Consumer Demand and Willingness to Pay for Healthy Food Diversity in Germany

Dr. Larissa Drescher
Department of Rural Economy
University of Alberta

Making Choices: Consumer and Their Impact on Canada's Agriculture and Food

November, 5th, 2007

Outline

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

1. The impact of food diversity

2. Measuring healthy food diversity
   - Traditional diversity measures
   - Healthy Food Diversity-Index (HFD-Index)

3. Theory
   - Demand for healthy eating
   - Consumer Goods Characteristics Model (CGCM)

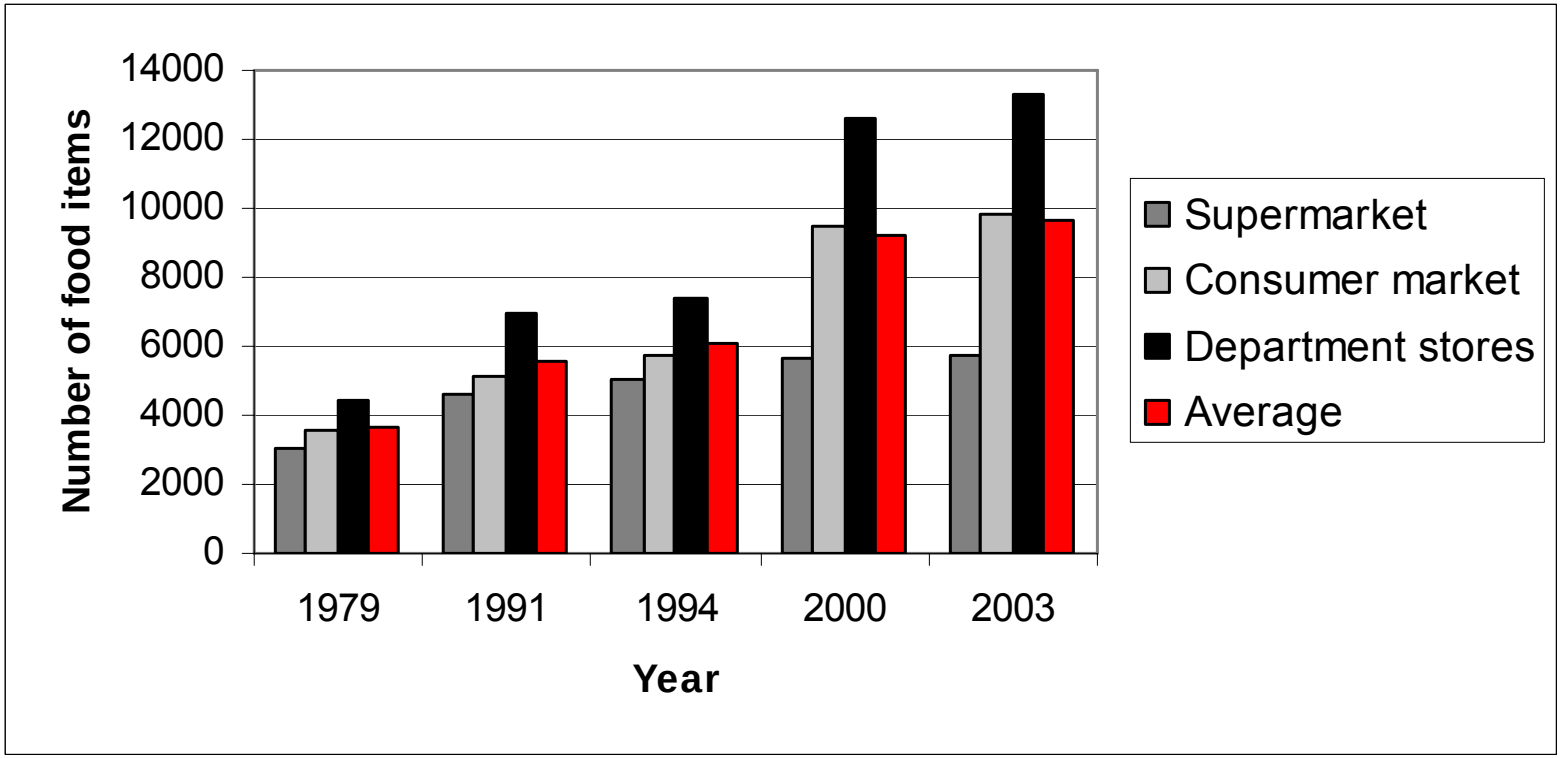
4. Data & estimation

5. Selected results
   - Demand analysis
   - Willingness to pay (WTP)

6. Conclusions & Implications

1. The impact of food diversity

Food supply in the German retailer over time



Eurohandelsinstitut, several years

1. The impact of food diversity

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

Positive health aspects of food diversity

- Assures supply with as many of **40 nutrients** that are necessary for survival (Royo-Bordonada et al., 2003)
- Increases **dietary quality** (Hatloy et al., 1998)
- Reduces probability of **excessive contaminant intake** from high amounts of any single food (Krebs-Smith et al., 1987)
- Reduces **morbidity**: variety in vegetables decreases cancer risk about 36% (Jansen et al., 2004)
- Decreases **mortality** risks: higher variety lowers mortality risk for all-sites cancer about 30% in women (Michels & Wolk, 2002)

→ High diversity of plant foods: healthy food diversity

1. The impact of food diversity

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

Food guidelines

- Advise food choices that promote health and decrease risk of chronic diseases of all healthy people
- Some differ across countries due to differences in food availablity, environment and eating patterns
- But: diversity guideline almost always the first one

Variety message in USDA‘s guidelines over time

Edition Year	Wording
1980-1999	Eat a variety of foods.
2000	Let the pyramid guide your food choice. Choose a variety of grains daily, especially whole grains. Choose a variety of fruits and vegetables daily.
2005	Consume a variety of nutrient-dense foods and beverages within and among the basic food groups while choosing foods that limit the intake of saturated and trans fats, cholesterol, added sugars, salt, and alcohol.

1. The impact of food diversity

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

- **1st of 10 guidelines of the German Nutrition Society (2005):** “Enjoy the great variety of foods. Selection from among a great many different foods, appropriate combination and adequate quantities of high-nutrient and low-energy food are characteristics of a well-balanced diet“

- **Eating well with Canada‘s Food Guide (2007):** „Enjoy a variety of foods from the four food groups.“

2. Measuring healthy food diversity

Traditional diversity measures

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

Count Measures

- Most frequently used
- Number of foods or food groups
- Disadvantages:
  - Equal weight for chocolate and apple
  - Distribution of foods not considered

Count measure = 2

Distribution measures

- Berry-Index $BI = 1 - \sum_{i=1}^{n} s_i^2$
- Number and distribution of foods
- Disadvantages:
  - Equal weight for chocolate and apple
  - Diversity higher, the more foods are eaten in equal amounts

50% 99%

Berry – Index = 0,5099

2. Measuring healthy food diversity

Healthy Food Diversity (HFD) - Index

$$= \left(1 - \sum_{i=1}^{n} s_i^2\right) * \left(\sum_{i=1}^{n} hf_i * s_i\right)$$

s_i = quantity share

hf_i = health factor

Berry-Index = diversity

x

health value (of the food basket)

health factors = hf_i

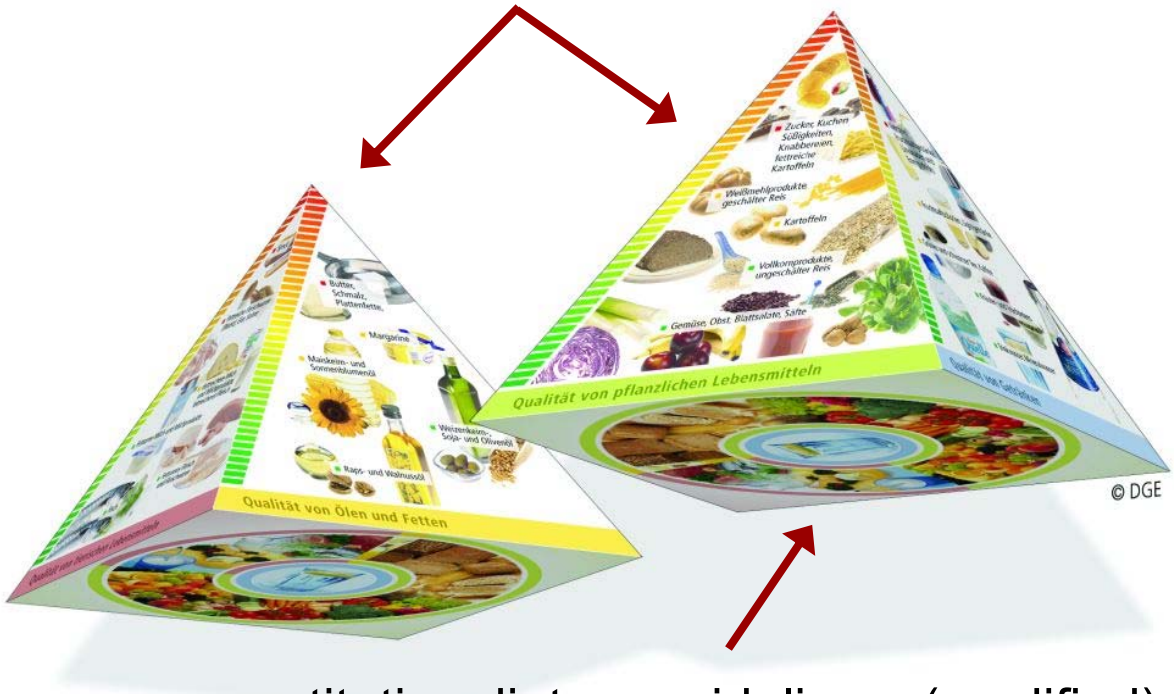
= describes the „value“ of single foods

→ derived from the German food pyramide (German Nutrition Society)

2. Measuring healthy food diversity

Healthy Food Diversity – Index

qualitative dietary guidelines: pyramide sides



quantitative dietary guidelines: (modified) nutrition circle

→ **15 health factors**

2. Measuring healthy food diversity

Share of food group (quantitative dietary guideline)	Share of food sub group (qualitative guideline → quantified)	Health factor
Plant foods **73%**		0.73 *
	Vegetables/fruits/leaf salads/juices **36%**	0.36 = 0.26
	Wholemeal products/paddy **28%**	0.28 = 0.20
	Potatoes **20%**	0.20 = 0.15
	White meal products/peeled rice **12%**	0.12 = 0.09
	Snacks and sweets **4%**	0.04 = 0.03
Animal foods **25%**		0.25 *
	Fish/low-fat meat/low-fat meat products **36%**	0.36 = 0.09
	Low-fat milk, low-fat dairy products **28%**	0.28 = 0.07
	Milk, dairy products **20%**	0.20 = 0.05
	…	
Fats & Oils **2&**	…	…

Health value = ∑health factor of food *i* * quantitative share of food *i*

2. Measuring healthy food diversity

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

- HFD-Index = Berry-Index **x** health value

- Properties of HFD
  - Within health factor groups (eggs and meat)
    - increases with increasing number of foods eaten
    - Increases the more equally distributed the foods are
  - If the distribution between health factor groups (meat and apple) changes in favour of healthy (unhealthy) food groups:
    - HFD increases (decreases)

- HFD-Index better reflects a healthy diet than traditional diversity measures (Drescher, Thiele, Mensink, 2007; Journal of Nutrition)

3. Theory

DEPARTMENT OF RURAL ECONOMY UNIVERSITY OF ALBERTA

Demand for healthy eating

Demand for	Selected studies	Demand theory	Criticism
Nutrients	Abdulai and Aubert (2004)	Lancaster‘s characteristics approach	Consumer don‘t demand nutrients; confounder problem
Foods	Brown and Schrader (1990)	Traditional demand theory	Incomplele picture of the diet; confounder problem
Dietary quality (nutrients)	Thiele et al. (2004)	No reference	Consumer don‘t demand nutrients; confounder problem
Dietary quality (Healthy Eating-Index)	Variyam et al. (1998)	Lancaster‘s characteristics approach	Consumer don‘t demand nutrients; confounder problem

→ Complete picture of the diet: utilization of the HFD-Index within Lancaster‘s characteristics approach

3. Theory

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

- **Lancaster's characteristics approach** (1966; 1971):
  - Not goods but rather characteristics provide utility
  - Linear production technology = amount of characteristics from the consumption of all products
- **Consumer Goods Characteristics Model** (CGCM)

  → extension of Lancaster's model by Ladd and Suvannunt (1976)
- **Assumption of the CGCM**

  A1) negative marginal utility of one or more characteristics provided that the sum of the marginal utility remains positive

  A2) common, not necessarily linear consumption technology

  A3) utility independent of the distribution of characteristics within the good
- CGCM version suggested by Eastwood et al. (1986)

Consumer Goods Characteristcs Approach

- "Health" is a utility providing good; produced by foods with the following characteristics:
  - Healthy food diversity (*HFD*)
  - Other nutritional characteristics, e.g. Vitamin C (C_j)

- Production functions
  - **Healthy food diversity (*HFD*) (non-linear)**
    - Influenced by human capital (**K**) (Chern, 2003)
    - Common:

$$HFD = g(q_1, ..., q_n, \mathbf{K})$$

q_i = quantity

  - **Other nutritional characteristics (C_j) (linear)**
    - Education is a proxy variable of nutritional knowledge (Variyam et al., 1998)
    - Common:

$$C_j = f(q_1, ..., q_n, \mathbf{K})$$

q_i = quantity

DEPARTMENT OF RURAL ECONOMY UNIVERSITY OF ALBERTA

Consumer Goods Characteristcs Approach

- Representative utility function

$$U = U\left(C_1(q_1,...,q_n,\mathbf{K}),...,C_m(q_1,...,q_n,\mathbf{K}),HFD(q_{1,...,}q_n,\mathbf{K})\right)$$

- Budget restriction (1st constraint)

$$\sum_{i=1}^{n} p_i q_i \leq Y$$

Y= income
p_i = price of good i
q_i = quantitiy of good i

- Quantity restriction (2nd constraint)

$$Q = \sum_{i=1}^{n} q_i$$

Q = total quantity (food basket)

Consumer Goods Characteristcs Approach

- Solving maximization problem with Lagrange

$$L = U\left(C_1(q_1,...,q_n,\mathbf{K}),...,C_m(q_1,...q_n,\mathbf{K}),HFD(q_1,...,q_n,\mathbf{K})\right)$$
$$+\lambda_1\left(\sum_{i=1}^{n} q_i - Q\right) + \lambda_2\left(Y - \sum_{i=1}^{n} p_i q_i\right)$$

- First order condition (FOC)

$$\frac{\partial L}{\partial q_i} = \sum_{j=1}^{m} \frac{\partial U}{\partial C_j} * \frac{\partial C_j}{\partial q_i} + \frac{\partial U}{\partial HFD} * \frac{\partial HFD}{\partial q_i} + \lambda_1 - \lambda_2 p_i = 0$$

- 2 ways of solving FOC:
  - Derivation of the demand function for characteristics

$$HFD = d_{HFD}(\mathbf{p}, Y, \mathbf{K})$$

  - Solving FOC for prices (p_i) → implicit prices for the characteristics → willingness to pay (WTP)

$$\sum_{i=1}^{n} p_i q_i = \sum_{j=1}^{m} \beta_j C_j + \beta_{HFD}\left(\sum_{i=1}^{n} \frac{\partial HFD}{\partial q_i} * q_i\right) + \beta_0 Q$$

4. Data & estimation

- German Nutrition Survey (1998): 4030 participants
  - Representative for Germany
  - 133 different foods
- External price data: MADAKOM and ZMP
- Demand analysis: multiple regression
  - Dependent variable: HFD-Index (logit transformation)
  - Independent variables: socioeconomic, attitude and knowledge variables
  - Endogeneity problem: two-stage least squares estimation
- Willingness to pay: multiple regression
  - Dependent variable: expenditure per unit (Box-Cox transformed)
  - Independent variables:
    - (Instrumented) characteristics of the food basket (HFD, Vitamin C, Calcium, quantity approximated by calories)
    - Socioeconomic variables (Nerlove, 1995)

5. Selected results

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

Demand analysis

Independent variables:	HFD-Index (transformed)	
	Parameter	t-value
Constant	0.0320	0.13
Household income in DM/1000	0.010*	1.83
Age (logarithm)	0.380***	3.79
Low education level	-0.112**	-2.74
High education level	0.059**	2.46
Supplement taker	0.064**	3.12
Vegetarian	0.290***	6.57
Sportive activity	0.100***	4.48
Smoker	-0.129***	-5.07
R^2	0.175	

***,**,* significance level 1%, 5%, 10%

DEPARTMENT OF RURAL ECONOMY UNIVERSITY OF ALBERTA

Willingness to pay (WTP)

Dependent variable: food expenditure per unit

	Parameter	Chi²-value
HFD'	164.638***	1016.25
Caloric density	19.442***	921.51
Vitamin C- density	37.043***	136.11
Calcium – density	-10.729***	200.56
Net equivalence income (DM/1000)	-0.162***	24.24
Age	-0.205***	163.80
Age^2	0.002***	131.96
Low education	0.218*	2.91
High education	-0.839***	85.55
Supplement taker	-0.226**	10.87
Smoker	1.080***	168.78
Vegetarian	-2.488***	263.58

***, **, * significance level 1%, 5%, 10%

5. Selected results

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

Willingness to pay

Variable	Implicit prices	Elasticities
HFD’	0.066 DM/HFD	1.721
Caloric density	0.008 DM/kcal	2.397
Vitamin C-density	0.015 DM/mg	0.298
Calcium-density	-0.004 DM/mg	-0.466

6. Conclusions & Implications

DEPARTMENT OF RURAL ECONOMY
UNIVERSITY OF ALBERTA

Linking the results:

- Higher income:
  - Demand for HFD ↑, food expenditures per unit ↓
  - No significant interaction effect between HFD and income on food expenditure per unit

  → High-income consumers are more efficient in selecting a good quality with less costly foods

- Higher education
  - Demand for HFD ↑, food expenditures per unit ↓
  - If low-educated consumers demand HFD of higher quality: food expenditures per unit would be higher

  → Low-educated consumers are less efficient in food demand

- Positive attitudes towards health
  – Vegetarians, supplement takers and nonsmokers have a higher demand for HFD but lower food expenditure per unit

  → A positive attitude towards health enables to obtain HFD with less costly foods

6. Conclusions & Implications

Implications for German nutrition and health policy

- Dietary information actions geared at consumers
  - With lowest education level
  - Who already reveal undesired health behavior (e.g. smoking)
  - Younger consumers

- Public health strategies
  - To increase awareness of HFD and to establish incentives that sustain consumer's self responsibility for health
  - To support changes in dietary behavior in favor of more nutrient- but less energy-dense diets

- Communicate how to obtain healthier diets with less costly food items

THANK YOU FOR YOUR ATTENTION!

Consumer Goods Characteristcs Approach

- **Derivation of demand functions**
  - Solving for optimal quantities of the characteristics by using the implicit function theorem
  - Demand function for Healthy Food Diversity:

$$HFD = d_{HFD}(\mathbf{p}, Y, \mathbf{K})$$

  - Demand function for other nutritional characteristics

$$C_j = d_j(\mathbf{p}, Y, \mathbf{K})$$

- **Derivation of implicit prices**

$$p_i = \frac{1}{\lambda_2}\left(\sum_{j=1}^{m} \frac{\partial U}{\partial C_j} * \frac{\partial C_j}{\partial q_i} + \frac{\partial U}{\partial HFD} * \frac{\partial HFD}{\partial q_i} + \lambda_1\right)$$

Consumer Goods Characteristcs Approach

Derivation of implicit prices

- Assumptions:
  - λ_1= marginal utility of the total quantity of foods consumed (assumed to be constant)
  - λ_2= marginal utility of income (Ladd and Suvannunt, 1976; Eastwood et al., 1986)
- With respect to the budget constraint, *Y* is replaced by expenditure (*E*)
- Hedonic price equation

$$p_i = \sum_{j=1}^{m} \frac{\partial C_j}{\partial q_i}\frac{\partial E}{\partial C_j} + \frac{\partial HFD}{\partial q_i}\frac{\partial E}{\partial HFD} + \frac{\partial E}{\partial Q}$$

Marginal rate of substitution of consumer's expenditure for quality of the implicit price for characteristic *j* → marginal implicit price for an additional unit of characteristic *j*

Consumer Goods Characteristcs Approach

- Empirically estimable hedonic price equation

$$p_i = \sum_{j=1}^{m} \beta_j c_{ji} + \beta_{HFD} \frac{\partial HFD}{\partial q_i} + \beta_0$$

- Prices of homogenous food products are similar among consumers and do not vary substantially → multiplication by q_i

$$\sum_{i=1}^{n} p_i q_i = \sum_{j=1}^{m} \beta_j C_j + \beta_{HFD} \left(\sum_{i=1}^{n} \frac{\partial HFD}{\partial q_i} * q_i \right) + \beta_0 Q$$

- Assumption of constant implicit prices not consistent for a unique maximum (Morse and Eastwood, 1989) → variable implicit prices: **Box-Cox transformation**

6. Summary & Conclusions

- Demand for HFD positively influenced by
  - Income
  - Education
  - Positive attitudes towards health

- WTP for healthy food diversity
  - Highly significant WTP for HFD (0.66DM/HFD)
  - WTP for caloric density is higher than for HFD
  - Participants with
    - high income
    - high education
    - positive health attitudes

    → have lower food expenditures per unit compared to their counterparts