Evolving Consumer Acceptance of Biotechnology Applications in Canada:

Evidence from the Public Opinion Surveys in 2001 (fifth wave) and 2011 (seventh wave)

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1. INTRODUCTION

Public perceptions and acceptability of biotechnology applications are important determinants of successful commercialization of biotechnology innovations (Siegrist, 2000; Wansink and Kim, 2001). In addition, public opinion plays an important role in shaping public policies governing biotechnology applications across the world (Vigani and Opler, 2012). Available evidence suggests that public attitudes towards biotechnology are evolving in a direction of greater acceptance but not universal acceptance (Shanahan, 2001; Shanahan et al. 2001; Blaine et al. 2002; Bonny, 2008). While many have attempted to explain underlying factors that shape public acceptability of biotechnology at a given point in time (Moon and Balasubramanian, 2004; Townsend and Campbell, 2004; Spence and Townsend, 2006; Lang and Priest, 2007; Poortinga and Pidgon, 2007; Lyndhurst, 2009), there is little research about what may account for evolving consumer acceptability over time. The objective of the research reported below is to understand the underlying drivers of the evolving - generally favorable - attitude towards biotechnology applications among the Canadian public.

Public opinions are diverse around the world about use of biotechnology and genetic engineering (GE[1]) in different applications (food vs. medicine). However, in general most European and many Asian countries are reputed to have the strongest opposition to biotechnology applications. A number of studies have explored the patterns of changes in consumer attitudes and opinions across countries, most notably among Europeans

[1] Genetic engineering is the process of introducing genes between different species of microbes, plants and animals, hence known as recombinant DNA or transgenic. Whereas biotechnology could be included other methods of genetic modifications (such a mutagenesis) that are not necessarily gene transfers among species.

(Eurobarometer 1991; Eurobarometer 2005; Environics International 2000; Hoban 2004; Bonny 2008). In Canada too, a series of public opinion surveys spanning from 1993 to 2011 have gauged the Canadian public perception on risk, benefit, and attitudes on many other attributes of biotechnological product and processes (see Blaine *et al.* 2002 for a review of survey findings in Canada from 1993 till 2001; see also Einsiedel, 2000). Within the span of 2000 to 2011, an increasing number of Canadians have expressed their support for use of biotechnological applications. As Figure 1 reveals, the gap has widened between the proportion of Canadians who "support" and who "oppose" biotechnological applications. Between 2000 and 2011, the lead for the "support" viewpoint has gone up by about threefold from 14 percentage points in 2000 to 51 percentage points by 2011[2]. The changes in the different "intensities" of support between 2001 and 2011 clearly indicate an increasing acceptance for biotechnological applications among the Canadian public (Table 1). For example, the "strongly support" category has doubled (from 8 to 16 percent); the "somewhat support" category has increased from 47 to 56 percent; the "somewhat oppose" category has dropped from 22 to 14 percent, and the "strongly oppose" category has dropped from 12 to 4.6 percent. All such temporal changes in different "intensities" of support are statistically significant at one percent level[3].

What are the potential underlying factors that could explain these temporal changes in public acceptance of biotechnology applications in Canada? Previous research mostly attempted to explain underlying factors that shape public acceptability of biotechnology at a given point in time (see Lyndhurst, 2009 for a review of such studies). To best of our knowledge, there is no

[2] In 2000, 51 percent of the respondents were supporters while 37 percent was opposing biotechnology application (51-37=14 percentage point lead). In 2011, 70 percent of the respondents were supporters while only 19 percent was opposing biotechnology application (70-19=51 percentage point lead).

[3] There is only one percent probability that 2001 and 2011 samples are drawn from a population with similar attitudes about the acceptability of biotechnology applications.

systematic research that explores what may account for evolving consumer acceptability over time. Some argue that lack of comparable identical questions from public opinion surveys is the main reason for dearth of systematic temporal comparisons of evolving consumer attitude on biotechnology. Bonny (2008) who compared the representative public opinion surveys between 1996 and 2008 on biotechnology applications in the EU and the U.S., highlighted the difficulty of obtaining identical questions for such comparisons:

"In deed, to compare opinions between countries or to study their evolution over the years, it must be able to compare answers over space or time, and the questions asked must therefore be identical, including their nuances after translating into different languages. However, this is rarely the case. Thus despite the numerous polls on opinions about GMOs, the necessity to compare answers to identical questions in the USA and in the EU leads to a much reduced number of usable survey….(p.2)".

The two Canadian public opinion surveys in 2001 and 2011 that are used for the present research provide some identical questions to undertake systematic analyses on the evolution of public acceptability of the biotechnology applications. To our knowledge, the present research is the first attempt in Canada to systematically explore evolving consumer attitude towards biotechnology applications based on the identical set of questions in two waves of public opinion surveys.

Temporal changes in consumer attitude towards biotechnology applications may be driven by changes in demography, changes in information and institutional environments including consumer trust in the regulatory environment, and the changes in overall consumer cognition of science and technology. Table two, three and four describe changes of public

viewpoints[4] on some of such aspects of biotechnology applications in Canada between 2001 and 2011. In general, the Canadian public has evolved to see technology in a positive light[5] as captured by "top of mind reaction to technology" and "top of mind reaction to biotechnology" (Table 2). Such evolving "optimism" about technology has been reported before (see Bonny, 2008 Figure 17). On the other hand, there is no noticeable increase in "familiarity" with either biotechnology itself or its regulations (Table 3). In fact, the Canadian public has become relatively more ignorant about regulations governing biotechnology[6] (Table 3). On average, public "confidence" has ebbed on the regulatory system governing biotechnology between 2001 and 2011 (Table 4).

However, these proportional changes in the aggregates of such potential drivers across time would mask the important underlying relationships. To unearth such relationships, one should use multivariate data analyses where impacts of many variables could be properly accounted for. The temporal changes in the nature and strength of the association between the above variables will be useful to discover the underlying factors that determine evolving consumer support for biotechnology. This study explores such temporal changes using ordered logistic regression method based on identical set of questions from 2001 and 2011 public opinion surveys. The paper is organized as follows: the next section briefly introduces the issues related to the public acceptability of biotechnology applications. Section 3 outlines the conceptual

[4] The public view points are: top of mind reactions to technology and biotechnology and exposure to biotechnology issues (Table 2); familiarity with biotechnology and their regulations (Table 3) and confidence in regulatory governance (Table 4). Table 5 provides surveys questions on such viewpoints.

[5] The proportions of Canadian public with a negative "top of mind reaction" to both technology and biotechnology have showed a significant drop between 2001 and 2011. In addition, proportion of those who have a neutral "top of mind reaction" has significantly increased. For biotechnology, even the proportion of those who have a positive top of mind reaction has significantly increased between 2001 and 2011.

[6] Between 2001 and 2011 both the percentages of categories for "very familiar" and "somewhat familiar" of biotechnology regulations have dropped significantly, while the percentage for the category of "not at all familiar" has significantly increased.

framework for enumerating consumer attitudes toward biotechnology and the conceptual approach used in the paper. Section 4 explains the data sources and the econometric methods followed by a discussion on the results of the estimations. Some concluding remarks ends the paper.

2. Significance in public acceptability and other related issues of biotechnology

Biotechnology is a broader concept that is in principle involves living organisms and their genetics and molecular structures related to food, health and human life. The official definition of biotechnology adapted in the 1993 Canadian Environment Protection Act is:

> "The application of science and engineering in the direct or indirect use of living organisms or parts or products of living organisms in their natural or modified forms"

The most cited benefits offered by biotechnological applications are in medical science, in food and agriculture and in environmental sciences (Biotechnology Industry Organization, 2012). A number of biotechnological developments in medical science were instrumental in elimination of diseases, better diagnostic techniques, treatments and drugs. Plant and animal biotechnologies in food and agriculture enhance agricultural productivity to meet ever increasing food, fiber and fuel demands and more nutritious and disease combating food products (bio-fortification). The GE based food innovation are aimed for direct human consumptions (such as GE tomatoes to GE salmon), feed for raising livestock (such as GE alfalfa) or for other societal goals (such as the *enviropig* – GE pig to control phosphorus pollution). In the environmental sphere, the noteworthy biotechnological applications are bioremediation using microbes to combat oil spills and hazardous mine-wastes.

Notwithstanding such potential benefits of biotechnological applications, unintended risks of such technologies to consumers and potential ethical concerns over the distribution of

their benefits have led to an intense debate about their wider applicability (Kinchy, 2012). Use of biotechnology and genetic engineering in food is arguably the most controversial and sensitive public perception issue among the uses of biotechnology. However, issues of public perceptions on biotechnology applications transcend beyond the consumable food to other domain that are adjacent to food including, feed, environment and animals. Adverse consumer reactions and agitation by potential interest groups (e.g., organic producers) and environmentalists (e.g., Green Peace) against biotechnological applications may undermine R&D investment in such technologies (MacIntosh and Cumming, 1999 and Bollag, 2000). However, once developed, their commercial success is most critically determined by consumers' acceptability of such technologies. For example, the adverse consumer reaction to genetically engineered (GE) crops in the European Union (EU) is one of the main reasons for little adoption of such crops by EU farmers compared to the U.S. rates of adoption (Bonny, 2008). From 1996 to 2007, the EU share of the global transgenic crop area stagnated around one percent while the U.S. managed almost half of the global transgenic crop area[7].

Significance of the public acceptability of biotechnological applications was emphasized in Canada at an early stage of public discourse on such technologies. For example, during the debate about rBST[8] hormone in the mid 1990's the House of Commons Standing Committee on Agriculture and Agri-Food in their final report had noted that:

"Governments, companies and other stakeholders must be aware that R&D will be supported only if the end user is convinced of the benefits, not only of the products themselves but of the *raison d' être* of the new technology. Biotechnology decisions cannot be made in a scientific vacuum if they are to receive the necessary public support and funding".

[7] In 2007, of the 114 million hectares of global GE crop area, EU had 0.11 million hectares while U.S, reported about 57.7 million hectares, see Moschini (2008).

[8] The rBST is genetically engineered –recombinant- version of the Bovine Somatotropin-a hormone that is naturally produced in the pituitary gland of cattle which could regulate the milk production of dairy cows. The rBST was the first GE product that was attempted to be introduced into Canada involving food production.

3. Conceptual Framework for exploring public acceptability of biotechnology

There is a substantial body of literature that demonstrates "public attitude" would influence public acceptability of biotechnology innovations and hence reinforce their commercial success (see a useful review of such studies by Lyndhurst, 2009). Attitudes can be used to explain why some people support particular social policies, or ideologies, while others oppose them. Evaluative responses of such "attitudes" have both direction (positive or negative) and intensity (a *very positive* evaluation is likely to have a very different impact on behavior compared to a *slightly positive* one). The intensity aspect of an attitude is explained by the multi-attribute theory of Fishbein and Ajzen (1975) which is based on the "beliefs" about various aspects or "attributes" and the "relative importance" of such attributes of the phenomenon that being evaluated to form an attitude. According to Fishbein and Ajzen's (1975) theory, attitude is the net sum of all positive and negative beliefs about the various aspects (attributes) of the phenomenon weighted by the importance weights of these aspects to the evaluator. Because beliefs are subjective, they vary across consumers. In addition, variation in the relative importance (which is again subjective) attached to the "multi-attribute" of the phenomenon could lead to divergent "attitude" among consumers.

A majority of analytical work that focuses on the drivers of public attitudes are designed as snapshot of a country or region at a given period of time (Lyndhurst, 2009). Our principal aim is to understand the drivers of temporal change (from 2001 to 2011) of public attitudes toward biotechnology application in Canada. The studies that explore the drivers of the changes in public attitudes toward biotechnology applications are limited in the literature. We are mindful about the hurdles in exploring temporal changes in public attitude on catch-all phrase such as "biotechnology", especially using some sorts of psychographics variables to account for the

"cognitive" and behavioral responses. One of such hurdles is the variation in degree of support across different applications of biotechnology. It is well known that public attitude vary considerably across types of biotechnology applications (Knight 2006; Siipi and Launis, 2009; Einsieded, 2000). Gaskell et al (1999) found that public support for biotechnology in the Europe and in the U.S significantly varied depending on the type of applications. For example, Gaskell et al (1999) report that the survey participants in the U.S. expressed a greater support for food and crop related biotechnology application by a sizeable margin compared to their European counterparts. On the other hand, the support among the Europeans for genetic testing using biotechnology is greater than that of the U.S. participants. The two surveys we have used in this research do not provide identical questions to address more nuanced changes in consumer attitudes across different applications (i.e., food vs. medicine) of biotechnology over time. On the other hand since consumers are exposed to different types of biotechnology application simultaneously, a more "general" attitude such as "acceptability of biotechnology" is needed to explore the "whole" or the "aggregate" phenomenon as against the components.

Similar to most of the analyses on the drivers of public attitude towards biotechnology (Poortinga and Pidgon, 2007; Moon and Balasubramanian, 2004; Townsend and Campbell, 2004; Spence and Townsend 2006; Lang and Priest, 2007), we also recognize that "cognitive mediating" process (Figure 2) driven by psychographic factors is the "attitude" formation mechanism. The antecedent of the final "attitude" or the degree of consumer receptivity of biotechnology is the "perceived risks and benefits of biotechnology". Researchers argue that the two most significant psychographic variables that influence the "perceived risks and benefits" are: "trust in the regulatory governance and the experts" and "awareness and knowledge about the science and technology" (Wansink and Kim, 2001; Frewer, 2003; Moon and

Balasubramanian, 2004). One could surmise that consumers' "trust on the experts and regulatory governance" and "awareness and knowledge about science and technology" have reinforcing feedback effects[9]. The cognitive mediating process described above is depicted in the middle box of Figure 2.

The dynamics of the cognitive mediating process is conditioned by the exogenous "institutional and information environment" (Figure 2 top row). The first of such exogenous factors is the "informational intervention and public awareness of biotechnology". One of the drivers of public rejection of new technologies is the "knowledge deficit" which is explicated in the literature as "deficit model" (Weldon and Laycock, 2009 and Sturgis *et al*. 2005). The "deficit" model suggests that a potential driver of negative attitude towards new technologies is the "deficit" in the knowledge and understanding about new technologies, hence the attendant irrational fear of their risk and ignorance about their benefit. For instance, based on Eurobarometer survey among 25 EU members in 2005, Weldon and Laycock (2009) found that public support for both biotechnology and pharmacogenetics (personalized therapeutics based on individual genetic makeup) is significantly correlated with the respondents' general scientific knowledge. The public information interventions are the suggested solution to ameliorate this knowledge deficit and many countries have adopted such interventions[10]. Their efforts and activities would influence awareness and knowledge as well as trust in the expert and regulatory governance.

[9] For example a more sympathetic views on "science" as an omnipotent force might lead to the world view that "science" based regulatory regimes are more trustworthy. Hence we recognize the reciprocal effects.
[10] In year 2000 "Council for Biotechnology Information" (www.whybiotech.ca) was established in all the NAFTA countries with: "the mandate has stayed true to presenting science-based information to the public".

The second exogenous factor that influences the cognitive mediating process is the regulations and their enforcement governing biotechnology. The trust in regulatory actors is determined by the institutional context of regulatory governance including the philosophies of regulation design (precautionary approach vs. substantial equivalent and familiarity approach) and their enforcement efforts. Gaskel et al (1999), in an attempt to explore the underlying factors responsible for very different degrees of biotechnology acceptance between European consumers and the U.S. consumers, noted that differences in the level of trust placed in government may account for such divergent views. In a recent paper, Vigani and Olper (2012), developed an index was to capture the regulatory stringency in biotechnology regulations across 61 countries. They used six dimensions[11] to evaluate the across country regulatory stringency. Some of these countries are "free" of genetically modified organisms. Arguably, such countries[12] are likely to have a higher degree of trust in the regulatory system. Some suggest that consumers' trust in science and technology expertise including public and private research and science enterprise is also important in consumers' risk benefit assessment of new technologies (Segrist, 1999 and 2000; Howlett and Migone, 2010). It is currently recognized that public trust and confidence in a given scientific phenomenon are determined both by the regulators and regulatory institutions and the "source credibility" of the sources or the developers of the scientific phenomenon (Frewer, 2003).

The third exogenous factor in the top row of Figure 2 that influences the cognitive mediating process is the existing general regulatory environment for consumer safety. Consumers' trust in regulations for new technology is likely to be positively or negatively

[11] The six dimensions are approval process; risk assessment; labeling; traceability; coexistence; membership in the international agreements.

[12] Vigani and Olper (2012) found that Zimbabwe is the most stringent regulatory regimes among the 61 countries they studied.

reinforced with the degree of efficacy of the existing general regulatory environment for assuring consumer safety in other product and processes. A higher degree of food safety assurance through stringent regulatory measures is likely to have an overall positive feedback effect on the trust status of the regulatory control of other food hazardous including biotechnological applications. The same argument might hold for the GE based medical diagnostics and treatments. These potential other "consumer safety" measures might come from both domestically or as international development. The Cartagena Biosafety Protocol (CBP) is a case in point. A more "risk aversion" philosophy of the CBP could boost the confidence and trust among the public, enhancing their trust status to a new higher level. The cognitive mediating process and the nature of influence of these other exogenous factors are conditioned by the demographic variables and hence these are included in our conceptual framework.

4. DATA AND METHODOLOGY

The fifth wave of the public opinion survey on issues related to biotechnology in Canada was conducted in September 2001 by Pollara/Earnscliffe (see Earnscliffe, 2001; n=1209) and the seventh wave was conducted by Harris Decima in February 2011 (see Harris Decima, 2011; n=1025). These two waves of surveys were administered across Canada (Table 5), where the sample was stratified based on age and provinces. As revealed by comparing with Canadian Census 2001 and 2011, the two survey samples are appear to be representative of the age and gender categories of the Canadian population. However, in both the survey samples the above 69 years age categories were underrepresented.

The identical questions from the two waves of public opinion surveys were used to develop covariates to capture: "awareness and knowledge about the science and technology" and "trust in the regulatory governance and the experts" (Table 7). The variables to characterize "awareness and knowledge about the science and technology" are: (1) the top of mind reaction to technology;

(2) the top of mind reaction to biotechnology; (3) the degree of media exposure and (4) the degree of familiarity of biotechnology. The variables to characterize "trust in the regulatory governance and the experts" are: (1) the knowledge about regulations; and (2) the degree of confidence in safety and regulatory approval process[13]. In addition, a variety of covariates were developed to account for the variation caused by respondents' socioeconomic status (age, education, gender, and income). The dependent variable of the ordered Logit regressions for 2001 and 2011 was the four levels of consumer support (strongly oppose (1); somewhat oppose (2) somewhat support (3); and strongly support (4)) for biotechnology applications. The variable construction is elaborated in Table 7 and the descriptive statistics are given in Table 8.

The "non-responses" (don't know or refused to answer) about attitudinal questions cannot be placed among the "ranked" values of the responses. Thus, we decided to drop the observations with "non- responses". The proportions of the respondents with such "non-responses" are comparable across the two surveys (Table 1). We also decided to drop observations when respondents did not provide household income. Dropping these would not significantly distort the temporal changes of the public acceptance of biotechnology applications. The final ordered logit model was estimated with fewer observations than the surveys' total sample size (see Table 9).

[13] A noteworthy exception here is the "confidence in regulatory system" in 2001 survey questions compared to the 2011 question (see Table 6 for the details). In 2011, it was a one question yet for 2001 there were three questions about "regulatory efficacy" of Health Canada, Environment Canada and Canadian Food Inspection Agency (the three significant regulatory departments in Canada involving biotechnology applications). In order to verify whether these three questions would map into a same underlying construct (confidence in overall regulatory system), we have undertaken some analyses. First, the Spearman correlations are calculated and these are high and statistically significant ($p<0.0000$) for all three pairwise correlations (q23/q24=0.62; q23/q25=0.61 and q24/25=0.60). Second, the three questions produced a single "factor" in a Principal Component Factor Analysis where the single factor explained 74 percent of the total variation of the three questions. The Chronbach's alpha for the inter-item correlation was 0.82. All these suggest that these separate three questions could be aggregated to represent one dimension about confidence in biotechnology regulatory system.

Since all the explanatory variables are dichotomous, their marginal effects are estimated as follows where X is the vector of explanatory variables:

$$\frac{\Delta \Pr(y=m|X)}{\Delta x_k} = \Pr(y = m|X, x_k = x_E) - \Pr(y = m|X, x_k = x_S) \qquad (1)$$

$\Pr(y = m|X, x_k = x_E)$ is the probability that *y* equals the '*m*' outcome of the ordered categories given $\boldsymbol{X}$ at their mean values and the dichotomous explanatory variable (x_k) is equal to one of its values (x_E). $\Pr(y = m|X, x_k = x_S)$ is the probability that *y* equals the '*m*' outcome of the ordered categories, given $\boldsymbol{X}$ at their mean values, and the dichotomous explanatory variable (x_k) is equal to the other value x_S .

5. RESULTS AND DISCUSSION

The ordered logit regressions were a reasonable fit as a model to explain the variation of consumer support for biotechnology in Canada. The Wald test for H_0: all the coefficients jointly equal to zero is rejected at $p<0.0000$ level with an F-test. In order to evaluate the temporal changes of the impact of the explanatory variables, we have estimated predicted probabilities for four outcomes. Table nine shows the results for "support" outcomes for both years and Table 10 shows the results for "oppose" outcomes for both years. For brevity, we discuss here only the factors that significantly affect the probabilities of the two extreme outcomes (i.e., strongly oppose and strongly support) and the changes in their effects between the two time periods.

The effects of variables on the probability of extreme outcomes are similar to the previous findings on the consumer attitudes towards biotechnology applications. For instance, having the positive "top of mind reaction" to biotechnology (BIOTPOS=1) increases the

probability of a respondent being in the "strongly supporting" category by 6.3 percent over and above the respondents who do not have the positive top of mind reaction to biotechnology (BIOTPOS=0). In general, Tables 9 and 10 reveal that, except for age and gender variables, most other socioeconomic variables such as level of education; household income; household type; residence, region of residence are not strongly associated with the public acceptability of biotechnology applications in Canada. On other hand, psychographic variables involving top of mind reactions; confidence in regulatory systems governing biotechnology appear to associate strongly with the public attitude towards biotechnology applications. In the models of two extreme outcomes, the effects of explanatory variables are opposite in sign (positive vs. negative) and this pattern is expected. For example, as noted before BIOTPOS=1 have 6.3 percent greater probability to be in "strongly support" category, on the contrary BIOTPOS=1 have 7 percent less probability (with negative sign) to be in the "strongly oppose" category (Table 10).

Temporal changes in the factors that affect "strongly support" or "strongly oppose" outcomes

Table 11 provides a comparison of marginal effects of the variables for "strongly support" outcomes of consumer acceptability. The temporal changes in the impact of "top of mind reaction to biotechnology" suggest that consumers seem to be polarized in their convictions. In fact the gap in the marginal effects between BIOTPOS and BIOTNEG has widened between 2001 and 2011(Table 9). The impact of exposure to biotechnology (HERDBT=1) increases the probability for strong support, though positive the effect was not significant in 2001 but has become significant and positive in 2011. The same effect of (HERDBT=1) is manifested in the model for "strongly oppose" outcome (Table 12), where the

effect was not significant in 2001 but has become significant and negative in 2011. This result suggests that the association between media exposure about biotechnology and consumer acceptance of biotechnology applications have changed between 2001 and 2011 from a weaker or no association to a positive and significant association. Further analyses are required to ascertain whether increasingly positive images of biotechnology in the media have a role here.

In 2001, a statistically significant positive association was found between familiarity with biotechnology and probability of being "strongly supportive" category (Table 11). In addition, a statistically significant negative association was found between familiarity with biotechnology and probability of being "strongly opposed" category (Table 12). Both these significant associations disappeared in 2011. This result suggests that over time the role of knowledge and familiarity with biotechnology has become less important in influencing public opinion about biotechnology applications in Canada. Perhaps, other perceptions other than familiarity dominate the attitude formation "cognitive mediating process."

A woman in 2001 had 1.9 percent lower probability to be in the "strongly supportive" category f compared to a male (Table 11). Correspondingly, a woman in 2001 had 2.9 percent greater probability to be in the "strongly opposed" category compared to a male (Table 12). Female aversion to biotechnology applications have been consistently reported by others (see Lyndhurst, 2009). However, by 2011, this statistically significant impact of gender has disappeared. Similar results between 2001 and 2011 are found for the age groups of above 40 years old respondents i.e., MIDDLE, PEROLD, OLD (Table 11 and 12). These results suggest that aversion to biotechnology application in 2001 based on the gender and age have disappeared among the Canadian population by 2011.

The impact of "confidence in the regulatory system governing biotechnology" on the probability of "strongly support" has considerably increased between 2001 and 2011. The probability for "strongly support" biotechnology applications in each of the confidence level has significantly increased. For example, in 2001 being a "moderately confident" had a 7.2 percent grater probability of "strongly support" biotechnology applications compared to the other confident levels (Table 11). By 2011, being a "moderately confident" has a 14.5 percent greater probability of "strongly supporting" view point compared to the other confident levels (Table 11). Similar trend is evident for the negative impacts of the "confidence on regulatory system" on the probability of being in the "strongly oppose" category (see Table 12). The increase in the strength of the association between the "confidence in regulatory system" and "acceptability of biotechnology applications" over time suggests that regulatory changes appear to be allaying the consumer concerns about biotechnology applications.

Being a resident of Quebec in 2011 had a 6.4 percent lower probability to "strongly support" biotechnology applications yet, such significant effects were not evident in 2001 (Table 11). A similar effect is manifested in the "strongly oppose" category (Table 12), where being a Quebec resident increases the probability of being in "strongly oppose" group by 1.6 percent. This effect not statistically significant in 2001 but became so in 2011. A potential explanation for this result is that Quebec residents are more likely to be exposed to European values and viewpoints. Thus, the Quebec public attitude may be differentiated from that of the rest of Canada.

The statistically significant marginal effects for 2001 and 2011 for the outcome of "strongly oppose" category in Table 12 reinforce many of the impacts of the variables discussed

above. The significant marginal effects are always in the opposite direction albeit in slightly different magnitudes.

The change over time of the positive association between confidence in the biotechnology regulations and consumer support for biotechnology applications indicates that between 2001 and 2011 biotechnology regulations are increasingly allaying consumer fears. These results support findings from a number of authors who argued that at the early stages of policy making for biotechnology regulations in Canada in the 1990s, such policies were disproportionately favouring the industry and biotechnology development rather than addressing consumer concerns (Abergel and Barret, 2002; Andree, 2006 and Moore, 2008). One of the watershed events related to re-directing biotechnology policies with a focus on consumer concerns and better risk regulation of biotechnological products, was the 2001 Royal Society's Report (Royal Society of Canada, 2001). Many have argued that since the 2001 Royal Society's critique of the weaknesses of biotechnology regulation in Canada a more risk aversion policy guidance, such as precautionary principle based approach, had influenced in number of new policy developments (Andree, 2006). The discussion around improving risk analysis for plants with novel traits[14] as recommended by the Royal Society report had impacts on the policies introduced by the Canadian Food Inspection Agency. In light of our results, one could argue that collectively some of these developments helped strengthen the consumer confidence such that their fears were allayed and support for biotechnology application was augmented.

[14] Canadian regulations is solely based on the products rather than the processes used to produce the product, including genetic engineering, the risk profiling was based on the substantial equivalent to the new product

6. CONCLUSIONS

The main focus in this research was to understand the drivers of the temporal changes in consumer support or opposition for biotechnology applications in Canada. We have used data from two waves of public opinion surveys in Canada in 2001 and 2011. We estimated ordered logit regression models for 2001 and 2011 separately, based on the identical questions in both time periods. Results indicate that the influence of demographic and socioeconomic variables such as age and gender on the attitude about biotechnology applications has diminished significantly between 2001 and 2011. On one had the strength of the association between "familiarity" and the "degree of acceptance" have disappeared between 2001 and 2011, while strength of association between "top of mind reaction" and the "degree of acceptance" has increased. Such results indicate that consumers are polarized in their opinions which are not necessarily based on accurate information. The "top of mind reactions" to biotechnology and the impact of exposure to media suggest that such information are likely to be more positive (such as Mark Lynas recent apology for his opposition to GM crops since 1995) and hence affect the probability of consumers becoming pro-biotech.

Another important determinant of temporal changes in the consumer support for biotechnology in Canada is their augmenting confidence in the regulatory system of biotechnology applications in Canada. Even though we have not directly included into the analysis, significant global policy developments such as Cartagena Protocol on Biosafety probably have influenced Canadians' acceptability of biotechnology applications as well. Cartagena Protocol on Biosafety, was introduced to international law in 2003 after 50 countries ratified it, is reputed to be more "precautionary" in its approach governing the cross border movement of live modified organisms (LMOs).

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Table 1: Changes in Canadian public acceptance of biotechnology application: 2001 (n=1209) vs. 2011 (n=1025)

Degree of Support*	Proportion (%)	99% Confidence Interval** Proportion (%)	
Strongly Support			
2001 (96 out of 1209)	7.94	5.80	10.11
2011 (162 out of 1025)	15.80	13.10	18.50
Somewhat support			
2001 (596 out of 1209)	47.10	43.36	50.75
2011 (574 out of 1025)	56.00	52.00	59.99
Somewhat Oppose			
2001 (272 out of 1209)	22.50	19.40	25.59
2011 (144 out of 1025)	14.00	11.25	16.84
Strongly Oppose			
2001 (146 out of 1209)	12.08	9.66	14.49
2011 (47 out of 1025)	4.59	2.90	6.27
Do not know/Refused			
2001 (126 out of 1209)	10.42	8.15	12.68
2011 (98 out of 1025)	9.56	7.91	11.92

*Based on the Question (in both 2001and 2011 Surveys): *In general, would you say you strongly support, somewhat support, somewhat oppose or strongly oppose the use of products and processes that involve biotechnology?*

** Z- test for comparing two independent proportions. The null: 2001 proportion is equal to 2011 proportion. If the proportion (for any given support level) of one year is inside the 99% confidence interval of the other year, then the two proportions are not statistically different at 1% significance level. Except the "Do not know/Refused" category, for all other degrees of support we reject the null hypothesis.

Table 2: Changes in Canadian public perceptions on "top of mind reaction to technology"; "top of mind reaction to biotechnology" & "exposure to biotechnology issues" between 2001 and 2011

Top of mind reaction to technology*		Proportion (%)	99% Confidence Interval Proportion (%)	
Positive				
	2001 (803 out of 1209)	66.42	62.9	69.9
	2011 (670 out of 1025)	65.37	61.5	69.2
Neutral				
	2001 (287 out of 1209)	23.74	20.6	26.9
	2011 (303 out of 1025)	29.56	25.9	33.2
Negative				
	2001 (88 out of 1209)	7.28	5.4	9.2
	2011 (42 out of 1025)	4.1	2.5	5.7
Do not know/Refused				
	2001 (31 out of 1209)	2.56	1.4	3.7
	2011 (10 out of 1025)	0.90	0.2	1.8
Top of mind reaction to biotechnology*				
Positive				
	2001 (397 out of 1209)	32.84	29.4	36.3
	2011 (390 out of 1025)	38.05	34.1	41.9
Neutral				
	2001 (494 out of 1209)	40.86	37.2	44.5
	2011 (487 out of 1025)	47.51	43.5	51.5
Negative				
	2001 (242 out of 1209)	20.02	17.1	23.0
	2011 (120 out of 1025)	11.71	9.1	14.3
Do not know/Refused				
	2001 (76 out of 1209)	6.29	4.3	8.2
	2011 (28 out of 1025)	2.73	1.5	3.9
Exposure to biotechnology Issues*				
Yes				
	2001 (578 out of 1209)	47.81	44.1	51.5
	2011 (312 out of 1025)	30.44	26.7	34.1
No				
	2001 (603 out of 1209)	49.88	46.2	53.6
	2011 (688 out of 1025)	67.12	63.3	70.9
Do not know/Refused				
	2001 (126 out of 1209)	10.42	8.15	12.68
	2011 (98 out of 1025)	9.56	7.91	11.92

*The relevant questions for these viewpoints in 2001 and 2011 surveys are given in Table 5 below.

Table 3: Changes in Canadian public perceptions on their "familiarity with biotechnology" and "familiarity with biotechnology regulations" between 2001 and 2011

Familiarity with biotechnology*		Proportion (%)	99% Confidence Interval Proportion (%)	
Very Familiar				
	2001 (71 out of 1209)	5.87	4.1	7.6
	2011 (79 out of 1025)	7.71	5.6	9.9
Somewhat Familiar				
	2001 (557 out of 1209)	46.07	43.2	51.2
	2011 (484 out of 1025)	47.22	42.4	49.8
Not Very Familiar				
	2001 (422 out of 1209)	34.9	27.6	35.1
	2011 (321 out of 1025)	31.32	31.4	38.4
Not at all Familiar				
	2001 (156 out of 1209)	12.9	10.6	16.1
	2011 (137 out of 1025)	13.37	9.7	14.5
Do not know/Refused				
	2001 (3 out of 1209)	0.25	0.0	0.6
	2011 (4 out of 1025)	0.39	0.0	0.9
Familiarity with biotechnology regulations*				
Very Familiar				
	2001 (30 out of 1209)	2.48	1.3	3.6
	2011 (9 out of 1025)	0.88	0.1	1.6
Somewhat Familiar				
	2001 (275 out of 1209)	22.75	19.6	25.9
	2011 (166 out of 1025)	16.20	13.2	19.2
Not Very Familiar				
	2001 (513 out of 1209)	42.43	38.8	46.1
	2011 (410 out of 1025)	40.00	36.1	43.9
Not at all Familiar				
	2001 (359 out of 1209)	26.69	26.3	33.1
	2011 (430 out of 1025)	41.95	38.0	45.9
Do not know/Refused				
	2001 (32 out of 1209)	0.25	0.0	3.8
	2011 (10 out of 1025)	0.98	0.0	1.8

*The relevant questions for these viewpoints in 2001 and 2011 surveys are given in Table 5 below.

Table 4: Changes in Canadian public perceptions on their "confidence in regulatory system governing biotechnology in Canada" between 2001 and 2011

Confidence in regulatory system governing biotechnology in Canada*		Proportion (%)	99% Confidence Interval Proportion (%)	
Extremely Confident				
	2001 (180 out of 1136)	15.85	13.1	18.6
	2011 (41 out of 1025)	4.00	2.4	5.6
Very Confident				
	2001 (147 out of 1136)	12.94	10.4	15.5
	2011 (116 out of 1025)	11.32	8.8	13.9
Moderately Confident				
	2001 (532 out of 1136)	46.83	43.0	50.6
	2011 (444 out of 1025)	43.32	39.3	47.3
Not Confident				
	2001 (102 out of 1136)	8.98	6.8	11.2
	2011 (215 out of 1025)	20.98	17.7	24.3
Not at all Confident				
	2001 (175 out of 1136)	15.40	12.6	18.2
	2011 (158 out of 1025)	15.41	12.5	18.3

*The relevant questions for these perceptions in the 2001 and 2011 questionnaires are given in Table 2 above.

Table 5 Information about the two public opinion surveys on biotechnology

Survey Characteristics	2001 5th Wave	2011 7th Wave
Target Population	All Canadians of 18 years or older	All Canadians of 18 years or older
Survey conducted by	Pollara and Earnscliffe	Harris-Decima
Provincial Quotas	Implemented	Implemented
Other soft quotas	Age and Gender	Age and Gender
Method of Access	Telephone -Random Digit Dialling	Telephone-Random digit dialling and On line by a Consumer Panel
Duration of data collection	Sept 26th to Oct 4th 2001	Jan 31st to Feb 11th 2011
Number of respondents	1209	1025 (Phone 812 & On line 213)
Weights for population	applied	applied
Definition of Biotechnology provided to the respondents	Biotechnology applies science to living things such as plants and animals in order to develop new products and processes. Biotechnology is sometimes referred to as life sciences, genomics or genetic modification	Biotechnology involves the use of living organisms, or parts of living organisms, to provide new methods of production and make new products. Related to biotechnology are the areas of life sciences, genetic modification and genomics

Table 6: Age and gender composition of the public opinion surveys Sample and the Canadian Census

Demographic Variables	2001 (%)		2011 (%)	
	Public Opinion Survey	Census 2001	Public Opinion Survey	Census 2011
Age Category				
19 to < 25years	11.9	8.8	9.7	8.5
25 to < 39 years	30.3	29.3	25.8	25.3
40 to < 54 years	32	31.5	30.4	29.8
55 to < 69 years	17.6	18	25.2	23
> 69 years	6.4	12.4	8.9	13.3
Gender				
Male	48.5	48.2	48.9	48.4
Female	51.5	51.7	51.1	51.6

Source: Public Opinion Survey 2001 and 2011 and Census 2001 and 2011

Table 7: Variables for ordered logit regression from the 2001 & 2011 Canadian public opinion surveys on biotechnology

Dependent variable (Acceptability of biotechnology applications)	**2001**	**2011**
Strongly Oppose=1	*In general, would you say you strongly support, somewhat support, somewhat oppose or strongly oppose the use of products and processes that involve biotechnology?*	
Somewhat Oppose=2		
Somewhat Support=3		
Strongly Support=4		
Explanatory variables	2001	2011
	Psychographic Variables	
Top of mine reaction to technology	*(When you hear the word technology do you have a positive reaction, a neutral reaction, or a negative reaction?)*	
	Base= Neutral	Base= Neutral
TECHPOS=1	If positive reaction; otherwise zero	If positive reaction; otherwise zero
TECHNEG=1	If negative reaction; otherwise zero	If negative reaction; otherwise zero
Top of mind reaction to biotechnology	*(When you hear the word biotechnology do you have a positive reaction, a neutral reaction, or a negative reaction?)*	
	Base= Neutral	Base= Neutral
BIOTPOS=1	If positive reaction; otherwise zero	If positive reaction; otherwise zero
BIOTNEG=1	If negative reaction; otherwise zero	If negative reaction; otherwise zero
Exposure to biotechnology Issues	*(Over the last three months, have you heard anything about stories or issues involving biotechnology)*	
	Base= Not heard about	Base= Not heard about
HERDBT=1	If "yes" to heard about; otherwise zero	If "yes" to heard about; otherwise zero
Familiarity with biotechnology	*(Would you say you are very familiar, somewhat familiar, not very familiar, or not at all familiar with biotechnology?)*	
	Base= Not at all familiar	Base= Not at all familiar

VFAMIL=1	If very familiar with biotechnology; otherwise zero	If very familiar with biotechnology; otherwise zero
SWFAMIL=1	If somewhat familiar with biotechnology; otherwise zero	If somewhat familiar with biotechnology; otherwise zero
NVFAMIL=1	If not very familiar with biotechnology; otherwise zero	If snot very familiar with biotechnology; otherwise zero
Familiarity with biotechnology Regulations	*(Would you say you are very familiar, somewhat familiar, not very familiar, or not at all familiar with ways biotechnology is regulated in Canada?)*	
	Base= Not at all familiar	Base= Not at all familiar
BTREGVFML=1	If very familiar with the ways biotechnology regulated in Canada; otherwise zero	If very familiar with the ways biotechnology regulated in Canada; otherwise zero
BTREGSWFML=1	If somewhat familiar with the ways biotechnology regulated in Canada; otherwise zero	If somewhat familiar with the ways biotechnology regulated in Canada; otherwise zero
BTREGNVFML=1	If not very familiar with the ways biotechnology regulated in Canada; otherwise zero	If not very familiar with the ways biotechnology regulated in Canada; otherwise zero
Confidence in regulatory system governing biotechnology in Canada	*(How confident would you say you are in the ability of health Canada (q23); Environment Canada (q24); and Canadian Food Inspection Agency (q25) to ensure that biotechnology products in its area of responsibility are safe?)*	*(On a scale of 1-5, where 1 is not at all confident and 5, where the mid-point 3 is moderately confident, how confident would you say you are in the safety and regulatory approval systems governing biotechnology?)*
	Base= lowest 20th percentile of the rank sum* of the responses to q23; q24 and q25	Base= Not at all confident
NOTCONFI=1	If in between 20th percentile and 40th percentile of the rank sum of the responses to q23; q24 and q25; otherwise zero	If not confident with ways biotechnology regulated in Canada; otherwise zero
MODCONFI=1	If in between 40th percentile and 60th percentile of the rank sum of q23; q24 and q25; otherwise zero	If moderately confident with ways biotechnology regulated in Canada; otherwise zero

VRYCONFI=1	If in between 60th percentile and 80th percentile of the rank sum of q23; q24 and q25; otherwise zero	If very confident with ways biotechnology regulated in Canada; otherwise zero
ETRMCONFI=1	If in between 80th percentile or above of the rank sum of q23; q24 and q25); otherwise zero	If extremely confident with ways biotechnology regulated in Canada; otherwise zero

	2001	**2011**
	Socioeconomic & Demographic Variables	
Education	Base= some high school or less	Base= some high school or less
HSGRAD=1	If high School Graduate; otherwise zero	If high School Graduate; otherwise zero
COLEG=1	If some college or technical school, CEGEP or graduate from college or technical school or CEGEP; otherwise zero	If registered apprenticeship or trade certificate or diploma; College, CEGEP or other non-university certificate or diploma; otherwise zero
UNIVE=1	If some university; graduate or postgraduate; otherwise zero	if university degree, certificate or diploma; otherwise zero
Annual Household Income	Base= Less than $ 20,000	Base= Less than $ 20,000
LOMID=1	If household income is more than $ 20000 just under $ 60,0000; otherwise zero	If household income is more than $ 20000 just under $ 60,0000; otherwise zero
UPMID=1	If household income is more than $ 60000 just under $ 100000; otherwise zero	If household income is more than $ 60000 just under $ 100000; otherwise zero
WELTHY=1	If household income is more than $ 100000; otherwise zero	If household income is more than $ 100000; otherwise zero
Age	Base= Between 19 years and 24 years old	Base= Between 19 years and 24 years old
YOUNG=1	If in between 25 years and 39 years old; otherwise zero	If in between 25 years and 39 years old; otherwise zero
MIDDLE= 1	If in between 40 years and 54 years old; otherwise zero	If in between 40 years and 54 years old; otherwise zero
PREOLD =1	If in between 55 years and 69 years old; otherwise zero	If in between 55 years and 69 years old; otherwise zero

OLD=1	If 70 years or older; otherwise zero	If 70 years or older; otherwise zero
Gender	Base= Male	Base= Male
FEMALE=1	If a female; otherwise zero	If a female; otherwise zero
Household Type	Base = "other" household types	Base = "other" household types
SINGLE=1	if single person with or without children; otherwise zero	if single person living alone; otherwise zero
MWIOUCHLD=1	If married or common law partners without children; otherwise zero	If married or common law partners without children; otherwise zero
MCHLDATHM=1	If married or common law partners with < 18 yrs. children at home ; otherwise zero	If married or common law partners with < 18 yrs. children at home ; otherwise zero
MCHLDOUT=1	If married or common law partners but children moved out; otherwise zero	If married or common law partners but children moved out; otherwise zero
WTHUNREL=1	If living with groups of unrelated individuals; otherwise zero	If living with groups of unrelated individuals; otherwise zero
Residence	Base=rural	Base=in a small town or village or in a rural area or remote village
URBAN=1	If reside in an urban area	If reside in near the center of a large city or the suburbs of a large city or in a small city or large town
Region of residence	Base=Atlantic Region	Base=Atlantic Region
QUEBEC=1	If reside in Quebec; otherwise zero	If reside in Quebec; otherwise zero
ONTARIO=1	If reside in Ontario; otherwise zero	If reside in Ontario; otherwise zero
PRAIRIES=1	If reside in Prairies; otherwise zero	If reside in Prairies; otherwise zero
BC_TERITRIS=1	If reside in BC or territories; otherwise zero	If reside in BC or territories; otherwise zero

*. Direct aggregation of Likert scores or the "ordinal responses" for the Q23, Q24 and Q25 is statistically invalid given that the magnitudes of ordinal responses are not linearly related (2-1≠4-3). Therefore, in order to aggregate these ordinal scores to develop a single measure of "confidence in the regulatory system", we have obtained the ranks of the responses to Q23; Q24 and Q25 and then these ranks were summated (rank sum). The rank sum could be treated as a linear magnitude and hence the range of the rank sum was grouped into five based each having 20^{th} percentile of the range of rank sum.

Table 8: Descriptive Statistics for the Variables in Ordered logit regression (2011 and 2001)

Variable	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
			2011					2001		
UPTOHS	715	0.042	0.201	0	1	843	0.093	0.290	0	1
HSGRAD	715	0.185	0.388	0	1	843	0.228	0.420	0	1
COLEG	715	0.344	0.475	0	1	843	0.324	0.468	0	1
UNIVE	715	0.429	0.495	0	1	843	0.356	0.479	0	1
age1	715	0.071	0.258	0	1	843	0.132	0.338	0	1
YOUNG	715	0.270	0.444	0	1	843	0.324	0.468	0	1
MIDDLE	715	0.326	0.469	0	1	843	0.331	0.471	0	1
PREOLD	715	0.255	0.436	0	1	843	0.154	0.361	0	1
OLD	715	0.078	0.269	0	1	843	0.059	0.236	0	1
POOR	715	0.071	0.258	0	1	843	0.120	0.325	0	1
LOMID	715	0.340	0.474	0	1	843	0.480	0.500	0	1
UPMID	715	0.308	0.462	0	1	843	0.268	0.443	0	1
WELTHY	715	0.281	0.450	0	1	843	0.132	0.338	0	1
FEMALE	715	0.498	0.500	0	1	843	0.469	0.499	0	1
ATLANTIC	715	0.099	0.299	0	1	843	0.083	0.276	0	1
QUEBEC	715	0.255	0.436	0	1	843	0.273	0.446	0	1
ONTARIO	715	0.330	0.471	0	1	843	0.361	0.480	0	1
PRAIRIES	715	0.190	0.393	0	1	843	0.161	0.368	0	1
BC_TERITRIS	715	0.126	0.332	0	1	843	0.122	0.328	0	1
URBAN	715	0.702	0.458	0	1	843	0.192	0.394	0	1
SINGLE	715	0.203	0.402	0	1	843	0.257	0.437	0	1
MWIOUCHLD	715	0.165	0.371	0	1	843	0.139	0.346	0	1
MCHLDATHM	715	0.283	0.451	0	1	843	0.325	0.469	0	1
MCHLDOUT	715	0.203	0.402	0	1	843	0.151	0.358	0	1
WTHUNREL	715	0.013	0.112	0	1	843	0.030	0.170	0	1
TECHPOS	715	0.678	0.467	0	1	843	0.695	0.461	0	1
TECHNEU	715	0.277	0.448	0	1	843	0.231	0.422	0	1
TECHNEG	715	0.045	0.207	0	1	843	0.074	0.261	0	1
BIOTPOS	715	0.403	0.491	0	1	843	0.357	0.479	0	1
BIOTNEU	715	0.473	0.500	0	1	843	0.419	0.494	0	1
BIOTNEG	715	0.124	0.330	0	1	843	0.224	0.417	0	1
HERDBT	715	0.343	0.475	0	1	843	0.535	0.499	0	1
VFAMIL	715	0.092	0.290	0	1	843	0.065	0.247	0	1
SWFAMIL	715	0.485	0.500	0	1	843	0.499	0.500	0	1
NVFAMIL	715	0.312	0.464	0	1	843	0.342	0.475	0	1
NALLFAMIL	715	0.110	0.314	0	1	843	0.094	0.292	0	1
BTREGVFML	715	0.013	0.112	0	1	843	0.027	0.163	0	1
BTREGSWFML	715	0.179	0.384	0	1	843	0.263	0.441	0	1
BTREGNVFML	715	0.435	0.496	0	1	843	0.466	0.499	0	1
BTREGNALFML	715	0.373	0.484	0	1	843	0.243	0.429	0	1
NALCONFI	715	0.133	0.340	0	1	843	0.163	0.369	0	1
NOTCONFI	715	0.218	0.413	0	1	843	0.205	0.404	0	1
MODCONFI	715	0.473	0.500	0	1	843	0.359	0.480	0	1
VRYCONFI	715	0.134	0.341	0	1	843	0.196	0.397	0	1
ETRMCONFI	715	0.042	0.201	0	1	843	0.077	0.267	0	1

Table 9. Canadian Public Support for biotechnology Applications: Ordered Logit Estimates

Variable	Strongly Support for biotech				Somewhat Support for biotech			
	2001		2011		2001		2011	
	Marginal Effects	P value	Marginal Effects	P value	Marginal Effects	P value	Marginal Effects	P value
Psychographic Variables								
Top of mind reaction to technology								
TECHPOS=1	0.007	0.321	0.020	0.246	0.031	0.344	0.004	0.452
TECHNEG=1	-0.010	0.418	-0.067***	0.001	-0.048	0.489	-0.091	0.245
Top of mind reaction to biotechnology								
BIOTPOS=1	0.063***	0.000	0.164***	0.000	0.178***	0.000	-0.020	0.364
BIOTNEG=1	-0.047***	0.000	-0.073***	0.000	-0.296***	0.000	-0.082	0.024
Exposure to biotechnology Issues								
HERDBT=1	-0.001	0.859	0.037*	0.062	-0.005	0.859	0.001	0.903
Familiarity with biotechnology								
VFAMIL=1	0.117	0.124	0.171	0.111	0.121***	0.000	-0.084	0.317
SWFAMIL=1	0.042***	0.004	-0.012	0.720	0.162***	0.001	-0.001	0.744
NVFAMIL=1	0.025	0.108	-0.026	0.362	0.086*	0.057	-0.006	0.573
Familiarity with biotechnology Regulations								
BTREGVFML=1	0.074	0.265	-0.085***	0.000	0.112***	0.000	-0.261	-0.269
BTREGSWFML=1	-0.002	0.831	-0.009	0.724	-0.008	0.834	-0.002	-0.799
BTREGNVFML=1	0.001	0.880	-0.010	0.587	0.005	0.880	-0.001	-0.686
Confidence in regulatory system governing biotechnology in Canada								
NOTCONFI=1	0.040**	0.018	0.123***	0.007	0.108***	0.000	-0.036	0.197
MODCONFI=1	0.072***	0.000	0.145***	0.000	0.194***	0.000	0.006	0.776
VRYCONFI=1	0.124***	0.000	0.374***	0.000	0.168***	0.000	-0.243***	0.001
ETRMCONFI=1	0.144***	0.005	0.700***	0.000	0.118***	0.000	-0.575***	0.000
Socioeconomic variables ***Education***								
HSGRAD=1	-0.007	0.612	0.039	0.626	-0.032	0.633	-0.003	0.874
COLEG=1	-0.010	0.462	0.012	0.860	-0.045	0.483	0.001	0.802
UNIVE=1	0.012	0.481	-0.012	0.855	0.044	0.458	-0.002	0.868

Contd.,

Variable	Strongly Support for biotech				Somewhat Support for biotech			
	2001		2011		2001		2011	
	Marginal Effects	P value	Marginal Effects	P value	Marginal Effects	P value	Marginal Effects	P value
Annual Household Income								
LOMID=1	0.012	0.348	-0.025	0.420	0.046	0.340	-0.005	0.626
UPMID=1	0.010	0.485	0.004	0.907	0.039	0.448	0.000	0.891
WELTHY=1	0.011	0.576	0.007	0.858	0.037	0.519	0.001	0.807
Demographic variables								
Age								
YOUNG=1	-0.014	0.177	-0.006	0.866	-0.063	0.205	-0.001	0.890
MIDDLE= 1	-0.025**	0.016	-0.045	0.130	-0.118**	0.028	-0.014	0.418
PREOLD =1	-0.027***	0.003	-0.032	0.301	-0.158**	0.026	-0.009	0.563
OLD=1	-0.030***	0.001	-0.006	0.884	-0.208**	0.031	-0.001	0.912
Gender								
FEMALE=1	-0.019***	0.005	-0.016	0.320	-0.077***	0.003	-0.002	0.535
Household Type								
SINGLE=1	0.012	0.351	0.016	0.571	0.045	0.294	0.001	0.835
MWIOUCHLD=1	0.006	0.669	0.053	0.159	0.023	0.641	-0.008	0.598
MCHLDATHM=1	-0.001	0.947	0.062*	0.060	-0.003	0.947	-0.006	0.642
MCHLDOUT=1	0.006	0.676	0.015	0.639	0.024	0.651	0.001	0.814
WTHUNREL=1	0.012	0.645	0.100	0.421	0.040	0.573	-0.040	0.639
Residence								
URBAN=1	0.000	0.961	0.026*	0.096	-0.002	0.961	0.006	0.392
Region of residence								
QUEBEC=1	-0.003	0.834	-0.064***	0.001	-0.012	0.837	-0.034	0.170
ONTARIO=1	0.005	0.721	-0.008	0.740	0.019	0.714	-0.001	0.791
PRAIRIES=1	0.007	0.667	-0.003	0.905	0.025	0.640	0.000	0.920
BC_TERITRIS=1	0.004	0.787	-0.050**	0.021	0.016	0.775	-0.031	0.332

2001: Number of observations =843; Wald Test (F Statistics) = 6.87; model p=0.0000
2011: Number of observations = 715; Wald Test (F Statistics) = 6.30; model p=0.0000
Significance levels are shown as: * = 0.1; **=0.05; ***=0.01

Table 10. Canadian Public Support for biotechnology Applications: Ordered Logit Estimates

Variable	Strongly Oppose for biotech				Somewhat Oppose for biotech			
	2001		2011		2001		2011	
	Marginal Effects	P value	Marginal Effects	P value	Marginal Effects	P value	Marginal Effects	P value
Psychographic Variables								
Top of mind reaction to technology								
TECHPOS=1	-0.012	0.351	-0.004	0.274	-0.026	0.335	-0.020	0.265
TECHNEG=1	0.019	0.505	0.029	0.153	0.040	0.465	0.129	0.092
Top of mind reaction to biotechnology								
BIOTPOS=1	-0.070***	0.000	-0.023***	0.000	-0.170***	0.000	-0.121***	0.000
BIOTNEG=1	0.141***	0.000	0.028***	0.004	0.202***	0.000	0.127***	0.001
Exposure to biotechnology Issues								
HERDBT=1	0.002	0.859	-0.006**	0.044	0.005	0.859	-0.032	0.045
Familiarity with biotechnology								
VFAMIL=1	-0.059***	0.000	-0.013***	0.004	-0.179***	0.000	-0.074	0.001
SWFAMIL=1	-0.064***	0.003	0.002	0.719	-0.141***	0.001	0.011	0.721
NVFAMIL=1	-0.032*	0.061	0.005	0.406	-0.079*	0.071	0.026	0.403
Familiarity with biotechnology Regulations								
BTREGVFML=1	-0.047**	0.010	0.081	0.365	-0.139**	0.037	0.264	0.108
BTREGSWFML=1	0.003	0.835	0.002	0.740	0.007	0.833	0.008	0.737
BTREGNVFML=1	-0.002	0.880	0.002	0.596	-0.004	0.880	0.009	0.596
Confidence in regulatory system governing biotechnology in Canada								
NOTCONFI=1	-0.041***	0.001	-0.013***	0.001	-0.107***	0.002	-0.073***	0.000
MODCONFI=1	-0.078***	0.000	-0.025***	0.000	-0.188***	0.000	-0.126***	0.000
VRYCONFI=1	-0.077***	0.000	-0.020***	0.000	-0.215***	0.000	-0.111***	0.000
ETRMCONFI=1	-0.064***	0.000	-0.018***	0.000	-0.198***	0.000	-0.107***	0.000
Socioeconomic variables ***Education***								
HSGRAD=1	0.012	0.637	-0.006	0.558	0.027	0.626	-0.030	0.560
COLEG=1	0.017	0.489	-0.002	0.856	0.038	0.475	-0.011	0.856
UNIVE=1	-0.017	0.460	0.002	0.856	-0.039	0.465	0.011	0.856

Contd.,

Variable	Strongly Oppose for biotech				Somewhat Oppose for biotech			
	2001		2011		2001		2011	
	Marginal Effects	P value	Marginal Effects	P value	Marginal Effects	P value	Marginal Effects	P value
Annual Household Income								
LOMID=1	-0.017	0.344	0.005	0.470	-0.041	0.341	0.026	0.459
UPMID=1	-0.014	0.446	-0.001	0.905	-0.035	0.460	-0.004	0.906
WELTHY=1	-0.014	0.517	-0.001	0.853	-0.034	0.539	-0.006	0.854
Demographic variables								
Age								
YOUNG=1	0.024	0.214	0.001	0.869	0.053	0.194	0.006	0.869
MIDDLE= 1	0.046**	0.037	0.010	0.209	0.097**	0.021	0.049	0.190
PREOLD =1	0.067*	0.052	0.007	0.386	0.119***	0.010	0.035	0.372
OLD=1	0.096*	0.086	0.001	0.890	0.142***	0.005	0.006	0.889
Gender								
FEMALE=1	0.029***	0.004	0.003	0.316	0.066***	0.003	0.015	0.322
Household Type								
SINGLE=1	-0.017	0.291	-0.003	0.534	-0.041	0.313	-0.014	0.542
MWIOUCHLD=1	-0.009	0.639	-0.007*	0.067	-0.021	0.651	-0.038*	0.071
MCHLDATHM=1	0.001	0.947	-0.009**	0.022	0.003	0.947	-0.048**	0.022
MCHLDOUT=1	-0.009	0.647	-0.002	0.607	-0.021	0.661	-0.013	0.613
WTHUNREL=1	-0.015	0.573	-0.009	0.127	-0.037	0.599	-0.051	0.141
Residence								
URBAN=1	0.001	0.962	-0.005	0.161	0.001	0.961	-0.027	0.136
Region of residence								
QUEBEC=1	0.004	0.838	0.016**	0.036	0.010	0.836	0.081**	0.017
ONTARIO=1	-0.007	0.714	0.001	0.746	-0.017	0.716	0.008	0.746
PRAIRIES=1	-0.009	0.638	0.001	0.908	-0.022	0.649	0.003	0.907
BC_TERITRIS=1	-0.006	0.774	0.013	0.171	-0.015	0.779	0.066	0.119

Table 11. Statistically significant variables for the outcome of "Strongly Support for biotech"

Variable	Strongly Support for biotech	
	2001	2011
	Marginal Effects	Marginal Effects
Psychographic Variables		
Top of mind reaction to technology		
TECHNEG=1	-0.01	-0.067***
Top of mind reaction to biotechnology		
BIOTPOS=1	0.063***	0.164***
BIOTNEG=1	-0.047***	-0.073***
Exposure to biotechnology Issues		
HERDBT=1	-0.001	0.037*
Familiarity with biotechnology		
SWFAMIL=1	0.042***	-0.012
Familiarity with biotechnology Regulations		
BTREGVFML=1	0.074	-0.085***
Confidence in regulatory system governing biotechnology in Canada		
NOTCONFI=1	0.040**	0.123***
MODCONFI=1	0.072***	0.145***
VRYCONFI=1	0.124***	0.374***
ETRMCONFI=1	0.144***	0.700***
Socioeconomic variables		
Demographic variables		
Age		
MIDDLE= 1	-0.025**	-0.045
PREOLD =1	-0.027***	-0.032
OLD=1	-0.030***	-0.006
Gender		
FEMALE=1	-0.019***	-0.016
Household Type		
MCHLDATHM=1	-0.001	0.062*
Residence		
URBAN=1	0.000	0.026*
Region of residence		
QUEBEC=1	-0.003	-0.064***
BC_TERITRIS=1	0.004	-0.050**

Table 12. Statistically significant variables for the outcome of "Strongly Oppose for biotech"

Variable	Strongly Oppose for biotech	
	2001	**2011**
	Marginal Effects	Marginal Effects
Psychographic Variables		
Top of mind reaction to biotechnology		
BIOTPOS=1	-0.070***	-0.023***
BIOTNEG=1	0.141***	0.028***
Exposure to biotechnology Issues		
HERDBT=1	0.002	-0.006**
Familiarity with biotechnology		
VFAMIL=1	-0.059***	-0.013***
SWFAMIL=1	-0.064***	0.002
NVFAMIL=1	-0.032*	0.005
Familiarity with biotechnology Regulations		
BTREGVFML=1	-0.047**	0.081
Confidence in regulatory system governing biotechnology in Canada		
NOTCONFI=1	-0.041***	-0.013***
MODCONFI=1	-0.078***	-0.025***
VRYCONFI=1	-0.077***	-0.020***
ETRMCONFI=1	-0.064***	-0.018***
Socioeconomic variables		
Demographic variables		
Age		
MIDDLE= 1	0.046**	0.01
PREOLD =1	0.067*	0.007
OLD=1	0.096*	0.001
Gender		
FEMALE=1	0.029***	0.003
Household Type		
MWIOUCHLD=1	-0.009	-0.007*
MCHLDATHM=1	0.001	-0.009**
Region of residence		
QUEBEC=1	0.004	0.016**

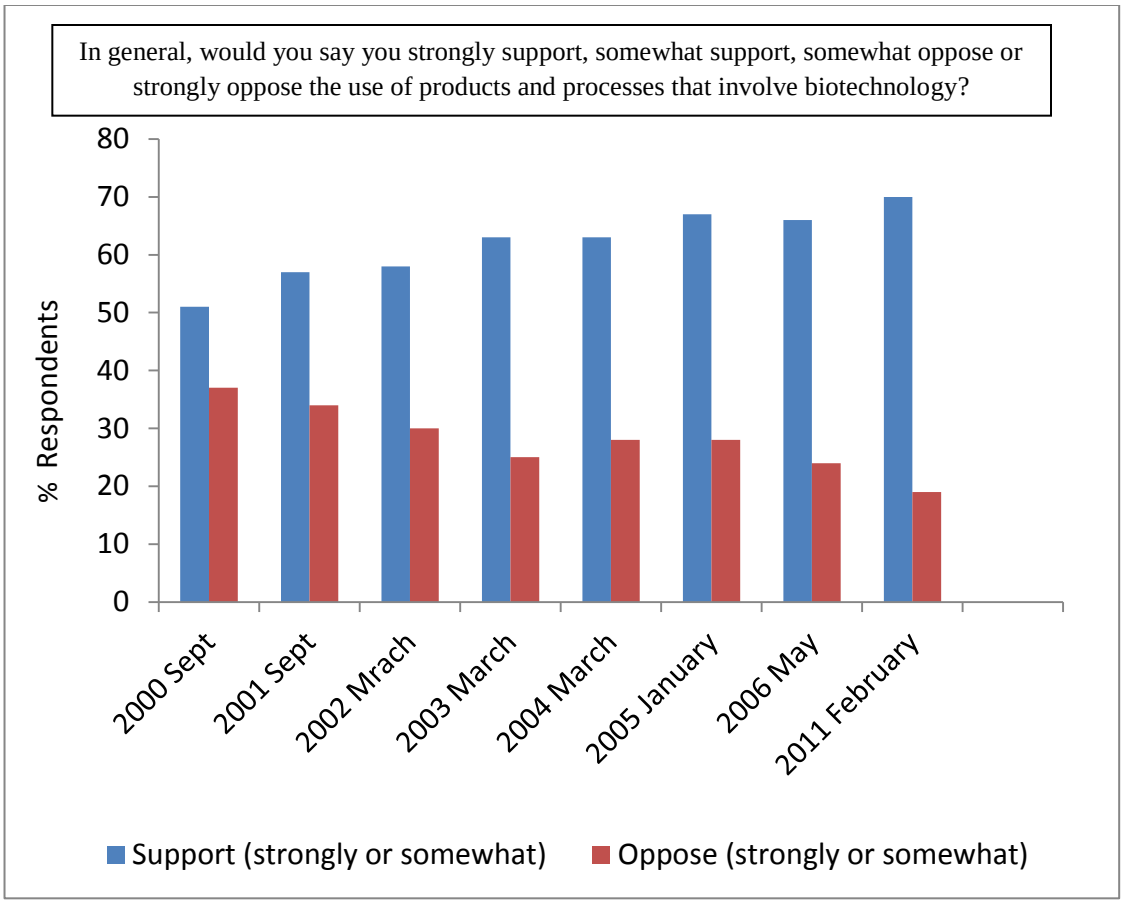

Figure 1. Changes in the Canadian public acceptability of products and processes that involve biotechnology

Source: From the Public Opinion Surveys conducted in Canada (see Harris Decima, 2011 p. 21)

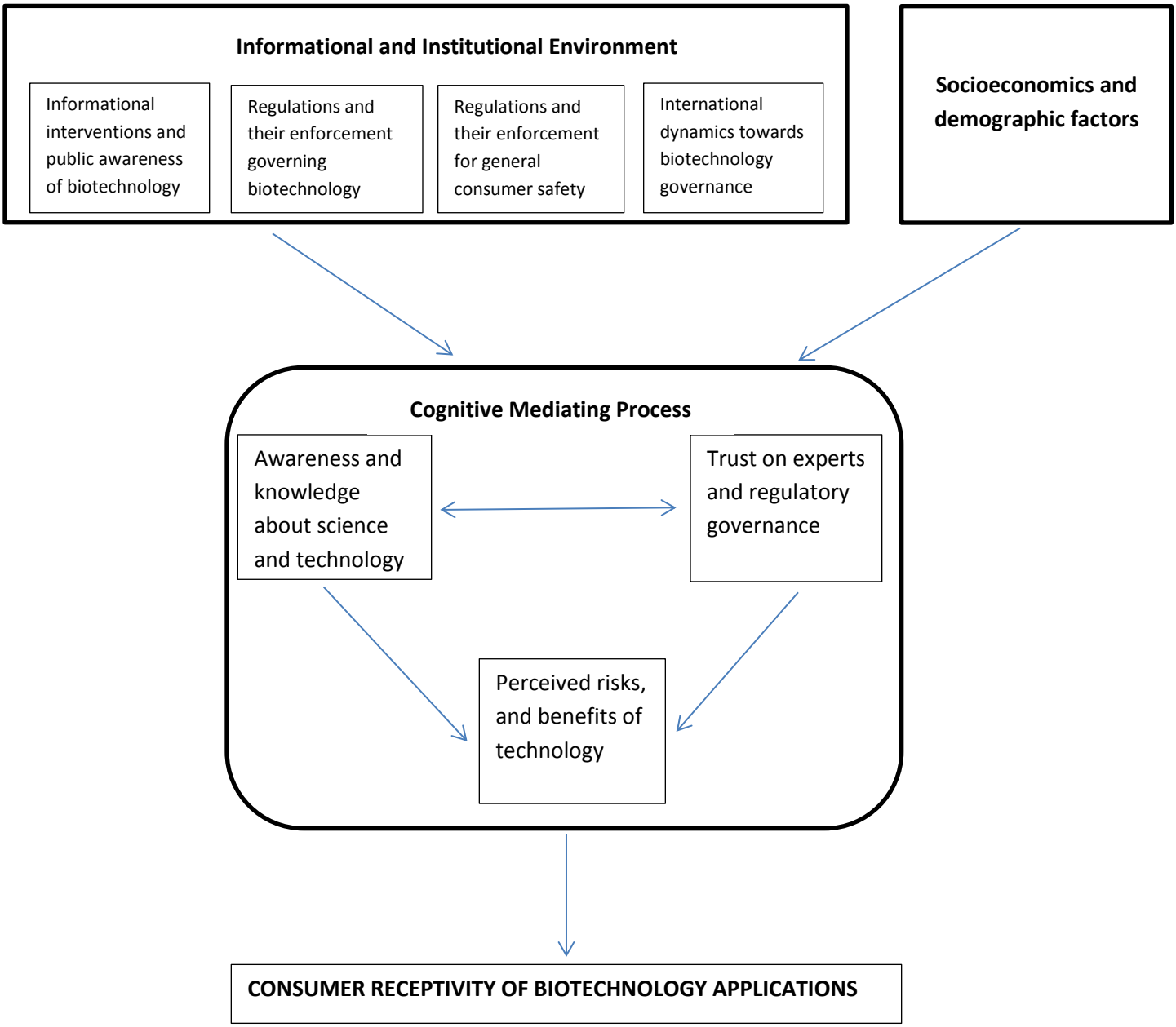

Figure 2: Factors influencing consumer receptivity for biotechnology applications