
# Consumer Willingness to Pay Price Premium for Credence Attributes of Livestock Products – A Meta-Analysis method

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***Abstract:***

*Livestock production is increasingly being regarded as resource-intensive and is attracting concerns about animal welfare and environmental sustainability. As a result, consumer awareness of these issues has led to an increasing demand for products with high quality attributes that cannot be directly experienced or identified, namely credence attributes (CAs). To our knowledge, so far no study has systematically identified the value of price premium associated with credence attributes of livestock products. In an effort to understand this issue this study conducted a meta-analysis to examine consumers' WTP for different credence attributes of livestock products based on a systematic review of relevant studies. Meta-regression models are used to control for the heterogeneity of WTP estimates and investigate factors that affect the estimation of WTP. There were 555 estimates derived from 94 papers reporting WTP. Meta-regression results established the presence of systematic WTP variation associated with types of products, CAs, and locations, yet also indicated that WTP is subject to systematic variation associated with study methodology. While results are promising with regard to the ability of research to provide insight regarding WTP for CAs, they also suggest that researchers should consider the potential for methodological effects when conducting empirical WTP analysis*

*Acknowledegment:*

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## Abstract

Livestock production is increasingly being regarded as resource-intensive and is attracting concerns about animal welfare and environmental sustainability. As a result, consumer awareness of these issues has led to an increasing demand for products with high quality attributes that cannot be directly experienced or identified, namely credence attributes (CAs). To our knowledge, so far no study has systematically identified the value of price premium associated with credence attributes of livestock products. In an effort to understand this issue this study conducted a meta-analysis to examine consumers' WTP for different credence attributes of livestock products based on a systematic review of relevant studies. Meta-regression models are used to control for the heterogeneity of WTP estimates and investigate factors that affect the estimation of WTP. There were 555 estimates derived from 94 papers reporting WTP. Meta-regression results established the presence of systematic WTP variation associated with types of products, CAs, and locations, yet also indicated that WTP is subject to systematic variation associated with study methodology. While results are promising with regard to the ability of research to provide insight regarding WTP for CAs, they also suggest that researchers should consider the potential for methodological effects when conducting empirical WTP analysis.



**Keywords: meta-analysis, credence attributes, livestock product, price premium**

## 1. Introduction

Since the middle 1990s, there has been an increasing demand for livestock products with high quality attributes that could be directly experienced, such as colour and taste, and also those named credence attributes (CAs) that could not be directly experienced or identified (Oude Ophuis and Van Trijp, 1995, Caswell, 1998). Consumers have been driven to purchase products with CAs by two reasons such that (a) their private interest such as the demand for food safety that is good for human health and (or) (b) social responsibility such as improving the environmental sustainability of agriculture (Tully and Winer, 2014). In general, CAs are classified into several main categories, including food safety (e.g. non-hormones, antibiotics-free and tractability), good quality (e.g. nutritional value), environmental benefit (e.g. carbon emission and water quality) and animal welfare (Caswell and Mojduszka, 1996).

The abstract characteristics of CAs have driven a growing interest in studies focusing on the design and implementation of policy instruments and marketing strategies to help consumers understand CAs (Florax et al., 2005). For example, food labelling, such as eco-labelling, might help better deliver information about CAs to consumers and facilitate their purchasing decisions. However, before policy instruments and suchlike could be implemented, it is important to understand whether or not consumers are willing to pay and how much they would like to pay for different CAs. In addition, as most credence attributes are highly-related to farm-level production process, understanding consumers' perceptions of credence attributes could help inform farmers as for how to adjust their farming practices in response to the market signal and gain price premium.

Up till now, an abundance of empirical studies have attempted to estimate consumers' willingness to pay (WTP) for CAs representing an additional of the value placed on the benefits that they derive (Caswell and Mojduszka, 1996). Results of most empirical studies have shown that consumers are willing to pay price premium for CAs of food products, but there are significant differences in the estimated values of WTP (e.g. Gath and Alvensleben, 1998; Kehlbacher et al., 2012; Kuperis et al., 1998; Li et al., 2016). Differences exist mainly because consumers' perceptions of CAs may vary (Oude Ophuis and Van Trijp, 1995) and the estimations are conditional on the particulars of a single study (e.g. Burgess et al., 2003; Loureiro and Umberger, 2007). Furthermore, some studies focus on estimating consumers' WTP based on their perceptions of the labelled or verified credence attributes (e.g. Gath and Alvensleben, 1998; Loureiro and Umberger, 2007; Janssen and Hamm, 2012), while others are purely interested in consumers' perceptions of the attributes without consideration of labelling and verification (e.g. Lusk and Schroeder, 2004; Feldkamp et al., 2005). Therefore, the estimated values of WTP from these studies are of limited generalizability and could not be seen as robust WTP estimates that farmers could rely on to assess potential benefits associated with providing specific attributes.

To our knowledge, so far no study has systematically identified the value of price premium associated with credence attributes of livestock products. In an effort to understand this issue this study conducts a meta-analysis to examine consumers' WTP for different credence attributes of livestock products based on a systematic review of relevant studies. Meta-regression models are used to control for the heterogeneity of WTP estimates and investigate factors that affect the estimation of WTP, with the consideration of methodological variability of the underlying studies. We aim to answer the following questions: (1) are there differences in price premium across types of attributes, such as animal welfare, geographical indication, and environmental-friendly? (2) Are there differences in price premium across types of livestock products, including dairy and red meat? (3) To what extent does the price premium vary over time? (4) Is the price premium sensitive to the method used to estimate WTP? (5) Are there regional differences, e.g. across different countries, in the price premium?  The paper is structured as follows. The following section will describe the meta-analysis method and data collected for the analysis. Section 3 will present the empirical results of meta-regression models. Section 4 concludes and provides potential implications.

## 2. Method and Data

Meta-analysis is generally defined as a systematic literature review supported by statistical methods where the goal is to aggregate and contrast the findings from several related studies (Glass, cited in (Viechtbauer, 2010). It is well-known as the 'analysis of analyses' and has a long history in various research fields, such as medical science, psychology and education. Accordingly, the application of meta-analysis has been conducted in an experimental context that has offered a series of standard statistical procedures for the measurement of effect sizes across studies examining the same research question. The term 'effect sizes' denotes summary statistics such as standardised differences in means of experimental and control groups, correlations, and odds-ratios (Florax et al., 2005).

Meta-analysis was firstly introduced to economists as a promising methodology of literature review by (Stanley and Jarrell, 1989), followed by whom a meta-regression analysis (MRA) method, namely the 'regression analysis of regression analyses', has been developed and mostly applied in environmental economics. In general, most analyses in economics collect a set of primary studies each of which produces a common empirical result, such as people's WTP for air pollution (Smith and Huang, 1995) and price elasticity of meat (Gallet, 2010). Notably, the quantitative measures used in economic studies are rather different from the typical effect sizes used in experimental sciences. For example, the primary studies in economics utilise different study design, model specification, and econometric techniques (Nelson and Kennedy, 2009). In particular, economists tend to fit so-called meta-regression models, that is, linear models that examine the influence of one or more explanatory variables, also called moderators, on the outcomes (e.g., Berkey et al., 1995; Van Houwelingen et al., 2002). With appropriate coding, such models can handle continuous and categorical variables.

Considering the rapid growth of application of MRA from environmental economics to other areas, such as labour economics, it then becomes crucial to improve transparency and to raise the quality of MRA in economics research. Therefore, several studies have attempted to provide a set of 'best practices' about reporting guidelines or/and econometrics techniques of MRA (Nelson and Kennedy, 2009; Rosenberger and Loomis, 2000; Stanley et al., 2013). Following these guidelines, the paper will firstly conduct a thorough search to compile a list of studies that provide a complete description of the characteristics considered in the meta-regressions.

### *2.1. Data collection*

To identify candidate studies, the literature review retrieval process consists of two steps. The initial search involved checking several economic and non-economic databases including EconLit, AgEcon, Google Scholar, Scopus, CAB Abstracts, PubMed, Biosis, and FSTA. Key words used in the search included 'price premium', 'willingness to pay' (or 'WTP' and variations), 'meat', 'beef', 'lamb', 'dairy', 'livestock', 'credence attributes', and 'high quality'. Then, the reference sections of qualitative and quantitative review papers identified in the initial search were examined and used to search for studies that were left out in the initial search. This produced a list of 138 studies reporting WTP. Several studies were excluded of which 13 were qualitative and quantitative review (e.g. Anselmsson et al., 2007; Tully and Winer, 2014; Lagerkvist and Hess, 2011; Cicia and Colantuoni, 2010; Deselnicu et al., 2013; White and Brady, 2014), 15 were about other food products such as wood, chicken and fruits (e.g. Aguilar and Vlosky, 2007; Campbell and Doherty, 2013; Janssen and Hamm, 2012), and 16 expressed WTP as awareness scores or a probability of WTP instead of monetary measurements. Therefore, our meta-analysis used 94 studies that produced 566 observations, where 11 WTP estimates were negative and excluded. We intended to control for this in the meta-regression models by including a dummy variable that equals one when negative WTP estimates were reported in a study. This produced the final list of 94 studies where 555 observations were included[1].

#### *2.1.1. The dependent variable*

WTP estimates used in this paper were drawn from studies across country, year and currency. We thus follow the example of several WTP analyses to use percentage premium WTP to standardise these differences. The percentage premium was measured by the percentage change in WTP from a base price for the CAs, which allows us to quantify the increased monetary value that consumers place on CAs[2]. In many cases, studies presented dollar value estimates of WTP premiums and a base price was sourced from the text. Base prices were either the average of the prices used in elicitation, the market price of the base product at the time of the study, or the WTP reported for a generic product, whichever was presented within the study. The average WTP across the 555 estimates is 0.46 while the median is 0.32, indicating the data is right-skewed shown in Figure 1. We thus took the natural logarithm of the WTP to smooth and normalise the data. In addition, considering the standard deviation of WTP is 0.53, there is much variation in the WTP estimates to be explained. Typical of other meta-analyses, information on a variety of study characteristics that might influence WTP estimates was collected, with the frequencies, median and mean WTP for each category provided in Table 1 (definitions of the variables can be found in Table 2). When categorised corresponding to different study characteristics, the median WTP is smaller than the mean in each category.

[1] A summary of the studies used in the analysis could be provided upon request to the authors.
[2] For simplicity, we will use WTP to represent percentage change of WTP in the following part.

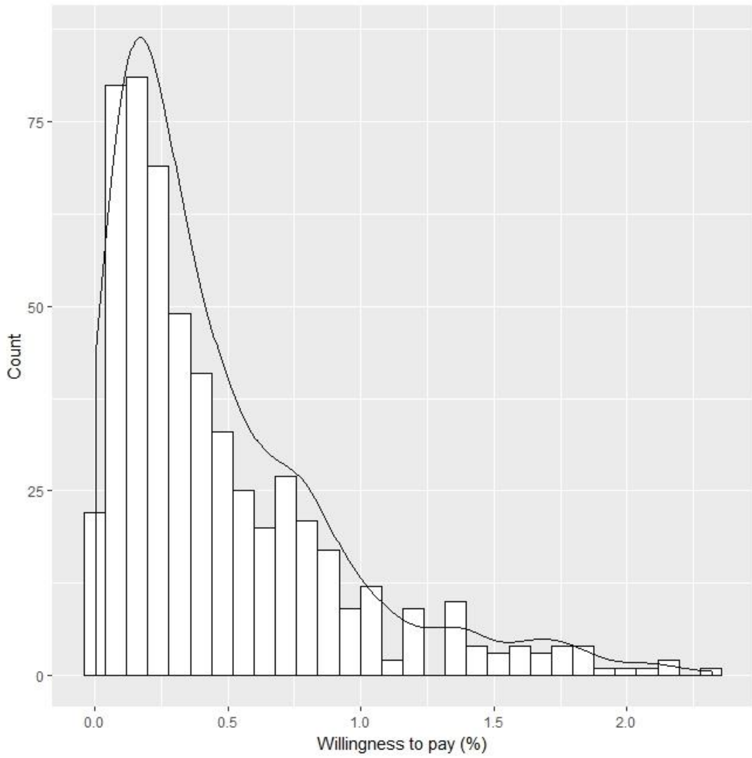


Figure 1. the distribution of percentage premium WTP

Table 1

Frequency of study characteristics, median and mean WTP

| Category | Variable | Frequency[a] | Median WTP[b] | Mean WTP |
|---|---|---|---|---|
| Product | Beef | 283 | 28.76 | 53.29 |
| | Lamb | 44 | 19.5 | 39.27 |
| | Dairy | 206 | 40.01 | 51.26 |
| | Other products | 22 | 26.92 | 31.57 |
| Data collection time | Before 2000 | 22 | 14.93 | 16.87 |
| | 2000-2004 | 116 | 25.9 | 37.47 |
| | 2005-2009 | 239 | 37.4 | 54.25 |
| | After 2010 | 178 | 29.92 | 45.89 |
| Publication type | Journal | 466 | 34.79 | 49.35 |
| | Others | 89 | 20 | 31.08 |
| Discipline | Economics | 283 | 32.4 | 43.78 |
| | Other business | 111 | 28 | 37.08 |
| | Science | 161 | 35.7 | 57.51 |
| Estimation method | CE | 276 | 41.5 | 53.48 |
| | CV | 39 | 16.88 | 17 |
| | CA | 63 | 26.06 | 31.58 |
| | Hedonic | 26 | 13.73 | 20.59 |
| | Others | 151 | 36.24 | 51.76 |
| Valuation method | Hypothetical | 405 | 32.61 | 49.1 |
| | Non-hypothetical | 150 | 32 | 39.3 |
| Survey methods | Mail | 61 | 38.04 | 54.8 |
| | Phone | 28 | 18.38 | 18.89 |
| | In person | 294 | 38.7 | 53.23 |
| | Online | 150 | 26 | 34.15 |
| | Not specified | 22 | 33 | 47.04 |

| | | | | |
|---|---|---|---|---|
| Credence attribute | Organic | 62 | 24.32 | 44.31 |
| | Genetically-Modified (GM) free | 28 | 45.43 | 57.65 |
| | Hormone/antibiotic-free | 36 | 51.79 | 60.18 |
| | Food safety | 43 | 20 | 63.33 |
| | Grass-based | 49 | 28.17 | 41.98 |
| | Traceability | 17 | 21.7 | 32.15 |
| | Geographical indication | 127 | 40 | 50.15 |
| | Environmental-friendly | 41 | 16 | 26.29 |
| | Animal welfare | 108 | 37.99 | 50.98 |
| | Mixed attributes | 44 | 23.62 | 33.86 |
| Region | North America | 152 | 27.92 | 33.89 |
| | Europe | 280 | 33.67 | 48.51 |
| | Asia | 72 | 38.5 | 56.13 |
| | Australasia | 6 | 33.17 | 78.37 |
| | Other regions | 45 | 39.1 | 54.43 |

***Note:*** (a) frequency refers to the number of observations in each category. (b) both mean and median WTP are in percentage.

We firstly report price differences across four categories of livestock products, with the greatest number of WTP corresponding to beef, and the fewest corresponding to other products. Across these four categories, beef with CAs has the largest potential price premium followed by dairy and lamb, while other products have the smallest WTP[3]. With regard to time of data collected for the analyses, there is an obvious increasing trend of numbers of studies with time, where only 22 studies happened before 2000. The increasing trend can also be seen from both the median and mean WTP, indicating consumers' WTP for CAs may increase over time. Furthermore, differences in WTP exist across publication type (peer-reviewed journal or others), discipline (economics journal/conference/thesis or other disciplines), survey method (e.g. in person, online and phone), and estimation method (e.g. choice experiment, choice valuation and hedonic). These are typical study characteristics that may reflect variation of WTP regarding methodological and discipline differences, and publication bias. Lastly, the WTP for price premium has been estimated in various parts of the world, and so Table 1 reports median and mean WTP for different regions. Most of the attention in the literature has been given to the WTP in Europe and North America. Across the five regions the consumers have the highest WTP for price premium of CAs in Australia and New Zealand, followed by Asia, other regions (including Chile, Russia, and Turkey) and Europe, while the lowest WTP is associated with North America.

### *2.1.2. Potential determinants of WTP*

[3] Here, some studies such as Kehlbacher et al. (2012) that focused on measuring consumers' WTP for improving animal welfare did not report what kinds of livestock products regarding WTP for animal welfare attribute. WTP estimates drawn from those studies were categorised into "other products".

As was discussed in the previous section, WTP estimates vary across different categories of study characteristics, which could be seen as potential determinants of WTP. As a result, the heterogeneity of WTP estimates in the sample data could be handled via mete-regression where the variation is explained by regressors for study characteristics, expecting to capture observed sources of heterogeneity. These potential determinants will be included in all the meta-regression models as explanatory variables, and detailed definitions and descriptive statistics of these variables are presented in Table 2. As most of the explanatory variables are either binary or categorical, there is a baseline for each study characteristics. Specifically, for categorical variables, 'other products' was set as the base for different livestock products; 'mixed attributes' was the base for credence attributes; 'other regions' was the base for regional differences; 'other methods' was the base for estimation methods; 'science' was the base for journal differences; 'not specified' was the base for survey methods; and 'before 2000' was the base for time trend. Here, in addition to the study characteristics listed in Table 1, we also include variables such as "Log GDP" representing gross domestic product per capita based on data collection year and study location to account for income effect, and "Negative" representing negative WTP estimates that were reported in the primary studies. Lastly, 'sample size', as a weighted variable, was considered in all meta-regression models, which will be explained in the next section.

Table 2

Variable definition and statistical description

| **Variable** | **Definition** | **Mean**[a] | **SD** | **Min** | **Max** |
|---|---|---|---|---|---|
| *Product* | | | | | |
| Dairy | 1 if study tested a dairy product, otherwise 0 | 0.37 | 0.48 | 0 | 1 |
| Beef | 1 if study tested a beef product, otherwise 0 | 0.51 | 0.50 | 0 | 1 |
| Lamb | 1 if study tested a beef product, otherwise 0 | 0.08 | 0.27 | 0 | 1 |
| Other products | 1 if study did not specified which kinds of livestock products, otherwise 0 | 0.04 | 0.20 | 0 | 1 |
| *Credence attribute* | | | | | |
| Environmental-friendly | 1 if study estimated an attribute associated with environment, otherwise 0 | 0.05 | 0.23 | 0 | 1 |
| Animal welfare | 1 if study estimated an attribute associated with animal welfare, otherwise 0 | 0.19 | 0.40 | 0 | 1 |
| Organic | 1 if study estimated organic product, otherwise 0 | 0.11 | 0.32 | 0 | 1 |
| GM free | 1 if study estimated GM free product, otherwise 0 | 0.05 | 0.22 | 0 | 1 |
| Hormone/ antibiotic-free | 1 if study estimated products with no hormone, antibiotic or growth enhancing technics, otherwise 0 | 0.04 | 0.20 | 0 | 1 |
| Grass-based | 1 if study estimated grass-fed or grass-finished attribute, otherwise 0 | 0.08 | 0.28 | 0 | 1 |
| Food safety | 1 if study estimated an attribute associated with safety, otherwise 0 | 0.08 | 0.27 | 0 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Geographical indication (GI) | 1 if study estimated an attribute associated with GI, such as traceability and country of origin, otherwise 0 | 0.18 | 0.39 | 0 | 1 |
| Traceability | 1 if study estimated an attribute associated with traceability, otherwise 0 | 0.04 | 0.20 | 0 | 1 |
| Mixed attributes | 1 if study estimated product with a vague description of credence attributes, for example 'good' or 'healthy', otherwise 0 | 0.08 | 0.27 | 0 | 1 |
| *Geographical characteristic* | | | | | |
| Log GDP | Natural logarithm of gross domestic product per capita[b] | 3.31 | 0.06 | 3.30 | 4.71 |
| North America | 1 if study was conducted in the US or Canada, otherwise 0 | 0.26 | 0.44 | 0 | 1 |
| EU | 1 if study was conducted in Europe, otherwise 0 | 0.50 | 0.50 | 0 | 1 |
| Asia | 1 if study was conducted in Asian, otherwise 0 | 0.13 | 0.34 | 0 | 1 |
| Australasia | 1 if study was conducted in Australia or New Zealand, otherwise 0 | 0.01 | 0.01 | 0 | 1 |
| Other regions | 1 if study was conducted in other regions, otherwise 0 | 0.09 | 0.30 | 0 | 1 |
| *Research method* | | | | | |
| CE | 1 if study used choice experiment method, otherwise 0 | 0.50 | 0.50 | 0 | 1 |
| CV | 1 if study used contingent valuation method, otherwise 0 | 0.07 | 0.26 | 0 | 1 |
| Hedonic | 1 if study used hedonic method, otherwise 0 | 0.05 | 0.21 | 0 | 1 |
| CA | 1 if study used conjoint analysis method, otherwise 0 | 0.11 | 0.32 | 0 | 1 |
| Other methods | 1 if study used other estimation method, e.g. auction, otherwise 0 | 0.27 | 0.45 | 0 | 1 |
| Hypothetical | 1 if study used a hypothetical valuation method, otherwise 0 | 0.73 | 0.45 | 0 | 1 |
| Economics | 1 if study was published/ released in a platform of economic discipline, otherwise 0 | 0.51 | 0.50 | 0 | 1 |
| Other business | 1 if study was published/ released in a platform of other business disciplines, such as management and marketing, otherwise 0 | 0.20 | 0.40 | 0 | 1 |
| Science | 1 if study was published/ released in a platform of science disciplines, otherwise 0 | 0.29 | 0.45 | 0 | 1 |
| Mail | 1 if study used mail survey to collect data, otherwise 0 | 0.11 | 0.31 | 0 | 1 |
| Telephone | 1 if study used telephone survey to collect data, otherwise 0 | 0.05 | 0.21 | 0 | 1 |
| Online | 1 if study used online survey to collect data, otherwise 0 | 0.27 | 0.45 | 0 | 1 |
| In person | 1 if study used face-to-face survey to collect data, otherwise 0 | 0.53 | 0.50 | 0 | 1 |
| Not specified | 1 if survey method is unknown, otherwise 0 | | | | |
| *Other characteristics* | | | | | |
| Published type | 1 if study was published in a journal, otherwise 0 | 0.84 | 0.37 | 0 | 1 |
| Negative | 1 if study reported negative WTP, otherwise 0 | 0.07 | 0.26 | 0 | 1 |
| Before 2000 | 1 if study collected data before 2000, otherwise 0 | 0.04 | 0.20 | 0 | 1 |
| Y2000-2004 | 1 if study collected data between 2000 and 2004, otherwise 0 | 0.21 | 0.41 | 0 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| Y2005-2009 | 1 if study collected data between 2005 and 2009, otherwise 0 | 0.43 | 0.50 | 0 | 1 |
| After 2010 | 1 if study collected data after 2010, otherwise 0 | 0.32 | 0.47 | 0 | 1 |
| Sample size | The inverse of sample sizes of included studies | 0.003 | 0.0029 | 0.0001 | 0.026 |

***Note:*** (a) Mean value for dummy and categorical variables represents percentage. (b) Gross domestic product was based on data collection year and study location and sourced from World Bank (2014).

*2.2. Meta-regression models*

Early meta-analyses in economics tended to use OLS to estimate linear models to estimate WTP for protection of endangered species and price elasticity of cigarette (e.g. Loomis and White, 1996; Lusk et al., 2005; Richardson and Loomis, 2009; Gallet and List, 2003). Following these studies, we could start the meta-regression with a typical linear model expressed as:

(1) $$WTP_i = \alpha + \beta X_i + \varepsilon_i$$

where $WTP_i$ is the $i^{th}$ WTP estimate $(i = 1, ..., n)$ that is explained by a vector of explanatory variables $x_i$ presented in Table 2, with the associated coefficient vector $\beta$ to be estimated. $\alpha$ is the intercept and $\varepsilon_i$ is a normally distributed error term with zero mean and constant variance $\sigma_\varepsilon^2$. However, being derived from several relevant studies, the sample data used in the analysis may provide various levels of precision in measuring WTP. Simply pooling the data and using the classical OLS estimator may ignored problems, such as data heterogeneity, heteroscedasticity, and non-independence of observations across and within studies, and cause serious estimation issues (Nelson and Kennedy, 2009). Models using weighted least-squares and panel-data regression techniques are highly recommended and regarded to be more appropriate to address the above estimation issues (Stanley et al., 2013). Hence, instead of using typical OLS estimator, we used a robust OLS estimator as well as panel regression techniques in the meta-regression models.

*2.2.1. Regression weights*

Treating each WTP estimate equally in the meta-regression is not statistically efficient because it fails to account for the fact that some values are estimated with relatively more precision than others and therefore contribute more information to the meta-analysis. We thus considered combining regression weights in the estimation process.

To maximize statistical efficiency, typical meta-analysis studies combine variance estimates from the primary studies as regression weights, where each estimate of the meta-analysis would ideally be weighted by the inverse of its variance (Lipsey and Wilson, 2000). Unfortunately, considering the non-experimental nature of economic studies, relatively few of the included studies reported variance estimates, neither did they report standard errors or confidence intervals for WTP estimates. This makes it impossible to calculate the relevant variance. To deal with the problem, several alternative measurement methods have been employed, and one of the most commonly used approaches is to approximate variances with sample sizes of the included studies (e.g. de Blaeij et al., 2003; Florax et al., 2005; Van Houtven et al., 2007). Thus, we used the inverse of sample sizes to proxy the variances where each WTP estimate from the included studies was weighted in proportion to its sample size.

### *2.2.2. Panel data structure*

The sample data used in meta-analysis usually has the panel nature that each study may provide more than one estimates for the same research question (e.g. WTP estimates and price elasticities) that may lead to with-in study autocorrelation. In the presence of panel data effects, the OLS assumptions of independent and identically distributed errors are likely to be violated (Van Houtven et al., 2007). In that case, using typical OLS to estimate meta-regression models may lead to biased parameter estimates, leading to invalid inferences from seemingly significant factor effects. Hence, if OLS is to be employed, one should use robust standard errors for inference rather than relying on simple OLS regression on pooled data (Jacobsen and Hanley, 2009). It should also be noted that, although using a robust OLS estimator (e.g. with Huber-White method) could correct regressors for heteroscedasticity and serial correlation, it could not affect the coefficient estimates of the meta-regression model (Gallet and List, 2003).

An alternative approach to address the panel data effects is to use panel data estimation techniques to estimate an unbalanced panel with unequal panel size, including the fixed effects panel data (FE) model and random effects panel data (RE) model. Specifically, the RE model provides a control for the commonality within a study, and control for the dependence of observations within and across each study. In addition, considering most of explanatory variables in our meta-regression models do not vary within studies, we consider using random effects counterpart to equation (1):

(2) $$WTP_{ij} = \alpha + X_{ij}\beta + \mu_{ij}$$

where $WTP_{ij}$ is the $i^{th}$ WTP estimate for the $j^{th}$ panel index $(j = 1,...,m)$. Although most common ways of creating panels are based on the primary studies included in meta-analyses, (Rosenberger and Loomis, 2000) illustrated that the latent panel effects may be sourced from other relevant stratifications, for example by researcher. Thus, we considered two stratification approaches in the RE model to form the panel index, including 'by study' $(m = 94)$ and 'by lead author' $(m = 77)$. Here, $j$ represents either the $j^{th}$ study or the $j^{th}$ lead author of the study. $\mu_{ij} = v_{ij} + \varepsilon_i$ is a composite error term, where $v_{ij}$ is the panel-specific error and $\varepsilon_i$ is a common error with zero mean and constant variance of $\sigma_v^2$ and $\sigma_\varepsilon^2$, respectively.

*2.2.3. Subsamples*

The sample data of the study includes WTP estimates of four livestock products, i.e. dairy, beef, lamb and other products. Using categorical variables in the meta-regression models could explain a proportion of the heterogeneity, but the variation of WTP estimates may be different among types of livestock products. For example, WTP estimates may respond to characteristics of the primary studies differently. The meta-regression model that pools the whole sample data may not provide the appropriate estimation of WTP for a specific livestock product. In addition to differences in the average values, the standard deviation of WTP for dairy products (0.46) is different from those for beef (0.59) and lamb (0.48). The distributions of WTP estimates for beef, lamb, red meat (beef and lamb) and dairy products are depicted in Figure 2. All four curves are right-skewed, while the dairy curve has a relatively shorter right tail than those of the beef and lamb curves. Nelson and Kennedy (2009), suggest that, when sample size permitting, meta-regressions could be estimated on more homogeneous subsamples. Considering the relative small sample size of lamb products (44 observations), while the distribution of lamb WTP is similar as that of beef WTP, we disaggregate the whole sample data into two subsamples, including red meat and dairy[4]. In addition to running RE model on the whole sample (the whole model), we also estimated two RE models on the subsamples of red meat and dairy (the red meat model and dairy model).

[4] There is only 22 observations belong to 'other products' that were not specified types of livestock product so that we did not consider running a meta-regression model on this small subsample.

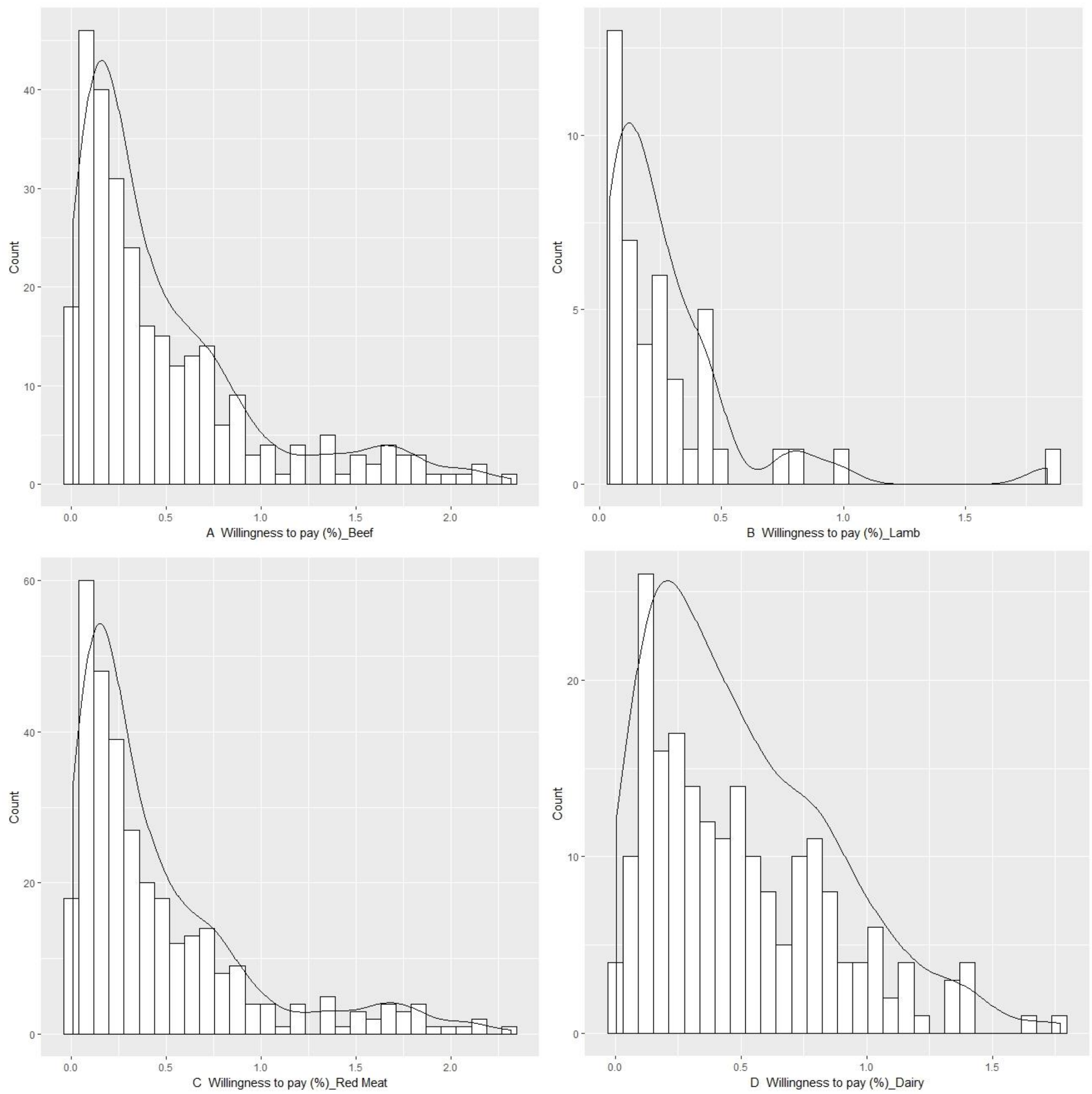


Figure 2 the distribution of percentage premium WTP across different livestock products

## 3. Estimation Results

### *3.1. The whole sample model*

Table 3 reports estimation results of meta-regression models on the whole sample data. For comparison purpose, we presented estimation results of the pooled OLS with a robust estimator, and results of RE model by study and RE model by lead author. The three meta-regression models provide a reasonably goodness of fit to the sample data, with $R^2$ statistics between 0.41 and 0.54.

As most meta-analyses did, restricted versions of the three meta-regression models were also regressed on the data, where the explanatory variables that were not individually significant at 1% level or less were excluded. We thus employed F-test to test for the jointly statistical significance of the excluded variables, where the null hypothesis is coefficients of the excluded variables are equal to zero (results shown at the bottom of Table3). According to the results, we must reject the null hypothesis and retain these variables for all three meta-regression models, even though the variables were not individually significant. In addition, we conducted two tests to verify the appropriateness of choosing the RE models (results shown at the bottom of Table 3). Firstly, the Breusch-Pagan Lagrange multiplier (LM) test was used to test for the existence of panel effects. Results of the LM test show that we must reject the null hypothesis at 1% statistical significance level and use RE model for the meta-regression, regardless of random effects by study or by author. Secondly, the Hausman test was used to test for whether to include fixed effects or random effects in the panel data models. Results of the test show that random effects are preferred over fixed effects, regardless of the inclusion of panel index by study or by author. All these verified that we should use RE models for the mete-regression.

Although the robust OLS estimator could correct regressors for heteroscedasticity and serial correlation, it could not affect the coefficient estimates of the meta-regression model so that the sign and magnitude of the coefficient estimates are different from those in the RE models (Gallet and List, 2003). However, the sign and statistical significance of the explanatory variables are relatively consistent across the two RE models. Thus, interpretation of the coefficient estimates of the meta-regression will be based on the estimation results of the RE model by study.

Table 3.

Regression results for full sample

| **Variable** / **Model** | **OLS**[a] | | | **RE – by study** | | | **RE – by lead author** | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Coef.* | | *SE.* | *Coef.* | | *SE.* | *Coef.* | | *SE.* |
| Intercept | 0.31 | | (4.31) | -0.17 | . | (3.07) | -0.48 | . | (3.04) |
| Dairy | 1.01 | ** | (0.38) | 0.62 | ** | (0.42) | 0.65 | * | (0.44) |
| Beef | 0.96 | ** | (0.35) | 0.57 | ** | (0.43) | 0.43 | ** | (0.4) |
| Lamb | -0.1 | *** | (0.48) | -0.03 | *** | (0.02) | -0.04 | *** | (0.03) |
| Environmental-friendly | -0.03 | * | (0.21) | -0.13 | * | (0.12) | -0.09 | * | (0.1) |
| Animal welfare | 0.63 | * | (0.27) | 0.39 | * | (0.18) | 0.45 | * | (0.17) |
| Organic | 0.63 | * | (0.27) | 0.8 | *** | (0.22) | 0.99 | ** | (0.22) |
| GM free | 0.7 | ** | (0.23) | 0.37 | ** | (0.23) | 0.42 | * | (0.21) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hormone/ Antibiotic free | 0.46 | *** | (0.19) | 0.43 | ** | (0.21) | 0.53 | * | (0.21) |
| Grass-based | 0.1 | | (0.2) | 0.22 | | (0.23) | 0.27 | | (0.21) |
| Food safety | 0.27 | | (0.18) | 0.49 | ** | (0.19) | 0.54 | ** | (0.18) |
| GI | 0.47 | * | (0.22) | 0.35 | * | (0.16) | 0.39 | * | (0.15) |
| Traceability | -0.4 | | (0.28) | -0.28 | | (0.24) | -0.21 | | (0.25) |
| Log GDP | 0.39 | | (0.66) | 0.18 | | (0.83) | 0.13 | | (0.84) |
| North America | -0.13 | | (0.22) | -0.09 | | (0.39) | -0.1 | | (0.22) |
| EU | -0.06 | * | (0.2) | 0.19 | | (0.35) | 0.12 | | (0.37) |
| Asian | 0.46 | * | (0.47) | 1.12 | ** | (0.36) | 0.94 | ** | (0.38) |
| Australasia | 1.31 | * | (0.79) | 1.52 | * | (0.7) | 1.02 | * | (1.01) |
| CE | 0.45 | * | (0.32) | 0.08 | ** | (0.28) | 0.05 | ** | (0.28) |
| CV | -0.38 | | (0.27) | 1.23 | * | (0.1) | 1.42 | * | (0.13) |
| Hedonic | -1.2 | | (0.32) | -0.68 | | (0.42) | -0.58 | | (0.52) |
| CA | -0.38 | | (0.26) | -0.44 | | (0.3) | -0.43 | | (0.32) |
| Hypothetical | 0.22 | * | (0.14) | 0.15 | * | (0.24) | 0.27 | * | (0.18) |
| Economics | -0.05 | | (0.11) | 0.05 | | (0.19) | 0.03 | | (0.18) |
| Other business | -0.06 | | (0.14) | 0.3 | | (0.28) | 0.46 | * | (0.24) |
| Mail | -0.33 | | (0.32) | -0.65 | | (0.57) | -0.5 | | (0.56) |
| Telephone | -1.72 | *** | (0.34) | -1.65 | ** | (0.62) | -1.8 | ** | (0.6) |
| Online | -1.41 | *** | (0.31) | -1.09 | * | (0.57) | -1.12 | * | (0.61) |
| In person | -0.63 | * | (0.28) | 0.82 | * | (0.49) | 0.98 | * | (0.46) |
| Published in Journal | 0.38 | ** | (0.22) | 0.27 | * | (0.21) | 0.25 | * | (0.22) |
| Negative | -0.89 | ** | (0.33) | -1.05 | ** | (0.44) | -1.31 | *** | (0.34) |
| Y2000-2004 | 0.28 | * | (0.23) | 0.01 | * | (0.36) | 0.06 | * | (0.37) |
| Y2005-2009 | 0.44 | * | (0.23) | 0.26 | * | (0.37) | 0.3 | * | (0.39) |
| After 2010 | 0.41 | ** | (0.25) | 0.31 | ** | (0.41) | 0.29 | * | (0.36) |
| $R^2$ | 0.54 | | | 0.43 | | | 0.41 | | |
| *F* test for restricted model [c] | *F=202.1* (*P* < 0.01) | | | *F=347.2* (*P* < 0.01) | | | *F=401.8* (*P* < 0.01) | | |
| LM test | - | | | $\chi^2 = 567.4$ ($P < 0.001$) | | | $\chi^2 = 278.5$ ($P < 0.001$) | | |
| Hausman test | - | | | $\chi^2 = 20.2$ ($P$ =0.96) | | | $\chi^2 = 47.8$ ($P$ =0.49) | | |

***Note:*** (a) for OLS estimation results, the numbers in parenthesis are the Huber-White standard errors clustered by study. (b) '***', '**', '*', indicate coefficients that are significant at 1%, 5% and 10% level, respectively.

Addressing the coefficient estimates across the livestock products, we found that higher WTP is significantly higher for dairy and beef products, while lamb has the lowest WTP (relative to other products). Turing to different CAs, most of the coefficient estimates of CAs are statistical significant, except for Grass-based and traceability. Compared to the product with 'mixed' CAs (a vague description of CAs, for example 'good' attribute), organic products were estimated to be associated with the highest price premium, followed by food safety, hormone/antibiotic-free, animal welfare, GM free, and GI. Notably, environmental friendly attribute was estimated to be associated with the lowest price premium.

WTP for price premium of CAs vary across different regions. Australasian consumers seem to have the highest WTP, followed by the second highest WTP from the Asian market, and the EU is the third. Among all the regions, the North American consumers show the lowest WTP for price premium of CAs.

Concerning research methods, including estimation and survey issues, there are several tendencies in the regression results. First, compared to other estimation methods, such as auction, WTP estimated by CE and CV method tends to be associated with higher value. In addition, compared to non-hypothetical analyses, such as analysis of scanned data, price premium was estimated to be higher under the hypothetical situations for consumers' decision-making. This indicates the difference between consumers' real WTP and their intentions to pay. Intuitively, consumers may have good intentions to pay a higher price premium for CAs, such as animal welfare, but real purchase may end up not happening in the supermarket. Additionally, different survey methods produce various levels of WTP, of which face-to-face survey gave the highest WTP while telephone and online survey produced relatively lower WTP.

As for the remaining categories, 'published in Journal' is found to affect WTP estimates. Here, the coefficient estimation of 'published in Journal' is positive and statistically significant. On one hand, this may indicate that publication is an indicator of study quality, and therefore higher quality studies tend to produce higher WTP estimates. On another hand, however, this variable could also be interpreted as a filter that favours larger, statistically significant values. Thus, this result may suggest the presence of publication bias. Meanwhile, when negative WTP estimates were reported in the primary studies, the values of WTP estimates tend to be lower, on average. Lastly, there is an increasing trend of WTP over time, according to the positive and statistically significant coefficient estimates of the time variables.

### *3.2. The subsample models*

Two subsamples of red meat and dairy were regressed using the RE model, with the estimation results shown in Table 4[5]. At the bottom of the table, for both models, results of the F-test reject the exclusion of variables that were not individually significant. Results of

[5] Here we only reported estimation results of RE model by study as the results of RE model by author have relative small differences in terms of magnitude and statistical significance level. The results appen.

the LM test and Hausman test also verify that random effects should be included in our meta-regression analysis The values of $R^2$ of the two models are 0.56 and 0.51, which reflects a relative good fitness to the two subsample data. Compared to estimation results of the whole sample counterpart in Table 3 (RE-by study), we can observe differences in various aspects, including sign, magnitude, and statistical significance level. Concerning the coefficient estimates of red meat model and dairy model, differences can be seen between the two models. These confirm our assumption that WTP estimates for different livestock products may respond to CAs and study characteristics differently, and thus the subsample models may provide more accurate prediction of WTP for each livestock product.

Table 4.

Regression results of subsample models

| Variable / **Model** | **Red meat model (*n*=283)** | | | **Dairy model (*n*=206)** | | |
|---|---|---|---|---|---|---|
| | *Coef.* | | *SE.* | *Coef.* | | *SE.* |
| Intercept | -10.83 | . | (1.52) | -5.54 | * | (0.24) |
| Dairy | | | | | | |
| Beef | 1.22 | *** | (0.35) | | | |
| Lamb | | | | | | |
| Environmental-friendly | -0.13 | * | (0.12) | 0.23 | | (0.36) |
| Animal welfare | 0.33 | * | (0.20) | 0.61 | ** | (0.29) |
| Organic | 0.87 | *** | (0.23) | 0.14 | *** | (0.02) |
| GM free | 0.64 | *** | (0.23) | 0.66 | ** | (0.23) |
| Hormone/Antibiotic free | 0.62 | *** | (0.19) | 0.65 | ** | (0.26) |
| Grass-based | 0.11 | | (0.63) | 0.25 | | (0.42) |
| Food safety | 0.52 | ** | (0.2) | 0.69 | ** | (0.25) |
| GI | 0.42 | ** | (0.19) | 0.45 | ** | (0.19) |
| Traceability | -0.36 | | (0.25) | 0.09 | | (0.55) |
| Log GDP | 1.08 | | (0.83) | 1.23 | | (1.83) |
| North America | -0.06 | | (0.39) | -0.09 | | (0.39) |
| EU | 0.14 | | (0.35) | 0.17 | | (0.33) |
| Asian | 1.06 | ** | (0.36) | 1.48 | ** | (0.36) |
| Australasia | 2.28 | *** | (0.84) | | | |
| CE | 0.26 | * | (0.24) | 0.49 | | (0.45) |
| CV | 0.73 | *** | (0.32) | 0.93 | | (0.89) |
| Hedonic | -2.5 | | (0.54) | -1.22 | | (0.84) |
| CA | -0.67 | ** | (0.28) | 0.59 | * | (0.21) |
| Hypothetical | 0.38 | * | (0.12) | 1.76 | ** | (0.25) |
| Economics | 0.06 | | (0.21) | 0.24 | | (0.21) |
| Other business | 0.1 | | (0.29) | 0.1 | | (0.58) |
| Mail | -1.46 | | (0.83) | -1.12 | | (0.83) |
| Telephone | -1.65 | ** | (0.62) | -1.23 | ** | (0.62) |
| Online | -0.7 | | (0.43) | -1.3 | | (0.43) |

| Model | Red meat model ($n$=283) | | | Dairy model ($n$=206) | | |
|---|---|---|---|---|---|---|
| In person | 1.29 | *** | (0.35) | 0.98 | *** | (0.35) |
| Published in Journal | 0.17 | * | (0.09) | 0.25 | ** | (0.11) |
| Negative | -1.62 | *** | (0.5) | -0.74 | *** | (0.23) |
| Y2000-2004 | 0.04 | * | (0.1) | 0.09 | * | (0.94) |
| Y2005-2009 | 0.37 | ** | (0.18) | 2.17 | ** | (1.32) |
| After 2010 | 0.40 | ** | (0.24) | 2.42 | *** | (1.61) |
| $R^2$ | 0.56 | | | 0.51 | | |
| *F test* for restricted model [c] | *F=487.5* ($P$ < 0.01) | | | *F=496.3* ($P$ < 0.01) | | |
| LM test | $\chi^2 = 928.9$ ($P < 0.001$) | | | $\chi^2 = 278.5$ ($P < 0.001$) | | |
| Hausman test | $\chi^2 = 18.8$ ($P = 0.84$) | | | $\chi^2 = 26.9$ ($P = 0.76$) | | |

The red meat model captured a higher WTP for beef products than that for lamb, where the coefficient of the variable ‘Beef’ is positive and statistically significant. Turning to coefficient estimates of CAs variables, the sign and statistical significance level are relatively consistent across the two models, except for ‘Environmental-friendly’ and ‘Grass-based’. Notably, however, the magnitudes of the CAs coefficients of the two models vary. Organic is estimated to be associated with the highest price premium for red meat products, which is consistent with the whole sample model. GM-free and hormone/antibiotic free products are also valued by consumers with a higher WTP, followed by products with food safety, GI and animal welfare. Here, for red meat products, consumer WTP for products with environmental-friendly attributes is ranked the lowest across all CAs. Nevertheless, for dairy products, food safety is estimated to be associated with the highest price premium, and WTP for products with animal welfare attributes is as high as that for GM-free and Hormone/ antibiotic free products. Particularly, organic products were associated with relative lower consumer WTP than all other CAs except for ‘Grass-based’, ‘Environmental-friendly’, and ‘Traceability’. Significantly, the sign of the coefficient associated with ‘Environmental-friendly’ is positive but not statically significant.

In terms of coefficients associated with regional differences, Australasian consumers value red meat products with CAs the most, followed by Asian, European and the North American consumers. As for dairy products, WTP ranks the highest in the Asian market, followed by EU and the North America. Concerning research methods coefficients, there are similar tendencies in the regression results of the two models. Similar as the whole sample model, WTP estimated by CE and CV method tends to be associated with higher value. Significantly, ‘Hypothetical’ has a positive impact on both dairy and red meat products, while the impact is greater on WTP for dairy than red meat. In addition, the survey methods provide various levels of WTP estimates, where information collected from in-person survey produce the highest WTP for both dairy and red meat products.

For both red meat and dairy, we found WTP estimates are affected by whether or not the primary studies have been published in academic journals. Here, the 'journal effect' is positive and statistically significant, which is consistent with the effect estimated by the whole sample model. Likewise, studies reporting negative WTP estimates tend to produce lower WTP estimates for both dairy and red meat, but the coefficient estimate of the red meat model is relative lower than that of the dairy model. Lastly, there is an increasing trend of WTP over time, according to the positive and statistically significant coefficient estimates of the time variables. Lastly, an obvious and similar time trend is shown by the positive and significant coefficients of the time variables in the two models. Nevertheless, we found a significantly larger rise in WTP for dairy products compared to the WTP rise for red meat over time.

### *3.3. Predicted WTP for price premium*

Although the individual coefficients in Tables 3 and 4 are sensitive to a number of modelling characteristics, it is worthwhile to consider the overall impact of the different meta-regression specifications on the WTP estimates for price premium of different CAs. A main purpose of WTP prediction is to evaluate the benefits of connecting market to farm by transferring price premium estimates that are based on the existing valuation literature. To do so, we choose the meta-regression results for the RE (by study) specifications of the whole model in Table 3 and the red meat model and dairy model in Table 4 to construct the predicted value of the WTP for price premium of each credence attribute. The predicted mean WTP estimates as well as the corresponding 95% confidence intervals are reported in Table 5. For all WTP predictions, the study year was set to be after 2010 to capture the recent demand for livestock products with CAs from the market Considering the uncertainties regarding whether the variable 'published in Journal' reflects study quality or publication bias, we followed Van Houtven et al. (2007) and set the value of the variable at 0.5. All other variables were set at their sample means, with the exception of the dummy variables corresponding to CAs, which are set to zero when they are not the predicted attribute.

Table 5.

Predicted WTP for price premium of livestock products (%)

| Model<br>CAs | Whole sample model | Red meat model | Dairy model |
|---|---|---|---|
| Environmental-friendly | 24.2 [2.2, 45.2] | 18.09 [-0.1, 36.28] | 25.36 [-1.53, 52.25] |
| Animal welfare | 32.28 [5.28, 59.28] | 18.35 [-2.19, 38.89] | 31.06 [10.51, 51.61] |
| Organic | 35.56 [14.12, 57] | 31.68 [8.4, 54.96] | 26.41 [3.13, 49.69] |
| GM free | 32.72 [11.82, 53.62] | 24.89 [1.53, 48.25] | 35.64 [22.28, 59] |
| Hormone/Antibiotic free | 31.65 [9.5, 53.8] | 24.58 [1.3, 47.86] | 34.51 [11.25, 57.77] |
| Grass-based | 25.11 [6.02, 49.55] | 22.62 [0.65, 44.59] | 25.11[6.02, 49.55] |
| Food safety | 29.32 [11.41, 47.23] | 22.29 [2.29, 42.29] | 39.23 [18.82, 59.54] |
| GI | 34.48 [19.41, 49.55] | 20.17 [1.17, 49.17] | 29.87 [11.33, 48.41] |
| Traceability | 19.77 [-1.39, 40.93] | 16.14 [-3.88, 36.16] | 18.39 [-1.83, 38.61] |

Using the whole sample model, for one unit change of livestock product associated with CAs, the estimated WTP for price premium is ranged from 19.77% (for 'Traceability') to 35.56% (for Organic). Turing to the red meat model, the predicted values of WTP should be seen as price premium of red meat products with CAs, where the predicted values are relatively lower than those in the whole sample model. The highest WTP is predicted to be 31.68% associated with organic red meat products, while the lowest value is associated with 'Traceability', with the predicted value of 16.14%. When looking at the dairy model, 'Food safety' is predicted to produce the highest WTP for price premium of dairy products, with the predicted value of 35.64%, whereas the lowest WTP ends up with 'Traceability', with the value of 18.39%.

## 4. Discussion and Conclusions

The number of empirical studies applied to estimate consumer WTP price premium of CAs of livestock products has expanded steadily since the mid-1990s. The resulting body of literature provides a potentially rich source of secondary data for designing policy instruments and marketing strategies to help consumers understand CAs, however, the heterogeneous results of the studies presents a challenge to provide reliable estimations of WTP. This paper explores how the existing literature can be used to systematically estimate WTP estimates of price premium across types of livestock products and CAs, with the consideration of heterogeneity of study characteristics.

Unlike qualitative literature reviews, which can be sensitive to the reviewer's subjective decision to emphasize particular price premium over others, our quantitative literature review statistically analyses tendencies in the literature to sway WTP estimates one way or the other.

Indeed, across the 94 studies included in the meta-analysis, we find several important results. For example, beef and dairy products with CAs are associated with higher price premium compared to lamb. In addition, to varying significance levels, the WTP estimates are particularly sensitive to the types of CAs, chosen estimation methods, publication characteristics, and time effects.

The results of our meta-analysis are useful in a number of respects. First, by knowing that the price elasticity of meat is sensitive to a number of characteristics, we gain additional insight into the nuances of meat demand. For example, in an effort to improve health outcomes, suppose a policymaker is considering levying a tax on beef and lamb or alternatively a subsidy on poultry and fish. Since the predicted absolute price elasticities of beef and lamb are quite similar, nearly 1 in table 4, a tax on these two meats would have similar effects on consumption, ceteris paribus. However, since the predicted absolute price elasticity of fish exceeds that of poultry, a subsidy on fish would promote a greater percentage increase in consumption compared with a similar subsidy on poultry, ceteris paribus. Second, since several model characteristics play an insignificant role in the meta regressions, the price elasticity of meat is somewhat insulated from these characteristics. In particular with the exception of meat demand at the firm level as well as demand in North America and parts of Europe, the price elasticity of meat is largely insensitive to data issues and the location of demand. Hence, less concern should be given to these issues when choosing a price elasticity. Finally, as a quantitative summary of the meat demand literature, the results of this meta-analysis are useful in many set settings. For example, not only can the results be incorporated into courses that address consumer behavior, but they also suggest avenues for future research, such as exploring in greater depth why some factors influence the price elasticity of meat, whereas other factors do not.

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