# Consumer Response to Genetically Modified Foods

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**Abstract**

      The consumer trait and characteristic identification, and corresponding relationship to the genetically modified food product's negative reactions was determined from a 354 respondent, 130 item mailed survey. The survey and partially mediated model from Mowen's 3M Model of Personality and Motivation explained how personality traits influence genetically modified food reactions.

**Keywords:** consumer acceptance, genetically modified organisms, survey

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**Introduction**

"It is therefore with considerable irony that we note that a society founded and nurtured by intellectuals, a society which has benefited so greatly from a spectacular development and utilization of knowledge, also is a society in which a spirit of anti-intellectualism has periodically slowed economic and social development (Bishop, p. 34)." A technological evolution from the early 1900's crossbreeding techniques to present-day gene splicing has altered the abilities, traits, and characteristics of farm production across the world. As science has more impact on the food supply, more debates are being heard. Misunderstandings, lack of product knowledge, and increased concerns may influence the speed and acceptance of foods from genetically modified organisms (GMOs).

Genetically modified foods have endured obstacles on their way to production and usage. Since the evolution of genetic modification or alteration of organisms from crossbreeding techniques in the 1900's, debates about the development and characteristics of genetically modified foods have been heard (McHughen). The evolution from crossbreeding to genetic alteration has created concern and trepidation as products containing genetically modified ingredients have become more prevalent. The production process is termed genetic engineering, genetic modification, genetic alteration, or recombinant DNA technology. Genetic modification is the alteration of the basic genetic material with "the introduction by man of a piece of genetic material into a plant or animal in a way that is not possible using breeding or natural recombination (Custers, p. 7)." In the 1980's, genetic transferring abilities advanced, which paved the

way for the first genetically engineered plants in 1983 (McHughen). In 1994, Calgene produced genetically modified tomatoes called FlavrSavr (Burkhart et al.). In 1995-96, the introduction and approval of Monsanto's Roundup Ready soybeans led to the 1997 commercialization of the product and the production of additional genetically modified products (Monsanto Company). Since 1997, over fifty genetically modified food sources have been permitted for commercialization and marketing (Burkhart et al.).

Biotechnology expenditures have increased. In the USA, research and development costs to produce biotechnology products were around $10.7 billion in 2000 (Biotechnology Industry Statistics). In 2000, the revenue from the entire biotechnology industry was $22.3 billion while the money invested in the industry was $353.5 billion (Biotechnology Industry Statistics). A Monsanto representative estimates global research and development expenditures to be around $1 million per day for GMO products (Rafferty). In Australia, $900 million was raised for funding biotechnology, 6000 people were employed, 35 public core companies were created, and 155 private core companies were created with $6.5 billion in combined market capitalization (Ernst & Young Australia). In Canada, 1997 research and development expenditures were estimated to total about $600 million (White). Biotechnology investments are occurring even though consumers are expressing some reluctance to purchase GMOs products and are currently debating the future marketing abilities and limitations of GMOs products. Abdul Jalil, director of Saskatchewan Agriculture's research branch expressed the situation the best by saying, "If there are no markets, there's no point for us to put money into some of these programs. We have to use it where the producers want it (as quoted by Morrison, p. 1)."

About ten years ago, GMOs began showing up quietly on the shelves of grocery stores and in farmers' fields. As more products and items emerged containing ingredients from GMOs, debates involving the production methods, safety, and need for new methods have taken place across the world. As laboratories and scientists are creating new products, consumers are concerned about how the changes will affect them. Society does not have final answers as to what alterations will occur in nature, how the transformations will affect them or the products, or the safety of product changes (Custers).

The questions posed by consumers and governments are increasing as opinions about the products are mounting and laws concerning the production and marketing are being passed. Europe and India are requiring "mandatory and comprehensive labeling of all products of biotechnology (McHughen, p. 202)." "Canada, the USA, Australia, New Zealand, and some South American countries request labeling only on products carrying new health or safety concerns and if the product is substantially equivalent to the traditional counterpart, no labeling is needed (McHughen, p. 202)." Substantial equivalence is determined as being similar and posing comparable risks to previous products based on the previous product's safe status (McHughen). Previous product safety is being used to indicate the new product's safety. Countries, spurred by activists debating each facet of the issue, are taking stands as to how the new product can be marketed and sold. Greenpeace, anti-GMO groups, and similar groups desire to ban GMOs while many pro-GMO groups are fighting for expanded acceptance. Research is used to support the viewpoints and desires of countries, consumers, and governments towards GMOs. Past research for consumers has mainly focused on consumers' attitudes,

responses, and knowledge of genetically modified organisms. Senauer focused on the perceptions of consumers towards genetically modified products and the level of the technology knowledge. As information is surfacing relating to genetically modified organisms and products, researchers are searching for answers as to why individuals are reacting in these manners.

Information concerning individuals' reactions and responses to GMOs is limited. Consumer preferences for the product, concerns about the manufacture of the products, and the knowledge levels of the majority of the population have been the topic of most research (Senauer). Companies, governments, and scientists are faced with locating information about genetically modified foods and attempting to understand what motivates concern about these products. The underlying factors influencing consumers' reactions to GMOs are not understood. Thus, the objective of this paper is to determine which consumer traits and characteristics are related to negative and positive reactions to food products made from GMOs. The approach taken in this paper explains the underlying psychological structure of consumer utility maximiziation.

**Personality Traits and Models**

Mowen's 3M model of personality and motivation is based in part on the Five Factor Model (Mowen). These basic traits were first identified in 1937 by Alports' lexicographical and Stagner's questionnaire models (Craik et al.). Over a half a century later, researchers generally agree the five traits of openness, conscientiousness, extroversion, agreeableness, and emotional stability are the basis of personality. Mowen added three additional traits: material needs, arousal needs, and physical/body needs. Mowen proposed that these eight traits form the basis for understanding the most abstract

portion of the human personality, which he called elemental traits. The 3M model is hierarchical in nature. The elemental traits combine to create compound traits. In turn, elemental and compound traits combine with situational forces to create situational traits. Finally, elemental, compound, and situational traits combine to create surface traits. Surface traits are enduring dispositions to respond in specific contexts. In our research, an enduring disposition to oppose GMO products represents a surface trait.

The diagram below shows how the trait hierarchy along with environment, task programs, cognitive appraisal, activities, outcomes, resources, and comparators interact to make a decision within the 3M model context. Starting at the left, the trait hierarchy begins with the abstract, elemental traits and descends to the concrete, surface traits. Each of these traits is linked to the comparator (the triangle with C). The comparator evaluates whether the outcome matches the desired result of action given the individual's personality structure. The comparator is linked to task programs, which used to meet short-run objectives[i]. If outcomes fail to match the personality structure, an interruption occurs, and cognitive appraisal takes place. Based upon the appraisal of why the interrupt occurred, the task program and/or activities implemented to run the program may be changed. Activities represent the specific actions that take place in order to complete tasks. Actions may happen through active or non-active measures. Examples of actions include: sleeping, communication, listening, eating, using tools, etc. In order to assist action and task completion, resources are used. Resources include money or income, other people, material goods, information, and body/physical assets. Outcomes result from the activity and resource inputs, as well as from the effects of environmental forces, including luck and chance.

**Data**

Consumer preferences were studied through use of a panel survey run by Market Facts, Inc. The four-page survey was sent to 600 members of the panel. They were selected by the administrator of the panel to match the population characteristics of the United States on age, household income, education, race, gender, and geographic location. Completed surveys were received from 354 respondents- a 59 percent response rate. The demographic characteristics of the sample are: 48 percent male, 68.4 percent married, and 83.3 percent Caucasian. Thirty-five percent have attended college, and 16.4 percent were graduated from college. The age of the respondents is evenly distributed between 25 and 64 years old. Eighty-eight percent of the respondents are in this age range.

Outlying observations resulted in the loss of four observations and minor changes in 21 observations, leaving 350 complete observations to use to estimate the 3M model. In the questionnaire respondents were asked how frequently they 'felt or acted this way'. Responses for the elemental and compound traits were measured on a nine-point rating scale bounded by 'never' and 'always'. The situational and surface traits were measured on a seven-point Likert scale.

Each of the elemental traits was accessed using a four-item scale developed by Mowen. Conscientiousness is the need to be organized, orderly, and efficient in carrying out tasks (e.g., 'precise'). Physical/body needs is the need to maintain and enhance the body (e.g., 'Focus on my body and how it feels').

The compound traits were measured using the same scale as the elemental traits. Competitiveness is the enjoyment of interpersonal competition and the desire to win and

be better than others (e.g., 'Enjoy competition more than others'). Poetry is the generic term used to represent the interest in the arts and culture (e.g., 'I consider myself to be a highly artistic person'). Present thinking is the desire to live in and for the future and to not plan in advance for future occurrences (e.g., 'The distant future is too uncertain to plan for').

The situational traits are measured using seven-point scales. Seers is measured by three responses (e.g., 'There are people who can predict the future'). Gambling interest is the desire and enjoyment gleamed from wagering money on questionable outcomes (e.g., 'I really enjoy gambling for money'). Belief in science is the understanding and conviction that science explains nature (e.g., 'I strongly belief that science explains nature'). Retirement is the withdrawal from one's position or occupation or from active working life or to plan for the withdrawal (e.g., 'I (we) have a financial plan that will take care of retirement'). Sports fan is the desire to and enjoyment gained from watching sports (e.g., 'Watching sports as a fan is fun for me'). Superstition is a belief or practice resulting from ignorance, from fear of the unknown, from trust in magic or chance, or from a false conception of causation (e.g., 'black cats bring bad luck'). Auto innovativeness interest is the interest and desire to own the newest, best car on the market (e.g., 'I like owning a car that I can show off to others').

The surface trait is measured using a seven-point scale. Bioengineered product interest is the negative response of consumers towards bioengineered products. The questions that measure bioengineered product interest are 1) the genetic engineering of foods is a serious threat, 2) biotechnology will do more harm than good, 3) genetically

modified foods should be banned until their safety is proven, and 4) I would pay 25%

more for a food product guaranteed NOT to contain genetically modified ingredients.

**Procedures**

The average of the composite questions is the sum of the individual trait's mean,

which is obtained by summing together the means of the particular trait's question

responses in the survey and dividing by the number of trait questions. Coefficient alpha is

used to determine whether or not the questions are internally consistent, resulting in the

lower bound of scale reliability. Coefficient alpha is calculated as

"$\rho_\alpha = \left[\dfrac{k}{k-1}\right]\left[1 - \dfrac{\sum \sigma_i^2}{\sigma_x^2}\right]$", where k is the number of variables, $\sigma_i^2$ is the variance of the

questionnaire items, $\sigma_x^2$ is the variance of the sum of the items. For example, the

introversion trait, k is four, $\sigma_i^2$ is the variance for $Q_1X_1$, $Q_1X_2$, $Q_1X_3$, and $Q_1X_4$, and $\sigma_x^2$ is

the variance of introversion. ($Q_1X_1$ is item one of question one; Q1X2 is item two of

question one). Internal consistency is indicated by the true measure divided by the

estimated measure. If the ratio of the measures is close to 1, this indicates the proximity

of the true measure versus the estimated calculations (Zumbo). If the coefficient alpha is

greater than .70, internal consistency is suggested. Listed in Table 1 are the means,

variances, number of variables (k), and the coefficient alpha of all elemental, compound,

situational, and surface traits. All the questions and traits passed the coefficient alpha test.

**Results**

A linear regression is estimated for the partially mediated model. The hypothesis

for each regression are based on a rejection region for each independent trait of a p-value

less than 0.10, which indicates significance at the 0.10 level. The equation is tested for

normality, heteroskedasticity, and non-linearity, using a rejection region of 0.10. The Kolmogorov-Smirnov testing procedure is used for normality testing. Non-linearity is tested using a joint conditional means test presented by McGuirk, Driscoll, and Alwang. Heteroskedasticity tests are based on a joint conditional variance test also presented by McGuirk, Driscoll, and Alwang. SAS version 8 is used to estimate the regressions and aid in the specification testing.

A partially mediated model with additional demographics is estimated. The regression is free of the problems associated with heteroskedasticity, nonlinearity, and normality. The results in Table 2 below show the partially mediated linear regression. The path diagram in Figure 2 shows the traits and demographics that are significant in the determination of the negative attitude toward bioengineered product surface trait. Along with the trait interaction is the positive or negative impact of the relationship.

The regression originally contained all twenty-eight variables. During the regression process, variables with t-values less than 0.90 were omitted. The final linear regression is free of nonlinearity, normality, and heteroskedasticity issues and has seven variables with coefficients that are significantly different from zero. The variables of retirement, auto innovativeness interest, sports fan, education, physical/body needs, poetry, and present thinking are significant. Retirement and education have negative coefficients, while the remaining traits have positive coefficients. The significant elemental trait is the physical/body needs. Physical/body needs is the need to maintain and enhance the body. The significant compound traits are poetry and present thinking. Poetry is the ability and desire to express oneself through poetic measures. Present thinking is the realization and focus on today's events. Significant situational traits are

retirement, sports fan, and auto innovativeness interest. Retirement is the focus on tomorrow and the future's events. Sports fan is the desire for individuals to watch sports. Auto innovativeness is the desire to have the newest and best car currently on the market. The other significant coefficient is a demographic variable. According to the linear regression, people who have more negative responses towards bioengineered products are less concerned with retirement, are sports fans, and have the desire to own the best cars. These individuals also generally do not have college degrees and do have higher physical/body needs, are more poetic, and are present thinkers.

The partially mediated model is free of the specification problems that plague a fully mediated model. The fully mediated model, counting for all traits from the elemental to the situational traits that compose the bioengineered product interest response, has eighteen traits of significance. The partially mediated model has seven significant coefficients. In analyzing the model's fit, there is significant evidence to show that the partially mediated model is a better fitting model. Mowen's findings coincide with the partially mediated model resulting in a better fitting model for surface trait evaluation (Mowen).

**Conclusions**

Genetically modified foods have evolved and increased in production. Currently over fifty genetically modified food sources have been permitted for production and commercialization. Billions of research and development dollars are being spent on genetically modified foods, but some consumers have yet to decide whether they desire to purchase the products or not. Some consumers and some governments across the world are expressing apprehension about the production methods and genetic modification of

food sources. Governments around the world have imposed bans on the importation of goods containing genetically modified organisms. The science of genetic modification is roughly a decade old and numerous questions remain regarding the alterations that could occur in nature, the methods of production currently in use, and the safety of the new products being developed. Answers to these questions are unavailable at this time.

The issues and concerns related to GMO products continue to emerge and increase, resulting in an increase in the amount of research needed to address the issues of acceptance, limitation, and knowledge of genetically modified foods. Current research has not yet determined what personality traits generate a reaction to or concern about genetically modified foods. Therefore, the factors underlying consumer concern need to be addressed and evaluated. The objective of the research is to determine which consumer's personality traits and characteristics are positively or negatively related to the fear of food products made from genetically modified organisms.

To determine the characteristics that result in a negative consumer reaction to genetically modified foods products, the result from the partially mediated model is evaluated. The partially model is the only estimated model because statistical tests that compare the fit of the partially and fully mediated models indicate that the partially mediated model is a significantly better model than the fully mediated model (Mowen).

For the partially mediated model, seven of the fifteen variables in the model are significant. The significant variables are sports fan, present thinking, auto innovativeness interest, poetry, retirement, education less than a college degree, and physical/body needs. Based on the partially mediated model, fear of bioengineered food products is found to be positively related to:

1. present thinking;

2. sports fan;

3. auto innovativeness interest;

4. poetry; and

5. physical/body needs.

Fear of bioengineered products is found to be negatively related to:

1. retirement; and

2.education less than a college degree.

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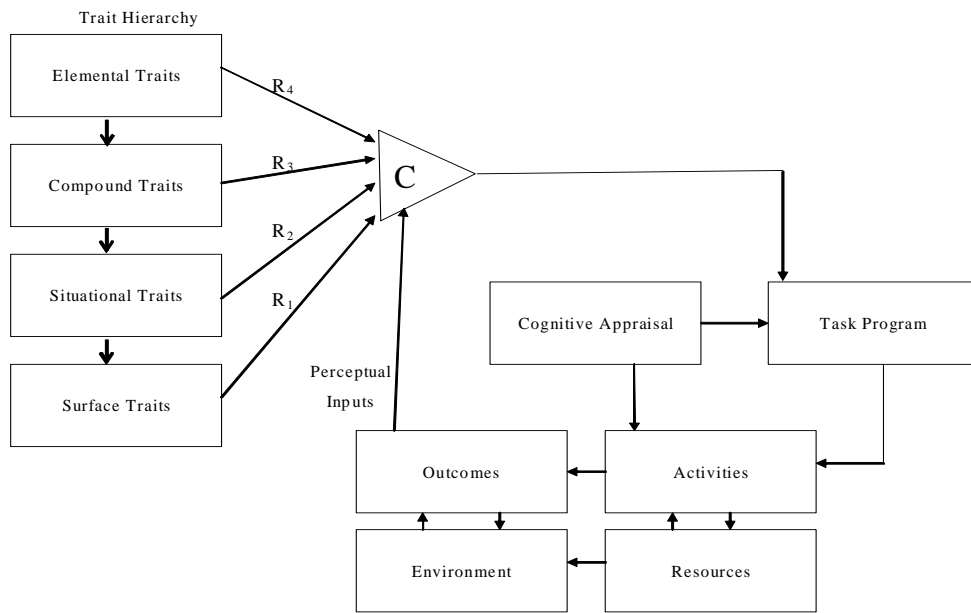
**Figure 1 The 3M Model of Motivation and Personality adapted from Mowen (2000, p. 33)**
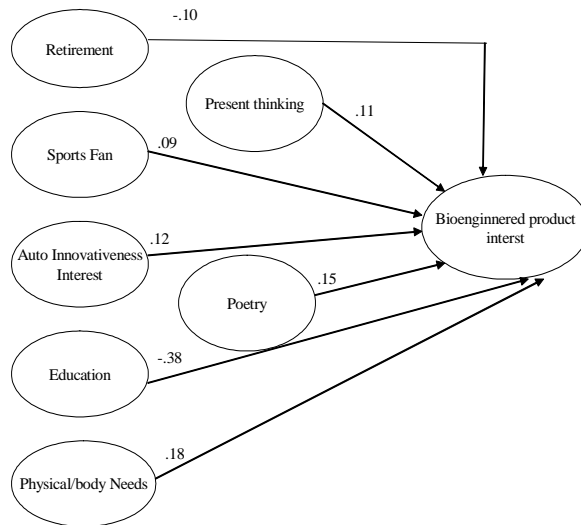


**Figure 2  Path diagram for partially mediated model**

**Table 1. Questions used to calculate the means, variances, and coefficient alpha for each trait.**

| Trait level | Trait | Questions | K | Mean | Variance | C Alpha |
|---|---|---|---|---|---|---|
| Elemental | | | | | | |
| | Introversion | Q1X1, Q1X2, Q1X3, Q1X4 | 4 | 3.893571 | 3.6625271 | 0.9132 |
| | Conscientiousness | Q1X5, Q1X6, Q1X7, Q1X8 | 4 | 6.562857 | 3.0203903 | 0.9229 |
| | Openness to Experience | Q1X9, Q1X10, Q1X11, Q1X12 | 4 | 5.423571 | 3.4362964 | 0.9394 |
| | Agreeability | Q1X13, Q1X14, Q1X15, Q1X16 | 4 | 7.069285 | 1.8456513 | 0.8723 |
| | Neuroticism | Q1X17, Q1X18, Q1X19, Q1X20 | 4 | 4.227857 | 3.6300599 | 0.9133 |
| | Material needs | Q1X21, Q1X22, Q1X23, Q1X24 | 4 | 4.064286 | 3.858678 | 0.8885 |
| | Need for arousal | Q1X25, Q1X26, Q1X27, Q1X28 | 5 | 3.433571 | 3.6135904 | 0.9152 |
| | Physical/body needs | Q1X29, Q1X30, Q1X31 Q1X32 | 5 | 4.937857 | 3.4167933 | 0.8883 |
| Compound | | | | | | |
| | Competitiveness | Q1X33, Q1X34, Q1X35, Q1X36 | 4 | 3.737857 | 4.2070514 | 0.9257 |
| | Altruism | Q1X37, Q1X38, Q1X39, Q1X40 | 4 | 6.114286 | 2.0352538 | 0.8325 |
| | Need for learning | Q1X41, Q1X42, Q1X43, Q1X44 | 4 | 6.055714 | 2.2723169 | 0.8568 |
| | Activity needs | Q1X45, Q1X46, Q1X47, Q1X48 | 4 | 6.287143 | 3.3732582 | 0.9102 |
| | Self-efficacy | Q1X49, Q1X50, Q1X51, Q1X52 | 4 | 6.182857 | 3.0155361 | 0.8988 |
| | Poetry | Q1X53, Q1X54, Q1X55, Q1X56 | 5 | 4.632143 | 3.4654753 | 0.8517 |
| | Voluntary | Q1X57, Q1X58, Q1X59, Q1X60 | 8 | 4.617143 | 3.6305793 | 0.9169 |
| | Present thinking | Q1X61, Q1X62, Q1X63, Q1X64 | 4 | 4.63 | 3.259914 | 0.8395 |
| Situational | | | | | | |
| | Seers/predictors | Q2X1, Q2X2, Q2X3 | 3 | 3.327619 | 2.5335554 | 0.9221 |
| | Sports interest | Q2X4, Q2X5, Q2X6 | 3 | 3.416191 | 3.7877664 | 0.9641 |
| | Astrology | Q2X7, Q2X8, Q2X9, Q2X10 | 6 | 2.705714 | 2.4425173 | 0.958 |
| | Gambling interest | Q2X11, Q2X12, Q2X13, Q2X14 | 7 | 2.013571 | 6.3216326 | 0.8904 |
| | Athleticism | Q2X15, Q2X16, Q2X17 | 6 | 2.514286 | 2.6491107 | 0.9209 |
| | Belief in science | Q2X18, Q2X19, Q2X20 | 3 | 4.428571 | 2.1150679 | 0.8458 |
| | Retirement | Q2X21, Q2X22, Q2X23, Q2X24 | 4 | 3.872857 | 3.127055 | 0.9417 |
| | Sports fan | Q2X25, Q2X26, Q2X27 | 5 | 3.701905 | 3.8023206 | 0.9253 |
| | Belief in superstition | Q2X28, Q2X29, Q2X30, Q2X31 | 4 | 1.692857 | 1.6127712 | 0.9572 |
| | Fashion interest | Q2X36, Q2X37, Q2X38, Q2X39 | 4 | 2.401429 | 1.8305138 | 0.9127 |
| | auto innovativeness interest | Q2X40, Q2X41, Q2X42, Q2X43 | 5 | 2.19 | 1.7951002 | 0.8375 |
| | travel innovativeness interest | Q2X44, Q2X45, Q2X46, Q2X47 | 5 | 3.670714 | 2.4129292 | 0.8188 |
| Surface | | | | | | |
| | Bioengineered product interest | Q2X32, Q2X33, Q2X34, Q2X35 | 4 | 3.942857 | 2.0683585 | 0.877 |

* If the coefficient alpha is greater than .70, the trait is adequately represented by the responses the questions.

Variances for the individual responses are shown in the Appendix.

C Alpha is coefficient alpha

**Table 2. Regression results for the surface trait based on a partially mediated model**

| Surface Trait | Independent Variables | Coefficient | Stnd error | P-value | F-value | $R^2$ |
|---|---|---|---|---|---|---|
| Bioengineered interest | Intercept | 2.82799 | 0.53087 | <.0001 | 4.77* | 0.1764 |
| | Seers | -0.03373 | 0.04918 | 0.4933 | | |
| | Gamble | -0.07745 | 0.06243 | 0.2156 | | |
| | Science | -0.05687 | 0.05198 | 0.2747 | | |
| | Retirement | -0.10401 | 0.04764 | 0.0297* | | |
| | Fan | 0.08969 | 0.0393 | 0.0231* | | |
| | Superstition | 0.06927 | 0.06058 | 0.2536 | | |
| | auto innovativeness interest | 0.11664 | 0.06285 | 0.0644* | | |
| | education | -0.38388 | 0.18478 | 0.0385* | | |
| | income | -0.01271 | 0.01339 | 0.3431 | | |
| | kids | 0.24756 | 0.15939 | 0.1213 | | |
| | Conscientiousness | -0.05274 | 0.04421 | 0.2337 | | |
| | Body | 0.17758 | 0.04217 | <.0001* | | |
| | Compete | -0.05953 | 0.03871 | 0.125 | | |
| | Poetry | 0.15205 | 0.04193 | 0.0003* | | |
| | Present | 0.10799 | 0.04343 | 0.0134* | | |
| Testing procedures | Normality | | | >0.150 | | |
| | Nonlinearity | | | 0.6894 | | |
| | Heteroskedasticity | | | 0.6562 | | |

* indicates a significance at .10

Stnd error is standard error