Strategic Behaviour in Stated Preferences and the Demand for Gene-edited Canola

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Selected Paper prepared for presentation at the

2019 Agricultural & Applied Economics Association Annual Meeting

Atlanta, GA, July 21 July 23

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Abstract

Gene-editing (GE) has the potential to be the next major technological innovation in agricultural production but relies on acceptance by consumer and regulators. While consumers can be slow to accept new technologies, they may be more receptive to this technology than existing genetic modification (GM) technologies. We conduct a stated preference survey to understand consumer preferences and willingness to pay for GE canola oil relative to the more conventional GM canola oil. The survey was specifically designed to identify and control for strategic behavior resulting from price or provision signaling on the part of respondents. We find that consumers prefer GE to GM canola oils and are willing to pay $1.20 to $2.14 more per litre for GE canola oil, which corresponds to a premium of 27-47% over average canola oil prices in Canada. We also find evidence that consumers strategic behavior conforms to economic theory, but these results are more mixed.

Key words: Canola, choice experiment, gene-editing, stated preferences, willingness-to-pay.

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1 Introduction

Gene-editing (also known as genetic-editing or genome-editing) technology is similar to existing genetic-modification technologies but differs in one important respect: with gene-editing, no foreign genetic material is transferred into the host organism. Instead, gene-edited (GE) products have their underlying genetic material altered directly without the addition of foreign or transgenic DNA; that is, DNA can be added, deleted or changed at the source. GE food products have the potential to be a transformative agricultural innovation in the near future. While this technology is not without its critics, the simple fact that foreign genetic material from a different species is not inserted into the host species has many scientists believing that consumers will be more receptive to GE food products than GM foods because there is no mixing of DNA from different organisms in the former (Hartung and Schiemann, 2014; Araki and Ishii, 2015). However, some recent empirical evidence suggests that consumers may view GE products as similar to GM products, with both being inferior to conventional version (Shew et al., 2018).

GE canola that is herbicide-resistant was commercially released in limited quantities in the U.S. and Canadian markets in 2018, and it is expected that more varieties of gene-edited canola with various process and product attributes will be released in the next few years. The success of these first few varieties will act as signals for the success of future gene-edited products, which will influence research and development (R&D) for years to come. A key question that we can and should ask before these products arrive on grocery store shelves is what is likely to be the consumer response? Given federal labeling laws governing genetically modified food products in the U.S., there is a good chance that gene-edited food products will be subject to the same or a similar set of regulations. Once the information asymmetry is removed, how will consumers respond to this new technology?

The valuation of novel products has been a topic of interest for economists and marketing scholars for many years. In the absence of actual consumption data, the best we can do is to ask consumers what they would be willing to pay for a novel product with a specific set of characteristics. Stated preference (SP) methods that elicit a consumer's willingness-to-pay (WTP) have been used in a wide range of contexts: from the WTP for genetically modified foods (Huffman et al., 2003) to the WTP for goods produced using humane animal welfare practices (Uzea et al., 2011).

Choice experiments are a common method to estimate the demand or value of new products or product attributes, particularly when revealed preference data are unavailable or unrealized. This study uses data from an online choice experiment to elicit consumer preferences and WTP for GE canola oil in comparison to GM canola oil. Lusk et al. (2007) show that, in the context of private goods, respondents have incentives to strategically over- or under-state WTP depending on perceived payment obligation and expectations surrounding the provision of the product. Specifically, respondents will overstate WTP (provision signalling) if they want to see the good provided and understate WTP (price signalling) if they believe the good will be provided but they want to encourage downward pressure on price.

We build on the work of Lusk et al. (2007) and Doyon and Bergeron (2016) by focusing on a private good whose desirability is not unambiguously positive: GE canola oil. It is highly likely that consumers will not universally desire GE food products. In this case, the problem becomes more complicated as respondents may strategically state prices in an attempt to discourage the introduction of the product to the marketplace. To the best of our knowledge, this study is the first to consider strategic bidding in the case of a product that is not ambiguously "good". Our study uses a novel approach that tests for the presence of price or provision signalling by including two treatment groups and a control group in our survey design. The inclusion of this aspect in the survey instrument results in estimates of WTP for canola oil attributes that are in theory more precise, as they control for the effect of strategic behavior by respondents. This study contributes to both theory and empirics. On the theoretical side, we examine consumer strategic behavior in private good stated preference surveys. On the empirical side, we investigate the consumer response toward a novel food produced using a disruptive technology that some scientists believe will revolutionize the agri-food sector. This study also provides insight into how best to introduce GE foods to consumers and avoid some of the difficulties surrounding the consumer acceptance of GM foods.

Specifically, we (1) characterize the potential market demand for and consumer response to foods produced using novel gene-editing food products; (2) design a survey instrument to measure WTP for GE canola oil using an approach that accounts for strategic behavior and (3) employ stated preference best-practices to account for hypothetical bias. Using data from a cross-Canada study on valuation of canola oil and its attributes, we look at the WTP values for different choice experiment attributes including: price, regular (GM) vs. GE labels, normal (7%) vs. low (3.5%) saturated fat content and country of origin (Made in Canada vs. Made in USA) information.

The remainder of the paper is organized as follows. Section 2 presents some background and a review of the relevant literature. In section 3, we describe our empirical approach and our data. Section 4 presents our main results and its implications, while section 5 concludes.

2 Background

Canola is arguably the most important crop in the Canadian agricultural sector, accounting for over $26 billion CAD of economic activity and contributing to nearly 250,000 jobs in Canada (Canola Council of Canada, 2016). Canola is currently planted on nearly 9 million hectares, and virtually all of this canola is a GM variety that is either herbicide tolerant, insect resistant or both. The transformation of this sector from an economically trivial crop to the juggernaut that it is today has been nothing short of spectacular and is considered one of the great Canadian agricultural success stories. Canola is known globally as a uniquely Canadian creation, and is most closely associated with the Prairie Provinces. Apart from its economic importance, the canola sector is interesting in several other ways. First, it was created by two Canadian scientists and is associated with Canada in a way that no other crop can claim. Second, canola has been arguably the greatest beneficiary of modern agricultural biotechnology in Canada. In 1995, shortly after the enactment of the Plant Breeders Rights Act (PBRA), Agriculture and Agri-food Canada approved the use of GM canola, specifically herbicide tolerant varieties (Carew, 2005). Herbicide-tolerant varieties of canola seed became extremely popular with producers, and the approval of GM canola opened new doors for private research programs. Between 1987 and 2001, investments in canola increased by almost 330 percent (Carew, 2005). As one of the first-generation biotechnology products, canola has been subject to the many regulations that govern the creation of genetically modified plants, such as regulations addressing food safety, research and development (R&D), and intellectual property. Third and most importantly, canola is economically important and a key export crop for Canada. Any significant changes to the product can have large economic implications to the sector, and should be carefully considered.

Currently, several GE versions of canola are being developed by various firms. Cibus is marketing an herbicide-tolerant[1] canola called Falco™produced using Cibus proprietary gene-editing technology. On the Cibus Canadian website (https://www.falcoseed.com/ca/), one of the features being advertised is that this canola is non-transgenic. Calyxt is another biotechnology company producing a GE canola variety. Their variety will have improved oil composition, likely in the form of lower saturated fat. Their product is not commercially available but is currently under development.

Existing meta-analyses have found that most consumers are generally averse to genetically modified (GM) foods and thus place a premium on non-GM foods (Frewer et al., 2013). Lusk et al. (2005) also found that consumers willingness-to-pay (WTP) is lower for GM foods compared to non-GM alternatives. With this said, they found that there was significant heterogeneity in consumer WTP depending on the type of food studied, location of study and other design properties.

SP methods estimate economic values through responses to survey questions, and are often

[1]Specifically, it is tolerant to sulfonylurea and is intended to be paired with the herbicide Draft™, which is produced by Rotam.

used when revealed preference data are not available. For example, SP methods have been used to estimate non-use or passive use values (Bishop et al., 2017) and to estimate the WTP for novel goods that are not available on the market (Teratanavat and Hooker, 2006). Even in cases where revealed preference data may be available, SP methods are sometimes preferred because they allow the researcher to have greater control over the assignment of various attributes and prices, are more flexible and less expensive to apply (Kroes and Sheldon, 1988). However, there are ongoing concerns regarding the validity of survey responses as people's stated choices may differ from their actual decisions leading to concerns regarding hypothetical bias (Murphy et al., 2005).

Carson and Groves (2007)'s seminal paper uses microeconomic theory to understand the problem of hypothetical bias. They show that rational respondents answer questions to maximize utility. As a result, when the respondent believes that her answer may have a real economic consequence, she is more likely to produce a truthful or incentive compatible – answer. This idea that perceived consequentiality can mitigate hypothetical bias has been empirically examined by Herriges et al. (2010), Vossler et al. (2012) and Vossler and Watson (2013). However, Carson and Groves (2007) further show that standard elicitation mechanisms, such as the single dichotomous choice referendum-style question, are only incentive compatible for public goods [2] but not for private goods.

For private goods, Carson and Groves (2007) argue that since any declared values cannot be imposed on the respondent, no elicitation mechanism for such a good in a SP setting can be completely consequential. They further suggest that the rational response depends on whether the good already exists on the market or is a new good that has yet to enter the market. For goods that already exist, respondents have an incentive to respond "no" to take-it-or-leave-it offers or to understate their true WTP. For new goods that are not yet available, respondents have an incentive to respond "yes" to take-it-or-leave-it offers or to overstate their true WTP. Lusk et al. (2007) describe these two situations as "price signalling"

[2] Carson and Groves (2007) provide a sketch of these conditions and Vossler et al. (2012) later develop a game theoretic model to show these conditions more explicitly. Carson et al. (2014) later extend Vossler et al. (2012)s results by relaxing the expected utility assumption.

and "provision signalling", respectively.

In the case of price signalling, the respondent has an incentive to understate her true WTP if she believes her answer will affect the pricing of the good. Therefore, she strategically undervalues the private good to influence the price and does not worry about this affecting its availability since its already on the market. In the case of provision signalling, the respondent may believe that her valuation will affect whether or not the product will be offered on the market. Therefore, she strategically overvalues the private good to influence its provision. Several recent studies have observed this strategic bidding behaviour in framed and hypothetical empirical settings (Lusk et al., 2007; Mitani and Flores, 2014; Doyon and Bergeron, 2016).

Lusk et al. (2007) examine strategic behaviour in the valuation of soda and parking facilities. The presence of strategic behaviour depends on how respondents believe their answers will affect the final outcome. Lusk et al. (2007) find stronger evidence of price signaling than provision signaling. More recently, Doyon and Bergeron (2016) examine price and provision signaling in the valuation of eggs (regular and free-run). Their study builds on Lusk et al. (2007) by: (1) asking open ended questions to gauge how participants think responses will be used; and (2) econometrically estimating the bias due to strategic behaviour. Doyon and Bergeron (2016) also find evidence of strategic bidding.

Reframing a private good as a public good with a consequential payment vehicle has been suggested as an option to reduce strategic behavior and reflect a closer value to truth preference revelation. This involves reframing the question as a single shot discrete choice referendum about a mandatory service that would or would not be offered by the government (Johnston et al., 2017). The payment vehicle could then be an increase or decrease in taxes to pay for the good as the authority can actually enforce this type of payment and the respondent would be more likely to believe they would actually have to pay for the service. This type of reframing still requires that the respondent cares about the outcome and the authority can in fact enforce payment by voters and elicitation involves a yes/no vote on a single project. This reframing might be superior to the private good framing because there is no incentive for truthful preference revelation in the private good framing, in which there is no perceived payment obligation and strategic behavior is very likely.

In this study, we build on the existing literature by considering strategic bidding for a private good that is not universally “good. We attempt to mitigate hypothetical bias and account for strategic behaviour by asking participants several questions on how they perceive gene-edited canola and GM products in general, and by asking them follow-up questions to identify what perceived consequences motivated their responses. Next, we describe our experimental design and empirical approach.

3 Data and Analysis

The choice experiment data were collected through an online survey approach administered through AskingCanadians, an online data collection firm. An internet panel approach was used in this instance as telephone and interview surveying are generally more expensive and time-consuming to the respondent. Before administering the final version of the survey, we conducted two pretests with 100 respondents in each pre-test. The final survey was administered to a nationally representative sample of 1500 English-speaking Canadian adults[3] who engage in grocery shopping and who had purchased canola oil in the previous year. We did pre-tests with 200 respondents and the final survey was approximately 20 minutes long with all surveys taking place between April and June 2018.

The purpose of the choice experiment is to isolate the preferences parameters and marginal value associated with each choice attribute. Each choice task presented two canola oils along with a “neither of these” opt-out option and the question order, among other things, was randomized across respondents. We used the software NGENE to generate a d-optimal efficient design (zero priors) with four blocks and four choice sets in each block (sixteen choice sets in total) for canola oil. A d-optimal efficient design maximizes the information in the experiment and leads to accurate utility estimates by minimizing the variance-covariance

[3]The survey excluded French speakers from Quebec, as well as residents from Yukon, the Northwest Territories and Nunavut.

matrix of the estimated utility coefficients (Vermeulen et al., 2008). To address the cognitively challenging task of answering multiple scenarios, each participant is only tasked with stating their preferences in four distinct choice scenarios.

Table 1: Attributes and levels used in the choice experiment on canola oils

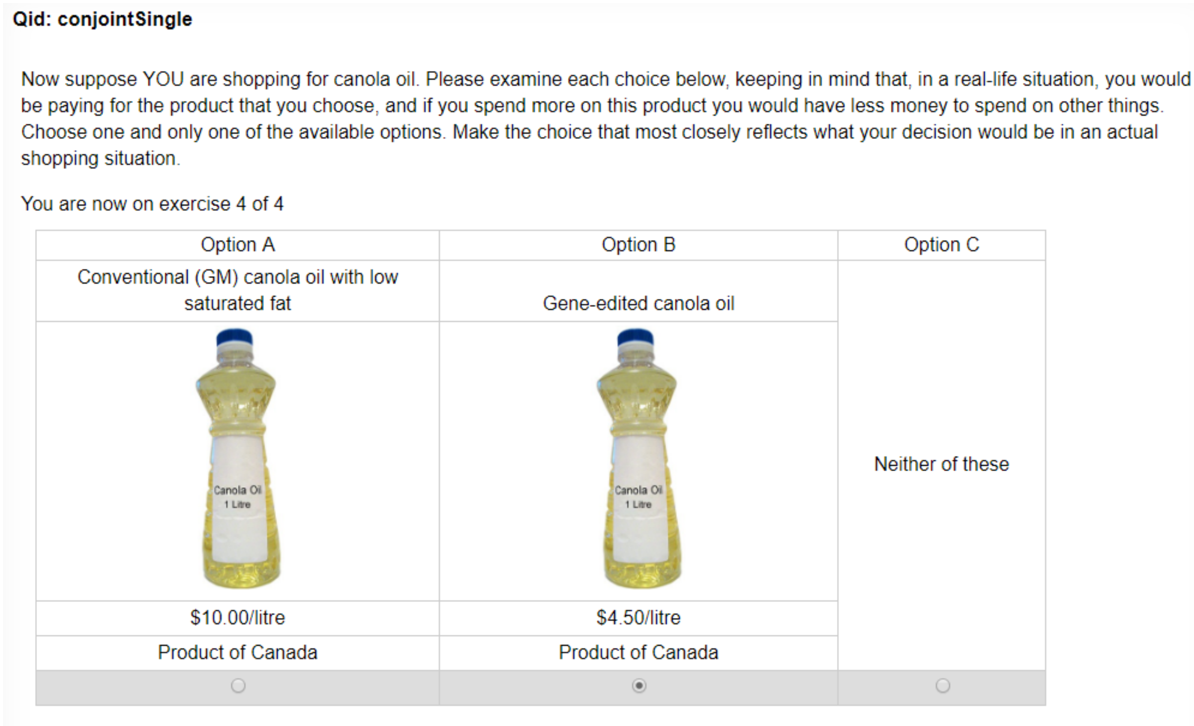
Attribute and levels	Attribute level label statements
Saturated fat content (2 levels)	Low saturated fat (3.5%); Normal levels of saturated fat (7%)
Seed type (2 levels)	Conventional (GM) canola oil; Gene-edited canola oil
Country of origin (2 levels)	Product of Canada; Product of USA
Price (4 levels)	\$3.00/litre; \$4.50/litre; \$6.00/litre; \$10.00/litre

Table 1 lists the attributes and levels included in the choice experiment include. During the survey, we provided additional information for some of the attributes. For example, we informed the respondents that canola oil typically contains 7% saturated fat while the canola oil that is low in saturated fat contains approximately half the amount or 3.5%. We chose the price levels based on nationally advertised prices for different types of canola oil (e.g., conventional and organic). Figure 1 shows an example of a choice set that was presented to respondents, which contains three choice options: respondents can choose between two canola oils that different in their attribute levels and a "Neither of these" no purchase option.

To mitigate hypothetical bias and to account for strategic behaviour in the form of provision or price signalling, we emphasized certain types of consequentiality in different treatments by suggesting that their responses may have an impact on actual retailer decisions. To this end, we randomly assigned respondents into one of three categories: (1) a *provision* treatment, (2) a *price* treatment or (3) no treatment control. Respondents assigned to the provision effect frame saw the following message:

> *Please answer the following questions as honestly as possible.*
>
> *Note that information from questions like these is often used by grocery retailers to decide what products to offer to their customers.*

Figure 1: Screenshot of choice set


Qid: conjointSingle

Now suppose YOU are shopping for canola oil. Please examine each choice below, keeping in mind that, in a real-life situation, you would be paying for the product that you choose, and if you spend more on this product you would have less money to spend on other things. Choose one and only one of the available options. Make the choice that most closely reflects what your decision would be in an actual shopping situation.

You are now on exercise 4 of 4

Option A	Option B	Option C
Conventional (GM) canola oil with low saturated fat	Gene-edited canola oil	Neither of these
Canola Oil 1 Litre	Canola Oil 1 Litre	
$10.00/litre	$4.50/litre	
Product of Canada	Product of Canada	

Similarly, respondents assigned to the price effect frame saw the following message:

> *Please answer the following questions as honestly as possible.*
>
> *Note that information from questions like these is often used by grocery retailers to decide how to set prices for the products.*

Lastly, respondents in the control group saw the following message:

> *Please answer the following questions as honestly as possible.*

To gauge whether participants actually considered the treatment frames in their decision-making; that is, to test for perceived consequence, we also asked a series of follow-up questions related to the extent to which the respondents thought retailers used the information they collected from consumer surveys when deciding what products to offer or what prices to set. Lastly, we asked a referendum question on how the respondent would likely vote if the government proposed a ban on gene-edited canola products to address the quasi-public nature of the good.

3.1 Econometric model

The choice experiment data is analyzed utilizing random utility theory by means of discrete choice models. The decision maker is assumed to maximize utility among a set of alternatives. The utility U_{ij} to consumer i from consuming product j can be represented as $U_{ij} = V_{ij} + \varepsilon_{ij}$, where V_{ij} is a function of the attributes of the consumed product, and can be represented as $V_{ij} = \sum \beta_m x_m$, where x_m is the m^{th} attribute and β_m is a parameter to be estimated. ε_{ij} denotes the random component of the utility function.

The probability that consumer i chooses alternative j over alternative k is $P_{ij} =$ Prob $(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik})$ where $j \neq k$. If we assume that the error terms are independently and identically distributed extreme values, we can estimate a conditional logit model of the form:

$P_{ij} = \frac{e^{\beta x_{ij}}}{\sum e^{\beta x_{ik}}}$

The conditional logit model is used to analyze the preferences of the respondents. Specifically, it is used to estimate consumer's utility and related WTP for saturated fat content, country of origin and the consumer's valuation of a GE product in comparison to the conventional (GM) canola oil product. From this analysis, we use the estimated indirect utility parameters to calculate the marginal WTP as the ratio of the marginal utility of a particular attribute divided by the marginal utility of income. In our case, the marginal utility of income is estimated to be the negative of the price coefficient. In our example, we are interested in calculating the marginal WTP for the independent attributes of the canola oil product with respect to the price, holding everything else constant. This provides us with an estimate of the average consumer's preference to trade-off between attributes and their relative importance in the purchasing decisions pertaining to canola oil.

Lastly, the marginal WTP is calculated as the negative of the ratio of the attribute coefficient k over the coefficient on price p as $WTP = \frac{dp}{dx_m} = \frac{-\beta_m}{\beta_p}$.

4 Findings

4.1 Conditional logit results

We estimated four different sub-samples of our data (models 1–4) as well as a specification that included interaction terms. In model 1, we only consider respondents who were given the provision treatment frame; in model 2, we only consider respondents in the price treatment frame; while in model 3, we only consider respondents in the control treatment. Model 4 considers all respondents. The parameter estimates have the same signs across all the treatment samples. In all cases, we find that price has a negative effect on the decision to choose a canola oil. We also find that respondents are more likely to choose canola oils from Canada (versus the U.S.), canola oils with lower saturated fat and canola oils that are GE (versus conventional or GM).

Lastly, we look at the entire dataset and add interaction variables to examine the effects of the treatments on the respondents' price sensitivity and likelihood of choosing a canola oil versus the no-buy option. We find that the price treatment makes consumers more price sensitive, which aligns with the price signalling theory of consumer responses. We find that the provision treatment has no statistically significant effect on the respondents likelihood of choosing a canola oil.

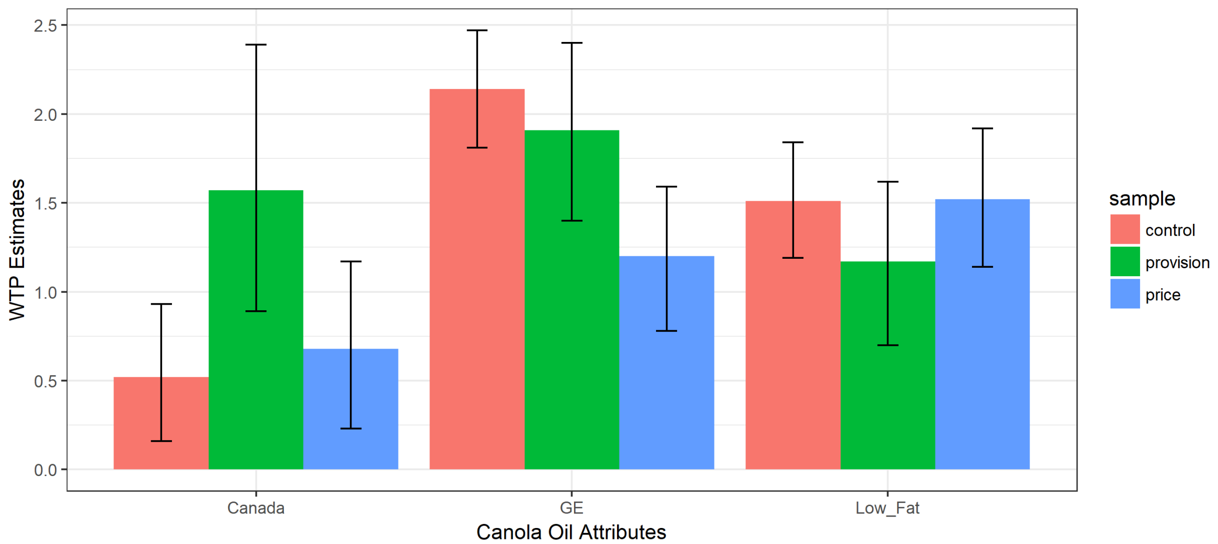
Using the estimated coefficients from the different models, we can calculate the WTP for the different attributes (figure 2). We find that respondents are willing to pay an additional \$0.50 to \$1.52 CAD per liter for Canadian-made canola oil. The marginal WTP for canola oil with half the saturated fat ranges from \$1.04 to \$1.50 CAD per liter. Lastly, we find the WTP (premium) for GE canola relative to GM canola oil ranges from \$1.20 to \$2.14 CAD per liter. These are fairly large WTP estimates given that the price for a litre of canola oil in Canada can range from \$1.50 CAD (no name bulk size) to over \$10 CAD (organic) with an average price of approximately \$4-5 CAD.

Table 2: Conditional logit results

	Dependent variable: choice				
	Provision	Price	Control	Full Sample	Interactions
	(1)	(2)	(3)	(4)	(5)
Price	−0.185***	−0.238***	−0.240***	−0.221***	−0.190***
	(0.020)	(0.020)	(0.019)	(0.011)	(0.018)
Canada	0.283***	0.159***	0.121**	0.183***	0.221***
	(0.059)	(0.060)	(0.053)	(0.033)	(0.042)
Low fat	0.215***	0.361***	0.361***	0.314***	0.286***
	(0.056)	(0.057)	(0.051)	(0.031)	(0.040)
Gene-edited	0.356***	0.288***	0.513***	0.394***	0.322***
	(0.070)	(0.070)	(0.063)	(0.039)	(0.049)
Canola	1.523***	1.884***	2.072***	1.831***	1.576***
	(0.135)	(0.138)	(0.133)	(0.078)	(0.124)
Price: treat_price					−0.043**
					(0.021)
Canola: treat_price					0.259
					(0.159)
Observations	1,872	1,824	2,236	5,932	3,696
Log Likelihood	−1,849.894	−1,780.730	−2,125.806	−5,771.142	−3,634.233

Notes: Asterisks indicate statistical significance where *p<0.1, **p<0.05, and ***p<0.01.

Figure 2: Estimates of willingness-to-pay



4.2 Latent class results

The previous models assume that all consumers have the same preferences for canola products and ignores the fact that each respondent answered four choice sets. To allow for preference heterogeneity and to account for the panel nature of our data, we present two sets of 2-class latent class model results. Table 3 shows the treatment results, where class 1 represents those who are less likely to choose the canola oil option while class 2 represents those more likely to choose the canola oil option. The main result from this analysis is that respondents who received the provision treatment are more likely to choose canola oils, which is what we expected. One unusual result is that we also find that respondents who received the price treatment are also more likely to choose canola results, which is the opposite of what theory would predict. Table 4 shows the motivation (or perceived consequence) results. Here, we find that respondents who are more price motivated than provision motivated are less likely to choose canola oils, which is what we expected.

Table 3: Latent class results - Treatment

Variable	Coefficient	Std. Err.
Class 1 - Price	-0.34***	0.05
Class 1 - Canada	0.28*	0.15
Class 1 - Low fat	0.49***	0.14
Class 1 - Gene-edited	1.23***	0.17
Class 1 - Canola	-0.64**	0.26
Class 2 - Price	-0.36***	0.02
Class 2 - Canada	0.00	0.04
Class 2 - Low fat	0.44***	0.04
Class 2 - Gene-edited	0.66**	0.05
Class 2 - Canola	4.47***	0.20
Intercept - class 2	1.18**	0.06
Provision treatment - class 2	0.43***	0.09
Price treatment - class 2	0.22***	0.08

Notes: *p<0.1, **p<0.05, and ***p<0.01.

5 Discussion and Conclusions

Our choice experiment results show that Canadian consumers show a positive and statistically significant preference for GE canola oil versus the existing conventional or GM canola oil, and are willing to pay $1.20 to $2.14 more per liter for GE canola oil. However, the results are less clear when we consider consumer responses to direct questions regarding their views on GE and GM foods in general. This may be due to unfamiliarity with genetic editing technologies in general and GE foods in particular, as the technology has yet to reach the market. Our study sheds light on how Canadian consumers will treat GE foods and is a first step toward a more detailed characterization of the market for GE foods in the future.

Our results also show that, at least in terms of provision bias, respondents react as expected and overstate their WTP if they feel this strategy will increase the chances of the good being provided. However, other findings on our attempts to address hypothetical bias are more mixed.

Table 4: Latent class results - Motivation

Variable	Coefficient	Std. Err.
Class 1 - Price	-0.34***	0.05
Class 1 - Canada	0.28*	0.15
Class 1 - Low fat	0.48***	0.13
Class 1 - Gene-edited	1.24***	0.17
Class 1 - Canola	-0.65**	0.26
Class 2 - Price	-0.34***	0.02
Class 2 - Canada	0.00	0.04
Class 2 - Low fat	0.45***	0.04
Class 2 - Gene-edited	0.66***	0.05
Class 2 - Canola	4.49***	0.20
Intercept - class 2	1.33***	0.05
Provision motivation - class 2	0.45***	0.12
Price motivation - class 2	-0.04	0.08

Notes: *p<0.1, **p<0.05, and ***p<0.01.

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