Hedonic Analysis of Origin of Meat In The United Kingdom

Mohamud Hussein[1†]

Iain Fraser[2]

Marco Costanigro[3]

Contributed Paper prepared for presentation at the 90th Annual Conference of the Agricultural Economics Society, University of Warwick, England

4 - 6 April 2016

[1]Visiting Researcher, School of Agriculture, Food and Rural Development, Agriculture Building, Newcastle University, Newcastle upon Tyne NE1 7RU, UK.

[†] Correspondence to be sent to Email: mhh5@kentforlife.net Tel: 0044 07984003898

[2] University of Kent, School of Economics, Keynes College, Canterbury, Kent, CT2 7NZ, UK

3 Colorado State University, College of Agricultural Sciences, Agricultural and Resource Economics, Fort Collins CO 80523-1172, United States

The authors wish to acknowledge funding from the Department for Environment, Food and Rural Affairs (Defra) for the research project (FA0156) on which this article is based. The views expressed in the article are entirely those of the authors and do not necessarily represent the views of Defra.

Abstract

We estimate the implicit prices consumers are willing to pay for country of origin labels, using hedonic price models and panel data on retail meat purchases in the United Kingdom (UK). We find that consumers place a significant value on the origin information, especially since the horsemeat incident in 2013. Both the horsemeat incident and resulting consumer response raise questions about the balance between mandatory and voluntary labelling. There is also the potential for unintended consequences for meat industry competitiveness and trade, which may affect consumer welfare negatively.

Keywords: Consumer Preference, Hedonic Price, Meat, Origin Labelling

JEL code: D120 Consumer Economics

Introduction

Use of country of origin labelling (CoOL) of food and agricultural products has increased markedly in recent years. There are a number of different reasons for the surge of origin-labelling of food such as increasing awareness and concern about food quality and safety (Herrmann and Teuber 2011). More importantly, a growing number of consumers place value on the traceability of the food they eat and, in addition, origin labelling is considered to be a counter-movement against increasing globalisation of food chains by multinational brands (Broude 2005, Herrmann and Teuber 2011). Meat authenticity and its origin has recently attracted the attention of European food regulators, industry and consumers, following a widely publicised incident which involved widespread fraud committed through undeclared intentional substitution of beef with horsemeat in a range of processed products in early 2013 (HM Goverment 2013). This fraud affected a wide range of branded and generic processed products including retail minced beef, burgers and ready meals such as lasagnes, pastas and pizzas sold in the United Kingdom (UK) and other European Union (EU) member states. A total of 4,144 beef products were tested for horse DNA across the EU and 192 beef samples (4.66%) of the total tested products, contained horsemeat at the time. The largest number of positive tests for undeclared horsemeat was identified in products on sale in France, followed by Greece and Denmark (House of Commons 2013). More disturbingly, some of the substitute meat came from horses not approved for human consumption as it contained a potentially harmful veterinary drug called phenylbutazone or bute. In particular, the products tested in UK had the largest number of positive results for bute (House of Commons 2013). In addition to the undeclared horsemeat, the tests also revealed the presence of substantial pork meat and traces of pork DNA in a range of processed products including burgers and lasagnes, and meat pies labelled as Halal respectively (HM Government 2013, FT Reporters 2013).

The horsemeat incident has in particular highlighted the complexity of the EU meat supply chain. It involved a food processor in France, its subsidiary in Luxembourg, a subcontractor in Cyprus, a meat trader in the Netherlands, abattoirs in Romania, and a number of food businesses in the UK and across Europe selling the end products (National Audit Office 2013). Even by 2015 the exact provenance of the adulterant horsemeat has not been established.[1]

In response to the incident the EU Commission initiated a range of administrative and legislative reforms intended to both increase industry compliance with existing compulsory CoOL for fresh beef plus its extension to other fresh meat. The existing provisions require producers to declare a unique product identification number or code, the name of the EU member state or third country in which the animal or group of animals were born, raised and slaughtered as well as the licence number of the cutting plant (European Parliament 2014).[2] In addition, as of April 2015, fresh, chilled and frozen pig, poultry, sheep and goat meat have to indicate the animal's country of rearing and slaughter (European Parliament 2013).

Nevertheless, existing EU mandatory CoOL regulations do not apply to beef sold unlabelled over the counter and uncooked meat that has been seasoned or included as an ingredient (e.g. processed beef burgers, steak and kidney pies). Nor do they apply to other (non-beef) processed products. As result, there are calls for extending the existing CoOL labelling for fresh meat to all processed meat to ensure the authenticity of these products (European

[1] In the UK some leading supermarkets, significantly affected by the scandal, such as Tesco, pledged to sources more meat domestically in the future (BBC 2013). Consumer preferences may also have shifted toward British-produced meats which are perceived more authentic than imports. According to a YouGov poll (2013) conducted immediate after the scandal, 79% UK consumers preferred to buy UK-sourced meat and poultry compared to imported meat.

[2] New enforcement measures directed at combating food fraud and more centrally coordinated testing programmes have been proposed. These include greater use of significant financial penalties, plus regulator-led mandatory unannounced official inspections and testing.

Parliament 2015). However, under the current legislation producers can voluntarily declare CoOL for meat incorporated in processed products, if they wish, providing that they follow the relevant guidelines.

Despite the significant shift in the EU meat labelling policy to stricter controls and the changes in the industry sourcing practices, it remains to be demonstrated whether consumers are willing-to-pay for meat and meat products labelled with British or other trusted CoOLs. Answers to these questions are pertinent as the current and future labelling EU/UK policies aim to address previous market failure – asymmetric information about meat authenticity – through potentially costly expenditures which will be borne by consumers, firms, and/or taxpayers as result of the mandatory CoOL.[3] Importantly, future policies should be socially optimal, in terms of balancing incremental cost and benefits of CoOL controls (Roe, Teisl, and Deans 2014).

In this article, we provide empirical evidence of UK consumers' valuation of CoOL for meat to inform future policymaking. We employ a hedonic price modelling approach and use retail meat sales data to estimate the implicit prices consumers' have paid for CoOLs across 20 top-selling meat and meat product lines, accounting for 170 different items sold by five leading UK retailers from 2010 to 2015. Previous studies on meat origin labelling use either in-store surveys, choice experiments or contingent valuations due to lack of suitable market data (Taylor and Tonsor 2013, Deselnicu et al. 2013). Market data is typically unavailable because the mandatory requirements for CoOL were not introduced until recently in the countries examined by these studies. This is not the case for the EU/UK where meat labelling requirement have existed since the late 1990s. Also, because we have monthly observations

[3] The costs of controls can be particularly high as meat authenticity requires use of sophisticated DNA- based analytical methods (O'Mahony 2013). Furthermore, since most of the processers handle more than one meat species, complete removal of trace levels of DNA may not be practical and hence adventitious presence can only be minimized, as a practical matter it cannot be eliminated entirely (Premanandh 2013).

our data also permits more flexible model specifications which can be tested for structural change in model parameters linked to any exogenous changes in industry and regulatory practices (Taylor and Tonsor 2013).

Our choice hedonic price analysis is motivated by two important reasons. First, CoOL is widely viewed as a key credence attribute which consumers value but cannot verify directly even after consumption and therefore often have to rely on other information such as brand reputation (Loureiro and Umberger 2007, Dentoni et al. 2009, Lim et al. 2013). A hedonic regression of meat price over CoOL allows us to determine the implicit price for such an attribute (Bajari and Benkard 2005, Costanigro and McCluskey 2011, Schulz, Schroeder, and White 2012). Second, using revealed preference panel data from actual retail sales enables us to provide greater insights into consumer purchasing behaviour and resulting implicit prices for CoOL, compared to stated preference research (Jones 1997, Capps 1989, Capps and Love 2002, Martínez-Garmendia 2010, Schulz, Schroeder, and White 2012). As such the main contribution of this article is the assessment of consumers' preferences and how they change over time as a result of the horsemeat scandal. Thus, our results can contribute to the current public policy debate on the role of CoOL in ensuring food authenticity in increasingly globalized supply chains.

Antecedent Literature

Consumers are continually confronted with a wide variety of product quality attributes provided through packaging, branding, advertising and other channels. Among these attributes is CoOL information which may influence consumers' preferences and purchase choice. Much past research suggests that CoOL has a significant effect on consumers' evaluations of products and that consumers tend to use CoOL as an extrinsic cue to make judgment about the quality of products (Agrawal and Kamakura 1999, Verlegh and Steenkamp 1999, Herrmann and Teuber 2011, Lim et al. 2013, Tonsor, Schroeder, and Lusk 2013, Deselnicu et al. 2013). If consumers hold a positive (negative) product–country image for a given product and country, this image could lead to a positive (negative) evaluation and attitude towards all the brands of a product associated with that country or region (Agrawal and Kamakura 1999). Essentially, origin information may provide a means to broadly categorise food choices, thereby facilitating consumer learning and the articulation of quality expectations (Deselnicu et al. 2013). Such beliefs and resulting expectations may exist even when consumers are largely unaware of origin labelling laws (Tonsor, Schroeder, and Lusk 2013).

Hedonic price functions have, in particular, been widely employed to determine implicit prices of food attributes for which there is no separate market. The underlying assumption is that the differentiated products in food markets are a bundle of utility-inducing product attributes (For an extensive review see, Costanigro and McCluskey 2011). Empirically, the prices of goods are regressed on the goods' attributes to estimate an implicit price for each attribute. The coefficients can be interpreted as the (marginal) market price for an attribute (Bajari and Benkard 2005). Thus, in a market equilibrium, this marginal price can be interpreted as a lower bound WTP for consumers who purchase a product with that attribute and an upper bound WTP for consumers who do not purchase the same product (Griffith and Nesheim 2013).

Meat products and associated quality attributes that are valued by consumers have been examined in the revealed preference literature. The types of attributes considered include product type, geographic origin, store type, sale items, composition (fresh, frozen, or cooked), and package size and branding (Lusk and Schroeder 2004, Parcell and Schroeder 2007, Schulz, Schroeder, and White 2012, Tonsor, Schroeder, and Lusk 2013). However, there are few revealed preference studies examining CoOL. This in part can be traced to the lack of data containing records of country of origin to estimate implicit prices for CoOL. Furthermore, the research that is published typically has a US focus. For example, Taylor and Tonsor (2013), used retail grocery-store scanner data to estimate a Rotterdam demand model of meat products. They did not detect any changes in demand for meat following a recent introduction of mandatory requirements for meat origin labelling in the US. Taylor and Tonsor (2013) argue that producers and consumers may have experienced a welfare loss due to the compliance costs imposed on the meat industry.

More generally, CoOL has been examined using stated preference research which reflects the need to understand consumer preferences prior to the introduction of CoOL. This research has been conducted in many countries, although much of the literature has focussed on beef. For example, Lim et al. (2013) conduct a discrete choice experiment (DCE) and estimate a latent class model with 1,079 US respondents, to examine consumers' willingness to pay for Canadian beefsteaks relative to US produced steaks. They estimated the range of discount needed for consumers to switch from U.S. to Canadian steak as $1.09 to $35.12 per pound. Pouta et al. (2010) also used a DCE to analyse the importance of broiler production methods and the country of origin for the Finnish consumers. They found strong consumer preferences for domestically produced broiler products.[4]

There is also limited research on meat origin labelling in the UK, and in particular on the potential effect of the recent horsemeat incident on demand. Although one study has reported a significant fall in demand for certain meat products sold by one the most affected UK retailers in the six weeks immediately following the horsemeat scandal (Yamoah and Yawson 2014), we are not aware of other published studies using actual market data. Other research that has examined meat CoOL has employed stated preference methods. For example, Meas et

[4] There are several stated preference studies which have examined US consumer preferences for CoOL for meat (Umberger et al. 2003, Ward, Bailey, and Jensen 2005, Miranda and Konya 2006, Mennecke et al. 2007, Loureiro and Umberger 2007, Gao and Schroeder 2009).

al.(2014) used a DCE to assess British consumers' preference for domestic and imported beef origins. They found a strong preference for domestic beef driven by consumer patriotism. As the survey data for this study were collected in autumn 2013, such ethnocentric preferences may have resulted from effects of the horsemeat scandal – an issue worth of investigation.

Thus, although there are accepted methods with which to examine CoOL there is a lack of research for the UK and more generally a lack of research based on market data to determine whether (a) the consumers stated preferences actually translate into revealed preferences, and (b) these preferences have changed over time and in response to the horsemeat incident.

Data

To undertake the analysis, we employed data obtained from the Kantar World panel, for retail meat sales of beef, lamb, pork, chicken and processed products of the same meats over a five year period between February 2010 and January 2015. The data is drawn from a panel of approximately 30,000 of households, who are geographically and demographically representative of the UK population. The households scan products they purchase by using technology provided by Kantar who then retrieve data automatically and collate it into databases on a four weekly cycle. In order to validate shopper-scanned data, Kantar also collects copies of purchase receipts. Each scanned item is identified by a unique stock keeping unit (SKU), a barcode used by retailers to manage stocks.

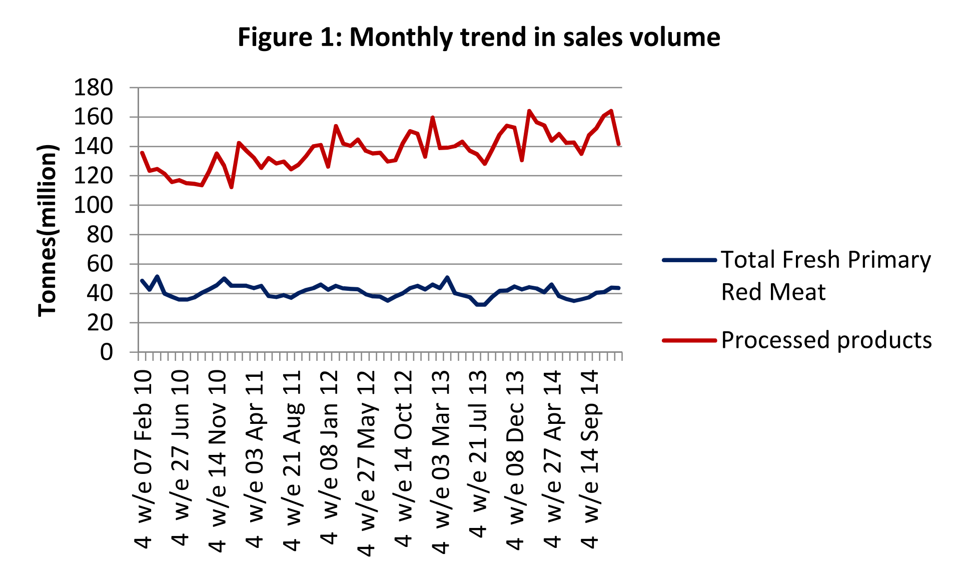
Our dataset is a balanced panel comprising of 20 SKUs, each containing either a single or multiple retail products. Although the multiple retail products within each SKU are differentiated by packaging size and other marketing strategies such as branding, price promotions, each SKU captures products with the same intrinsic attributes and CoOL label which is the variable of main interest here. Crucially, the data captures products legally required to carry a CoOL – mostly fresh beef products.

A description of the variables used in our analysis is provided in Table 1.

Table 1: Sample Data from Kantor World Panel for Meat Products		
Variable	Description	Categories/Range
SKUCode	Panel identifier (product code)	1 to 20
Price	Price/per Kg of meat product (£)	Average = £5.75 (£1.62-£18/Kg)
CoOL	Country of origin label	British, England, Irish, New Zealand, Undeclared
branv	Brand value categories	Premium, mid-range, value
packz	Pack size for different items under the same SKUCode	Large, medium, low
retai	Retailers	Asda, Morrisons, Sainsburys, M&S, Tesco
Eatq	Eating quality	Standard, quality-described
year	Year of purchase	2010 to 2015

Our data are composed of 881 observations over the five year period 2010 to 2015. Apart from price, which is a continuous variable, all other variables in the data set are categorical variables. In some cases, these attribute levels reflect an ordinary Likert-type scale with a ranking from lowest to highest value – e.g., low value, mid-range value and premium brands of marketed meat products. In other cases, they are unordered data such as names of retailers who own those brands.

In term of sales volumes, fresh meat accounts for the bulk of sales in the data set, see Figure 1. However, the demand for fresh meat shows a downward trend with some degree of seasonality, whilst the demand for processed products (including burgers, ready meals and pizza) has remained relatively stable over the five years. In terms of value, revenue from sales shows an upward trend across the product categories. The diverging trends in volume and value of sales point toward increased prices.



Our dependent variable, price, which has been adjusted for inflation and quality changes over the years, using the UK National Statistics Office's Consumer Price Index (CPI) for meat. This is a Laspeyres index which measures the change in the price of a basket of fixed composition, quantity and quality (Office of National Statistics 2014). The mean adjusted price in our data is £5.75/Kg, with range from £1.62 to £18/Kg. We can report that the highest prices are for products labelled as British origin, followed by New Zealand (which is typically lamb). We also note that most products sold for between £2.5/Kg and £7/Kg over the five year period covered by the data, whilst there are a small number of premium fresh and processed products with average prices higher than £10/Kg.

The use of the price Laspeyres index means we have accounted for the effect of any changes in quality on price which can be a major source of bias in the estimation of implicit prices if not properly accounted for (Hulten 2003, Diewert, Heravi, and Silver 2009). In the context of meat labelling, it is reasonable to expect that two types quality changes may have occurred over the five year period covered by the data: (i) compositional change, which may have resulted from reformulation of processed meat product, and (ii) (CoOL) innovation which may have affected consumers' perception of quality (Hulten 2003). By using the index, we remove the quality effect due to composition change, so that we can investigate the exogenous effects that the labelling innovation may have had on consumer's preferences and henceforth implicit prices for a product labelled with a CoOL.

The data includes the following four countries of origin: British, English, Irish, and New Zealand, plus an undeclared origin for the products not legally required to carry such information. As result, we code CoOL as a categorical variable with five different attribute levels. The composition of our sample by origin and product are shown in Table 2.

Table 2: Species versus country of origin

Species	British	English	Irish	New Zealand	Undeclared	Total	%
Beef	383	36	93	0	107	619	70
Chicken	0	0	0	0	80	80	9
Lamb	0	0	0	60	0	60	7
Pork	88	0	0	0	34	122	14
Total	471	36	93	60	221	881	100

The remainder of the (independent) variables we employ in our analysis can be considered as controls. First, we have brand value which has three categories: finest value coding for premium fresh meat cuts, mid-range value coding for most branded fresh meat and chilled or frozen processed products, and value coding for the lowest value mostly processed products such as pizza and burgers. Previous research has shown that brand value is an important determinant of price include Owen et al., (2000). In addition, Parcell and Schroeder (2007) found significant effects of brand, retailer type and pack size on implicit prices for beef and pork, and Roheim et al. (2007) also found that, in addition to brand; package size, product and process types have an impact on implicit prices.

Next we have pack size which is a categorical variable for different pack sizes sold under a specific SKU. We have grouped products in three sizes depending on weight: large (>0.9kg), medium (0.5kg-0.9kg) and small (<0.5kg). This coding strategy aims at grouping products under a smaller number of manageable categories which allow us to examine effects of origin on different types of products which may have been affected by the horsemeat incident.

Another control we have is a categorical variable coding the five major UK retailers (Tesco Asda, Sainsburys, Morrisons and M&S) selling the top 20 SKUs in our data. These retailers currently[5] have a grocery market shares of 29%, 16.9%, 16.7%, 11.1 and <2.7%. Thus, they account for more than 70% of UK grocery sales. However, we have a single product for M&S. To avoid biases due to infrequency of this retailer and reducing data for certain products, we merged M&S with Sainsbury which has more overlap in market share compared to other retailers in the data.

The final control variable is eating quality which is captured as a dummy variable if eating quality is explicitly signalled on a food label, with standard meaning no reference to specific quality attributes and the quality-described category referring to eating quality attributes such as meat, lean and thin cut.

Empirical Specification

Let y denote a $n \times 1$ vector of prices consumers pay for a unit of meat products and $\boldsymbol{X}'$ is an $n \times p$ matrix of meat quality attributes desired by consumers. We specify a hedonic price function based on a mixed linear effects model to describe the relationship between the price and attributes of a particular product as follows:

[5] Grocery Market Share, 12 weeks ending 01.02.2015, http://www.kantarworldpanel.com/en/grocery-market-share/great-britain

$$y_{it} = \boldsymbol{X'}_{it}\boldsymbol{\beta} + \boldsymbol{Z'}u_i + \varepsilon_{it} \tag{1}$$

where β is a vector of parameters for meat attributes whilst subscripts identify product (i) and time of purchase (t) respectively. $\boldsymbol{Z}$ is a set of observable product attributes, whereas u_i and ε_{it} are independent, identically distributed (i.i.d) errors; where $u_i \sim N(0, \Sigma_u)$ and $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$, where Σ_u is the variances and covariances of the random effects parameters (Cameron and Trivedi 2009, 298).

Given equation (1) how $\boldsymbol{Z}$ is modelled yields various different specification. For example, when **Z**=0 we have the standard pooled OLS specification, whereas a random effects (RE) specification is yielded when **Z**=1. However, treating u_i as an observed random effect drawn from the population alongside y_{it} and $\boldsymbol{X'}_{it}$, a Mixed Effects (ME) model can be employed to estimate effects of changes in one or more of the product attributes $\boldsymbol{X'}$ on the implicit prices (Rabe-Hesketh and Skronda 2008, p433-436).

The main advantage of this approach is that it allows an efficient estimation of $\boldsymbol{X'}_{it}\boldsymbol{\beta}$, the derivation of correct standard errors for $\widehat{\boldsymbol{\beta}}$ and consistent estimation of $\boldsymbol{\Sigma}_u$ and σ_u^2 even if ε_{it} is not homoskedastic as implied by the above i.i.d error structure (Cameron and Trivedi 2009,p300-304). This assumption is true if the variance of ε_{it} is much smaller than the $\boldsymbol{Z'}u_i$ component that accounts for the random intercept, so that the combined overall error, $\boldsymbol{Z'}u_i + \varepsilon_{it}$ can be allowed to be heteroskedastic (Cameron and Trivedi 2009,p304). We implement this empirical specification using our panel data and suitably specified ME random slopes and random trend models.

Model Selection

We considered several empirical specifications, including linear-linear, log-linear and log-log. However, as most variables in our data are categorical measures whose response to the changes in the dependent variable cannot be interpreted as absolute marginal changes but rather relative to a base or reference level within each variable, we focussed on linear-linear ME models and evaluated these based on tests for the presence of REs, normality of the residuals and model misspecification[6].

In line with previous research, we selected a model with price explained by country of origin and a set of other relevant covariates including brand, pack size, retail outlet and eating quality. We also add seasonal dummies to check whether the implicit prices are significantly affected by any changes in demand over the year.

General Specification

The model we specify is a simple hedonic price model based on the above empirical linear mixed effects specification (Equation 1):

$$Price_{it} = \beta_0 + \beta_1 cool_{it} + \beta_2\, branv_{it} + \beta_3 packz_{it} + \beta_4\, retai_{it} + \beta_5 eatq_{it} + \beta_6 Season_{it} + \ Retai(u_i) + \varepsilon_{it} \qquad (2)$$

As we are primarily concerned with estimating the average household valuation of CoOLs across product items and over time, a '*random-slopes*' ME model is appropriate, providing that the i.i.d error structure is specified correctly. We satisfy this condition by using a maximum likelihood estimator, clustering the variance Σ_u around our panel (product) identifier $SKUCode$ and allowing the random intercept u_i to be correlated with a key observed attribute in our data, the variable $retai$ (Cameron and Trivedi 2009,p300-304). We chose the variable *retai* to represents $\boldsymbol{Z}$ in this case because of the widely reported significant differences in the way UK retailers sourced and (mis)labelled meat products following the horsemeat scandal.

[6] We carried out the Breusch and Pagan Lagrangian multiplier test for random effects which strongly rejected the null hypothesis that there are no significant panel effects across the product items i.e. var(u_i) = 0, Chi-bar2(1)=415.27, pvalue=0.00. Thus, this finding justifies our choice for the ME model rather than a random effects model to deal with the heteroskedasaticity. The Doornik–Hansen test for bivariate normality test for pairs of *price* and other variables in the model is strongly also rejected the null hypothesis. We also tested the selected model for multicollinearity based on Variance Inflation Factor (VIF) test.

Also, previous research found that the retail outlet is an important determinant of the consumers preferences in relation to the implicit prices for country of origin (Parcell and Schroeder 2007). Therefore, it is reasonable to expect that much of the heterogeneity in our data lies in the product type-retailer space such that the variance of the error component $\boldsymbol{Z}'u_i$ is much larger than the variance of the idiosyncratic component ε_{it}. Ascertaining the relative size of variances is thus a crucial test in our case to verify whether the heteroscedasticity of the combined error can be tolerated, so that the implicit prices and random effects are estimated both efficiently and consistently.

Detecting Structural Breaks

Given that the random intercept accounts for the product-specific heterogeneity, the time-varying error component ε_{it} is essentially left with capturing residual heterogeneity across SKUCodes. Additionally, as we have adjusted the price for both inflationary and qualify effects, the time-varying unobserved heterogeneity is then due to exogenous changes such as structural shifts in consumers' preferences toward or away from consumption of a product(s) with a certain CoOL over time. Therefore, in addition to estimating the mean implicit prices for different CoOLs, we can exploit our data properties more and evaluate the impact the horsemeat scandal on the estimated implicit prices.

As noted above, the advantage of the monthly retail consumption data in hand is that is allows for more accuracy in the matching any consumption changes due to the horsemeat scandal and tests of structural change in parameters in the estimated models (Taylor and Tonsor 2013). For this purpose, we generate a time dummy variable d, with $d = 0$ coding meat sales before the onset of the scandal, January 2013, and $d = 1$ after 2013, and interact d with CoOL, so that we can test for structural changes in the parameters due to horsemeat scandal (see Baltagi et al.

(2009) and Rajan and Zingales (2003). The addition of these new regressors means that we modify equation (2) as follows:

$$Price_{it} = \beta_0 + \delta_1 d_t + \beta_1\, cool_{it} + \delta_2 d_t * cool_{it} + \beta_2\, branv_{it} + \beta_3 packz_{it} + \beta_4\, retai_{it} + \beta_5 eatq_{it} + \beta_6 Season_{it} + Retai(u_i) + \varepsilon_{it} \qquad (3)$$

The resulting structural model is a special case of what is known as '*random trend model'*, with both d_t and $\boldsymbol{Z}'u_i$ now allowed to correlate with the variable $retai$, so that the mean implicit prices for different CoOLs depend on a product-specific time trend, in addition to the random intercept u_i (Wooldridge 2002 , p318). If δ_2 is statistically significant and different from zero, the parameters for individual CoOLs have changed, meaning consumers preferences have shifted across different SKUCodes. Therefore, the equation (3) has a fundamental causal interpretation: holding other regressors and u_i constant, the difference between the slopes for $cool$ category levels is a direct measure of the effect of exogenous changes in preferences for the respective declared origins due to the horsemeat incident (Wooldridge 2002 see p308).

Results

Our results are based on the estimation of equations (2) and (3). First, we examine the results for the general model based on equation (2). We then examine the structural equation (3) to assess the impact of the horsemeat incident on CoOL.

General Model Specification

The results for the equation (2) are reported in Table 3. These are organised in three parts: first part of the Table reports the estimated (fixed effects) coefficients, the second part reports parameters for the random part of the model, and the third part reports the goodness of fit measures for the estimated model.

With regard to CoOLs, the coefficients for English and Irish origins are positive but highly insignificant. In contrast, the coefficient for Undeclared origin is negative and highly significant, suggesting that households are willing to pay on average £2/Kg less for the products with no declared origin compared to those labelled with a British origin which is set a reference level for CoOL. The coefficient for New Zealand is large, positive and highly significant. This finding indicates that, after adjustment for any differences in covariates, the mean difference in price for a product originating in New Zealand was approximately £4/Kg greater than for the same product, with the same SKU, of British origin. The New Zealand origin label reflects some premium lamb products with long-established markets in the UK.

The estimated coefficients for $packz$ are positive but only the coefficient for small packs is significant. As the largest pack size is set a reference level, the findings suggest that smaller size packs are more expensive, in terms of aggregate weight per kilo. With regard to brand, the coefficients for mid and value ranges are negative and but only the implicit price for the value range is marginally significant at 5%. This unsurprisingly suggests that, in general, households place less value on these brands compared to the premium brands. In contrast, products carrying label description indicating a superior eating quality attract higher prices compared to the standard category.

Table 3: Estimated Coefficients, (N=881)				
Price (Dependent variable)	Coeff.	S.E	z	P>|z|
CoOL(base=British†)				
English	0.933	0.577	1.62	0.106
Irish	0.679	0.499	1.36	0.174
New Zealand	4.129	0.502	8.23	0.000
Undeclared	-2.043	0.731	-2.80	0.005
branv (premium)				
Mid-range	-1.570	0.798	-1.97	0.049
Value	-0.796	0.575	-1.39	0.166
packz (large)				
Medium	0.873	0.605	1.44	0.149
Small	2.466	0.217	11.34	0.000
retai(Asda)				
Morrisons	-2.784	0.995	-2.80	0.005
Tesco	-0.874	0.897	-0.97	0.330
Sainsbury/M&S	-2.101	1.016	-2.07	0.039
Eatq(standard)				
Quality	1.326	0.458	2.89	0.004
Seasonality				
S1 (Jan-March)	-0.012	0.116	-0.10	0.921
S2 (April-June)	0.092	0.115	0.80	0.424
S3 (July-Sept)	-0.0109	0.114	-0.10	0.924
Intercept(β_0)	6.261	1.431	4.38	0.000
Random effects parameters ($\boldsymbol{u_i}$)				
Var(retai)	0.119	0.057		
Var(β_0)	2.955	1.350		
cov(retai,β_0)	1.462	0.070		
var(Residual)	1.462	0.070		
LR test vs. linear model	chi2(3) = 110.96, Prob > chi2 = 0.000			
Goodness of fit				
Likelihood Ratio	=-1434.5874			
Wald chi2(15)	=643.77, Prob>chi2 = 0.000			

The results for random part of the model justify our decision to correlate retailers with the heterogeneity captured by the random intercept. Not only the most of the estimated coefficient for retailers are significant but also the variance of u_i (2.95) is twice of the size of the variance of ε_{it} (1.46). This means that the random intercept shifts the overall model constant by its sizeable standard deviation of 1.72. Also, the covariance between u_i and the constant (β_0) is relatively large (-0.59), and based on the size of the estimated standard errors, the random parameters are significant. Furthermore, likelihood ratio (LR) the tests for null hypothesis that the linear regression model in which a single intercept (and hence ignoring the random intercept for SKUCode) is strongly rejected by the data, Chi^2=110.96, P value=0.00.

With regard to overall fit, the model has Wald Chi^2 test statistic of (15) =643.77 and is significant at 1%.

Structural Model Specification

The results for Equation 3 are reported in Table 4 which summarises the coefficients for CoOLs and respective structural parameters (bold font). The null hypothesis that δ_2 (for d*cool) is not significantly different from zero is strongly rejected for all CoOLs except New Zealand; hence there has been a significant shift in the preferences for most meat and meat products in the data following the horsemeat incident. Furthermore, the parameters for all CoOLs levels are all positive, including the parameter for products not governed by the mandatory labelling scheme but can nevertheless be labelled voluntarily. The insignificant parameter for New Zealand would indicate in this case that the horsemeat had a negative impact on imported products compared to meat produced in the British Isles.

Table 4: Estimated Coefficients and Structural Parameters (N=881)				
Price (Dependent variable)	Coeff.	S.E	z	P>|z|
CoOL(*base=British†*)				
English	0.039	0.625	0.06	0.951
d*English	**1.419**	**0.424**	**3.34**	**0.001**
Irish	0.008	0.498	0.02	0.986
d*Irish	**1.519**	**0.278**	**5.45**	**0.000**
New Zealand	3.915	0.503	7.78	0.000
d*New Zealand	**0.492**	**0.329**	**1.50**	**0.134**
Undeclared	-2.480	0.721	-3.44	0.001
d*Undeclared	**0.347**	**0.200**	**1.73**	**0.084**
branv (premium)				
Mid-range	-1.815	0.775	-2.34	0.019
Value	-0.706	0.556	-1.27	0.204
packz (large)				
Medium	0.535	0.590	0.91	0.365
Small	2.480	0.212	11.71	0.000
retai(Asda)				
Morrisons	-3.029	0.964	-3.14	0.002
Tesco	-1.061	0.867	-1.22	0.221
Sainsbury/M&S	-2.292	0.985	-2.33	0.020
Eatq(standard)				
Quality	1.330	0.444	2.99	0.003
Seasonality				
S1 (Jan-March)	-0.022	0.114	-0.19	0.849
S2 (April-June)	0.101	0.112	0.91	0.364
S3 (July-Sept)	-0.004	0.111	-0.04	0.970
Intercept(β_0)	6.721	1.393	4.82	0.000
Random effects parameters ($\boldsymbol{u_i}$)				
Var(retai)	0.110	0.053		
Var(β_0)	2.746	1.255		
cov(retai,β_0)	-0.550	0.258		
var(Residual)	1.387	0.066		
LR test vs. linear model	chi2(3) = 118.77, Prob > chi2 = 0.000			
Goodness of fit				
Likelihood Ratio	=-1411.09			
Wald chi2(15)	=727.90, Prob>chi2 = 0.000			

With regard to the changes in the sign of the parameter for undeclared origin, it appears that, following the horsemeat producer started to declare British origin voluntarily on products not required legally to carry such information. This would suggest that, as consumers started to purchase less of the processed products with no origin labels, the producers and retailers started to declare the origin of these products more voluntarily. In this case, the greater uptake of the voluntary scheme may also have reflected a pre-emptive industry move to respond to the potential threat of stricter regulation from the calls for extension of the existing mandatory CoOL labelling for fresh meat to all processed meat to ensure the authenticity of these products.

Discussion and Conclusion

In this article we have assessed UK consumers' valuation of CoOL as a signal of authenticity attribute for meat and meat products. We have also assessed the extent to which the consumer valuation has been affected by the horsemeat incident. Our findings suggest that consumers do place a significant value on CoOL for meat, with British origin valued greater than Irish and English origin labels.

We also found that the widely reported horsemeat scandal in early 2013 has resulted in significant changes in industry practices. Due to the greater awareness of meat authenticity, demand appears to have shifted in favour of British and Irish origins, in particular for processed products which were historically labelled less with origin as they are not legally required to carry such information. This finding is not surprising as consumers' confidence in these products was ostensibly dented severely due to the widely reported lack of control of authenticity of imported meat which involved long and complex supply chains (Crane and Brown 2013).

Two broad policy-relevant conclusions can be drawn from our analysis. First, the threat of stricter meat regulation with potentially an expanded scope across species and product categories appears to have forced the industry to origin-label processed products voluntarily. However, given the voluntary nature of this effort, its effectiveness is uncertain in the longer. If consumers' WTP for home-grown meat is not sustained, meat supply for certain products may shift back to imports with possible repeats of past authenticity incidents, especially where the current industry governance systems for testing and verification of the authenticity are not sustained in the future. The extension of the existing mandatory labelling scheme may not be economically justified in this scenario as the preferences for origin-labelled meat might gradually dissipate in the absence of consumer trust in labels in the future. Also, the social benefits of the mandatory scheme over the voluntary approach may evaporate once cost advantages of imported unlabelled meat are realised and CoOL becomes legally required. The mandatory CoOL could in fact see an increase in imports because of the higher prices of UK-produced meat.

Second, the growth in the uptake of the extension of the mandatory scheme may have trade implications, if the demand for CoOL persists. On the one hand, labels highlighting positive meat attributes may stimulate high-value exports from third countries with valued labels such as New Zealand. On the other hand, the exporters of less valued labels may face a significant decline in their export revenues and as result resort to trade disputes against the mandatory labelling scheme. Less than one year after new mandatory CoOL labelling rules were introduced in the US, Canada and Mexico challenged these rules in the World Trade Organization (WTO), arguing that the scheme has a trade-distorting impact by reducing the value and number of cattle and hogs shipped to the U.S. market, thus violating WTO trade commitments agreed to by the United States (Jurenas and Greene 2013). If they occur in Europe, such lawsuits and WTO hearings may call into question the relative value of CoOL labelling to consumers as compared to costs faced by both domestic meat processors and trading partners.

Also, if demand for CoOL persists and UK-produced meat significantly displaces imports, it is likely that this will have supply-side implications for the UK meat industry, potentially reducing its competitiveness in the longer run. Any decline in the technical efficiency resulting in further price increases may also have demand-side implications as low income consumers spend higher proportions of their income on meat purchase and consequently may not be able to afford meat as a basic food category unless they reallocate income away from other nutritionally critical food categories such as fruits and vegetables.

References

Agrawal, Jagdish, and Wagner A. Kamakura. 1999. "Country of origin: A competitive advantage?" *International Journal of Research in Marketing* 16 (4):255-267. doi: http://dx.doi.org/10.1016/S0167-8116(99)00017-8.

Bajari, Patrick , and C. Lanier Benkard. 2005. "Demand Estimation with Heterogeneous Consumers and Unobserved Product Characteristics: A Hedonic Approach." *Journal of Political Economy* 113 (6):1239-1276.

Baltagi, Badi H., Panicos O. Demetriades, and Siong Hook Law. 2009. "Financial development and openness: Evidence from panel data." *Journal of Development Economics* 89 (2):285-296. doi: http://dx.doi.org/10.1016/j.jdeveco.2008.06.006.

BBC. 2013. "Tesco pledges to sell meat from 'closer to home'." 27 February 2013.

Broude, Tomer 2005. "Taking "Trade and Culture" Seriously: Geographical Indications and Cultural Protection in WTO Law." *Journal of International Law* 4 (4).

Cameron, A. Colin , and Pravin K. Trivedi. 2009. *Microeconometrics Using Stata, Revised Edition*: Stata press.

Capps, Oral, Jr. 1989. "Utilizing Scanner Data to Estimate Retail Demand Functions for Meat Products." *American Journal of Agricultural Economics* August:750-60.

Capps, Oral, Jr., and Alan H. Love. 2002. "Considerations in the Use of Electronic Scanner Data to Conduct Consumer Demand Analysis." *American Journal of Agricultural Economics* 84 (3):807-816.

Costanigro, Marco, and J. McCluskey, Jill. 2011. "Hedonic Price Analysis in Food Markets." In *The Oxford Handbook of the Economics of Food Consumption and Policy*, edited by Jayson L. Just, Jutta Roosen and Jason F. Shogren. Oxford University Press.

Crane, Jill , and Georgiana Brown. 2013. FSA–consumer attitudes to towards the horse meat contamination issue. Food Standards Agency.

Dentoni, Domenico, Glynn T. Tensor, Roger J. Calantone, and H. Chistopher Peterson. 2009. "Direct and indirect effects of 'locally grown' on consumers attitude to agri-food products." *Agricultural and Resource Economics Review* 38 (3):184-196.

Deselnicu, Oana C. , Marco Costanigro, Diogo M. Souza-Monteiro, and Dawn Thilmany McFadden. 2013. "A Meta-Analysis of Geographical Indication Food Valuation Studies: What Drives the Premium for Origin-Based Labels?" *Journal of Agricultural and Resource Economics* 38 (2):204–219.

Diewert, W.Erwin , Saeed Heravi, and Mick Silver. 2009. "Hedonic Imputation versus Time Dummy Hedonic Indexes." In *Price Index Concepts and Measurement*, edited by W.Erwin Diewert, John S. Greenlees and Charles R. Hulten. University of Chicago Press.

European Parliament. 2013. Commission Implementing Regulation(EU) 1337/2013 of 13 December 2013, laying down rules for the application of Regulation (EU) No 1169/2011 of the European Parliament and of the Council as regards the indication of the country of origin or place of provenance for fresh, chilled and frozen meat of swine, sheep, goats and poultry.

European Parliament. 2014. Regulation(EU) 635/2014 fo European Parliament and of the Council 14 May 2014, amending Regulation (EC) No 1760/2000 as regards electronic identification of bovine animals and labelling of beef.

European Parliament. 2015. Press Release:Food safety MEPs call for country of origin labelling of meat in processed foods, 21-01-2015 - 19:17.

FT Reporters. 2013. "Supermarkets withdraw contaminated burgers." *Financial Times*, January 16, 2013.

Gao, Zhifeng, and Ted C. Schroeder. 2009. "Effects of Label Information on Consumer Willingness-to-Pay for Food Attributes." *American Journal of Agricultural Economics* 91 (3):795-809. doi: 10.1111/j.1467-8276.2009.01259.x.

Griffith, Rachel, and Lars Nesheim. 2013. "Hedonic methods for baskets of goods." *Economics Letters* 120 (2):284-287. doi: http://dx.doi.org/10.1016/j.econlet.2013.04.040.

Herrmann, Roland, and Ramona Teuber. 2011. "Geographically differentitated products." In *The Economics of Food Consumption and Policy*, edited by Jason L. Lusk, Jutta Roosen and Jill J. McCluskey. Oxford University Press.

HM Goverment. 2013. Elliott Review into the Integrity and Assurance of Food Supply Networks – Final Report.

HM Government. 2013. Information about the actions following discovery of undeclared horse DNA in meat products.

House of Commons. 2013. Food Contamination:Fifth Report of Session 2013–14, Volume I. edited by Food and Rural Affairs Committee Environment.

Hulten, Charles R. 2003. "Price Hedonics: A Critical Review." *FRBNY Economic Policy Review* September.

Jones, Eugene 1997. "An Analysis of Consumer Food Shopping Behavior Using Supermarket Scanner Data: Differences by Income and Location." *American Journal of Agricultural Economics* 79 (5):1437-1443.

Jurenas, Remy , and Joel L. Greene. 2013. CRS Report for Congress Prepared for Members and Committees of Congress Country-of-Origin Labeling for Foods and the WTO Trade Dispute on Meat Labeling edited by Congressional Research Service.

Lim, Kar H., Wuyang Hu, Leigh J. Maynard, and Ellen Goddard. 2013. "U.S. Consumers' Preference and Willingness to Pay for Country-of-Origin-Labeled Beef Steak and Food Safety Enhancements." *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 61 (1):93-118. doi: 10.1111/j.1744-7976.2012.01260.x.

Loureiro, Maria L., and Wendy J. Umberger. 2007. "A choice experiment model for beef: What US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability." *Food Policy* 32 (4):496-514. doi: http://dx.doi.org/10.1016/j.foodpol.2006.11.006.

Lusk, Jayson L., and Ted C. Schroeder. 2004. "Are Choice Experiments Incentive Compatible? A Test with Quality Differentiated Beef Steaks." *American Journal of Agricultural Economics* 86 (2):467-482. doi: 10.1111/j.0092-5853.2004.00592.x.

Martínez-Garmendia, Josué. 2010. "Application of hedonic price modeling to consumer packaged goods using store scanner data." *Journal of Business Research* 63 (7):690-696. doi: http://dx.doi.org/10.1016/j.jbusres.2009.05.002.

Meas, Thong, Wuyang Hu, Carola Grebitus, and Greg Colson. 2014. "The Effects of Country of Origin Image and Patriotism on British Consumers' Preference for Domestic and Imported Be." Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting,, Minneapolis, MN, July 27- 29, 2014.

Mennecke, B. E. , A. M. Townsend, D. J. Hayes, and S. M. Lonergan. 2007. "A study of the factors that influence consumer attitudes toward beef products using the conjoint market analysis tool." *Journal of Animal Science* 85 (10):2639-2659.

Miranda, Mario J., and Laszlo Konya. 2006. "Is mandatory country-of-origin labelling a retrograde step in the long run?" *The International Review of Retail Distribution and Consumer Research* 12.
National Audit Office. 2013. Food safety and authenticity in the processed meat supply chain.
O'Mahony, J. P. 2013. "Finding horse meat in beef products—a global problem." *Q J Med* 106:595–597.
Office of National Statistics. 2014. Consumer Price Indices:Technical Manual, 2014 Edition.
Owen, Kate , Vic Wright, and Garry Griffith. 2000. "Quality, Uncertainty and Consumer Valuation of Fruits & Vegetables " *Australian Agribusiness Review* 8.
Parcell, Joseph L. , and Ted Schroeder. 2007. "Hedonic Retail Beef and Pork Product Prices." *Journal of Agricultural and Applied Economics* 39 (1):29-46.
Pouta, E., J. Heikkilä, S. Forsman-Hugg, M. Isoniemi, and J. Mäkelä. 2010. "Consumer choice of broiler meat: The effects of country of origin and production methods." *Food Quality and Preference* 21 (5):539-546. doi: http://dx.doi.org/10.1016/j.foodqual.2010.02.004.
Premanandh, Jagadeesan 2013. "Horse meat scandal - A wake-up call for regulatory authorities." *Food Control* 34:568-569.
Rabe-Hesketh, Sophia , and Anders Skronda. 2008. *Multilevel and Longitudinal Modeling Using Stata:Categorical Responses, Counts, and Survival*. Second ed: Stata Press.
Rajan, Raghuram G., and Luigi Zingales. 2003. "The great reversals: the politics of financial development in the twentieth century." *Journal of Financial Economics* 69 (1):5-50. doi: http://dx.doi.org/10.1016/S0304-405X(03)00125-9.
Roe, Brian E., Mario F. Teisl, and Corin R. Deans. 2014. "The Economics of Voluntary Versus Mandatory Labels." *Annual Review of Resource Economics* 6 (1):407-427. doi: doi:10.1146/annurev-resource-100913-012439.
Roheim, Cathy A., Lacey Gardiner, and Frank Asche. 2007. "Value of Brands and Other Attributes: Hedonic Analysis of Retail Frozen Fish in the UK." *Marine Resource Economics* 22: 239–253.
Schulz, Lee L. , Ted C. Schroeder, and Katharine L. White. 2012. "Value of Beef Steak Branding: Hedonic Analysis of Retail Scanner Data." *Agricultural and Resource Economics Review* 41 (2):260–273.
Taylor, Mykel R. , and Glynn T. Tonsor. 2013. "Revealed Demand for Country-of-Origin Labeling of Meat in the United States." *Journal of Agricultural and Resource Economics* 38 (2):235–247.
Tonsor, Glynn T., Ted C. Schroeder, and Jayson L. Lusk. 2013. "Consumer Valuation of Alternative Meat Origin Labels." *Journal of Agricultural Economics* 64 (3):676-692. doi: 10.1111/1477-9552.12010.
Umberger, Wendy J. , Dillon M. Feuz, Chris R. Calkins, and Bethany M. Sitz. 2003. "Country-of-Origin Labeling of Beef Products: U.S. Consumers' Perceptions." *Journal of Food Distribution Research* 34 (3).
Verlegh, Peeter W. J., and Jan-Benedict E. M. Steenkamp. 1999. "A review and meta-analysis of country-of-origin research." *Journal of Economic Psychology* 20 (5):521-546. doi: http://dx.doi.org/10.1016/S0167-4870(99)00023-9.
Ward, Ruby A., DeeVon Bailey, and Robert T. Jensen. 2005. "An American BSE Crisis: Has it affected the Value of Traceability and Country-of-Origin Certifications for US and Canadian Beef?" *International Food and Agribusiness Management Review* 8 (2).
Wooldridge, Jeffrey M. 2002. *Econometric analysis of cross section and panel data*: MIT Press.
Yamoah, Fred A. , and David E. Yawson. 2014. "Assessing Supermarket Food Shopper Reaction to Horsemeat Scandal in the UK." *International Review of Management and Marketing* 4 (2):98-107.
YouGov. 2013. Meat & poultry: Locally-sourced key.