Is Embedding Entailed in Consumer Valuation of Food Safety Characteristics?

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Abstract. *Consumers' preferences for food safety characteristics are investigated with particular focus on existence of an embedding effect. Embedding exists if consumer valuation of food safety is insensitive to scope. Two choice experiments have been conducted valuing food safety in respectively minced pork and chicken breasts, exemplified by avoiding human risks of Salmonella infections and strengthening the restrictions of using antibiotics in the pork production and in terms of avoiding human risks of Salmonella and Campylobacter infections respectively. The results showed no indications of an embedding effect between the food safety characteristics, in neither of the cases.*

Keywords: Valuation, Choice Experiment, Market Goods, Food Safety, Embedding.

1. Introduction

Modern agriculture produces a great variety of animal food products today which provides us with clear evidence of a consumer demand for specific product features. Besides quality attributes, animal products are associated with a wide variety of food safety characteristics such as for instance zoonotic bacteria, pesticide residues, whether Genetically Modified Organisms (GMO) or hormones are used in production, medicine residues, etc. Food safety characteristics are typically not directly visible. The lack of visibility is a problem as it makes it difficult for consumers to identify and accordingly incorporate safety characteristics of the product in their purchase decisions. In addition, as food products are associated with an increasing number of quality/safety characteristics, the relationship between the value of a single characteristic and the overall value of a given food product becomes more and more complex. Although, labelling of the end product can be used as a remedy to make the food safety characteristics more readily visible to consumers, this is not done consistently in practice.

Due to these difficulties, the market prices for products containing non-visible characteristics (as food safety) do not necessarily reflect the values that consumers place on them. In such situations, stated preference methods offer a way to elicit consumer preferences for specific characteristics and accordingly estimate the value of these characteristics.

To our knowledge, most of the existing literature on stated preference valuation of food safety has incorporated food safety by only including one food safety characteristic in the valuation tasks[1,26,30]. Two exceptions were found in respectively Goldberg & Roosen[13] and Hayes *et al.*[18], where the risks of several different pathogens are included. Potential embedding problems will not be detected when only one food safety characteristic is included in stated preference tasks, as it will not be possible to identify whether the stated Willingness-To-Pay (WTP) associated with this single characteristic reflects the consumer value of the specific attribute, or food safety *per se*. If consumers allocate a certain fixed amount of their disposable household income to food safety in general, and they perceive a single food safety attribute as an indicator of the general food safety of a product, they might allocate the entire amount to that attribute. Thus, the valuation of one food safety characteristic may lead to an overestimation of the given characteristics since respondents might embed other food safety characteristics in the one characteristic being evaluated.

In this paper we investigate whether embedding is a prevalent feature of consumer preferences for food safety characteristics. In particular, we perform two different Choice Experiment (CE) surveys to assess whether consumer preferences for a single food safety characteristic is affected by the introduction of an additional food safety characteristic. Our hypothesis is that there is an embedding effect present in consumer valuation of food safety characteristics. In particular, we suspect that the introduction of an additional food safety attribute will significantly reduce the estimated value of any initially present food safety attribute. However, both our case studies fail to support this hypothesis. The first case study focuses on food safety in minced pork. Our results show that the value of a "Salmonella-free" label is not significantly affected by introducing "reduced use of antibiotics". It could be argued that these two attributes present quite different aspects of food safety in general, and, hence, they might not be considered close substitutes. As such, it may not be surprising that we find no evidence of embedding. However, we find similar results in our second case study which concerns food safety in chicken breast fillets. In this study, we focus on two much more closely related food safety attributes that much more likely could be perceived by consumers as almost perfect substitutes, namely "Salmonella-free" labelling and "Campylobacter-free" labelling. Thus, the preconditions for identifying embedding should be more than satisfied. Nevertheless, our findings again reject the presence of embedding.

The article is organized as follows. First, we present the embedding issue with focus on the various approaches and definitions of the term in the existing literature. Section 3 briefly describes the theory behind the choice experiment method used in the survey. In section 4 the survey is described, followed by presentation of the results in section 5. Finally we discuss and conclude in section 6.

2. Embedding

In economic theory, consumers are often assumed to conform to rational and utility-maximizing behaviour. The basic axioms of such utility maximizing behaviour include completeness, transitivity, continuity and non-satiation[14]. Hypothetical experiments such as CEs are often used to elicit quantified estimates of consumer preferences in terms of willingness to pay (WTP) estimates when market data are not available. Ideally WTP estimates should reflect the underlying preferences of the individual, but sometimes empirical studies find that consumers' behaviour is inconsistent with economic theory. In particular, a number of studies have shown that consumer preferences are insensitive to scope in that they place the same value on a small amount of a good as on large amounts[6,10,36]. This behaviour is called an *embedding effect* by Kahneman & Knetsch[22] and is also referred to as *nesting* or *part-whole bias*[5,12]. The existence of embedding threatens the validity of WTP estimates as insensitivity to scope seems to contradict one of the basic axioms of economic theory: the assumption of non-satiation. Embedding can be seen as an extreme type of diminishing marginal utility of a good or characteristic where the marginal utility abruptly drops to zero.

Horowitz[21] distinguished between embedding that occurs *within* as opposed to *between* characteristics. The most well-known type of embedding effect is found within a given characteristic, and this is related to the definition that a respondent places the same value on a small amount of a good as on a large amount of the good[22]. In relation to the present paper, embedding within food safety characteristics would occur if a respondent places the same value on a small as on a large risk reduction for a given food safety characteristic.

A pioneering example of embedding between characteristics is presented by Horowitz[21]. He found that respondents stated roughly the same WTP for 'clean beaches in New Jersey' as for 'clean beaches in New Jersey and clear views in Grand Canyon'. Hence, embedding between characteristics can be interpreted as a situation where the consumer has preferences for a compound good (such as a clean environment in general) which might consist of any combination of clear views and clean beaches (were the individual environmental attributes might be considered as substitutes). In the case of food safety, embedding between characteristics will be present if the value of including an additional food safety attribute does not change the overall value of food safety, i.e. it reduces the value of already present food safety characteristics.

There are several explanations of why an embedding effect might occur. The three most important are moral satisfaction, limited cognitive ability, and mental accounting. They will be described in turn below.

Kahneman & Knetsch[22], Horowitz[21], and Loomis *et al*.[27] suggest that embedding effects can be explained by moral satisfaction, where moral satisfaction is triggered through signalling a concern or an interest. Since focus is on demonstrating a WTP for the compound good, little attention is given to the actual magnitude of impact of a given intervention. This explanation is consistent with embedding being a reflection of consumers not acting according to the non-satiation axiom. Kahneman & Knetsch[22] suggest that moral satisfaction as an explanation of embedding is more applicable when valuing non-marketed public goods, such as the environment or animal welfare where emotions and perceptions are expected to be more prominent than in the valuation of private goods.

Another explanation of the occurrence of embedding concerns limitations in the respondents' cognitive ability to understand and remember the scenario description when answering the valuation questions. Olsen *et al*.[32] observe that respondents in some cases may, in an attempt to simplify the valuation task, value the attribute *per se* regardless of how much of the attribute that is offered. Limited cognitive ability in relation to food safety would result in respondents valuing risk reduction *per se* rather than the actual size of risk reduction or the number of individual food safety characteristics. The underlying behavioural explanation is that because they do not understand what the risk reduction actually means, they invoke some simplifying heuristic decision rule. When caused by limited cognitive ability, embedding is clearly a methodological challenge when using stated preference methods. However, Brookshire *et al*.[7] suggest that in cases where private purchase is conceivable, it is not so likely that embedding occurs due to the use of simplifying heuristics because the respondents have experience in determining their WTP through their daily shopping.

Thaler[38] presents his theory of mental accounting as another explanation of the embedding effect which also rests on consumers resorting to some simplifying decision making processes. Thaler[38] argues that consumers divide their income into sub-budgets for groups of goods. This division is not based on optimal trade-offs between sub-groups but obtained using heuristics. Within these sub-budgets, consumers optimize the mix of goods. Hence, trade-offs are possible within but not between these sub-budgets[1]. This implies that when the budget constraint in one of the sub-budgets is binding, marginal utility of income will be infinite and consequently, marginal WTP for any additional goods bought within the sub-budget will equal zero. Such a preference structure will clearly result in a violation of the non-satiation axiom.

Embedding effects have mainly been studied and identified in surveys valuing non-market goods related to environmental issues[6,10,36]. There are relatively few studies of the existence of embedding in the context of market goods. These are mentioned below.

Hayes *et al*.[18] examined consumers' WTP for five different pathogens through an experimental auction setting. Besides estimating WTP for the five different pathogens separately they tested for what they call "surrogate" bidding. This is the case where the value elicited for a combination of pathogens would not be significant different from the values elicited for each individual pathogen – hence similar to what we define as an embedding effect. The results showed no differences between WTP estimates for the single pathogens and the WTP derived for the combination of pathogens. This implies that the values derived from the survey could be indicators of general food safety preferences, and, hence, pointing towards the presence of an embedding effect.

Another study on consumers' WTP for reduction of pathogens in food was carried out by Goldberg & Roosen[13]. This study included both a contingent valuation study (CV) as well as a CE. The particular aim was to measure consumers' WTP to reduce the risk of Salmonella- and Campylobacter-infection acquired from consumption of chicken breast. In the CV an average WTP for a reduction in the risk of Salmonella and Campylobacter was found to be in the range of €1.48-2.92. The WTP in the CE was in the range €-0.16-6.68. A chi-test of the parameters for the different risk reduction levels was conducted to

[1] This is very similar to the nested structure of utility functions often assumed in econometric studies of consumer behaviour, such as studies involving computable general equilibrium models.

test for embedding. In the CV, an embedding effect was observed when the two diseases were valued jointly. In the CE survey, the test showed that the WTP was not proportional in health risk reductions for small changes in risk. This suggests the presence of an embedding effect, both when valued individually as well as jointly. Hence, an embedding effect is detected both within the characteristics and between the characteristics. Goldberg & Roosen[13] suggest that the differences in their results obtained using CV and CE indicate that presentation format and the response mode influence the choices consumers make.

According to Carlsson *et al*.[8] and Ryan & Wordsworth[35], CE reduces the problem of embedding when valuing attributes rather than goods, because the valuation tasks in CE and the relations between different attributes are more transparent than in traditional CV experiments. This is further supported by Fischhoff *et al*.[11], who found a reduced embedding effect when using paired comparison CV instead of open ended CV.

Overall the literature points towards embedding being most likely in the preferences for public goods that are not marketed – and when using CV rather than CE. Food safety has private as well as public good characteristics, and as safety characteristics are typically not visible (or made visible through labelling) they might be considered not being marketed. However, consumers might value such characteristics differently depending on the weight they place on the place on the public or private good characteristics. Goldberg & Roosen[13] define the two food risks, Salmonella and Campylobacter, as having private good characteristics (private health benefits/costs). Hamilton *et al*.[16] investigate the issue of a good having both public and private good characteristic, in the case of banning the use of pesticides. According to Hamilton *et al*.[16], use of pesticides has not only the private good characteristic of personal health, but also the public good characteristic of environmental concern. They found that some individuals were not willing to pay a premium for pesticide-free food, but nonetheless support a ban on the use of pesticides. They explain this result by the fact that food quality regulation jointly produces both private and public goods – individuals with preferences for environmental quality but with little concern for personal health, may well favour regulation of pesticides residues. As opposed to Goldberg & Roosen[13], in the present paper, we focus on food safety characteristics that show both private and public good characteristics as stated below in section 4.

3. Method

The values of food safety in minced pork and chicken breast fillets are estimated using the stated preference method CE. This method is very suitable in the present context as we are interested in preferences for specific characteristics.

The underlying theory of CE is based on Lancaster's Consumer Theory (LCT)[25] and Random Utility Theory (RUT) [29,31].

In the present CEs respondents were presented with choice sets consisting of their current choice (status quo) of minced pork and chicken breasts fillets, respectively, as well as two experimentally designed alternatives. Analyses of the datasets confirmed that the Independence of Irrelevant Alternatives (IIA)[2] criterion was violated in both data sets. Consequently, the models used in this paper are the less restrictive mixed logit model specifications which allow for correlation in the unobserved part of the utility – captured in the random term. The model is also referred to as an *error component model*[19,39]. Allowing U_{tij} to represent the utility function, describing the utility from alternative j in choice situation t by person i, the utility of the error component model with panel structure is specified as:

$$U_{tij} = \beta' S_{tij} + \varepsilon_{tij} + \mu_i' \zeta_{tij} \quad (1)$$

[2] IIA: A standard logit model requires independence between the ratios of probabilities of choosing any two alternatives of the availability of other alternatives. This is also formulated as the model exhibiting independence from irrelevant alternatives (IIA)[20]. The restrictive nature of the IIA assumption is often illustrated by the red-bus/ blue-bus problem[4]. The IIA was tested using a Hausman test[17].

where S_{tij} is a vector of observed variables related to alternative j, β is a vector of fixed coefficients and the ζ_{tij} are normally distributed random effects of alternatives $j=1,2,3$ with zero mean. The term $\mu_i'\zeta_{tij}$ are error components that along with ε_{tij} define the unobserved part of the utility, but where the coefficients μ_i only vary over individuals but not over time (choice sets).

The error component model accounts for correlation across alternatives by introducing error components which are either shared between alternatives that are closer substitutes for each other or unique for the different alternatives. The error components are normally distributed random variables with zero mean and a standard deviation of $\sigma_{\mu i}$ and the estimated standard deviation is related either to the correlation between the alternatives or as the covariance of the different alternatives. If alternatives one and two each contain a common subset of the error component, a nested system for the three alternatives is specified[15], and the estimated coefficient of the error component captures the correlation across the alternatives. In the present CEs we *ex ante* assume that the two experimentally designed alternatives will represent closer substitutes than the current choice due to some degree of inertia. Therefore, a nested structure of the error components is appropriate.

4. The survey approach

The two CE surveys were conducted using an internet panel. The samples were obtained from Nielsen's online database. In Denmark, there are approximately 2.4 million private households, of whom 87% are online. The panel members are all aged 15 years or above, and they all reside in a household with internet access.

Prior to the design of the CEs, three focus group interviews were performed[3]. In the focus groups the following attributes were identified as being important in relation to choice of minced pork: Type of production, country of origin and fat content. With respect to chicken breast fillets the following important attributes were identified: Type of production, country of origin and, to some extent, food safety (mainly Salmonella). Food safety did not appear to be of great concern within the two products, but since the purpose of the present study was to elicit the relative weighting of food safety, we included two food safety attributes connected to each of the pork products and chicken products, respectively: "Salmonella-free" and "reduced use of antibiotics" for the pork product, and "Salmonella-free" and "Campylobacter-free" for the chicken product. Inclusion of two food safety attributes for each product allows us to test for embedding. The two specific food safety attributes for the two products were chosen because of their relevance to each of the products and also because they were judged as representing an increasingly important issue from a scientific as well as a political perspective. Moreover we chose to conduct two surveys testing for an embedding effect. Firstly, the minced pork survey where the two food safety characteristics do not appear to be very obvious substitutes in a narrow sense. Hence, we might expect that an embedding effect is less likely between the two food safety attributes. Secondly, the chicken breast fillet survey where Salmonella and Campylobacter are more likely to be perceived as substitutes for each other. Thus we would expect an embedding effect to be more likely than in the first survey.

The characteristics and the associated levels are presented in tables 1 and 2, and the description of the two food safety characteristics are presented in appendix 1, tables A1 and A2.

The two food safety attributes, Salmonella-free and reduced use of antibiotics in the pork survey, are different in nature. Reduced Salmonella content is largely a private good since it is associated with decreases in own risk of ill health. Also the benefits are most commonly experienced around the time of purchase. In contrast, reduced use of antibiotics is more of a public good since reduced use of antibiotics is associated with a reduction in the prevalence of resistant bacteria which is to the benefit of society as a whole. Also the benefits are experienced in the future, and not at the point of consumption. Because of these differences in characteristics, our *a priori* expectation of the value associated with tightening the rules on the use of antibiotics is that respondents will not value it as highly as the Salmonella-free

[3] The focus groups were headed by the sociologist Korzen, S., Department of Human Nutrition, University of Copenhagen, who works with qualitative studies on food perceptions.

characteristic. The two food safety attributes in the chicken survey, Salmonella-free and Campylobacter-free are more alike. They both exhibit private good characteristic to a large extent, and both give rise to more or less the same picture of illness. Though, the risk of getting infected by Campylobacter is much higher than the risk of a Salmonella infection. Consequently, our *a priori* expectation of the value of a Salmonella-free chicken is that respondents will not value it as highly as the Campylobacter-free characteristic.

Table 1. The characteristics and their levels in the Choice Experiment for the minced pork survey (samples A and B)

Characteristics	Levels
Type of production	Conventional (indoor), Alternative (outdoor)
Country of origin	Denmark, Foreign
Fat content	3-6%, 7-10%, 11-13%, above 13%
Salmonella-free [a]	Not labelled Salmonella-free, Salmonella-free
Reduced use of antibiotics (sample B only) [a]	Existing rules, Tightened rules
Price (DKK)	20, 26, 38, 51, 65, 80

Note: DKK 10 ~ EUR 1.34.
[a] see also table A1 in appendix 1 for further explanation.

Table 2. The characteristics and their levels in the Choice Experiment for the chicken breast fillet survey (samples C and D)

Characteristics	Levels
Type of production	Conventional (indoor), organic (outdoor)
Country of origin	Denmark, Foreign
Campylobacter-free [a]	Not labelled Campylobacter-free, Campylobacter-free
Salmonella-free (sample D only) [a]	Not labelled Salmonella-free, Salmonella-free
Price (DKK)	25, 28, 33, 40, 50, 65, 85, 115

Note: DKK 10 ~ EUR 1.34.
[a] see also table A2 in appendix 1 for further explanation.

Each respondent in the pork product survey received 6 choice sets whereas respondents in the chicken product survey received 8 choice sets. In each choice set, the respondents were faced with two alternative minced pork or chicken breasts fillet products, respectively, plus a third status quo alternative (all packages of 500 g). The latter characterised the respondents' usual purchase, which was identified earlier in the questionnaire. This approach, using the respondents "own" status quo values, has been recommended and used in other studies to mimic the actual purchasing situation as close as possible[23,34].

A D-optimal fractional factorial design was used in the survey[9]. The pork product survey consisted of 12 choice sets (2 blocks of 6 choice sets each), and the chicken product survey consisted of 8 choice sets.

The embedding effect was tested using a split-sample design. Respondents in the pork product survey were randomly assigned to choice sets which besides the "Salmonella-free" attribute were constructed either without the "reduced use of antibiotics" attribute (sample A), or with the "reduced use of antibiotics" attribute included (sample B). In the chicken survey the experimental setup was similar: Sample C is presented with only one food safety attribute, namely the "Campylobacter-free" attribute, whereas Sample D is presented with the same plus the additional "Salmonella-free" attribute.

5. Results

The socio-demographic distributions of the two samples in both surveys (A and B, C and D) of Danish consumers are shown in appendix 2, tables A3 and A4, with respect to gender, age, number of children, and household income. Samples sizes for samples A and B were 1278 and 1322, respectively, resulting in an overall sample of 2600 respondents in the pork survey. In the chicken survey, samples C and D consisted of 381 and 372 respondents, respectively. In tables A3 and A4, the demographic distributions in

these samples are compared with each other and with the Danish population in 2007, as this was considered the relevant target population. The results show that there is an overrepresentation of individuals who are middle aged, have a high income, or have children in samples A and B and women, individuals above 50 age old, or have a high income in sample C and D. However, when samples A and B are compared (chi-square test p-values presented in the outer right column, A/B), the results suggest that they are very similar in their socio-demographic distributions. The only examined characteristic which differs between the two samples is the number of children present in the household, but further analyses indicated no correlation between this variable and WTP. This also holds for sample C and D – the only socio-demographic characteristic which differs across samples is income, but when analysing the data further we find that income does not affect choice in either sample C or D.

Table 3. The models of samples A and B for the minced pork survey and of samples C and D for the chicken breast survey estimated with an Error Component Model

Parameter	Sample A Estimate (Robust Std. Err.)	Sample B Estimate (Robust Std. Err.)	Sample C Estimate (Robust Std. Err.)	Sample D Estimate (Robust Std. Err.)
Alt. Production	0.3580 (0.0432)	0.3992 (0.0446)	0.3796 (0.0833)	0.4747 (0.0790)
Denmark	1.5530 (0.0675)	1.1034 (0.0526)	1.4353 (0.0847)	1.2229 (0.0822)
Campylobacter-free label	- -	- -	0.8821 (0.0720)	0.8565 (0.0644)
Salmonella-free label	0.9820 (0.0575)	0.9017 (0.0555)	- -	0.4950 (0.0725)
Fat 3-6%	1.4614 (0.0746)	1.2219 (0.0824)	- -	- -
Fat 7-10%	1.3914 (0.0794)	1.1417 (0.0766)	- -	- -
Fat 11-13%	0.9094 (0.0717)	0.6750 (0.0703)	- -	- -
Use of antibiotics	- -	0.3287 (0.0475)	- -	- -
Price	-0.0502 (0.0020)	-0.0461 (0.0019)	-0.0404 (0.0024)	-0.0338 (0.0024)
ASC	0.7522 (0.0770)	0.9465 (0.0779)	0.0704 (0.1058)	0.4857 (0.1035)
$\sigma_{\mu 1\_2}$	1.9356 (0.0785)	1.9504 (0.0708)	1.7168 (0.1165)	1.6997 (0.1138)
Log L	-5504	-5784	-2327	-2362
Adj. LRI	0.3466	0.3362	0.3034	0.2754
N	7668	7932	3048	2976

Note: ASC is an alternative specific constant for the status quo alternative. LRI refers to the Likelihood Ratio Index presented by Louviere *et al*. [28]. Because the discrete variables are effect coded, these coefficients have been multiplied with two, to account for the fact that the reference level is assigned a value of -1 instead of 0.

For analysis of the CE data, we apply a mixed logit error component model with 300 halton draws in the simulation process. The results of the four main effect models of sample A and B, and C and D respectively are presented below in table 3. All the discrete variables were effect coded[3] whereas the price is coded as a continuous variable.

All the main effects of the models from sample A and B presented in table 3 show statistically significant effects on the choice of the minced pork product at the 0.1% significance level. All the signs of the coefficients are as expected with positive coefficients for all "quality" attributes, and a negative coefficient associated with the price. As expected, the coefficients of the variables for the fat content decreases as the fat content increases. The coefficients capture the marginal increase in the probability of

choosing a minced pork product when the given characteristic is present as compared to a base level (indoor, produced outside Denmark, no Salmonella label, fat more than 13%, existing rules for using antibiotics).

Both models for sample A and B indicate that fat content and whether or not the minced pork is produced in Denmark are the most important characteristics, followed by the product being Salmonella-free. The alternative specific constant (ASC) shows that respondents associate positive utility with the status quo scenario *per se*, which suggests some reluctance to switching product. Furthermore, the log-likelihood ratio index (LRI) indicates that the two models provide a good fit to the data with values at 0.35 and 0.34, respectively.

The main effect models for the chicken product are also presented in table 3. All the estimates but the ASC are statistically significant at the 0.1% significance level. Furthermore the signs are as expected relative to the base levels (indoor, produced outside Denmark, no Salmonella label, no Campylobacter label).

Also in the case of the chicken product, the models indicate that whether or not the product is produced in Denmark is the most important characteristic, but now followed by the product being Campylobacter-free. Furthermore, the LRI indicates that the two models provide a good fit to the data with values at 0.30 and 0.28, respectively.

All models show that the correlation coefficients between alternative one and two ($\sigma_{\mu 1\_2}$) are different from zero, suggesting a more flexible substitution pattern than the one assumed in a standard multinomial logit model.

In order to set up an explicit test of our main hypothesis of embedding being present, we compare preferences at the attribute level across the two splits. Direct comparison of utility parameter estimates across splits is not appropriate as the utility parameter estimates confound the unobserved scale factors which may differ across the splits. The workaround it to compare WTP estimates instead. The scale factor cancels out when calculating the ratio of two coefficients, and this is exactly how the WTP is calculated. Hence, when comparing WTP estimates across different splits, the scaling issue is of no concern[39].

Table 4. Comparison of WTP estimates for sample A and B, and C and D.

	Sample A	**Sample B**	**H_0: WTP_A=WTP_B**		**Sample C**	**Sample D**	**H_0: WTP_C=WTP_D**	
Parameter	**WTP (Std. Dev.)**	**WTP (Std. Dev.)**	**T-value**	**P-value CC test**	**WTP (Std. Dev.)**	**WTP (Std. Dev.)**	**T-value**	**P-value CC test**
Alt. Production	7.13 (0.944)	8.66 (1.185)	-1.007	0.854	9.40 (2.14)	14.06 (3.11)	1.255	0.102
Denmark	30.94 (0.786)	23.93 (1.060)	5.307	0.000	35.54 (2.48)	36.21 (2.89)	0.168	0.433
Campylobacter					**21.84 (1.86)**	**25.36 (2.04)**	**1.338**	**0.088**
Salmonella label	**19.56 (0.961)**	**19.56 (1.067)**	**0.004**	**0.507**		14.66 (1.83)		
fat 3-6%	29.11 (1.314)	26.50 (1.560)	1.280	0.091				
fat 7-10%	27.72 (1.436)	24.77 (1.501)	1.423	0.074				
fat 11-13%	18.12 (1.692)	14.64 (1.431)	1.568	0.058				
Use of antibiotics		7.13 (1.030)						

Note: The WTP estimates are presented in DKK.

The WTP estimates presented in table 4 are calculated as the marginal rate of substitution between a given attribute and the price attribute. The standard errors of the WTP estimates are obtained using the Krinsky-Robb method[24] with 1000 replications. We test whether or not the relative importance, as measured by the WTP, of consuming "Salmonella-free" minced pork or "Campylobacter-free" chicken breast fillet changes when the "reduced use of antibiotics" attribute or the "Salmonella-free" attribute is

added to the attribute mix, respectively. If the WTP estimates remain unaffected (null hypothesis) we conclude that an embedding effect is not present and that consumer's preferences for one food safety characteristic is independent of the introduction of another food safety characteristic. To compare the different WTP estimates across the two splits, we have applied both a t-test and the Complete Combinatorial test (CC test) suggested by Poe *et al*.[33]. The combinatorial test is a non-parametric test, which involves comparing differences in WTP estimates for all possible combinations of the estimates obtained by the Krinsky-Robb method. We have generated 1000 WTP estimates for each sample, which implies 1,000,000 differences. The main reason for also applying the CC test is that we by doing so, does not assume that WTP is symmetrically distributed, as is the case for the t-test.

The results from the t-tests and CC tests are shown in table 4. The mean WTP estimates for the "Salmonella-free" attribute are DKK 19.56 for both samples A and B in the pork survey. Using the usual 5% cut-off level for statistical significance, WTP does not differ significantly across the samples for 5 out of the 6 attributes (including the attribute Salmonella-free), as indicated by both the low t-values and p-values from the CC test[4]. Hence, the null hypothesis cannot be rejected which suggests that embedding between the food safety characteristics is not present in this study. Moreover, the result shows that the introduction of the "reduced use of antibiotics" characteristic causes a statistically significant increase in the consumers' WTP for food safety as a whole by on average DKK 7.13 for the pork product.

In the chicken product survey the results are more or less the same. The mean WTP estimates for the "Campylobacter-free" attribute is DKK 21.84 and 25.36 for the sample C and D, respectively, which is shown both by the t-test and by the CC test not to be significantly different from each other. Finally, the model for sample D shows that the respondents express a positive WTP for the "Salmonella-free" attribute in a chicken product at DKK 14.66. As this does not significantly affect the WTP for the chicken breast fillet being "Campylobacter-free", it constitutes a significant increase in the consumers' WTP for food safety in general.

In summary, both surveys show that the introduction of an additional food safety attribute does not reduce the value of the initially present food safety attribute, and, hence, we find no evidence of embedding.

6. Discussion and conclusion

The present article seeks to improve our understanding of consumers' WTP for food safety. This is done by performing a choice experiment that focuses on testing the presence of embedding between two food safety characteristics for two different products. The results indicate that consumers are willing to spend an extra amount of money on food safety when they are introduced to products with additional food safety characteristics. More specifically, we found that the willingness to pay for avoiding Salmonella in pork and for avoiding Campylobacter in chicken was not affected by the introduction of a second food safety attribute (reduced use of antibiotics and Salmonella-free, respectively). Hence, we did not find evidence of an embedding effect between the food safety attributes in question. Going back to the underlying potential reasons for embedding, this suggest that adding additional food safety attributes was in none of the present choice experiments associated with an excessive cognitive burden leading to the application of heuristics. Furthermore, we can conclude that if the underlying preference structure is steered by mental accounting, the budget related to the compound good food safety was not exhausted by our two food safety attributes.

It should be noted that had results shown that the WTP for "Salmonella-free" in the pork product survey or "Campylobacter-free" in the chicken product survey declined due to the introduction of either the "reduced use of antibiotics" characteristic or the "Salmonella-free" characteristics, it would not

[4] The only effect the introduction of the characteristic "reduced use of antibiotics" has on consumer preferences is that WTP for domestic originated meat decreases. The explanation of this decrease may be found in the respondents' attitude towards domestic produce. A reason could be that the respondents associate reduced use of antibiotics with domestic produce. However, only 7 percent of the respondents state that they believe domestic meat are produced with reduced use of antibiotics, so given this answer, the explanation has to be found elsewhere.

necessarily have been possible to conclude that an embedding effect was present. If the decrease in WTP for either a Salmonella-free pork product or a Campylobacter-free chicken product had been less than the WTP associated with stricter rules in relation to antibiotics or Salmonella respectively, this could in principle be a reflection of decreasing marginal utility of the compound good food safety.

As mentioned, Carlsson *et al*.[8], Fischhoff *et al*.[11], and Ryan & Wordsworth[35] found that CE reduces the problem of embedding when valuing attributes instead of goods. Hence, our results may also be linked to the elicitation method used. Another explanation, which partly is connected to the elicitation method, might be found in what Ariely *et al*.[2] define as "coherent arbitrariness". They find that valuations of goods and experiences have a large arbitrary component, but after one valuation has been made, people provide subsequent valuations that are coherent in the sense that consumers remember earlier choices, which in the sense of a CE reflect some kind of anchoring effect to the first choice set. Ariely *et al*.[2] show that consumers' absolute valuation of goods is surprisingly arbitrary, but that consumers' relative valuations of the different amounts of the good appeared orderly. In the present analysis, it is interpreted as an indicator of no embedding that consumers' relative valuation of the different characteristics does not change when a new food safety characteristic is introduced. However, Ariely *et al*.[2] add an interesting twist to our discussion as our result might also (or instead) be due to the presence of coherent arbitrariness and further analyses are required to distinguish between these explanations.

Finally respondents might consider the two food safety characteristics in the two surveys to be very different food safety characteristics and hence do not relate them to an overall food safety characteristic. The review of existing literature revealed two studies on embedding effect between food safety characteristics[13,18]. These authors focus on reduced Salmonella and Campylobacter bacteria and three other pathogens respectively, and find evidence of an embedding effect across these attributes. This result is most likely due to the very similar nature of the food safety characteristics, which with regards to consequences and illnesses are very similar. In the present paper, this is taken into consideration by examining food safety characteristics which are very similar with respect to consequences and illnesses (the chicken product survey), and at the same time investigate food safety characteristics which are not (the pork product survey). As the results show the inclusion of related food safety characteristics gave rise to the same conclusions regarding embedding as the inclusion of food safety characteristics more dissimilar in nature. Other studies suggest that embedding is generally of minor importance, when valuing market goods[7,22] which supports the conclusions of the present paper. More research is clearly needed in order to further understand the extent to which food safety characteristics are perceived as a compound good. Our results do however indicate that valuing only one food safety characteristic in stated preference studies does not necessarily give rise to overestimated values due to embedding.

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Appendix 1: The Description of the four Food Safety Characteristics.

Table A1. The Description of the Two Food Safety Characteristics Presented to the Respondents for the pork product survey

Salmonella-free	**Reduced use of antibiotics**
The risk of a Salmonella infection can be eliminated by good kitchen hygiene. Nevertheless, there were between 25 and 100 incidents of Salmonella infection per 100000 Danes in 2005, which could be traced back to pork meat. Usual symptoms of a Salmonella infection are fever, headache, nausea, vomiting, and diarrhoea for a duration of 3-6 days (on occasion weeks). In rare cases Salmonella can cause death. Today it is not possible to purchase pork labelled Salmonella-free. Now imagine that it is possible, and that you can choose between a product which has been tested and found free of Salmonella (**Salmonella-free**) and a product which has not been tested (**Not labelled Salmonella-free**).	Antibiotics are used to fight bacteria related illnesses in pigs. Use of antibiotics increases the risk of resistant bacteria (e.g. Salmonella). If humans become infected with resistant bacteria, it is difficult to find effective treatment. Medical residue from antibiotics can cause allergic reactions in human. Tests show that medical residue from antibiotics are only found in very rare cases in meat. By reducing the use of antibiotics in the pork production, a reduction of the above mentioned risks is expected. In the choice experiment we distinguish between pork produced under the existing rules of the use of antibiotics (**Existing rules**) and pork produced under tightened rules, where the use of antibiotics is reduced (**Tightened rules**).

Table A2. The Description of the Two Food Safety Characteristics Presented to the Respondents for the chicken product survey

Campylobacter-free	**Salmonella-free**
Campylobacter is the most common cause of food poisoning from especially poultry. In average 1 out of 3 chickens in Danish supermarkets are infected with Campylobacter. The risk of a Campylobacter infection can be eliminated by good kitchen hygiene. Nevertheless, there are between 20.000 and 40.000 incidents of Campylobacter infection per year, which can be traced back to chicken. Usual symptoms of a Campylobacter infection are fever, headache, nausea, vomiting, and diarrhoea for a duration of 3-6 days (on occasion weeks). In rare cases Campylobacter can cause death. Imagine that you can choose between a product which has been tested and found free of Salmonella (**Campylobacter-free**) and a product which has not been tested (**Not labelled Campylobacter-free**).	Salmonella is the second most common cause of food poisoning from especially eggs, poultry and other meat. In average 6 out of 100 chickens in Danish supermarkets are infected with Salmonella. The risk of a Salmonella infection can be eliminated by good kitchen hygiene. Nevertheless, there are between 1.500 and 3.000 incidents of Salmonella infection per year, which can be traced back to chicken. Usual symptoms of a Salmonella infection are fever, headache, nausea, vomiting, and diarrhoea for a duration of 3-6 days (on occasion weeks). In rare cases Salmonella can cause death. Imagine that you can choose between a product which has been tested and found free of Salmonella (**Salmonella-free**) and a product which has not been tested (**Not labelled Salmonella-free**).

Appendix 2: Socio-demographic distributions of the four samples.

Table A3. Socio-demographic distribution of the respondents in the two samples, A and B for the minced pork survey.

	Sample A	**Sample B**	**STAT Denmark**			**Chi-square test p-values**		
	Freq. (A)	Freq. (B)	Percent	Exp. (A)	Exp.(B)	A	B	A/B
Total	1278	1322						
Gender								
Men	626	652	49.01	626	648	0.9860	0.8205	0.8051
Women	652	670	50.99	652	674			
Age								
18-19	3	3	2.91	37	38			
20-24	39	42	7.00	89	93			
25-29	99	89	7.65	98	101			
30-39	321	335	18.13	232	240	4.42E-22	9.11E-23	0.9371
40-49	228	246	18.86	241	249			
50-61	312	319	20.93	268	277			
62-66	108	112	7.37	94	97			
67-	168	176	17.15	219	227			
Children								
No Children	737	763	68.32	873	903			
1 Child	204	240	13.02	166	172			
2 Children	237	241	13.38	171	177	1.76E-15	1.83E-14	0.01491
3 Children	85	61	4.09	52	54			
4 Children	13	13	0.79	10	10			
5 Children or more	2	4	0.40	5	5			
Household income								
Up to DKK 99999	18	15	3.77	48	50			
DKK 100000-199999	112	102	26.05	333	344			
DKK 200000-299999	137	139	17.19	220	227	1.03E-82	3.28E-95	0.3448
DKK 300000-399999	181	194	12.48	159	165			
DKK 400000 or more	830	872	40.50	518	535			

Note: The first and second p-values of the chi-square tests concern sample A and B, respectively, compared to Denmark in general. The third p-value, A/B, concerns the comparison of distributions between samples A and B. It is calculated from the actual number of respondents in sample B compared to an adjusted sample A.

Table A4: Socio-demographic distribution of the respondents in the two samples, C and D for the chicken breast survey.

	Sample C	**Sample D**	**STAT Denmark**			**Chi-square test p-values**		
	Freq. (C)	Freq. (D)	Percent	Exp. (C)	Exp.(D)	C	D	C/D
Total	381	372						
Gender								
Men	167	166	49.01	187	182	0.0433	0.0908	0.7570
Women	214	206	50.99	194	190			
Age								
18-19	5	3	2.91	11	11			
20-24	9	10	7.00	27	26			
25-29	12	18	7.65	29	28			
30-39	43	52	18.13	69	67	3.2E-19	2.7E-13	0.3184
40-49	57	59	18.86	72	70			
50-61	113	106	20.93	80	78			
62-66	65	60	7.37	28	27			
67-	77	64	17.15	65	64			
Children								
No Children	284	268	68.32	260	254			
1 Child	45	49	13.02	50	48			
2 Children	42	45	13.38	51	50	0.0811	0.2682	0.7644
3 Children	9	8	4.09	16	15			
4 Children	1	2	0.79	3	3			
5 Children or more	0	0	0.40	2	1			
Household income								
up to DKK 99.999	9	8	3.77	14	14			
DKK 100000-199999	35	26	26.05	99	97			
DKK 200000-299999	49	46	17.19	66	64	9.15E-21	7.38E-22	0.0054
DKK 300000-399999	44	70	12.48	48	46			
DKK 400000 or more	244	222	40.50	154	151			

Note: The first and second p-values of the chi-square tests concern sample C and D, respectively, compared to Denmark in general. The third p-value, C/D, concerns the comparison of distributions between samples C and D. It is calculated from the actual number of respondents in sample D compared to an adjusted sample C.