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Health Attitudes, Environmental Attitudes and Vegetable Consumption

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ABSTRACT

According to World Health Organization a diet high in vegetables may reduce the risk of coronary heart diseases, stroke, and certain types of cancer. In addition, vegetables have lower carbon footprints than most other foods. But what is the most important motivation to consume vegetables? Is it health or is it climate and the environment? The main objective in this paper is to find drivers behind vegetable consumption, with emphasis on health and environmental motivation. To analyze the connection between individual's attitudes towards the climate, environment and health and the frequency of vegetable consumption we used survey data from 2015. The individual attitudes are hidden but through questions regarding perceptions and behavior the attitudes may be retrieved. We constructed latent variables to represent measures of environment and health attitudes. These latent variables were included in an econometric model linking attitudes with frequency of vegetable consumption. We applied the model to test for differences in frequencies of vegetable consumption for individuals with little and high degree of environmental and health consciousness. The main results show that health is a stronger motivator for vegetable consumption than environmental consciousness.

Keywords: vegetables; drivers; beta regression; The graded response model

Introduction

The food and agriculture organization of the United Nations defines a sustainable diet as: “those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.” (FAO, 2016). The consumption of most vegetables is connected to low greenhouse gas emission and use of land (Mertens et al, 2019; Rose et al, 2019). It means that for a for a sustainable point of view it is recommended that a large part of a sustainable diet is vegetables. In addition, according to World Health Organization a diet high in vegetables may reduce the risk of coronary heart diseases, stroke, and certain types of cancer (WHO, 2019).

But what is the most important motivation to consume vegetables? Is it health or is it climate and the environment? The objective in this paper is to find drivers behind vegetable consumption, with emphasis on health and environmental motivation. Central questions are: In what way do attitudes toward environment and health translate into vegetable consumption? And what role do the socioeconomic factors play in vegetable consumption?

The individual attitudes are hidden but through questions regarding perceptions and behavior the attitudes may be retrieved. We used the graded response model (GRM) to construct latent variables to represent measures of environment and health attitudes. These latent variables are then included in models linking

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attitudes with frequency of vegetable consumption. To account for differences between individuals who consume vegetables with low, medium and high frequency we constructed a bounded beta regression model together with attitude variables and other predictors as age, gender, income, place of living, social status, and education. We applied the model to test for differences in frequencies of vegetable consumption for individuals with little and high degree of environmental consciousness. Tests were also performed for individuals with low and high health consciousness.

In the next section the data from the Norwegian Monitor database is presented. In the following section the methods are described. After that the estimation results are presented. Then statistical tests are performed and discussed, and finally the paper concludes.

Data

We analyzed the frequency of consumption of vegetables using the Norwegian Monitor (NM) survey. This survey is a nationally representative cross-sectional survey of adults that has been repeated every second year since 1985. In each survey, 3,000-4,000 respondents answer questions about food consumption, health, time use, and preferences. Our data is from 2015.

Our analysis focused on the answers to one question: (i) How often do you eat vegetables? The respondents checked one of the following responses: 4 times a day, 3 times a day, 2 times a day, 1 time per day, 5-6 times a week, 3-4 times a week, 1-2 times per week, 2-3 times per month, less than once a month or never. Table 1 shows the frequency and the relative frequency of vegetable eating in the NM database in 2015. Table 1 shows that 1930 individuals, or 50 % of the sample eat vegetables at least once a day. Less than 2 percent eat vegetables less than once a week.

Table 1. Frequencies and percentages of vegetable consumption

	4 day	3 day	2 day	1 day	5-6 week	3-4 week	1-2 week	2-3 month	1 month	Seldom/ never	N
#	49	119	496	1266	902	728	229	55	12	9	3865
%	1.3	3.1	12.8	32.8	23.3	18.8	5.9	1.4	0.3	0.2	

Table 2 shows percentages to responses to four questions about environmental attitudes. 58% of the respondents totally or somewhat agree to the question It matters to me what I can do to protect the environment and the natural resources. Just 35.8% responded totally or somewhat agree on the question that they support environmental organizations. 45.6% don't buy products from producers which pollute the environment and 68.5% totally or somewhat agree that the climate changes are man-made.

Table 2. Environmental attitudes

	Totally agree	Somewhat agree	Somewhat disagree	Totally disagree	N
It matters to me what I can do to protect the environment and the natural resources	19.6	39.1	37.0	4.3	3899
I support environmental organizations	12.4	23.4	41.4	22.8	3893
I don't buy products from producers that pollute the environment	15.7	29.9	41.9	12.5	3891
The climate changes are by and large man-made	32.0	36.5	25.8	5.7	3882

Table 3 is about environmental concern. The individuals checked one of the following responses: Very worried, somewhat worried, a little worried or not worried at all. More than 90% of the sample were a little worried or

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more about extinction of animal and plant species, global warming, environmental poison and air quality in cities and urban areas.

Table 3. Environmental concern: How worried are you about the following environmental problems?

	Very worried	Somewhat warried	A little worried	Not worried at all	N
Greenhouse effect and climate change	18.6	31.0	39.7	10.6	3900
Decomposition of the ozone layer	11.9	29.6	41.9	16.6	3894
Acid deposits	7.3	23.0	48.5	21.2	3879
Development of waterways and mountain regions	8.1	19.9	42.0	29.9	3884
Dismantling of farmland	26.4	30.6	31.2	11.8	3891
Clogging of cultivated landscape	23.1	31.6	31.4	13.8	3889
Extinction of animal and plant species	32.9	35.0	26.3	5.8	3889
Loss of cultural monuments	17.9	32.4	37.7	11.9	3887
Global warming	29.0	32.8	29.9	8.2	3885
Environmental poison in products that you use	26.1	36.9	30.7	6.3	3887
Air quality in cities and urban areas	22.9	39.4	32.0	5.6	3887

Table 4 shows responses for questions about environmental actions. The individuals check one of the following: often, now and then, seldom or never or not relevant. Most people (71.3%) often deliver special category waste or electronic waste to special waste storages. Just 22.8% often used public transportation instead of a car and just 21.6% purchased commodities labelled good for the environment.

Table 4. Environmental action. How often have you done the following because you wanted to take care of the environment?

	Often	Now and then	Seldom or never	Not relevant	N
Used public transportation even if you could have used car	22.8	32.5	31.6	13.0	3902
Deliver special category waste or electronic waste to specialty waste storage	71.3	21.4	6.2	1.1	3902
Reduced the consumption of electricity	35.1	45.5	16.7	2.7	3897
Purchased commodities labelled “Good for the environment”	21.6	51.9	23.7	2.8	3895
Used a bike or walked instead of using car	32.8	38.5	19.3	9.4	3899

Table 5 contains two questions about health and food and health. 87% of the sample answered that they partly or totally agree on the question that they are always concerned about living healthy and keep in good physical shape. 61.6% answered that they partly or totally agree that taste is more important than health.

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Table 5. Health concern. Do you agree or disagree on the following assertions:

	Totally disagree	Partly disagree	Partly agree	Totally agree	Impossible to answer	N
I am always concerned about living healthy and keeping in good physical shape	2.1	10.2	52.7	34.3	0.7	3915
I am more concerned about the taste of the food than how healthy it is	8.1	29.7	44.5	17.1	0.6	3936

Table 6 shows the socioeconomic predictor used to explain the consumption frequency for vegetables. The mean age in the data is 47.5 years old, the average household income is 497 000 NOK, 55% have a university degree, 55% is women, 62% are married or cohabit and 25% live in one of Norway's 4 biggest cities. Before being used in the estimation, the continuous variables age and income are standardized, i.e., the mean is withdrawn, and the new variable is divided by the standard deviation.

Table 6. The socioeconomic predictors used in the model

Predictor	Explication	Mean	sd
Age	Age of the individual, in years	47.47	18.93
Income	= household income in 2015 (in 1000 NOK)	497	268
University	=1 if 3 years or more of university education, 0 otherwise	0.55	0.50
Woman	= 1 if woman, 0 otherwise	0.55	0.50
Married	=1 if married or cohabit, 0 otherwise	0.62	0.49
wm	= 1 if woman and married (interaction term)	0.31	0.46
BCity	=1 if place of living is one of the 4 largest cities in Norway: Oslo, Bergen, Trondheim, Stavanger	0.25	0.43

The sample consists of individuals from 15-96 years of age. *n*=3981

The questions in table 2-5 are used to construct latent variables for environmental attitude, environmental worries, environmental action, and health attitudes. These variables are included in the bounded beta regression model together with the socioeconomic predictors in table 6. Then the bounded beta regression model is estimated.

Methods

To unpack the relation between individuals' attitudes toward the environment, environmental worries, environmental action, health attitudes and vegetable consumption we first make use of the Graded Response Model to estimate the latent variables. The four latent variables are then incorporated into a bounded beta regression model together with other predictors. Then the models are estimated with maximum likelihood to find associations between the environment, health and frequency of vegetable consumption.

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The Graded Response Model

The Graded Response Model was suggested by Samejima (1969). It is defined as:

$$P(y_i = k \mid \theta) = P(y_i \geq k \mid \theta) - P(y_i \geq k+1 \mid \theta) = \frac{\exp(\alpha_i(\theta - \beta_{ik})}{1+\exp(\alpha_i(\theta - \beta_{ik})} - \frac{\exp(\alpha_i(\theta - \beta_{i,k+1})}{1+\exp(\alpha_i(\theta - \beta_{i,k+1})}, \quad k = 1,2,..,K, \text{(1)}$$

which is the probability to choose the response *k* from *K* possible choices, where *K* = 4 when constructing variables for environmental attitude, environmental worries and health attitude (4 point Likert scale) and 3 in the case of environmental action (3 point Likert scale). Our aim is to find θ for each individual. θ is the latent variable that describes the position of the individual on the scale from the lowest to highest. These four environmental and health variables are then included in the bounded beta regression model. In addition to the latent variables, the predictors in Table 6 are included in the models.

The Bounded Beta Regression model

The beta distribution for a continuous variable *q* is a two- parameter distribution within the range of (0,1). We can think of this as a relative frequency of vegetable eating. Assuming that the frequency of vegetable consumption, *q*, is beta distributed, i.e.

$$f(q|a,b) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} q^{a-1}(1-q)^{b-1}, 0 < q < 1 \qquad (2)$$

where Γ( )is the gamma function, and a and b are parameters.

To be able to include covariates the beta distribution is reparametrized as in Ferrari and Cribari-Neto (2004). But we also have to include individuals who eat vegetables at the censoring point, i.e., the individuals bounded at q=1, which in our case means 4 times per day. This is done by including the probabilities of eating vegetables 4 times per day in the likelihood function. Assuming the same covariates in the three parts, the whole conditional distribution then becomes:

$$f(q|x) = \begin{cases} P_1(x) & if \quad q = 1 \\ f(x) & if \quad 0 < q < 1 \end{cases} \qquad (3)$$

Where *f*(*x*) in our case is the Beta distribution. The likelihood function will then be based on

$$(1 - P_1(q = 1|x))f(q|x) \qquad (4)$$

Estimation results

First, we used the GRM and the variables shown in tables 2-5 to estimate the latent variables for environmental attitudes, environmental worries, environmental action, and health attitudes. Grm is included in the ltm package (Rizopoulos, 2006) of the statistical software, R. Histograms for the latent variables are shown in figure 1. We can see that the 4 variables are very similar in shape with the midpoint at approximately 0 and with most of the probability mass between -2 and 2. These variables are included in the beta regression model together with the predictors in table 6 to estimate the frequency of vegetable consumption.

To construct the dependent variable, monthly frequency of vegetable consumption, we started out with the data shown in table 1. The alternative “4 times a day” was set to 120, “3 times a day” is set to the interval (75, 119.999), twice a day is set to the interval (45, 75), and so on. The variables below 4 times a day are set to the interval containing the midpoint between the variable above and the variable below. The variable

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seldom/never is set to (0.0001, 0.5). Then, within each interval and for each respondent, we drew the frequency from a uniform distribution with the limits of the intervals used as the limits of each distribution. Dividing all these frequencies by 120, we obtained the beta distribution, bounded in 1.

The model may then be estimated with the R package GAMLSS (Stasinopoulos et al, 2015), where the probabilities are included as odds ratios with log link functions to include covariates in the likelihood function (Stasinopoulos et al., 2017). We bootstrap the model to find the beta regression parameters, the standard deviations and to construct tests for the differences in vegetable eating between individuals with different degrees of health and environmental attitudes. The estimated parameters are shown in table 6.

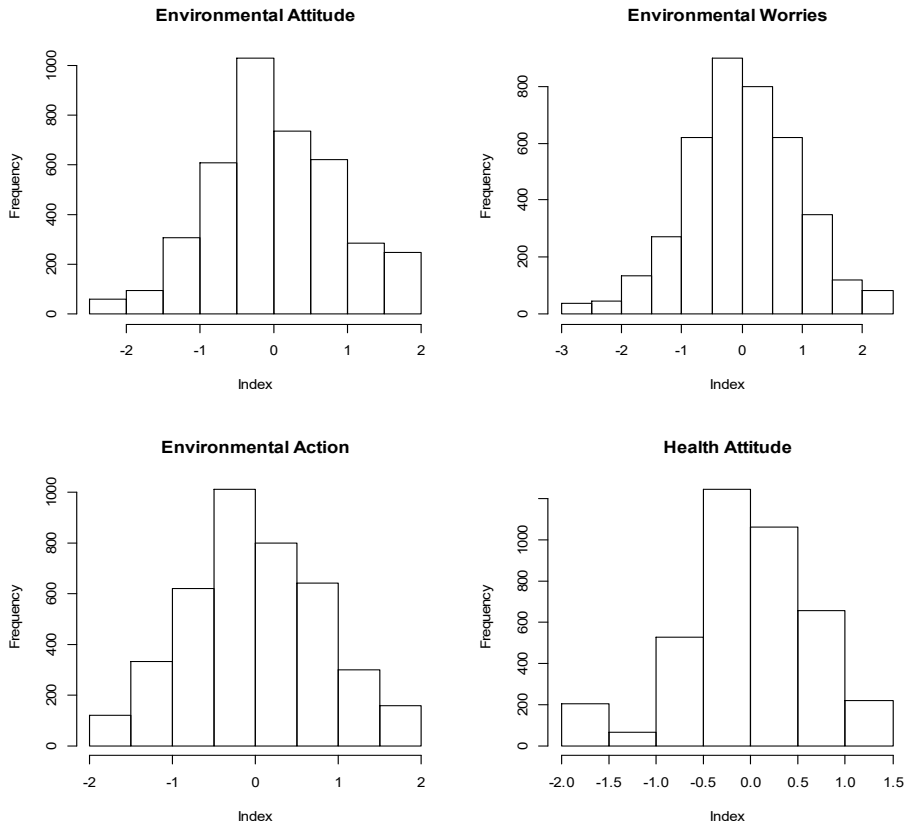

Figure 1: Histogram over latent environmental variables and health index

Table 6 shows the estimated parameters in the beta distribution part of the model, *BE*(0,1), and the part bounded in 1, O_1, (4 times a day). The bounded part is included as an odds ratio, the odds of eating vegetables 4 times a day. The environmental attitude index, the environmental action index, and the health attitude index are all significantly different than 0, and the health attitude parameter is about twice the size of environmental indexes. But the environmental index is not significantly different from 0. Further, older individuals eat less vegetables than younger individuals, higher income people eat more than lower income people, all other things equal, university educated individuals eat more than individuals without a university education, and women eat more vegetables than men, ceteris paribus. Finally, married people eat more vegetables than singles. For the odds ratio part of the model, just the intercept and the income variable are significantly different than 0. It means that there is a low probability that high income individuals eat vegetables 4 times a day.

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Table 6: Estimated parameters in the Beta regression models for vegetables

		BE(0,1)		O_1	
Explanation	Variable name	Coef	Sd	Coef	Sd
Intercept	Int	–0.22*	0.04	–4.84*	0.48
Environmental attitude	*Eatt*	0.07*	0.02	–0.26	0.23
Environmental worries	*Ewor*	0.01	0.02	0.21	0.22
Environmental action	*Eact*	0.10*	0.02	0.41	0.23
Health attitude	*Hatt*	0.18*	0.02	0.19	0.26
The age of the individual	*Age*	–0.05*	0.01	0.23	0.16
Household income per consumer unit	*Inc*	0.03*	0.01	–0.62*	0.26
University education	*Univ*	0.10*	0.03	0.41	0.36
Woman	*W*	0.19*	0.04	0.38	0.49
Married	*M*	0.13*	0.04	0.57	0.60
Woman and Married	*W·M*	-0.01	0.05	–0.21	0.71
Big City (Oslo, Bergen Trondheim, Stavanger)	*BCity*	0.03	0.03	–0.07	0.34

Note: Standard deviations in parentheses. The numbers marked with asterisk are significantly different from zero at 5% level.

What works best? Is it health attitude or environmental attitude?

To capture the quantitative connection between environmental attitude, environmental worries, environmental action, health attitudes and the frequency of vegetable eating we estimated the same model as in table 6 using nonparametric bootstrapping with 500 iterations. In each iteration we constructed the conditional expected frequency evaluated at the 90^{th} quantile and the conditional expected frequency evaluated at the 10^{th} quantile of each of the latent attitude variables. When constructing the frequencies all the other attitude variables and other predictors were fixed at their means. From the bootstrapped differences in frequencies, we constructed the average differences and their respective *t*-statistics. The *t*-statistics could then be used to test the following hypotheses:

H1: There is no difference in expected frequency of vegetable consumption between individuals high in environmental attitude and individuals low in environmental attitude.

H2: There is no difference in expected frequency of vegetable consumption between individuals high in environmental worries and individuals low in environmental worries.

H3: There is no difference in expected frequency of vegetable consumption between individuals high in environmental action and individuals low in environmental action.

H4: There is no difference in expected frequency of vegetable consumption between individuals high in health attitude and individuals low in health attitude.

The significant associations at the 5% level when $|t| > 1.96$ are marked with an asterisk. The results are shown in Table 7.

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Table 7: The difference in expected frequency of monthly vegetable consumption between individuals high (90 quantile) and low (10 quantile) in attitudes toward environment and health

	Vegetables		
	90 quantile	10 quantile	Difference
Environmental Attitude	35.19* (0.69)	31.62* (0.71)	3.56* (1.15)
Environmental Worries	33.79* (0.72)	32.87* (0.62)	0.92 (1.07)
Environmental Action	36.21* (0.71)	30.64* (0.58)	5.56* (1.01)
Health Attitude	37.41 (0.67)	29.58* (0.53)	7.83* (0.89)

[a] Standard deviation in parentheses. The numbers marked with asterisks are significantly different from zero at 5% level.

Table 7 shows the expected monthly frequencies of vegetable consumption evaluated at the 90 quantile and the 10 quantile of the attitudinal variables and their differences. All the frequencies are evaluated at the mean of all the other predictors. We see from table 7 that H1, H2, and H4 are rejected when t-tests are performed. Individuals high in environmental attitude have a higher frequency of vegetable consumption than individuals low in environmental attitude. Also, individuals high in environmental action have a higher frequency of vegetable consumption than individuals low in environmental action. Also, individuals high in health attitude have a higher vegetable consumption than individuals low in health attitude. Finally, there is no difference between individuals high in environmental worries and individuals low in environmental worries. Evidently, this indicates that health attitude is a larger motivator, or driver for vegetable consumption than environmental attitudes or behavior.

Discussion and Conclusion

A sustainable diet is a diet is said to be a diet which is good for health and does not harm the environment. A lot of research recommends a diet high in vegetables both for health reasons and for environmental reasons. It means that both environmental concerns and health concerns are potential drivers for vegetable consumption.

In this paper four different latent variables indicating environmental attitude, environmental worries, environmental action, and health attitudes are constructed and included in an econometric model for frequency of vegetable consumption. The model is estimated and tests statistics concerning association between environment and vegetable consumption, and health and vegetable consumption are compared.

The tests indicate that health attitude is a stronger motivator for vegetable consumption than environmental attitude, environmental worries and environmental action. What is the implication of these findings? One of the implications is that to increase the frequency of vegetable consumption it is more efficient to emphasize health than to emphasize environment. Another implication is that if environmental information is used to increase vegetable consumption, environmental worries should not be highlighted.

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