Exploring factors that influence perceptions of using genomics for emission reductions in beef cattle.

Anna Kessler
ajkessle@ualberta.ca
MSc candidate, Department of Resource Economics and Environmental Sociology,
University of Alberta

Ellen Goddard
ellen.goddard@ualberta.ca
Professor, Department of Resource Economics and Environmental Sociology,
University of Alberta

John Parkins
john.parkins@ualberta.ca
Professor, Department of Resource Economics and Environmental Sociology,
University of Alberta

515 GSB
University of Alberta
Edmonton, AB
T6G 2H1

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Abstract

Given the quantity of greenhouse gas emissions resulting from beef production and rising concerns with climate change, genomics have been introduced to facilitate selective breeding for increased feed efficiency in beef cattle as one area of emissions reductions. Public perception is an important consideration in this endeavour. In this study data collected from a survey of 1803 participants from across Canada is analysed and the influence of attitudes and knowledge pertaining to the environment and biotechnologies on the degree of acceptance and relative perceived benefit to human health of this use of genetic technology is examined. Upon grouping respondents into categories of those who oppose, doubt, and support this use of genomics, multinomial logistic regressions are used to determine the factors influencing an opposing or supporting position, relative to doubt, the relatively neutral position. Results suggest that distinct characteristics influence the likelihood of supporting or opposing this use of technology with respect to two different measures of acceptability of the technology - degree of acceptance and relative perceived benefits to human health.

Introduction

There are certain topics that, when raised in the right company, can spark heated debate. Among these are climate change and biotechnology, both of which are intricately related to agriculture. Agricultural, particularly livestock, sectors have come under increased scrutiny with regards to greenhouse gas emissions (GHG) emissions given the sector effects on climate changes and related changes in the environment (McAlpine *et al*, 2008; Subak *et al*, 1997). Polluting emissions occur at several phases throughout beef production: fertilizer and pesticide production and fuel use create emissions associated with the production of feed, transportation fuel costs occur at multiple intervals from transporting feed through transporting cattle and beef products, and a large portion of greenhouse gas emissions occur from the live cattle themselves, related to methane produced in digestion (Bell *et al*, 2011). Furthermore, intensive feedlot systems of livestock production emit more than double the carbon dioxide equivalents of pastoral production systems (Subak, 1997). With increases in demand for beef, due to global population growth and rising incomes in the developing world, and the subsequent need for increased supply from North America where intensive feedlots are predominant a challenge exists for the sustainability of livestock production (McAlpine *et al*, 2008; Subak *et al*, 1997). The solutions to these challenges require both scientific innovation and social support.

Increased feed efficiency in cattle has been proposed as a means of reducing greenhouse gas emissions at both the feed production and live cattle nodes in the production system (Bell *et al*, 2011; de Haas *et al*, 2011). Increases in feed efficiency would allow the same quantity of beef to be produced with less feed inputs and less waste output from the cattle. Importantly, enteric fermentation, in cattle results in the passing of methane (CH_4), a powerful greenhouse gas. In fact, up to 44.7% of the GHG emissions from livestock production are the result of enteric fermentation (Tan *et al*, 2012). Therefore, efforts to reduce emissions, through reduced feed intake, are considered especially effective (de Haas *et al,* 2011). Subsequently, researchers are attempting to determine the most efficient means of achieving increased feed efficiencies and reducing enteric fermentation. To date, it has been found that this can be achieved through nutritional and microbial manipulation as well as genetic improvements using "natural variation to breed for animals with lower CH_4 yield" (de Haas *et al,* 2011, p.6122). Genetic improvements are the most effective and require the study of genomics, to accelerate progress, and subsequent selective breeding (Bell *et al,* 2011; de Haas *et al*, 2011). However, this mitigation strategy also requires consumer and producer acceptance of the technology.

When considered simultaneously, climate change and biotechnologies applied to food present an interesting selection of problems, solutions, and areas of study. For one, these present a venue in which to explore the factors influencing decision-making and opinion forming. The use of genomics for the pro-environmental intent of reducing greenhouse gas emissions presents an opportunity to explore pro-environmental attitudes and behaviours and as well as factors influencing acceptance or rejection of the use of these applications of biotechnology in food. The inquiry of this paper involves determining influences on public perceptions with respect to the use of genomics to undertake selective breeding to increase feed efficiencies in beef cattle, thereby reducing greenhouse gases emitted in beef production.

Objectives

This study is aimed at describing factors influencing acceptance or rejection of the use of genomics in undertaking selective breeding for increased feed efficiency in beef cattle. Due to the environmental impact of this use of genomics, factors influencing environment related opinions and behaviour are of particular interest. The objectives of this analysis are as follows: (1) to determine degree of acceptance and relative perceived benefit of the use of genomics in selective breeding to increase feed efficiency in beef cattle; (2) to determine the impact of environmental related beliefs and knowledge on these perceptions; and (3) to determine the impact of demographic and other attitude characteristics on these perceptions.

Literature Review

Genomics is "the science that studies the structure and function of genomes and, in particular, genes" (van den Heuvel *et al*, 2006, p.345) wherein specific genotypic variations of certain characteristics, such as feed efficiency, can identified (Bell *et* al, 2011; de Haas *et al,* 2011).

Tools such as functional molecular markers can be used in selecting individuals with desirable genotypic traits for reproduction (van den Heuvel *et al*, 2006). Thus, using genomics in selective breeding is only slightly different than conventional breeding methods; the genes are studied but are not actively modified as would occur in genetic modification. However, public perception of genomics may remain similar to perceptions of GM for a number of reasons including a lack of information or understanding (van den Heuvel *et al*, 2006). Therefore, a variety of factors may influence public perception of using genomics in beef cattle production. In order for the use of genomics in selective breeding to increase feed efficiency to be a viable solution to rising emissions from beef production, the public ought to be accepting of the technology. In this case both factors influencing environment related opinions and behaviours and factors influencing opinions about the use of genomics may impact this acceptance.

With regards to the environment, attitudes, knowledge, values, and ethics have been demonstrated to impact an individual's decision to participate in pro-environmental behaviour (Corral-Verdugo *et al,* 2008; Dietz *et al*, 1998; Dunlap *et al* 2000; McFarlane and Boxall, 2003; Spash and Hanley, 1993; Osbaldiston and Schott, 2012). In general, weak relationships have been noted between environmental attitudes and perceptions of food related technologies; however, GM "products have been found to be environmentally less favourable" (Hosseini-Matin *et al,* 2012, p.150). However, potential exists for this study to yield different results given the pro-environmental intent of this use of genomics and the fact that the technology is not genetic modification of animals. Further, it is worth noting that the results of studies regarding pro-environmental attitudes and behaviours are mixed. Numerous studies observe that those with strong pro-environmental attitudes fail to carry out pro-environmental behaviours; however, a full explanation of this gap has not been achieved (Kollmuss and Agyeman, 2002). For example, with respect to food and environment specifically, Hosseini-Matin *et al* (2012) demonstrated that despite the potential environmental improvements of the use of nanotechnology in food packaging, environmental attitude effects were minimal and those with the strongest pro-environmental attitudes were the least accepting, although statistical significance varied. The influence and interaction of values, attitudes, and behaviours has been assessed in some studies attempting to model causality. For the purposes of this study however, environmental related factors are determined using a variety of scales in attempt to present a holistic picture of environmental related mindset influencing decision-making.

The scales used in this survey have been used and tested throughout the related literature. Some scales are intended to assess ethics or values. The New Ecological Paradigm (NEP) was developed by Dunlap and Van Liere in the 1970s as an alternative to the Human Exemptionalist Paradigm that dominated at the time. The NEP measures the degree to which a respondent embodies an ecocentric, as opposed to anthropocentric, worldview. The authors then further assessed the NEP scale in 2000 and a refined scale was determined (Dunlap *et al*, 2000). The New Human Interdependence Paradigm was developed to assess "individuals' adherence to the major principles at the basis of the Sustainable Development concept" (Corral and Verdugo, 2008, p.705). This scale takes into account "functional interdependence between human development and the long-lasting functioning of ecosystems" (Corral and Verdugo, 2008, p.705). Used in combination, the NHIP and NEP allow for a variety of anthropocentric and ecocentric views to contribute to proecological behaviour (Corral and Verdugo, 2008). This is in keeping with the notion that anthropocentric and ecocentric views may each contribute to values and subsequent attitudes and behaviours in unique ways (McFarlane and Boxall, 2003). Additionally, animal specific attitudes are relevant to this study. The animal attitudes scale assesses attitudes towards the use of animals and anthropomorphic values associated with animals (Herzog *et al*, 1991).

Knowledge also plays a role in values, attitudes, and behaviours related to the environment. One possible implication of the use of genomics, which can speed up genetic progress towards specific breeding goals, is a possible impact, positive or negative, on biodiversity of the particular domestic animal species. In this regard, biodiversity familiarity, which could influence acceptance, can be assessed using a three indicator scale developed by Spash and Hanley (1995). Each statement is a definition of biodiversity accepted within the literature pertaining to species, genetic, and ecosystem diversity (Spash and Hanley, 1995). This allows testing for actual knowledge which may influence environmental and other perceptions. Self perceived knowledge of environmental problems may also be important, but reflects personal reflections on one's knowledge rather than an accurate test. This is relevant as perceived knowledge may influence environment related behaviours in different ways than actual knowledge (McFarlane and Boxall, 2003).

On the other hand, attitudes toward science and technology, technological optimism, trust in experts and regulations, perceived risks and perceived benefits of genetically modified foods, risk benefit interaction, knowledge, gender, and education have been shown to influence individuals' attitudes towards genetically modified (GM) foods (Costa-Font and Gil, 2009; Gaskell *et al*, 2004). The organisms produced through cross breeding are not considered genetically modified organisms (GMOs). However, both the study of genomics, learning about the natural genotypic and phenotypic variation (Bell *et* al, 2011; de Haas *et al,* 2011), and genetic modification technologies that alter naturally occurring DNA and RNA (Kuiper, Kok, and Engel, 2003), are biotechnologies. The use of genomics in selective breeding enhances traditional breeding processes by providing genetic information sooner than would be evident otherwise, through phenotypic observation alone (Bell *et* al, 2011; de Haas *et al,* 2011). However, the existing literature focuses primarily on factors influencing acceptance or rejection of GM food products. Given the biotechnology theme throughout, these indicators may also serve to impact perceptions of the use of genomics for selective breeding.

The results from studies examining influences on opinions on applying biotechnologies to food in general are varied. For example, researchers Larue *et al* (2004), suggest that niche markets for GM foods exist within Canadian consumers; efforts are being made to create functional GM foods with targeting health benefits and some, though a minority of, consumers prefer GM products even without demonstrated health impacts (Larue *et al*, 2004). Other researchers in this realm expose that "consumers exhibit a high level of concern regarding the future of novel food supplies (Baker and Mazzocco, 2002), genetic modification (Hu *et al*, 2004, 2006; Larue *et al*, 2004) and the consumption of foods produced with novel technologies" (Hosseini-Matin *et al*, 2012, p.149). In general, Costa-Font and Gil (2009) suggest "that acceptance of genetically modified food rather than being well endowed in people's attitudes, is still in a very early stage of the behavioural process that has both knowledge and time dependent constrains (experience). Therefore, individuals still do not appear to have a clear cut position on the matter" (p.407). Furthermore, in cases where consumers perceive risks to GM foods but benefits to health or the environment trade-offs are made and are dependent on individual characteristics (Wuyang *et* al, 2004) A selection of factors shown to influence opinions on GM food, such as perceptions of trust, risks and benefits, and knowledge as well as demographics are included in this study.

Methods

The survey used to collect the data in this study was gathered as part of a larger project interested in this topic from several angles. The questionnaire consisted of 72 questions, many of which had sub-questions or multiple scale items; a selection of questions was used for this specific analysis based on the research questions of interest. The questionnaire was distributed and completed electronically. The sampling frame consisted of a panel intended to be representative of the Canadian population. In total, 12,300 panelists maintained by the market research company TNS Global were approached, based on stratified sampling to maintain geographical distribution, to complete to complete the survey. Responses were accepted until 1803 completed questionnaires were received, in keeping with the pre-set quota.

Participants were given the following information regarding genomics and its climate change related used. All participants were told "Genomics is the study of the genes and genetic characteristics of organisms like plants, animals, and humans. Genes carry information that determines many of the features and characteristics of organisms. A genome is all the genes of an organism. The Human Genome Project and the sequencing of the SARS virus are examples of research in genomics." Additionally, participants who ate meat and therefore answered additional questions were told: "Methane production from cattle is a large source of greenhouse gases. At the same time feed is one of the biggest costs facing cattle producers. Enhancing feed efficiency in cattle could have the effect of making beef production more environmentally and economically sustainable" and "The study of genomics in cattle allows for the identification of specific genes that are linked to enhanced feed efficiency. With knowledge of the presence (absence) of these genes, selective breeding can produce cattle that are more efficient converters of feed into meat, reducing greenhouse gases and improving farm profitability."

Two dependent variables were separately tested for this analysis: degree of acceptance and relative perceived benefit. A respondent's overall degree of acceptance was determined through the following question: "For you, the use of *genomic information to undertake selective breeding to increase feed efficiency* in cattle is:" followed by a seven indicators - useless-useful, worthless-valuable, harmful-beneficial, foolish-wise, awful-nice, disagreeable-agreeable, unpleasant-pleasant.

Respondents indicate their responses on a seven point scale, with higher scores indicate positive positions. Responses to each of the seven indicators were summed, resulting in end scores of 7 through 49. This scale, the Personal Involvement Inventory (PII) was originally developed and tested by Zaichkowsky (1984). Relative perceived benefit was determined through two consecutive five-point scale questions: “How risky do you consider the use of genomic information, to undertake selective breeding for increased feed efficiency of cattle, to be for your health?” and “How beneficial do you consider the use of genomic information, to undertake selective breeding for increased feed efficiency of cattle, to be for your health?” were answered on scales from 1 (not at all) to 5 (very). The score of perceived risk to health of this use of genomics was subtracted from the score of perceived benefits to health for overall relative perceived benefit scores ranging from -4 through 4. All participants assessed for relative perceived benefit eat beef and therefore received all of the above information; the end sample included only those who responded to both dependent variable questions and therefore all participants included in the analysis eat beef.

Independent variables include values, knowledge, and perceptions as well as demographics. Environment related variables were measured through scales and include the New Ecological Paradigm (NEP) (Dunlap *et al*, 2000), the New Human Interdependence Paradigm (NHIP) (Corral and Verdugo, 2008), self-perceived knowledge of environmental problems, biodiversity familiarity (Spash and Hanley, 1995), and attitudes towards animals (Herzog *et al*, 1991). Where applicable, scale scores were calculated in keeping with the respective original methods. Factors shown to influence perception of food related biotechnologies were also measured. Trust in food processors, food researchers, and government were assessed through scales questions. Trust in food processors and in food researchers were determined with one indicator 5-point scales in response to the question “How much trust do you have in the following groups or institutions regarding their responsibility for food in Canada? (scores range from 1 = little trust to 5 = very high trust).” Trust in government was assessed through a scale, originally with 6 indicators; however, one indicator was ambiguous in terms of reflecting a negative or positive experience and was therefore not included in sum of the final score. Respondents indicated their level of agreement (from 1, strongly disagree, through 5, strongly agree, or 6, don't know) with statements regarding the government's competency with regards to biotechnology. "Don't know" responses were also excluded from the sum score. Participants were also asked whether the world is better or worse off because of science and technology and if they had heard of genomics prior to the survey. Familiarity of and interaction with livestock production were also determined through yes or no questions. Six information treatments were also provided to participants who ate meat. This information was provided prior to the dependent variable questions but after the opinion related independent variables. Information treatments noted additional risks and benefits related to the animals, the beef industry, and biodiversity.

Descriptive statistics and multinomial logistic regressions were completed for both dependent variables using SPSS version 13.0 and Stata 12.1. Both degree of acceptance and relative perceived benefit scores were then grouped into the three categories –those who oppose, doubt, and support this use of genomics - in keeping with the analysis found in Vandermoere *et al* (2011) and Hosseini Matin *et al* (2012), and similar to the work of Gaskell *et al*, 2004. Opposers show disapproval and see risks, doubters demonstrate uncertainty or neutrality, and supporters show approval and see benefits. For degree of acceptance, score categories are 7 to 22 for opposers, 23 to 33 for doubters, and 34 to 49 for supporters. For relative perceived benefit score categories are -4 to -1 for opposers, 0 for doubters, and 1 to 4 for supporters. Independent sample t-tests were completed to assess the difference in the mean environmental related and other continuous variable scores for those in each of the dependent variable categories. Cross tabulations were used to explore the distribution of demographic variables in the three categories for each dependent variable. The primary means of data analysis used was multinomial logistic regressions. These models were run with doubters as the base category. Results from descriptive and regression analyses are compared for consistency.

Results

A sample size of 1115 from the original 1803 was used for this analysis. Only participants who completed the questions regarding the risks and benefits to human health of this use of genomics, all of whom eat beef, were included. Further, cases were removed for incomplete answers in independent variable scales. Of the 1115 respondents, roughly two thirds identified as female. The majority are educated to a technical school or bachelor's level, over half are above 50 years of age, and the most common income bracket is $40,000 to $64,000. Approximately two thirds of respondents live in Eastern Canada, one third live in the prairies or British Columbia, and none were from the northern territories. The majority, 86.7%, of respondents live in urban settings (Table 1.).

[Insert Table 1 here.]

Dependent variable scale scores are present for the full range of possible responses. The mean degree of acceptance is 28.98, only slightly above the midpoint. When categorised into three groups based on degree of acceptance 393 (21%) oppose, 923 (51%) doubt, and 487 (27%) support this use of genomics. The means for perceived risk and perceived benefit to personal health are 2.71 and 2.51 respectively and the mean relative perceived benefit is -0.20. The categorised distribution for relative perceived benefit shows 583 (35%), 692 (42%), and 388 (23%) oppose, doubt, and support this technology respectively.

[Insert Figure 1 here.]

Environment related variable scores also cover the full range of possible responses, except in the case of NEP (Dunlap *et al*, 2000) where no respondent had the lowest possible scores. The means for all environmental related variables are above the midpoint of the scales; the NEP mean is 54.36, the NHIP mean is 21.09, the mean for knowledge of environmental problems is 5.46, the mean for biodiversity familiarity is 11.15, and the mean for animal attitudes is 42.05. Variables shown to influence perception of biotechnologies in food and GM food were also measured and respondents demonstrate varied perceptions for each of the variables. Trust levels range from no trust to absolute trust for food processors, food researchers, and government with means of 2.80, 3.22, and 16.02 respectively. The mean score for considering if the world is worse or better off because of science and technology is 6.45, slightly above the midpoint. With respect to knowledge related variables, half of respondents had heard of genomics, a quarter are familiar with livestock production, and only 1% live or work on a ranch or farm.

[Insert Table 2 here.]

Independent sample t-tests were used to compare the means of continuous independent variables between opposer, doubter, and supporter categories for both the dependent variables degree of acceptance and relative perceived benefits. The means of several variables are consistently significantly different ($p<0.05$) when comparing those of opposers and doubters, opposers and supporters, and supporters and doubters, while the means of other variables are relatively similar across categories (Table 3 and Table 4). For the samples derived from the categorization of the dependent variable degree of acceptance the means for trust in government, trust in food processors, trust in food researchers, and perceived benefits of science and technologies significantly different for each category pairing. The means of knowledge of environmental problems, biodiversity familiarity, having heard of genomics, and education are significantly different between opposers and supporters and between supporters and doubters. The means of livestock production familiarity is different between doubters and both supporters and opposers. For NEP the means are only significantly different between opposers and supporters. For income, means are only significantly different between supporters and doubters. The means of NHIP and living or working on a ranch or farm are never significantly different.

For the three categories of respondents derived for the dependent variable relative perceived benefit the difference in means between categories is even greater. There is a significantly difference in mean between all category pairings for biodiversity familiarity, animal attitudes, trust in government, trust in food processors, trust in food researchers, and benefits of science and technology. The means of NEP and NHIP are significantly different between opposers and both doubters and supporters. The means for having heard of genomics and education are significantly different between supporters and both opposers and doubters. The means for knowledge of environmental problems, livestock production familiarity, and income are different between supporters and doubters. Again, the differences in means for living or working on a ranch or farm are never significant.

[Insert Table 3 here.]

[Insert Table 4 here.]

Multinomial logistic regressions were run for each dependent variable (Table 5). Doubters were used as the base category; therefore, results indicate a negative or positive effect of shifting a perspective from one of doubt to one of opposition or support. For dependent variable degree of acceptance and knowledge of environmental problems has a positive significant ($p<0.10$) impact on explaining falling into an oppose category rather than the more neutral doubter category. Biodiversity familiarity, animal attitudes, trust in food researchers, and having heard of genomics have a negative effect on the probability of being an opposer relative to being a doubter ($p<0.10$). Familiarity with livestock production as well as age have a positive significant effect on being an opposer rather than a doubter ($p<0.05$). Higher perceived benefits of science and technology has a significant negative effect on the probability of being an opposer ($p<0.001$).

For the dependent variable degree of acceptance biodiversity familiarity and animal attitudes have significant, positive effects ($p<0.10$) on the probability of being a supporter relative to being a doubter. Knowledge of environmental problems has significant positive effects ($p<0.001$). Trust in food processors has a positive effect ($p<0.10$), as do higher levels of trust in government ($p<0.001$). Higher perceived benefits of science and technology has a positive effect on the probability of being a supporter ($p<0.01$). Demographically, living in Quebec or Ontario ($p<0.05$) or the Prairies ($p<0.01$) also have positive effects.

For the dependent variable perceived relative benefits a somewhat different selection of variables are significant. In explaining the probability of being an opposer as compared to a doubter, the NEP is the only significant environmentally related variable and it has a positive effect ($p<0.10$). Trust in food researchers has a negative effect ($p<0.10$) as does trust in government ($p<0.01$). Higher perceived benefits of science and technology also has a negative effect ($p<0.01$). Information treatment 3 ("Scientists believe that there are some risks associated with the use of genomic information about feed efficiency in breeding decisions in cattle. It is possible that by selecting for cattle with specific feed efficiency, other negative traits, including susceptibility to diseases, could be enhanced in the animals.") has a positive effect on the probability of being an opposer ($p<0.05$). Age also has a positive effect ($p<0.05$) on the probability of being an opposer.

For the dependent variable perceived relative benefits familiarity with biodiversity has a positive effect on the probability of being a supporter relative to a doubter and is the only environment related variable that is significant ($p<0.001$). Trust in food researchers has a positive effect ($p<0.05$) but no other trust variables are significant. Having heard of genomics has a positive effect ($p<0.10$) and higher perceived benefits of science and technology also have a positive effect ($p<0.001$). Additionally, information treatment 5 ("Biodiversity of farm animal genetic resources has been rapidly declining in recent decades. In Europe, for example, 18% of the breeds existing in the early 20th century have already been lost. Scientists believe that better understanding of the bovine genome might allow us to protect biodiversity in cattle.") has a positive effect ($p<0.10$) on the probability of being a supporter.

[Insert Table 5 here.]

Discussion

The distribution of responses for the dependent variables demonstrate a mix of responses to this use of genomics. The degree of acceptance is slightly positive whereas relative perceived benefit is slightly negative. When asked about this use of genomics more generally through the PII (Zaichkowsky, 1994) respondents show greater uncertainty, with over half falling into the doubter category. However, when risks/benefits to human health are considered, more respondents are opposers and fewer are doubters or supporters. This shows that some respondents do not fall into the same category when comparing the different dependent variables.

The scale variable means speak to the average attitudes and beliefs of respondents. On average, participants exhibit moderately pro-environmental attitudes. The mean of biodiversity familiarity suggests that overall there is an understanding and knowledge of scientifically correct definitions of biodiversity. However, self perceived knowledge of environmental problems is not high overall. The mean for animal attitudes is well above the median which indicates high regard for non-human animals among study participants. Trust, which may influence perceptions of biotechnology in foods, is varied. Trust in food researchers is higher than trust in food processors, and average trust in government with regards to biotechnologies in foods is below the midpoint. Overall, the benefits of science and technology are recognised. Knowledge specific to this study, including knowledge of genomics and knowledge of livestock production, is low.

Independent sample t-test results demonstrate a significant difference in values, attitudes, and knowledge levels between opposers, doubters, and supporters based on both dependent variables. A wide range of variables are characterise the respondents in each of the categories. For the degree of acceptance dependent variable slightly fewer variables have different means, however the majority of variables are at least different between two categories. For the majority of variables there is a directional change in means; for example, for both dependent variables, an increase in mean from that of opposers to doubters and then from doubters to supports is present for all trust variables. The direction of mean change is as expected, based on past studies, for the majority of variables. It was anticipated that environmental values could be associated with either negative or positive perceptions of this use of genomics; while the intention of the technology is to reduce emissions the involvement of biotechnology may have mixed environmental effects. NEP, NHIP (for perceived relative benefit only) and animal attitudes scores are highest in opposers and decrease for doubters and further decrease for supporters. This suggests that strong ecocentrism may be associated with negative perceptions of this use of genomics. In contrast, supporters have the highest mean biodiversity familiarity and knowledge of environmental problems. Interestingly, for knowledge of environmental problems and livestock production familiarity an increase in score seems to be associated with groups who have an opinion rather than being neutral. This suggests that similar types of knowledge assist in development firm perceptions but can be applied to perceptions in different ways. In addition to opposers and supporters being different from each other a notable difference from doubters occurs. The categories have different demographic characteristics as well; increased education is associated with supporters. This is consistent with the changes in means in knowledge of environmental problems and biodiversity familiarity, as well as with studies that suggest that increased education is associated with increased concern about the environment (Slimak and Dietz, 2006), in this case concern is a with climate change. Additionally, the mean for income increases from opposers through to supporters, however the reasons for this are unclear.

The results of the multinomial logistic regression indicate that specific factors influence the probability of being an opposer or a supporter as compared to being a doubter and that there are some differences in the influential factors between dependent variables. This indicates that participants in each category are different from one another in significant ways. In this line, Gaskell *et al* (2004) also determined that different groups "make judgments about GM foods in different ways" (p.192). Further, this identifies a difference between the two dependent variables. The frame of reference being used to gauge attitudes towards this use of genomics is therefore important; when thinking of this technology in broad terms different attitudes are involved than when thinking of this technology in terms of impacts to personal health. This is consistent with the results of the independent t-tests.

Environment related variables have mixed effects, as may be anticipated from the means comparisons. Scores from the frequently used NEP scale and the related NHIP scale have limited influence in any direction; a higher NEP score influences the likelihood of being in the oppose category for the relative perceive benefits dependent variable only. This is consistent with the t-tests where means for these scales varied less between categories. This suggests that when developing perceptions for this use of genomics environmental ethics, either ecocentric or anthropocentric, have negligible direct influence. Knowledge of environmental problems is influential in grouping participants in categories of degree of acceptance but not categories of relative perceived benefits to human health. Knowledge of environmental problems has a larger positive effect on being a supporter which could speak to the impact of being informed about climate change on support for GHG emissions mitigation or how understanding problems related to biodiversity influences perceptions of selective breeding. Results for biodiversity familiarity, which increases the likelihood of being a supporter in both dependent variables, echo this finding and suggest that understanding how biodiversity functions influences comfort with genomics generally and applied to food products. Throughout studies on pro-environmental behaviour and environmental values the effects of attitudes and values are varied (Osbaldiston and Schott, 2012). The mixed effects of environmental values in this study could be due to the possible mixed environmental impact of this application of genomics or simply to the predominance of other factors considered to be more relevant or important.

Some factors shown previously to impact perceptions of GM products are influential in the context of using genomics for selective breeding as well. Trust in government, food processors, and food researchers not always significant, however where significant higher scores in all forms of trust are associated with being a supporter rather and a doubter. This importance of trust is consistent with findings in the literature that suggest that both trust in science and in public officials is integral to the acceptance of biotechnologies (Costa-Font and Gil, 2009). Perceived benefits of science and technology consistently has significant influence for each category; positive views of science and technology overall lead to positive views of this specific technology and thinking the world is worse off because of science has the opposite effect. Knowledge related factors have limited influence however; while having heard of genomics reduces the likelihood of being an opposer for the dependent variable degree of acceptance it has no significant effect on other categorisations. Additionally, familiarity with livestock production has makes it more likely to oppose the technology rather than simply doubt it, again only when considered generally in dependent variable degree of acceptance. It is unclear why this is the case, as increased knowledge in other areas increases the likelihood of being a supporter. The direction of information treatment effects as expected; information treatment 3 provided a negative aspect of this use of genomics and positively influences the likelihood of being in the oppose category. Likewise, information treatment 5 identified an added positive outcome of this use of genomics and makes being a supporter more likely. It is unclear why these two information treatments had an effect and only for the dependent variable relative perceived benefit to human health. While this use of genomics is not the same as the introduction of genetic modifications into food similar concerns can, in some instances, influence perspectives for both biotechnologies. This is in keeping with the findings of van den Heuvel *et al* (2006) who determined that consumers maintain a link between the use of genomics and genetic modifications, and a subsequent preference for traditional foods over foods produced using genomics, even when information is provided. Van den Heuvel *et al* (2006) suggest that information does not necessarily change beliefs or preferences overall but impacts the saliency of certain beliefs, which may in part explain the interaction between knowledge and other attitudes in this study.

Demographics have limited effect as well, suggesting that attitudes themselves have more of an effect than the influences that may occur from gender, age, education, income, or place of residence. Being male increases the likelihood of being a supporter when considering relative perceived benefits to human health, a finding that is consistent with literature that suggests women are more risk averse with respect to environmental issues (Slimak and Dietz, 2006), novel technologies (Gaskell *et al*, 2004), and health concerns of technologies in food (Hosseini Matin *et al,* 2012). Older individuals are more likely to fall into the opposer category for both dependent variables but age has no influence over being a supporter; this may indicate risk aversion with respect to biotechnologies in older populations.

Overall, the results of this study present interesting points to consider. The categories of opposers, doubters, and supporters exhibit attitudes, beliefs, and knowledge characteristics that are distinct to each group. Different factors influence the likelihood of being an opposer rather than a doubter and of being a supporter rather than a doubter. Further, different factors influence being the likelihood of being an opposer or supporter when the categories are based on degree of acceptance or relative perceived benefit. Strong environmental ethics may not predict individuals' perception of this use of genomics but high degrees of knowledge, actual and self reported, are linked with support for the technology. Further, trust is determined to be an essential element in support of this use of genomics. Positive regard for science and technology overall, also encourages supportive perspectives. Given that many individuals are undecided on their perspective of this use of genomics it is interesting to note that the adoption of certain values or accumulation of certain knowledge may sway a person to oppose or support the technology but the opposite value or knowledge may have limited influence in the other direction. Additionally, it is necessary to consider not only attitudes and knowledge but also the frame of reference applied when forming a perception of this use of genomics, as the same individual may have a different perception when asked about this technology generally and when human health is brought to mind.

Conclusion

While the environmental sustainability of the livestock sector faces considerable challenges on a number of fronts innovative opportunities for reducing environmental impacts are emerging. GHG emissions from cattle are significant contributors to climate change and are frequent targets of criticism and mitigation efforts (McAlpine *et al*, 2009; Subak, 1998; Tan *et al*, 2012). The study of genomics can assist in selective breeding for increased feed efficiency and subsequent emission reductions (Bell *et al*, 2009; de Haas *et al*, 2011). However, such a mitigation measure requires public support.

This study examined the degree of acceptance and relative perceived benefits to personal health for this use of genomics and found mixed views within a sample of Canadians. There are distinctive characteristics between those who oppose, those who doubt, and those who support this technology in terms of environmental values and knowledge, perceptions of trust, opinions regarding science and technology, general knowledge of either genomics or livestock. Additionally, specific variables influence the likelihood of being in the oppose, doubt, or support category and the set of influential factors are varied depending on whether the categories are based on degree of acceptance or relative perceived benefit. Environment related variables are influential in placement within some categories but not all. The same applies for factors that have previously been shown to influence perceptions of GM and biotechnology affected foods. This demonstrates the complexity of public perceptions of this use of genomics. Further, this suggests that the frame of reference applied by an individual, such as general qualities of the technology vs. personal health impacts, can cause an individual's perception of the technology to change. Overall, many respondents exhibited fairly neutral views with respect to the use of genomics in selective breeding for increased feed efficiency but also demonstrate that being swayed towards opposition or support can be driven by a variety of different attitudes and knowledge.

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Appendix:

Table 1: Demographic Variable Results

Variable		Frequency (N=115)	Percentage
Gender	Male	372	33.6
	Female	743	66.4
Education	Elementary	7	0.6
	Secondary	246	22.1
	Technical	370	33.2
	University Bachelors	369	33.1
	Masters or PhD	123	11.0
Age	18-29	76	6.8
	30-39	180	16.1
	40-49	178	16.0
	50-64	429	38.5
	65+	252	22.6
Income	$24,999 or under	120	10.8
	$25,000-$39,999	188	16.9
	$40,000-$64,999	251	22.5
	$65,000-$79,999	150	13.5
	$80,000-$99,999	155	13.9
	$100,000-$119,999	115	10.3
	$120,000 +	136	12.1
Residence	Maritimes	58	5.2
	Quebec	276	24.8
	Ontario	412	37.0
	Prairies	199	17.8
	BC	170	15.2
	Territories	0	0
	Urban	967	86.7
	Rural	148	13.3

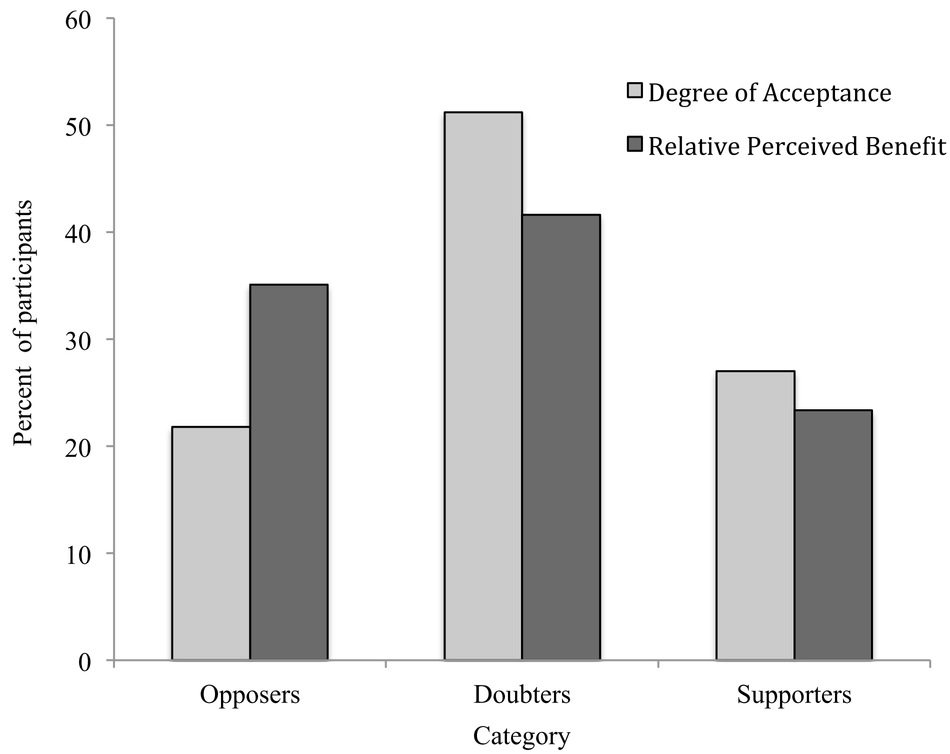

Figure 1. Distribution of opposer, doubter, and supporter participants for Degree of Acceptance and Relative Perceived Benefit.

Table 2: Distribution of responses for scale variables

Variable	Possible Range	Low	High	Mean	S.D.
Dependent Variables					
Personal Involvement Inventory[1]	7 - 49	7	49	28.98	9.85
Perceived Risk	1 – 5	1	5	2.71	1.01
Perceived Benefit	1 – 5	1	5	2.51	0.99
Relative Perceived Benefit	-1 - 4	-1	4	-0.20	1.66
Independent Variables					
NEP[2]	15 – 75	19	75	54.36	8.93
NHIP [3]	5 – 25	5	25	21.09	4.11
Know Environmental Problems	1 - 10	1	10	5.46	2.10
Biodiversity Familiarity[4]	3 – 15	3	15	11.15	2.84
Animal Attitudes[5]	13 - 65	13	65	42.05	7.81
Trust in Government	6 – 30	6	30	16.02	4.99
Trust in Processors	1 - 5	1	5	2.80	0.90
Trust in Researchers	1 – 5	1	5	3.22	0.91
Benefits of Science and Technology	1 - 10	1	10	6.45	2.10
Heard of Genomics	0 – 1 (no-yes)	0	1	0.50	0.50
Familiar w/ Livestock Production	0 - 1 (no-yes)	0	1	0.24	0.43
Live/Work on Farm/Ranch	0 - 1 (no-yes)	0	1	0.01	0.09

[1] Zaichkowsky (1994); [2] Dunlap *et al* (2000); [3] Corral-Verdugo *et al* (2008); [4] Spash and Hanley (1993); [5] Herzog *et al* (1991);

Table 3: Independent sample t-tests comparing independent variable means between Degree of Acceptance categories

Variable	Degree of Acceptance		
	Opposer	Doubter	Supporter
NEP	55.56 [2]	54.41	53.42 [2]
NHIP	21.17	20.93	21.31
Knowledge of Enviro. Problems	5.38 [2]	5.17 [3]	6.01 [2,3]
Biodiversity Familiarity	10.62 [2]	11.01 [3]	11.75 [2, 3]
Animal Attitudes	42.65 [2]	42.64 [3]	40.60 [2, 3]
Trust in Government	14.33 [1, 2]	15.51 [1, 3]	18.08 [2, 3]
Trust in Food Processors	2.58 [1, 2]	2.75 [1, 3]	3.05 [2,3]
Trust in Food Researchers	2.94 [1, 2]	3.17 [1, 3]	3.49 [2,3]
Benefits of Science and Technology	5.70 [1, 2]	6.35 [1, 3]	7.42 [2,3]
Heard of Genomics	0.42 [2]	0.47 [3]	0.60 [2,3]
Livestock Production Familiarity	0.29 [1]	0.20 [1, 3]	0.28 [3]
Live or Work on Ranch or Farm	0.00	0.01	0.02
Age	50.12	48.45	49.03
Income	66,016.85	64,304.44 [3]	69,088.03 [3]
Education	14.49 [2]	14.49 [3]	14.95 [2, 3]

1 – Opposer and Doubter significantly different at $p<0.05$
2 - Opposer and Supporter significantly different at $p<0.05$
3 - Supporter and Doubter significantly different at $p<0.05$

Table 4. Independent sample t-tests comparing independent variable means between Perceived Relative Benefit categories

	Perceived Relative Benefit		
Variable	Opposer	Doubter	Supporter
NEP	56.69 [1, 2]	53.48 [1]	52.54 [2]
NHIP	21.59 [1, 2]	20.87 [1]	20.73 [2]
Knowledge of Enviro. Problems	5.46	5.25 [3]	5.78 [3]
Biodiversity Familiarity	11.14 [1, 2]	10.75 [1, 3]	11.76[2, 3]
Animal Attitudes	43.61 [1, 2]	42.04 [1, 3]	39.95[2, 3]
Trust in Government	14.21 [1, 2]	16.40 [1, 3]	17.90[2, 3]
Trust in Food Processors	2.56 [1, 2]	2.86 [1, 3]	3.04 [2, 3]
Trust in Food Researchers	2.96 [1, 2]	3.23 [1, 3]	3.65 [2, 3]
Benefits of Science and Technology	5.87 [1, 2]	6.48 [1, 3]	7.51 [2, 3]
Heard of Genomics	0.49[2]	0.43 [3]	0.60 [2, 3]
Livestock Production Familiarity	0.26	0.22 [3]	0.26 [3]
Live or Work on Ranch or Farm	0.01	0.01	0.01
Age	48.41	49.64	48.73
Income	63,942.18	64,999.88 [3]	70,627.88 [3]
Education	14.59 [2]	14.51 [3]	14.84 [2, 3]

1 – Opposer and Doubter significantly different at p<0.05
2 - Opposer and Supporter significantly different at p<0.05
3 - Supporter and Doubter significantly different at p<0.05

Table 5: Multinomial Logistic Regression Results for both Degree of Acceptance and Relative Perceived Benefit Opposers and Supporters relative to Doubters

Variable	Degree of Acceptance		Relative Perceived Benefit	
	Opposer	Supporter	Opposer	Supporter
NEP	0.01	0.01	0.02*	0.00
NHIP	0.01	0.02	0.01	-0.02
Knowledge of Environmental Problems	0.08*	0.14****	0.03	0.02
Biodiversity Familiarity	-0.06*	0.04*	0.02	0.10****
Animal Attitudes	-0.02*	-0.02	-0.00	-0.02
Trust in Food Processors	-0.02	0.18*	-0.12	0.01
Trust in Food Researchers	-0.18*	0.06	-0.18*	0.27**
Trust in Government	-0.02	0.09****	-0.6***	0.03
Benefits of Science and Technology	-0.15****	0.13***	-0.12***	0.17****
Heard of Genomics	-0.32*	0.15	0.17	0.37*
Livestock Production Familiarity	0.44**	0.18	0.18	0.04
Live or Work on Ranch or Farm	-0.61	0.15	-0.29	0.10
Information Treatment 1	0.46	0.15	0.25	0.23
Information Treatment 2	-0.11	0.11	0.01	0.32
Information Treatment 3	0.39	-0.33	0.62**	-0.11
Information Treatment 4	-0.02	-0.48	0.03	-0.06
Information Treatment 5	0.36	-0.13	-0.23	0.18
Gender	-0.22	0.17	0.1	0.33*
Age	0.02**	0.01	0.62**	-0.01
Income	0.00	0.00	0.00	0.00
Education	0.04	0.04	0.03	-0.05
Maritimes	0.49	0.42	-0.54	0.04
Quebec	-0.12	0.63**	-0.15	0.19
Ontario	0.35	0.50**	-0.20	-0.03
Prairies	0.30	0.83***	-0.27	0.14
Urban	0.44	0.01	-0.17	0.16
Constant	-1.06	-6.88****	1.06	-3.10***
Number of Observations	1115	1115	1115	1115
Pseudo R-Squared	0.1155	0.1155	0.1109	0.1109
Log likelihood function	-1023.15	-1023.15	-1074.37	-1074.37

Note: * p<0.10; **p<0.05; *** p<0.01; **** p<0.001