Canadian Consumers' Preferences for Food Products Produced By Novel Technologies

by

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Abstract

This research examines the applications of novel technologies (nanotechnology and genomics) and the public's purchasing intentions in the Canadian food industry (national online surveys). Canadian consumers' preferences and their willingness to pay for four hypothetical products treated with two novel technologies are examined: juice produced with two nanotechnology applications, pork chops and steak which are produced from pigs and cattle bred using genomic information. The respondents were asked to answer a series of stated preference questions to determine their preferences for a specific product produced by means of either of the novel technologies. The choice experiment analysis suggests that a Canadian representative consumer chooses the attributes of higher functionality in the products (e.g. nutrition enhancement, UV-light protection bottle, less disease susceptibility, more feed efficiency) with no novel technology involved. Socio-demographic variables such as trust, levels of education and income, self-assessed extent of knowledge about scientific developments, belief in science and technology advances, having children under 18 in the household, familiarity with nanotechnology prior to survey, and pro-animal welfare attitudes also affect consumers' preferences regarding the livestock products and their production technologies.

Dedication

I would like to dedicate this thesis to my family who supported me with love, without whom neither I nor this thesis would be completed.

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1.1 Introduction

The debate over the introduction of new technologies, such as agri-biotechnology, Genetically Modified Organisms (GM/GMO) and GM production, cloning, nanotechnology, and potentially genomics in the food and agribusiness industry continues. The debate varies with different socio-cultural contexts for specific technologies. Part of the debate is focussed on whether consumers and their surrounding society value these food products, and whether they perceive any risks or benefits for their health and the environment (Costa-Font et al., 2008).

Communication seems to be very important in the development of new technologies, in the sense that communication must address consumer perceptions to influence market acceptance and to enable consumers to make informed choices (Matin and Goddard, 2013). In a wide range of studies public opinion and awareness, acceptance, social aspects and controversies facing new foods developed with technological innovations have been discussed (Bouwmeester et al., 2009; Boyce, 2009; Busch, 2008; Dunkley, 2004; Hallman et al., 2003; Ronteltap et al., 2007; Turk et al., 2008; Onyango and Govindasamy, 2004; Parr, 2005), as well as health and environmental risks, social risks, benefits, and views on regulation (Besley et al., 2008). Many studies have shown 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 (Matin et al., 2012). These studies have indicated that clearly, there is a general lack of awareness and understanding of new food technologies (i.e. nanotechnology, cloning, genetically modified, agri-biotechnology, genomics, etc.) including both their presence and applications in food production and in the agri-food industry (Hallman & Aquino, 2003; Matin et al., 2012; Onyango et al., 2006; and Waldron et al., 2006). There are also ethical concerns regarding their acceptance (Sheetz et al., 2005). As a result, some consumers are unable to decide whether or not new

foods produced by such technologies are associated with significant risks, and they seem to be hesitant in accepting and consuming foods produced with novel technologies given potential new risks without any clear benefits.

Some of these emerging technologies have shown great potential for delivering bioactive compounds in functional foods to improve human health, and in ensuring the safety of food (Chen et al., 2006). With these benefits, research on the risk perceptions associated with the use of the novel technologies is important. Without this effort, negative perceptions could lead to a lack of support by the public, reduce potential health improvements and, ultimately, set back technological innovation for a significant period of time (Smiley et al., 2008).

The ultimate aim of conducting this study is to identify Canadian consumers' preferences, for four products: fortified juice produced by nanotechnology applications, juice with UV-light protected bottle packaged by means of nanotechnology, pork and steak which are produced from pigs and cattle bred using genomic information. Evaluation of consumers' WTP (i.e. whether or not they are willing to buy the products at different prices), their preferences and demand is essential for producers to decide whether or not these novel technologies are worth adopting. In this study, the effects of demographic characteristics and Canadian consumers' attitudes, on purchase intentions about products created using these novel technologies are examined. Furthermore, insights for policy makers over future development of these two specific novel technologies are provided. It is important for producers and policy makers to understand different levels of support for different types of technology amongst consumers. Understanding consumers' behaviour also helps firms to improve their marketing strategies by how consumers think and select between alternative products and technologies. The two technologies (i.e. genomics and nanotechnology) examined in this study differ considerably from the more general genetic modification of food products which has been examined in previous studies.

1.2 Nanotechnology

Nanotechnology involves the characterization, fabrication and/ or manipulation of structures, devices or materials as discrete entities that have at least one dimension (or contain components with at least one dimension) that is approximately 1-100 nm in length. When particle size is reduced to this threshold, the resulting material exhibits physical and chemical properties that are significantly different from the properties of macro-scale materials composed of the same substances (Duncan, 2011).

It is claimed that "Nanotechnology will be a key technology for improving peoples' standard of living, in the short-term (by significantly improving existing processes and products and in the long-term) by providing revolutionary and life-changing advances across a wide variety of industries such as agriculture, engineering, etc." (Helland and Kastenholz, 2008, pp. 885) Nanotechnology is expected to be the dominant general purpose technology for the next decades. Its market potential is immense and both supply-side and demand-side arguments will have far reaching consequences for nanotechnology innovations and adoption (Ott et al., 2009). Nanotechnology has a wide range of practical applications, from wine making (Tkac et al., 2007), to its impact on emissions in the paper industry (Puurunen and Vasara, 2006) to providing clean water (Street et al., 2009). Nanotechnology has a similar trajectory to biotechnology, stemming also from basic science breakthroughs (Zucker and Darby, 2005).

The incorporation of nanotechnology applications in the food industry has the potential to improve the quality, texture, taste, flavor, odour, consistency, and nutritional value of the food products. For example, by means of nanoscale additives, food nutrients and ingredients such as minerals and vitamins can be enhanced, and hence offer a healthier option to consumers (Duncan, 2011; Sekhon, 2010). The incorporation of nanotechnology into food packaging, food preservation is expected to improve the barrier properties of packaging materials and should thereby help to reduce the use of valuable raw materials and the generation of waste (Sozer and Kokini, 2009).

Kraft Foods was one of the first companies to recognize the potential of nanotechnology, launching a lab in 1999 and a 'Nanotek' consortium of 15 universities and research laboratories worldwide in 2000. Both Unilever and Nestlé are also undertaking nanotechnology research efforts (Sealy, 2006).

Social scientists in a variety of fields employing a diversity of research methods and analytical theories have started to examine the growing significance of nanotechnology for modern civilization. Many studies (Hallman et al., 2003, Boyce, 2009, Busch, 2008, Ronteltap et al., 2007) have examined public opinions on this newly introduced technology, since analyzing public opinion could play a vital role in the process of the development and regulation of nanotechnology.

Based on the current state of knowledge, the debate on the benefits and risks of applying nanotechnology in the food industry, and its impacts is still growing, and is an issue of some controversy. Although there are currently no conclusive data about the undesirable results of nanotechnology, governments and the public may prefer a precautionary approach in terms of possible regulatory control until proven completely safe (Chau, et al., 2007).

1.2.1 Knowledge Gap

At the first International Food Nanotechnology Conference organized by the Institute of Food Technologists (IFT) in 2006, participants agreed that nanotechnology is still in its infancy, with food applications being in a pre-infancy state, but also recognized a great amount of enthusiasm and anticipation surrounding this technology (Bugusu et al., 2006). The use of nanotechnology in food and agriculture was recognized by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) of the United Nations. These organizations decided to work together on identifying knowledge gaps in areas related to food safety and risk assessment procedures, as well as on developing global guidance on adequate and accurate methodologies to assess potential food safety risks that may arise from nano-particles (WHO, 2002; www.fao.org).

However, the general public strongly associates nanotechnology with nano-particles and therefore assumes that the risks of all applications of nano-technologies are comparable with the risks of non-soluble free nano-particles. The risk of nano-particles is perceived as a potential human health risk, risk of consequences to the environment, and risk of toxicity effect. Deliberate or accidental release of nano-particles into environmental compartments can alter its characteristics, since reduction in size to the nano-scale level results in an enormous increase of surface to volume ratio, and relatively more molecules are present on the surface, thus it enhances the chances of toxicity (Donaldson et al., 2004). Inhaled nanoparticles and their uptake by biological human cells, and cellular interactions may also lead to a potential health risk. In the absence of mandatory product labeling anywhere in the world, it is not easy to pinpoint exactly how many commercial products now contain nano- ingredients. It is also clear that applications of nanotechnology such as sensors or process innovations have very different risk profiles than those where nanostructures are added to food products and are ingested by the consumer. Consumer acceptance and regulatory issues will dominate and dictate nanotechnology's growth in the future (Rizvi et al., 2011). More research on understanding particular uses of nanotechnology in food is warranted.

1.3 Overview of Genomics

Genomics is the study of genes and genetic characteristics of all organisms including humans and animals. Genomics is defined as the science that studies the structure and function of genomes and, in particular, genes. With genomics the complete study of the hereditary material of all living beings is envisioned (van den Heuvel et al., 2006; Lexicon EncycloBio, 2006). Although genomics can be in use in many areas of food biotechnology and microbiology, for example for identification of pathogens, the area with of interest here is its use for genetic improvement of livestock. The emphasis is on identifying genomic variation associated with desirable breed characteristics that have a major impact on livestock industry profit (Gibson et al., 2007; Wenzel, et al., 2004).

Genomic selection, which enables prediction of the genetic merit of animals using genome-wide SNP (Single Nucleotide Polymorphisms), has already been adopted by some livestock industries worldwide and is expected to double genetic gains for production and other traits (Hayes et al., 2013). Using genomic relationships can improve the precision of estimated genetic parameters (heritability and genetic correlations between traits) (Veerkamp et al., 2011). This use of genomic information in animals allows researchers to select the animals such that the progeny can be bred for specific traits.

The advantage of genomic selection over traditional selection is that animals can be selected accurately early in life, based on their genomic characteristics, and can be selected for traits that are difficult or expensive to measure; fertility, disease resistance, methane emissions, and feed conversion are prime examples (Hayes et al., 2013; Meuwissen et al., 2001). Genomic selection also potentially shortens the time to genetically improve livestock in a particular direction due to decisions being made to include younger animals with/without a specific gene in breeding as opposed to waiting for their numerous progeny to express these traits over their lifespans. Genomics can enhance reproduction efficiency and increase longevity of animals. Consumers, on the other hand, may benefit from genomic selection by being provided with the meat that could come from a healthier animal, could be a safer product and could be pathogen free (Allen et al., 2013) sooner than traditional breeding might produce.

Future breeding objectives may also emphasize performance under lower levels of nutrition. Before the 20th century, livestock used resources with few or no alternative values, such as pastureland unsuitable for cropping. However, modern livestock production uses expensive inputs, such as grain. Both the competition for grain (for human consumption and bio-fuels) and the impact of climate change on grain production are likely to continue to drive grain prices higher (Godfray et al., 2010). These economic factors may change livestock production systems and, consequently, the desired genetic attributes (Hayes et al., 2013). The use of genomic information could facilitate this process by using information beyond phenotypic information to select for feed efficiency, for example.

The wealth of genomic information in pigs in particular, could allow the identification of specific genes which are linked to disease resistance. There are currently two major infectious diseases in pigs that are of global concern (amongst some other diseases such as foot and mouth disease): PRRS (Porcine Reproductive and Respiratory Syndrome), and PCVAD (Porcine Circovirus Associated Disease). They are both infectious diseases that occur in pig populations. Selecting for genes that reflect disease resistance could reduce the spread and intensity of the diseases potentially.

Also the cattle farming industry is benefiting from new applications of genomics science that enable more feed efficient cattle to be produced by breeding. Methane production from cattle is a large source of greenhouse gases. Feed is one of the biggest costs facing livestock producers. Enhancing feed efficiency in cattle could have the effect of making beef production more environmentally and economically sustainable. Cattle producers might be able to take advantage of genomics, using genomic testing as a tool to increase the accuracy of predicting an animal's feed efficiency. It gives the farmers a more indicative idea of the type of cow they're breeding which could be more efficient converters of feed into meat, reducing greenhouse gases and improving farm profitability.

1.3.1 PRRS

Porcine reproductive and respiratory syndrome (PRRS) emerged as a widespread reproductive and respiratory disease of swine in the late 1980s in the USA, and in 1990 in Europe and since then the disease has spread widely throughout many pig-producing countries (Murtaugh & Genzow, 2011; Albina, 1997; Zimmerman et al., 2006). PRRS has caused devastating losses to swine herds in North America and Europe since the early 1990s.

Porcine reproductive and respiratory syndrome (PRRS), caused by the porcine reproductive and respiratory syndrome virus (PRRSV), is characterized by reproduction failure in pregnant sows and respiratory distress in piglets and growing pigs. The clinical

signs of PRRS have been linked to reproductive outbreaks such as reductions in farrowing rates, increased numbers of stillbirths and mummies (i.e. if the piglet dies in the early stages of pregnancy), abnormal abortion storms, preweaning mortality in sows and death in growing pigs (Zhang et al., 2012; Holtkamp et al., 2010). Since its emergence, PRRS continues to impose a significant and tremendous economic burden on the swine industry worldwide affecting all stages of production (Beilage et al., 2009; Dewey et al., 1999; Neumann et al., 2005; Zhang et al., 2012). The total cost of productivity losses due to PRRSV in the US national breeding and growing-pig herd was estimated at US$664 million in 2011(Holtkamp et al., 2013), an increase from the US$560 million annual cost estimated in 2005 (Neumann et al., 2005), and with a greater share of this cost in the breeding herd as some progress has been made in controlling the disease in growing pigs. The results of 2011 study show that although since 2005, some progress has been made in dealing with the cost of productivity losses due to advances in controlling the disease in the growing pig, these were offset by greater losses in the breeding herds.

Vaccination is the principal means of controlling and treating PRRSV infection. Many vaccines have been produced to combat PRRSV. They include products containing live virus derived by cell culture attenuation of virulent field isolates (Murtaugh and Genzow, 2011). Current vaccines conventionally attenuated or inactivated viruses are important choices for the control of PRRS (Zhang et al., 2012). Studies indicate a decrease in productivity post-vaccination in herds that had been vaccinated which may have been because the vaccine sped up the return to normal production post outbreak (Dewey et al., 1999).

These vaccines can provide partial protection of pigs against PRRSV; however, vaccination has frequently failed to induce protection against PRRSV infections in some situations due to many factors (Zhang et al., 2012). Dead vaccines may reduce levels of viremia in some pigs, but are not demonstrated to show consistent benefits against infection or disease in a respiratory model (Zuckermann et al., 2007; Nilubol et al., 2004). Dead virus vaccination improved the percentage of pigs weaned in a reproductive PRRS model, but did not improve overall reproductive performance (Scortti et al., 2007).

However, despite extensive efforts, little progress has been made to improve efficacy since the first introduction of a live, attenuated vaccine in 1994 in the US (Murtaugh and Genzow, 2011), and infection by PRRS virus (PRRSV) is still widespread and the virus is frequently reintroduced to farms after eradication (Mateu and Diaz, 2008).

Identifying the unique genetic indicators (structural protein of the virus) of PRRS is important since genetic differences exist and are expressed differently between susceptible or resistant pigs in the same trait in response to PRRSV. In other words, there is within-breed genetic variation that could be exploited in future breeding programs against PRRSV infection (Lewis et al., 2009).

1.3.2 PCVAD

Porcine circovirus-associated disease (PCVAD) was first described in Canada in the early 1990s and has since emerged as an economically important disease worldwide (Allan & Ellis, 2000). The causative agent of PCVAD is PCV2 (Porcine circovirus type 2) a small, non-enveloped, single stranded circular DNA virus belonging to the Circovirus genus (Chae, 2004). PCVAD encompasses a group of diverse multi-factorial syndromes, including porcine multi-systemic wasting syndrome (PMWS), porcine dermatitis and nephropathy syndrome (PDNS), porcine respiratory disease complex (PRDC), reproductive failure, and others (Chae, 2005; Opriessnig et al., 2007; Ramamoorthy & Meng, 2009).

PCVAD is associated with weight loss or decreased rate of weight gain, wasting, increased mortality, diarrhea, respiratory distress, dermatitis, enteritis, reproductive failure, paleness or jaundice and a failure to grow in pigs (Opriessnig et al., 2007; Gillespie et al., 2009). PCVAD can affect a varying percentage of a population (1–50%) (Opriessnig et al., 2009). Eventually due to the contagiousness of this disease all the pigs affected must be destroyed. PCVAD has notably affected losses in pig farms and is arguably among the most economically significant disease facing the global swine industry today (Cecere et al.,

2012; Lyoo et al., 2011; Opriessnig et al., 2007; Ramamoorthy and Meng, 2009; Segales et al., 2005).

Since PCVAD has a major economic impact worldwide, two recent studies have analyzed the cost, marginal benefits and economic efficiency of implementing control strategies for PCVAD infection in pig farming industry in UK (Alarcon et al., 2013(a); Alarcon et al., 2013(b). They assessed the marginal costs and marginal benefits obtained from the implementation of a series of the control measures. For each strategy (combination of control measures), the total cash flow for each 21 day period and for the whole 5 year period was estimated. Also economic costs and benefits were calculated separately for the different categories of infected, diseased and healthy pigs. The net benefit analysis result suggested the improvement of biosecurity measures in pig farms. The economic tools used for these analyses such as budget analysis can widely be used in animal health economics.

Unlike with PRRS vaccination has been shown to be effective in combating PCVAD. Several field investigations have clearly demonstrated the efficacy of the current vaccines. It was found that vaccination improved average daily gain, overall growth performance and reduced morbidity, mortality, and the time to market (Opriessnig et al., 2009; Segales et al., 2005). The recombinant vaccines containing PCV2a (a major genotype of the virus) are also effective in reducing morbidity and mortality and improve overall growth performance. Experimental and field studies have clearly demonstrated the efficacy of these vaccines in reducing viremia in vaccinated herds, based on the hypothesis that the immune responses to vaccination versus infection are quantitatively and qualitatively different (Trible et al., 2012).

Although the current inactivated and recombinant vaccines are effective against PCV2 (Ellis et al., 2004; Fort et al., 2008; Horlen et al., 2008; Opriessnig et al., 2007; Opriessnig et al., 2008; Segale et al., 2005), a live-attenuated vaccine will be more potent and could reduce the costs associated with vaccination. Research indicates that a live vaccine against PCV2 can be developed by replacing the immunogenic gene with the virus

gene (Gillespie et al., 2008). However, vaccination against either of the diseases (e.g. PCVAD or PRRS) would have no impact on the other disease which imposes great amount of economic costs to control both diseases together at the same time (Genzow et al., 2009). So far, Canadian government has invested over $29 million to cover the cost of vaccination to support the swine industry[1]. The ongoing cost of vaccination requires the government to look for new strategies of disease control to decrease these costs and increase the welfare of this industry.

1.3.3 Feed Efficiency & Methane Emissions

Livestock production is associated with the release of methane produced by anaerobic microbial metabolism in the digestive tract and in manure, and also the release of nitrous oxide from agricultural soils (Moss et al., 2000), both are greenhouse gases. During the recent decades new tools have been developed to enable the cattle industry to decrease environmental damage from methane emissions, and to improve efficiency and feed utilisation. Current knowledge is significantly advancing in this sector in terms of understanding how ruminant gastrointestinal microbial ecosystems, or microbiomes, are controlled by the animal and by the diet consumed, and how this impacts on greenhouse gas emissions, efficiency and product quality[2].

Cattle produce methane as a by-product of digestion in the rumen. The livestock sector is responsible for 35-40% of annual methane emissions the result from enteric fermentation in ruminants and farm animal manure (Steinfeld et al., 2006). Efforts to lower emissions from cattle production systems are important for achieving long term domestic emissions targets and moderating their impacts on climate change[3].

[1] Canadian Food Inspection Agency http://www.inspection.gc.ca/about-the-cfia/newsroom/news-releases/2014-01-30/eng/1391125043503/1391125051515
[2] European Commission of Food, Agriculture and Fisheries, and Biotechnology, http://ec.europa.eu/research/bioeconomy/agriculture/projects/ruminomics_en.htm
[3] Sheep CRC http://www.sheepcrc.org.au/management/nutrition-and-feeding/feed-efficiency-greenhouse-gas-reduction.php

The ruminant industries strive to improve the conversion of pasture dry matter (DM) into animal product. This conversion efficiency incorporates both harvesting efficiency (the ratio of DM grown to DM consumed) and the efficiency of conversion of consumed DM into animal product. The effect of differences in feed digestibility on daily methane production is confounded with associated changes in DM intake (DMI) in animals that consume feed ad libitum. It is argued that there is a relationship between feed intake, feed quality and daily methane production and opportunities for nutritional manipulation (Hegarty, et al., 2010). Studies have found that more energy efficient animals produce less waste in the form of methane and nitrogen excretion per unit product (van de Haar and St Pierre, 2006; Chagunda et al., 2009; Okine et al., 2003). Decreasing the length of time feeder cattle that are on low quality feeds also reduces methane emission (Barsab et al., 2012).

Methane production is largely dependent on diet quality and feed intake. Animals superior for RFI consume less feed than average for their live weight (LW) and level of performance (Hegarty et al., 2010). It has been shown that cattle selected for higher efficiency of feed utilization produce less methane per kg dry matter intake (DMI) than cattle selected for lower efficiency. This suggests that reducing methane emissions and improving productivity through genetic selection is feasible. Genomics is a powerful tool that can be used to make ongoing and permanent improvements in animal breeding and their genetic selections. The extent of the genetic improvements depends on the amount of variation that the trait exhibits and what proportion of this variation is heritable (Bell et al., 2012).

Genomic selection can be used to improve residual feed intake (RFI) as a feasible means of reducing the daily methane production (DMP) of cattle. Animals superior for RFI consume less feed than the average for their live weight (LW) and level of performance (Nkrumah et al., 2006; Hegarty et al., 2007). Genomic method can be used to derive genetic parameters to underpin a process to selectively breed cattle for lower methane emission without impacting other production traits (Pickering et al., 2013).

Vaccination is considered to be one of the possible ways of reducing emissions by ruminants in extensive grazing environments that offer little prospect of sustained dietary manipulation (Wedlock et al., 2013). Methanogens are a group of microorganisms that produce methane as the animal by-product. Animal respond to injection of crude methanogen extracts by forming antibodies against the methanogens present in the rumen and suppress methanogen growth and CH_4 production (Buddle et al., 2011; Wright et al., 2004; Cook et al., 2008). However, the majority of vaccine formulations based on crude methanogen cultures have failed to reduce methane emissions and has shown to be coinciding with other management activities (Wright et al., 2004; Williams et al., 2009). These vaccines also show an ability to agglutinate methanogens and reduce methane production by methanogen cultures (Wedlock et al., 2010) but have not been tested for efficacy in reducing emissions in cattle in vivo at this time (Hegarty, et al., 2010).

1.3.4 Knowledge Gap

PRRS and PCVAD continue to pose major threats to the swine industry worldwide, and are considered to be economically important infectious diseases afflicting this industry on a global basis (Segales et al., 2005; Zhao et al., 2012). Apart from the economic cost, vaccination can cause adverse reactions. In PRRS, as mentioned earlier it can only provide partial protection of pigs. In cattle it has been tested that it is not completely efficient to eliminate microbes in the rumen. Vaccination has shown to be effective only in combating PCVAD. However, as mentioned earlier, it is costly, and there is a potential that the vaccine mutate to a pathogenic state (Gillespie et al., 2009).

However, the public reactions to genomic technology are important for future policy implementation depending on whether or not the public is willing to purchase food produced this way. The public could be opposed to this use of technology worrying that the application could speed up genetic processes to the detriment of genetic diversity, for example. They could also be concerned about the ethics of such genetic selections of animals. Their views may also be context specific – disease resistance could be more

important than feed efficiency, for example or vice versa in applications of genomic technology.

1.4 Economic Problem

New innovations in the food industry could change social and economic trends in society as well as affect an individual's lifestyle and preferences. The development and acceptance of novel food products arises through processes that involve scientists, government, industry, and the consumer. When a new technology is adopted in a food industry, it may increase productivity causing the supply curve to shift outward (reducing the costs for example of producing a unit of a particular product), changing social welfare. The consumer demand curve could be influenced by the technology innovation in three ways. The demand curve can shift outward, meaning the demand for the food product produced by the novel technology increases, or it can shift inward, meaning the demand decreases, or it could have no shift at all. Consumers could accept the product with enthusiasm, reject it or their preferences could remain unchanged. The government objective of increasing social welfare will be affected by the technology impact on supply and by the potential shifts in the demand curve. As a result, the relative size of supply or demand shifts plus the direction of demand curve shifts (consumer preferences) can determine the changes in social welfare resulting from the adoption of products produced with new technologies. Given the possible actions and reactions in a market, it is a matter of significant importance for the government to understand, ex-ante, the adoption of the innovative food technology in case public action is required to protect the public or encourage development.

In the adoption of novel technologies in the food industry, the government has to consider whether it is necessary to intervene in order to maximize social welfare through the possibility of externalities and/or market failures arising. For example, governments might need to take regulatory actions to mandate labelling, for instance, to prevent creating information asymmetry problems between industry and consumers (if, for example, consumers exhibit concern about new technology adoption). It is also necessary for the

government to understand potential changes in social welfare associated with the new technology, to decide on whether to continue to support public investments in research, and/or to support industry level commercialisation of the technology. Government also need to consider health and safety aspects of the new technology in the supply chain to avoid unintended consequences and the potential rate of consumer adoption could influence this. Understanding consumers' preferences is necessary information for the government as part of their oversight of the development and implementation of new technologies, particularly in the food supply chain. Understanding consumer public preferences can help the government in making welfare enhancing policies and targeting research developments.

At the individual consumer level, on the other hand, there may be a possible disconnect between the potential benefits of these new innovations (i.e. improving the quality of their life, making them happier, increasing life satisfaction, providing higher health standards, etc.) and the fact that consumers view using technology innovations in their food products as a risky process. Social benefits cannot be achieved if consumers do not adopt the new beneficial food products (should such be developed). Governments and industry can each benefit from understanding the potential pitfalls in using technologies in the development of food products since they can take action to ensure appropriate policies are in place to safeguard public interest, address information gaps and regulate the marketing of products produced with novel technologies in the public interest. Industry could even request the implementation of policies or regulations to facilitate transparency in the production and marketing of food products produced with novel technologies should public concerns warrant.

1.5 Problem Statement

As mentioned earlier, in terms of novel technology applications in the food industry, while science is important in the development of a technology, ultimately society decides what is acceptable. In other words, when a new technology is introduced in the food industry, consumers can make their personal purchase decisions based on their safety and

information perceptions if they know about the technology. Information asymmetries can cause issues in the supply chains for foods produced by novel technologies, and they can impact consumers' final purchase decisions, even with governments implementing labelling and packaging regulations. As a result, consumers' preferences, and their willingness to pay to buy foods produced using these technologies is important. It is also worthwhile to examine whether or not consumers' views are or are not similar across technologies, applications and food products in order to be able to provide a better sense of welfare measures across products (Hobbs et al., 2012; Lusk and Marette, 2010).

The ultimate aim of conducting this study is to ascertain Canadian consumers' preferences, for three products produced with two novel technologies: juice produced with nanotechnology applications, and pork and steak which are produced from pigs and cattle bred using genomic information. Public investment in the development of these technologies (by Genome Canada and the National Institute of Nanotechnology) is significant and understanding public perceptions and preferences is a key to planning industry adoption. Evaluation of consumers' WTP, their preferences, technology attitudes, and product demand is essential for producers to decide whether or not these novel technologies are profitable, and whether or not their potential profit can outweigh the costs of production of using such technologies.

1.6 Objectives

The objectives of this study are

1. To elicit Canadian consumers' preferences for the foods produced from two novel food applications (nanotechnology and genomics).
2. To understand the effect of socio-demographic characteristics on Canadian consumers' attitudes and their purchasing behaviour on foods from different novel technologies.
3. To compare the pattern of responses amongst consumers towards these two novel technologies in order to add to the base of knowledge on how public response is or is not technology specific.

4. To establish insights for future policy developments for these two specific novel technologies and how the technology adoption might impact on social welfare

1.7 Thesis Structure

The rest of this thesis is structured as follows. In Chapter 2, the stated preference experimental methods, ambiguity avoidance concepts, previous studies on nanotechnology, willingness to pay for nanotechnology, consumers' opinions on genomic applications, and other novel technologies in the food industry are reviewed. Based on the reviewed studies three online surveys are designed, one for nanotechnology applications, and two for the use of genomics information in pork and beef with the actual online surveys conducted in 2010 and 2012, respectively. The surveys provide Canadian consumers with choices of products with different attributes to determine their preferences.

In Chapter 3, the socio-demographic data and the choice experiments, choice set designs and bid levels used in the thesis are reviewed. The empirical framework (conditional logit and random parameter logit models) is also discussed.

In Chapter 4, the results of the three online surveys are analyzed. The willingness to pay for products produced with each novel technology (nanotechnology and genomics) is calculated, and is used as the partial basis of a determination of whether or not there is a general market for further use of these applications in the Canadian food industry.

In Chapter 5 the study is summarized with a combination of results of these two applications in today's food industry. The limitations of the study and further research recommendations are also discussed.

Chapter 2: Literature Review

2.1 Introduction

In order to assess the implications of foods developed with novel technologies for consumer welfare, the focus should be on the theoretical aspects of an individual's purchase decisions. In reality ex-ante, consumer preferences are being assessed hypothetically since the actual products either do not yet exist or are not available for sale. Thus revealed preference methods cannot be used to determine consumer preferences ex-poste. The general characteristics of stated preference methods applicable to this study will be identified. In this chapter the previous literature on different aspects of consumer behaviour and genetic modifications, functional foods, nanotechnology and genomic applications is also reviewed. From this literature review, specific consumer characteristics that are related to stated or revealed preferences for foods produced with novel technologies can be identified.

2.2 Stated Preference Experiments

Lancaster models of consumer behaviour (1966) assume that consumers' utility is not derived from goods directly, but from the actual properties or characteristics of the goods or bundles of attributes. This approach allows a researcher to identify how changes in the characteristics of the goods will affect consumer's preferences and behavior.

Previous studies have found that there are certain characteristics that partially determine consumers' attribute preferences. According to McFadden (1986) product attributes, market information, consumer's socio-economic characteristics, perceptions and beliefs are all important factors that contribute to consumer's market behaviour or decision making about purchasing a product.

Stated preference (SP) experiments are often used to evaluate consumers' attribute preferences for product, particularly for products that do not currently exist in the marketplace. The stated preference method presents respondents with choice options in hypothetical markets. Consumers are most often asked to make hypothetical trade-offs between different alternatives (either products or attributes) to elicit their preferences and their purchasing intent (Lagerkvist et al., 2006). Stated preference experiments also allow organizations to test the market for new products or products with new attributes (Louviere et al., 2000). By making choices of different bundles (goods/attributes) at different prices consumers are providing a measure of the utility generated by each particular bundle.

The strength of the stated preference (SP) method is that consumers can be asked about their willingness to purchase any product, including those currently unavailable in the marketplace and the researcher can control the data collection process in order to ensure that price changes are uncorrelated with other variables of interest (Brooks and Lusk, 2010). Compared to revealed preference methods, stated preference methods are less time consuming and cheaper to collect. The other strength of SP methods is that numerous observations can be collected from each respondent which allows for more data points on which to estimate models of behaviour (Louviere et al., 2000). The data collected by stated preference methods can be constructed to contain more variability and can be used to test for a bigger range of utility functions (Louviere and Timmermans, 1990) than is the case for revealed preference data. An acknowledged weakness of stated preference methods is hypothetical bias. Hypothetical bias arises in stated preference valuation studies when respondents report a willingness to pay in laboratory or field experiments, that exceeds what they actually pay using their own money. Unfortunately, there is no widely accepted general theory of respondent behaviour that can deal with hypothetical bias (Harrison, 2006; Hensher, 2010; List and Gallet, 2001; Loomis, 2011). Recognizing the potential for hypothetical bias is important in designing stated preference scenarios and in describing results.

Many studies have employed stated preference methods to elicit consumers' preferences and willingness to pay for different products such as GM food, foods produced

by nanotechnology, cloning, etc. A summary of some of the literature employing stated preference methods is depicted in Appendix A. As can be seen contingent valuation methods (CV) (Adamowicz et al., 1995; Boccaletti and Moro, 2000; Lin et al., 2006) and choice experiments (CE) (Lusk and Parker, 2009; Lusk et al., 2003; Lusk and Rozan, 2008; Roosen et al., 2011) are two types of stated preference methods used commonly in the literature (Appendix A).

In contingent valuation methods consumers are asked to choose between a base case and a specific alternative (Brewer et al., 1994). In contingent valuation methods, a consumer is asked whether s/he is willing to pay to purchase a product with an individual attribute or a combination of differentiated attributes (Sanders et al., 2007). Respondents in the contingent valuation approach are given a scenario describing a proposed good (e.g. novel food product) that would alter the quality of the good of interest in a binary choice setting. They are then asked to choose the product at particular prices aimed at eliciting their maximum utility from selecting one alternative. In some studies (Bateman et al., 2001; Lin et al., 2006; Boccaletti and Moro, 2000; Adamowicz et al. 1998) if the response to the initial amount is positive, they can be presented with higher bid prices and asked whether they would purchase again, and if they respond negatively in the first case, they can be presented with lower bid prices to identify their preferences (Alberini et al., 1997).

In choice experiments on the other hand, individuals are asked to choose from alternative bundles of attributes (Adamowicz et al. 1998). They also allow the researcher to evaluate attributes and situational changes (Brewer et al., 1994).

Because stated preference methods deal directly with consumers' reactions to marginal changes, the utility measure can be summarized in the following equation:

$$\nu(\mathrm{P}^0, \mathrm{Q}^0, \mathrm{y}) = \nu(\mathrm{P}^1, \mathrm{Q}^1, \mathrm{y} - \mathrm{c}),$$

where $\nu(\,)$ is an indirect utility function, P^0 is the current price level of good considered. Q^0 is the current quantity of the good consumed, and y is income. On the other

side of the equation, P^1 and Q^1 represent the new price and compensation level, and c is the Hicksian compensating variation, or WTP. In other words, this equation states that maximum WTP is the amount that makes utility level equal when considering different price levels, quantities, and disposable income (Gonzalez et al., 2008; Adamowicz et al., 1995; Lusk and Parker, 2009). In choice experiments there are questions about the number of attributes, the number of goods to choose between, whether or not to have a 'none of the above' option and the number of actual choices one individual can make without fatigue setting in and these issues must be dealt with in experimental designs.

Different models have been used in the literature to estimate the probability of a particular choice from stated preference questions in order to identify preferences. Some of the previous literature has employed different forms of logit and probit models in their studies. These studies determined consumers' preferences, attitudes, and acceptance of newly introduced food products in the food industry to analyze how prosperous the markets for these products might be in the future (Costa-Font and Mossialos, 2005; Baker and Burnham, 2001; Adamowicz et al., 1995; Baker and Mazzocco, 2002; Harrison and Mclennon, 2004; Moon, et al. 2006, Bukenya and Wright, 2004, Gifford et al., 2005; Lusk and Briggeman, 2009; Lusk and Marette, 2010; Chern et al., 2002) in Japan, Norway, Taiwan, and the United States, United Kingdom, and Europe, and measured consumers' willingness to pay (WTP) (Boccaletti and Moro, 2000; Bosch et al., 1995; Lin et al., 2006; Lusk et al., 2002; Marette et al.,2009; Lusk and Rozan, 2008; Onyango and Nayga, 2004; Lusk et al., 2003; Hanemann, 1984; Lusk and Parker, 2009; Sheikh et al., 2003; Vandermoere et al., 2010; Veeman and Adamowicz, 2004; Zbinden and Lee, 2005). Researchers were able to discern distinct preferences for foods produced with novel technologies (e.g. GM foods, biotech food, nanofoods, etc.) as compared to conventional, organic, etc. foods using stated preference methods (Onyango et al., 2004; Lusk and Parker, 2009; Louviere et al. 2000; Veeman and Adamowicz, 2004).

Most of the literature reviewed used conditional and/or random parameter logit models to estimate their consumers' attribute preferences and responses. The logit and probit models are quite similar as the cumulative normal and logistic distributions are very

close to each other but the logistic transformation can be more convenient to compute (Ashton, 1972). The random utility model in a conditional logit specification for alternative j for choice t can be specified as: $U_{jt} = \beta V_{jt} + \varepsilon_{jt}$, where β is the vector of coefficients to be estimated, V_{jt} is the observable, systematic portion of the individual's utility function, and ε_{jt} is the stochastic error term (Verbeek, 2008).

In this thesis stated preference methods will be employed to elicit the consumers' preferences for foods produced with nanotechnology and genomics applications. Conditional logit and random parameter logit regressions will be used to estimate the choice probabilities, and WTP for the individual foods can be calculated from the regression results. Further details for the method of analysis, data set up, regression and WTP results are explained in chapter 3, and chapter 4.

2.3 Ambiguity Avoidance

The previous literature on novel food technologies (i.e. nanotechnology and genomics) highlights the potential scepticism of the public to new technologies (Besley et al., 2008; Moon et al., 2006; Siegrist et al., 2008; Vandermoere et al., 2011; Bieberstein et al., 2013). People tend to be concerned and uncertain about the use of the new technologies. When it comes to choosing a food option produced with a novel technology, it is possible that people could try to avoid the 'unknown'. This behaviour in choice making can be described as "ambiguity". Ambiguity is an attitude which could depend on the amount, type, reliability, and unanimity of information provided in a specific situation. The ambiguity effect is a bias which suggests people tend to select options with known probabilities of outcome, over an option with unknown probabilities (Ellsberg, 1961). Moreover, according to Ellsberg, "The choices themselves do not appear to be careless or random. They are persistent, reportedly deliberate, and they seem to predominate empirically; many of the people who take them are eminently reasonable" (Ellsberg 1961, p. 656).

Ambiguity is uncertainty about probability of outcome, created by missing information that is relevant and could be but isn't known. Not knowing important information is upsetting. Indeed, one explanation of ambiguity aversion is that people transfer a heuristic that is helpful in many natural situations which is to avoid choosing a product for which they lack information others might have (Frisch and Baron, 1988).

There are hypothesized characteristics of ambiguity avoidance which, although not empirically substantiated, are theoretically and intuitively reasonable. Firstly, the hostile nature hypothesis (Yates and Zukowski, 1976) which conjectures that the decision makers perceive the process by which the outcomes are determined as non-random for the ambiguous option. Instead, the outcome is perceived to be the result of a process which is competitive, toward other options. Also, the forced-choice (Roberts, 1963) hypothesis states that the less ambiguous option is selected only when all other considerations are equal. Finally, the uncertainty avoidance hypothesis states that ambiguity avoidance is a consequence of a more general attitude of uncertainty avoidance. Although not fully explanatory, this hypothesis attempts at least to clarify the behavior itself. Accordingly, this hypothesis would predict that those who avoid ambiguity might also exhibit an avoidance of other aspects of uncertainty. For example, risk aversion, the preference for a guaranteed amount over an uncertain gamble with equal expectation, might be correlated with the avoidance of ambiguity. This concept has been applied to risk-avoiding and risk-seeking behaviors (Fellner, 1961), and may operate in ambiguous situations also (Curley et al., 1986).

Ambiguity attitudes are broadly classified into three categories: Ambiguity aversion, or willingness to pay to avoid ambiguous alternatives; ambiguity neutrality, or unwillingness to pay to avoid ambiguous situations; and ambiguity seeking, or willingness to pay to avoid unambiguous alternatives (Charness et al., 2013).

Previous research in ambiguity has established that people, when given a choice between two options differing in their degree of ambiguity, tend to prefer the less ambiguous option, exhibiting ambiguity avoidance behaviour (Curley et al., 1986).

Camerer and Weber (1992) provided an extensive survey of the experimental work regarding ambiguity attitudes up to that time. According to this survey, the results regarding the percentage and intensity of ambiguity aversion of decision makers, measured by the (relative) size of the premium decision makers were willing to pay to avoid the ambiguous bets, varied substantially across studies. In other words how much people know about a state's probability does influence their willingness to bet on the state.

Charness and Gneezy (2010) examined ambiguity aversion in an investment task in which one has 100 units and can invest as many as desired in a risky asset that has a 50% chance of success; whatever is not invested is kept. The risky asset pays 2.5 to 1 if successful and the investment is lost if it fails. Decision makers are asked how much they would invest. There is one treatment in which they know there is one urn that is 50/50 black/red balls and another urn has 100 balls of unknown distribution. 72% of people chose the known distribution; the difference from 50/50% is significant suggesting the overall presence of ambiguity aversion when it is costless to make a choice. Trautmann et al. (2011) shows that elicitation methods matter a lot under ambiguity. For example, in the two-color problem (one with the known urn contained 20 red and 20 black balls, and the ambiguous urn contained 40 red and black balls in an unknown proportion) with willingness-to-pay, virtually 100% of decision makers are ambiguity averse, and almost no WTP for ambiguity seeking person is found.

Muthukrishnan et al. (2009) proposed that ambiguity aversion drives a preference for established brands in multi-attribute choices among branded alternatives and causes consumers to systematically favor established brands. Established brands are those for which the consumers' belief in quality is held with greater confidence, even if specific attributes or quality of the established brand might be inferior to those of competing alternative brands. They showed a correlation between ambiguity aversion (revealed through choices among monetary choices) and the preference for established brands. The study concluded that the preference for established brands is enhanced when ambiguity aversion is made more salient in unrelated preceding choices. Thus, ambiguity aversion

carries across choices, and ambiguous information about brand attributes tends to increase the preference for established brands.

An example of a hypothetical scenario can help relate the ambiguity avoidance concept to willingness to pay for food produced by novel technologies (nanotechnology and genomics). A hypothetical consumer is faced with two choices, the first choice is a food product with a distinct attribute (e.g. nutrition enhancement) produced with conventional methods, and the second choice is the same food product with a similar distinct attribute, produced by nanotechnology (for instance). The consumer is asked whether or not s/he is willing to pay a certain amount for either of the products. The first choice generates a known payoff distribution for the consumer, so it is not risky; however, the second choice generates an unknown distribution, so it is ambiguous. As previous research has shown, the consumer might systematically avoid the ambiguous choice in favor of the less risky choice. The ambiguity avoidance might help justify why certain consumers avoid foods produced by novel technologies in the literature (Marette et al., 2009; Lusk and Rozan, 2008; Onyango and Nayga, 2004; Roosen et al., 2011; Siegrist et al., 2007).

Ambiguity avoidance is a behaviour that must be considered in the design of the stated choice experiments and is also something that must be considered in examining the result from the empirical analysis.

2.4 Review of Nanotechnology Applications in the Food Industry

Nano-science and nanotechnology are new frontiers of this century (Garcia et al., 2010). Nanotechnology has the potential to revolutionize the global food system. The application of nanotechnology to the agriculture and food sectors is relatively recent compared to its use in drug delivery and pharmaceuticals. Nanotechnology will impact food security, design of new food products, nutrient and flavor encapsulation, packaging materials, bio-availability, and delivery systems (Bouwmeester et al., 2007; Chen et al., 2006; Mallika, 2005; Maynard et al., 2006; Weiss et al., 2006). Novel agricultural and food

safety systems, disease-treatment delivery methods, tools for molecular and cellular biology, sensors for pathogen detection, pesticides, packaging materials, environmental protection, and education of the public and future workforce are examples of the important impact that nanotechnology could have on the science and engineering of agriculture and food systems (Bouwmeester et al., 2009; Moraru et al., 2003).

Nanotechnology seems certain to impact on food structure and production in the future. The potential applications of nanotechnology in the agro-food production chain are throughout all phases of food production (Moraru et al., 2003).The applications of nanoparticles in the food industry can be described as nano-sized food additives, bio-active compounds or supplements claiming to enhance the uptake of nutrients, producing stronger flavors and color quality, innovative food packaging, detection of food deterioration and monitoring storage conditions, and detection food contaminants in order to lengthen the storage time while keeping the products fresh (Bouwmeester et al., 2009; Chaudhry et al., 2008; Sekhon, 2010).

Nanotechnology is being used in the development of new foods and food packaging with an array of benefits (for example, prevention of micro-organism growth or stronger mechanical and thermal performance (Chowdry, 2010)). The term 'nanofood' describes food that has been cultivated, produced, processed or packaged using nanotechnology techniques or tools, or to which manufactured nanomaterials have been added (Joseph and Morrison, 2006). Nanotechnology may also be used in food production, for example, to produce healthier foods, or to enhance organoleptic properties (Weiss et al., 2006). A promising class of new materials is represented by nano-composites made of nano-scale structures with unique characteristics. Omega 3 and omega 6 fatty acids, probiotics, prebiotics, vitamins and minerals have found their applications in food nanotechnology as bioactive compounds (Sozer and Kokini, 2008). Nano-structuring adds value to traditional materials by enhancing their mechanical strength, superconductivity, and ability to incorporate and efficiently deliver active substances into biological systems, at low cost and with limited environmental impact (Garcia et al., 2010). These characteristics are important with respect to potential risks for consumers' health and determine their fate and

behavior (Bouwmeester et al., 2009). Consumers are particularly conservative when it comes to perception and acceptance of foods produced by nanotechnology (Ueland et al., 2012).

Nanotechnology foods and food packaging are already commercialized, though the number of products is still low. In the near future, nanotechnology may become increasingly important in the food sector (Allianz & OECD, 2005), with governmental agencies and industry investing considerable resources in its development and implementation (Kuzma & Verhage, 2006). A possible known list of all food products currently containing nanoproducts include: Canola Active Oil (Shemen, Haifa, Israel), Nanotea (Shenzhen Become Industry Trading Co. Guangdong, China), Fortified Fruit Juice (High Vive.com, USA), Nanoceuticals Slim Shake (assorted flavors, RBC Lifesciences, Irving, USA), NanoSlim beverage (NanoSlim), Oat Nutritional Drink (assorted flavors, Toddler Health, Los Angeles, USA), and 'Daily Vitamin Boost' fortified fruit juice (Jamba Juice Hawaii, USA) and nanocapsules containing tuna fish oil (a source of omega 3 fatty acids) in "Tip-Top" Up bread (Enfield, Australia) (Sekhon, 2010). Worldwide sales of nanotechnology products to the food and beverage packaging sector jumped from USD $150 million in 2002 to USD $860 million in 2004. The value of the application of nanotechnology in food surged to USD $20.4 billion in 2010, worldwide (Fletcher, 2006; Kaiser, 2011).

Nanotechnology also makes food packaging intelligent, smart and long-lasting, providing better safety against bacteria and microorganisms than traditional market packaging methods (Farhang, 2009). Developing smart packaging to optimize product shelf life has been the goal of many companies. Such packaging systems would be able to repair small holes/tears, respond to environmental conditions (e.g. temperature and moisture changes), and alert the customer if the food is contaminated (De Jong, 2005; Joseph and Morrison, 2006).

The application of nano-composites promises to expand the use of edible and biodegradable films (Lagaron et al., 2005). It will help to reduce the packaging waste

associated with processed food and will support the preservation of fresh foods extending their shelf life (Labuza and Breene, 1988; Vermeiren et al., 1999). The so-called nano-sensors are designed to respond to environmental changes (e.g., temperature or moisture in storage rooms), degradation products of the food commodities, or contamination by micro-organisms. No data is available on possible migration of nanoparticles into food using these applications (Moraru et al., 2003). Bioactive packaging materials need to be able to keep bioactive compounds, such as prebiotics, probiotics, and encapsulated vitamins in optimum condition until they are released in a controllable manner into the food product (Lopez-Rubio et al., 2006; Guerra et al., 2005; Brody, 2005).

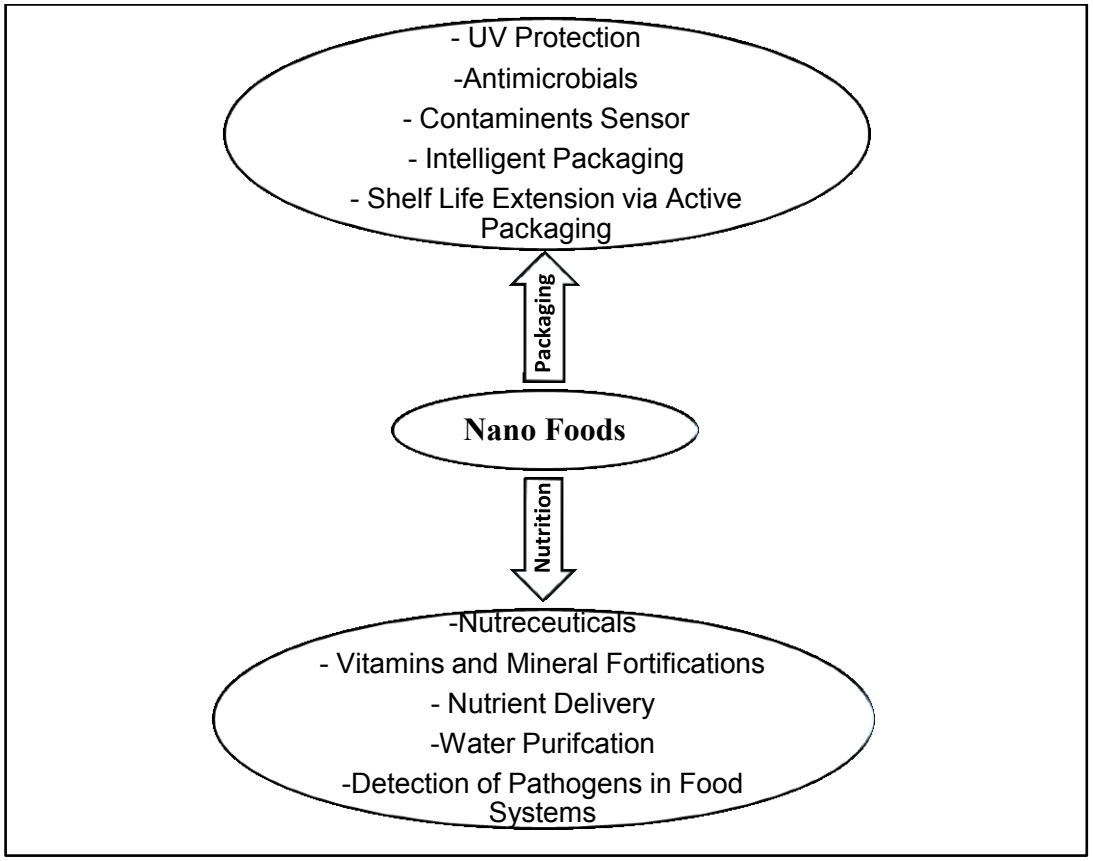


Figure 2.1: Potential Applications of Nanotechnology in Food Industry (Adapted from Duncan, 2011; Sozer and Kohini, 2008)

Bioactive-packaging materials can help to control oxidation of food stuffs and to prevent the formation of off-flavors and undesirable textures of food. Researchers reported

the challenges of using nanotechnology to create low-cost packaging that assists in functionality, weight, and ease of processing (Arora and Padua, 2009). Figure 2.1 shows a summary of the potential uses of nanotechnology in food industry discussed in this section.

2.4.1 Nanotechnology and Society Responses

Previous studies show that many factors can influence consumers' acceptance of food innovations including nanotechnology. Understanding consumers' socio-demographic characteristics, knowledge and information awareness, as well as trust in the source of information could be crucial to the realisation and success and acceptance of technological advances (Rollin et al., 2011). At present, public awareness regarding agri-food nanotechnology is low. Waldron et al. (2006) showed in their study that, with the exception of 14-28 year olds, over 60% of respondents say they have never heard of nano or nanotechnology. Although a small slice of the adult population is somewhat familiar with nanotechnology, clearly, there is a general lack of awareness and understanding of nanotechnology (Smiley et al., 2008; Waldron, 2006). The current state of development regarding commercialisation and implementation in the agri-food sector is similar to GM in the early 1990's (Frewer et al., 2011). To avoid some of the problems GM technology was faced with, it is important to take public views of nanotechnology foods into account at an early stage of product development (Siegrist et al., 2008).

As a result, numerous studies have been conducted on the perceived benefits of nanotechnology in health, economic, social, and environmental aspects in the agri-food industry. Food applications are less accepted than applications in other domains. Nanotechnology food packaging is more accepted than nanotechnology foods (Pidgeon et al., 2009; Siegrist et al., 2007; Siegrist et al., 2008; Stampfli et al., 2010). Benefits from natural additives are preferred to nanotechnology additives. The issue of naturalness may become a more relevant issue for specific applications (for example, smart pesticides) (Siegrist et al., 2009).

In Appendix A some of the studies on nanotechnology and the socio-economic aspects of the previous research are reviewed. The characteristics of studies presented in Appendix A include the countries, objectives, and method of analysis for each study. For the majority of the studies, presented in the table, the results show that there is a general lack of trust in the technology introduced (GM technology, nanotechnology, etc.), and that the public perceives the risks to be greater than the benefits for nanotechnology, GM, etc. Some of these studies also examined the role of consumers' perceived risks, and preference differences for novel technologies in their food using logit/probit regressions. These studies then derived the consumers' willingness to pay for specific foods generated by the technology, which mostly reflected the fact that consumers generally were willing to pay less for any food produced with any form of novel technology than what they would pay for a conventionally produced product (e.g. biotechnology, GM, nanotechnology etc.) involved in their food (Moon et al., 2006; Marette et al., 2009; Lusk and Rozan, 2008).

Hossain, et al. (2003) analyzed public acceptance of biotechnology in food production in US and identified the influence of consumers' socio-economic and value attributes on their perceptions of biotechnology and acceptance of its use by applying an ordered probit model. He found that younger and more-educated individuals are generally more supportive of biotechnology. Attitudes toward biotechnology differ substantially between males and females, and between whites and non-whites. While people's religious and social views and confidence in scientists, corporations, and government have significant influences, income and regional differences do not have significant effects on public acceptance of biotechnology. Empirical results also suggest that while there is general optimism about biotechnology and support for its use in plants, public approval of its use in animals is perhaps more limited.

Bainbridge (2002) did an internet survey in the U.S. about the public perceptions of nanotechnology. Based on his quantitative analysis, he found that many respondents expressed unconditional confidence that nanoscience and nanotechnology will benefit mankind, without necessarily saying exactly how. Other respondents hoped nanotechnology would benefit rather than harm humanity, but acknowledged a degree of

uncertainty, expressed caveats, or otherwise hinted that their confidence was conditional. Many of the respondents had clearly heard something about nanotechnology, and others were able to react intelligibly to the brief description of the field conveyed by two agree-disagree items. The chief finding of this initial, exploratory study was that science-attentive members of the general public are very enthusiastic about nanotechnology, and a rather large number of ideas about its benefits have already entered popular culture. While several studies on the public opinion of nanotechnology have pointed to a rather enthusiastic U.S. public, the public uptake of nanotechnology in Europe is more restrained. The results of the Swiss public survey on nanotechnology reveal a pragmatic attitude of citizens toward the emerging technologies (Burri and Bellucci, 2008).

A recent review commissioned by the Food Standards Agency (FSA) in the UK (Fell et al., 2009) confirmed that European consumers still tend to associate more negative than positive attitudes towards agro-biotechnology in general, such as wariness, unease and uncertainty. However, there are minorities with strongly positive or negative opinions and a majority who are undecided or feel that they don't know enough to form a view. Puurunen and Vasara (2006) found that nanotechnology affords great opportunities in the form of an enormous variety of applications and nanotechnology may aid in the modification of product features.

A survey in the United States by Cobb and Macoubrie (2004) showed that respondents expected benefits of nanotechnology to be more prevalent than risks, and they reported feeling hopeful about nanotechnology rather than worried. The most discouraging aspect to that data is the respondents' lack of trust in business leaders to minimize nanotechnology risks to human health. Results further suggest, however, that nanotechnology packaging is perceived as being more beneficial than nanotechnology foods (Siegrist et al., 2007).

Moon and Balasubramanian (2004) analyzed the influence of four predictor variables (trust in regulatory agencies, knowledge/ awareness of biotech issues, outrage factor, and demographic characteristics) on attitudes toward agro biotechnology in the US and the UK

using an ordered probit model. Results show that trust, sense of outrage, and socio-demographic factors play an important role in shaping public attitudes about agrobitoechnology, largely via their links to risk perceptions. Moreover, risk perceptions exert a greater effect on public attitudes toward agrobiotechnology than benefit perceptions, and the attitudes of UK consumers were more susceptible to negative attributes when compared with US consumers. In 2007 they also conducted another survey in the UK and they found that when consumers perceived risks in connection with agrobiotechnology or GM food, they were more likely to decide to pay a certain premium to avoid GM food or require discounts to purchase GM food in exchange for giving up non-GM food and they are more willing to pay a premium to avoid the risk of agrobiotech food (Moon et al., 2007).

Also in a study by Siegrist et al. (2008) in Switzerland showed notable relationships were found between demographic variables, attitudes and behaviors towards nanotechnology. Consumers may be more likely to accept innovations related to packaging than those related to foods. Social trust (trust in sciences/consumer protection agencies) had a significant effect on the perceived risks and the perceived benefits of nanotechnology applications. As a result, some studies claim safety and lack of trust as causes of reluctance to accept nanotechnology (Onyango et al., 2003). It is important to educate people about these developments (Kasturi, 2009). Universities can act as the principle provider of broader knowledge to raise nanotechnology awareness, and they indeed serve as a principal seedbed for future development of the cutting edge nano-biotechnology (Xia, 2009).

Consumer preferences about attributes of functional foods and nutraceuticals in Canada were investigated by Hailu et al. (2009) using conjoint analysis. The results suggested that consumers place a strong premium on claims verified by government, but little value on ‘non-verified’ claims made by product manufacturers.

Smiley et al. (2008) found in his study that respondents who were highly educated were significantly more likely to have heard a lot or some about nanotechnology (for with

younger respondents more significantly to agree that the benefits of nanotechnology outweighs the risks. The study also suggested that women are, as a group, more risk averse than men.

Attitudes towards nanotechnology also depend, in part, on the knowledge available to the public from mass media. News media content provides information which helps to shape public attitudes toward this emerging technology. Tyshenko (2014) analysed Canadian newspaper content for nanotechnology coverage, and discussed that the Canadian media coverage, at this point in time, emphasizes positive frames and focuses mostly on the potential near-term benefits of this new technology rather than any adverse social, risk, legal or ethical considerations or unforeseen consequences related to nanotechnology development. To increase public knowledge in Canada the news media content should go beyond its current narrow framing of scientific innovation and near term research applications. The study also argues that in Canada, the societal impact of nanotechnology should also be considered and more dialogue is necessary as a way to realize a more comprehensive oversight of nanotechnology. "Media content in other countries has provided more information on broader societal, ethical, legal, policy, regulatory and international issues over time" (Tyshenko, 2014, pp. 38).

Bieberstein et al. (2013) revealed a gender gap in risk assessment for the case of food nanotechnology. They found that men perceived the health-risks of nanotechnology food significantly lower than women, and as a result, they have higher level of trust compared to women. Furthermore, trust seems to be important for the evaluation of this new food technology but not equally and not in the same way for women and men: women compared to men rely more on social trust in order to assess health risks due to nanotech food and the impact of trust does not depend on levels of self-assessed nanotech familiarity. Thus, in women's mind it is the behavior and decision of the food industry, regulatory bodies and science and technology which determine the hazards consumers will be exposed to. Here, social trust does not serve as a heuristic in order to replace lacking scientific knowledge. Interestingly, men seem to make the link between public authorities' decisions and the

safety of new nanotech food applications only when they have some or a lot of knowledge about nanotechnology.

Vandermoere et al. (2011) examined the risk/benefit assessment of nanotechnology in France and found that knowledge of nanotechnology, familiarity with nanotechnology, views of the benefits (risk) of science and technology for society and demographic variables such as age, gender and trust were significant in explaining views of nanotechnology in food packaging and in food applications.

Matin et al. (2012) also found similar results (to Vandermoere et al., 2011) in Canada. They found that male, younger people pay more positive attention to nanotechnology in the food industry. Also people who are strong supporters of the use of nanotechnology, believe that the effects of science and technology are beneficial for society. Those respondents, who have heard of nanotechnology prior to the study, were also supporting applications of nanotechnology.

Schnettler et al. (2013) in a study on southern Chile showed that consumers differed in their knowledge of nanotechnology, willingness to purchase foods involving nanotechnology, age, socioeconomic level and lifestyle using cluster analysis. In their investigation it was also ascertained that the application of nanotechnology in packages was more accepted than those that involve the use of nanotechnology in food.

Roosen et al. (2011) developed an experiment in which participants are asked to evaluate an orange juice fortified with Vitamin D using nanotechnology to evaluate the impact of different information sequences on consumer choice of products involving innovations, like nanotechnology that may have uncertain consequences for health, the environment, and society, using tobit regressions. Their results suggest that participants have a real concern for the health impacts of nanotechnology and health information is a priority in participants' information choice, and information on potential health risks significantly decreases WTP for orange juice. Furthermore, only gender was significant from the socio-demographic variables used in the study (i.e. gender, age, and income), with

men having a higher WTP for the orange juice fortified by means of nanotechnology as compared to women. The study shows consumer benefit very much depends on assuring consumers of the sanitary safety of nanotechnology food products.

Marette et al. (2009) recommended that food safety agencies should focus on studies on safety, guaranteeing a higher level of certainty for innovative food products, and that there is a social benefit to eliminate uncertainty linked to health questions for improving the nano-food chances of being accepted by consumers.

Vandermoere et al. (2010) examined the socio-economic background as a proxy of the predictors of familiarity with nanotechnology by using binary logistic regression analysis in Germany. They also had a focus on the determinants of attitudes toward nanotechnology in general. They found that men are more likely to have a positive attitude toward nanotechnology than women. The age of the respondents is not significantly related to nanotechnology familiarity. Further, educational background is positively related to familiarity with nanotechnology. Pro-science and technology views are positively related to familiarity. However, belief in God and religiosity does not differentiate positive and negative attitudes toward nanotechnology. Further results showed that concerns about the changing relationships between nature, technology, and society significantly predict attitudes toward nanotechnology.

2.4.2 Nanotechnology and Links to GM Food

The commercialisation trajectory of emerging applications of nanotechnology has been frequently compared to that of genetic modification of foods (Mehta, 2004). Early studies (in early 2000's) in the US and Canada suggest that nanotechnology was perceived as less risky/more beneficial than GM (Currall et al., 2006). Recent research suggests considerable variation in attitudes according to predictable individual differences (Cobb & Macoubrie, 2004; Priest, 2006), although food-related applications in general are viewed less positively, or at least differently, to other areas of application. The level of risk perception varies across applications (such as food packaging or food production), with

food associated with higher risks (Cobb and Macoubrie, 2004; Currall et al., 2006; Kahan et al., 2008; Priest, 2006; Siegrist et al., 2008). This may vary between individuals (Kahan et al., 2008). The European public seems to be less optimistic about nanotechnology compared with consumers in the U.S. and Canada (Gaskell et al., 2004; Matin et al., 2012).

Many opinion leaders and academics have suggested that affective or emotional responses may play a key role in determining acceptance for nanotechnology in general (Kahan et al., 2008; Lee et al., 2005; Siegrist et al., 2007). The public engagement research also suggests the consideration of public participation in the formulation of regulatory policies governing nanotechnology which is essential to the establishment of public confidence in the governance of the technology (Tyshenko, 2014). Previous research show that there has been some concerns about the effectiveness of public regulation, oversight and control in agrifood applications (Burri and Bellucci, 2008; Gavelin et al., 2007; Macnaghten et al., 2005; Rogers-Hayden and Pidgeon, 2007). Acceptance of a technology is also partly driven by the perception of the potential benefits (Ronteltap et al., 2007). A lack of perceived benefits leads the majority of people to question the need for, and usefulness of, novel food technologies, and may even accentuate perceived risks and moral concerns (Gaskell, 2000).

2.5 Review of Genomic Applications in the Agriculture and Food Industry

The meat industry is faced with the challenge of increasing demands for safe and minimally processed products and increasing global prices. Specific genetic markers can be identified and used to develop accurate identification methods for microbial contaminants to use in both health institutions and the food industry (Abee et al., 2004). These specific markers with genome sequence information provide a more sensitive, rapid and informative detection method for food products than the classical ‘culture’ method. The completion of the genome information marks a new era in biomedical and veterinary research that ultimately will also impact other aspects of animal agriculture. It helps animal scientists in the areas of health, fertility and production. Further characterization of livestock genes and genomes will provide the research tools critical to understanding how

animals can be genetically enhanced through selective breeding, to safely meet consumer needs while minimizing environmental effects.

The application of tools of genomics in molecular genetics has led to the identification of genes that affect traits of interest in livestock. Genomic studies allow the detection of those genes and regions that affect quantitative traits (Mullen et al., 2006). Genomic based agri-food activities include improving both human and animal health. Producing food with enhanced food safety or nutritional and functional attributes can improve human health, as well as the health of livestock by improving their immune responsiveness to infectious diseases. This latter kind of focus reduces the risk of transmission of animal diseases with human health implications to people (Genome Canada, 2013) and also reduces transmission of diseases which only affect animals improving the welfare of animal populations.

Meat quality is of economic importance in farm animals. It is controlled by multiple genes and the environment. Factors affecting meat quality can be largely divided into two aspects: the genetic basis and on management systems. Meat quality is difficult to improve by traditional selection because the heritability of meat quality characteristics is low to moderate and the measure of quality trait is difficult, expensive, and only possible after slaughter. During the past few decades, advances in molecular genetics have led to the identification of genes, or markers associated with genes, that affect meat quality (Gao et al, 2007). The development of farm animal genomics, to describe the strategies and technologies to map and characterize meat quality, has progressed rapidly in recent years, moving from linkage maps to genome sequence. Work on sequencing farm animal genomes can help us to understand how genes function in various organisms and might be applied in the field to study the molecular control of meat quality (Gao et al., 2007). With genome information applications, especially the sequence information, meat quality could be improved by producing a healthier pathogen free meat and/or higher proportion of relative muscle to fat tissue in the meat product.

2.5.1 Genomic Applications and the Public

Developments in genomic science and its applications raise significant public policy issues. Public pressure indeed had some effect on the scientific research on genomics (Pin and Gutteling 2009). Consumers are both highly skeptical of genomic science's purported benefits, and apprehensive about the potential risks to individuals and society (Weldon and Laycock, 2009).

Researchers have identified several factors to explain differences in individual support for genomic applications (e.g. genomic selection) to improve the effectiveness of animal breeding in livestock. These factors include consumers' general level of scientific knowledge and attentiveness, their perceptions of the technologies' risks and benefits, demographic factors, consumers' moral and ethical concerns, and their trust in governmental regulatory bodies (Barnett et al., 2007; Gaskell et al., 2004). Public support may also vary depending on intended uses of specific technologies (Barnett et al., 2007; Fischhoff and Fischhoff, 2001). In Europe, the public viewed medical genomics much more favorably than agrifood genomics as compared to the US and Canada (Bauer, 2005). For example Pin and Gutteling (2009) in a meta-analysis study indicate that in 2006, the total amount of research done on public perception about different genetic applications in the US and Canada dropped whereas in Europe, the overall quantity of research done was rising (with 29% of the research in the US and Canada vs. 59% of the research in Europe). The Europeans measured risk perception more often than benefit perception.

Research findings indicate that public opinion towards genomic science and modern biotechnology is highly complex, with many factors affecting individual attitudes (Weldon and Laycock, 2009). Previous research confirms the importance of trust in institutional actors for support of new technologies. Priest (2001) finds that for explaining variations in individual support for genetic applications in the United States, trust in agricultural, and food retail corporations is more important than knowledge about genetic or genomic science. Pin et al. (2009) also indicated that the range of specific determinants that influenced the public perception of genomics studied so far has been trust, knowledge about genetic science, religion belief system, and socio-demographic characteristics.

Almeling and Gadarian (2013) examined public opinion on policy issues in genetics and genomics related to public health, including federal spending on genetic research in United States. The majority of the respondents (57%) believed that the federal government should spend more on genetic research and 65% said that clinicians should be involved in explaining genetic test results to public. On policy issues, gender and political party affiliation were statistically significantly associated with respondents' views, whereas race/ethnicity and education were less consistently associated with public opinions about genomics.

Dijkstra et al. (2010) indicated public participation as the ideal solution for the growing gap between science and society. They suggested that the factors most predictive of public participation were respondents' relative knowledge of genomics research, their information-seeking behaviour, and their level of education, age, gender, social involvement, social trust and institutional trust, in a survey conducted in the Netherlands using factor analysis. In other words, persons who have a higher score for public participation issues are more knowledgeable about genomic issues. Also people who exhibit more interest in genomics issues are more active participants in genomics research and are more socially involved. Education contributes to public participation as well, meaning that higher educated people are more inclined to participate in genomics research.

2.5.2 Genomic Application and GM Food

Genomic science has seen rapid advances in recent years with new applications in medicine, agriculture, and their related fields (Weldon and Laycock, 2009). Genomics in agriculture include food genomics, plant breeding, animal breeding, GM foods, and biodiversity (Bauer, 2005; Pin and Gutteling, 2009). In the case of agri-food genomics (e.g. gene assisted selection for animal breeding, etc.) it has been less obvious who will benefit from the technology: the consumer, the farmer, or the multinational corporation that provides the agricultural products (Gaskell et al., 2004).

Consumer beliefs are an important determinant of their purchasing intent and their decision making process with regard to a new food product. Previous studies show that consumer preferences can be influenced to accept the technology in two ways: by consumer beliefs and/or by the evaluations of the beliefs. An important influence on consumer beliefs is information (van den Heuvel et al., 2006). Consumers can gather information regarding the product, based on the true qualities of the product (as in tasting) or by the information that accompanies the product very closely (as the color or packaging of the product) or more importantly information regarding the method of production. Various studies (Caporale and Monteleone, 2004; Kihlberg et al., 2005; Smythe and Bamforth, 2002) show that information on the production technology changes the consumer beliefs about the product.

Genetically modified (GM) content in food has been a topic for intensive public debate over several decades and while available technologies for animal breeding now have come to include non-GM biotechnologies such as genomics, the subject is still highly controversial. Genetically modified products may contain gene modifications, and/or enzyme modifications (Hess et al., 2013). It is predicted that consumer preferences for genomics products might be low because of the negative attitudes towards non-traditional products. The bias might be because of the associations it may evoke with genetic modification (GM food) (van den Heuvel et al., 2006). Consumers tend to have a negative perception of genetically engineered foods, which has resulted in the withdrawal of some products and encouraged some governments to require mandatory labelling of GM food products in an effort to preserve individual choice (Lang and Hallman, 2005; Siipi and Uusitalo, 2008).

Costa-Font et al. (2008) studied public acceptance of genetically modified (GM) food across Europe and the US, and suggested that consumer attitudes towards GM food are driven by risks and benefit perceptions associated to GM food. Lusk and Coble (2005) found that risk perceptions and risk preferences were important determinants of acceptance of GM food in explaining consumer behavior of avoiding these foods. Lusk et al. (2004) assessed the impact of consumers' knowledge on acceptance of genetically modified foods

in United States, England, and France. Their research indicate that the impact of education was a significant determinant on the acceptance of genetically modified foods, and it would be an important issue for policy makers in the acceptance (or rejection) of genetically modified foods. O'Connor et al. (2006) examined Irish consumer's acceptance of second-generation GM products (yogurt), as those which are expected to exhibit a specific consumer-oriented benefit. The results indicated that while the majority of Irish yogurt consumers continued to harbour an overall negative perception about GM foods, a sizeable sub-section of this population (about 40%) might be receptive to a second-generation product when perceiving a health benefit.

Chern et al. (2002) estimated the consumer willingness to pay (WTP) for selected genetically modified (GM) foods in Japan, Norway, Taiwan, and the United States, and found that the consumers in all of these countries were willing to pay premiums in order to avoid GM foods. Moon et al. (2007) reported that consumers expressed concern about the health and the effects of GM food in the future. Also when consumers perceived risks in connection with agro-biotechnology or GM food, they were more likely to decide to pay a certain amount of premium to avoid GM food or require discount to purchase GM food in exchange for giving up non-GM food. Lusk et al. (2005) conducted a meta-analysis of 25 studies that collectively report 57 valuations for GM food in the US, EU, Asia, Canada, and Australia. They found that GM meat is least desired GM food by consumers and GM oil (derived from GM plant, e.g. soybean, corn, vegetable oil, etc.) draws least concern. Pin et al. (2009) reveals that large parts of the Dutch public are concerned about the abuse of gene technology, are not willing to buy gene-tech products, and want their opinion to have an influence on legislation and enforcement. Dannenberg (2009) found that consumers in Europe and the US had significantly higher aversion to GM food when animal genes involved. The study also suggested that GM food products in Europe may have chance only as a niche product whereas they may rapidly spread out in other regions of the world. According to Pin et al. (2009) trust in authorities, personal interest in gene technology (e.g. genomics) and perception of gene technology are important predictors of people's reactions.

While there is much public concern about genetically modified animals, it seems that there is a much more positive opinion of other animal biotechnologies, such as using genomics for improving selection (Burfening et al., 2006). For example, an opinion poll (Eenennaam, 2006) in the US indicates that the public is more favorably disposed towards the concept of genomics (53%) than genetic engineering (39%) or cloning (15%). The study concluded that although some individuals with a moderate knowledge of science are more inclined to approve of biotechnology in general, this paradigm does not necessarily hold true for the genetic engineering and cloning of animals, where support for the use of these technologies tends to be limited to those with a very high level of scientific knowledge. Sturgis et al. (2005) also carried out a series of multivariate analyses in the UK and realized those people who pay more attention to genomics are less likely to be supportive of GM foods.

The studies reviewed above are some of the studies conducted on consumers to examine their perceptions and attitude towards genetic modification and genomics. The overall strongest negative effect on attitudes in most studies occurring for a genetically modified food product is that it is more expensive than its conventional counterpart (Hess, et al., 2013) which clearly indicates that the benefits are unclear as are the risks to the majority of consumers.

A key finding that emerged from the previous research indicates that while the majority of people tend to oppose the use of genetic modification in their food, their attitude towards genomics may have changed over time (Sturgis et al., 2005). Modern genomics is relatively new, especially in terms of animal breeding for feed efficiency and/or disease resistance. It would be worthwhile to see how people evaluate different applications of genomic technologies on the basis of the cost and/ or value each application would add to or subtract from the prices of their current conventionally produced product.

2.6 Chapter Summary

Undoubtedly nanotechnology and genomics technology have a broad future ahead for development. Nanotechnology has emerged as one of the most innovative technologies to occur in decades and has the potential to improve food quality and safety (Farhang, 2009). At the same time animal genomics has played an amazing role in innovation revolutions such as improving potential disease resistance or feed efficiency in animals (Pin and Gutteling, 2009).

Although many food scientists would claim that the industry has already embraced nanotechnology and genomics, in fact, the food industry is only beginning to realize the full potential of these novel food technologies (Chau et al., 2007). In order to obtain societal benefits from use of nanotechnology and genomics, regulators must consider public acceptance of the technology including the accuracy and level of public risk perceptions, and the legitimacy and level of societal and ethical concerns. Sensitivity (i.e. understanding and responsiveness) on the part of industry, science, and regulation to the public domain is necessary. A societal and ethical research program for these novel technologies (nanotechnology and genomics) has therefore been recommended to ensure that societal concerns regarding the potential unintended consequences of this new technology (ranging from negative human and environmental impacts to questionable military and surveillance applications) are considered (Fisher, 2005; Helland and Kastenholz, 2008).

As the application of these novel technologies in the food industry is growing rapidly, it is foreseeable that the safety research, development of regulatory standards, and public awareness and acceptance of the use of nanotechnology in the food industry will also be growing (Chau et al., 2007).

Literature on methods to use in assessing public preferences for the adoption of novel technologies in food products and other contexts was also reviewed in the chapter. The role of ambiguity avoidance in public lack of acceptance towards the novel technologies was also described. A background about stated preference experiments and

the common methods of analysis was also presented. The chapter also reviewed the literature on various methods of analysis such as ordered probit, multinomial logit, and tobit regression models to measure the probability of people selecting products with novel technologies in their experiments. Although there is a potential for hypothetical bias in stated preference experiments, it is possible that respondent behaviour are not driven by this weakness,

A majority of studies indicate that a large number of their studied populations are unfamiliar with novel technologies and their applications. This may give rise to ambiguity avoidance concept that consumers tend to avoid the technology that is unknown to them and they are uncertain about. This research showed that education, gender, age, and knowledge about science and technology, level of income, etc. can have a positive/negative impact on views towards applications of these technologies. In the case of nanotechnology applications for example, according to Roosen et al. (2011) consumers are avoiding nanotechnology applications if they exist in their food, but they seem to be accepting of nanotechnology applications when it involves packaging.

In the next chapter, the description of surveys for nanotechnology and genomics is undertaken and the socio demographic data analysis is presented. Chapter 4 presents further results and analysis of consumers' preferences, and calculates willingness to pay (WTP) for different food products produced and/or packaged by means of nanotechnology, and meats from animals bred using genomic applications. The results will suggest whether Canadians are willing to value these novel applications, and how their choices are impacted by their socio-demographic characteristics, and whether or not the findings of this study are different from other studies of the reviewed literature.

Chapter 3: Methods, Data Collection, and Descriptive Analysis

3.1 Introduction

In this chapter the data collection process, the stated preference model specification and the demographic characteristics of respondents for each sample are described. This chapter is organized as follows. A section discussing the details of data collection and design and analysis plan for each of the surveys will be followed by presenting the socio demographic and attitude characteristics from the surveys. The characteristics of each sample population will be discussed and where appropriate, compared to each other. Graphical analysis will be presented. Respondents' agreements with certain attitude statements will also be presented. The choice experiment methods, the data setup, and the model specification to be used for this study will also be described.

3.2 Data Collection

There were three surveys conducted online across Canada, including: nanotechnology in 2010, genomic information in cattle in 2012, and genomic information in pigs in 2012 in Canada in order to elicit Canadian preferences for juice produced by nanotechnology, pork chops and steaks that are produced from pigs and cattle bred using genomic information, respectively. In each case panelists maintained by a market research company were recruited for the respective surveys. There are several advantages to online surveys. The lower cost of the survey is the most common benefit of online surveys (compared to the additional costs of mail surveys or interviewer-administered surveys, etc.). The comparatively low cost of online surveys enables large sample sizes, and an increased potential for sub-group analysis and decreases sampling variance (Madge, 2006). The speed of data collection and ease of access is another advantage. Providing colours, innovative question displays, split screens, animation, sound tracks and other advanced

design features makes the survey more appealing for respondents (Fleming and Cook, 2007). The limitation of online surveys lies within non-random exclusion of individuals, without internet access, from the sample frame implying that certain social groups are underrepresented among internet users (Dillman, 2000).

The previous chapter identified several socio-demographic characteristics that impact consumers' preference elicitations (Roosen et al., 2011; Vandermoere et al., 2011; Matin et al., 2012; Schnettler et al., 2013). In order to address the second objective of this study, which is to understand the effect of socio-demographic characteristics on Canadian consumers' attitudes and their purchasing behaviour on foods from different novel technologies, several variables were chosen to be included in the analyses.

The socio-demographic characteristics included as independent variables are: gender (1=male, 0= female), age (in years), income (in thousands of dollars), education (in years), area (0=rural, 1=urban), region (dummy variables for Maritimes, Quebec, Ontario, Alberta, Manitoba, Saskatchewan and British Columbia), trust (1=if people can be trusted, 0=otherwise), children (1=if there are children under 18 living in household, 0=no). A dummy variable was created for each data on whether or not they have heard about the novel technology (nanotechnology or genomics) prior to survey (1=yes, 0=no). As mentioned in the literature prior familiarity with the technology seems to affect consumers' responses to food products from novel technology. The social indicator variables included self-rated extent of knowledge about science and technology (on a scale from 1 to 10), and belief in science and technology (on a scale from 1 to 10) has also been included following the literature (Bieberstein et al., 2013; Vandermoere et al., 2011).

An Animal Attitude Scale (AAS) (Herzog et al., 1991) is also used as an explanatory variable in the pork and beef analysis. The AAS assesses individual differences in attitudes toward the treatment of animals. It is probable that when the production technology changes for domesticated animals (e.g. pigs, cattle, etc.); people with certain level of animal attitude react positively/ negatively to the type of technology used. It would be

interesting to examine the type of technology that respondents may prefer in relation to their attitudes towards animals.

3.3 Choice Experiment Framework

In order to determine the probability that Canadian consumers will purchase a hypothetical product produced with different types of food novel technologies, stated preference methods were applied. Specifically for this study respondents were given a scenario describing a proposed novel technology produced food option that would alter the quality of the good of interest. They are then asked to choose the product at particular prices aimed at eliciting their preferences and from those their willingness to pay (WTP) can be calculated in dollar amounts. The questions often couple with follow up questions depending on their responses.

The advantage of this type of approach is that few prices were determined, so it makes the analysis simple and quick. It also gives the researcher to ability to elicit information only on whether a respondent's preference lies above or below a nominated price for a particular attribute. The reason for choosing this type of design is that it allows focusing on the interpretation of proposed alternative by moving from one price level to another rather than being faced with multiple choices of prices, and attributes. One of the main concerns for applying this approach is that it often requires larger sample because it collects less information from each respondent. Another area of concern is the follow-up question which is dependent on the response from the first question. The dependency of responses may reduce the accuracy of estimates.

3.3.1 Nanotechnology Survey

In the nanotechnology survey, two orange juice price levels of $1.75 and $2.5 per litre were chosen. Respondents were randomly given the lower or upper price. If their answer to the first price was positive/negative, then they would receive the relevant

higher/lower amount in a follow-up question. There is a maybe option in the nanotechnology survey which is considered as "no" option in the analysis.

There are two sets of questions in each survey – in the first set the respondent is asked to choose a product with higher functionality (higher vitamin content juice /UV-light protected bottle) and in the second set they are asked to choose a product with higher functionality, produced by means of a particular nanotechnology method. In the first set of questions in the nanotechnology survey, respondents are not given any information about the method of vitamin fortifications or packaging enhancement.

The survey design for the nanotechnology applications is shown in Table 3.1. The first set of questions asks the respondents, whether or not they wish to buy orange juice fortified with vitamin D, at the specific price. And at the same time they are asked whether or not they wish to buy orange juice in a plastic bottle that is fabricated to reduce UV-light exposures. Before they were given the second set of questions, the respondents were provided with information about nanotechnology, as shown below:

For the vitamin enhanced juice this information was provided:

"Nanotechnology refers to materials, systems and processes which exist or operate in the range of about 1 to 100 nanometers (nm). One nanometer (nm) is one millionth of a millimeter (mm). Materials at this scale show novel properties that lead to novel applications in diverse fields such as medicine, cosmetics, biotechnology, energy production and environmental science. There is uncertainty regarding how nanomaterials may interact with human health and the environment.

For the packaging enhanced juice this information was provided:

Nanotechnology offers new opportunities for food industry application. Manufactured nanomaterials are already used in some food products, nutritional supplements, and food packaging applications. Nanotechnology allows for the improvement of barrier functions in food packaging to reduce UV-light exposure or

microbial growth and thus extend the shelf-life of many food-products. Furthermore, nano-biosensors are able to control the food's level of freshness by indicating spoiled food to the consumers by means of colour change. There is not much known about the effects on Human health and environment."

They are then asked another two questions – the first being their choice of whether or not to purchase vitamin enhanced juice , the second being their choice of whether or not to purchase packaging enhanced juice, both produced by means of nanotechnology.

Table 3.1: Choice Set Questions in Nanotechnology Survey

Choice Set I

In what follows we will present you information about two pure orange juices sold in one litre bottles. On the market, the average price of this type of orange juice varies between $1.75 and $2.50 per litre.

"Orange juice A"	**"Orange juice B"**
This orange juice is fortified with vitamin D. According to scientific estimation, many Canadians have vitamin D intakes below recommendations as a result of inadequate intake and inadequate sunlight exposure.	This orange juice is filled in a plastic bottle that is fabricated in a way to reduce the juice's exposure to UV-light. Exposure to UV-light has an adverse effect on important food nutrients like vitamin C.
(Randomized selection of the price: lower value $1.75 or upper value $2.50) If lower Value Would you buy this product at a price of $1.75 per litre	(Randomized selection of the price: lower value $1.75 or upper value $2.50 Would you buy this product at a price of $2.50 per litre.
Yes / No	Yes / No
IF YES, would you buy the product if it were offered at a price of $2.50 per litre	IF NO, would you buy the product if it were offered at $1.75 per litre
Yes / No	Yes / No

Information about nanotechnology provided here

Choice Set II

Nanotechnology offers new opportunities for food industry application. Manufactured nanomaterials are already used in some food products, nutritional supplements, and food packaging applications.

<table>
<tr>
<td>“Orange juice A”
“Orange juice A” is fortified with vitamin D by means of nanotechnology. The vitamin D is enclosed in a nanoscale capsule that allows a better absorption and mobilization of the vitamin. According to scientific estimations, many Canadians have vitamin D intakes below recommendations as a result of inadequate intake and inadequate sunlight exposure.

(Randomized selection of the price: lower value $1.75 or upper value $2.50)
If lower Value
Would you buy this product at a price of $1.75 per litre?
<table><tr><td>Yes</td><td>No</td></tr><tr><td></td><td></td></tr></table>
IF YES, would you buy the product if it were offered at $2.50 per litre?
<table><tr><td>Yes</td><td>No</td></tr><tr><td></td><td></td></tr></table></td>
<td>“Orange juice B”
“Orange juice B” is produced by means of nanotechnology. The bottle is imbued with nano titanium dioxide particles that reduce UV damage of food nutrients. Exposure to UV-light has an adverse effect on important food nutrients like vitamin C.

(Randomized selection of the price: lower value $1.50 or upper value $ 2.50)

Would you buy this product at a price of $2.50 per litre?
<table><tr><td>Yes</td><td>No</td></tr><tr><td></td><td></td></tr></table>
IF NO, would you buy the product if it were offered at $1.75 per litre?
<table><tr><td>Yes</td><td>No</td></tr><tr><td></td><td></td></tr></table></td>
</tr>
</table>

3.3.2 Pork Survey

For the pork genomics survey the respondents were provided with a brief explanation about PCVAD, and PRRS diseases in pork, and their economic costs. Similarly to the nanotechnology survey, two levels of pork chop prices ($4.37 and $8.74 per kg) were selected and used in the first question, and based on the initial response, the respondents were asked in a follow-up question if they wanted to purchase the product at the other (higher or lower as appropriate) price level. In the first set of questions they are asked a choice between pork chops and pork chops with disease resistance – they could not say yes to both. After the first choice set in the pork survey some information specific to genomics was provided as below: (It should be noted that nothing specific to vaccination, another method of reducing disease susceptibility was provided).

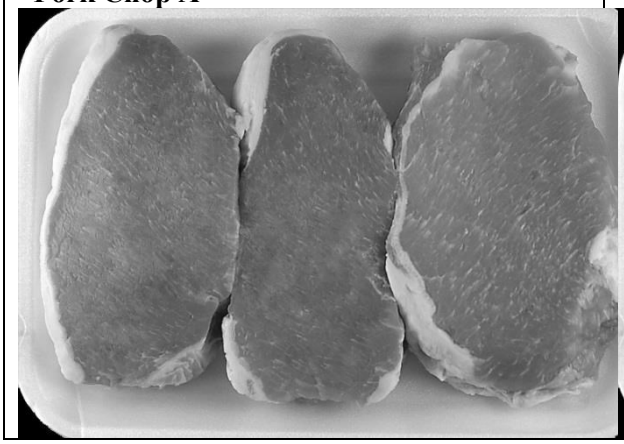
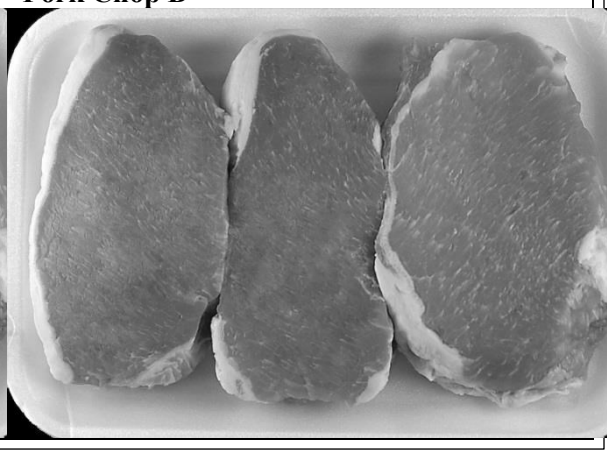
"Genomics is the study of the genes and genetic characteristics of organisms like plants, animals, and humans. The study of genomics in pigs can allow for the identification of specific genes that are linked to disease susceptibility. With knowledge of the presence (absence) of these genes, selective breeding can produce pigs with significantly lower probabilities of contracting PCVAD or PRRS. PCVAD and PRRS are both diseases that are spreading rapidly throughout the world. Traditional breeding techniques have not proven successful in enhancing disease resistance in the pigs. Treatments for the diseases, PCVAD and PRRS, currently include vaccination of the pigs."

Then the respondents were asked a second set of questions. In the second set of questions both pork chops have reduced disease susceptibility produced with different methods - vaccination or genomic selection (Table 3.2). People could choose the pork chops produced through genomic selection or the pork chops produced from pigs who had been vaccinated – they could not choose both. They were asked to choose at an initial set of prices and then subsequent to that were asked follow-up questions at a second set of prices relative to their first choices.

Table 3.2: Choice Set Questions in Pork Genomics Survey

Choice Set I

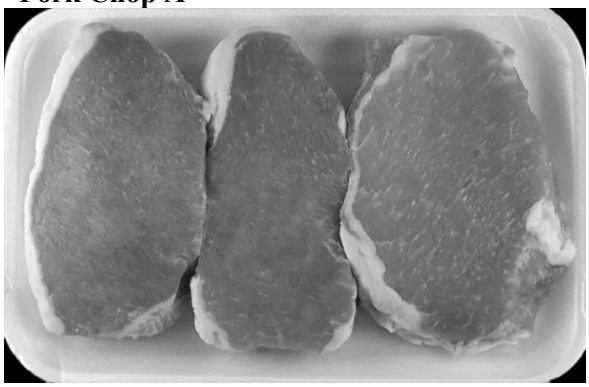
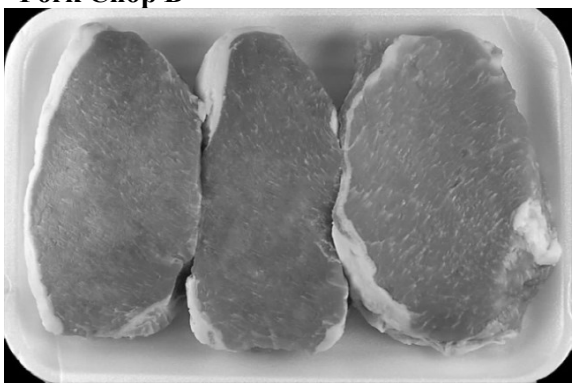
In what follows we will present you with information about two packages of pork chops, as sold in grocery stores. Currently, the average price of this type of pork chop is $4.37 per kg.

"Pork Chop A"	**"Pork Chop B"**
	

This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and are produced with no sub therapeutic use of antibiotics. (Randomized selection of the price: lower value $4.37/Kg or upper value $8.74) If lower value A. Would you buy this product at a price of $4.37 per kg Yes / No B. IF YES, would you buy the product if it were offered at a price of $8.74 per kg Yes / No	This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and are produced with no sub therapeutic use of antibiotics. In addition this hog is raised on a farm where the hogs have a significantly lower probability of contracting PCVAD or PRRS. (Randomized selection of the price: lower value $4.37/Kg or upper value $8.74) If higher value A. Would you buy this product at a price of $8.74 per kg Yes / No B. IF NO, would you buy the product if it were offered at $4.37 per kg. Yes / No
PCVAD and PRRS are both diseases that are spreading rapidly throughout the world. Traditional breeding techniques have not proven successful in enhancing disease resistance in the pigs. Treatments for the diseases, PCVAD and PRRS, currently include vaccination of the pigs. Information about genomics provided here	

Choice Set II

In what follows we will present you with information about two packages of pork chops, as sold in grocery stores. Currently, the average price of this type of pork chop is $4.37 per kg.

"Pork Chop A"	**"Pork Chop B"**
	
This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as a Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and there was no sub therapeutic use of antibiotics during the animal's life. This pork chop was produced from a pig that was bred using genomic information and is less susceptible to PRRS and PCVAD. (Randomized selection of the price: lower value $4.37/Kg or upper value $8.74) If lower value A. Would you buy this product at a price of $4.37 per kg Yes / No B. IF YES, would you buy the product if it were offered at a price of $8.74 per kg. Yes / No	This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as a Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and there was no sub therapeutic use of antibiotics during the animal's life. This pork chop was produced from a pig that has been vaccinated against PCVAD and PRRS. (Randomized selection of the price: lower value $4.37/Kg or upper value $8.74) If higher value A. Would you buy this product at a price of $8.74 per kg Yes / No B. IF NO, would you buy the product if it were offered at $4.37 per kg. Yes / No

3.3.3 Beef Survey

For the beef genomics survey, two levels of steak prices ($15.39 and $30.78 per kg) were also offered first, and based on the initial response, the respondents were asked if they wanted the product at the other (higher or lower as appropriate) price level. The respondents were provided with a brief explanation about methane emissions and economically sustainable beef production. Then they were given the first set of questions. The first set of questions asked respondents to choose between basic steak and steak by an animal which has produced 10-20% less methane – they could not say yes to both (Table 3.3).

In the second set of questions both steaks are from cattle raised on a farm where animals produce 10-20% less methane, with different methods – being vaccinated to eliminate the microbes in the rumen, to reduce greenhouse gas emissions, or the animal bred using genomic information which is 20% more feed efficient – they could not choose both. Before the second set of questions, there was brief information about genomics in cattle, and its application provided as below:

"Genomics is the study of the genes and genetic characteristics of organisms like plants, animals, and humans. 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."

Table 3.3: Choice Set Questions in Beef Genomics Survey

Choice Set I

In what follows we will present you with information about two packages of steak, sold in random weights. Currently, the average price of this type of steak is $15.39 per kg ($6.98/lb).

"Steak A"	**"Steak B"**
	
This steak is produced in a Canadian family beef cattle operation.	This steak is produced in a Canadian family beef cattle operation. The cattle are raised in a way that they produce between 10 and 20% less methane per animal. Methane is a significant contributor to greenhouse gas emission.
(Randomized selection of the price: lower value $15.39/kg or upper value $30.78/kg ($13.69/lb)) If lower Value A. Would you buy this product at a price of $15.39 per kg Yes / No B. IF YES, would you buy the product if it were offered at a price of $30.78 per kg. Yes / No	(Randomized selection of the price: lower value $15.39/kg or upper value $30.78/kg $13.69/lb) If Higher Value A. Would you buy this product at a price of $30.78 per kg ($13.69/lb) Yes / No B. IF NO, would you buy the product if it were offered at $15.39 per kg. Yes / No

Information about genomics provided here
Choice Set II

In what follows we will present you with information about two packages of steak sold in random weights. Currently, the average price of this type of steak is around $15.39 per kg.

"Steak A"

This steak is produced in a Canadian family beef cattle operation.

The cattle are raised on a farm where they produce between 10 and 20% less methane per animal, as compared to other cattle operations.

This steak was produced from a bovine animal that was bred using genomic information and is 20% more feed efficient, reducing greenhouse gas emissions.

(Randomized selection of the price: lower value $15.39/kg or upper value $30.78/kg ($13.69/lb))
If lower Value

A. Would you buy this product at a price of $15.39 per kg

Yes	No

B. IF YES, would you buy the product if it were offered at a price of $30.78 per kg.

Yes	No

"Steak B"

This steak is produced in a Canadian family beef cattle operation.

The cattle are raised on a farm where they produce between 10 and 20% less methane per animal, as compared to other cattle operations

This steak was produced from a bovine animal that has been vaccinated to eliminate the microbes in the rumen of the animal that produce the methane, reducing greenhouse gas emissions.

(Randomized selection of the price: lower value $15.39/kg or upper value $30.78/kg $13.69/lb)
If Higher Value

A. Would you buy this product at a price of $30.78 per kg

Yes	No

B. IF NO, would you buy the product if it were offered at $15.39 per kg.

Yes	No

3.4 Data Setup

Once the data were collected, they were recorded in Excel, 2010, adjusting gender codes to gender dummies, provincial codes to provincial dummies, rescaling education into number of years at school, etc. Then the data was stacked into one file containing all socio-demographics and food product characteristics as independent variables necessary for the analysis. The collected dummy variables were coded as 0/1, as some variables in the surveys were not originally in the format that could be used directly in the regression analysis. For the dependent variable the setup of data in nanotechnology survey is quite different than the data setup in genomic surveys.

In the nanotechnology survey, the preference for orange juice fortified with vitamin D, orange juice fortified with vitamin D produced by means of nanotechnology, orange juice packaged in UV light protected bottle, and orange juice packaged in UV light protected bottle imbued in nanoparticles are measured. The factors affecting Canadian consumers' choices, such as socio-demographic variables, attitudes towards science and technology, their knowledge about technological advances, and whether or not they have heard about nanotechnology prior to survey, as well as bid levels (price) are also analyzed. Each person saw two pairs of questions in 'Choice Set' I and II. The dependent variable is consumer's choice i (1 or 0) or (yes or no) in each choice question with regard to a randomly drawn price as the initial bid.

As a result the first row in setting up the data for each person belongs to the first bid with the randomized price, and the second row (depending on whether or not they said yes/no to the initial bid) is for the follow-up question with the drawn price selected dependant on what they saw on the initial bid price. For example if a sample respondent said yes to the first question at $2.5, then s/he wouldn't be given a follow-up question (would you buy the product at a higher price). If s/he has said no to the first price of $2.5, then they will be given the follow-up question at the lower price ($1.75). Also if s/he chose the orange juice at a lower price ($1.75) in the first question, then there would be a follow-up question to examine whether or not the respondent is willing to select the product at the

higher bid or not. Figure 3.1 shows an example of how the data was set up for the first 3 respondents in the nanotechnology survey.

Figure 3.1: Example of Data Set-up, Nanotechnology Survey

Respondent ID	Question	CHOICE	Price
1	1	0	2.5
1	2	1	1.75
2	1	1	2.5
3	1	1	1.75
3	2	0	2.5

In the pork survey, the preference for pork chops that are less susceptible to PCVAD and PRRS diseases, and for pork chops that are resistant to these diseases produced from animals bred by genomic applications as compared to pork chops in which the animals have been vaccinated against PCVAD, and PRRS are measured. The socio-demographic variables as well as general trust, knowledge, attitude towards science, familiarity with genomics, and animal attitude score (in pork) are also included the regressions. The dependant variable is consumer's choice *i* (*yes*, *no*, or *neither*). The price was determined based on which bid was randomly drawn first ($4.37 or $8.74) and based on the initial bid the respondent would be presented with a follow-up question. If the respondent chooses neither of the pork chops then the price would be 0. Figure 3.2 shows an example of how the data for the pork survey was organized.

For example, in the part of the pork survey called "Choice Set I" if a sample respondent have said yes to the pork chops that are less susceptible to PCVAD and PRRS diseases, in the first question at $8.74, then s/he wouldn't be given a follow up question (which is to buy a product at a higher price). If s/he has said no to the pork chops that are less susceptible to PCVAD and PRRS diseases, in the first question at $8.74, and yes to the conventional pork chops at $4.37, then they will be given the follow up question at the lower price ($4.37) for the pork chops that are less susceptible to PCVAD and PRRS diseases. Also if s/he chose the pork chops that are less susceptible to PCVAD and PRRS

diseases at a lower price ($4.37) in the first question, then there would be a follow-up question to examine whether or not the respondent is willing to select the product at the higher bid or not.

Figure 3.2: Example of Data Set-up, Pork Survey

Respondent ID	Question	Price	Choice
7	1	8.74	1
7	1	4.37	0
7	1	0	0
10	1	8.74	0
10	1	4.37	1
10	1	0	0
10	2	4.37	0
10	2	8.74	1
10	2	0	0
13	1	4.37	1
13	1	8.74	0
13	1	0	0
13	2	8.74	0
13	2	4.37	1
13	2	0	0

Like the pork survey, in the beef survey, the preference for steak bred from animals that produce less methane per animal, and the steak that is bred from an animal that is more feed efficient by means of genomics over steak produced from an animal that has been vaccinated to eliminate microbes that produce methane in cattle rumen. The socio-demographic variables, general trust, knowledge, attitude towards science, familiarity with genomics, and animal attitude score (in beef) are also included in the regressions analysis. The dependant variable is consumer's choice *i* (yes, no, or neither). The data setup was similar to the pork survey, with three price level ($15.39, $30.78, and $0). Each respondent was presented with the initial bid question, and based on their price level choice; where applicable they were given the follow-up question. Figure 3.3 shows an example of data setup in the beef survey.

Figure 3.3: Example of Data Set-up, Beef Survey

Respondent ID	Question	Price	Choice
13	1	30.78	0
13	1	15.39	1
13	1	0	0
13	2	15.39	1
13	2	30.78	0
13	2	0	0
14	1	15.39	0
14	1	30.78	1
14	1	0	0
15	1	15.39	1
15	1	30.78	0
15	1	0	0
15	2	30.78	1
15	2	15.39	0
15	2	0	0

For example, in "Choice Set I" section of the beef survey, if a respondent said yes to steaks bred from animals that produce less methane per animal, in the first question at $15.39, s/he would be given a follow-up question to examine whether or not the respondent is willing to select the product at the higher bid ($30.78) or not. If the respondent said yes to steaks bred from animals that produce less methane per animal at $30.78 in the first question, then there would be no follow-up question. If s/he does not choose steaks bred from animals that produce less methane per animal at $30.78, then a follow-up question would be given to the respondent at the lower price ($15.39).

As mentioned earlier data for the explanatory variables include price, socio-demographic variables such as: age, gender, level of education, level of income, presence of children under 18, the general trust indicator, living in rural areas and whether or not they have heard about the novel technology (either nanotechnology or genomics) prior to survey or not, their extent of knowledge about science and technology development, and to what extent science and technology would make our lives better off or worse off.

3.4.1 Inconsistency with Follow-up Questions

In the two-part question setup experimental frame, the main purpose of follow-up question is to provide the researcher with an understanding of the different types of responses to a proposed scenario (Curtis, 2001). Follow-up questions have previously helped improve researchers' understanding of respondents' intentions; however, it has been proven that it fails to create a complete awareness of respondents' motives. In some cases the difficulty in interpreting the follow-up question will lead the respondent to have ambivalence responses (Curtis, 2001).

In addition, a number of empirical studies have argued that there is often a lack of consistency between the initial and the follow-up responses (Alberini et al., 1997; Bateman et al. 2001; Cameron and Quiggin, 1994; Deshazo, 2002; Herriges and Shogren, 1996). Failure to correct for inconsistency can lead to false conclusions and inaccurate value estimates (Alberini et al., 1997; Chien et al., 2005; Kang et al., 2013).

Cameron and Quiggin (1994) discuss that the inconsistency pattern is often defines as the downward shift in the mean of second response. In other words, respondents tend to choose lower bids in their second responses more often than the initial bid. As a result, several behavioral motivations have been discussed to be the true reason for such pattern.

Carson et al. (1994) and Alberini et al. (1997) argue that respondents who initially say '*yes'* may refuse to pay the increased second amount because they feel that paying more than requested initially, for a specific product is a waste of money. Also, the respondents who reject the first offered bid may consider the lower second bid a sign of decreased quality of the product provided. The consequence of this explanation is that people are more likely to vote against the second offered bid regardless of whether they accept or reject the first offered bid. Mitchell and Carson (1989) argue that the respondents answer the first question truthfully but answer the second one strategically because they may feel that they are stuck in a bargaining situation when they are asked additional flexible prices. Thus, respondents try to lower the price by rejecting any additional prices. This argument implies that the respondents will be more likely to answer '*no'* to any

follow-up question, regardless of whether their true willingness to choose is higher or lower than the follow-up bid. Understanding the behavioral motivation of respondent choices helps the researcher better decide how to analyze and control potential sources of inconsistency (Kang et al., 2013).

Adopting the same argument in this thesis to the data for the nanotechnology, pork, and beef surveys, it can be argued that the chance of inconsistency is probable within the data sets. Although both the initial and follow-up choices are made by one person, the second response is very much dependant on the initial response. As a result the first and second choices are correlated and are not independent. Conditional logit and random parameter logit models assume independency in choices. Since this condition cannot be held, because of correlation of initial and follow-up choices, logit analysis might not be appropriate and it might give inaccurate and inefficient estimates.

In order to solve the inconsistency of responses, and increase the accuracy and efficiency of estimates two different approaches can be suggested in the surveys:

1- In the nanotechnology survey: In this approach in the nanotechnology survey, the second row questions (follow-up responses) for each respondent were deleted. A dummy variable for each orange juice attribute (vitamin D fortified, vitamin D fortified produced by means of nanotechnology, UV-protected juice bottle, and UV-protected juice bottle imbued by nanoparticles) was created, and the data was stacked together in the order of respondents identification number, so that the number of observations are four per each respondent. Conditional logit, and mixed logit models would then be used to estimate the relative preferences of Canadian respondents for different types of orange juices as compared to the vitamin D fortified juice without any technology involved.

2- In the pork and beef surveys:

a- In this approach, in the pork survey, the follow-up question for each pork attribute (I. Pork chops that are less susceptible to PCVAD and PRRS diseases, and attribute II.

Pork chops that are resistant to these diseases produced from animals bred by genomic applications) were deleted. Then conditional logit and random parameter logit models would be applied for each of the pork attributes.

b- In the beef survey, similar to the pork survey, the follow-up question for each steak attribute (I. Steaks bred from animals that produce less methane per animal, and II. Steak that is bred from animals that are more feed efficient by means of genomics) was deleted and then conditional logit and random parameter logit models would be employed for each steak attribute.

3.5 Model Specification

Models with discrete dependent variables are frequently specified as index function models (McFadden, 1973). In most of the studies of this sort, the values taken by the dependent variables are merely a coding for some qualitative outcome (Greene, 2008). This type of choice model data can be defined in a way that each respondent tries to maximize the difference between 2 or 3 options (in this thesis) on an underlying scale of importance (Lusk and Briggeman, 2009). As mentioned previously in chapter 2, the utility of respondent i would be $U_{ij} = W_i + \varepsilon_{ij}$, which is based on information choice. W_i is the deterministic component, and ε_{ij} is the error component in the utility function. If he or she chooses j, it must be the one yielding the highest utility (Huffman et al., 2004).

The probability of an individual *n* choosing alternative *i* from a set of alternatives *j* can be estimated using a conditional logit model (CL). The estimated probabilities are taken to be a linear function of specific characteristics in which their random error term is identically and independently distributed (*iid*) (Greene, 2008; Lusk and Briggeman, 2009; Ndunda and Mungatana, 2013).

Therefore, the estimated probabilities in this case are:

$$\text{Prob}\,(Y_i = j \mid W_i) = P_{ij} = \frac{\exp(W_i \alpha_j)}{\sum_{j=1}^{J} \exp(W_i \alpha_j)}, \quad j = 1,2,3 \quad \text{(Greene, 2008)}$$

As a result, based on the characteristics of the data that exist in this study, one of the methods (as reviewed in earlier chapter) used is a conditional logit model to analyze the data. The regression models estimated would be:

-For the nanotechnology survey:

$$U_{ij}\,(Choice) =$$
$$\beta_{pr}\,Price + \beta_{Vit\ D\ Nano}\ \text{Vit D Nanotechnology} + \beta_{Vit\ C\ no\ nano}\ \text{Vit C no Nanotechnology} +$$
$$\beta_{Vit\ C\ nano}\ \text{Vit C Nanotechnology} + \beta_{Vit\ D\ nano\_soc_i}\ \text{Socio\_D}emographics \times$$
$$\text{Vit D Nanotechnology} + \beta_{Vit\ C\ no\ nano\_soc_i}\ \text{Socio\_D}emographics \times$$
$$\text{Vit C no Nanotechnology} + \ldots + \beta_{Vit\ C\ nano\_soc_i}\ \text{Socio\_D}emographics \times$$
$$\text{Vit C Nanotechnology} + \varepsilon_{ij}$$

Since the choices are 1 or 0 (*yes* or *no*), a binomial conditional logit model can be used. In this regard, three willingness to pay calculations can be obtained after regression estimation: WTP (Vitamin D fortified juice with nanotechnology), WTP (UV-protected juice bottle), and WTP (nanotech packaged UV-protected juice bottle). Hence, expected willingness to pay can be calculated by: $E[C_i] = \beta_0 + \beta_1 X_{1i} + \cdots + \beta_K X_{Ki} - \gamma P_i$ for the sample average, so that WTP $= {}^{\alpha_0}/_{\gamma}$. $\alpha_0 = \beta_0 + \beta_1 X_{1i} + \cdots + \beta_K X_{Ki}$.

-For the pork survey:

$$U_{ij}\,(Choice) = \beta_{pr}\,Price + \beta_{Pork\ Attribute}\ \text{Pork Attribute I} + \beta_{Ni}\,Neither\ Option + \beta_{Pork\ Attribute\_soc_i}\ Demographics \times Pork\ Attribute\ I + \cdots + \varepsilon_{ij}$$

$$U_{ij}\,(Choice) = \beta_{pr}\,Price + \beta_{Pork\ Attribute}\ \text{Pork Attribute II} + \beta_{Ni}\,Neither\ Option + \beta_{Pork\ Attribute\_soc_i}\ Demographics \times Pork\ Attribute\ II + \cdots + \varepsilon_{ij}$$

Pork attribute I, refers to the "pork chops that are less susceptible to PCVAD and PRRS diseases". Pork attribute II refers to the "pork chops that are resistant to these diseases produced from animals bred by genomic applications". In the pork choice models, two WTP calculation measures will be resulted after regressions estimations. These alternatives are labelled as: WTP (Less disease susceptible pork chop), WTP (Pork chop bred by genomic application).

-For the beef survey:

$$U_{ij}\,(Choice) = \beta_{pr}\,Price + \beta_{Beef\ Attribute}\ \text{Beef Attribute I} + \beta_{Ni}\,Neither\ Option + \beta_{Beef\ Attribute\_soc_i}\ Demographics \times Beef\ Attribute\ I + \cdots + \varepsilon_{ij}$$

$$U_{ij}\,(Choice) = \beta_{pr}\,Price + \beta_{Beef\ Attribute}\ \text{Beef Attribute II} + \beta_{Ni}\,Neither\ Option + \beta_{Beef\ Attribute\_soc_i}\ Demographics \times Beef\ Attribute\ II + \cdots + \varepsilon_{ij}$$

Likewise, beef attribute I, refers to the "steaks bred from animals that produce less methane per animal". And steak attribute II refers to the "steak that is bred from animals that are more feed efficient by means of genomics with less methane emissions". Also in beef survey, two WTP calculation measures would be resulted after regressions estimations labelled as: $WTP_{(\text{Less Methane emission produced steaks})}$, WTP (Steak more feed efficient bred by genomic application).

One of the challenging issues in this study is that there could be heterogeneity in the individuals' choices associated with the attributes and consumer's characteristics. Models that incorporate heterogeneity in consumer's preferences include random parameter logit (RPL) models. The random parameter logit model (McFadden and Train, 2000), allows for a heightened level of flexibility by specifying the taste coefficients to be randomly distributed across decision-makers and hence gives unbiased estimates in the presence of preference heterogeneity among respondents and is a fairly common approach in modeling choice behavior (Greene, 2008; Nahuelhual et al., 2004; Ndunda and Mungatana, 2013; Train, 1998).

According to McFadden and Train (2000) a mixed logit (random parameter logit) model is defined as a multinomial logit model with random coefficients, drawn from a cumulative distribution function G (α; θ) as follows:

$$P_C(i|x,\theta) = \int L_C(i;x,\alpha).\, G(d\alpha;\theta) \text{ with } L_C(i;x,\alpha) = e^{x,\alpha} / \sum_{j\in C} e^{x_j\alpha}$$

In this setup, C = {1,…, J} is the choice set; the xi are 1 × K vectors of functions of observed attributes of alternative *i* and observed characteristics of the decision maker, with $= (x_1, \ldots, x_j)$; α is a K× 1 vector of random parameters; $L_C(i;x,\alpha)$ is a MNL model for the choice set C; and θ is a vector of deep parameters of the mixing distribution G. The random parameters α may be interpreted as arising from taste heterogeneity in a population of MNL decision makers. If the x_i contain alternative-specific variables, then the corresponding components of α can be treated as alternative-specific random effects. Alternately, the model may simply be interpreted as a flexible approximation to choice probabilities generated by a random utility model (McFadden and Train, 2000).

In this approach, α_i is specified as a random variable that is normally distributed across the sampled respondents following a normal density function $f(\alpha)$ with mean α_{i0} and standard deviation $\sigma_{\alpha i}^{i}$. The choice probability becomes: $P'_{ni} = \int P_{ni}\, f(\alpha)\, d\alpha$ (Veeman and Adamowicz, 2004; Onyango and Rodolfo, 2004).

The probability of individual *n* choosing alternative *i* from a set of alternatives *j* in RPL model can be estimated as below:

$$\text{Prob}\,(Y_i = n) = \frac{\exp\left[W\left(X_n(\gamma + \delta_i)\right)\right]}{\sum_{j=1}^{J} \exp\left[W\left(X_j(\gamma + \delta_i)\right)\right]} \;;\; U_{in} = W\left(X_n(\gamma + \delta_i)\right) + \varepsilon(X_n)$$

Where W and $\varepsilon(X_n)$are deterministic and error components, respectively, and γ is a parameter which varies by random component δ due to preference heterogeneity across individuals (Train, 1998).

The model is estimated by simulating the log-likelihood function rather than direct integration to compute the probabilities (Train, 2003). In this study, this simulated log-likelihood function, was evaluated at 50 pseudorandom Halton draws, in which the random draws are orange juice, pork, and beef attributes mentioned above.

When the price of selecting an alternative is included as an attribute, an estimate of WTP (willingness to pay) can be yielded for an attribute as below, which is used to calculate WTP in nanotechnology, beef and pork surveys (Ndunda and Mungatana, 2013, p. 51):

$$\text{WTP} = -\left(\frac{\beta_{\text{attribute j}} + \sum \beta_{\text{attribute j} \times \text{interactions}}}{\beta_{\text{price}}}\right)$$

3.6 Data Analysis

Analysing the socio demographic data across three surveys, there were 830 respondents in the nanotechnology survey, 1568 respondents in pork, and 1663 respondents in the beef surveys. Each survey consisted of different sections including descriptions of respondents' food in their everyday life, their opinion about food safety, environment, science and technological development, animal attitudes, choice questions, and some background information questions. Table 3.4 provides the summary statistics for surveys' respondents and related census information about the Canadian population in 2006 and 2011 (only voluntary and possibly unrepresentative) data.

Most respondents stated that they had limited knowledge of science and technology developments. Only 56%, 44%, and 46% in the nanotechnology, pork, and beef genomics surveys, respectively, self-assessed as having a great deal of knowledge about science and technology developments. In all three surveys, Canadian respondents exhibited a high level

of agreement that science benefits society (mean response of 7.2, 6.3, and 6.5 in the nanotechnology, pork, and beef genomics surveys, respectively, (on a 1-10 scale (1= "the world is a lot worse off", and 10= "the world is a lot better off.")).

In the nanotechnology, pork, and beef genomic surveys, 27%, 25%, and 21% of the population, respectively, have children under 18 in their households. A general trust variable, derived from the General Social Survey (GSS) used in Canada and the United States exhibits results similar to other national surveys (Statistics Canada, 2008) (Generally speaking would you say that most people can be trusted? Responses: People can be trusted; you can't be too careful in dealing with people; don't know) with around 40%, 45%, and 49% of respondents, in the nanotechnology, pork, and beef genomic surveys, respectively, believing that 'other people can be trusted' as compared to 47.06% of the population in GSS (2008) who believed 'other people can be trusted'.

The demographic variables of the national samples are compared to Canadian population census data from 2006 and 2011. The nanotechnology sample has 2% fewer females than males. Census population 2006 and 2011 have more females than males. Pork and beef samples have 28% and 42%, more females than males, respectively, as compared to 2% more females in census populations from 2006 and 2011. The samples consist of respondents ranging from 15 to 65 plus (average age is 49 to 53). The percentage of respondents who are 65 plus in the beef sample is 21.7% as compared to 16.3% and 14.2% in the pork and nanotechnology samples, respectively. The 65 plus population percentage is 13% and 15% for census 2006 and 2011, respectively. Respondents in the three samples are somewhat older than the census populations, with 94.3%, 95.7%, and 98.2% of the nanotechnology, pork, and beef samples, respectively, being of 25 years and older as compared to 67% and 71% of the census populations in 2006 and 2011, respectively. In all three samples, respondents have a mean level of education of 14 years (equivalent to having completed college) with 62%, 60%, 66% of the nanotechnology, pork, and beef samples, respectively, having a college or university degree. People in the samples have slightly higher education levels than people in the census population (60% in 2006, and 59% in 2011 census).

Table 3.4: Socio-Demographic Characteristics of Canadian National Survey Respondents (N=830, Nanotechnology Survey; N=1568, Pork Survey; N=1663, Beef Survey)

Variable	Definition	Nanotechnology Survey (2010) (%)	Pork Survey (2012) (%)	Beef Survey (2012) (%)	Census, 2006 (%)	Census, 2011 (%)
Gender	Male Female	51 49	36 64	29 71	49 51	49 51
Child	If child under age of 18 living in household	27	25	21	-	-
Trust	If people can be trusted	40	45	49	-	-
Urban Areas	If resides in a city >100.000 inhabitants/ or 1 if resides in a town > 10.000 inhabitants	84	80	86	81	81
Rural	If resides in the countryside/rural district	16	20	14	19	19
Maritimes	If resides in Maritimes	7	8	6	8	7.7
Quebec	If resides in Quebec	24	25	25	24	23.6
Ontario	If resides in Ontario	38	33	37	38	38
Manitoba	If resides in Manitoba	3	5	5	3.6	3.6
Saskatchewan	If resides in Saskatchewan	2	4	4	3	3.1
Alberta	If resides in Alberta	13	10	9	10.4	11
British Columbia	If resides in British Columbia	13	15	14	13	13
Heard of Nanotechnology *prior to survey*	If yes	46	-	-	-	-
Heard of Genomics *prior to survey*	If yes	-	39	44	-	-
Belief in Science and Technology	Scale of agreement from 1 (society is a lot worse off) to 10 (society is a lot better off) (Mean in %)	72	63	65	-	-
Extent of knowledge about science and technology developments	Scale of agreement from 1 (you have little knowledge) to 10 (you know a lot) (Mean in %)	56	44	46	-	-
Animal Attitude Scale (AAS)	Summated scale from 13 to 65 (Mean reported)	-	41.9	42.1	-	-
Age	15-19	0.8	1	0.4	7	6

	20-24 25-29 30-39 40-49 50-64 65 plus	4.9 7.7 14.6 19.7 38.1 14.2	3.3 5.7 14.5 17.4 41.8 16.3	1.4 4.8 16.4 15.7 39.6 21.7	7 6 13 16 19 13	7 7 13 15 21 15
Education	Elementary school Secondary high school College degree University degree Post graduate	2 28 36 26 8	1.5 32.6 36.7 23.2 6	0.6 23.1 34.2 31.7 10.4	13 23 36 24 4	12.7 23.2 34.1 24.9 5.1
Income	$ 24999 or under $ 25000 - 39999 $ 40000 - 64999 $ 65000 - 79999 $ 80000 - 99999 $ 100000 - 119999 $ 120000 or more	10 15 26 16 15 9 9	9.7 18 23.8 17.7 13.5 8.9 8.4	11.1 17 22.9 14.3 12.8 9.9 12	10 14 28 15 12 10 12	9 14 27 16 11 10 13

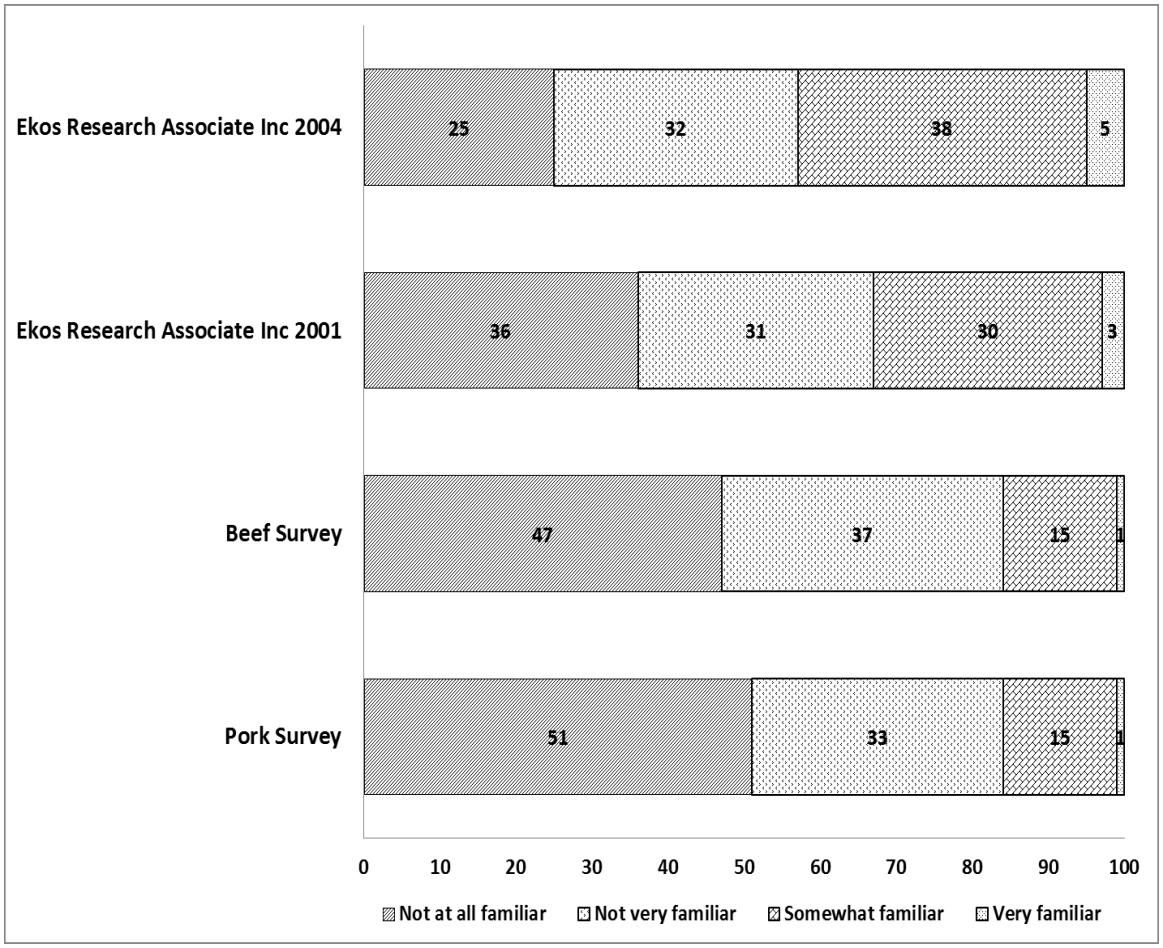
The samples in this study had quite similar percentages of respondents from different regions while comparison to the population censuses of 2006 and 2011 showed that people living in Maritimes in the beef sample are 2% fewer than the census populations would suggest. Respondents who live in urban areas (cities and towns) consisted of 84%, 80%, and 86% of the people in the nanotechnology, pork and beef surveys, whereas the census populations of 2006 and 2011 both suggest that 81% of the population being urban. The nanotechnology and beef samples each have slightly higher percentages of urban residents than the census data. The range of household incomes in all three surveys is higher than the census data from 2006 and 2011, implying that more respondents have an annual income of $40,000-$99,000. In summary, people in the surveys are older, more female, better educated, and richer, which represents a better sample of respondents.

3.6.1 Familiarity with Nanotechnology or Genomics

Respondents were asked whether they had heard of nanotechnology, and genomics prior to the survey and about their familiarity with these technologies. Approximately 44% of the respondents in the beef survey and 39% in the pork survey had heard about genomics prior to the survey as compared to Ekos Research Associates Inc. in 2001 and 2004, in which 64% and 75% of the respondents, respectively, had heard about genomics. The majority of respondents (54% in the nanotechnology survey) had never heard about this technology earlier which indicates that more people have familiarity with genomics than nanotechnology. About 47% of the respondents in the beef survey and 51% in the pork survey stated that they were not at all familiar with genomics, 37% in the beef survey and 33% of the respondents in the pork survey were not very familiar, 15% in both surveys were somewhat familiar and only 1% in both surveys were very familiar with genomics. The familiarity percentages are compared to studies conducted by Ekos Research Associates Inc. in 2004 and 2001 (same questions asked), and it seems that more respondents in the current surveys stated that they are not familiar with genomics and fewer respondents stated that they are somewhat familiar with genomics (Figure 3.4). This

shows that the number of Canadians who are very familiar with genomics remains very small. Since majority of the respondents in all three surveys are not very familiar with these two novel technologies it might cause them ambiguity in the choices they make when they are presented with food products produced by means of these two technologies.

Figure 3.4: How would you describe your familiarity with genomics? (Beef and Pork Survey)



3.6.2 Animal Attitude Scale (AAS)

The animal attitude scale has been used to explain avoidance of meat products (Herzog and Golden, 2009) previously but has not been used to describe public's acceptance of the particular technologies considered in this study as used in livestock production.

Meat production systems are changing, led by market demand for higher intrinsic quality, better animal welfare, care for the environment and sustainability (Verbeke et al., 2010). Some of these novel technologies which are primarily reproductive technologies (i.e. cloning, genomic applications, etc.) are appealing to ranchers and farmers because they enable them to more quickly breed desirable traits into their herds (Paterson et al., 2003). Genetic improvements allow producers to potentially lower prices, to increase the quality of products (i.e. meat or milk), and possibly to increase resistance to diseases (Paterson et al., 2003; Wall et al., 2005). However, consumers and animal welfare organizations oppose the technologies on moral and ethical grounds, and on concerns about food safety (Mellman Group, 2006; Storey, 2006). It has also been shown that consumers view high animal welfare standards at the production stage as an indicator that the resulting food is safe, healthy and of high quality (Fallon and Earley, 2008; Weddle-Schott, 2009).

Animal attitudes have been measured in a variety of ways including the animal attitude scale (AAS) that is based on statements about perceptions about the use of animals and how they are treated (e.g. Herzog et al., 1991; Armstrong and Hutchins, 1996)). There are differences in the ways in which people define good treatment of animals. Some people regard eating flesh from animals, use of animals in research and activities such as sport hunting as being cruel and unreasonable (Mathews and Herzog, 1997).

Animal attitudes (Herzog et al., 1991) might influence public acceptance of the use of genomics for disease resistance and increased feed efficiency or vaccination for disease prevention and reduced methane production in animals. A priori it isn't clear whether or

not people who have higher levels of concern about the use of animals might be more appreciative of the use of genomics/vaccination or not. Public acceptance of such technologies is important for their adoption by producers. Previous analyses of public acceptance of technologies in terms of meat consumption, has not accounted for animal attitudes. Since there is limited literature on linkages between animal attitudes and public's opinion about using vaccination or using genomic information for selective breeding for improved disease resistance and increased feed efficiency, in food animals, this thesis can examine whether or not there is a link between people's purchasing intent of using genomics information to improve disease resistance in pigs and increase feed efficiency/reduce methane production in cattle, and their attitudes towards animals.

Elements of AAS developed by Herzog et al. (1991) are used to assess differences in people's attitudes with respect to treatment of animals. It is composed of items which subjects rate on a five-point Likert scale (1- strongly agree to 5- strongly disagree). The items are scored so that a high score indicates pro-animal welfare attitudes. The thirteen statements used in the calculation of the AAS for the pork and beef surveys are shown in Table 3.5. Questions 3, 4, 5, 6, 9, 10 were reversed (Figure 3.5) to assess whether the individual supported the use and good welfare of animals.

Cronbach's alpha values for the thirteen statement scale were 0.775 for the beef survey and 0.774 for the pork survey which indicates high internal consistency. Given a maximum AAS score of 65, the mean AAS score is 42.04 (sd = 7.73) for the beef survey and 41.96 (sd = 8.00) for the pork survey which shows that people generally support good treatment of animals. Results on net agreement percentages[4] (Roselius, 1971) (Figure 3.5) show that most people agreed that one of the worst things someone can do is to hurt a defenseless animal and that the slaughter of whales and dolphins should be immediately stopped even if it means some people will be put out of work. Most people did not agree with the statement which stated that "I do not think that it is perfectly acceptable for cattle and hogs to be raised for human consumption" and that "hunting wild animals for food is

[4] Net agreement percentage = ((number of people who gave responses of agree and strongly agree − number of people who gave responses of strongly disagree and disagree)/sample size)*100

morally wrong". Results show that most people value animal welfare i.e. they have positive attitudes towards animals. After reversing responses to certain statements, responses to the questions outlined were summed in order to create a single AAS score. Figure 3.6 illustrates the distribution of the animal attitude scores across respondents in beef and pork surveys with majority of the respondents having AAS score between 31 and 50.

Table 3.5: Assessment of Animal Attitudes

No.	Statement
i	It is morally wrong to hunt animals for sport
ii	Wild animals, such as mink and raccoon, should not be trapped so that their skins can be made into fur coats
iii	There is nothing morally wrong with hunting wild animals for food
iv	I think people who object to raising animals for meat are too sentimental
v	I think it is perfectly acceptable for cattle and hogs to be raised for human consumption
vi	Basically, humans have the right to use animals as we see fit
vii	The slaughter of whales and dolphins should be immediately stopped even if it means some people will be put out of work
viii	I sometimes get upset when I see wild animals in cages at zoos.
ix	Too much fuss is made over the welfare of animals these days when there are many human problems that need to be solved
x	Continued research with animals is necessary if we are ever to be able to conquer diseases such as cancer, heart disease and AIDS.
xi	It is unethical to breed purebred dogs for pets when millions of dogs are killed in animal shelters each year.
xii	The production of inexpensive meat, eggs and dairy products justifies maintaining animals under crowded conditions
xiii	One of the worst things someone can do is to hurt a defenceless animal

Note: Questions were adopted from Herzog et al. (1991)

Figure 3.5: Animal Attitude Score (*Net Agreement Percentage*)

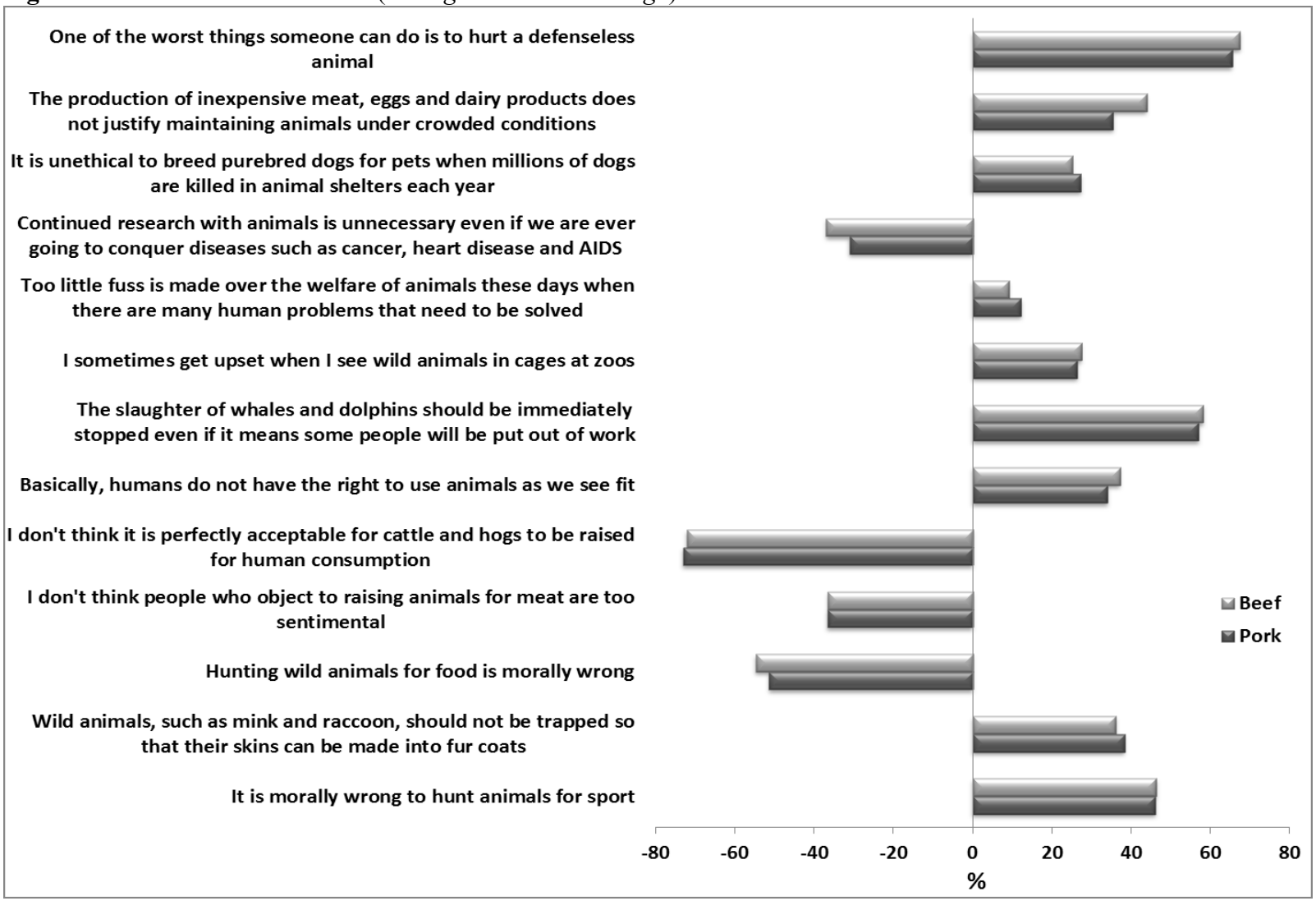
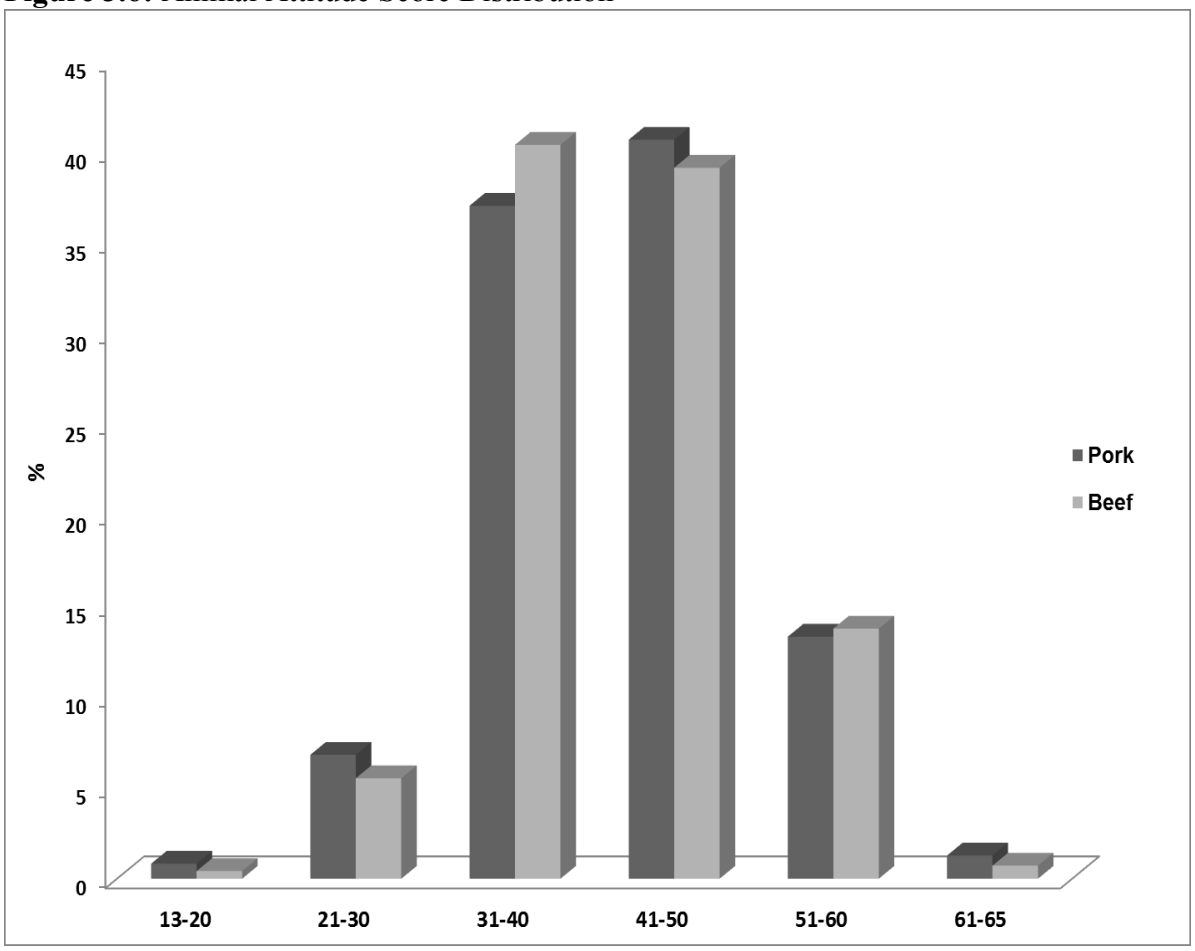


Figure 3.6: Animal Attitude Score Distribution



3.7 Descriptive Analysis of Perception of Health Risks, and Attitudes towards Animal Vaccination

The main purpose of the descriptive results discussed in this section is to identify the general understanding of survey respondents as to what limit they are concerned about food additives, supplements, and what their general level of agreement is about animal vaccination. It also gives a general idea of what the majority of respondents believe is risky, and how this general perception might affect their preference for different food products by nanotechnology and genomics. The descriptive results discussed in this section will not be used in regression analyses.

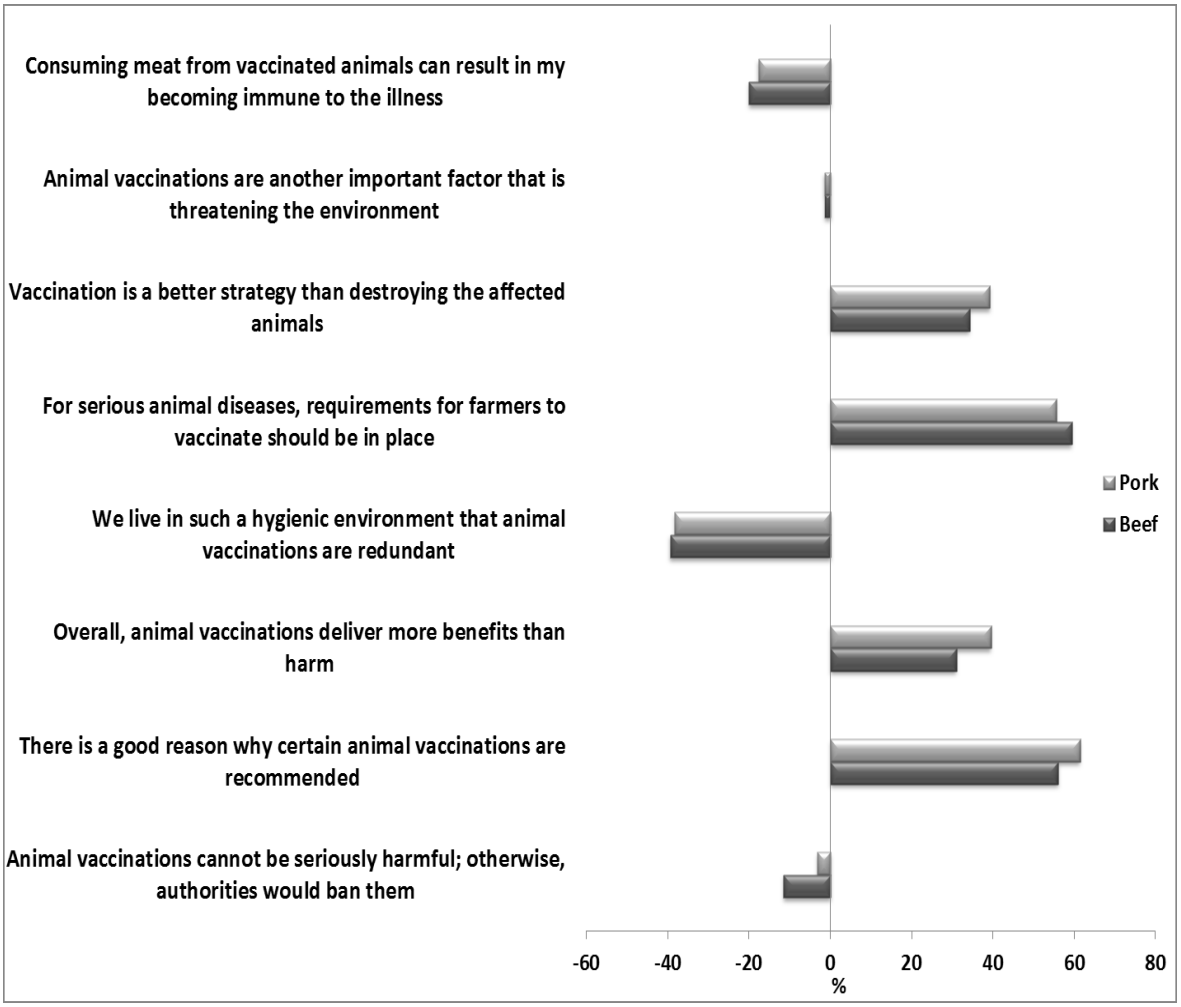
As part of information asked in the three questionnaires, most Canadian respondents are very to somewhat confident (81% in the nanotechnology survey, 89% in beef and 90% in pork genomics surveys) that the food they purchase is not harmful for them. Net agreement percentages (Roselius, 1971) were calculated to compare people's agreements with a series of statements about issues of interest. Net agreement percentages compare respondents that feel strongly about a certain issue to those who do not. High percentages indicate that many people agree with the statement, zero implies that the numbers of people who feel strongly about the statement are equal to those who do not while negative numbers indicate that most people strongly disagree with the statement.

There are a series of questions in both beef and pork genomics surveys regarding respondents' opinions on vaccination. Since in willingness to pay questions vaccination is used as the alternate technology to the use of genomics, it is important to understand the general agreement of respondents on animal vaccination subject. People's attitudes towards vaccination have been shown to influence their willingness to consume/pay for meat from animals vaccinated for diseases. Previous literature has shown that although animal vaccinations were highly accepted among people, only a small percentage of them would eat meat from vaccinated animals (Zingg and Siegrist, 2012). As a result it would be interesting to examine to what extent Canadian survey respondents agree different aspects

of animal vaccination, and whether or not they would actually be willing to choose vaccinated meat product.

Figure 3.7 indicates that majority of Canadians agree that for serious animal diseases, farmers are required to vaccinate and that there are certain reasons for the recommendation of animal vaccinations. Most of the respondents disagreed that animal vaccinations were redundant.

Figure 3.7: Animal Vaccination (Net Agreement Percentage)

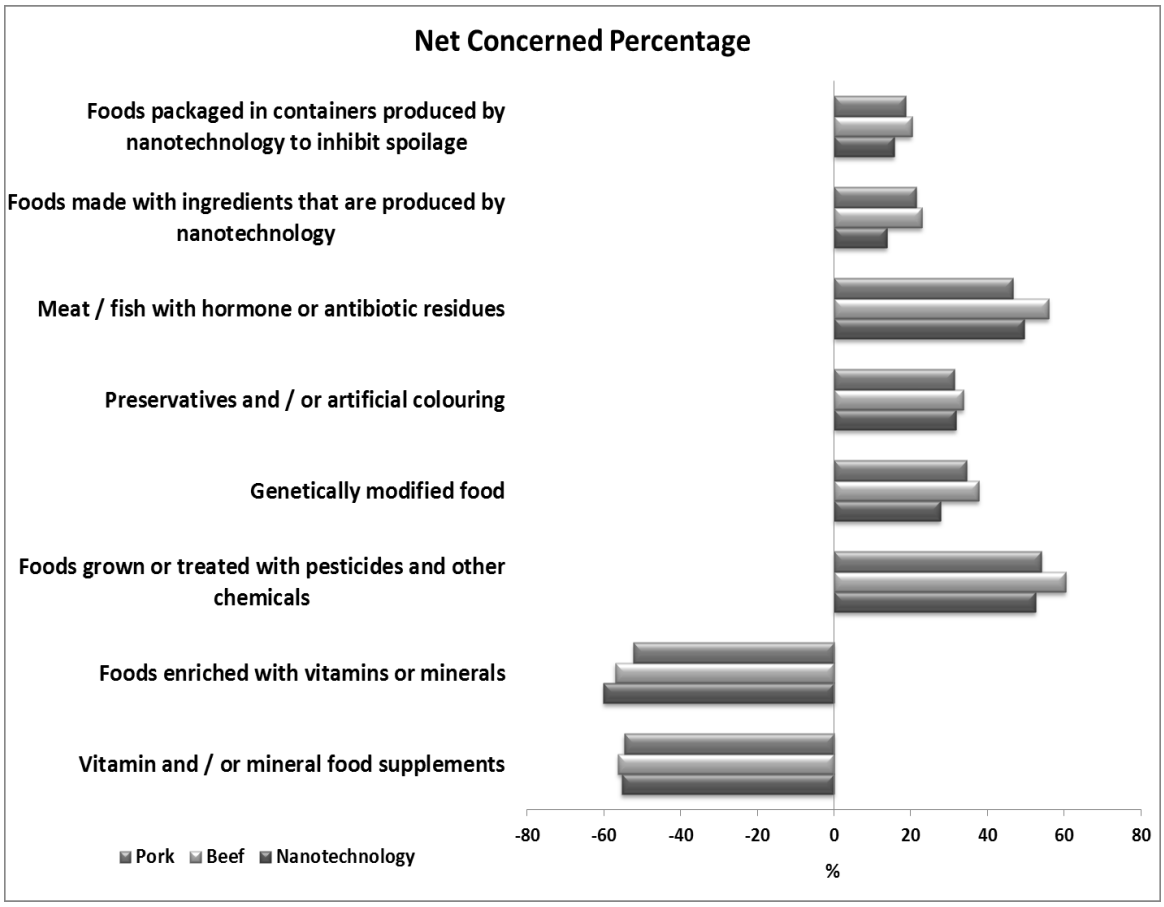


In order to assess the importance of consumers' rankings of different novel technologies, "net concerned percentage" (NCP) is evaluated, through a bunch of different statements. If the percentage is largely positive, the NCP would suggest that respondents are really concerned about the issue, and zero or negative value suggest consumer's lack of concern. The method was done to provide an effective ranking of the issues which cause serious concerns in the questionnaires (Muringai and Goddard, 2011). Following Roselius (1971), the net concerned percentage were calculated as:

$$NCP = (\text{number of "concerned" [extremely concerned + concerned] response} - \text{number of "unconcerned" [not at all concerned + little concerned] responses}) / \text{sample size} \times 100$$

The net concerned percentage analysis results (Figure 3.8) in all surveys, also implies that the majority of Canadian consumers (55%) are least concerned about vitamins and mineral food supplements and foods enriched with vitamins/minerals as compared to other food issues. However, the respondents were extremely concerned about foods grown or treated with pesticides and other chemicals, meat or fish with hormone/antibiotic residues, preservatives or artificial coloring, respectively. Only 25% of the Canadian respondents had concerns over genetically modified food (GMOs), foods made with ingredients that are produced by nanotechnology, or foods packaged in containers produced by nanotechnology.

Figure 3.8: How do you rate the health risks for consumers of regular consumption of the following? (Net Concerned Percentage)



3.8 Chapter Summary

This chapter covered descriptive analysis as well as the methods of analysis, choice experiments design, and the model specification of this thesis. In terms of socio-economic variables, the excess percentage of female respondents in pork and beef sample might be a problem with the data that precludes the generalizability of the results regarding gender effects, as in the census populations the percentage share of male/female is more equal.

The regional distribution is quite similar to the population censuses of 2006 and 2011 in all three samples. However, the surveys samples have slightly more highly

educated respondents than the census populations. Comparing the Ekos Research Associates Inc. (2004) results to the current beef and pork surveys, the percentage of people familiar with genomics are fewer than respondents in 2004 research.

A somewhat complex relationship seems to exist between people's attitudes and behavior towards animals, and public acceptance of genomic technologies used in pigs and cattle. In terms of the risks that concern them about their food, respondents expressed their concerns about foods treated with pesticides or other chemicals, hormone/antibiotic residues, preservatives or artificial coloring. The descriptive results in section 3.7 were used to understand what Canadian consumers in general believe regarding different aspects of food additives such as hormones or supplements, or animal vaccination. The descriptive results can be compared to estimation results to see whether or not the general outcome of respondents' agreements or concerns related to risks from certain products, and/or vaccination approve the probability of the choice they make.

Data setup, model specification, and the probabilities of the responses being estimated were also discussed. The estimation approaches have been specified to be conditional logit, and random parameter logit models and these models will be used subsequently for nanotechnology, pork and beef regression estimations. The results of the estimation models and willingness to pay (WTP) calculations will be presented in the next chapter. The ambiguity avoidance effect will also be calculated as the percentage of those individuals who had positive WTP for a specific product when no novel technology was identified, shifted to negative WTP when the technology was introduced in the food product (nanotechnology or genomics). It is important to notice that the results depicted in the next chapter are hypothetical, and in other research different approaches or using real data could be undertaken.

Chapter 4: Results

4.1 Introduction

This chapter contains the econometric analysis of the data from the juice produced by means of nanotechnology survey conducted in 2010, and from the pork chop and steak produced from animals bred using genomic information surveys conducted in 2012. Conditional logit (CL) and random parameter logit (RPL) models are developed to analyze the data and from those willingness to pay for each product can be calculated. A comparison of regression results from the conditional logit and random parameter logit models will also be presented.

4.2 Regression Results

Conditional logit and random parameter logit analysis were undertaken using Nlogit (Version 5.0) for the nanotechnology, pork and beef data. In order to ensure the standard deviations can change in sign throughout the full models, the distribution of all attributes were considered to be normal in the random parameter estimation models (Train, 2003).

Employing attribute based choice experiment methods in this study, respondents are required to choose a product with particular attributes over another choice of a similar product with different attributes. In the beef and pork surveys, consumers are confronted with a choice based framework between alternative products defined by a quality attribute (i.e. for pork, disease resistance, for beef, more feed efficiency) and price.

However, in the nanotechnology survey, respondents were required to choose or not (take it or leave it) a particular product (i.e. orange juice fortified with vitamin D), at a particular price. In this setting, the specific preference for different orange juice products is modeled.

As mentioned in section 3.4, in order to avoid the problem of the follow-up question dependency on the initial question, the second responses were not included in this model specification. As a result, this section represents the results of the data setup covered in section 3.4. The results for conditional and random parameter logit model regression estimations, and willingness to pay calculations, for the models including second (follow-up) responses for nanotechnology, pork and beef data are presented in Appendix E for comparison purpose.

4.2.1 Nanotechnology Survey Regression Results

At first, a basic model with attributes and price was estimated to explain the choice of different products (vitamin D fortified juice and UV-light protected bottle orange juice) with/without nanotechnology among respondents. In the RPL models, price was specified as non-random variable, and the preference for vitamin D fortified juice produced by means of nanotechnology, orange juice UV-light protected bottle, and juice UV-light protected bottle produced by means of nanotechnology, were considered as random attributes.

In the nanotechnology regression, 284 respondents (34%) said *yes* (i.e. chose the product) to the initial bid price, and 547 respondents (66%) said *no* (did not choose the product).

Table 4.1 shows the results of the basic model from the nanotechnology survey data. Since all three of the product preferences are positive and statistically significant, it is understood that the orange juice attributes are desired by consumers. However the attribute UV protected bottle produced by nanotechnology is not significant in the RPL and is only significant at the 10% level in the conditional logit model.

The results for the conditional and random parameter logit regression analyses with socio-demographic variables are reported in Table 4.2. The regression diagnostics indicate that the Pseudo R-squared value in the conditional and random parameter logit models

with interactions were found to be higher (0.057 and 0.125 for CL, and RPL models, respectively) than the basic model without interactions (0.034, and 0.104 for CL, and RPL models, respectively) suggesting that the model with socio-demographic interaction provides better estimation results than the basic model.

The notable variables of significance are people who have/ have not heard about nanotechnology prior to the survey, people who believe science and technology makes their society better off, respondents' self-assessed knowledge about scientific developments, and people who believe others can be trusted.

In the orange juice fortified with vitamin D produced with the means of nanotechnology, as compared to orange juice fortified with vitamin D with no technology involved, those people who believe other people can be trusted choose orange juice fortified with vitamin D produced with nanotechnology. Those people who believe science and technology will make their world better off, and who have higher than average self-assessed knowledge about scientific and technological developments also choose orange juice fortified with vitamin D with higher functionality (nanotechnology), as compared to orange juice fortified with vitamin D with no technology identified.

Also those respondents, who believe science and technology will make society better off, choose orange juice in a UV-light protected bottle with no means of technology identified , compared to orange juice fortified with vitamin D. However, people who had not heard about nanotechnology prior to the survey did not choose UV-light protection by means of nanotechnology, in their juice.

Table 4.1: Estimates of Conditional Logit and Random Parameter Logit Basic Models (Nanotechnology Survey)

Attributes	Nanotechnology			
	CL Model		RPL Model	
	Coefficient	Standard Error	Coefficient	Standard Error
Mean Effects				
Price	-0.39***	0.03	-0.40***	0.03
Vitamin D Fortified by means of nanotechnology	0.18**	0.11	0.18*	0.10
UV-protected juice bottle	0.31***	0.10	0.30***	0.11
UV-protected juice bottle by means of nanotechnology	0.16*	0.10	0.16	0.11
Standard Deviation Effects				
Vitamin D Fortified By means of nanotechnology			0.02	0.39
UV-protected juice bottle			0.01	0.37
UV-protected juice bottle by means of nanotechnology			0.05	0.46
Model Statistics				
Log-likelihood	*-2063.23*		*-2053.31*	
ρ^2 *(Pseudo R-squared)*	*0.034*		*0.104*	
# of Observations	*3324*		*3324*	

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table 4.2: Estimates of Conditional Logit and Random Parameter Logit Models with Interactions (Nanotechnology Survey)

Attributes	CL Model		RPL Model	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Mean Effects				
Price	-0.39***	0.03	-0.40***	0.04
Vitamin D Fortified by means of nanotechnology	-1.39*	0.77	-1.40*	0.78
UV-protected juice bottle	-1.03	0.75	-1.04	0.76
UV-protected juice bottle by means of nanotechnology	-2.47***	0.84	-2.48***	0.85
Vitamin D Fortified by means of nanotechnology				
Gender	0.19	0.16	0.19	0.15
Age	-0.08	0.06	-0.09	0.06
Education	0.05	0.05	0.06	0.05
Trust	0.51***	0.16	0.50***	0.16
Children under18	0.18	0.18	0.18	0.19
Rural	0.11	0.21	0.12	0.21
Income	-0.006	0.05	-0.007	0.05
Heard of Nanotechnology	-0.04	0.16	-0.04	0.16
Science & Technology	0.07*	0.04	0.07*	0.04
Knowledge	0.06*	0.04	0.07*	0.04
Ontario	-0.03	0.17	-0.03	0.17
Manitoba	-0.40	0.45	-0.41	0.44
Saskatchewan	0.61	0.50	0.62	0.51
Alberta	0.20	0.24	0.19	0.24
UV-protected juice bottle				
Gender	0.04	0.15	0.05	0.15
Age	-0.03	0.06	-0.02	0.06
Education	0.02	0.05	0.02	0.04
Trust	0.18	0.16	0.18	0.16
Children under18	0.17	0.17	0.17	0.17
Rural	0.25	0.20	0.26	0.20
Income	0.009	0.04	0.01	0.04

Heard of Nanotechnology	-0.16	0.16	-0.17	0.16
Science & Technology	0.11***	0.04	0.10***	0.04
Knowledge	0.04	0.04	0.05	0.04
Ontario	0.11	0.17	0.12	0.17
Manitoba	-0.20	0.43	-0.22	0.43
Saskatchewan	-0.30	0.54	-0.29	0.54
Alberta	0.26	0.24	0.25	0.24
UV-protected juice bottle by means of nanotechnology				
Gender	0.51***	0.17	0.52***	0.17
Age	-0.03	0.06	-0.03	0.05
Education	0.08	0.05	0.07	0.05
Trust	0.39**	0.17	0.39**	0.18
Children under18	0.42**	0.19	0.43**	0.19
Rural	-0.04	0.23	-0.04	0.23
Income	-0.03	0.05	-0.04	0.05
Heard of Nanotechnology	-0.32**	0.17	-0.32*	0.17
Science & Technology	0.13***	0.04	0.14***	0.05
Knowledge	0.01	0.04	0.01	0.04
Ontario	0.11	0.18	0.12	0.18
Manitoba	-0.58	0.53	-0.59	0.53
Saskatchewan	0.78	0.51	0.78	0.51
Alberta	0.15	0.26	0.15	0.27
Standard Deviation Effects				
Vitamin D Fortified by means of nanotechnology			0.04	0.42
UV-protected juice bottle			0.02	0.37
UV-protected juice bottle by means of nanotechnology			0.03	0.42
Model Statistics				
Log-likelihood	*-2015.47*		*-2011.46*	
ρ^2 *(Pseudo R-squared)*	*0.057*		*0.125*	
# of Observations	*3324*		*3324*	

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Males choose orange juice in a UV-light protected bottle produced by the means of nanotechnology, as compared to vitamin D fortified juice with no specified technology. By the same token, those consumers who believe other people can be trusted, believe that science and technology will make their world better off, and have higher average self-rated knowledge about scientific advances chose juice packaged for UV-light protection by means of nanotechnology. People who have children under 18 choose UV-light protection by means of nanotechnology in their orange juice bottles. There were no significant preference differences in age levels amongst respondents.

Comparing the regressions results in Table 4.2 to Table E3 in Appendix E, the significance of socio-demographic variables in the 'first response' regression model for each product attribute was very similar to the two-part question specification models. Only the significance of the level of education in vitamin D fortified juice produced by nanotechnology showed up in the follow up question specification and not in the first response specification in Table 4.2.

4.2.1.1 WTP Calculation Results (Nanotechnology Survey)

The WTP calculated as premia from the basic regression model is reported in Table 4.3, indicate that consumers in general are willing to pay a premium for the packaging attribute with no technology specification. The estimated coefficients in Table 4.2 were used to calculate willingness to pay (WTP) for the three types of orange juice, as compared to vitamin D fortified juice, for an arbitrarily selected representative respondent (a 45 year old man who lives in a rural area with no children under 18 in the home, who has heard about nanotechnology prior to the survey, has average education and income, and believes other people cannot be trusted).

The WTP results in Table 4.4 indicate that out of all the WTP options, a representative Canadian respondent prefers UV-Protected juice bottle packaged by means of nanotechnology the least, as compared to orange juice fortified with vitamin D without any novel food technology. They choose to pay $1.40 per litre for this attribute. The

representative consumer, however, prefers to have their juice in UV-light protected bottle which reduces the UV damage of food nutrients, for orange juice (willingness to pay of $1.60 per litre). The WTP results for the two-part question choice models in Table E.5 indicates that consumers are willing to pay for vitamin D fortified orange juice with no technology involved, higher than the other three products, which demonstrates a similar pattern compared to data in Table 4.4.

Figure 4.1 demonstrates the distribution of WTP for the various technology attributes with socio demographic interactions, in orange juice across the choices made by the entire respondents' population in the nanotechnology survey (calculated for each attribute).

Figure 4.1: Distribution of WTP for Attributes in Nanotechnology Choice Models

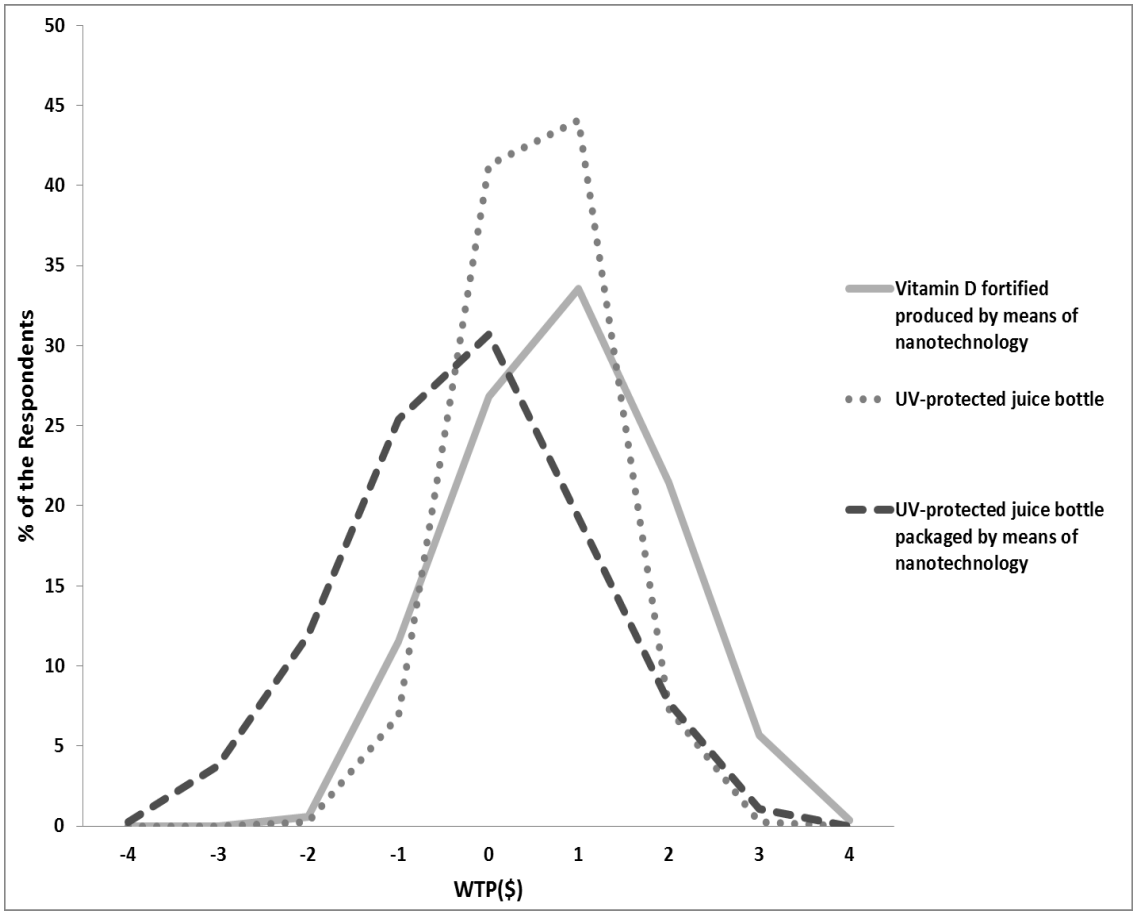


Table 4.3: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis)(Basic Model) (Nanotechnology Survey) (Premium Reported)

	CL	RPL
Vitamin D fortified juice produced by means of nanotechnology	$0.45**/litre	$0.40**/litre
UV-Protected juice bottle	$0.77***/litre	$0.75***/litre
UV-Protected juice bottle packaged by means of nanotechnology	$0.41*/litre	$0.45*/litre

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table 4.4: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis) (With Interactions) (Nanotechnology Survey)

For attributes in Juice (For a 1 Litre bottle) relative to orange juice fortified with vitamin D– 45 year old Male, living in rural area, with no children at home, with average income ($69,000 annually) and average education (college degree '14 years'), who has heard about nanotechnology prior to survey, and believes science and technology can make the society better off, and believes others cannot be trusted.

	CL	RPL
Vitamin D fortified juice produced by means of nanotechnology	$1.59**/litre	$1.48**/litre
UV-Protected juice bottle	$1.61***/litre	$1.53***/litre
UV-Protected juice bottle packaged by means of nanotechnology	$1.40**/litre	$1.41**/litre

Note: ***, **, *, Significant at 1%, 5%, and 10% level

According to Figure 4.1, for the vitamin D fortified juice produced by means of nanotechnology, the arbitrarily selected respondent is willing to pay $1.59/litre and 60% of the choices suggest a positive willingness to pay between $0 and $4. Conversely, for the UV-light protected bottle packaged by means of nanotechnology 40% of the choices made by respondents are negative. For the UV-light protected bottle with no technology identified, on the other hand, 41% of the respondents are not willing to pay either a positive amount or be compensated to purchase the product.

4.2.2 Pork Survey Regression Results

The empirical results of conditional logit and random parameter logit regressions in the pork survey for the basic model are presented in Table 4.5. In the RPL model, price, and neither option were specified as non-random variables and the pork attributes (less disease susceptible in the first model and in the second model pork chop being less susceptible to disease bred by genomic application) as random.

In the pork survey, only nineteen percent (309 respondents) of the choices said *yes* to the offered price, sixty-six percent (1032 of respondents) said *no* to the offered bid, and 217 of respondents (14%) chose neither of the price options, in the first models (pork chop being less susceptible to disease). In the second pork attribute model (pork chop being less susceptible to disease bred by genomic application), 632 of the respondents (41%) chose the price offered to them, 42% (651 of respondents) did not choose the offered bid, and 17% (275 of respondents) chose neither of the prices.

Table 4.5 represents the basic models in the pork survey including the pork attribute (in the first model (less disease susceptible) and second model (pork chop being less susceptible to disease bred by genomic application)), price, and neither option. The pork attribute is statistically significant in both conditional and random parameter analyses for both models indicating that the overall pork attributes are desirable by consumers.

The regression models were then analyzed in conjunction with socio-economic variables and attributes, and the results are presented in Table 4.6. The distribution of each

pork attribute was assumed to be normal in the random parameter estimation models (Train, 1998). In the pork surveys, the regressions show consistency of signs of variables with two-part question choice models in Appendix E.7, indicating the clarity of respondent preferences in the survey.

The regression diagnostics indicate that the Pseudo R-squared value in the conditional and random parameter logit models with interactions are higher (0.107 and 0.294 for CL, and RPL models, respectively in the first regression, and 0.049 and 0.103 for CL, and RPL models, respectively in the second regression) than the basic models without interactions (0.108 and 0.289 for CL, and RPL models, respectively in the first regression, and 0.045 and 0.098 for CL, and RPL models, respectively in the second regression). In the first regression, the CL diagnosis in basic model is slightly higher than the model with interaction as an exception (0.108 for basic model, and 0.107 for the model with interaction).

In the pork survey (Table 4.6), for the first choice (pork chop being less susceptible to disease) in both conditional and random parameter logit models people who have higher levels of income are willing to choose pork chops from more disease resistant pigs. Also, people who have higher animal attitude scores (pro-animal welfare) are willing to choose pork chops that are from animals more resistant to diseases.

The significant socio-demographic characteristics in the pork survey for the second model (pork chop being less susceptible to disease bred by genomic application) are level of income and gender. Those respondents who have higher levels of income choose pork chops produced by genomics technology as compared to vaccinating the animals to achieve disease resistance. The female gender is skeptical about the use of genomics in pigs, and therefore they are not willing to choose pork chops from genomic technologies, whereas there is no significant differences in the choices made by people who have higher or lower animal attitude scores. Compared to the results of Appendix E7, education level and some provincial differences, found in the specification with questions and follow up questions were not significant in Table 4.6.

Table 4.5: Estimates of Conditional Logit and Random Parameter Logit Basic Models (Pork Survey)

Attributes	(Pork Attribute I) Lower Probability of PCVAD/PRRS Disease versus Conventional Pork (No Technology Introduced)				(Pork Attribute II) Genomics versus Vaccinated Pork Chops (Both with Lower Probability of PCVAD/PRRS Disease)			
	CL Model		**RPL Model**		**CL Model**		**RPL Model**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Mean Effects								
Price	-0.33***	0.02	-0.34***	0.03	-0.21***	0.02	-0.20***	0.01
Pork Attribute	1.43***	0.07	1.42***	0.08	0.04*	0.06	0.03*	0.05
Neither option	-2.41***	0.16	-2.40***	0.15	-2.20***	0.13	-2.21***	0.13
Standard Deviation Effects								
Pork Attribute			0.02	0.24			0.01	0.2
Model Statistics								
Log-likelihood	*-1216.43*		*-1211.33*		*-1542.81*		*-1540.80*	
ρ^2 *(Pseudo R-squared)*	*0.108*		*0.289*		*0.045*		*0.098*	
# of Observations	*1558*		*1558*		*1558*		*1558*	

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table 4.6: Estimates of Conditional Logit and Random Parameter Logit Models with Interactions (Pork Survey)

Attributes	(Pork Attribute I) Lower Probability of PCVAD/PRRS Disease versus Conventional Pork (No Technology Introduced)				(Pork Attribute II) Genomics versus Vaccinated Pork Chops (Both with Lower Probability of PCVAD/PRRS Disease)			
	CL Model		**RPL Model**		**CL Model**		**RPL Model**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Mean Effects								
Price	-0.34***	0.02	-0.35***	0.02	-0.20***	0.02	-0.21***	0.01
Pork Attribute	0.24	0.69	0.25	0.70	0.24	0.64	0.24	0.65
Neither option	-2.43***	0.16	-2.43***	0.16	-2.20***	0.14	-2.21***	0.14
Gender	0.05	0.12	0.05	0.13	0.09*	0.12	0.10*	0.11
Age	-0.02	0.05	-0.02	0.05	0.01	0.04	0.02	0.04
Trust	-0.01	0.12	-0.015	0.12	-0.06	0.11	-0.05	0.12
Child	0.006	0.14	0.006	0.14	0.08	0.13	0.08	0.13
Education	0.002	0.04	0.003	0.03	-0.04	0.03	-0.04	0.04
Alberta	-0.23	0.19	-0.23	0.19	-0.17	0.19	-0.18	0.19
Ontario	-0.16	0.13	-0.16	0.13	0.14	0.12	0.13	0.11
Manitoba	0.06	0.28	0.06	0.28	-0.19	0.26	-0.20	0.27
Saskatchewan	-0.26	0.30	-0.26	0.30	0.03	0.29	0.03	0.28
Rural	0.04	0.14	0.04	0.15	-0.21	0.14	-0.20	0.13
Income	0.07**	0.04	0.073*	0.04	0.06*	0.03	0.06*	0.04
Heard of Genomics	0.01	0.13	0.02	0.13	-0.07	0.12	-0.06	0.12
Science & Technology	0.01	0.03	0.02	0.03	0.03	0.03	0.03	0.02
Knowledge	-0.007	0.03	-0.007	0.03	0.006	0.03	0.006	0.03
AAS	0.02***	0.007	0.024***	0.007	0.005	0.007	0.006	0.007

Standard Deviation Effects				
Pork Attribute		0.016 0.27		0.015 0.22
Model Statistics				
Log-likelihood	*-1207.92*	*-1206.91*	*-1534.88*	*1534.78*
ρ^2 *(Pseudo R-squared)*	*0.107*	*0.294*	*0.049*	*0.103*
# of Observations	*1558*	*1558*	*1558*	*1558*

Note: ***, **, *, Significant at 1%, 5%, and 10% level

4.2.2.1 WTP Calculation Results (Pork Survey)

Table 4.7 indicates the results of the calculated WTP for the basic models. A selected consumer is willing to pay $4.3 per kg to have a pork chop that is less susceptible to diseases. This indicates that the selected consumer neither needs to be compensated nor be better off to have this product. The estimated coefficients in Table 4.6 for the conditional logit and random parameter logit were used to calculate willingness to pay (WTP) for the pork attributes (Attribute I. Pork chops that are less susceptible to PCVAD and PRRS diseases, and Attribute II. Pork chops that are resistant to these diseases produced from animals bred by genomic applications). Similar to the nanotechnology calculations, the arbitrarily selected respondent is a 45 year old man who lives in a rural area with no children under 18 in the home, who has heard about genomics prior to survey, average education and income, and believes other people cannot be trusted, with animal attitude score at mean level (AAS=42).

Table 4.8 indicates the results of the WTP for the representative consumer for the CL and RPL regressions, for the models with socio demographic interactions. In this context, according to Table 4.8, in both CL and RPL models, the arbitrarily chosen consumer is willing to pay $4.6 per kg to have a pork chop that is less susceptible to diseases. When the technology (genomic versus vaccination) is introduced, the consumer is willing to pay $3.8 per kg to have a pork chop less disease resistant by genomic technology rather than one produced by vaccination. Compared to the WTP calculations in Appendix E8, the WTP calculations for the first response choice models demonstrate slightly higher values for each pork attributes.

Figure 4.2 shows the distribution of WTP for the two pork attributes with socio demographic interactions, across the choices made by the entire respondent population (calculated for each choice). Figure 4.2 shows that for the pork chop attribute of lower probability of PCVAD/PRRS disease, a majority of (82%) choices made by respondents suggest a WTP between $4 and $5. None of the choices made by respondents had a

negative WTP. In the second pork attribute (pork chops produced with genomics (with lower disease susceptibility)), most choices (66%) made by respondents were between $3 and $4. The distribution of WTP is in accordance with the WTP calculation for a representative consumer.

Figure 4.2: Distribution of WTP for Attributes in Pork Choice Models

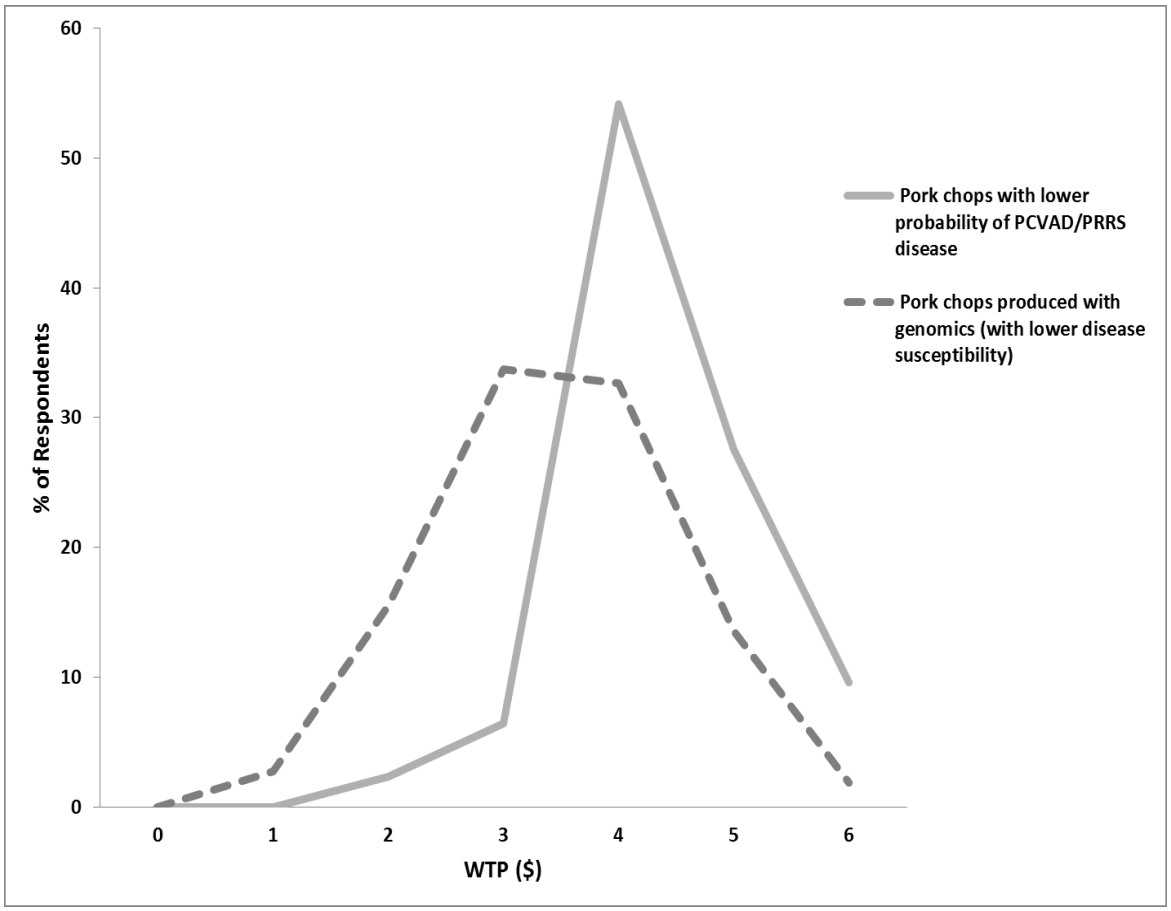


Table 4.7: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis) (Basic Model) (Pork Survey)

	CL	RPL
Pork chops with lower probability of PCVAD/PRRS disease	$4.28***/Kg	$4.17***/Kg
Pork chops produced with genomics (with lower disease susceptibility)	$4.08*/Kg	$3.93*/Kg

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table 4.8: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis) (With Interactions) (Pork Survey)

For attributes in pork chop (For a 1 Kg package) – 45 year old Male, living in rural areas, with no children at home, with average income ($72,000 annually) and average education (college degree '14 years') , and animal attitude score (AAS) at mean (41.9), who have heard about genomics prior to survey, and believes others cannot be trusted.

	CL	RPL
Pork chops with lower probability of PCVAD/PRRS disease	$4.54***/Kg	$4.50***/Kg
Pork chops produced with genomics (with lower disease susceptibility)	$3.83*/Kg	$3.12*/Kg

Note: ***, **, *, Significant at 1%, 5%, and 10% level

4.2.3 Beef Survey Regression Results

Similar to the nanotechnology and pork analyses, a basic model is also estimated for beef data including price, neither option, and a steak attribute for each models (steak from cattle with lower methane emissions in the first model, and steak from more feed efficient cattle bred by genomics in the second regression model (Table 4.9)). In the RPL model, price, and neither option were specified as non-random variables and the steak attribute as random. Also the distribution of steak attributes was considered to be normal in the RPL.

In the beef survey, in the first choices (steak from cattle with lower methane emissions), 428 of respondents (26%) said *yes* to the bid price, forty-eight percent (794 of respondents) said *no* to the offered price, and 26% (431 of respondents) chose neither of the prices. In the second choices (steak from more feed efficient cattle bred by genomics as opposed to vaccination), 43% of the respondents (707 consumers), chose the bid price they were offered, 465 of the respondents (28%) did not choose the offered bid price, and 29% of them (481 of respondents) chose neither of prices they were offered.

The steak attribute in each model is statistically significant, indicating that the attributes are desirable by consumers. The empirical results for the steak attributes regressions interacted with socio-economic variables are presented in Table 4.10. The standard deviation coefficients are statistically significant at the 1% and 10% level respectively, indicating that the variance of random effects is significant in the random parameter model estimates.

Table 4.10 reports the regressions results for both random parameter and conditional logit models for the beef survey with interactions with demographic and attitude variables. The significant explanatory variables in the first regression (steak from cattle with lower methane emissions) are age, respondents' self-rated belief of knowledge about technological developments, science and technology belief, those consumers who live in Ontario, and those people who have higher animal attitude scores. Older people chose meat from more feed efficient animals. However, those Canadian respondents who have pro

animal welfare attitudes, and believe science and technology will make society better off, with higher than average self-assessed knowledge about scientific and technological developments choose steaks from animals with lower methane emissions/higher feed efficiency. People residing in Ontario chose steaks with the lower methane emissions attribute.

In the second regressions (steak from more feed efficient cattle bred by genomics) the significant socio-demographic variables are those who live in Ontario, people who have higher levels of income, and people who believe that science and technology make society better off.

People who believe scientific advances will make our society better off chose the steak that is more feed efficient produced by means of genomics; however, those people who live in Ontario have different preferences than the rest of Canada. There are no significant preference differences between rural and urban areas amongst respondents. There are also no significant preference differences (for genomics versus vaccination) amongst people who have pro-animal welfare attitudes. Comparing the regression results to Appendix E10, in the second steak attribute regression 'people who had heard about genomics prior to survey' was significant in the two-part question choice models, whereas in Table 4.10, such significance cannot be observed.

Table 4.9: Estimates of Conditional Logit and Random Parameter Logit Basic Models (Beef Survey)

Attributes	**(Steak Attribute I)** Lower Methane per Animal Production versus Conventional Steak (No Technology Introduced)				**(Steak Attribute II)** Genomics versus Vaccinated Steaks (Both with Lower Methane Production and More Feed Efficient)			
	CL Model		**RPL Model**		**CL Model**		**RPL Model**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Mean Effects								
Price	-0.07***	0.05	-0.09***	0.09	-0.05***	0.004	-0.06***	0.07
Steak Attribute	0.68***	0.06	0.67***	0.08	0.44***	0.06	0.43***	0.08
Neither option	-1.56***	0.13	-1.95***	0.21	-1.18***	0.13	-1.20***	0.18
Standard Deviation Effects								
Steak Attribute			1.50***	0.45			0.39***	0.89
Model Statistics								
Log-likelihood	*-1639.95*		*-1636.59*		*-1722.57*		*-1722.52*	
ρ^2 *(Pseudo R-squared)*	*0.057*		*0.098*		*0.034*		*0.051*	
# of Observations	*1653*		*1653*		*1653*		*1653*	

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table 4.10: Estimates of Conditional Logit and Random Parameter Logit Models with Interactions (Beef Survey)

Attributes	**(Steak Attribute I)** Lower Methane per Animal Production versus Conventional Steak (No Technology Introduced)				**(Steak Attribute II)** Genomics versus Vaccinated Steaks (Both with Lower Methane Production and More Feed Efficient)			
	CL Model		**RPL Model**		**CL Model**		**RPL Model**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Mean Effects								
Price	-0.07***	0.005	-0.09***	0.10	-0.06***	0.005	-0.06***	0.007
Steak Attribute	-0.68	0.70	-1.16	0.99	0.33	0.68	0.32	0.71
Neither option	-1.59***	0.13	-1.96***	0.21	-1.19***	0.13	-1.22***	0.18
Gender	0.05	0.12	0.08	0.17	-0.05	0.12	-0.06	0.13
Age	-0.16***	0.04	-0.22***	0.07	-0.007	0.04	-0.008	0.05
Trust	0.01	0.11	0.02	0.15	0.14	0.11	0.15	0.11
Child	-0.15	0.14	-0.21	0.19	0.05	0.13	0.05	0.14
Education	0.06*	0.03	0.08	0.05	-0.03	0.03	-0.03	0.04
Alberta	-0.04	0.19	-0.05	0.27	-0.18	0.19	-0.19	0.20
Ontario	-0.20*	0.12	-0.28*	0.17	-0.22*	0.12	-0.23*	0.13
Manitoba	0.14	0.24	0.19	0.33	-0.34	0.24	-0.35	0.25
Saskatchewan	-0.21	0.28	-0.32	0.39	-0.29	0.28	-0.30	0.29
Rural	-0.12	0.15	-0.15	0.21	-0.10	0.15	-0.11	0.16
Income	0.04	0.03	0.06	0.04	0.07**	0.03	0.07**	0.03
Heard of Genomics	0.11	0.11	0.14	0.16	0.08	0.11	0.09	0.12
Science & Technology	0.07**	0.03	0.09**	0.04	0.05*	0.03	0.05*	0.02
Knowledge	0.03*	0.03	0.05*	0.04	0.02	0.02	0.02	0.03
AAS (Animal Attitude Scale)	0.01**	0.007	0.02**	0.01	-0.003	0.007	-0.003	0.07

Standard Deviation Effects				
Steak Attribute		1.46*** 0.44		0.38* 0.86
Model Statistics				
Log-likelihood	*-1615.51*	*-1612.36*	*-1711.96*	*-1711.90*
ρ^2 (Pseudo R-squared)	*0.072*	*0.112*	*0.040*	*0.057*
# of Observations	*1653*	*1653*	*1653*	*1653*

Note: ***, **, *, Significant at 1%, 5%, and 10% level

4.2.3.1 WTP Calculation Results (Beef Survey)

The calculated WTP results for the basic models (Table 4.11) indicates that an arbitrarily selected consumer is willing to pay around $9.7 per kg to have a steak with lower methane per animal production. When the technology (genomic versus vaccination) is introduced, the consumer is willing to pay $8.2 per kg. The WTP measure for an arbitrarily selected respondent in the beef survey, for the RPL and CL models is reported in Table 4.12. Similar to the pork survey, the arbitrarily selected respondent is a 45 year old man who lives in a rural area with no children under 18 in the home, who has heard about genomics prior to the survey, average education and income, and believes other people cannot be trusted, with an animal attitude score at mean level of 42. Both Table 4.8 and 4.12 indicate that in case of preference heterogeneity, the representative Canadian consumer WTP is very close to the conditional logit regression WTP calculations.

As can be seen, a representative Canadian consumer is willing to pay $10.9 per kg for the steak with feed efficiency attribute without information on the genomic application breeding. The consumer is willing to pay $7.4 per kg when the genomic technology is introduced as the application which improves the feed efficiency/methane emissions in cattle. Contrary to the pork choice models, the WTP for steak attributes are lower than Appendix E.11 that was calculated by two-part question regression models.

Figure 4.3 demonstrates the distribution of WTP for the two steaks attributes with socio demographic interactions, across the choices made by the respondents (calculated for each choice). Figure 4.3 indicates that for steak attribute with lower methane per animal production/more feed efficient, 72% of the choices were made for the WTP between $10 and $15. For the steak attribute with genomics application (with lower methane production and more feed efficiency), 80% of the choices were made for the positive willingness to pay between $5 and $10, which is similar to the selected consumer WTP amount. However in this case there are people who need to be compensated to have these products and they do not see the attribute as important.

Figure 4.3: Distribution of WTP for Attributes in Steak Choice Models

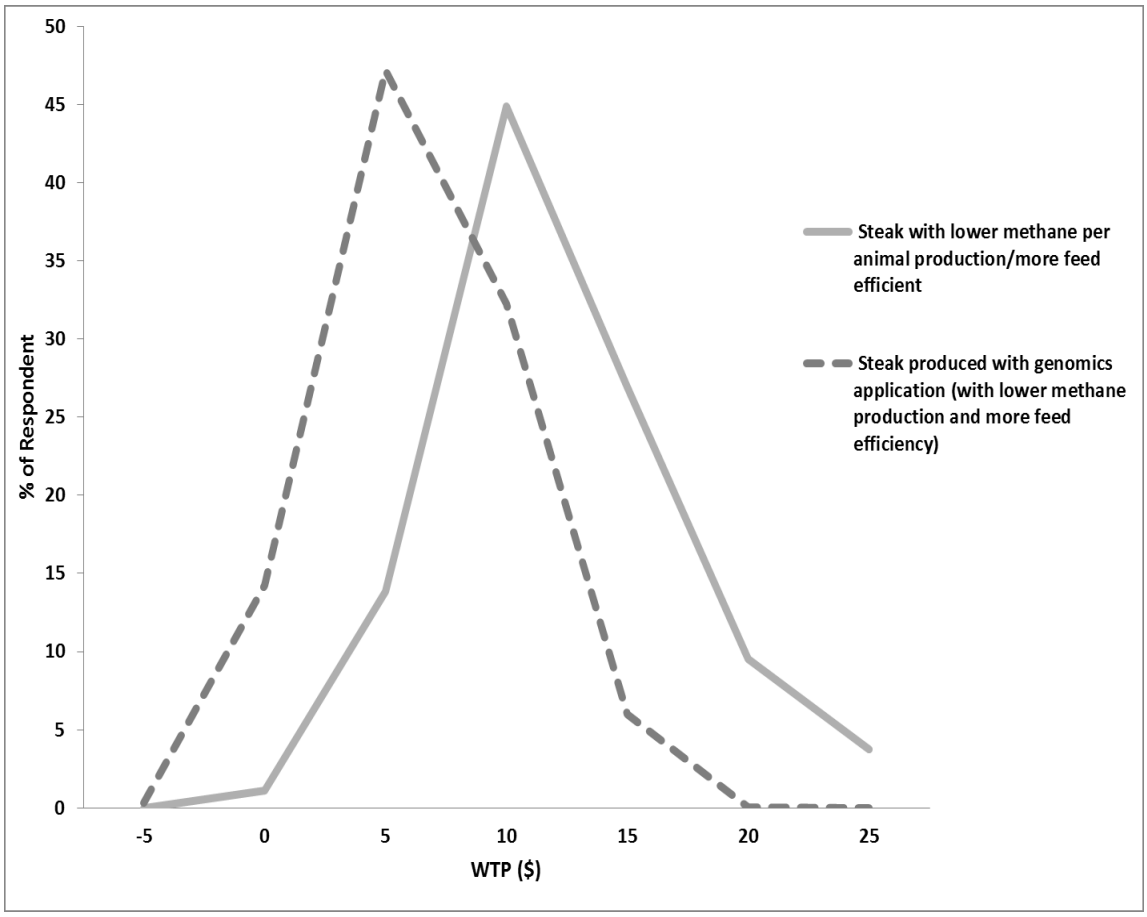


Table 4.11: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis) (Basic Model) (Beef Survey)

	CL	RPL
Steak with lower methane per animal production	$9.64***/Kg	$8.38***/Kg
Steak produced with genomics application (with lower methane production and more feed efficient)	$8.2**/Kg	$7.16**/Kg

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table 4.12: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis) (With Interactions) (Beef Survey)

For attributes in steaks (For a 1 Kg package) – 45 year old Male, living in rural areas, with no children at home, with average income ($70,000 annually) and average education (college degree '14 years'), and animal attitude score (AAS) at mean (42.1), who have heard about genomics prior to survey, and believes others cannot be trusted.

	CL	RPL
Steak with lower methane per animal production /more feed efficient	$10.85***/Kg	$9.25***/Kg
Steak produced with genomics application (with lower methane production and more feed efficient)	$7.37**/Kg	$7.28**/Kg

Note: ***, **, *, Significant at 1%, 5%, and 10% level

4.3 Animal Attitude and Willingness to Pay

Human attitudes to animals are a matter of central concern to the public. At the individual level, it is known that negative attitudes to animals are associated with less human behavior towards them, and vice versa (Hemsworth, 2003). At the level of society, changes in people's attitudes and opinions are usually the driving force behind improvements in animal-related legislation and public policy (Kirkwood and Hubrecht, 2001). When considering changes in technology in domesticated animal production it is possible that animal attitudes might play a role in the types of technology preferred.

The animal attitude score (AAS) is statistically significant in both the pork and beef choice models, in the first regressions where the meat has a higher quality attribute (disease resistant pork or feed efficient steak), but is not significant when the attribute technology is identified (use of genomic/vaccination technology).

The regression results in Tables 4.6 and 4.10 also indicate that people with pro-animal welfare attitude are willing to pay higher prices for the quality attribute in both pork and beef choice models. To illustrate the importance of the variable, the willingness to pay for the arbitrary representative consumer is calculated at the maximum animal attitude score of 65. The willingness to pay is then compared with the representative consumer assumed to have a mean value score of AAS (41.9, and 42.1 in the pork and beef data, respectively). The rest of the socio-demographic variables for the arbitrary consumer are kept similar to the original WTP calculations in order to have the unity of comparison.

Since in the previous section the WTP calculation results between the random parameter logit and conditional logit regressions portrayed quite similar dollar amounts per kg, and this section is for comparison purposes, only the conditional logit WTP estimates are compared across the maximum and mean level of animal attitude score in the pork and beef choice models.

The willingness to pay calculation with mean and maximum level of AAS, for a representative consumer who is a 45 year old male, living in a rural area, with no children at home, with average income and average education, who has heard about genomics prior to survey and believes others cannot be trusted, for the beef and pork choice models is presented in Table 4.13.

Table 4.13: Willingness to Pay (in $) AAS (Conditional Logit Regression Analysis)
(For a representative respondent – 45 year old male, living in a rural area, with no children at home, with average income and average education, who has heard about genomics prior to survey, and believes others cannot be trusted.)

	Animal Attitude Score (AAS) at mean value	**Animal Attitude Score (AAS) at maximum value**
WTP pork with lower probability of PCVAD/PRRS disease	$4.54***/Kg	$6.19***/Kg
WTP for pork chops produced with genomics (with lower disease susceptibility)	$3.83*/Kg	$3.73*/Kg
WTP steak with lower methane per animal production/more feed efficient	$10.85***/Kg	$16.02***/Kg
WTP for steak produced with genomics application (with lower methane production and more feed efficiency)	$7.37**/Kg	$7.24**/Kg

Note: ***, **, *, Significant at 1%, 5%, and 10% level

In the second regressions for the pork and beef surveys where the genomic technology is introduced as the quality attribute (pork chop by more disease resistant pigs, and steak by more feed efficient cattle), the AAS variable was not significant in the regression models, indicating that pro or anti animal attitudes didn't have any significant impact on the preferences between genomics and vaccination and representative consumer's meat consumption.

However, there is a large difference in the arbitrarily selected consumer's WTP who has extreme pro-animal attitudes, as compared to the selected consumer who has an

average animal attitude score, in the first regression analyses from the pork and beef choice models when the product is of better quality (reduced disease susceptibility or enhanced feed efficiency) but there is no technology identified. The regression results in Table 4.6 and 4.10 earlier indicated the AAS variable as being positively significant. The representative consumer with extreme pro-animal welfare attitude is willing to pay a 42% premium to have the "disease resistant pigs" attribute, and 10% premium, in order to have the "more feed efficient" attribute in cattle.

The results also indicate that consumers in general support the development of technologies that can improve the health attributes of animals that are then slaughtered for meat. However, there are also people who need to be compensated to have these meat products since they do not consider the health or feed efficiency attributes as important.

The results also indicate that consumers in general support the development of technologies that can improve the health attributes of animals that are then slaughtered for meat. However, there are also people who need to be compensated to have more feed efficient beef since they do not consider the feed efficiency attribute as important.

4.4 Chapter Summary

The regression results in all choice models across three surveys show that socio-demographic characteristics are important in shaping consumers' preferences. In the nanotechnology, and steak choice models, it appears that a positive attitude towards science and technology and/or higher levels of self-assessed knowledge of scientific advances is important in respondents' views towards products that involve the applications of nanotechnology and genomics. Consumers' levels of income, age, gender, and their general trust (whether or not they believe other people can be trusted) were also significant in more than one regression. Familiarity with nanotechnology prior to the survey was significant in shaping the respondents' preferences to make choices in orange juice with UV-protected bottle packaged by means of nanotechnology, whereas familiarity with

genomics prior to survey had no significant impact in respondents' preferences for pork or steak. Comparing the results of nanotechnology, pork, and steak choice models to the follow-up questions specification models, the significance and signs of variables were similar. However, the follow up questions did capture extra socio-demographic (such as level of education, provincial differences, prior familiarity with genomics) significance in some of the regression models (although recognizing the potential bias in assuming independence between the first and follow up questions).

Attitudes towards animals also were shown to be significant in respondents' choices of different attributes in the pork and steak choice models. Those consumers with extreme pro-animal welfare attitudes were shown to have significant differences in choices of pork chops and steaks with higher quality but no technology identified.

Preferences for the attributes for the two novel technologies are somewhat different. In some cases, but not all, the distribution of WTP includes negative values. In the UV-light protected bottle packaged by means of nanotechnology 35% of the WTP calculated for individuals were between $-2 and $-1, whereas in the vitamin D fortified juice produced by means of nanotechnology, 12% of the WTP calculated for individuals were between $-2 and $-1. Only 7% of the WTP by individuals for the UV-light protected bottle, without technology identified were negative (between $-2 to $-1). None of the choices made by the individual respondents for the two pork attributes show negative WTP. In the steak attribute with genomics application (with lower methane production and more feed efficiency), 15% of the individuals had to be compensated to purchase beef, at values between $-5 and $0. In general there was more negativity associated with nanotechnology applications than for the genomic applications.

Examining the possibility of ambiguity avoidance surrounding the two novel technologies indicates that ambiguity may exist for nanotechnology. For example, 24% of the individuals with positive WTP for UV-light protected orange juice with no technology identified, switched to negative WTP for UV-light protected orange juice when

nanotechnology was defined as means of production technology. Although shifts also occurred in the two genomics surveys they were smaller and in the pork case did not cause anyone to shift from a positive to a negative willingness to pay.

Comparing the nanotechnology choice model regression results to previous research in Germany (Roosen et al., 2011), Canadians depicted similar behavior to Germans as there was a tendency to avoid nanotechnology applications if they exist in food. The additional information about the vitamin D enriched orange juice produced by means of nanotechnology decreased the WTP of German participants significantly, as compared to when there was no information about the type of technology used in orange juice vitamin enrichment.

The current results in this thesis can be used for comparison purposes to future research involving actual purchases with different information sets and attributes to investigate if the hypothetical bias associated with the current research results can be reduced.

Chapter 5: Summary and Conclusion

5.1 Introduction

The inclusion of new technological and scientific advances in the food industry has been a matter of controversy in the past decade. This thesis concludes with providing a summary of what has been discussed earlier regarding results assessed in relation to the research objectives and economic problem outlined in chapter one. Methodological and study limitations and future research and social implications will conclude this chapter.

5.2 Overall Discussion

The application of nanotechnology in the food and packaging industry offers many potential benefits for both consumers and manufacturers. By its nature, nanotechnology can provide smart delivery systems and help enhance the nutritional quality of food thought fortification. In the packaging industry, by developing nanotechnology smart systems, customers can be alerted about possible food contamination or be provided with a smart protection system (e.g. temperature or direct UV-light changes).

On the other hand, as discussed in Chapter 1, genome sequencing and genomic selection for gene that highlight either resistance to certain diseases in pigs or cattle that produce less methane can help producers and society to have meat from healthier, more efficient, and more cost effective animals.

This thesis examined the preferences of consumers in Canada for different novel technologies used in food products. Socio demographic characteristics and product attributes had significant power in explaining choices made by consumers. Three data sets were used. Utilizing these data sets, the following actions were conducted:

1- Conditional logit and random parameter logit models were employed on the data to determine consumers' preferences.

2- Using stated preference data, regressions were run with and without demographic variables and results were generated from the regressions

The stated research objectives of this study and the results are discussed here:

Objective # 1: To elicit Canadian consumers' preferences for the foods produced from two novel food applications (nanotechnology and genomics).

Respondents clearly differentiated between products produced by the two novel food technologies introduced in this thesis. In the nanotechnology survey, the representative Canadian consumers preferred the orange juice with UV light protected bottle without specification of nanotechnology as compared to orange juice fortified with vitamin D with no technology involved. Canadian consumers did not prefer the orange juice fortified with vitamin D produced by means of nanotechnology, and orange juice with UV-light protected bottle imbued by nanoparticles, as compared to orange juice fortified with vitamin D.

In the genomics surveys, the sample respondent preferred pork chops that are produced from animals that are less disease susceptible in their choice models, and steak produced from animals that are more feed efficient. Basically, it can be concluded consumers chose the quality attribute (i.e. vitamin enhancement, packaging protection, disease resistance) when the innovative technology is not identified.

When the technology is introduced in their choice options, they project avoidance towards these two novel technologies however they still prefer them by positive WTP. In the meat ones they didn't have a choice of something without technology they were only asked a choice between two technologies. In the beef survey, the number of respondents

who need to be compensated in order to have steak from cattle bred by genomics application is more than the people who need to be compensated to have pork chops from pigs bred using genomic applications.

Objective # 2: To understand the effect of socio-demographic characteristics on Canadian consumers' attitudes and their purchasing behaviour on foods from different novel technologies.

In all three surveys, socio-demographic analyses for Canadian consumers indicated that different groups of people made different choices regarding their preferences for these novel technology attributes.

In the nanotechnology survey, people who believe other people can be trusted, are more knowledgeable about scientific developments and believe that science can make the world better chose the nanotechnology attribute in both orange juices (vitamin D fortified, and UV-protected bottles to preserve the nutrition inside the bottle) as compared to vitamin D enhanced juice with no technology specification. Also, the group of people who have children under 18 at home chose the nanotechnology attribute in their juice packaging, perhaps due to nutrition preservation.

In the pork survey, males with higher levels of income chose the genomic method of production for pork chops produced from pigs with more disease resistance. In the beef survey, those people who are younger, with higher levels of income, and who believe science and technology will make their society better off, chose the steak with the feed efficiency attribute developed by genomics in cattle. In both pork and beef surveys, those consumers who have pro-animal welfare attitudes chose the quality attribute of disease resistance in pigs or feed efficiency in cattle, when genomic technology are not mentioned as the mechanism.

Objective # 3: To compare the pattern of responses amongst consumers towards these two novel technologies in order to add to the base of knowledge on how public response is or is not technology specific.

The WTP distribution showed that for the UV-light protected bottle packaged by means of nanotechnology, vitamin D fortified juice produced by means of nanotechnology, and UV-light protected bottle without technology identified, there are negative values associated with calculated WTP for some individuals. 40% of the WTP calculated for individuals had negative values, implying the necessity to be compensated for that attribute. Whereas, the distribution of calculated WTP for individuals in pork analysis did not have any negative values. In steak choices, however, 15% of consumers preferred to be compensated to purchase the steak attribute with genomic applications. It can be concluded that consumers avoid products produced by nanotechnology applications to a greater extent than the genomics application.

The ambiguity avoidance effect may also be seen in the nanotechnology applications, as about a quarter of the individual consumers shifted from a positive WTP to a negative WTP, when nanotechnology was identified in UV-light protected orange juice product as the application. In genomics surveys, this shift was very small for steak, and did not exist for pork chops.

Objective # 4: To establish insights for future policy developments for these two specific novel technologies and how the technology adoption might impact on social welfare.

Agriculture is a fundamental industry in many countries around the world. Technological advances in agriculture have increased today's food quality. At the same time, food safety issues are significant in the public's attention. Perceived food safety incidents such as Bovine Spongiform Encephalopathy (BSE), hoof-and-mouth disease in pork, E. coli outbreak in beef in Canada, and real food safety incidents such as microbial

contamination of fresh spinach are a few examples of food safety events that have drawn public attention. During a food safety outbreak, the industry can be impacted by loss of sales. As a result developing new and improved systems for monitoring and delivering nutrients or disease outbreaks can improve the society's standard of life and enhance consumers' nutritional gain.

So far there has not existed any scientific evidence that food products by novel technologies are riskier than the conventional food products. While food innovation is highly efficient and effective in developing new products with better quality, it is the consumer who decides whether to purchase that product or not.

To address the economic problem, firstly it was discussed earlier that the government objective of increasing social welfare in the case of new technology adoption, is affected by the impact on the relative size of supply or demand shifts and the direction of demand curve shifts (defined as consumer preference), resulting from the adoption of products.

In the case of technology for products with higher functionality (without identifying the specific technology) such as UV-light protected orange juice, pork chops from less disease susceptible pigs, and steak from more feed efficient cattle, as the consumers' preferences analysis showed, the respondents prefer the products with better quality, as a result the demand curve could shift outward, as the supply of the product increase, and the government can increase social welfare. However, when the specific type of technology was defined then some consumers avoided the product. This could shift the demand curve inward, leading to a decrease in demand, and as a result decrease in social welfare.

The second issue in the economic problem, discussed earlier in the thesis, was the potential need for government intervention to maximize social welfare in case externalities and/or market failure occurs. Although the results of the thesis do not suggest any market failures or externalities they do suggest varying levels of concern about the technologies across the population. Given strong concerns by certain segments of the population,

governments may be required to mandate guidelines for the use of these technological innovations (e.g. nanotechnology and genomics) in food industry to avoid information asymmetries. For instance, labelling these types of products may alleviate opposition from those concerned members of the population

Governments also need to establish health and safety guidelines for the new technologies, to gain consumers' confidence that the use of such products involves little risk.

Thirdly, it was discussed that at the individual consumer level, there is a possibility of disconnect in understanding the potential benefits of these new food technologies. Public investments in research can change the consumers' view by providing the consumers with easy intelligible information they deserve. In this case as their knowledge towards these technological innovations increases, and the more they would be informed and educated about the potential benefits, their demand towards the products produced by these innovations would eventually increase. The shift in demand curve could also change/increase the social welfare.

For example, introducing the genomic technology adoption as a scientific breakthrough and the potential advantages that this technology can play in the future, by research institutes and related industries with the purpose of expanding consumers' information could help to increase the demand for the products by this technology, and will lead to commercializing the technology.

5.3 Issues, Study Limitations and Implications

In this thesis two novel technologies were introduced (nanotechnology and genomics) and their applications in agrifood industry to determine consumers' preferences of these innovations. Previous studies have been reviewed, indicating that most people have little to no knowledge about these technologies.

The methodology and modeling approach (stated preference) used in this thesis is specifically beneficial to understand how consumers would react when faced with a hypothetical product which might not exist in the market at the time of survey. However, the existence of hypothetical bias in the stated preference method should not be ignored, as for a hypothetical product such as UV light protected bottle in the choice sets; their actual WTP might be lesser than what they stated. Conditional and random parameter logit models were applied to capture a broader substation patterns among choice alternative in case heterogeneity exists amongst respondents.

Also the survey design and data collection were different in the nanotechnology and genomic surveys. In the pork and beef surveys, respondents were asked whether or not they prefer to choose a product with certain characteristics at certain dollar amount versus another product. In the nanotechnology survey, respondents had to choose whether or not they are choosing for a specific product at a specific price, with no relative preference.

The main issue in the experimental design was the way that the choice sets were originally designed (two-part question setup experimental frame). Since the second response to choices is very much dependant on the response for the first question, then the consumers' choices would not be independent and regression analysis estimation without accounting for interdependence cannot be accurate. A solution was offered which has been discussed earlier. Still it is suspected that some bias in choice making might exist since all respondents answered every choice question in the same order the questions with the technology defined and those without, and the questions were not randomly distributed over the surveys.

The results implied that not all the technologies are accepted by consumers equally for all products. Moreover, pro-animal welfare attitude has an impact on purchasing behavior of those consumers who have concerns towards the treatment of animals. One of the implications of this thesis can be to provide future reference in product differentiation

and their type of technology when applying these technologies in the agri-food industry. This thesis also supported the conclusion of the previous literature in examining consumers' view across products, applications and technologies (Hobbs et al., 2012; Lusk and Marette, 2010) that consumers do not behave in the same way when faced with different products and different technologies. As a result government should consider a technology which has the highest relative social welfare at the lowest cost, by investing in the product that has high potential demand, and the production cost can be reduced when producing in large scale.

Familiarity of consumers with these technologies and their applications should also be emphasized, as for instance, in nanotechnology survey for UV-light protected bottle by nanotechnology their lack of knowledge about this innovative technology and their applications was the main reason for their negative attitude. Providing the trustworthy sources of information which is easily communicable for consumers in order to raise the public awareness can reduce their concerns in terms of technological innovations in agri-food industry, and would increase the public acceptance of these novel technologies.

The result of this study is a hypothetical analysis of consumers' preferences when faced with new products produced with novel innovations that do/may not exist in the market. Future research can employ different approaches in terms of choice experiment designs and methods of analysis. Also the consumers can be provided with a real product with higher functionality, and examine how their choices might be affected, and measure their actual preferences.

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Appendix A: Previous Studies on Nanotechnology and Biotechnology

	Author	Country	Major Objective	Type Of Analysis
1	Bainbridge (2002)	United States	Public perceptions of nanotechnology (science-attentive members of the general public are very enthusiastic about nanotechnology, and a rather large number of ideas about its benefits have already entered popular culture)	Quantitative analysis of statistics
2	Bieberstein et al. (2013)	France and Germany	Assessed the perceived health-risks of nanotechnology in food	Logit Model
3	Bauer et al. (2007)	Germany	Life cycle assessment on nanotechnology and related market products (Environmental prospects of nanotechnology)	Sensitivity Analysis
4	Besley et al. (2008)	United States (scholars recently active in creating published research regarding some aspect of nanotechnology)	To investigate the social scientific study of nanotechnology (Nanotechnology risk, health and environmental risks, social risks, benefits, and regulation views)	Factor Analyses
5	Boccaletti and Moro (2000)	Italy	To measure the respondent's awareness and willingness-to-pay food products obtained through the application of biotechnology	(Ordered Probit Model) (Contingent valuation) (CV)
6	Bouwmeester et al. (2009)	Netherland	Risk Assessment of nanotechnologies and nanoparticles in agro-food products	Review Article (Discussing Toxicological effect of nanotech in food)
7	Boyce (2009)	United States	Public Awareness of Nanotechnology	Review (Discussing percentage statements)

8	Burri and Bellucci (2008)	Switzerland	To explore the public's attitudes toward the emerging technologies. Public engagement in processes of technology assessment.	Discussion (balanced approach)
9	Busch (2008)	US EU	Overview the introduction of nanotechnology in agri-food industry to offer the promise of purer foods, improved environmental management, and tastier food products	Discussing different Aspect of nano
10	Chau et al. (2007)	Taiwan	Identify Benefits and Risks of applying nanotechnology in food industry	Review (Preliminary discussion on the development of regulation for nanofoods)
11	Cobb and Macoubrie (2004)	United States	Perception and knowledge of public understanding about nanotechnology	Descriptive Analysis (Random-digit dialed survey)
12	Coles and Frewer (2013)	Europe	Discussed various ethical issues associated with agri-food nanotechnology, linked to concepts of autonomy, beneficence, non-malfeasance and justice (ensuring safety, effective risk assessment, transparency, consumer benefits and choice) with a focus on EU regulation	Review and Discussion Article
13	Costa-Font and Mossialos (2005)	European Union	examines the magnitude and the impact of ambivalence in explaining support for biotechnology applications	(Ordered logit model)
14	Darby and Zucker (2003)		Demonstrates linkage between entry of firms into nanotechnology and the strength of the science base, suggestive of natural excludability or other sources of knowledge localization industries	Inventions of Methods of Inventing (Poisson Regressions)

15	Diallo et al. (2009)		Use of Nanotechnology in providing efficient, cost-effective, and environmentally acceptable solutions for improving water quality	Use of passive nanomaterials
16	Dunkley (2004)	US	Social effects of Nanotechnology	Review Article
17	Farhang (2009)		Global issues in Nanotechnology	Review
18	Friedrichs and Schulte (2007)		Legislation of the environmental, health and safety aspects of nanotechnology	Review
19	Gruère (2012)	OECD Countries	Provides a summary of the implications of the growth of nanotechnology in the agriculture and food sector with a focus on OECD countries.	Review and Discussion
20	Hailu et al. (2009)	,Canada (Guelph, Ontario)	Consumer preferences over attributes of functional foods and nutraceuticals	Conjoint Analysis (CA) (Stated Preferences), OLS, Cluster analysis and chi-square,
21	Harrison and Mclennon (2004)	Unites States	Measure the preference of Unites States Consumers for labeling of Biotech foods	Ordered probit model Conjoint Analysis Rank order(RO) Interval rating(IR)
22	Helland and Kastenholz (2008)	Switzerland	How nanotechnology can be developed in a sustainable way over the whole life cycle	Review Article (Discusses the question, whether nanotechnology can be made sustainable and how its potential can be assessed and realized)
23	Hillie and Hlophe (2007)	Africa	Implementation of a nanotechnology water treatment project for the improvement of water quality.	Discussion of the effect implementing new technology

24	Hossain et al. (2003)	Unites States	Analyzes public acceptance of biotechnology in food production to identify and estimate the influence of consumers' socio-economic and value attributes on their perceptions of biotechnology and acceptance of its use	Ordered probit model
25	Hoyt and Mason (2008)		Health Issues in nano particles	Review Article
26	Huffman et al. (2004)	United States	Understanding the formation of trust in understanding consumers' preferences new products.	(Multinomial logit model)
27	Hull (2010)		Risks associated with nanotechnology health issues in small businesses	Book chapter
28	Kasturi (2009)	U.S	To look at the role of information technology, biotechnology and nanotechnology in improving food production and food security from an integrated perspective and in providing solutions to the problem of world hunger	Review and Discussion
29	Lin et al. (2006)	China	Estimate consumers' willingness to pay (WTP) for biotech foods in China.	(Double-bounded logit model) (Contingent valuation)
30	Lusk et al. (2002)	United States	To investigate consumer reaction to genetically engineered foods i.e. chip corn, (premium that consumers are willing to pay for non-GM food)	Conjoint Analysis (choice experiment), (Multinomial Logit Model)
31	Lusk and Parker (2009)	United States	To determine consumers' preferences ,willingness to pay , and importance for fat content in ground beef relative to other beef attributes	Choice-Based Conjoint Experiment (Multinomial Logit Model Estimates)

32	Lusk et al. (2003)	United States Germany France U.K	To determine if differences in consumer preferences for hormone-treated/GM-fed beef across countries are reflected in willingness to pay, To analyze implication of trade policies	Conjoint Analysis (choice experiment), (Multinomial Logit Model)
33	Lusk and Rozan (2008)	United States	To investigate whether individual's beliefs about government policy were related to beliefs about the safety of genetically modified (GM) food and their willingness to consume.	Stated preferences for GM food, willingness to pay, buy and consume GM food in hypothetical valuation, using Maximum likelihood
34	Malanowski and Zweck (2007)	Germany	Analyze economic potential of nanotechnology, which uses elements from both foresight and traditional market research	Integrating research methods (qualitative and quantitative methods)
35	Marette et al. (2009)	Germany	To evaluate the impact of environmental, societal and health information about nanotechnology on consumers' willingness to pay for two types of orange juice produced by means of nanotechnologies.	Welfare estimate regression analysis (WTP surplus calculations)
36	Matin et al. (2012)	Canada	To examine Canadian attitudes towards nanotechnology, in general, and in applications in the food industry. The relationship between the food technology neophobia scale, environmental attitudes and nanotechnology is analyzed.	Multi-nomial Logit Analysis (nation-wide survey)
37	Michelson (2008)	United States, China, India	Examines how nanotechnology will raise new science and policy questions and lead to new strategic linkages.	Discussing and comparing the current state of nanotechnology in these three countries, offering policy suggestions
38	Moon and Balasubramanian (2001)	U.S U.K	Evaluates how consumer perception about various attributes of agri-biotechnology are related to public acceptance of biotech foods	Ordered probit model Multi attribute model

39	Moon and Balasubramanian (2004)	U.S U.K	Analyze the influence of four predictor variables (trust of regulatory agencies, knowledge/ awareness of biotech issues, outrage factor, and demographic characteristics) on attitude toward agro biotechnology	Ordered probit model
40	Moon et al. (2006)	U.S	Examines the role of consumers' perceived risks and benefits of agro-biotechnology in shaping patterns for organic food	Ordered probit model
41	Onyango et al. (2006)	U.S	Explores the importance of public awareness and knowledge of, interest in, and skepticism toward biotechnology and its acceptance.	Factor and Cluster analysis
42	Onyango and Nayga (2004)	U.S	Examine the effects of various factors on consumers' willingness to consume each of these three nutritionally enhanced breakfast cereals derived from either of the two gene transfer technologies considered	Ordered probit models
43	Ott et al. (2009)	Germany	Demand for nano-components in industry	Review Articles (Due to the technology's controversial character, the consumer's attitude towards risk and technology affects private demand)
44	Parr (2005)	UK	Public acceptability of risk in environmental and health protection	Discussing controversies over nanotechnology
45	Patuelli and Grimpe (2008)	Germany EU	To investigate what conditions and configurations allow a regional innovation system to be competitive in a cutting-edge technology like nanomaterials	OLS estimations, Poisson regressions ,generalised linear model (GLM) (spatial filtering)

46	Puurunen and Vasara (2006)	Finland	Current role of nanotechnology and its applications in the paper industry, discussing challenges and opportunities	Discussing challenges and opportunities
47	Ramsden (2009)		Viability of an investment in a nanotechnology venture	Book Chapter (The consumer may not even be aware of any change; the main advantage is to the producer (lower manufacturing costs through a simplified process or design)
48	Robinson (2009)	Netherlands	To develop support tools for exploring potential benefits and risks of the development of co-evolutions of nanotechnology and governance arrangements	In the form of scenarios into interactive workshop activities
49	Ronteltap et al. (2007)		To develop a comprehensive conceptual framework for consumer acceptance of food innovations based on an integration of food-related literature enriched with relevant findings from other domains.	Review previous studies based on the attitudinal models of Fishbein and Ajzen
50	Roosen et al. (2011)	Germany	Evaluated the impact of different information choice on participants' hypothetical willingness to pay (WTP) for food produced using nanotechnology.	Tobit regression
51	Schnettler et al. (2013)	Southern Chile	To investigate the relationship between food neophobia, satisfaction with life and food-related life, and acceptance of the use of nanotechnology in food production.	Cluster analysis (Including SWLS (Satisfaction with Life Scale), SWFL (Satisfaction with Food-related Life) and FNS (Food Neophobia Scale) scales)

52	Sealy (2006)	Unites States	To address the potentialities and implications of nanotechnology in relation to food and food packaging	Review
53	Sheetz et al. (2005)	United States	To address current social and ethical concerns as well as the public's perception of research and development in nanotechnology	Descriptive analysis
54	Siegrist (2008)		To determine factors that affect consumers' acceptance of innovative food Tech	Review (Most consumers are unable to decide whether new foods produced by such technologies are associated with possible risks)
55	Siegrist et al. (2007)	German-speaking part of Switzerland	To examine how lay people perceive nanotechnology foods and nanotechnology food packaging.	Descriptive analysis, Anova Analysis, (assessing affect, perceived benefit and risk, and willingness to buy (WTB) the products
56	Siegrist et al. (2008)	German speaking part of Switzerland	To examine public perceptions of 19 nanotechnology applications in food and food packaging	Descriptive Analysis, test Statistics Analysis (psychometric paradigm considering risk and benefit perception)
57	Smiley et al. (2008)	Unites States	To assess opinion change of risk perception about nanotechnology	Descriptive & quantitative analysis (national random digit dialing telephone survey)
58	Sozer and Kokini (2008)	U.S	To summarize the applications of nanotechnology relevant to food and nutraceuticals, and identifying the outstanding challenges	Review Article

59	Street et al. (2009)	U.S	How to provide Clean water safe, and inexpensive with the help of nanotechnology in developing countries. And reviewing public engagement and overall acceptance of exotic techniques and novel treatment technologies.	Book chapter
60	Tahan (2007)	UK	Considers what different groups are referring as nanotechnology, how this relates to the science involved	Review Article (Very Brief)
61	Tkac et al. (2007)	Italy	To show further practical applications of Nanotechnology (Winemaking)	Article
62	Tyshenko (2014)	Canada	Analyzed national news media content for nanotechnology developments and public attitude knowledge contents in Canada	Descriptive Analysis (Review news articles)
63	Turk (2007)	Europe	leading research and opinions on the social, ethical and legal implications of nanotechnology applications (NT) in Europe	Discussion
64	Vandermoere et al. (2011)	France	Examined the risk/benefit assessment of nanotechnology in terms of knowledge of nanotechnology, views of the benefits (risk) of science and technology for society and demographic	Logit Model
65	Vandermoere et al. (2010)	Germany	To examine public attitudes toward and awareness of nanotechnology and its relation with science and technology views, religious beliefs, and environment, and other demographic variables.	Multinomial Logit
66	Veeman and Adamowicz (2004)	Canada	An assessment of public attitudes to biotechnology and to GM food based on evidence from polls and other studies	Mixed Logit Conditional Logit (Discrete choice Theory)

67	Waldron (2006)	U.S	Public understanding of nanotechnology	Article (Clearly, there is a general lack of awareness and understanding of nanotechnology)
68	Waldron et al. (2006)	United States (1500 individuals ranging in age from 6 to 74 selected Via stratified Random sampling)	Public Awareness & Public Understanding Nanotechnology	Descriptive Analysis (In percentage form using Graphs mainly for result display)
69	Wiek et al. (2009)	Switzerland	Possible future developments of nanotechnology for the year 2020	Correspond to five distinct market situations for nanotechnological applications. Formalized and functional scenario methodology, featuring system analysis, consistency analysis and trans disciplinary collaboration
70	Xia (2009)	United States	To assess the productivity of university basic and applied research and education in Nanobiotechnology	system of three equations (represent the productions of a university's scientific publications, patents, and graduate training outputs) (can be fitted alternately with OLS, SUR, a fixed-effects estimator, and a GLS model)
71	Zucker and Darby (2005)	United States	To design Nano Bank as a data archive of nanoscience and nanotechnology	To build theoretically important relationships among variables that are predicted to alter the socio-economic impact of nanoscale research

Appendix B: Nanotechnology National Survey (2010)

Survey Instrument

Nanotechnology

1. In general, to what extent do you feel informed about scientific and technological developments?: 1 means that "you have little knowledge", and 10 means that "you know a lot."

1	2	3	4	5	6	7	8	9	10

2. How do you consider the health risk posed to consumers by regular consumption of…

	Very low risk	Low risk	Moderate risk	High risk	Very high risk	Don't Know
Vitamin and mineral food supplements						
Foods enriched with vitamins or minerals						
Foods grown or treated with pesticides and other chemicals						
Genetically modified organisms (GMO's)						
Meat or milk produced from cloned animals						
Irradiated food						
Preservatives and artificial colouring						
Meat/ fish containing hormones and antibiotics						
Foods that are based on nanotechnology						

Trust

3. How much trust do you have in the following institutions regarding their responsibility in the food domain? (Scores range from 1 = no trust to 5 = very high trust)

	No trust	Some trust	Moderate Trust	Trust	Very High Trust
Agriculture					
Food Industry					
Science/research					
Pharmaceutical Industry					
Government agencies/public authorities					
Consumer organizations					

Science and Technology, Environment

4. All things considered, would you say that the world is better off, or worse off, because of science and technology? 1 means that "the world is a lot worse off," and 10 means that "the world is a lot better off."

1	2	3	4	5	6	7	8	9	10

Willingness to pay

5. In what follows we will present you information about two pure orange juices sold in one litre bottles. On the market, the average price of this type of orange juice varies between $1.75 and $2.50 per litre.

Only one answer is possible *(control by the computer) (each product and WTP on one page)*

"**Orange juice A**"
This orange juice is fortified with vitamin D. According to scientific estimation, many Canadians have vitamin D intakes below recommendations as a result of inadequate intake and inadequate sunlight exposure.

Reminder: The average price of this type of orange juice varies between $1.75 and $2.50 per litre.

(Randomized selection of the price: lower value $1.75 or upper value $2.50)
If lower Value
Would you buy this product at a price of $1.75 per litre

Yes	No	Maybe

IF YES, would you buy the product if it were offered at a price of $2.50 per litre

Yes	No	Maybe

"Orange juice B"
This orange juice is filled in a plastic bottle that is fabricated in a way to reduce the juice's exposure to UV-light. Exposure to UV-light has an adverse effect on important food nutrients like vitamin C.

Reminder:The average price of this type of orange juice varies between $1.75 and $2.50 per litre.

(Randomized selection of the price: lower value $1.75 or upper value $2.50
Would you buy this product at a price of $2.50 per litre.

Yes	No	Maybe

IF NO, would you buy the product if it were offered at $1.75 per litre

Yes	No	Maybe

Nanotechnology / Nanofood

6. Have you ever heard about nanotechnology?
_____ Yes
_____ No

Nanotechnology refers to materials, systems and processes which exist or operate in the range of about 1 to 100 nanometers (nm). One nanometer (nm) is one millionth of a millimetre (mm). Materials at this scale show novel properties that lead to novel applications in diverse fields such as medicine, cosmetics, biotechnology, energy production and environmental science. There is uncertainty regarding how nanomaterials may interact with human health and the environment.

Willingness to pay II

Nanotechnology offers new opportunities for food industry application. Manufactured nanomaterials are already used in some food products, nutritional supplements, and food packaging applications.

7. Two examples in development are the two orange juices than have already been presented to you above. (In the market, the average price of this type of orange juice varies between $1.75 $ and $2.50 per litre)

<table>
<tr>
<td>"Orange juice A"
"Orange juice A" is fortified with vitamin D by means of nanotechnology. The vitamin D is enclosed in a nanoscale capsule that allows a better absorption and mobilization of the vitamin
According to scientific estimations, many Canadians have vitamin D intakes below recommendations as a result of inadequate intake and inadequate sunlight exposure.
Reminder: The average price of this type of orange juice varies between $1.75 and $2.50 per litre.
(Randomized selection of the price: lower value $1.75 or upper value $2.50)
If lower Value

Would you buy this product at a price of $1.75 per litre?

<table>
<tr><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

IF YES, would you buy the product if it were offered at $2.50 per litre?

<table>
<tr><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>
</td>
<td>"Orange juice B"
"Orange juice B" is produced by means of nanotechnology. The bottle is imbued with nano titanium dioxide particles that reduce UV damage of food nutrients. Exposure to UV-light has an adverse effect on important food nutrients like vitamin C.
Reminder:The average price of this type of orange juice varies between $1.75 and $2.50 per litre.
(Randomized selection of the price: lower value $1.50 or upper value $ 2.50)

Would you buy this product at a price of $2.50 per litre?
<table>
<tr><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

IF NO, would you buy the product if it were offered at $1.75 per litre?

<table>
<tr><td>Yes</td><td>No</td><td>Maybe</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
</table>

Section 3: Background Questions

8. In which of the following age groups do you fall?

1.	❒	15-19
2.	❒	20-24
3.	❒	25-29
4.	❒	30-39
5.	❒	40-49
6.	❒	50-64
7.	❒	65+

9. Generally speaking, would you say that most people can be trusted?

People can be trusted	**Can't be too careful in dealing with people**	**Don't know**
1	**2**	**3**
❒	❒	❒

10. Please indicate your gender.

1.	❒	Male
2.	❒	Female

11. How many people live in your household?

1.	❒	1
2.	❒	2
3.	❒	3 +

12. How many children younger than 18 live in your house?

1.	❒	No home living children < 18 years
2.	❒	1
3.	❒	2
4.	❒	3
5.	❒	4
6.	❒	More than 4

13. What is your position in the household? **ONLY ONE ANSWER POSSIBLE**

1.	❒	Head of household/main income
2.	❒	Partner of head of household
3.	❒	Child
4.	❒	Other family member
5.	❒	Other person (no family)

14. What is your marital status? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Married/Living together/Common Law
2. ❒ Single
3. ❒ Divorced/Separated
4. ❒ Widowed

15. What is the highest level of education you've achieved? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Elementary school
2. ❒ Secondary (high) school
3. ❒ Technical/ business school/Community college
4. ❒ University
5. ❒ Post graduate studies (Masters or PhD)

16. What is the approximate range of your total household income? **ONLY ONE ANSWER POSSIBLE**

1. ❒ $ 24,999 or under
2. ❒ Between $ 25,000 and $ 39,999
3. ❒ Between $ 40,000 and $ 64,999
4. ❒ Between $ 65,000 and $ 79,999
5. ❒ Between $ 80,000 and $ 99,999
6. ❒ Between $ 100,000 and $ 119,999
7. ❒ $ 120,000 or more

17. Which region do you live in? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Maritimes
2. ❒ Quebec
3. ❒ Ontario
4. ❒ Manitoba
5. ❒ Saskatchewan
6. ❒ Alberta
7. ❒ British Columbia

18. Do you live in a city, in a town or in the countryside? **ONLY ONE ANSWER POSSIBLE**

1. ❒ In a city (>100.000 inhabitants)
2. ❒ In a town (> 10.000 inhabitants)
3. ❒ In the countryside/rural district

Appendix C: Pork National Survey (2012)

Survey Instrument

Food

1. How much trust do you have in the following groups or institutions regarding their responsibility for food in Canada? (scores range from 1 = no trust to 5 = absolute trust)

	No trust	Some trust	Moderate Trust	Trust	Absolute Trust
Farmers					
Food processors or manufacturers					
Research organizations/universities					
Pharmaceutical industry which provides drugs to treat animals					
Government agencies/public authorities					
Advocacy consumer organizations					
Advocacy environmental organizations					
Advocacy organizations for animal welfare					

2. How do you rate the health risks for consumers of regular consumption of the following?

	Very low risk	Low risk	Moderate risk	High risk	Very high risk	Don't Know
Vitamin and/or mineral food supplements						
Foods enriched with vitamins or minerals						
Foods with pesticide or other chemical residues						
Genetically modified food (GMOs)						
Preservatives and/or artificial colouring						
Meat/ fish with hormone or antibiotic residues						
Foods made with ingredients that are produced by nanotechnology						
Foods packaged in containers produced by nanotechnology to inhibit spoilage						

Science and Technological Development

3. In general, to what extent do you feel knowledgeable about scientific and technological developments? 1 means that "you have little knowledge", and 10 means that "you know a lot."

1	2	3	4	5	6	7	8	9	10

4. All things considered, would you say that the world is better off, or worse off, because of science and technology? 1 means that "the world is a lot worse off," and 10 means that "the world is a lot better off."

1	2	3	4	5	6	7	8	9	10

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 of the genes in an organism. The Human Genome Project and the sequencing of the SARS virus are examples of research in Genomics.

5. Have you ever heard about genomics?
1. _____ Yes
2. _____ No

6. How would you describe your familiarity with genomics?

Not at All Familiar	Not Very Familiar	Somewhat Familiar	Very Familiar
1	2	3	4
□	□	□	□

Animal Attitudes, Anthropomorphism

7. Please identify whether you agree or disagree with the following statements:

Statement	Strongly Disagree	Mildly Disagree	Neither Agree or Disagree	Mildly Agree	Strongly Agree
It is morally wrong to hunt animals for sport					
Wild animals, such as mink and raccoon, should not be trapped so that their skins can be made into fur coats					
There is nothing morally wrong with hunting wild animals for food					

I think people who object to raising animals for meat are too sentimental					
I think it is perfectly acceptable for cattle and hogs to be raised for human consumption					
Basically, humans have the right to use animals as we see fit					
The slaughter of whales and dolphins should be immediately stopped even if it means some people will be put out of work					
I sometimes get upset when I see wild animals in cages at zoos.					
Too much fuss is made over the welfare of animals these days when there are many human problems that need to be solved					
Continued research with animals is necessary if we are ever to be able to conquer diseases such as cancer, heart disease and AIDS.					
It is unethical to breed purebred dogs for pets when millions of dogs are killed in animal shelters each year.					
The production of inexpensive meat, eggs and dairy products justifies maintaining animals under crowded conditions					
One of the worst things someone can do is to hurt a defenceless animal					

(animal attitudes Scale – Herzog, Betchart and Pittman 1991)

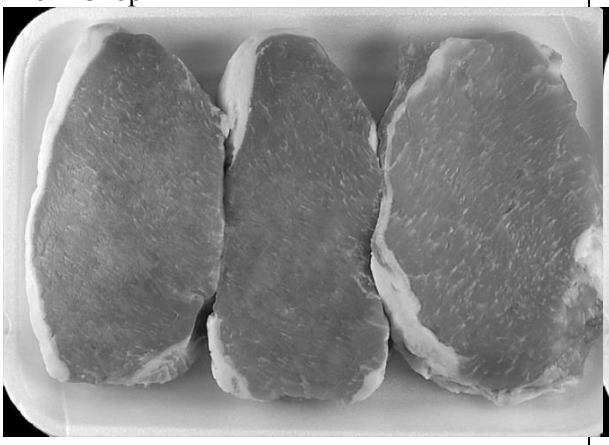
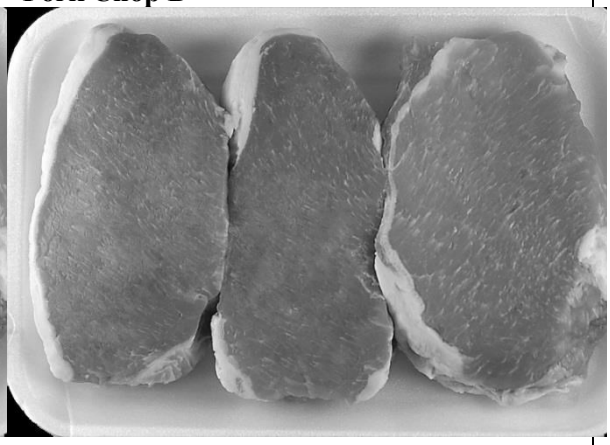
Pork Analysis

Porcine Circovirus Associated Diseases (PCVAD) and Porcine Reproductive & Respiratory Syndrome (PRRS) are two highly infectious diseases that occur in pig populations. They have serious implications for both pigs and pig farmers. PCVAD is associated with weight loss or decreased rate of weight gain, paleness or jaundice, and gauntness and a failure to grow in pigs. PRRS has been linked to reductions in farrowing rates (number of piglets born per sow), increased numbers of stillbirths and in some cases, abortion storms in sows and death in pigs. The highly contagious nature of the diseases makes it necessary that all pigs in an affected production enterprise be destroyed. Economic costs are very high for hog producers. There is no possibility that the diseases can be transferred to people through eating pork from animals with low or indistinguishable levels of the diseases.

In what follows we will present you with information about two packages of pork chops, as sold in grocery stores. Currently, the average price of this type of pork chop is $4.37 per kg.

Only one answer is possible *(control by the computer) (each product and WTP on one page)*

8.

<table>
<tr>
<td>"Pork Chop A"</td>
<td>"Pork Chop B"</td>
</tr>
<tr>
<td>  </td>
<td>  </td>
</tr>
<tr>
<td>This pork chop is produced in a Canadian family hog farm.

The farm satisfies all of the criteria as Canadian Quality Assured (CQA®) for on farm safety protocols.

The hogs are fed 100% grain (no animal by-products) and are produced with no sub therapeutic use of antibiotics.

(RANDOMIZED SELECTION OF THE PRICE: LOWER
VALUE $4.37/KG OR UPPER VALUE $8.74)
IF LOWER VALUE
A. Would you buy this product at a price of $4.37 per kg
<table><tr><td>Yes</td><td>No</td></tr><tr><td></td><td></td></tr></table>
B. IF YES, would you buy the product if it were offered at a price of $8.74 per kg
<table><tr><td>Yes</td><td>No</td></tr><tr><td></td><td></td></tr></table></td>
<td>This pork chop is produced in a Canadian family hog farm.

The farm satisfies all of the criteria as Canadian Quality Assured (CQA®) for on farm safety protocols.

The hogs are fed 100% grain (no animal by-products) and are produced with no sub therapeutic use of antibiotics.

In addition this hog is raised on a farm where the hogs have a significantly lower probability of contracting PCVAD or PRRS.

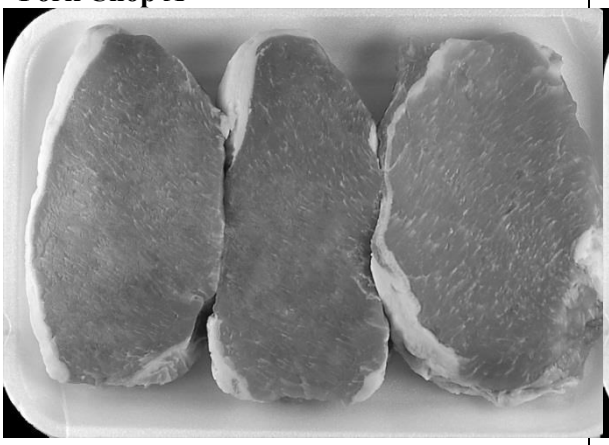
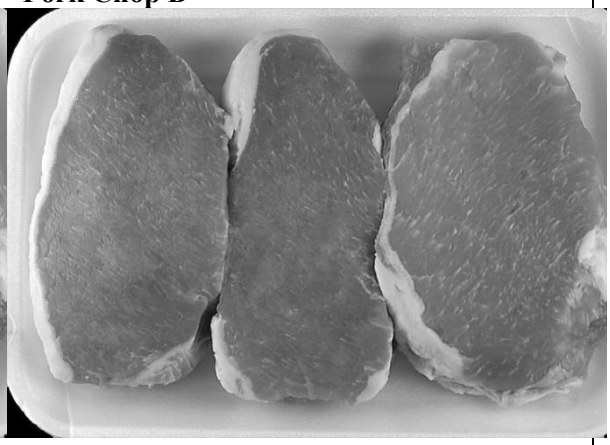
(RANDOMIZED SELECTION OF THE PRICE: LOWER
VALUE $4.37/KG OR UPPER VALUE $8.74)
IF HIGHER VALUE
A. Would you buy this product at a price of $8.74 per kg
<table><tr><td>Yes</td><td>No</td></tr><tr><td></td><td></td></tr></table>
B. IF NO, would you buy the product if it were offered at $4.37 per kg.
<table><tr><td>Yes</td><td>No</td></tr><tr><td></td><td></td></tr></table></td>
</tr>
</table>

Genomics is the study of the genes and genetic characteristics of organisms like plants, animals, and humans. The study of genomics in pigs can allow for the identification of specific genes that are linked to disease susceptibility. With knowledge of the presence (absence) of these genes, selective breeding can produce pigs with significantly lower probabilities of contracting PCVAD or PRRS.

PCVAD and PRRS are both diseases that are spreading rapidly throughout the world. Traditional breeding techniques have not proven successful in enhancing disease resistance in the pigs. Treatments for the diseases, PCVAD and PRRS, currently include vaccination of the pigs.

9. In what follows we will present you with information about two packages of pork chops, as sold in grocery stores. Currently, the average price of this type of pork chop is $4.37 per kg.

Only one answer is possible *(control by the computer) (each product and WTP on one page)*

"Pork Chop A"	**"Pork Chop B"**
	
This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as a Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and there was no sub therapeutic use of antibiotics during the animal's life. This pork chop was produced from a pig that was bred using genomic information and is less susceptible to PRRS and PCVAD. (RANDOMIZED SELECTION OF THE PRICE: LOWER VALUE $4.37/KG OR UPPER VALUE	This pork chop is produced in a Canadian family hog farm. The farm satisfies all of the criteria as a Canadian Quality Assured (CQA®) for on farm safety protocols. The hogs are fed 100% grain (no animal by-products) and there was no sub therapeutic use of antibiotics during the animal's life. This pork chop was produced from a pig that has been vaccinated against PCVAD and PRRS. (RANDOMIZED SELECTION OF THE PRICE: LOWER VALUE $4.37/KG OR UPPER VALUE

$8.74/KG) IF LOWER VALUE A. Would you buy this product at a price of $4.37 per kg Yes ☐ No ☐ B. IF YES, would you buy the product if it were offered at a price of $8.74 per kg Yes ☐ No ☐	$8.74/KG) IF LOWER VALUE A. Would you buy this product at a price of $8.74 per kg Yes ☐ No ☐ B. IF NO, would you buy the product if it were offered at $4.37 per kg. Yes ☐ No ☐

10. Please identify whether you agree or disagree with the following statements.

Statement	Strongly Disagree	Mildly Disagree	Neither Agree or Disagree	Mildly Agree	Strongly Agree
	1	2	3	4	5
Animal vaccinations cannot be seriously harmful; otherwise, authorities would ban them					
There is a good reason why certain animal vaccinations are recommended					
Overall, animal vaccinations deliver more benefits than harm					
We live in such a hygienic environment that animal vaccinations are redundant					
For serious animal diseases, requirements for farmers to vaccinate should be in place					
Vaccination is a better strategy than destroying the affected animals					
Animal vaccinations are another important factor that is threatening the environment					
Consuming meat from vaccinated animals can result in my becoming immune to the illness					

(Zingg and Siegrist)

Background Questions

11. In which of the following age groups do you fall?

1. ❒ 18-20
2. ❒ 21-24
3. ❒ 25-29

4. ❒ 30-39
5. ❒ 40-49
6. ❒ 50-64
7. ❒ 65+

12. Generally speaking, would you say that most people can be trusted?

Most people can be trusted	**Can't be too careful in dealing with people**	**Don't know**
1	**2**	**3**
❒	❒	❒

13. Please indicate if you are:

1. ❒ Male
2. ❒ Female

14. Including yourself, how many people live in your household?

1. ❒ 1
2. ❒ 2
3. ❒ 3
4. ❒ 4
5. ❒ 5 or more

15. How many children younger than 18 live in your household?

1. ❒ No children < 18 years live in my house
2. ❒ 1
3. ❒ 2
4. ❒ 3
5. ❒ 4
6. ❒ More than 4

16. What is your marital status? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Married/Living together/Common Law
2. ❒ Single

3. ❒ Divorced/Separated

4. ❒ Widowed

17. What is the highest level of education you've achieved? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Elementary school

2. ❒ Secondary (high) school

3. ❒ Technical/ business school/Community college

4. ❒ University

5. ❒ Post graduate studies (Masters or PhD)

18. Which region do you live in? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Maritimes

2. ❒ Quebec

3. ❒ Ontario

4. ❒ Manitoba

5. ❒ Saskatchewan

6. ❒ Alberta

7. ❒ British Columbia

8. ❒ Yukon, Northwest Territories, Nunavut

19. Do you live in a city, in a town or in the countryside? **ONLY ONE ANSWER POSSIBLE**

1. ❒ In a city (>100.000 inhabitants)

2. ❒ In a town (> 10.000 inhabitants)

3. ❒ In the countryside/rural district

20. What is the approximate range of your total household income? **ONLY ONE ANSWER POSSIBLE**

1. ❒ $ 24,999 or under

2. ❒ Between $ 25,000 and $ 39,999

3. ❒ Between $ 40,000 and $ 64,999

4. ❒ Between $ 65,000 and $ 79,999

5. ❒ Between $ 80,000 and $ 99,999

6. ❒ Between $ 100,000 and $ 119,999

7. ❒ $ 120,000 or more

Appendix D: Beef National Survey (2012)

Survey Instrument

Food safety

1. 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)

	No trust	Some trust	Moderate Trust	Trust	Absolute Trust
Farmers					
Food processors or manufacturers					
Research organizations/universities					
Pharmaceutical industry which provides drugs to treat animals					
Government agencies/public authorities					
Advocacy consumer organizations					
Advocacy environmental organizations					
Advocacy organizations for animal welfare					

2. How do you rate the health risks for consumers of regular consumption of the following?

	Very low risk	Low risk	Moderate risk	High risk	Very high risk	Don't Know
Vitamin and/or mineral food supplements						
Foods enriched with vitamins or minerals						
Foods with pesticide or other chemical residues						
Genetically modified food (GMOs)						
Preservatives and/or artificial colouring						
Meat/ fish with hormone or antibiotic residues						
Foods made with ingredients that are produced with nanotechnology						
Foods packaged in containers produced by nanotechnology to inhibit spoilage						

Science and Technological Development

3. In general, to what extent do you feel knowledgeable about scientific and technological developments? 1 means that "you have little knowledge", and 10 means that "you know a lot."

1	2	3	4	5	6	7	8	9	10

4. All things considered, would you say that the world is better off, or worse off, because of science and technology? 1 means that "the world is a lot worse off," and 10 means that "the world is a lot better off."

1	2	3	4	5	6	7	8	9	10

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 of the genes in an organism. The Human Genome Project and the sequencing of the SARS virus are examples of research in Genomics.

5. Have you ever heard about genomics?
   1. _____ Yes
   2. _____ No

6. How would you describe your familiarity with genomics?

Not at All Familiar	Not Very Familiar	Somewhat Familiar	Very Familiar
1	2	3	4
□	□	□	□

Animal Attitudes, Anthropomorphism

7. Please identify whether you agree or disagree with the following statements:

Statement	Strongly Disagree	Mildly Disagree	Neither Agree or Disagree	Mildly Agree	Strongly Agree
It is morally wrong to hunt animals for sport					

Wild animals, such as mink and raccoon, should not be trapped so that their skins can be made into fur coats					
There is nothing morally wrong with hunting wild animals for food					
I think people who object to raising animals for meat are too sentimental					
I think it is perfectly acceptable for cattle and hogs to be raised for human consumption					
Basically, humans have the right to use animals as we see fit					
The slaughter of whales and dolphins should be immediately stopped even if it means some people will be put out of work					
I sometimes get upset when I see wild animals in cages at zoos.					
Too much fuss is made over the welfare of animals these days when there are many human problems that need to be solved					
Continued research with animals is necessary if we are ever to be able to conquer diseases such as cancer, heart disease and AIDS.					
It is unethical to breed purebred dogs for pets when millions of dogs are killed in animal shelters each year.					
The production of inexpensive meat, eggs and dairy products justifies maintaining animals under crowded conditions					
One of the worst things someone can do is to hurt a defenceless animal					

(animal attitudes Scale – Herzog, Betchart and Pittman 1991)

Beef Analysis

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.

8. In what follows we will present you with information about two packages of steak, sold in random weights. Currently, the average price of this type of steak is $15.39 per kg ($6.98/lb).

Only one answer is possible *(control by the computer) (each product and WTP on one page)*

"Steak A"

This steak is produced in a Canadian family beef cattle operation.

(Randomized selection of the price: lower value $15.39/kg or upper value $30.78/kg ($13.69/lb))
If lower Value
A. Would you buy this product at a price of $15.39 per kg

Yes	No

B. IF YES, would you buy the product if it were
offered at a price of $30.78 per kg

Yes	No

"Steak B"

This steak is produced in a Canadian family beef cattle operation.

The cattle are raised in a way that they produce between 10 and 20% less methane per animal. Methane is a significant contributor to greenhouse gas emission.

(Randomized selection of the price: lower value $15.39/kg or upper value $30.78/kg $13.69/lb)
If Higher Value
A. Would you buy this product at a price of $30.78 per kg ($13.69/lb)

Yes	No

B. IF NO, would you buy the product if it were offered at $15.39 per kg.

Yes	No

Genomics is the study of the genes and genetic characteristics of organisms like plants, animals, and humans. 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.

9. In what follows we will present you with information about two packages of steak sold in random weights. Currently, the average price of this type of steak is around $15.39 per kg. Only one answer is possible *(control by the computer) (each product and WTP on one page)*

"Steak A"

This steak is produced in a Canadian family beef cattle operation.

The cattle are raised on a farm where they produce between 10 and 20% less methane per animal, as compared to other cattle operations.

This steak was produced from a bovine animal that was bred using genomic information and is 20% more feed efficient, reducing greenhouse gas emissions.

(RANDOMIZED SELECTION OF THE PRICE: LOWER VALUE $15.39/KG OR UPPER VALUE $30.78 ($13.69/LB))
IF LOWER VALUE
A. Would you buy this product at a price of $15.39 per kg

Yes	No

B. IF YES, would you buy the product if it were offered at a price of $30.78 per kg

Yes	No

"Steak"

This steak is produced in a Canadian family beef cattle operation.

The cattle are raised on a farm where they produce between 10 and 20% less methane per animal, as compared to other cattle operations

This steak was produced from a bovine animal that has been vaccinated to eliminate the microbes in the rumen of the animal that produce the methane, reducing greenhouse gas emissions.

(RANDOMIZED SELECTION OF THE PRICE: LOWER VALUE $15.39/KG OR UPPER VALUE $30.78 ($13.69/LB))
IF HIGHER VALUE
A. Would you buy this product at a price of $30.78 per kg

Yes	No

B. IF NO, would you buy the product if it were offered at $15.39 per kg.

Yes	No

10. Please identify whether you agree or disagree with the following statements.

Statement	Strongly Disagree	Mildly Disagree	Neither Agree or Disagree	Mildly Agree	Strongly Agree
	1	2	3	4	5
Animal vaccinations cannot be seriously harmful; otherwise, authorities would ban them					
There is a good reason why certain animal vaccinations are recommended					
Overall, animal vaccinations deliver more benefits than harm					
We live in such a hygienic environment that animal vaccinations are redundant					
For serious animal diseases, requirements for farmers to vaccinate should be in place					
Vaccination is a better strategy than destroying the affected animals					
Animal vaccinations are another important factor that is threatening the environment					
Consuming meat from vaccinated animals can result in my becoming immune to the illness					

(Zingg and Siegrist)

Section 3: Background Questions

11. In which of the following age groups do you fall?

1. ❒ 18-20
2. ❒ 21-24
3. ❒ 25-29
4. ❒ 30-39
5. ❒ 40-49
6. ❒ 50-64
7. ❒ 65+

12. Generally speaking, would you say that most people can be trusted?

Most people can be trusted	Can't be too careful in dealing with people	Don't know
1	**2**	**3**
❒	❒	❒

13. Please indicate if you are:

1. ❒ Male
2. ❒ Female

14. Including yourself, how many people live in your household?

1. ❒ 1
2. ❒ 2
3. ❒ 3
4. ❒ 4
5. ❒ 5 or more

15. How many children younger than 18 live in your house?

1. ❒ No children < 18 years live in my house
2. ❒ 1
3. ❒ 2
4. ❒ 3
5. ❒ 4
6. ❒ More than 4

16. What is your marital status? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Married/Living together/Common Law
2. ❒ Single
3. ❒ Divorced/Separated
4. ❒ Widowed

17. What is the highest level of education you've achieved? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Elementary school
2. ❒ Secondary (high) school

3. ❒ Technical/ business school/Community college
4. ❒ University
5. ❒ Post graduate studies (Masters or PhD)

18. Which region do you live in? **ONLY ONE ANSWER POSSIBLE**

1. ❒ Maritimes
2. ❒ Quebec
3. ❒ Ontario
4. ❒ Manitoba
5. ❒ Saskatchewan
6. ❒ Alberta
7. ❒ British Columbia
8. ❒ Yukon, Northwest Territories, Nunavut

19. Do you live in a city, in a town or in the countryside? **ONLY ONE ANSWER POSSIBLE**

1. ❒ In a city (>100.000 inhabitants)
2. ❒ In a town (> 10.000 inhabitants)
3. ❒ In the countryside/rural district

20. What is the approximate range of your total household income? **ONLY ONE ANSWER POSSIBLE**

1. ❒ $ 24,999 or under
2. ❒ Between $ 25,000 and $ 39,999
3. ❒ Between $ 40,000 and $ 64,999
4. ❒ Between $ 65,000 and $ 79,999
5. ❒ Between $ 80,000 and $ 99,999
6. ❒ Between $ 100,000 and $ 119,999
7. ❒ $ 120,000 or more

Appendix E (The Two Row Specification Model Analysis)

Table E.1: Estimates of Conditional and Random Parameter Logit Models in Nanotechnology Survey (Basic Model)

	Vitamin D Fortified		Vitamin D Fortified - Nanotechnology		UV-Protected Juice Bottle		UV-Protected Juice Bottle - Nanotechnology	
	CL	**RPL**	**CL**	**RPL**	**CL**	**RPL**	**CL**	**RPL**
Constant	4.46*** (0.32)	4.64*** (0.39)	2.35*** (0.33)	2.43*** (0.37)	3.29*** (0.32)	3.08*** (0.39)	1.96*** (0.34)	1.72*** (0.37)
Price	-2.32*** (0.15)	-2.54*** (0.17)	-1.49*** (0.16)	-1.57*** (0.18)	-1.88*** (0.15)	-1.91*** (0.18)	-1.46*** (0.17)	-1.34*** (0.19)
Standard Deviation Effects								
Price		0.22*** (0.39)		0.35*** (0.40)		0.26*** (0.35)		0.17 (0.32)
Model Statistics								
Log-likelihood	*-887.16*	*-864.12*	*-883.48*	*-862.36*	*-890.53*	*-874.42*	*-817.12*	*-805.77*
ρ^2 *(Pseudo R-squared)*	*0.161*	*0.186*	*0.064*	*0.117*	*0.103*	*0.128*	*0.054*	*0.107*
# of Observations	*1513*		*1492*		*1507*		*1511*	

Note: 1- ***, **, *, Significant at 1%, 5%, and 10% level
2- Standard Error in parenthesis

Table E.2: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis) (Basic Model) (Nanotechnology Survey)

	CL	RPL
Vitamin D fortified juice	$1.91***/litre	$1.82***/litre
Vitamin D fortified juice produced by means of nanotechnology	$1.58***/litre	$1.54***/litre
UV-Protected juice bottle	$1.71***/litre	$1.62***/litre
UV-Protected juice bottle packaged by means of nanotechnology	$1.32***/litre	$1.28***/litre

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.3: Estimates of Conditional Logit with Interactions in Nanotechnology Survey

	Vitamin D Fortified		Vitamin D Fortified - Nanotechnology		UV-Protected Juice Bottle		UV-Protected Juice Bottle - Nanotechnology	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Constant	3.28***	0.66	0.69	0.67	2.12***	0.67	0.24	0.72
Price	-2.40***	0.16	-1.57***	0.16	-1.94***	0.16	-1.55***	0.17
Gender	-0.006	0.12	0.15	0.13	0.16	0.13	0.39***	0.13
Age	-0.07	0.05	-0.06	0.05	-0.01	0.05	-0.07	0.05
Trust	0.24*	0.13	0.48***	0.13	0.15	0.13	0.39***	0.13
Child	0.09	0.14	0.16	0.14	0.13	0.14	0.27*	0.15
Education	0.04	0.04	0.06*	0.04	0.01	0.04	0.06	0.04
Ontario	0.05	0.13	0.09	0.14	0.09	0.14	0.15	0.14
Manitoba	-0.32	0.34	-0.32	0.35	-0.53	0.35	-0.88**	0.43
Saskatchewan	0.76**	0.40	0.74**	0.39	0.09	0.41	0.65	0.41
Alberta	-0.02	0.19	0.22	0.19	0.20	0.19	0.03	0.20
Rural	0.28*	0.16	0.06	0.17	0.15	0.16	-0.17	0.19
Income	0.07*	0.04	-0.04	0.04	-0.04	0.04	-0.06	0.04
Heard of Nanotechnology	-0.15	0.13	-0.09	0.13	-0.28**	0.13	-0.37***	0.13
Science & Technology	0.07**	0.03	0.09***	0.03	0.09***	0.03	0.14***	0.04
Knowledge	0.06*	0.03	0.08**	0.03	0.08**	0.03	0.07**	0.05
Model Statistics								
Log-likelihood	*-869.1*		*-854.9*		*-873.74*		*-780.95*	
ρ^2 *(Pseudo R-squared)*	*0.184*		*0.102*		*0.125*		*0.101*	
# of Observations	*1513*		*1492*		*1507*		*1511*	

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.4: Summary of the Regressions Analyses of Table E.3 in Nanotechnology Survey

	Vitamin D Fortified	Vitamin D Fortified - Nanotechnology	UV-Protected Juice Bottle	UV-Protected Juice Bottle - Nanotechnology
	Coefficient	**Coefficient**	**Coefficient**	**Coefficient**
Constant	+***		+***	
Price	-***	-***	-***	-***
Gender				+***
Age				
Trust	+*	+***		+***
Child				+*
Education		+*		
Ontario				
Manitoba				-**
Saskatchewan	+**	+**		
Alberta				
Rural	+*			
Income	+*			
Heard of Nanotechnology			-**	-***
Science & Technology	+**	+***	+***	+***
Knowledge	+*	+**	+**	+**

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.5: Willingness to Pay (in $) (Conditional Logit Regression Analysis) (with Interactions) (Nanotechnology Survey)

For attributes in Juice (For a 1 Litre bottle) – 45 year old Male, living in rural area, with no children at home, with average income ($69,000 annually) and average education (college degree '14 years'), who has heard about nanotechnology prior to survey, and believes others cannot be trusted.

Vitamin D fortified juice	$1.76***/litre
Vitamin D fortified juice produced by means of nanotechnology	$1.45***/litre
UV-Protected juice bottle	$1.55***/litre
UV-Protected juice bottle packaged by means of nanotechnology	$1.28***/litre

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.6: Estimates of Conditional Logit and Random Parameter Logit Basic Models (Pork Survey)

Attributes	(Pork I) Lower Probability of PCVAD/PRRS Disease versus Conventional Pork (No Technology Introduced)				(Pork II) Genomics versus Vaccinated Pork Chops (Both with Lower Probability of PCVAD/PRRS Disease)			
	CL Model		**RPL Model**		**CL Model**		**RPL Model**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Mean Effects								
Price	-0.25***	0.02	-0.32***	0.02	-0.11***	0.01	-0.17***	0.02
Pork Attribute	1.04***	0.05	1.18***	0.07	0.02***	0.04	0.09***	0.06
Neither option	-2.16***	0.10	-2.55***	0.13	-1.55***	0.09	-1.98***	0.12
Standard Deviation Effects								
Pork Attribute			0.98***	0.12			1.08***	0.13
Model Statistics								
Log-likelihood	*-2520.23*		*-2506.21*		*-2909.43*		*-2891.38*	
ρ^2 (Pseudo R-squared)	*0.068*		*0.220*		*0.014*		*0.081*	
# of Observations	*2934*		*2934*		*2864*		*2864*	

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.7: Estimates of Conditional Logit and Random Parameter Logit Models with Interactions (Pork Survey)

Attributes	(Pork I) Lower Probability of PCVAD/PRRS Disease versus Conventional Pork (No Technology Introduced)				(Pork II) Genomics versus Vaccinated Pork Chops (Both with Lower Probability of PCVAD/PRRS Disease)			
	CL Model		RPL Model		CL Model		RPL Model	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Mean Effects								
Price	-0.26***	0.02	-0.32***	0.02	-0.11***	0.01	-0.17***	0.02
Pork Attribute	0.24	0.48	0.20	0.59	0.66	0.47	0.73	0.60
Neither option	-2.19***	0.09	-2.56***	0.13	-1.58***	0.08	-1.97***	0.12
Gender	0.03	0.09	0.03	0.11	0.22**	0.08	0.26**	0.11
Age	0.04	0.03	-0.002	0.04	-0.01	0.03	-0.01	0.04
Trust	-0.05	0.09	-0.004	0.10	-0.01	0.08	-0.02	0.10
Child	-0.08	0.09	-0.09	0.12	0.10	0.09	0.11	0.13
Education	-0.05	0.03	-0.002	0.03	-0.06**	0.03	-0.07**	0.03
Alberta	-0.24*	0.14	-0.27*	0.17	-0.21	0.14	-0.23	0.17
Ontario	-0.08	0.09	-0.09	0.11	0.11	0.09	0.14	0.11
Manitoba	-0.12	0.19	-0.12	0.24	-0.36*	0.19	-0.41*	0.25
Saskatchewan	-0.07	0.22	-0.11	0.27	-0.23	0.22	-0.23	0.27
Rural	-0.07	0.09	-0.08	0.11	-0.15	0.09	-0.16	0.11
Income	0.03	0.03	0.03	0.03	-0.03	0.02	-0.03	0.03
Heard of Genomics	0.04	0.09	0.05	0.11	-0.10	0.09	-0.13	0.11
Science & Technology	0.006	0.02	0.01	0.03	0.03*	0.02	0.04*	0.03
Knowledge	-0.013	0.02	-0.02	0.03	0.08	0.02	0.09	0.03
AAS (Animal Attitude Scale)	0.02***	0.005	0.03***	0.006	-0.001	0.005	-0.002	0.007
Standard Deviation								

Effects				
Pork Attribute		0.95*** 0.12		1.04*** 0.13
Model Statistics				
Log-likelihood	*-2509.2*	*-2496.4*	*-2893.1*	*-2877.6*
ρ^2 (Pseudo R-squared)	*0.072*	*0.226*	*0.019*	*0.086*
# of Observations	*2934*	*2934*	*2864*	*2864*

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.8: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis) (Pork Survey)

For attributes in pork chop (For a 1 Kg package) – 45 year old Male, living in rural areas, with no children at home, with average income ($72,000 annually) and average education (college degree '14 years') , and animal attitude score (AAS) at mean (41.9), who have heard about genomics prior to survey, and believes others cannot be trusted.

Basic Model		
	CL	**RPL**
Pork chops with lower probability of PCVAD/PRRS disease	$4.16***/Kg	$3.68***/Kg
Pork chops produced with genomics with lower disease susceptibility	$3.93*/Kg	$3.16*/Kg
With Socio Demographic Interactions		
	CL	**RPL**
Pork chops with lower probability of PCVAD/PRRS disease	$4.43***/Kg	$3.95***/Kg
Pork chops produced with genomics with lower disease susceptibility	$3.77*/Kg	$3.09*/Kg

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.9: Estimates of Conditional Logit and Random Parameter Logit Basic Models (Beef Survey)

Attributes	**(Steak I)** Lower Methane per Animal Production versus Conventional Steak (No Technology Introduced)				**(Steak II)** Genomics versus Vaccinated Steaks (Both with Lower Methane Production and More Feed Efficient)			
	CL Model		**RPL Model**		**CL Model**		**RPL Model**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Mean Effects								
Price	-0.04***	0.003	-0.05***	0.004	-0.03***	0.003	0.03***	0.004
Steak Attribute	0.43***	0.04	0.42***	0.05	0.39***	0.04	0.36***	0.05
Neither option	-1.17***	0.08	-1.33***	0.09	-0.54***	0.08	-0.64***	0.09
Standard Deviation Effects								
Steak Attribute			0.69***	0.11			0.69***	0.11
Model Statistics								
Log-likelihood	*-3262.28*		*-3254.77*		*-3276.13*		*-3269.17*	
ρ^2 (Pseudo R-squared)	*0.026*		*0.055*		*0.009*		*0.024*	
# of Observations	*3136*		*3136*		*3050*		*3050*	

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.10: Estimates of Conditional Logit and Random Parameter Logit Models with Interactions (Beef Survey)

Attributes	(Steak I) Lower Methane per Animal Production over Conventional Steak (No Technology Introduced)				(Steak II) Genomics over Vaccinated Steaks (Both with Lower Methane Production and More Feed Efficient)			
	CL Model		RPL Model		CL Model		RPL Model	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Mean Effects								
Price	-0.05***	0.03	-0.05***	0.004	-0.03***	0.004	-0.03***	0.004
Steak Attribute	-0.27	0.49	-0.43	0.56	0.03	0.49	0.15	0.55
Neither option	-1.21***	0.08	-1.38***	0.09	-0.56***	0.09	-0.65***	0.09
Gender	0.05	0.09	0.05	0.09	0.04	0.09	0.04	0.09
Age	-0.11***	0.04	-0.12***	0.04	-0.04	0.03	-0.05	0.04
Trust	-0.01	0.08	-0.005	0.09	0.03	0.08	0.02	0.09
Child	-0.07	0.09	-0.08	0.11	0.01	0.09	0.02	0.11
Education	0.004	0.03	0.005	0.03	0.005	0.03	-0.001	0.03
Alberta	-0.20	0.14	-0.22	0.16	-0.12	0.14	-0.13	0.16
Ontario	-0.24***	0.09	-0.28***	0.09	-0.33***	0.09	-0.35***	0.09
Manitoba	-0.11	0.18	-0.13	0.19	-0.13	0.17	-0.16	0.19
Saskatchewan	-0.27	0.21	-0.28	0.23	-0.46**	0.21	-0.51**	0.23
Rural	-0.06	0.11	-0.06	0.12	0.01	0.113	0.007	0.12
Income	0.03	0.02	0.04	0.02	0.05**	0.02	0.05**	0.02
Heard of Genomics	0.11	0.08	0.13	0.09	0.14*	0.08	0.16*	0.09
Science & Technology	0.06***	0.02	0.07***	0.02	0.05**	0.02	0.05**	0.02
Knowledge	0.04**	0.02	0.04**	0.02	0.01	0.02	0.02	0.02
AAS	0.02***	0.005	0.02***	0.006	-0.004	0.005	-0.002	0.006
Standard Deviation Effects								
Steak Attribute			0.73***	0.11			0.67***	0.12

Model Statistics				
Log-likelihood	*-3234.4*	*-3226.1*	*-3255.9*	*-3250.1*
ρ^2 *(Pseudo R-squared)*	*0.035*	*0.064*	*0.015*	*0.030*
# of Observations	*3136*	*3136*	*3050*	*3050*

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.11: Willingness to Pay (in $) (Conditional Logit and Random Parameter Logit Regression Analysis) (Beef Survey)

For attributes in steaks (For a 1 Kg package) – 45 year old Male, living in rural areas, with no children at home, with average income ($70,000 annually) and average education (college degree '14 years'), and animal attitude score (AAS) at mean (42.1), who have heard about genomics prior to survey, and believes others cannot be trusted.

Basic Model		
	CL	**RPL**
Steak with lower methane per animal production	$10.75***/Kg	$8.4***/Kg
Steak produced with genomics application with lower methane production and more feed efficient	$9.8*/Kg	$7.9*/Kg

With Socio Demographic Interactions		
	CL	**RPL**
Steak with lower methane per animal production over steak	$13.34***/Kg	$12.64***/Kg
Steak produced with genomics application with lower methane production and more feed efficient	$11.89***/Kg	$10.59**/Kg

Note: ***, **, *, Significant at 1%, 5%, and 10% level

Table E.12: Summary of the Regressions Analyses Estimates of Table E.7 and Table E.10 in Pork and Beef Surveys

Attributes	(Pork I)		(Pork II)		(Steak I)		(Steak II)	
	CL	RPL	CL	RPL	CL	RPL	CL	RPL
Mean Effects								
Price	-***	-***	-***	-***	-***	-***	-***	-***
Pork/ Steak Attribute								
Neither option	-***	-***	-***	-***	-***	-***	-***	-***
Gender			+**	+**				
Age					-***	-***		
Trust								
Child								
Education			-**	-**				
Alberta	-*	-*						
Ontario					-***	-***	-***	-***
Manitoba			-*	-*				
Saskatchewan							-**	-**
Rural								
Income							+**	+**
Heard of Genomics							+*	+*
Science & Technology			+*	+*	+***	+***	+**	+**
Knowledge					+**	+**		
AAS	+***	+***			+***	+***		
Standard Deviation Effects								
Pork/ Steak Attribute		+***		+***		+***		+***

Note: ***, **, *, Significant at 1%, 5%, and 10% level