Risk Attitudes, Social Interactions and the Adoption of Genotyping in Dairy Production

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Abstract

We estimate the effects of risk attitudes and social interactions on technology adoption using a survey of dairy producers in Ontario. We find strong evidence that social interactions and risk attitudes have significant effects on the willingness to pay for DNA genotyping service for susceptibility to chronic mastitis in dairy.

Key Words: Technology Adoption, Risk Attitudes, and Social Network
JEL: Q16, C81, C83

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1. Introduction

Understanding the determinants of the adoption of technology has been of interest to economists (e.g., Feder, Just, and Zilberman, 1985; Foltz and Chang 2002; Barham *et al*. 2004). Of particular interest has been the role of risk attitudes and social interactions in technology adoption by firms (e.g., Foster and Rosenzweig, 2010; Liu, 2013;Manski, 1993; Foster and Rosenzweig, 1995; Baerenklau, 2005; Bandiera and Rasul, 2006). Risk attitudes and social interactions have important implication for the competitiveness of firms as the adoption of new technologies often have the potential to considerably enhance agricultural productivity. Empirical evidence, however, shows that adoption rates of new technologies are sub-optimally low (e.g., Foster and Rozensweig, 1995; Conley and Udry, 2010).

The adoption of new technologies is made difficult by the uncertainty surrounding the unexpected consequences of the technology, which is inevitably associated with the use of any new technology. Despite the fact that many new technologies aim to reduce production risk, one may expect a seemingly profitable agricultural technology to be adopted at a different rate given the variations in risk attitudes among farmers. It is likely that the 'costs' of perceived uncertainty about the new technology may outweigh the expected potential benefit and hence, discourage the diffusion of technologies. As a result, much empirical evidence suggests that risk-averse individuals are less likely to adopt new technology, despite risk-reducing nature of the technology (Liu, 2013). Meanwhile, social interactions[1] among producers may enable farmers to learn about benefits of new technologies from their peers, imitate their peers' decisions, or respond to their peers' experience, meaning that social interactions can be a vital source of information in agriculture (Foster and Rosenzweig, 1995; Conley and Udry, 2010). Thus one way to increase adoption rate might be to reduce uncertainty about the technology and to explore the effects of social interactions on the adoption of new technologies. In particular, social interactions are expected to reduce the concern and uncertainty about new technology and ultimately help farmers to accept the innovations. Therefore, the understanding of the impact of risk attitudes and social interactions, and their interactions on the adoption of new technologies is of paramount importance to the adoption decision process. Despite some previous work that combines risk attitudes and social networks in the technology adoption studies (e.g., Baerenklau, 2005; Liu, 2013), there remains a gap in the literature that simultaneously estimates the influence of social interactions and risk attitudes on technology adoption.

This study uses the adoption of DNA genotyping services to select for mastitis resistance in Ontario dairy industry as an example to examine the effects of risk attitudes and social interactions on adoption decision and the willingness to pay the technology. Most adoption studies are conducted *ex post*, providing very little insight of how the adoption decisions are made initially. This can be less problematic if the adoption study accounts for demographic factors that are most

[1] Durlauf and Ioannides (2010) define social interactions as "interdependencies among individuals in which the preferences, beliefs and constraints faced by one socioeconomic actor are directly influenced by the characteristics and choices of others."

likely to be constant over time, but it leads to some potential bias in interpreting the results when it comes to behavioral determinants. First, since many of the determinants of adoption may have already changed over time, the characteristics observed now could be different from those at the time the decision is made. Such variables may include risk attitudes as there is evidence showing that risk aversion is not stable over time (Bucciol and Miniaci, 2013). Second, the *ex post* measure of the determinants could be affected by the adoption decision itself and therefore suffer from endogeneity problem (Besley and Case, 1993). For example, larger farm has been found to be early adopter of new technology (Jamison and Lau, 1982; Feder, Just, and Zilberman, 1985; Klotz, Saha and Butler, 1995), but some evidence from hog industry has suggested that adoption of technology has led to an increase in farm size (Reimund, Martin, and Moore, 1981; Gillespie, Karantininis, and Storey, 1991). Our study, however, may not suffer from the same problem, as the technology examined in our study has not been commercially available to dairy farmers and we examine the adoption decision *ex ante*. Therefore, our study is unique in that we provide an *ex ante* evidence of the determinants of the adoption of new technology. We create a hypothetical market scenario to reveal producers' potential willingness to pay (WTP) for the new technology.

In this paper we use a survey of dairy producers in Ontario to: (1) estimate willingness to pay (WTP) for DNA genotyping service to select for mastitis resistance and (2) estimate the effects of risk attitudes and social interactions on the WTP. The data used in this study is gathered through a survey of Ontario dairy farms in summer 2013. We use contingent valuation with double bound dichotomous choice to elicit farmers' WTP for DNA genotyping service to select for mastitis resistance. Our results suggest that the mean WTP for DNA genotyping service for mastitis is approximately $50, which compares well to the price of current genotyping for general traits. We find strong evidence of social interactions and risk attitude effects on WTP. Dairy producers who discuss (via email, letters, etc.) their production practices with more farmers have higher WTP for DNA genotyping service. We find risk-seeking farmers are WTP more for DNA genotyping service for mastitis. The main effect of risk attitudes dissipates when we allow for interaction between social interactions and risk attitudes – the effect of risk attitudes on WTP is no longer statistically significant. However, the interaction effect is positive and significant. This result underscores the importance of the interaction between risk attitudes and social interactions, and may suggest that the secondary effect of social interactions in this study is to moderate the risk attitude effect.

The rest of paper is organized as follows. Section 2 describes DNA genotyping technology and costs of mastitis in dairy production. Section 3 provides a review of literature on risk preferences and social interactions as well as other determinants of agricultural technology adoption; and evidence on WTP for genetic testing. Section 4 discusses the double bound dichotomous choice method, the empirical method, and our survey design and summary statistics. Section 5 presents the estimate of WTP and risk attitudes and social interaction effects. Section 6 provides a discussion of the main findings. Section 7 concludes.

2. Cost of Mastitis and Genotyping

Bovine Mastitis, defined as the inflammation of the mammary gland (Petrovski, Trajcev and Buneski, 2006), is one of the most frequent and costly production diseases in dairy industry worldwide (Sargeant *et al*., 1998; Camps *et al*., 2008; Heikkila *et al*., 2012), causing major animal welfare and environmental problems (Vilkki *et al*., 2013). The incidence rate of mastitis is relatively high compared to other dairy diseases (Hardeng and Edge, 2001), but differs across countries and regions (Barnouin *et al*., 2005; Bradley *et al*., 2007; Thompson-Crispi and Mallard, 2013). In Canada, the incidence is around 20 - 26% in terms of clinical mastitis (McLaren *et al*., 2006; Olde Riekerink *et al*., 2008; Thompson-Crispi and Mallard, 2013). The major impact of mastitis on dairy herds is the reduction in milk production or productivity and milk quality and therefore, increases in the cost of production. In Canada, the average cost of mastitis per cow per years was estimated to be $382, while a farm spent $27,891 per year on mastitis and $983 per clinical case (Camps *et al*., 2007). In the European Union (EU), more than 6 million cows are affected by mastitis annually, and costs approximately €600 per cow (Heikkila *et al*., 2012). In the U.S., the associated production losses of mastitis were estimated to be around $108 to $295.24 per cow depending on the severity of the disease and most of the cost is due to loss in milk yield or productivity (Ott, 1999).

Controlling for mastitis-causing pathogens through selection of cows is important to enhancing dairy herd productivity. Milk somatic cell count is traditionally used as an indirect indicator in the selection of cows to reduce mastitis susceptibility. However, with low heritability and complex biological background, mastitis resistance is difficult to include in a breeding program (Vilkki *et al*., 2013).

One recent major progress in dairy genetics is the development of DNA genotyping[2]. Genotyping provides information at gene level and show how individual or a group of genes can determine a particular trait or behavior. Currently, the most widely used genomic tests are a medium density Illumina 50k test (50k test) and a low density Illumina 6k test (6k test), which identifies 54,609 SNPs[3] (Illumina, 2013) and 6,909 SNPs (Illumina, 2012), respectively. Genotyping enable one to test the production, health, and conformation traits of cows (Schefers and Weigel, 2012), which allows producers to genotype the herds to select the animals with the best genetic merits. With the recent advance in dairy genomics to identify the gene regions affecting resistance of mastitis (Vilkki *et al*., 2013; Dolezal *et al*., 2014; Bowen, 2014; Wang *et al*., 2014), producers may in the near future genotype their young animals for mastitis resistance as well. This can be appealing to dairy producers for selecting animals with disease resistance and avoiding potential high cost associated with mastitis. As genomic test for mastitis is developed and move toward commercialization in the future, the use of genotyping for mastitis can be treated as a risk management and productivity-enhancing tool in dairy production, as it helps to reduce the risk

[2] In this paper, genotyping, genomic testing (test) and genetic testing (test) are used interchangeably.
[3] SNP (single nucleotide polymorphisms) is a place in a chromosome where the DNA sequence can differ among individuals.

of mastitis by allowing farmers to identify young heifers with mastitis resistance at their early lifecycle.

3. Literature Review

3.1 Risk Attitudes, Social Interaction and Other Determinants of Technology Adoption

Risk attitude is widely recognized as an important factor in shaping farmers' adoption decisions (Barrett *et al*., 2004; Gillespie *et al*. 2004; Baerenklau, 2005). Abadi Ghadim *et al*. (2005) suggested that risk aversion and relative riskiness of the innovation are the two risk-related factors that largely affect the adoption decision. The direction of the impact of risk attitudes on adoption is of empirical matters. In most situations, new technologies are expected to reduce the production risk, increase productivity, save cost and increase profitability. Gillespie *et al*. (2004) found that in hog industry, more risk-averse producers were more likely to adopt technologies such as artificial insemination and intensive breeding that help to improve profitability. Shapiro, Brorsen and Doster (1992) indicated that the adopters of double-crop rotations are more risk-averse than the non-adopters. However, such evidence does not guarantee a positive relationship between risk aversion and adoption decisions. Instead, many studies have shown the opposite. A positive association between risk-tolerance and adoption has been found by several empirical studies. For instance, Cole (2007) examined the adoption of cold-tolerance cereals in Alberta and revealed that risk-seeking individuals are willing to pay more for frost tolerance trait than the risk-averse ones. Similarly, a recent study on Bt cotton adoption in China by Liu (2013) suggested that risk-averse or loss-averse producers tend to adopt agricultural innovation later than their risk-seeking counterparts. One possible explanation for these mixed findings is that despite the expected risk-reducing nature of certain technologies, the imperfect knowledge and associated uncertainty about new technologies, which make the risk-averse individuals reluctant to use the innovation, would discourage early adoption.

A common approach to reduce uncertainty is through information accumulation. Previous literature has recognized two types of information gathering process: learning by doing and learning from others (Foster and Rosezweig, 1995). Learning by doing refers a situation whereby an agent gains experience and updates beliefs from using technology over time, which emphasizes an active or internal learning process through self-experimenting with the technology. Learning from others, however, puts more weight on external information from peer influences and social interactions. Given the nature of genotyping for mastitis, which is not yet available on the market, our emphasis will be on the latter case. In the context of technology adoption, information externality has commonly been known as social network effect, social learning effect or neighborhood effect. The underlying point of information externality is that farmers learn from peers, friends, neighbors or experts through active or passive learning (Feder and Slade, 1984). Evidence on social network effect has been widely reported in previous studies and the information externality has generally been found to be a positive factor in stimulating technology adoption. Burger, Collier, and Gunning (1993) studied the effect of social learning in Kenya and they found that producers value the choices of others who are considered similar to them. Foster and Rosenzweig (1995) provided evidence of learning spillovers in the context of the adoption of high-yield seed varieties. Farmers with more experienced neighbors were found to be more profitable. However, Bandiera and Rasul (2006) argued that the previous assumption of the linearity of social learning and adoption could be dubious. In their study of sunflower adoption in Mozambique, they measured the information externality as the number of adopters among one's self-reported network of family and friends. The likelihood of adoption was found to increase with the number of adopters when few of farmers in their network adopt, but decrease when they are many. This inverse U-shape curve suggested the existence of free ride or strategic delay on others' knowledge. In addition, they also indicated a stronger effect of the adoption choices among family and friends than religion cohorts. Similar findings of the stronger social ties between farmers and their family or friends were reported by Granovetter (1985), who considered long-term relationship, mutual trust and reciprocity to be the factors that strengthen such social ties.

3.2 WTP and Genetic Testing

The literature on WTP for healthcare technology has grown in the past few years. Although most of the previous studies have been focusing on the predictive testing for various human diseases rather than dairy diseases, the methods and findings in these researches can provide a similar research basis and reference point for our study. Generally, people are found to have positive WTP for genetic testing, despite the absence of test consequences (Neumann *et al*, 2012). Previous studies have emphasized both social-demographic and psychological factors as the main determinants of taking genetic testing (Bosompra *et al*., 2001). Tubeuf *et al*. (2013) assessed the WTP for inherited retinal diseases. Their results showed a positive relationship between WTP and patients' age and income levels. Similar result was found in studies focusing on the demand for prenatal diagnostic testing (Caughey *et al*., 2004), the WTP for prostate-specific antigen testing (Yasunaga *et al*., 2006) and the WTP for colorectal screening test (Frew *et al*., 2001). Additionally, Yasunaga *et al*. (2006) also found a negligible influence of education and highlighted the impact of hospitalization history, while Frew *et al*. (2001) emphasized the role of gender.

In terms of psychological determinants, a number of studies have noted the importance of perceived disease risk and the attitudes towards the test, health and life. Research on the test for breast cancer suggested a positive relationship between undergoing a genetic test and the perceived risk and perceived likelihood of carrying cancer gene (Lerman et al., 1994; Struewing *et al*., 1995; Jacobsen *et al*., 1997), as well as having positive attitudes towards genetic test for breast cancer (Tambor, Rimer and Strigo, 1997). Bosompra *et al*. (2000) showed that the likelihood of having cancer risk test is positively associated with perceived susceptibility, perceived benefits and a pessimistic outlook on life. Similarly, risk perception and attitudes towards health promotion have been found to significantly affect the WTP for colorectal screening test (Frew *et al*., 2001)

4 Method

4.1 Contingent Valuation with Double Bounded Dichotomous Choice Form

The contingent valuation method (CVM) is commonly used in literature to elicit peoples' willingness to pay (WTP). The underlying assumption of the CVM is that respondents know approximately what their maximum WTP for the good under evaluation is and will report this value (Kristom, 1990). This method was originally applied in the assessment of economic value of non-market goods, such as natural resource damage (Whittington *et al*., 1990). Although CVM is mostly used in the context of environmental economics and natural resource economics (Barreiro *et al*., 2000, Bandara and Tisdell, 2004), recent application has been expanded to the measure of consumer response to GM food (McCluskey *et al*., 2003) and public WTP for cancer test (Neumann *et al.*, 2012), among others.

The format of CVM can be either open-ended or close-ended. Previous studies have indicated some serious drawbacks associated with open-ended question, such as protest answers, bias response and strategic behavior (Shultz, Pinazzo and Cifuentes, 1998), which can bias the WTP estimates. The close-ended form usually refers to the dichotomous choice CVM. Single bound and double bound are typically the two types of dichotomous choice used mostly in the literature. Specifically, in dichotomous choice, a respondent is asked whether he or she would be willing to pay certain amount of money for a particular good in a hypothetical market. Depending on the perceived value the respondent places on the good, he or she is expected to answer "Yes" or "No" to the proposed price. Empirically, double bound format is widely preferred over the single bound approach given the statistical efficiency gained by the follow-up bids (Hanemann, Loomis and Kanninen, 1991).

However, the double bound method is not totally exempt of criticism. The main problem is the inconsistency between the first and second bid (McFadden and Leonard, 1993; Cameron and Quiggin, 1994; Kanninen, 1995), which could be a result of cost expectation (Carson *et al*., 1992), loss aversion (DeShazo, 2000) or a switch from a market setting for the first bid to a bargaining setting for the second (Altaf and DeShazo, 1994)[4]. Cooper, Hanemann and Signorello (2002) presented a new method called one and one-half bound to address the bias, in which the respondents are told ahead of time that they will be faced with a price interval and either the upper

[4] A detailed discussion on this issue can be found in the study by Cooper, Hanemann and Signorello (2002), in which they wrote the following:
"…Several explanations have been proposed for the anomaly. Carson *et al*. (1992) suggest an explanation based on cost expectations: a respondent who said "yes" to the initial price sees the second price as a price increase, which he rejects; a respondent who said "no" and is then offered a lower price may suspect that an inferior version of the item will be provided, which he also is disposed to reject. Altaf and DeShazo (1994) suggest that the second bid converts what had seemed to be a straightforward posted-price market into a situation involving bargaining; if this is bargaining, the respondent should say no in order to drive the price down. DeShazo (2000) offers a prospect-theory explanation involving loss aversion and framing of the first price…"

bound or lower bound will be provided as first bid then comes another.

In this study, we choose the double bound approach over one and one-half bound for two reasons. First, the empirical evidence of using the one and one-half bound method is relatively weak. Second, the potential root causes of inconsistency, such as the bargaining setting and cost expectation, are often associated with interview-based survey, as the second price sometimes comes unexpectedly (Cooper, Hanemann and Signorello, 2002). In our study, we used the mail survey approach and the respondents can see the entire bid amounts provided in the question. This ensures that the second bid does not come with surprise and prevents the respondents from falling into a bargaining situation.

4.2 Empirical Model

Assuming the individual *i*'s WTP can be modeled as a linear function (e.g., reference):

$$WTP_i = x_i \beta + u_i$$

where x_i is a vector of explanatory variables, β is a vector of parameters and u_i is the error term assumed to be normally distributed with mean zero and constant variance, σ^2. An individual is expected to answer *yes* to the proposed bid (*B*) when $WTP_i \geq B$ and *no* when $WTP_i \leq B$.

In double bound format, a respondent is first provided with a bid amount (B^1), and then each is given a follow-up bid (B^{2H} *or* B^{2L}, where H=higher than the first bid, L= lower than the first bid) based on the answer for the first bid, which provides more information for the range of WTP. Given the double bounded dichotomous nature of the answers, we can categorize all the responses into four groups: (1) Yes, Yes; (2) Yes, No; (3) No, Yes; (4) No, No. We provide detailed estimation strategy on (No, Yes) case as an example:

$$\begin{aligned}
\Pr(N,Y) &= \Pr(B^{2L} \leq WTP_i < B^1) \\
&= \Pr(B^{2L} \leq x_i'\beta + u_i < B^1) \\
&= \Pr(\frac{B^{2L} - x_i'\beta}{\sigma} \leq \frac{u_i}{\sigma} < \frac{B^1 - x_i'\beta}{\sigma}) \\
&= \Phi(\frac{B^1 - x_i'\beta}{\sigma}) - \Phi(\frac{B^{2L} - x_i'\beta}{\sigma})
\end{aligned}$$

$$\Pr(N,Y) = \Phi(x_i'\frac{\beta}{\sigma} - \frac{B^{2L}}{\sigma}) - \Phi(x_i'\frac{\beta}{\sigma} - \frac{B^1}{\sigma})$$

where Φ is the standard cumulative normal. Let $D_i^{YN}, D_i^{YY}, D_i^{NY}, D_i^{NN}$ be the dummy variables indicating the relevant case for each respondent. The log likelihood function that needs to be maximized is:

$$\ln L = \sum_{i=1}^{N} \{ D_i^{YN} \ln[\Phi(x_i ' \frac{\beta}{\sigma} - \frac{B^1}{\sigma}) - \Phi(x_i ' \frac{\beta}{\sigma} - \frac{B^2}{\sigma})] + D_i^{YY} \ln[\Phi(x_i ' \frac{\beta}{\sigma} - \frac{B^2}{\sigma})]$$

$$+ D_i^{NY} \ln[\Phi(x_i ' \frac{\beta}{\sigma} - \frac{B^2}{\sigma}) - \Phi(x_i ' \frac{\beta}{\sigma} - \frac{B^1}{\sigma})] + D_i^{NN} \ln[1 - \Phi(x_i ' \frac{\beta}{\sigma} - \frac{B^2}{\sigma})]\}$$

4.3 Survey and Data

The data used in this study is obtained from a mail survey of dairy farmers that was implemented across Ontario to assess the adoption of dairy genomic technology in summer 2013. A total of 2520 dairy farmers were randomly selected by Dairy Farmers of Ontario (DFO) to participate in the survey. We received 204 surveys from the respondents, representing an 8.1% response rate[5]. Among these 204 observations, only 159 of them have completed all the questions that relate to the analysis in this study.

Since the survey is relatively large and serves for different purposes, only the questions that are related to this study will be briefly discussed. The survey begins with questions on the adoption of various dairy technologies and farmers' general attitudes towards genomics. Then a set of questions is presented to ask about farmers' previous experience of genotyping heifers and bulls. Note that, genotyping for mastitis has been available in the market, so any experience of using genotyping is with respect to the test for general traits. We also included questions that help us to rank the importance of traits or reasons that make farmers to genotype animals. Finally in this section, farmers are asked how concerned they are about the incidence of chronic mastitis.

Farmers in general have neutral or positive reaction when they hear the word "genomics", as only 12.58% reported that they feel negative about genomics. Of our sample, 34 out of 159 dairy farmers claimed that they had experience about genotyping their bulls or heifers before, which represents a 21.38% adoption rate of current genotyping for general traits (Figure 1). Among those who genotyped, reasons such as "Genomic proof to enhance sales of breeding animals", "For interest" and "For breeding decision" were ranked as the most important reasons to genotype bulls and heifers. Somewhat surprising, "Identify presence of specific genes of economic importance" has been ranked as the least important trait in both bull and heifer genotyping. In terms of the attitudes towards mastitis, most of the respondents showed a great deal about the incidence of mastitis. It turns out that 53.46% of sample said that they are very concern about mastitis, 43.40% said they have little or some concern, while only 3.14% that expressed no concern about mastitis.

The next section comes with the double bound dichotomous choice questions (see Appendix 1). Six versions have been created, as each has a different starting price: (A) \$30; (B) \$50; (C) \$70; (D) \$90; (E) \$110; (F) \$130. After answering to the first bid, respondents are directed to the follow-up bid, which is designed to be \$20 more or less than the starting bid conditional on the

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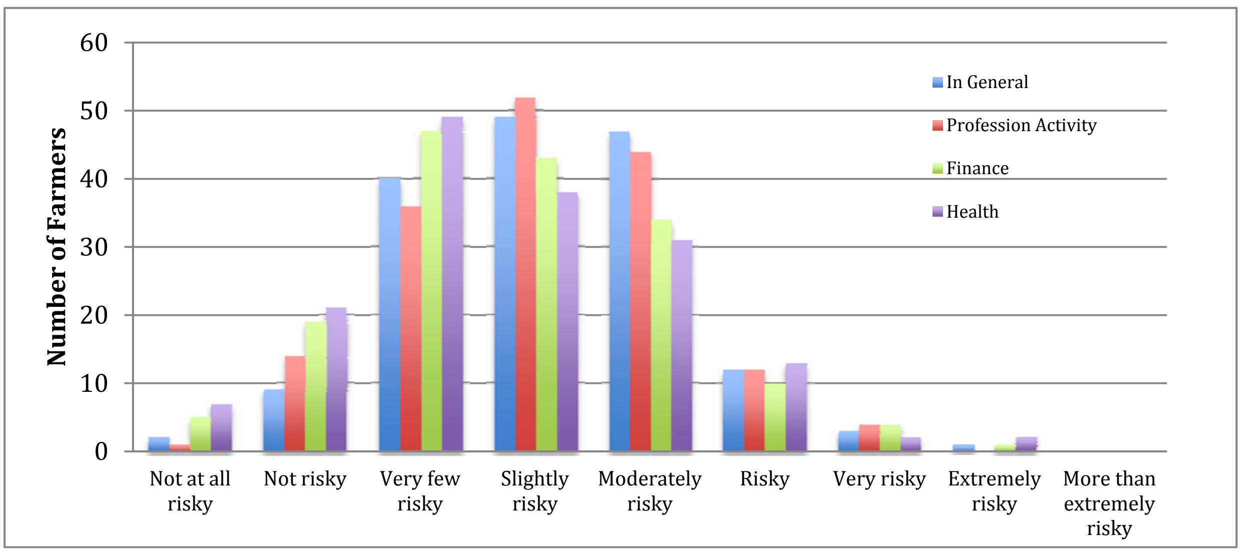
5 The low response rate of our survey may have something to do with the overall length of the survey and the time we conducted the study.

answer for the starting price. The next questions explore farmers' risk attitudes, in which we intend to include both stated and revealed preferences for risk. We use lottery tickets question, which is a typical approach in the literature, to examine the revealed risk attitudes. The stated preference questions are formulated in a 1-to-9 scaled-based format, where 1 refers to "Not at all risky" and 9 refers to "More than extremely risky". The risk attitude questions are framed to refer to risk attitudes in *general*, and towards *professional* activity, *finance* and *health*.

Most of respondents considered themselves to be somewhere between very few risky and moderately risky across the four types of measures[6]. Particularly, farmers are slightly risky in general and towards professional activities, but more conservative when it comes to financial decision and health decision (Figure 1). Note that, our measure does not specifically indicate whether a farmer is risk-averse, risk-neutral or risk-loving, but rather, it provides a relative degree of risk tolerance. In our analysis, we use principal component analysis (PCA) to generate a new variable "*Risk Tolerance*" that allows us to take into account the four measures of farmers' risk preferences. Our PCA result (Appendix 2) suggests only one component be used to predict the new variable. The factor loading in "*Risk Tolerance*" concentrated more on general risk attitudes and less on risk attitudes towards health, while almost equally distributed between professional and financial actions (Appendix 3). A summary of "*Risk Tolerance*" can be seen in Table 1, as higher number is associated with higher degree of risk tolerance.

Figure 1. Farmers' Perceived Risk Attitudes towards Different Activities



The third set of questions is on farm characteristics, such as farm size, disease cost, debt ratio and farm structure. The final part of survey is about personal characteristics, such as age, gender, education, farming experience and social interaction. Additionally, we also ask a set of psychological questions regarding respondents' beliefs, attitudes towards genomic technology in

[6] The revealed risk preferences questions did not work well in our study as many respondents skipped over the questions or stated that they don't gamble. Therefore, our measures of the risk attitudes are solely depended on the answers for the stated preferences.

animal disease control.

A farm, on average, spends $7,347 on animal disease treatment cost annually and has 28% of the total farm assets as debt. Of the sample, 33.33% of the farms are structured as corporation, while partnership and owner operator are 34.62% and 32.05%, respectively. With respect to farm size, the average milk quota held by a dairy farm is 79.33kg in Ontario. We also include the total number of milking cows as an alternative measure of farm size, and the mean value is 76 cows per farm.

In terms of personal characteristics, over 90.57% of the respondents in our study are male. Most of the respondents are in the age groups between 30-64 years old, while the average dairy farming experience is about 24 years. Approximately 28% of the respondents reported that they completed university degree, 26.42% said they had some education at community or technical college, compared to 22.01% that had secondary school diploma or equivalency certificate. With respect to social interaction, a producer on average discusses his or her production decisions with 3.85 farmers within a given month. There is also consensus among respondents in considering that using genomic information in cattle selection for disease resistance is positive and appealing. A summary statistics of the variables in our regression analysis are provided in Table 1.

Table 1. Summary Statistics of Selected Variables

	Obs	Mean	Std.Dev	Min	Max
Farmer Characteristics					
Age	159	5.088	1.245	1	7
Gender	159	0.906	0.293	0	1
Education	159	4.113	1.747	1	7
University Degree	159	0.283	0.452	0	1
Experience	159	23.654	13.917	0	62
Social Interaction	159	3.852	5.396	0	50
Concern_Mastitis	159	3.321	0.888	0	4
Farm Characterisitcs					
Number of Milking Cow	159	75.844	105.043	5	1100
Farm Size (<51)	159	0.509	0.501	0	1
%Income from Dairy	150	85.120	20.779	0	100
Quota	148	79.333	120.487	10	1200
Annual Disease Cost	112	7346.670	10143.280	0	80000
Debt Ratio	119	28.170	24.162	0	100
Towards Genomics					
Genotyping	159	0.214	0.411	0	1
Belief in Genomics	159	5.415	1.433	1	7
Trust	159	4.082	1.518	1	7
Risk Attitudes					
Risk Tolerance	159	-0.003	1.591	-4.423	5.299
Risk_General	159	4.119	1.193	1	8
Risk_Profession	159	4.069	1.191	1	7
Risk_Finance	159	3.811	1.356	1	8
Risk_Health	159	3.767	1.397	1	8

4.4 Independent Variables Included in Analysis

A number of independent variables have been chosen according to the adoption literature and WTP for genetic testing. We provide a discussion of these variables regarding the measures and expected impact in this section, a brief description of these variables can be seen in Table 2.

Risk Tolerance is a continuous variable reflects farmers' risk attitudes. Specifically, the variable indicates the individual's perceived level of risk tolerance, which is derived from the PCA analysis aforementioned. Higher value indicates the respondent is more risk seeking. While theories may suggest risk-averse individuals should be more willing to adopt risk-reducing technology, empirical evidence indicates an ambiguous sign of this relationship. On the one hand, people who are risk-averse may see the benefits of using the technology to reduce the potential risk of having sick animals. On the other hand, they may also suspect the actual performance or effectiveness of the technology because of the uncertainty of new technology. If the uncertainty about the new technology prevails, then the risk-averse individuals are less likely to be early adopter and hence, will express a lower WTP.

Social Interaction is a continuous variable that measures the number of dairy producers one discuss production practices and results with within a given month. Previous studies have suggested a number of proxies to measure the information externality that matters to adoption decision. For instance, Bandiera and Rasul (2006) used "the number of adopters in the farmers' network of family and friends" as the proxy for social network; Conley and Udry (2010) defined information link as the number of farmers individuals communicate farming advice with; other measurements include geographical proximity (Liu, 2013) and neighbors' experience at village level (Foster and Rozensweig, 1995). The measurement used in our study is somewhat similar to Conley and Udry's (2010), and in additional to that, we further specify the information interconnection to be within one month[7]. Therefore, our definition provides the frequency of social interaction. Since the technology is not available, we do not expect the farmers to have specific communication about the test, but rather we assume that frequent communication of farming practice would contribute to their perception towards general new technology and help to reduce the related uncertainty when they are facing the adoption decision. Overall, a positive sign is expected from social network on farmers' WTP for genotyping for mastitis.

Genotyping is a dummy variable indicating whether a farmer has genotyped their animals before. We expect the past experience of using genotyping could reduce the concern about the technology, and successful experience may even further facilitate the use of new genotyping with mastitis detection function.

Concern_Mastitis is a discrete variable that indicates the extent to which a farmer concerns about the incidence of mastitis. Since the incidence of mastitis is relatively high, farmers who are more concerned about the outbreak of cow disease would like to use the genotyping to reduce the

[7] In Conley and Udry's study, they asked the respondent: "Have you ever gone to (farmer's name) for advice about your farm?" and then counted the number of information neighbors. However, we consider this approach to be less accurate when a farmer did communicate with someone but only at a rare basis.

risk, so a higher WTP is expected to associate with deeper concern about the disease.

Belief in Genomics is a discrete variable that measures the extent to which a producer positively believe in using genomic information to selectively breed for disease resistance. Previous literature has highlighted the importance of considering farmers' perceptions of technology-specific characteristics in adoption model (Adesina and Zinnah, 1993) as well as the attitudes towards genetic test (Tambor, Rimer and Strigo 1997). However, in our study the technology hasn't been available to farmers, so their perception of technology-specific characteristics cannot be fully measured. Since the genotyping for mastitis is mainly used for disease resistance, we construct a set of questions to test if farmers hold positive attitude on the use of this technology in disease resistance[8]. It is expected that those who are positive about the technology would be willing to pay more.

Trust is a discrete variable that indicates farmers' trust on breeding companies. We also expect a positive sign of its effect.

Age is a discrete variable that takes index of 1 to 7. Each number represents an age group. Age has been found to negatively associate with the likelihood of adopting new technologies. For instance, Khanal and Gillespie (2011) found that in U.S. dairy sector younger farmers are more likely to adopt advanced breeding technologies such as sexed semen, artificial insemination (AI) and embryo transplants. Similar result was found in the study by Howley *et al*. (2012), in which they demonstrated a negative relationship between operators' age and the adoption of AI in Irish dairy industry. Therefore, it is hypothesized that younger farmers will show higher WTP for the technology.

Gender is the dummy variable that takes 1 when the respondent is male. We expect male to show willingness to adopt the technology. Some studies noted that males in general tend to adopt improved technologies at a higher rate compared to females (Doss and Morris, 2001; Zhou *et al*., 2008), which may be caused by time and resource constraints faced by women (Tanellari, Kostandini and Bonabana., 2013), while others found insignificant effects of gender on adoption (Overfield and Fleming, 2001). It seems that gender issue is subject to the specific technology and the role female and male play in the adoption process.

University Degree is the dummy variable that indicates whether the respondent has a university degree. A number of studies have investigated the effect of education in shaping adoption decision of agricultural technologies. Education is expected to create favorable attitudes for the acceptance of innovations, particularly in information- and management-intensive technologies (Waller *et al*. 1998; Caswell *et al*., 2001). Despite some conflicting findings in the adoption of water-saving technology in China (Zhou *et al*., 2008), it is generally agreed that education is positively associated with the probability of adopting new technology (Prokopy *et al*., 2008). The positive relationship, for example, has been found in the adoption of hybrid maize in Kenya (Gerhart, 1975), high-yield grain in the Punjab Region of India (Rosenzweig, 1978), and

[8] We find the measurements are highly correlated in this set of questions, in order to keep more observations we only use one question that measures whether the respondent is positive about using genomics in disease resistance.

the DHIA[9] dairy record keeping system in California (Zepeda, 1994).

Experience is a continuous variable that measures how many years a farmer has been involved in dairy farming. Foster and Rosenzweig (1995) showed that the increase farmer's experience is associated with increasing farm profitability of the adoption of high-yielding seed varieties (HYVs). Farming experience is an important component in decision-making process because more experienced farmers are expected to be more knowledgeable in terms of farming practice and farm management. Specifically in our study, we expect the experienced farmers to be more aware of the risk of mastitis, and therefore are willing to pay a larger premium for the test.

Farm Size (<51) is a dummy variable indicating whether a farm has less than 51 milking cows. We use the number of milking cows as a proxy of dairy farm size[10], and the median is 51 cows. The impact of farm size has been discussed in a number of studies. The effect of farm size is somewhat complex, since it can be influenced by other factors affecting adoption decisions, such as fixed cost, human capital, and credit constraint (Baradi, 2009). Even so, most studies suggested that a positive relationship exits between adoption and farm size (Jamison and Lau, 1982; Feder, Just, and Zilberman, 1985; Klotz, Saha and Butler, 1995).

Table 2. Variable Description

Variables	Units	Description
Age	1-7	Higher number suggests an older age
Gender	0,1	0 as female and 1 as male.
University Degree	0.1	Whether a farmer has university degree or not
Experience	Years	Number of years that one has been in dairy farming
Farm Size (<51)	0,1	A farm has total number of milking cow less than 51
Genotyping	0,1	Whether a producer has genotyped animals before
Risk Tolerance	Number	Higher number represents higher degree of risk tolerance
Social Interaction	Number	The number of dairy producers one discuss production practices and results with within a given month
Concern_Mastitis	0-4	Respondents' concern about the incidence of chronic mastitis, 4 as very concerned
Belief in Genomics	1-7	The extent to which a producer positively believe in using genomic information to selectively breed for disease resistance
Trust	1-7	The extent to which a producer trust breeding companies in using genomics for disease selection

9 DHIA is the abbreviation for Dairy Herb Information Association

10 Ideally, we would like to include more farm characteristics (e.g. debt ratio, income, disease cost) into our analysis, but due to the shortage in corresponding data, we could only include farm size as a measure of farm characteristics.

5 Results

5.1 WTP Estimation

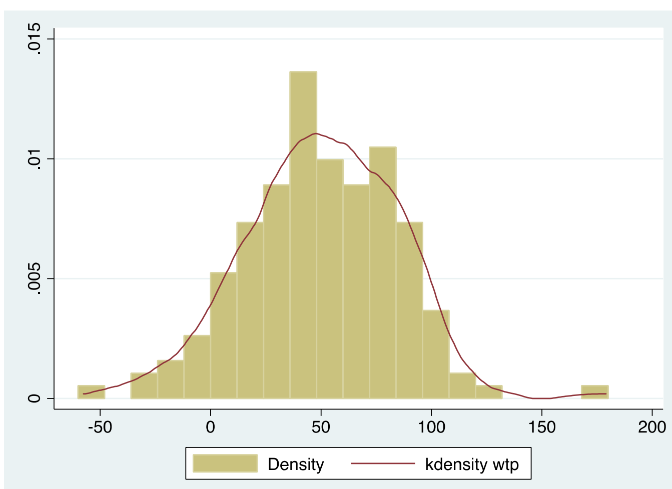
The estimated WTP are reported in Table 3. We have estimated the mean WTP with and without control variables. We present the WTP estimation without control variables for two different sample sizes. The first sample size excludes 5 observations that do not have completed answers for the dichotomous choice questions and the second sample size eliminates observations that have missing data for the independent variables we choose. The result suggests that the mean WTP for genotyping an animal for the susceptibility to chronic mastitis is around \$47 to \$50. Our estimate with control variables, based on 95% confidence intervals, indicates that the lower and upper bounds of the mean WTP are \$41.82 and \$58.68, respectively, which compares well with the two estimates without control variables. In addition, we provide the WTP estimate at individual level (Figure 2). The predicted mean WTP is \$50.25, close to our previous estimates. The 25%, 50% and 75% quantiles of individual estimated WTP are \$26.95, \$48.75 and \$77.16, respectively.

Table 3. Willingness to Pay Estimation Results

	Sample Size	Mean WTP	Lower Bound	Upper Bound
WTP without control variables	200	\$47.48	\$37.44	\$57.53
	159	\$49.26	\$38.53	\$59.99
WTP with control variables	159	\$50.25	\$41.82	\$58.68

Note: The Estimation for lower and upper bound are based on 95% confidence intervals

Figure 2. Distribution of Individual WTP Estimation



Note: the distribution is drawn with \$12 bandwidth.

5.2 Marginal Effects

The marginal effects of the explanatory variables on Mean WTP are reported in Table 4. The marginal effects measure the impact of per-unit change of explanatory variables on mean WTP. We specify the models with and without interaction term between risk attitude and social interaction in our regression. Table 4 compares two models (i.e., with and without interaction term) with three scenarios of producers' concern about mastitis. Panel 1 includes all the observations, Panel 2 considers those respondents who answered *somewhat or little concern* about the incidence of mastitis. Panel 3 includes the farmers who are *very concern* about mastitis.

Table 4 shows, evidence of strong risk-attitudes and social interactions effects. We find social network has a positive statistically significant effect on farmer' WTP for genotyping an animal for the susceptibility to chronic mastitis for most models. All other things being constant, our result suggests that a unit increase in the number of peer may result in a \$3.089 (Panel 1) increase in WTP for genotyping. In terms of risk attitudes, we find risk-takers are willing to pay more for genotyping. This result is unexpected given the risk-reducing nature of genotyping. But it may highlight the fact that effect of uncertainty about new technology may outweigh the risk-reducing nature of the technology; hence, risk-seeking individuals are more inclined to take risky action.

When we include the interaction term for risk attitude and social interactions, we find a significant change in the impact of risk attitudes: the direct effect of risk attitude dissipates, but the interaction effect is statistically significant. The interaction term is positive and statistically significant. The inclusion of interaction term allows us to separate the risk attitudes effect into its main effect and the interaction effect with social network. Our results suggest that negative non-significant main risk attitude effect, but a positive interaction effect. A positive value for the effect of the interaction term would imply that the higher the number of peers is, the greater the effect of risk-attitudes on the potential WTP is. Similarly, the more risk-seeking a farmer is, the greater effect of social network on the potential WTP is.

In Panel 2 and Panel 3, we spit the sample into two: those who show *little or somewhat* (Panel 2) concern about mastitis; and those who are *very concerned* (Panel 3) about mastitis. The first model in Panel 2 shows a significant positive effect of risk-seeking attitudes on WTP for genotyping. This suggests that among the producers that are less concerned about mastitis, potential risk reduction benefit is less appealing to them. The use of genotyping can be treated as a future investment and hence, risk seeking farmers are willing to adopt the technology. Comparing this result with Panel 3, we find risk attitudes to be less important when farmers show a higher concern about mastitis, as the marginal effects estimated in both models under Panel 3 are statistically insignificant. The interaction terms in both cases are statistically significant and positive, which further emphasizes the importance of the interaction between social network and risk attitudes.

Table 4 shows a significant positive effect of social network across different panels, except for the second model in Panel 3. As we expected, the positive impact suggests that farmers with more peers are willing to pay more for the technology. Previous studies have shown the role of information externality during the process of technology adoption. Given that our measure of social interaction is before the adoption decisions take place, it provides evidence that the information externality can also be a crucial factor that hastens the initial adoption decisions.

The rest of coefficients estimated are regarding to the conventional determinants and some psychological factors. We find that respondents who are more concerned about mastitis had the perception that they would be willing to pay higher for the test to avoid the potential disease risk. Similarly, farmers who hold positive belief of using genomics in disease resistance are willing to pay more for the technology, meaning that creating a positive image of genomics can substantially increase the probability of adoption. In terms of the farmer's characteristics, age has a negative sign across different models, but it is only significant for those who are very concerned about mastitis. Our results indicate that farmers with more dairy experience are likely to pay a higher price for the technology; meaning that more experienced farmers would be willing to pay higher. The marginal effects for University degree are statistically insignificant. Furthermore, the marginal effects of previous genotyping experience and trust in breeding companies are statistically insignificant.

Table 4: Comparison of the Marginal Effects with Different Panels

Variables	Panel 1 (Obs=159)		Panel 2 (Obs=69)		Panel 3 (Obs=85)	
	Without Interaction	With Interaction	Without Interaction	With Interaction	Without Interaction	With Interaction
Intercept	-101.487***	-110.022***	-27.456	-29.728	21.429	3.353
	(34.500)	(33.439)	(32.446)	(30.069)	(51.898)	(50.456)
Age	-7.721	-7.634	-7.871	-9.500	-18.315*	-16.219
	(6.248)	(5.974)	(6.906)	(6.351)	(10.890)	(10.353)
Gender	11.767	11.030	16.786	21.511	-3.460	-9.615
	(14.040)	(13.455)	(15.471)	(14.544)	(22.851)	(21.913)
University Degree	9.014	8.915	16.087	15.652	-5.705	-4.155
	(9.496)	(9.137)	(11.051)	(10.455)	(15.299)	(14.499)
Experience	0.965*	1.013*	0.848	1.019*	1.804**	1.628*
	(0.548)	(0.528)	(0.666)	(0.623)	(0.902)	(0.860)
Farm Size (<51)	12.060	9.902	7.751	6.056	22.127*	19.244
	(8.643)	(8.447)	(10.842)	(10.470)	(13.400)	(12.914)
Genotyping	-3.153	-2.826	-8.868	-8.174	15.916	11.306
	(10.293)	(9.913)	(11.078)	(10.402)	(17.733)	(16.785)
Risk Tolerance	6.298**	-1.385	9.165***	4.607	4.147	-9.098
	(2.688)	(3.447)	(2.971)	(3.633)	(4.283)	(6.096)
Social Interaction	3.089***	3.625***	3.319***	3.162***	2.481**	2.704
	(0.868)	(1.034)	(1.050)	(0.986)	(1.213)	(1.832)
Concern_Mastitis	21.779***	22.665***	/	/	/	/
	(4.982)	(4.856)	/	/	/	/
Belief in Genomics	9.606***	11.297***	8.891**	10.263***	10.672*	15.256***
	(3.625)	(3.249)	(3.659)	(3.573)	(5.508)	(5.585)
Trust	3.258	1.945	0.888	(0.252)	4.603	2.804
	(2.757)	(2.679)	(3.771)	(3.571)	(4.181)	(4.021)
Risk*Social		1.954***		1.438*		2.462**
		(0.618)		(0.742)		(1.003)
Log Likelihood	-161.116	-155.045	-53.41	-51.641	-96.490	-91.505
Wald Chi2	52.61	61.37	37.49	45.72	14.22	18.27

Notes: Standard error in parentheses, significant at *10%,**5% and ***1%; Panel 1 includes all observations; Panel 2 represents the group who are little or somewhat concerned about mastitis; Panel 3 repsents the group who are very concerned about mastitis

6 Discussion

Our results underscore the importance of social network effect in terms of the direct effect on WTP and the interaction effect between risk attitudes and social network. Our measure related to social interaction is the number of producer in a given month a farmer shared information with, such as production decision or milking advice. Our result shows that farmers with larger social network are willing to pay more for the technology, which is in line with some other studies that indicate positive social network effect (Foster and Rosezweig, 1995; Conley and Udry, 2010). Moreover, by adding the interaction effects, we find a distinct role social network play in stimulating risk-seeking individuals to adopt the technology. This finding provides a potential alternative interpretation for the case where many studies have found a positive relationship between risk tolerance and new technology adoption. In addition, our result also emphasizes the role of social network before an adoption decision occurs. Most previous studies that examined the role of social network examined the effect of how peers' adoption decisions influence ones adoption of a technology. Social network effect captures the peer influence in the process where early adoption begins to provide information externality to the non-adopters. Unlike previous studies, we examine the social network one has before any adoption decisions occur, which means the impact of social interaction does not have to come from others' early success of technology adoption. Instead, we consider such long-term relationship between peers not only provides a fundamental information externality available to farmers when facing brand new technology, but also reshapes their perception towards new technology. Therefore, the positive impact found in our study implies that in spite of farmer's imprecise knowledge and different attitudes towards using agricultural innovations, one's social network can potentially reduce uncertainty about the technology and contributes to a higher willingness to adopt a new technology. Since peer interaction can be one of the major sources that farmer obtains information from (Ramirez, 2013) and the trust within the peer groups provides the power of word-of-mouth, the significant effect of social interaction also emphasizes the importance of forming organizational affiliation, such as producer club or co-operative, in which farmers should be encouraged to serve as both providers and recipients of knowledge and information.

In terms of risk attitudes, our results provide some interesting findings to the understanding and future research on technology adoption and risk preferences. First, by decomposing the risk attitude impact, we find a strong tie between risk attitudes and social interaction. This impact has not been examined in empirical works before. Our results highlight the importance of the interaction between social network and risk attitudes, and provide an example where failure to separate interaction effect can lead to a misinterpretation of the results. Second, by grouping the producers based on their concern about mastitis, we are able to capture a positive relationship between risk tolerance and potential WTP. One may argue that risk-takers are more likely to be early adopters since the uncertainty of the potential outcome of new technology may discourage risk-averse individuals to adopt. In our case, because the technology is specifically designed for mastitis susceptibility detection, it is possible that farmers who are less concerned about mastitis may not be interested in the adoption of the DNA genotyping service as much as farmers with higher concern. Therefore, it provides very little incentives for risk-averse individuals to adopt the technology. But for the risk-seeking individuals, adoption decision can be seen as an investment in productivity enhancing and risk reducing technology, which may cause risk taking farmers express higher WTP. Nonetheless, as the technology has not yet been introduced to the marketplace, it is interesting for future research to test the impact of risk attitudes after this technology has been available on the market.

In addition, the lag in the benefit realized from the investment in technology may suggest the potential influence of producers' time preference. Previous literature has indicated a negative correlation between the degree of risk aversion and the implicit discount factors (Anderhub *et al*., 2001), meaning that risk-averse individuals value more for the present. If this is the case, then a risk-averse farmer would be hesitant to invest on testing animals at the current period and rather wait to see how the test performs. Further research is useful in this regard to include time preferences as explanatory variable.

Our estimate of the mean WTP for genotyping for mastitis is approximately $50. The result compares very well with the current market price of DNA genotyping service for general attributes, which is $47. It is worth noting that our estimate is based on a single disease-detection feature of genotyping and the current test actually contains a number of other important traits (e.g., production, fertility, conformation). This finding raises a very interesting question for the supplier of genotyping service: Will producers expect information on the mastitis trait to be bundled with existing attributes or will they be willing to pay extra for specific mastitis information? Our study does not provide compelling evidence with respect to this issue, but one thing to notice from our results is that previous genotyping experience is not shown to improve the respondents' WTP for test for mastitis. This may suggest that, among those who genotyped their animals before, the effectiveness of the genotyping may not turn out to be as well as they expected, at least from a cost-benefit standpoint. Another thing to notice is that the most important reasons for genotyping heifers, according to those who have genotyped, are the genomic proof to enhance sales of animals and for interest, while the identification of specific genes is ranked as one of the least important factors. This may explain a bit about the insignificant impact of genotyping experience, since DNA genotyping service for mastitis susceptibility is to detect the specific disease genes in cattle.

One of the limitations of our study is the relative small sample size in estimating the WTP. The willingness to pay estimate in our analysis is based on a hypothetical purchase situation, and a large sample size therefore, is needed to ensure the statistical efficiency of the WTP estimate. A common limitation of CVM is that it tends to overestimate the individuals' WTP than what is actually revealed in the real marketplace (Lusk, 2003). Thus, our estimate of $50 may be overrated, but since the technology has not been introduced, we are expecting that the future availability of the test would sell itself in terms of providing effectiveness to select heifers less susceptibility to mastitis and reduce the uncertainty associated with the technology. Also, our measure of producers' risk attitudes is solely dependent on their own stated preferences, which could be less efficient as it assumes that the agent is able to be fully aware of his or her own preferences. Also, it is worth noting that we do not distinguish between risk-aversion and ambiguity aversion. Recent works have provided empirical evidence that ambiguity aversion can be an important factor explaining the disparity in technology adoption (Engle-Warnick, Escobal and Laszlo, 2011; Barham et al., 2014). The result found in our study may imply the role of ambiguity aversion towards new technology and a more precise measure of producers' attitudes towards risk and ambiguity may provide some useful insights in terms of the effect of uncertainty.

7 Conclusion

This paper examines the effect of risk attitudes and social interaction on the willingness to pay for DNA genotyping service for mastitis susceptibility. One major concern in dairy production is the incidence of bovine mastitis, which is one of most frequent and costly diseases. The recent development in genomics promises to bring the genomic testing for mastitis in the near future in order to provide selective breeding for disease resistance. Despite the technology aims to reduce dairy production risk, the uncertainty associated with new technology may lead to sub-optimally slow diffusion of the technology

We find that both risk attitudes and social interactions have significant impact on producers' WTP for DNA genotyping service for mastitis susceptibility. Risk seeking individuals and those with larger social network are found to have higher WTP. The positive relationship between risk tolerance and the WTP is more significant for those who are less concerned about mastitis. Considering the risk-reducing nature of genotyping, this positive influence suggests that agent's perceived uncertainty of genotyping may exceed its potential benefit. For those who are less concerned about mastitis, the adoption of genotyping can be treated as an investment in productivity enhancing technology. Furthermore, by adding the interaction between risk attitudes and social network, we find that the main effect of risk attitudes dissipates. However, the interaction effect is positive and significant.. Our findings shed light on the importance of the interaction effect between risk attitudes and social network, which emphasize the need to simultaneously consider both risk attitudes and social network into the model to avoid potential bias of results. One novelty of our study is the ability to account for various determinants in an *ex ante* examination of adoption decision. The effects of social network and risk attitudes measured in our study are different from other studies since most of the adoption studies are performed after the adoption has taken place. It is possible that farmers would have adjusted their social interaction and risk attitudes because of the adoption of specific technology. Therefore, the results provided in this study suffer less from the potential endogeneity problem that oftern occurs in other studies.

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Appendix 1.

Q19. Consider for a moment that you have access to the latest genomic (DNA marker-assisted) testing (genotyping) that may enable you to gain information about genetic factors related to mastitis susceptibility for young animals. The technology may allow you to cull heifers with very high **predicted** susceptibility to chronic mastitis that might not respond to antibiotic therapy. If the price of testing an animal for the susceptibility to chronic mastitis were **$130** per test, would you genotype your animals for susceptibility to chronic mastitis?

Yes ☐ ***[If Yes, go to Q19.1]*** No ☐ ***[If No, Go to Q19.2]***

Q19.1. **If your answer to Q19 is YES**, if the cost were **$150** per test, would you still genotype your animal?

Yes ☐ No ☐

Q19.2. **If your answer to Q19 is NO**, if the cost were **$110** per test, would you genotype your animal?

Yes ☐ No ☐

Appendix 2. Eigenvalue of PCA Components

Component	Eigenvalue
Comp1	2.789
Comp2	0.613
Comp3	0.385
Comp4	0.212

Appendix 3. Factors Loading for PCA

Variables	Comp1
Risk_General	0.541
Risk_Profession	0.529
Risk_Finance	0.499
Risk_Health	0.429