Consumer Preferences for Genetically Modified Organisms in Cape Town: A Choice Experiment Approach

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Abstract

This paper reports a study done on Cape Town consumers, with the aim to understand how their purchasing decisions are shaped with respect to GMOs. A choice experiment approach was used to examine consumer preferences for biotechnology products in the food market. Four models were run to analyse the data, i.e., the conditional logit and random parameters logit models, with and without iteration terms. The results revealed a large status quo bias, indicating that the majority of consumers were reluctant to consume foods that incorporated certain technologies in their production process. The paper concludes by stating that producers need to align the development of GMOs to better meet consumers desires rather than suppliers. Finally, the paper takes an understanding that to increase the acceptance of GMOs, a larger portion of the population needs to be educated better about this technology.

1 Introduction

We live in a world that currently hosts just over seven billion people, and according to predictions, this upward trend is not likely to stop anytime soon (United Nations 2019). With this increase in population, it is evident that specific resources will diminish. One of the most important resources that is likely to face depletion, and hence the focus of this paper, is food. Food, being a vital source of life, has urged scientists to prevent its depletion: arguably

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the most groundbreaking of these solutions being the development of modern biotechnology. Modern biotechnology started in the 1980s and ever since has been evolving. The United States Food and Drug Administration (2001) defines the technology as a technique used to modify DNA or other genetic material such as bacterium, animals or plants in order to deliberately bring about an individual or number of desirable traits. Modern biotechnology is associated with several terms the main ones being "genetically modified organism" (GMO) or (GM), "genetic engineering" (GE) and "bioengineering". Statistics show that 99% of all GM output comes from only six countries, namely USA, Argentina, Canada, Brazil, China and South Africa (Vermeulen 2004). With the world increasing in population, the importance of increasing food supplies is apparent. However, GMOs may not be the only solution to this problem. The conflicting preferences of consumers are the key challenge to the survival of this technology and are led by the western world, with a rejecting Europe and an accepting USA (Lusk et al. 2002).

Food supply will become increasing more important for every continent around the globe, but by no means will it be as critical as it will be for Africa (Pereira 2014). The continent is expected to have the most rapid growth rates in the 21st century, with statistics predicting the population to overtake Asia by the end of the century (UN 2019).The little research that has been done shows that most African consumers have not yet shaped opinions about whether they would purchase GM foods or if they even approve of them (AfricaBio 2014; Joubert 2002; Vermeulen 2004). Understanding consumer's thoughts and attitudes towards GMOs is vital in a country or continent where the population is believed to continue growing. To meet consumer demands, food needs to be produced in efficient and cost-effective ways, irrespective of whether or not GMOs are used to do this.

Food choices based on attributes such as environmental concerns, health, price and shelf life are made daily by consumers, which in turn could lead to either product acceptance or rejection (Baker and Burnham 2001). Consumer acceptance of a product is vital for future success and survival of both the product and associated production technology. This statement holds, especially if the product is new, in development or consumers have little information about the product or technology used in the production process. Therefore, the main objective of this paper is to understand the attributes that are most important to consumers when making a purchasing decision using choice experiments. Both cognitive and socioeconomic variables are used to assess what drives consumers to make certain decisions. Focus will also be put on how knowledgeable consumers are about GMOs, as well as what their views are on labelling and if they will be more accepting if GMOs bring about tangible benefits.

By studying these issues, a contribution could be made to understanding consumer decisions in a more intuitive manner and better address certain market inefficiencies in the GMO industry. This information will certainly bring about value to all those who use it. For instance, understanding how consumer's perception, attitudes and beliefs are shaped could allow producers to create better-suited technologies for consumers. A better understanding of how consumers make purchasing decisions can also help align consumer interests to those of role-players involved in biotechnology, agriculture and food industries within South Africa, these include retailers, biotech companies, farmers and policy makers. As such, the paper does not only aim to give guidance to producers, marketers and consumers around the use and development of GMOs, but also to provide pragmatic evidence to policymakers that will allow them to interrogate their policies and strategies. Furthermore, this paper will contribute to the literature methodologically through the use of an online survey in the context of an African country given that online surveys are increasingly gaining popularity as modern tools of data collection (Benfield and Szlemko 2006; Wright 2005).

The literature addressing consumer preferences and GMOs in South Africa is limited. To the best of our knowledge, this is one of the first studies to analyse this relationship using choice experiments in the country. Therefore, over and above the significance of understanding consumers, the paper contributes to an important gap in literature, which could impact the survival of biotechnology in the future of South Africa. Past research done in South Africa repeatedly showed that there was a lack of knowledge around GMOs, especially in rural and peri-urban areas (Pereira 2014; Peter and Karodia 2014; Vermeulen 2004; Pouris 2003). For this reason, Cape Town was the chosen geographical point of the investigation with the intention of having a sample group that was more informed.

1.1 Review of empirical literature

GM crops have led to enhanced yields with a reduction in production costs, thus giving GM crops the potential to produce higher profits (Harrison et al. 2004). Whilst this is good for the well-being of the producer, consumers, as well as other parties, have expressed concerns regarding various aspects of GMO foods and products (Harrison et al. 2004). This paper has identified two significant concerns that have repeatedly appeared in previous literature. These concerns have to do with food safety (Hobbs and Plunkett 2000; Vermeulen 2004; Burton et al. 2001) and environmental concerns (Harrison et al. 2004; Peter and Karodia, 2014; Hobbs and Plunkett 2000).

Hobbs and Plunkett (2000) break food safety concerns into three groups.

The first group and more fundamental concerns are to do with the potential for allergenic responses to GM foods. A second concern is an ethical one, to do with the fact that the process in which GMOs happen is unnatural. The last concern is that of the unknown, long-term side effects and the belief that GMOs may be the cause of illnesses such as cancer and diabetes. However, there is insufficient evidence to back this up. Hobbs and Plunkett's findings link to the literature presented by Vermeulen (2004) and Burton et al. (2001).

Environmental concerns shown by Harrison et al. (2004) include the potential in which biotech crops interact with non-GMO crops, which leads to contamination of organic crops. In line with this argument, Peter and Karodia (2014) observed that contaminated crops can cause certain non-targeted insect species to perish (for example bees), they too may reduce the effectiveness of pesticides and lastly may create " superweeds" as well as " superbugs".

Consumer reaction to, and acceptance of GM foods can vary significantly among countries (Vermeulen 2004). The majority of research in this field has taken place in Europe and the USA (Chen and Chern 2002; Harrison et al. 2004; Lusk et al. 2002; Soregaroli et al. 2003). This paper, although focusing on South Africa specifically, a country very different from those mentioned above, needs a broader understanding and thus it is essential to incorporate the European and US literature. In general, studies show US consumers are generally more positive with acceptance rate towards modern biotechnology in comparison to those in European countries. (Vermeulen 2004; Burton et al. 2001). Given that we are now living in a global village where technology has greatly reduced distances between countries, the studies done in the first world countries can be used to inform future policy reforms in developing countries in Africa and in particular emerging economies such as South Africa, since the literature is still at an early stage of development in these countries.

Hoban (1998) indicated that two-thirds of Americans were positive about plant biotechnology. Similarly, the International Food Information Council (2018) surveys showed public acceptance to be in accordance with Hoban; however, it dropped from 78% in 1997 to 59% in 1999. The acceptance of GMOs today remains relatively unchanged, remaining at approximately the same rate as it did in 1999 (International Food Information Council 2018). Although levels of acceptance in the USA have dropped since 1997, they are still substantially higher than in Europe (Harrison et al. 2004).

A survey by Dewalde et al. (2015) revealed that, on average, 36% of the 3002 participants from Europe were willing to consume GM foods, ranging from 23% in France, to 47% in the UK. Despite the more accepting nature towards GMOs in the US, several studies revealed that there are still adverse consumer reactions toward GMO foods (Burton et al. 2001; Lusk et al. 2002; Hossain 2003; Harrison et al. 2004). Chen and Chern (2002) found that respondents discounted GM-labelled food products by approximately 14% relative to their standard-labelled counterparts in the US. Approximately, the same level of acceptance was found in Lusk et al. (2002) paper, they too found that British and French consumers demand much higher compensation to consume GM food products than the US consumers did. Core contributing factors are likely to have driven these negative reactions to GM foods in Europe. One of the main factors is consumers' distrust in the European food market after the 1990s food crisis associated with the Mad Cow Disease caused by Bovine Spongiform Encephalopathy and dioxins (Soregaroli et al. 2003).

According to research done by Moon and Balasubramanian (2001), consumer acceptance of food biotechnology was not only related to perceptions of risk and benefits, but also their moral and ethical views associated with GMOs. They found public views about corporations involved in biotechnology, knowledge of science and trust in the government all played roles in acceptance of this technology. The government itself has a vital role in how consumers view GMOs (Paarlberg 2014). A key example would be the case of Zimbabwe, where the government with the influence of pressure groups (said to be representing the public), has forced a country that is facing food scarcity and very low agricultural productivity to ban GMO farming (Paarlberg 2014; News24 2016). The topic is highly controversial, but is, for one thing, speaking against the countries needs for food security.

Hossain (2003) adds to the findings of Moon and Balasubramanian (2001) and concludes that public support is considerably higher when it brings out tangible benefits to society in comparison to those biotechnologies that do not. Their findings show that less than 60% of participants support the use of GM products when there are no additional tangible benefits. The number rises to 80% when there are such benefits in existence. These benefits include (1) Improved taste, (2) extended shelf life and (3) reduced price of the products. We must remain cautious when considering these benefits as questionable downfalls, such as health and environmental risks, are also associated with GMOs (Paarlberg 2014). In this study, we use both the benefits (i.e., taste, shelf life and price) and potential challenges (health and environmental concerns) as important attributes of GMOs.

Similar studies have been investigated in South Africa (Vermeulen 2004; Peter and Karodia 2014; Aerni and Bernauer 2006; Joubert 2002). The readings have shown that consumers support the idea of biotechnology improving the taste of food, nutritional value and reduction in costs (Peter and Karodia 2014). When consumers were asked if they would buy GM foods if they were healthier, 51% agreed they would, 37% disagreed and 12% were uncertain. The study highlighted that 50% of the consumers who had disagreed had tertiary education (Peter and Karodia 2014). Joubert (2002) revealed in his study, 40% of the respondents were favourable toward the use of biotechnology if it brought about improved taste and nutrition, 41.7% were unsure and 18.4% disagreed entirely.

A survey done in South Africa, Philippines and Mexico by Aerni and Bernauer (2006) concluded that stakeholders believed that agricultural biotechnology had the potential to create solutions to pressing problems and that it did not pose a significant health risk to consumers. However, these stakeholders main concerns were to do with the unforeseen effect that may occur in the natural environment. The research done in these countries suggests that local NGOs who are active in promoting for, or protesting against, GMOs have established links to the western world. As a result, they tend to adopt foreign donors political agenda. European stakeholders, being the more dominant donor, have caused NGOs to take a more European stance on the new technology (Aerni and Bernauer 2006). Paarlberg (2003) argues that the EU has successfully exported its preventative GMO regulatory systems to developing countries.

Certain studies contradict the European influence on developing countries. In research done by Li et al. (2003), Chinese consumers were, in fact, willing to pay a premium for GM foods over non-GMO alternatives. The premiums were ranging from 16% to as high as 38% on certain products. A study conducted in Colombia also found that 66% of participants were willing to purchase GM foods without any benefit (Pachico et al. 2002). Pouris (2003) shows contrasting results and indicated approximately less than 25% of South Africans were willing to pay more for non-GMO foods.

Most developing countries, including South Africa, have little research done in their countries regarding this topic. However, low levels of awareness, exposure and information about GMOs were revealed in the readings to do with developing countries (Vermeulen 2004; Aerni and Bernauer 2006; AfricaBio 2004). Kempen et al. (2004) showed as little as 27% of respondents knew about "genetically modified foods" in South Africa. AfricaBio (2004) indicated similar statistics to Kempen et al. (2004), however, the knowledge was much higher in urban areas. 64% Of consumers in Cape Town knew about the use of biotechnology for development of new drugs (versus 59% of Gauteng consumers), 67% for fibers and plastics (56% for Gauteng) and 82% for development of new crop varieties (65% for Gauteng). Lack of knowledge and understanding has caused consumer fears and misconceptions about GM foods according to Kempen et al. (2004).

Consumer perceptions about GMOs are still taking shape in developing countries. Unless research and knowledge sharing is enhanced in developing regions of the world, our understanding of consumers' thoughts and beliefs around GMOs will remain poor (Kempen et al. 2004). The papers discussed above gave reasonable information to allow one to identify the core attributes that affect GMO consumption. The result of this study, will hopefully give a more genuine reflection of what shapes these consumers thoughts and perceptions around GMOs. The paper will make use of the literature reviewed to build onto its model in order to produce this evidence.

As shown in the literature and for South Africa in particular, the vast majority of studies done on GMOs are descriptive in nature and very few used rigorous econometric modelling to understand consumer's preferences for GMO attributes. One exception to this is Burton et al. (2001), who used a choice experiment approach to understand UK consumer attitudes toward GMOs. Onyango et al. (2004) used choice experiments to understand how consumers view GMOs in the use of different products, Baker and Burnham (2001), also used similar procedures to assess certain characteristics of GM consumers in the US. This paper, therefore, extends our knowledge and analysis of consumer preferences by applying the models used in previous studies in the context of South Africa. By doing so, we hope to add value to a literature that has received very little attention in South Africa, while at the same time it is rarely explored in most developing nations.

The paper proceeds as follows: section 2 presents the methodology of the model and the survey design. Followed by sections 3 and 4 which give the results and a short discussion respectively, while finally concluding in section 5.

1.2 Empirical Model and Survey Design

The relevancy of qualitative research in policy formulation is often limited by the fact that its findings are subjective in nature and does not yield an objective measure of the variable of interest. Furthermore, studies which employ this research design do not identify the attitudes of the respondents independently of each other (Burton et al., 2001). Realistically, attitudes are conditional upon the circumstances in which they appear. Thus, it becomes imperative to use a quantitative design than a qualitative one if the objective of the study is to address policy questions in an objective manner. Would the price discount of GMO foods offset the potential health risks? Or does the positive impact GMOs have on a poverty-stricken area justify its ethical grey area? These questions suggest that the outcomes of consumer's decisions are generally limited to constrained choices (Burton et al. 2001). Choice modelling, in particular, gives a solution to the above. It does this by presenting possible choices that explicitly highlight specific trade-offs that appear in real life. Most importantly, it allows a single issue of interest to be broken up into several attributes that will enable detailed analysis.

1.3 *Choice Modelling Theory*

The core foundation of choice modelling is giving consumers a choice between alternative options that contain attributes with several different levels of outcomes. In doing so, respondents are solely asked to identify which of a number of options they prefer. They, therefore, are not asked to report how much they prefer an alternative; nor are they asked how much they value individual attributes, independent of each other.

The framework addresses two crucial characteristics - first being the goods theory, founded in Lancaster's Model of choice (Lancaster 1966); and the second being the random utility theory (Mansky 1977; McFadden 1974). The goods theory suggests that people derive utility from both consumption of physical goods and the attributes related to that of the commodity, while the latter theory proposes that we cannot tell all the predictors of utility when observing a consumers choice (Ntuli et al. 2019).

Rational consumer behaviour requires that the preferred alternative chosen will derive the highest level of utility in the choice set (Birol et al. 2006a). Equation (1) infers that utility derived by an individual i can be expressed in a basic additive function (Mansky 1977), where the following characteristics are true for all individuals i =1,2,....N, with a preferred and chosen alternative j=1,2,....N, in a choice set C, which contains all possible alternatives in the choice experiment.

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

According to Mansky (1977), the utility equation of an individual i basically compromises of two parts. First, represented by V_{ij} a deterministic (observable) component and second, represented by ε_{ij} a stochastic or unobservable component. We must include an important note; that purely for research purposes, the stochastic part is only seen from the researchers' point of view and not the consumers. For a better understanding of the application, this paper will give a simple case represented in equation (2) in its simplest form. We will assume there are different options of attributes that are associated with different technologies and costs in food production. In reality these options range from purely traditional approaches to GM technology with different combinations in between. Subject to some constraints, the consumer is assumed to maximize a utility function of the form:

$$U_{ij} = \beta_1 Tech_{ij} + \beta_2 Price_{ij} + \varepsilon_{ij} \tag{2}$$

where U_{ij} is the utility individual i obtains from the option j and the parameters β_1 and β_2 are the coefficients of the model being estimated. Finally, the variable $Price_{ij}$ represents the price level paid by consumer i for the food products produced using technology j, while the variable $Tech_{ij}$ represents a dummy variable equal to one when using GM technology and zero otherwise. Choice experiments require that the respondent will choose option j over alternative k when it accumulates more utility. In a simpler explanation the individual will choose option j over alternative k if $U_{ij} > U_{ik}$. Given a choice set C, the probability j is preferred to k can be expressed in the following equation.

$$\begin{aligned} p(j \mid C) &= p[(U_{ij} > U_{ik}] \ for \ all \ j \neq k \\ p(j \mid C) &= p[(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik} \ ] for \ all \ j \neq k \\ p(j \mid C) &= p[(V_{ij} - V_{ik} > \varepsilon_{ik} - \varepsilon_{ij}] \ for \ all \ j \neq k \end{aligned} \tag{3}$$

Equation (3) implies that the difference in observable utility between the two options (j and k) exceeds the difference in the random utility of these alternatives. When using this framework for experimental purposes, we can link the observed utility to that of the attributes of the other options. Hence, the difference in attributes will give us a reasonable estimation of the equation above. Here we can conclude that the visible part of a consumers behaviour is best defined as a function of attributes of the consumer and that of the alternative (Ntuli et al. 2019).

McFadden (1973) shows in his paper that random utility can be modelled using a conditional logit (CL) model and can be used to analyse a consumer choices. The assumption under the CL model is that every ε_{ij} is independent and identically distributed (IID). Where the distribution takes on a Gumbel distribution, which is sometimes, mistaken for a Weibull distribution (Onyango et al. 2004). If we consider that the ε_{ij} is given, then the expression will possess a cumulative distribution for each ε_{ik} evaluated at ε_{ij}+ V_{ij}-V_{iK}, which is expressed below:

$$F(\varepsilon_{ik}) = exp[-exp(\varepsilon_{ij} + V_{ij} - V_{iK})] \tag{4}$$

Since we have assumed that all the $\varepsilon' s$ are independent of each other, the cumulative distribution for all $i \neq j$ is simply the product of all the individual cumulative distributions. The ε's, however, can never be given and so we must go about calculating the choice probability differently. The choice probability, therefore, is calculated by the integral of the probability of an individual choosing alternative j given ε_{ij} divided by all values of ε_{ij} weighted by its density function. This equation is simplified with the use of algebra to equal the following:

$$P_{ij} = \frac{exp(V_{ij})}{\sum_{K=1}^{C} exp(V_{ik})} \tag{5}$$

The above can be further transformed to represent utility that is linear in its parameters: $V_{ij} = \beta' X_{ij}$,where X_{ij} is a vector of observed variables which are related to the alternate j.

$$P_{ij} = \frac{exp(\beta' X_{ij})}{\sum_{K=1}^{C} exp(\beta' X_{ik})} \tag{6}$$

Equation (6) and (5) in simpler words are the CL models, which represents the probability of individual i choosing alternate j. We, however, must be careful in the application of the CL model as it imposes two limitations in its assumptions. Firstly, CL models do well at representing systematic taste variation (taste variation related to observable characteristics, e.g.: income, education), but not random taste variation (differences in taste that are not linked to observable traits). Secondly, substitution patterns in the CL imply proportional substitution across alternatives.

The CL model assumptions about the distribution of the error terms imposes a particular condition called the independence of irrelevant alternatives (IIA), required for parameters to be unbiased. IIA states that " the relative probabilities of two options being chosen are unaffected by introduction or removal of other alternatives" (Birol and Villalba 2006b). If the IIA condition is violated then the CL model will produces biased estimates and the random parameter logit (RPL) yields superior results since it does not require the IIA assumption.

The RPL model also addresses another limitation to the CL model in that it also accounts for unobserved, unconditional heterogeneity in preferences across individuals. Allowing for heterogeneity in a model is important as it allows one to have a better understanding of individuals and enable the researcher to target specific groups rather than the population as a whole (Boxall and Adamowicz 2002). The random utility function in a RPL is given by:

$$U_{ij} = V(Z_j(\beta + \eta_i)) + e(Z_j) \tag{7}$$

Similar to the CL model, the utility is broken up into two components: deterministic component (V) and an error component stochastic term (e).

It assumes that indirect utility is a function of the choice attributes (Z_j), with parameters β, which due to the presence of heterogeneity in preferences may vary across participants by a random component η_i. The probability of choosing j in each of the choice sets can be derived by specifying the distribution of η and the error terms e. Accounting for the hetergoeneity, the transformed equation now becomes:

$$P_{ij} = \frac{exp(V(Z_j(\beta + \eta_i)))}{\sum_{k=1}^{C} exp(V(Z_k(\beta + \eta_i)))} \tag{8}$$

As the RPL is not restricted by the assumption of IIA, the stochastic part of utility can now be correlated among the alternatives and across the sequence of choices through the introduction of the term η_i. In order to treat preference parameters as random variables an estimation by simulated maximum likelihood is required. The maximum likelihood uses an algorithm which searches for a solution by simulating m draws from distributions with given standard deviation and means. One can then calculate probabilities by integrating the joint simulated distribution (Birol and Villalba 2006b). RPL models being able to account for unobserved heterogeneity makes the model in many ways superior to the CL, however, the model still fails to explain the sources of heterogeneity (Boxall and Adamowicz 2002).A solution to this problem is to included interactions of consumer specific attributes in the utility function. This will allow the RPL models to better analyse preference variation in both unconditional taste heterogeneity and individual characteristics in consumers. Since the consumer specific attributes are constant across choices for every given individual, these characteristics only act as an interaction term with the given attributes.

1.4 *Survey Design*

The survey was both an online and hard copy survey, which was completed by a total of 310 individuals in and around Cape Town during the months of July, August and September in 2019. It was targeted at a variety of different homes in different locations. The goal was to try and get a vast diversity in the participants who took the questionnaire and although this paper somewhat achieved that, it cannot claim to be a whole representation of the real population of Cape Town. For reason of the digital version, the majority of the participants were of a higher income group. Although this is not a problem due to the unique characteristics of choice modelling done in this paper (Burton et al. 2001), it must still, however, be analysed with a degree of caution.

The questionnaire is split into four sections: 1. Identification, 2. Demographic and socioeconomic variables, 3. Choice experiment and 4. Knowledge and attitudes about GMOs. The main aim of the questionnaire was to collect data about consumers'attitudes and behaviours towards GMOs (this corresponds with the choice experiment section). There is one issue with choice experiment surveys; this issue being that the survey may give the topic at hand unwarranted prominence (Burton et al., 2001). In simpler words, if the participant believed that the survey was about GMOs, they may not represent their genuine opinion on the matter. The section on " knowledge and attitudes about GMOs" is, therefore, after the choice experiment section. To further solve this issue, participants were told that the paper is about consumers behaviour when consuming food products.

Table 1 demonstrates the attributes and their levels. With five different attributes and their various levels, there are precisely 64 ($4^2 \times 4^1$) possible combinations in which attributes and their levels can be presented. A software called NGENE was used to minimize biasedness in the combinations. The software produced 24 alternative profiles with a full factorial orthogonal design. This, therefore, successfully gave two efficient alternatives per scenario and the status quo. The 24 scenarios were split equally into six blocks. Thus, a total of six different questionnaires were developed in accordance with the various blocks, with four unique scenarios per questionnaire. The surveys were too, randomly assigned to assure compatibility with the theory behind unbiasedness.

Figure 1 is an example of one of the 24 scenarios given to the participants. The levels of the attributes used pictures so that education levels would not affect the results. Those who took part in the choice experiment were told to choose one of the three alternatives of the same food product, these being " alt1", " alt2" and the " status quo". They were also told that the status quo was what they would expect to buy on a day-to-day basis from their local supermarket or shops. The status quo also had no pictures as it was assumed the participant would have a fair idea of what the status quo attributes would be. " Alt1" and " Alt2" were described as different technologies which produced food differently from one another and the " status quo". The " 5" and " 10" shown in " Cost (Rands)" is the premium above the status quo they would pay for the alternative. Hence, zero is the cost in the last column. If appropriately interpreted, the three different ways of production can be assumed by a participant to be different GMO and non-GMO (status quo) technologies. The reason for the ambiguity in the experiment is to combat the presence of unwarranted prominence.

2 Results

2.1 Descriptive Statistics

Table 2 represents the demographics of the people who completed the survey. To better understand the make up of the sample, most of the figures in the table are expressed in percentages except for monthly expenditure and the age of the respondent. We used monthly expenditure in place of household income since it was easier to measure. A higher propotion of females participated in the surveys being 58% of the respondents.

Majority of participants who responded to the survey were Africans (50%). Coloureds who represent the majority of the population in Cape Town, approximately 42% according to UN (2019), are the racial group with the least respondents in the sample (13%). The average expenditure per month on groceries is R3544.11 per month. The rest of the demographic makeup shows a comparably young sample having an average age of approximately 35, who are mostly single (45.8%) and with a majority of people who have enrolled no further than secondary education (56.1%). The most dominant religion is Christianity (64%) followed by no religion (25%).

2.2 Consumer Knowledge about GMOs

Figure 2 below demonstrates what consumers value when purchasing food items. The survey asked individuals to indicate by saying "yes" or "no", which of the following attributes they found important when deciding whether or not to consume GM foods. Health is shown to be the attribute which most people care about, followed by cost. What poses as an interesting outcome is that taste is chosen as an important aspect, more so than environmental concerns. Shelf life, compared to the other choice experiment variables, has shown to have the lowest importance to consumers. We will later discuss these results in relation to the results of the choice experiment.

According to the survey data presented in the Appendix A, 85% of the participants said that they were aware of what GMOs are. Only 35% of these participants, however, were able to answer the true or false question correctly, thus showing that a maximum of 30% of the participants truly had a good idea of what GMOs really were. When individuals were asked if GMOs brought about tangible benefits, would they consume GM products, 33% said they would be "very willing", while 53% said they were "neutral" and 14% said that they were "not willing". Lastly, consumers were asked the importance of labelling GM or non-GM products, 13% answered "very unimportant", 11% answered "unimportant", 28% answered "neutral", 33%

answered " important" and 15% answered " very important".

A simple regression was run to determine how characteristics determine an individual's awareness of GMO's. If people answered the true or false question incorrectly they were assumed to be unaware of what GMOs were. The regression is shown in the appendix B and it shows that education was the most significant determinant for people to be aware about GMOs, showing that ceteris paribus, an increase in education level increased awareness by 4,3%. An increase in age showed less likelihood to be aware of GMOs. White respondents were approximately 40% more likely to be aware of GMOs than both coloureds and black respondents. Finally, monthly expenditure on food products showed no significance in awareness or magnitude in the awareness of GMOs, indicating that wealth isn't a necessity in understanding of GMOs.

2.3 Status Quo Bias

The data was coded according to the level of the attributes. All attributes were coded as dummy code except for the cost attribute. Effect-coding was also used to reach estimates that would be uncorrelated to the model intercept (Adamowicz et al. 1994; Louviere et al. 2000). The coding procedure inherits one base category for the level attributes (besides cost attributes). The estimated coefficients represent an individual's preference in order to move from a lower to higher utility level (Bergman et al. 2006).

This type of choice experiment involves generic options opposed to labelled options. Thus, in order to control for status quo and non-status quo alternatives the model included an alternative specific constant (ASC). The ASC is equal to zero if either " ALT 1" or " ALT 2" options were chosen and otherwise equal to one if " Status Quo" was the chosen. The reason for incorporating the ASC in this manner was because the two alternatives other than status quo had the same sign and approximately equal magnitudes. The inclusion of ASC also allows one to measure if there is a propensity to choose a zero-cost option or if there is protesting behaviour. Therefore, a higher ASC will indicate a greater propensity for individuals to choose the " status quo" alternative, better known as status quo bias. Table 3 represents the frequency and percentage of times individuals choose each alternative. Status quo has the largest frequency and, thus, there is sufficient evidence that individuals preferred the status quo alternative. Our results show that 35% of the respondents preferred the status quo.

2.4 Model Estimation Results

Basic CL and RPL models were used to analyse how the selected attributes explain the choice of different alternatives in a choice set. In this section, we present and compare the results of the CL and RPL models. We use Stata V14 to obtain the choice experiment estimates from these models. The explanatory variables used in the basic models include the following: ASC, health, environment, taste, shelf life and cost. The model building process was done in three stages. First we estimated the multinomial logit (MNL) and conditional logit (CL) models. The model estimation results for the MNL and CL models were similar in magnitude and sign (see Appendix C). Thus, the interpretation of the two models is effectively the same. However, the CL model was preferred to the MNL model as the latter model does not account for data being entered in panel data format, i.e., for each individual multiple choices were made.

During the second stage, we performed the Hausman and McFadden test to examine the null hypothesis of no violation of the IIA assumption (Hausman and McFadden 1984). Following the requirements of the test introduced by Hausman and McFadden (1984), if any of the alternatives are excluded from the choice set, and there is a violation of IIA, the whole model will be in violation. The results of the test in Table 4 show that the CL model violates the IIA assumption. Therefore, the CL model yields biased estimators.

These findings, somewhat, support the use of alternative models such as the RPL model or Latent Class Analysis (LCA) as both models do not need the IIA assumption to yield unbiased estimators. Although LCA has an added advantage in that it allows us to analyse heterogeneity across classes, we choose to fit the basic RPL model to account for only heterogeneity across preferences as this is not the main aim of the paper. When the McFadden's pseudo R^2 value is compared between the CL and RPL models, the results suggest that the former has a higher level of parametric fit than the latter. This means that the CL model may be better for analysing the survey data for this study. The only problem, however, is that the CL model needs to satisfy the IIA assumption to yield unbiased coefficients and because the model is in violation of this assumption an alternative approach which does not require this assumption such as the RPL model becomes inevitable. For comparability reasons, the CL model will still be presented together with the results of the RPL model, but we only interpret the results of the latter model. The results for both the basic CL model and basic RPL model without interaction terms are shown in Table 5.

All the random parameters in the RPL models were specified to be normally distributed, and distribution simulations were based on a 1000 random draws, following the amount suggested by Train (1998). The RPL models with a 1000 draws showed that participants of the survey have heterogeneous preferences when purchasing foods. This is confirmed at 1% significance level in both RPL models and we can conclude that attributes involving health, environment, taste and shelf life can all be treated as random parameters. In the RPL models, cost and ASC were the only variables specified as non-random. The random variables were also normally distributed, in order to ensure that standard deviations can change in sign throughout the full range of the models (Carlsson et al. 2003; Train 1998; Revelt and Train 1998).

During the third stage, two additional models with interaction terms were estimated to give more information about socioeconomic characteristics. Additional variables were generated by interacting the ACS variable with specific socioeconomic characteristics (age, awareness of GMOs, expenditure, gender and education). Several different models were tested and compared, and through trial and error. The models with the best fit are shown in Table 6. Although the CL and RPL models with interactions had approximately the same Pseudo R^2 as the models without interaction terms in Table 5, the former were chosen, as they generated more information.

The RPL model in Table 6 shows that health, environment, taste, shelf life and cost are all significant at 1% significance level. ASC has a large and significant coefficient at the 5% level in the model. As expected, the coefficient for cost is negative and highly significant, which allows us to estimate mean WTP in the preference space. Health, environment and taste have positive coefficients. Surprisingly, the coefficient for shelf life is negative and highly significant. In absolute terms, health has the largest coefficient, followed by environment, while taste has the least. The interaction terms showed that age and education are positive and significant at a 10% level, while the interaction term for awareness of GMOs is negative and significant. The coefficients of the standard deviations of all the attributes are still positive and highly significant as before.

Finally, we conclude the analysis by running mean willingness-to-pay (WTP) estimates for each of the attributes presented in Table 7. Following standard procedure in the literature, the mean WTP estimates were calculated by dividing the coefficient of each attribute by the coefficient of price attribute (Ntuli et al. 2019; Okumu and Muchapondwa 2017; Birol et al. 2006; Carlsson et al. 2003). The results show that respondents are willing to pay more for Healthy food (R22.00) followed by environmentally friendly technology (R14.53), then shelf life (R8.15) and finally taste (R4.42).

3 Discussion

In general, the demographic statistics are consistent with other studies done in Cape Town and South Africa (see AfricaBio 2004; Aerni et al. 2006; Vermeulen 2004). Our finding that a lower proportion of the respondents were male (42%) seems reasonable as females are relatively more responsible for grocery shopping in South Africa and in most African countries in general. Nielsen (2019) reported that females have more influence on the choice of food bought and consumed by households. Interestingly, a higher proportion of the respondents were of African origin suggesting increasing awareness or interest in food products than in previous literature. Inline with this observation, we also need to highlight that the proportion of this popuation category is relatively small compared to the coloured and white population in Cape Town. Previous studies reported environmental awareness and more interest in healthy food among the white communities (Vermeulen 2004).

The fact that Christianity totally dominates other religions in our sample contradicts our expectations. However, this is not surprising given lack of representation by the coloured population, which contributes significantly to the Muslim community in Cape Town. The low response in the coloured population may be contributed to how the surveys were distributed. The online version of the surveys might have created a barrier to those in poorer areas, and thus, may be the reason for the high participation rate of white individuals (37%), which in turn might explain a relatively high expenditure per month on groceries. If we were to interprete the response rate as a measure of interest in the subject matter, then our result could mean lack of interest in food among the coloureds, which happens to be the majority of the population in Cape Town. It is not clear in this study, if this lack of interest in food matters among the colourds also translate into high prevalence of obesity in Cape Town within this subgroup as established by previous studies (Puoane et al. 2002). Most studies of this nature reported sampling bias associated with online surveys (Paarlberg 2014). Therefore, when examining the data caution must be put on the sample with respect to the racial groups that responded.

The descriptive statistics also show that respondents in this study preferred food products that yield better health as opposed to better tasting foods and environmental benefits in general. The respondents also preferred food products with better taste than environmental concerns, indicating that most respondents placed more weight on this former than the latter attribute. This is likely to be linked to the large evolvement of Africans in this study. In contrast, Vermeulen (2004) reported that white communities placed more weight on the environment than improved taste.

As long as biotechnology continues to make its way into the food production systems, acceptance of GM food products by consumers becomes a more vital component for the survival of the technology. GMOs may be a critical element for sustainable agriculture in countries like South Africa with high inequality, to ensure that food supply meets the demand from the increasing population. There is a wide consensus that sound science within the biotech industry will drive consumer acceptance of GMOs (Hossain et al. 2003). However, as this study shows from the large status quo bias, individuals are reluctant to choose other alternatives or willingness to move away from the status quo. Therefore, technology progress by itself might not necessarily lead to a greater acceptance rate in biotechnology.

A large and significant coefficient at the 5% level for the ASC provides enough evidence to confirm the presence of status quo bias. Four reasons are likely to explain why the majority of people have chosen the status quo. Firstly, individuals may find that the cost associated with moving to another alternative too high. In addition to physical costs, there are also hidden costs associated with consumption of a technology, e.g., searching or information costs (Harrison et al. 2004; McCluskey 2003). Secondly, people are generally afraid of the risk or uncertainty associated with switching from one regime to another (Harrison et al. 2004; Onyango et al. 2004). Some studies classify uncertainty under hidden costs, while others isolate risk from the cost function. Thirdly, individuals may be content with the food they are already consuming or the status quo and hence have no reason to change. This is consistent with proportions of African and white population in the sample, who are believed to prefer traditional food and healthier food respectively (Vermeulen 2004). And finally, choice experiment surveys may be hard to understand, and therefore participants choose the status quo as an easy option. Birol et al. (2006) observed that respondents sometimes choose the status quo as the default option if they feel that the exercise is difficult. With a large portion of online participation there may have been a lack of guidance in the survey and possibly could explain the greater taste for the status quo.

Although, good practise in science may not be the only driver in changing consumer behaviour and acceptance of GMOs, aligning consumer preferences and the development of GMOs is certainly a step in right direction. Traditionally, GMOs have been developed to bring about durability in crops, longer shelf life, enhanced nutrition, better taste and greater yields (Onyango et al. 2004). Interestingly, however, extended shelf live showed a significantly large negative coefficient in the choice experiment. The descriptive statistics also show that shelf life is the least favoured trait when consumers make a decision to purchase GMOs. The large negative coefficient seen in the choice experiments may therefore, be explained by the majority participants demanding naturally fresher foods that have not been preserved or altered.

This key finding, in some ways, seems contradictory to the philosophy behind the development of GMOs, which is to increase the lengthiness in food shelf life. The demand for GMOs to produce food with a longer shelf life, have most likely come from supermarkets and manufactures as opposed to consumers, as an effective way to improve their profits. This also supports the idea that shelf life is a supply side factor and the profit maximization behaviour of biotechnology firms is likely to be one of the key drivers in the development of the technology in this case. Furthermore, combining negative coefficient of cost and shelf life we can deduce that consumers in the survey preferred food products that are relatively cheaper and have shorter shelf life.

Based on the rest of the results from the RPL model, the parameters of the utility function behaved well in the sense that they are theoretically consistent in their signs. Looking at the factors that respondents found favourable in foods, health and environment have large positive and significant coefficients indicating that food products are valued more when they bring benefits to one's health and the environment. The marginal effects show that the health variable has the largest coefficient followed by the environment, while taste has the least magnitude (see Appendix D). The mean WTP for healthy food is 1.5 times the magnitude of the second largest WTP value (environmental concerns) and more than 5 times the magnitude of the least WTP value (taste). These results have shown to repeat themselves in both developing and developed countries around the world (Aerni et al. 2006; Harrison et al. 2004; Hobbs et al. 2000). As a result, we can classify health and environmental concerns as important demand side factors. If our results were to hold true in a larger sample, more emphasis must therefore be put on developing GMOs that better aligned consumer interests and encourage producers to target healthy and environmental benefits more than shelf life and taste. Invoking previous theoretical and empirical accounts, supply side technologies are bound to fail in a competitive market, while demand driven products triumph because they address a genuine need (Zhao 2018; Guerzoni and Raiteri 2015).

The negative sign on the interaction term between environmental awareness and ASC suggest that respondents are more likely to move away from the status quo to a better and environmentally friendly technology. This means that those participants who were aware of GMOs were more likely to choose alternatives to the status quo. This result is important as it highlights that people who have a better understanding of GMOs are more likely to support biotechnology in the production of food products. Harrison et al. (2004) argue that misconceptions and little understanding of GMOs have continuously driven consumers away from consuming GMOs. The literature suggests that education in this area will improve acceptance of GMOs (Aerni et al. 2006; Baker and Burnham 2001; Burton et al. 2001; Kempen et al. 2004; Vermeulen 2004).

Surprisingly, participants who had higher levels of education were more likely to stick to the status quo alternative. This result could be true because of the increasing number of awareness campaigns that influence people to eat organic foods which are environmentally friendly and lead to misconceptions about the health impact of GMOs (Aerni and Bernauer 2006). On one hand, well educated people might have more knowledge about healthy food and environmental consequences than their uneducated counterparts. Hence, the highly educated are likely to stick to the status quo if they perceive it as the most healthy and environmentally friendly option even if it isn't. This finding contradicts the belief that awareness of GMOs increases acceptance of GMOs, as one would assume individuals who are better educated would have a better knowledge about GMOs (Baker and Burnham 2001). On the other hand, those who are uneducated are found to rely on instincts or what they believe (which is shaped by their past experience) when choosing to consume GMOs rather than informed decisions that are based on credible information sources (Burton et al. 2001). As a result, both scenarios can often bring about inefficiencies in the food market (Baker and Burnham 2001). This being said, more awareness of GMOs results in individuals shifting away from the status quo.

Finally, the positive signs displayed by the education and age interaction terms, suggested that those who are older and have higher levels of education are more likely to choose the status quo. As already alluded to, risk aversion can also prevent individuals from moving away for the status quo since the other alternatives are not known with certainty (Harrison et al. 2004). For instance, the impact of consuming GMOs on health or the production process on the environment is not known with certainty. From the literature, risk aversion is known to increase with both age (Kurnianingsih et al. 2015; Steven and Duffy 2012), while the effect of education is mixed (e.g., Black et al. 2015; Moran 2015; Jung 2014).

3.1 *Policy Implications:*

Our results show that consumers put more weight on health and the environment in making decisions. Policymakers should therefore focus on designing instruments that align consumer preferences with the objectives of producers. This will create an enabling environment that will in turn encourage the production of GM foods that increase both health and environmental benefits. Governments must spearhead research into these areas through the provision of funding and expertise in order to explore options that will bring about health and environmental benefits, while at the same time taking an active role in communicating information about the pros and cons of GMO products to the masses. In this the government can address the problem of information asymmetry by bridging the gap between the producers and consumers.

The study also showed that individuals who were aware of what GMOs are, were more likely to choose alternatives based on improved production technology. More regulations are required in as far as communication with the general public is concerned. Such regulations might come in the of form mandatory labelling of GM products so that consumers can get detailed information on specific aspects of a product ranging from its nutritional content to environmental impacts of the production process. There is a need to increase awareness campaigns through conventional media such as television and radio, and non-conventional media platforms such as Facebook, WhatsApp and Twitter in order to educate a larger percentage of the population, seeing that so little of the population have a true understanding of GMOs. The internet can also act as an important educational tool by making information readily available to consumers. It is highly unlikely that increasing regulations in the food industry will, in hindsight, bring about more trust from consumers by ensuring that risk adverse consumers feel that products for sale are deemed safe to use without proper communication. On the other hand, drawing unnecessary attention to GM products may increase the fear in consumers.

3.2 *Implications for producers and marketers:*

Since health safety and the environmental sustainability are the two most important traits to consumers, plant developers must therefore put greater emphasis on beneficial qualities that consumers are most interested in to protect the survival of the technology. Today, producers of GM products mainly focus on three types of genetic modifications which include: yield enhancements – such as improved photosynthesis, input substitution traits through disease resistance and herbicide resistance, and quality traits, such as longer shelf life, but at the expense of improved nutrition and greater tolerance to the environment (Baker and Burnham 2001), the motive behind this being supply driven rather than consumers driven. The results of this paper suggest that the plant developers must shift their main point of focus away from shelf life and taste towards health and environmental attributes.

The paper shows that awareness and tangible benefits increase the number of participants willing to consume GMOs. Consumers who are unaware of the benefits of GM products will likely be reluctant in accepting even small perceived risks associated with the technology (Baker & Burnham 2001). Producers must seek to effectively communicate both tangible and non-tangible benefits of a technology to consumers. This can be done by providing better platforms to educate the public about GMOs or provide advertising plans that allow consumers to see what benefits GM products may have. This should allow consumer to easily compare benefits and costs that will likely bring about more acceptance. Furthermore, different communication strategies can be used to target various segments of the society by age, race and education level. Finally, to complement the mandatory labelling requirements by the government, producers can participate in voluntary certification programmes that will in turn provide information to consumers about the health aspects such as the nutritional content of their products and environmental behaviour of the firm.

4 Conclusion

Using a choice experiment framework, this paper examined consumer preferences for attributes of GMO food products based on modern procedures. Surveys were distributed online to respondents in different segments in Cape Towns through various platforms including universities, email, Facebook and WhatsApp. The survey participants were asked a number of questions that involved socioeconomic variables, knowledge about GMOs and a choice experiment. The choice experiment involved three alternatives including a status quo and five different attributes measured at different levels. The attributes included: environmental effects, health, taste, shelf life and cost. The random parameter logit model was chosen as the best model to analyse the data given from the surveys through a model building process with four steps and rigorous testing.

We verified non-participation in one of the population categories as a major source of bias associated with online surveys which could be avoided by implementing face-to-face surveys. The results showed significance in all the cognitive variables (the different attributes), with health being the most important variable to consumers, followed by the environment. A large status quo bias showed that many respondents were either against the use of technology in food products or had little incentive to move to another alternative. To get a better understanding of the socioeconomic variables, an alternative specific constant interacted with these variables was used. The results showed that the participants who were aware of GMOs were more likely to choose alternatives other than the status quo, indicating more trust in GMOs. The large status quo bias may also be explained by the fact that fewer respondents actually knew what GMOs were. Thus, indicating that education in this area may be the first step in promoting GMOs.

The key findings of this paper have some important implications for policymakers, producers and marketers. GMOs are more likely to be accepted with a better understanding of what they are. It must be understood that sound science is most likely not going to improve consumer acceptance by itself. Therefore, a greater emphasis must be put on aligning consumer demands with producer goals. Education on GMOs also need to improve to drive consumer acceptance, which need to be targeted at certain segments of the population. The government should spearhead research and make sure that appropriate information is communicated to the public in addition to regulating the industry. If GMOs are to be the future of agriculture, they must bring better benefits to society than what the status quo is currently providing and allow consumers to shape the development of these products. Certain approaches in product development need to ensure that consumers are gaining tangible and intangible benefits above those of traditional foods to improve acceptance. Focus must be put mainly on health and environmental benefits, because if GMOs are continuously being linked to terminal illnesses and poor environmental conditions, then this might lead to the destruction of this technology. Finally, the private sector must complement the government's efforts, by ascribing to voluntary certification programs to guarantee consumers they are producing according to prescribed standards.

5 Abbreviations

- ALT 1 : Alternative one
- ALT 2 : Alternative Two
- ASC : Alternative Specific Constant
- CL : Conditional Logit
- GE: Genetic Engineering
- GM: Genetic Modification
- GMOs: Genetically Modified Organisms
- IIA: Independent and Irrelevant Alternatives

- MNL: Multinomial Logit
- RPL: Random Parameter Logit
- UK: United Kingdom
- UN: United Nations
- US: United States
- USA: United States of America

6 Declaration

Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request

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Authors Contribution

Questionnaire design (BD); data collection (BD & HN); data analysis (BD); write up (BD & HN); Supervision (HN).

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Table 1: Attributes with the given levels

Attributes:	**Levels:**			
Environment	1 = Bad		2 = good	
Health	1 = Bad		2 = Good	
Improved taste	1 = Bad		2 = Good	
Improved shelf life	1 = Short		2 = Long	
Cost	0	5	10	15

Source: survey data, Jul - Sep 2019.

Table 2: Charateristics of Survey Respondents

Variables:	**N (%)**	**Mean**	**Variables:**	**N (%)**	**Mean**
Age	100	34,94	**Education:**		
			No School	0.3	
Gender:			Primary	2.6	
Male	42		Secondary	11.6	
Female	58		Matric	41.6	
			Diploma	11.3	
Race:			Undergraduate	18.0	
African	50		Honours	9.7	
White	37		Masters	2.3	
Coloured	13		PHD	2.6	
Religion:			**Marital Status:**		
No Religion	25		Single	45.8	
Christian	64		Married	38.4	
Judaism	0.66		Divorced	7.4	
Hindu	0.33		Separated	3.9	
Muslim	6		Widowed	4.5	
Other	4				
			Expenditure p/m		3544,11
Employment Status:					
Unemployed	36				
Self employed	22				
Formally Employed	42				

Source: survey data, Jul - Sep 2019.
Statistics are represented in percentage form.
Expenditure p/m, represents the amount individuals spent on groceries per month.

Table 3: Frequency of Choices from Survey Respondents

Choice	Frequency	Percent (%)
ALT 1	395	31.85
ALT 2	407	32.82
Status Quo	438	35.32
Total	**1240**	**100**

Source: survey data, Jul – Sep 2019

Table 4: Hausman and McFadden Test For IIA Violation

Alternative Dropped	Chi Square	P-value	Violation of IIA
Alt 1	3.18	0.6726	Yes
Alt 2	8.97	0.1102	Yes
Status Quo	28.01	0.0000	No

H0:Rejected at a 5% significance level
Source: survey data, Jul – Sep 2019

Table 5: The Conditional Logit and Random Parameter Logit Models

Attribute:	CL Model Coefficient	CL Model Standard Deviation	RPL Model Coefficient	RPL Model Standard Deviation
Mean Effects:				
ASC	3.3853***	(0.6706)	2.2802***	(0.6766)
Health	1.3946***	(0.1149)	1.1401***	(0.1277)
Environment	1.0004***	(0.1372)	0.7484***	(0.1515)
Taste	0.2997**	(0.1283)	0.2280*	(0.1349)
Shelf Life	-0.3511***	(0.1320)	-0.4232***	(0.1378)
Cost	-0.0533***	(0.0091)	-0.0525***	(0.0098)
Standard deviation Effects:				
Health			0.4635***	(0.1182)
Environment			0.7114***	(0.0998)
Taste			0.4506***	(0.1282)
Shelf Life			0.4028**	(0.1610)
Model Statistics:				
Log-Likelihood	-1734.9927		-1157.2456	
ρ^2(Pseudo - R^2)	0.0980		0.0511	
Observations	3720		3720	

Notes: ***,**,* show significant at a 1%, 5% and 10% level respectively. The RPL model used a 1000 draws to obtain its estimates and kept the cost attribute constant
Source: survey data, Jul – Sep 2019

Table 6: The Conditional Logit and Random Parameter Logit Models with interactions

	CL Model		RPL Model	
Attribute:	Coefficient	Standard Deviation	Coefficient	Standard Deviation
Mean Effects:				
ASC	2.9774***	(0.7511)	1.7671**	(0.8880)
Health	1.3976***	(0.1151)	1.1419***	(0.1268)
Environment	1.0045***	(0.1374)	0.7541***	(0.1508)
Taste	0.3027**	(0.1284)	0.2296***	(0.1346)
Shelf Life	-0.3508***	(0.1321)	-0.4231***	(0.1377)
Cost	-0.0534***	(0.0091)	-0.0519***	(0.0097)
ASC × Age	0.0214***	(0.0075)	0.0210*	(0.0122)
ASC × Awareness of GMOs	-0.7288***	(0.2024)	-0.6066*	(0.3291)
ASC × Gender	-0.0447	(0.1481)	-0.0901	(0.2375)
ASC × Expenditure	-0.0001**	(0.0000)	-0.0001	(0.0000)
ASC × Education	0.1331**	(0.0526)	0.1448*	(0.0862)
Standard deviation Effects:				
Health			0.4460***	(0.1201)
Environment			0.6898***	(0.1010)
Taste			0.4460***	(0.1327)
Shelf Life			0.4211***	(0.1579)
Model Statistics:				
Log-Likelihood	-1723.9014		-1163.6039	
ρ^2(Pseudo - R^2)	0.1037		0.0483	
Observations	3720		3720	

Notes: ***,**,* show significant at a 1%, 5% and 10% level respectively. The RPL model used a 1000 draws to obtain its estimates and kept the cost attribute constant
Source: survey data, Jul – Sep 2019

Table 7: Mean WTP Estimates for the CL and RPL models

Attribute	**WTP Estimates**	
	CL Model	*RPL Model*
Health	26.17	22.00
Environment	18.81	14.53
Taste	5.67	4.42
Shelf Life	6.57	8.15

Source: survey data, Jul – Sep 2019
Currency denoted in South African Rands

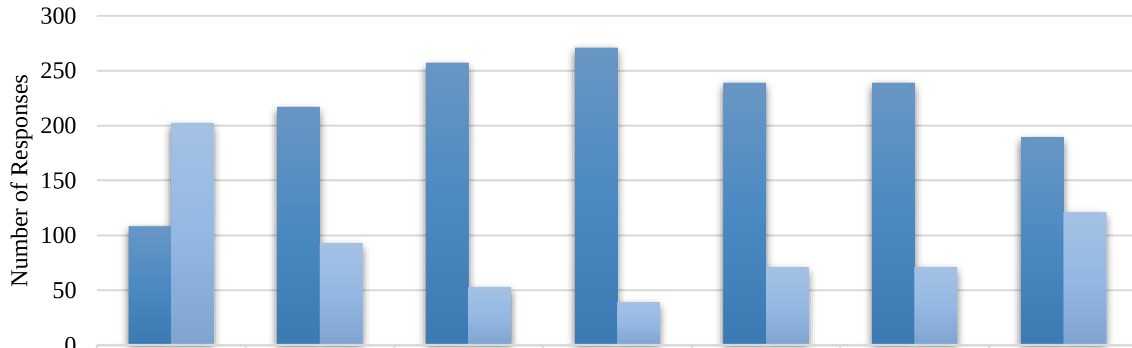
Figure 1: Choice experiment example of a scenario

Scenario 11

	alt1	alt2	Status Quo
Environmental Effect			
Health			
Improved taste			
Improved Shelf Life			
Cost (Rands)	10	5	0
Choice question:			

Source: Own design (Sept 2019)

Figure 2: Important Individual Attributes for Consumption of GMOs



	Ethical or Religious Concerns	Enviromental Concerns	Price	Health Concerns	Improved Taste	Improved Nutrition	Improved shelf life
Yes	108	217	257	271	239	239	189
No	202	93	53	39	71	71	121

Source: survey data, Jul – Sep 2019

Appendix

Appendix A: Descriptive Stats about Knowledge of GMOs, Reaction to Benefits and Labelling of GMO Products

Questions:	**Answers in Percentages**
Aware of GMOs	85%
Unaware of GMOs	15%
Aware of GMOs and Correctly answering questions about GMOs	30%
How important is it to label GMOs:	
Very important	13%
Important	11%
Neutral	28%
Unimportant	33%
Very Unimportant	15%
Are you willing to consume GMOs if it brings about tangible benefits:	
Very willing	33%
Neutral	53%
Not willing	14%
Source: survey data, Jul – Sep 2019	

Appendix B: Linear regression on Awareness of GMOs (If Correct Answer to True or False)

Variables:	**Coefficients**	**Standard Deviation**
Education Level	0.0430***	(0.0052)
Male (Female base category)	0.0238*	(0.0133)
Age	-0.0029***	(0.0007)
Expenditure	-0.000	(0.0000)
Race (Black African base):		
White	0.3752***	(0.0176)
Coloured	-0.0337*	(0.0205)
Constant	0.0910***	(0.0307)
Model Statistics:		
R squared	0.2553	
Observations	310	

Notes: ***,**,* show significant at a 1%, 5% and 10% level respectively
Education level is made up of: no school, primary, secondary, matric, diploma, undergraduate, honours, masters, PHD
Source: survey data, Jul – Sep 2019

Appendix C: MNL model and without with interaction terms

Variables:	**MNL Models**	
	Base model without interaction terms	*Model with interactions terms*
ASC	3.5746***	3.3073***
	(0.6905)	(0.7481)
Enviro	1.0691***	1.0691***
	(0.1417)	(0.1417)
Health	1.4988***	1.4988***
	(0.1182)	(0.1182)
Taste	0.3146**	0.3146**
	(0.1328)	(0.1328)
Shelf	-0.3929***	-0.3929***
	(0.1368)	(0.1368)
Cost	-0.0581***	-0.0581***
	(0.0095)	(0.0095)
AgeA		0.0140**
		(0.0061)
AwareA		-0.4959***
		(0.1641)
GenderA		-0.0430
		(0.1221)
ExpenditureA		-0.0000**
		(0.0000)
EducationlevA		0.0927**
		(0.0431)
Constant	-4.1795***	-4.1795***
	(0.6879)	(0.6879)
LR chi2(11)		424.33
Prob > chi2		0.0000
Pseudo R2		0.0896
Log likelihood		-2155.668
Observations		3,720

Notes: ***,**,* show significant at a 1%, 5% and 10% level respectively
Education level is made up of: no school, primary, secondary, matric, diploma, undergraduate, honours, masters, PHD
Source: survey data, Jul – Sep 2019

Appendix D: Marginal effects for the RPL

Variables:	dy/dx	Std.Err.
ASC*	0.673***	0.107
cost	-0.013***	0.002
health	0.322***	0.025
enviro	0.229***	0.030
taste	0.068**	0.029
shelf	-0.084***	0.029
ageA	0.003**	0.001
awareA*	-0.102***	0.032
genderA*	-0.009	0.026
expenditureA	-8.85e-06**	0.000
educationlevA	0.020**	0.009

Notes: ***,**,* show significant at a 1%, 5% and 10% level respectively
(*) dy/dx is for discrete change of dummy variable from 0 to 1 (shown on the variable name)
Source: survey data, Jul – Sep 2019

Appendix E: WTP estimates of the MNL

Attribute:	WTP Estimates of the MNL Model
Health	56,92
Environment	18,40
Taste	25,80
Shelf Life	5,41
	6,76

Source: survey data, Jul – Sep 2019
Currency denoted in South African Rands