varieties. This information may aid in the channeling of cold tolerant varieties through targeting individuals with these key characteristics. Surprisingly frost damage experience was not significant in the regression however attitudes surrounding risk were and may have overshadowed the frost experience questions.

The willingness to pay results conveys that producers value frost tolerance slightly more than a decrease in days to maturity. Furthermore the PCA variables included in the regression highlight that both heavy and light technology users, risk loving individuals and respondents who are heavily engaged in current production contracts are willing to pay more for the frost tolerance trait than risk averse ones indicating that there is more value in the production of varieties with this specific trait.

Future uses of the WTP findings may be valuable in demand curve derivation and include further market segmentation. Other possibilities for further research in this area are vast. Further exploration of how demographics and attitudes are related to the WTP for the new variety would be helpful in marketing decisions and determining the scale of adoption in the commercialization stage. Other regression arrangements or PCA variable sets may reveal different characteristics of early adopters that could be applied to channeling the technology introduction phase of this technology. The first step has been taken toward efficiently allocating research efforts in the area of cold tolerant cereal breeding shedding some insight on the demands of the end user.

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