Willingness to pay (WTP) for food produced with recirculated nutrients

Sinne Smed, University of Copenhagen (ss@ifro.ku.dk) , EAAE Congress Sep. 2023

Background

Nitrogen and phosphorous are essential for food production, but phosphorous reserves are declining and nitrogen production has huge environmental consequences. Re-cycling of nutrients from gasified biological household waste (HHwaste), gasified biological waste from the food industry (FIwaste) and sewage bio-solids (Biosolids) could solve some of these problems. However, there is limited knowledge about the consumers' acceptance of food grown with recirculated nutrients. Consumers are found to have low knowledge about current fertilizer practices in agriculture, but to have strong opinions on the matter. Consumer acceptance/rejection of food grown with recirculated fertilizers is therefore not necessarily based on objective risks and benefits associated with the use of these. Knowledge about consumers attitudes towards re-circulation of nutrients is important

Aim of study

1) What is consumers' WTP for foods grown with recirculated nutrients as fertilizers?
2) How does attitudes, as e.g. perceived risks and benefits ofrecirculation affect this WTP

Design choice experiment (CE) and survey

Sent to a Danish panel of food consumers n=1324 in 2022. Two types of products; Carrots (eaten raw, grown in the soil) and bread (processed and grown above the soil).

Table 1: Attributes and levels of CE

Production:	Organic, Conventional
Fertilizer:	Manure (status quo), Biosolids, Gasified biological waste from food industry , Gasified biological waste from households.
Origin fertilizer:	Organic, Mixed organic and conventional
Price:	10 levels, within the span of real price variation

Example of Choice card

	Type 1	Type 2	Type 3
Production form	Organic	Organic	Conventional
Fertilizer type	Manure	Biosolids	Biosolids
Fertilizer origin	Mixed	Organic	Mixed
Price	8 DKK/kg	10 DKK/kg	6 DKK/kg
Which do you prefer	☐	☐	☐

The dimensions of the survey is based on focus groups, the literature on acceptance of new foods and the elements of the Theory of Planned Behaviour (TPB)

Table 2: Dimensions of survey

Question battery	
1	Warm up questions
Information to respondents concerning attributes and levels and the choice situation	
Choice Experiments (16 choices, 8 with carrots and 8 with bread)	
2	Validation questions in relation to Choice Experiments
3	19 questions: Attitudes concerning health risks and disgust of the use of, as well as adverse residuals in the specific fertilizer types that are applied in this project
5	16 questions: Attitude concerning what is associated with organic
6	16 questions: Attitude concerning what is associated with sustainable food production
7	16 questions: Attitude concerning what is associated with recirculation
8	The 10 item Food Disgust Scale (Hartmann and Siegrist, 2018)
9	The 15 item New Ecological Paradigm scale (Dunlap et al., 2000)
10	8 questions: Trust in authorities and the food industry to take care of food safety and trust in the information from these bodies.
11	10 questions: Social acceptance of recirculating and the importance of others peoples view of own behaviour

Results and discussion

1) WTP

There is a positive WTP for bread produced with household (HH) waste for bread, and negative WTP for food industry (FI) waste and bio-solids for both carrots and bread. The share of positive WTP for bread (carrots) is: 61(54) %, 44(43)% and 36(32)% for HH waste, FI waste and bio-solids respectively. Comparing the distribution of WTP with the average price paid for bread and carrots imply that 20% should be paid to eat food produced with biosolids, (6 – 10% for HH and FI waste.)

2) Effect of attitudes

Attitudes have limited effects on WTP. An anthropogenic attitude leads to positive WTP for food produced with bio-solids. To associate sustainability with organic production leads to positive WTP for food produced with HH waste. The largest positive effect is if important others will eat food produced with a specific fertilizer (subjective norms). The importance of if others view respondent as caring for sustainability leads to a negative WTP for FI waste and bio-solids. Perceive Behavioural control, specific risks leads to negative WTP while general risk and benefits of recirculation have limited effects. Food disgust lead to negative WTP as well.

Conclusion

The perceived risk of using a fertilizer and if important others are willing to eat food produced with this specific fertilizer are the most important elements for consumer acceptance. This is important knowledge if the consumer should accept of using recirculated nutrients for food production.

Estimation of WTP's

The model is estimated as a RPL (Random Parameter Logit) with correlation. Subsequently the conditionals are retrieved and these are used in a post estimation on the effect of attitudes (Hess & Train, 2017, Train &Weeks, 2005)

Table 4: Share pos. WTP, share WTP > aver. price

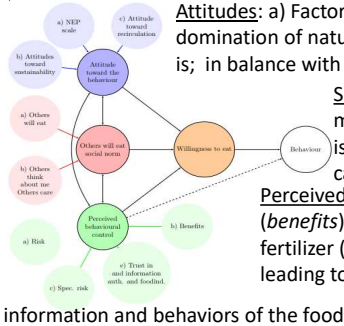
	Bread		Carrot	
	WTP		WTP	
	> 0	> -14	> 0	> -8
HHwaste	0.61	0.94	0.54	0.90
Flwaste	0.43	0.94	0.44	0.88
Wwaste	0.36	0.80	0.32	0.78

Table 3: Estimated parameters

	Bread						Carrots					
	RPL			RPL w. corr.		Cond.	RPL			RPL w. corr.		Cond
	Parm		Rob.s.e.	Parm	Rob.s.e.	Parm.	Parm		Rob.s.e.	Parm	Rob.s.e.	Parm
ASC	-0.25		0.23	-0.44 *	0.25		0.32		0.25	-0.54 ***	0.23	
β_org	2.68	***	0.38	2.89 ***	0.52	2.87	3.5	***	0.41	4.13 ***	0.51	4.2
std._org	12.11	***	0.55	0.44	1.25		12.19	***	0.52	7.76 ***	2.38	
$\beta\_hhwaste$	3.18	***	0.48	4.17 ***	0.52	4.16	0.68	**	0.32	0.3	0.3	0.23
std._hhwaste	10.88	***	0.68	8.66 ***	1.57		6.65	***	0.3	0.94	1.81	
$\beta\_invaste$	-1.46	***	0.31	-0.91 **	0.43	-0.82	-0.86	***	0.32	-1.9 ***	0.31	-1.94
std._iwaste	8	***	0.4	0.09	10.1		6.17	***	0.47	1.52	1.82	
β_wwaste	-4.07	***	0.45	-3.49 ***	0.43	-3.33	-3.11	***	0.36	-3.41 ***	0.35	-3.53
std._wwaste	11.69	***	0.6	3.42 ***	1.25		6.46	***	0.36	2.28	2.85	
β_fert_org	1.22	***	0.24	0.13	0.27	0.11	1.75	***	0.21	0.74 **	0.35	0.72
std._fert_org	5.9	***	0.37	5.81 ***	0.36		3.35	***	0.31	2.73 ***	0.44	
Log-Lik			-8644		-8216				-8440		-8064	
Rho sqr.			0.2572		0.2940				0.2746		0.3069	
Adj.Rho.sqr.			0.2562		0.2921				0.2736		0.3050	
AIC			17311		16475				16906		16173	
BIC			17398		16635				16992		16334	

*Notes: (Adj.) Rho sqr. – (Adj.) Rho-squared vs equal shares, Cond.– Conditionals averaged over all respondents, Org. – Organic production, Fert. Org. Fertilizer of organic origin, HHwaste – Household waste, Iwaste – waste from food-industry, Wwaste – biosolids from wastewater plants, risk – perceived risk involved with recirculation, bene – perceived benefits involved with recirculation. *** significant at 1% level, ** significant at 5% level, * significant at 10% level*

Post-estimation using conditionals (based on TPB)



Attitudes: a) Factor analyses (EFA) on the New Ecological Paradigm (NEP) questions gives 3 value orientations; limits to growth (*limit*), human domination of nature (*antro*), balance of nature (*nature*), b) EFA on sustainability questions gives 3 factors, sustainability means food production is; in balance with nature (*balance*), organic (*organic*), fairness (*not used*), c) Sustainability means recycling, question is used directly (*recycle*)

Subjective norms: a) People that are important to me don't mind eating foods fertilized with this fertilizer (*soc_oth*), b) It is important to me that others consider me as someone who care a lot about sustainability (*soc_sus*),

Perceived behavioral control (PBC): General a) risk (*risk*) and b) benefits (*benefits*) with recirculation, c) specific health risks applying this specific fertilizer (*spec_risk*). We also use disgust as a measure of health risks leading to the same results d) Food disgust scale (*FD*) and e) trust in information and behaviors of the food industry and the authorities (*trust_aut, trust foodind, info_aut, info_foodind)*. Eq.(1) is estimated individually for each fertilizer type.

Table 5: Estimation results with conditionals

	Bread						Carrots					
	HHwaste		Flwaste		Biosolids		HHwaste		Flwaste		Biosolids	
	Parm	SE	Parm	SE	Parm	SE	Parm	SE	Parm	SE	Parm	SE
Limit	-0.58 *	0.34	-0.20	0.26	-0.14	0.36	-0.19	0.21	-0.14	0.19	0.11	0.19
Antro	0.21	0.34	0.41	0.26	0.75 **	0.36	-0.57 ***	0.22	-0.16	0.19	0.45 **	0.19
Nature	-0.19	0.30	-0.29	0.23	-0.37	0.32	0.28	0.19	0.06	0.16	-0.13	0.17
Recycle	-0.22	0.37	-0.69 **	0.28	-0.66 *	0.39	-0.09	0.23	0.05	0.20	-0.28	0.20
Organic	0.72 **	0.35	0.13	0.26	-0.23	0.37	1.16 ***	0.22	0.35 *	0.19	-0.43 **	0.19
Recycle	-0.76	0.63	-0.71	0.47	-0.49	0.66	-0.48	0.39	-0.58 *	0.34	-0.29	0.35
Soc_oth	1.32 ***	0.39	1.75 ***	0.29	2.28 ***	0.39	0.82 ***	0.25	1.19 ***	0.21	0.96 ***	0.20
Soc_sust	-0.22	0.34	0.60 **	0.25	0.85 **	0.35	0.45 **	0.21	0.35 *	0.18	0.91 ***	0.18
FD	-0.05	0.04	-0.09 ***	0.03	-0.10 **	0.04	0.05 *	0.02	0.06 ***	0.02	0.07 ***	0.02
Benefit	-0.03	0.27	0.15	0.20	0.11	0.28	0.02	0.17	-0.01	0.15	0.11	0.15
Risk	-0.85 *	0.45	-0.14	0.34	-0.80 *	0.47	0.06	0.28	-0.13	0.25	0.04	0.25
Spec_risk	-0.89 ***	0.33	-1.19 ***	0.26	-1.64 ***	0.34	-0.20	0.21	-0.62 ***	0.19	-1.13 ***	0.18
Trust_aut	0.12	0.49	-0.12	0.37	-0.31	0.52	-0.21	0.31	0.20	0.27	-0.27	0.27
Info_aut	0.33	0.49	-0.24	0.37	0.04	0.51	0.45	0.31	0.01	0.27	0.08	0.27
Trust_foodind	0.06	0.54	0.09	0.41	0.34	0.57	-0.42	0.34	-0.40	0.30	-0.09	0.30
Info_foodind	-0.80	0.55	-0.06	0.41	-0.58	0.58	-0.10	0.35	0.02	0.30	-0.10	0.30
Const.	5.58	4.41	-5.24	3.46	-4.51	4.80	0.30	2.77	0.19	2.53	1.43	2.52
R-squared	0.06		0.13		0.16		0.11		0.09		0.18	
Controls	yes		yes		yes		yes		yes		yes	

*Notes: SE is robust standard errors. *** significant at 1% level, ** significant at 5% level, * significant at 10% level*

Equation 1:

$$WTP_{ij} = limit_i + antro_i + nature_i + organic_i + balance_i + recycle_i + soc\_oth_{ij} + soc\_sus_i + FD_i + benefit_i + risk_i + spec\_risk_{ij} + trust\_aut_i + info\_aut_i + trust\_foodind_i + info\_foodind_i + Income_i + Female_i + Age_i + Age^2{}_i + Capital_i + Urban_i + Voc\_edu_i + Short\_edu_i + Medium\_edu_i + Long\_edu_i + u_{ij}$$

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