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Jose Eduardo Ribeiro, Adelina Gschwandter and
Cesar Revoredo-Giha

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Estimation of a Hedonic Price Equation with instruments for Chicken Meat in the UK: Does the Organic Attribute matter?

Jose Eduardo Ribeiro, Adelina Gschwandter and Cesar Revoredo-Giha[*]

Abstract

Chicken meat consumption has increased substantially in the last decades due to farming and processing intensification and due to perceived health and environmental benefits for consumers. Organic chicken additionally, is perceived to have better taste, lead to higher animal welfare and additional benefits for the environment. Thus understanding consumers' preferences for organic chicken is central for policy-making and market strategies that can shape this market in the future. This paper uses a comprehensive data set of scanned shoppings from UK consumers, to show that they are willing to pay an average premium of 135% for the organic attribute in the case of chicken. In addition, this paper contributes to the literature of environmental valuation, demonstrating that household characteristics can be used as instruments into a GMM approach to a hedonic price model, to address the endogeneity issues usually ignored in this literature.

JEL classification: C26, Q18, Q51

Keywords: Hedonic Pricing Method, Instrumental Variables, Organic Food

[*]The first two authors are from the School of Economics of the University of Kent/UK. The third author is from SRUC/Edinburgh/UK. The second author is the corresponding author: a.gschwandtner@kent.ac.uk

Non-technical summary

The consumption of chicken meat has increased significantly worldwide in the last few decades. Increasingly, consumers substitute red meat for chicken meat, which is perceived to be healthier and to have a lower carbon footprint. ***Organic*** chicken meat is perceived additionally to have a better taste, to lead to higher animal welfare and to be healthier.

In the present study we estimate the premium that UK consumers are willing to pay for the ***organic attribute*** in the case of chicken meat. This is essential at the present time when the UK is exiting the European Union and agricultural policy is likely to be reformed.

We use a comprehensive data set of scanned shopping of UK consumers and employ a methodology that allows us to disentangle precisely the contribution of the organic attribute to the price of chicken meat and to control for potentially omitted variables.

We find that the organic attribute accounts for a much larger proportion of chicken meat value than previously believed. Organic food products provide a series of benefits to consumers involving their direct use and their value to the environment and the society as a whole, and the present paper suggests a way in which these can be estimated more accurately to be better suited for potential policy recommendations.

1 Introduction

There has been a significant increase in breeding and consumption of chicken globally, altogether with a potential positive effect on consumers' diet (health) and reduced carbon footprint.[1] The rise in chicken consumption has driven large attention among consumers, producers and suppliers and, has been reflected in the media more recently (BBC, 2018; The Economist, 2019; The Guardian, 2018). The organic approach to food production adds to these potential benefits a perceived better taste, more environmentally friendly production and higher animal welfare. Thus, understanding consumer preferences for the organic attribute in chicken appears as a necessary step forward. This paper values the premium UK consumers actually pay for the organic attribute, and this information can be used in policy-making considerations, from social marketing (considering organic food as merit good) to the valuation of the right supply incentive to match local demand.

According to the OECD (2017) global consumption of chicken has grown 134 percent since 1990. The bird counts for 23bn of the 30bn land allocated to animals living in farms (Bennett et al., 2018). Intuitively, price is one of the main drivers of such an increase in consumption, as producers have been able to reduce average costs through methods such as selective breeding and as a consequence, reduce the price. Chickens are not only large in numbers, but have also grown in size. The average weight of a 56 days old chicken in 1957 was 0.9 kilograms, while in 2005 was 4.2 kilograms (Zuidhof et al., 2014). Chicken appears to be the most consumed meat in the world at this point, and this applies to the UK too, as shown in Figure 1 (Appendices). Because of this reason, it is useful to understand the contribution of each attribute to the willingness to pay for broiler chicken and especially the one of the organic attribute.

Ribeiro (2019) shows in his meta-analysis that on average organic products are considered to have a positive overall impact on individuals (especially health), the environment (soil, pollination and biodiversity protection), and animal welfare (humane farming).[2] These perceived benefits have been pivotal to the significant increase in the production and consumption of organic products worldwide. However, in the UK, the picture looks somewhat different. While sales were increasing, in-line with the global trend up to 2008, there was a noticeable dip after the 2008-2010 financial crisis (Figure 2, Appendices). Despite 6 years of strong growth, sales are only just regaining their 2008 level, while organic farmland has decreased 5 percent per annum since 2011 in the country, as farmers are converting back to conventional production (Soil Association, 2018) potentially missing out important financial and environmental opportunities.

The present paper aims to estimate in a robust manner the premium consumers are willing to pay for the organic attribute in chicken meat. This is important for organic chicken farmers but also in order to appreciate the merits of any policy options related to consumption and production of organically farmed chicken in the UK. In order to do so the present study employs a hedonic price (HP) method using an instrumental variable approach where consumers characteristics are employed as instruments. HP is a revealed preference approach that uses information from actual behaviour of consumers, and shows how different product characteristics contribute to the price of the product. However, as discussed in the literature, the model suffers from econometric issues, which are often ignored in empirical work. Most notably the endogeneity of the product characteristics, which in the case of this study, includes the organic attribute. To address this issue, the present paper uses the generalised method of moments (GMM), using consumer characteristics as instruments. This is something that to our knowledge has not been done before and constitutes the main

[1] If consumers replaced red meat with chicken.

[2] There is a valid argument however, that organic agriculture has lower yields than conventional agriculture, and critiques argue that it would therefore need more land to produce the same amount of food resulting in more deforestation and biodiversity loss undermining the principle of environmentally friendly production (Seufert et al., 2012; Meemken and Qaim, 2018).

contribution of the paper.

The issue of endogeneity in HP models derived from the simultaneous estimation of supply and demand, has been first risen by Rosen (1974) in his seminal work. Despite of this, very few studies have tried to address it. Follain and Jimenez (1983) & Follain and Jimenez (1985) seem to be two of the few exceptions. Other studies that use instrumental variables in a hedonic price model are Combris et al. (1997) and Gopalakrishnan et al. (2011). However, these two studies do not address the original endogeneity problem discussed by Rosen (1974). Combris et al. (1997) analyze the importance of the attribute 'Quality' in the determination of the price of Bordeaux wine and use instruments to address the endogeneity between the length of the jury reports and the quality of the wine assessed by these reports. Gopalakrishnan et al. (2011) estimate the value of beach width capitalized in the values of properties situated close to those beaches using instruments to address the endogeneity between the two. Properties close to beaches with a larger width have higher prices but beaches close to properties with higher values tend to be broader due to more frequent beach nourishment programs that combat erosion. Both these studies address endogeneity caused by reversed causation and find that instrumenting has a significant impact on the results. Nevertheless, most HP studies do not address the endogeneity issue at all. Kahn and Lang (1988) and Wooldridge (1996) are two of the few exceptions that addresses it both from a theoretical and empirical point of view and suggest how instruments can be used to solve it (Kahn and Lang, 1988 in a 3SLS and Wooldridge, 1996 in a GMM setting). However, the main focus of these two papers is the econometric theory and not the empirical applications. In the present case the robust estimation of the premium for the organic attribute of chicken in the UK is essential. Some of the papers mentioned here will be discussed in more detail in the next section when explaining the instrumental strategy which constitutes the main novelty of the present paper.

The present paper contributes to the environmental valuation literature, by comparing results obtained with OLS and 2SLS with the ones obtained with GMM - the method that is considered to be most appropriated for an instrumental variable approach in a hedonic pricing setting according to Wooldridge (1996). The results show that ordinary least square (OLS) is potentially underestimating the contribution of the specific attributes while 2SLS appears to overestimate it when applied in the hedonic pricing setting. This is relevant as HP is widely accepted for its reliance on actual market prices, whilst alternative stated models from surveys and experiments are often criticized for their hypothetical nature. The present paper shows how the simultaneity of the marginal price and quantity of attributes implies that the product characteristics are potentially endogenous. It illustrates that GMM offers a reliable solution to this endogeneity problem and appears to be more appropriate not only than OLS but also than 2SLS. In line with Wooldridge (1996), this study suggests that, whenever applicable, consumer attributes can form a suitable source of instruments to address the endogeneneity problem of product characteristics. In the present case, the contribution of the organic attribute to the price of chicken meat was treated with instruments generated from family structure of respondents that passed the required statistical tests. Using this strategy, the present paper estimates a premium of 135 percent for the organic attribute of chicken meat in the UK.

Additionally, the present results also offer insights about the heterogeneity of organic premia across chicken parts and the UK regions.

The paper is structured as follows: section 2 describes the theoretical background and the issue of endogeneity in HP models. Section 3 describes the data used. Section 4 presents the empirical results and section 5 concludes.

2 Theoretical background

This chapter applies the hedonic price model in order to estimate the contribution of attributes associated with organic chicken, considering consumers' perception that such a product offers better results in terms of the environment, human health, and animal welfare, and potentially quality and taste (Wier et al.2008, Grifth and Nesheim 2008, Aertsens 2009, Gschwandtner 2018). The HP model is one of the most popular revealed preferences approach to environmental valuation. It is widely used to estimate the added value of housing attributes, e.g. environmental amenities, but also has been applied to markets in the food industry, including dairy, produce, and eggs (Griffith and Nesheim, 2010; Kolodinsky, 2008; Schollenberg, 2012; and many others). The method is derived from consumer theory, based on the assumption that a consumer's utility for a good or service is driven by the attributes associated with it (Garrod et al., 1999). The theoretical framework of the hedonic method was proposed by Rosen (1974), which applied his model to a commodity with many characteristics.

The method, however, whilst widely used, is often applied ignoring its econometric issues, notably the simultaneity problems derived either from supply and demand equilibrium or marginal price and quantity of attributes, the latter being associated with the non-linear characteristics of the price function, as illustrated by Follain and Jimenez (1985), Wooldridge (1996), Bishop and Timmins (2011), and others.

In this section, it will be argued that in the present case, the supply and demand simultaneity is not a problem, thus there is no need to incorporate supply-side information. Instead, the second simultaneity problem derived from the non-linear nature of the price function has to be addressed.

Starting with the two-steps baseline hedonic price model proposed by Rosen (1974) for a product with characteristics z, where $z = (z_1, \dots, z_n)$, the approach involves estimating the hedonic price from equation (1), then supply and demand functions. In the first step, the marginal price of z, given as $(p(z))$, is estimated using the best fitting function form by OLS. This would involve regressing observed differentiated product prices on their characteristics (z) and other characteristics related to consumers or suppliers, e.g. geographical location, that may influence prices, given as x^h. The price function is defined as a function of its characteristics z_i, x^h and the stochastic error term ϵ, given as:

$$P = f(z_i, x^h, \epsilon) \tag{1}$$

From the results, one can compute the marginal implicit prices $p(z)$ (the marginal price of z) for each buyer and seller. In Rosen's second step, the marginal implicit prices of each entry are used as an exogenous variable in both demand and supply functions. It is important to stress that firms and households are assumed to be price-takers, thus p is defined by the market clearing conditions, i.e. market equilibrium. It is also realistic to assume that equation (1) is non-linear. We will come back to these assumptions and their implications later. Meanwhile, the utility function is given by:

$$u = u(x, z)$$

Where x is a unity price composite commodity. The budget constraint posed to consumers would, given income y, then be $y=p(z)+x$.

The first order condition (the marginal effect of attributes z on price) entails:

$$\frac{\partial p}{\partial z_i} \equiv p_i = u_{zi}/u_x, i = 1, ..., n$$

While the amount consumers are willing to pay for characteristic z is given by the function:

$$\omega(z, u, y, \alpha)$$

Given their utility and income:

$$u = u(y - \omega, z, \alpha)$$

Where α is a taste parameter (differs across individuals). Therefore, the amount individuals are willing to pay for the characteristic z_i is given by:

$$\omega_i = u_z/u_x \tag{2}$$

As *p(z)* is assumed to be given, it represents the minimum price consumers are willing to pay to maximise their utility, i.e. only individuals who have a willingness to pay (wtp) above or equal to the equilibrium price would consume the good. This reveals that their lower bound wtp, i.e. *p(z)* is the minimum price the consumer must pay in the market. The utility is maximised at tangent point[3], where:

$$\omega(z^*, u^*, y^*, \alpha) = p(z^*) \tag{3}$$

* indicating optimum quantities.

It is important to note that $p(z^*)$ is also determined by supply. Thus, assuming firms are also price-takers, and profit maximisers, they are willing to accept a value ϕ, subject to the potential profit π and its cost structure c(z,β), where β indicates the factor prices and production parameters. Thus, the firm's willingness to accept (wta) is given by:

$$\phi(z^*, \pi^*, \beta) = p(z^*) \tag{4}$$

The fact that the equilibrium price $p(z^*)$ is simultaneously defined by demand and supply poses some econometric issues. In the hedonic pricing sorting, the product characteristics z are identified to be endogenous. The second possible source of endogeneity comes from simultaneity of z and $p(z)$. As the price function is likely to be non-linear, when individuals maximise their utility, both attributes z and $p(z)$ affect their choices simultaneously.[4] Therefore, either way z needs to be instrumented, as explored in the following subsections.

2.1 First simultaneity problem: supply and demand

The equilibrium point (price and quantity) is reached when supply equals demand, thus $p(z*)$ is defined simultaneously by (3) and (4). This poses empirical problems to infer preference structures from the price equilibrium and data from households and firm characteristics, as error terms are correlated with explanatory variables in either the demand or supply functions (Follain and Jimenez, 1983). Rosen's two-step approach can be used to estimate this system. However, as Follain and Jimenez (1985) demonstrate, in micro-data an

[3]Assuming consumers' indifference curves are convex, i.e. we should expect that higher income always increases maximum attainable utility (Rosen, 1974)

[4]For example one such characteristic could be the quantity of the product purchased. The quantity determines the price that the consumer has to pay for a specific product in the market. However, at the same time, the price of this quantity determines how much the consumer wants to buy of the specific product. Hence both the attribute z and marginal price paid for it $p(z)$ are determined simultaneously.

individual's demand (and its error terms) for a particular good would not affect the market hedonic price function. Micro-data studies explore individuals' behaviour, thus a demand-side analysis does not need to incorporate supply equations and simultaneous price determination approach in order to estimate consumers' wtp. Similarly, Kahn and Lang (1988) demonstrate that in different markets, the distribution of consumers and firms do not influence supply and demand equations, as they do not affect the relationship between demand for the product attribute, consumers' characteristics and marginal prices.

Follain and Jimenez (1985) have also argued that a number of studies have addressed an inexistent problem (simultaneity in micro-data). Meanwhile, Bishop and Timmins (2011) show that supply-side shifters, commonly used as instruments to address the endogeneity problem, including Kahn and Lang (1988), are not valid to justify the demand equation (not relevant), and some other researchers have chosen weak instruments based on assumptions often difficult to justify. In fact, it is better to use OLS than two or three stage regressions with weak instruments, when the correlation between the instruments and z is low (Wooldridge, 2010). Therefore, a simple linear hedonic price model that attempts to estimate the determinant of demand for the product attributes z is commonly used. Usually, the wtp for the attributes z is simply inferred from the coefficients of the hedonic functions estimated with linear regressions.

A number of studies have applied the hedonic price model to investigate the price premium consumers are willing to pay for the organic attributes, thus offering only a demand-side analysis. These studies include Nouhoheflin et al. (2005), Kolodinsky (2008), Blow et al. (2008), Schröck (2014), and Griffith and Nesheim (2013), Gschwandtner (2018). What these studies have in common is that they, at least partially, have applied linear regressions, assuming price is in equilibrium, and an individual consumer cannot affect the market price, thus avoiding the first simultaneous problem.

In order to define the organic premium which is the main focus of the present study, we adapt equation (2) from Griffith and Nesheim (2013). A household with characteristics x_h chooses an organic product o if the utility generated by this organic product is greater or equal to the one associated with the conventional counterpart n, given as:

$$\sigma(x_h, z^o, p^o) \geq \sigma(x_h, z^n, p^n) \tag{5}$$

The mean value theorem would indicate that there is a $p^* \in [p^o, p^n]$ which would satisfy the following equation:

$$\Sigma(x_h, z^o, p^o) + [\frac{\partial \sigma}{\partial p}(x_h, z^o, p^*)](p^o - p^n) \geq \sigma(x_h, z^n, p^n)$$

where $-\frac{\partial \sigma}{\partial p}(x_h, z^o, p^*) > 0$ is the marginal utility of income as defined in Griffith and Nesheim (2013) on page 285.
Given that:

$$\frac{\partial \sigma}{\partial p}(x_h, z^o, p^*) > 0$$

Therefore, after rearranging we would get:

$$\frac{\sigma(x_h, z^o, p^n) - \sigma(x_h, z^n, p^n)}{\frac{\partial \sigma}{\partial p}(x_h, z^o, p^*)} \geq (p^o - p^n) \tag{6}$$

Similar to Follain and Jimenez (1985), the left-hand-side of equation (6) represents the wtp for the organic characteristics, while the right-hand-side represents the organic premium.

2.2 Second simultaneity problem: non-linear price function

Although the problems associated with the simultaneous supply and demand system may not be an issue in micro data (which is the case of this study), the second source of simultaneity derived from the non-linear characteristic of the hedonic function, i.e. p is non-linear in z, might arise. The hedonic price model is estimating the marginal effect of the attributes z on price (as in Rosen's step one), i.e. it attempts to investigate the change in price when the attribute changes by one unit. However, this marginal price paid by the consumer, which is the first order condition ($\partial p/\partial z$) of the price function, is simultaneously determined by the choice of quantity of the attribute, which can be at any point along the price function, and is affected by unobserved consumer characteristics that shape their preferences. Thus, the implicit price of an attribute is also affected by the amount of consumption of the attribute z, as it will remain in the marginal price function, i.e.z also affects p_i^z. The logic here is that the non-linear nature of the price function implies simultaneity, which for instance makes the attributes z endogenous, as further explained below.

Starting with the non-linearity of the price function, in the utility maximisation process, the marginal price (first order derivative) and quantity of attribute consumed change simultaneously, given that the utility maximisation point change according to consumers' preferences (and budget constraints). The hedonic price of an attribute will change systematically with the quantity when the hedonic pricing function is nonlinear (Bishop and Timmins, 2011). As we are using in our empirical analysis an exponential form which is nonlinear this concern applies.

Following Follain and Jimenez (1983), the second simultaneity problem can be illustrated as in Figure 3. The graph shows two observation points A and B on the same price function for an attribute i, which represents different marginal prices faced by two individuals with different preference structures θ_i^1 and θ_i^2, respectively. Their preference structures are assumed to be the same, apart from one socio-economic characteristics (e.g. income). Both individuals face the same price function, which they take as given, but the implicit price is not fixed. The consumer accepts the price structure, but can choose any point on the curve, simultaneously with the quantity of attribute z. Thus, a regression of z_i and the hedonic price p_i using OLS generates biased results, as this does not incorporate unobserved consumer characteristics that define their preferences, thus variations of the quantity of z.

The simultaneity acts as a source of endogeneity of characteristics z simply because in the first order condition p_i^z changes with z_i.

Considering the issues described above, Kahn and Lang (1988) applied demand-shifter instruments in a three-stage least square (3SLS) for the simultaneous equations estimation system. However, Wooldridge (1996) demonstrates that the hedonic model does not fit into the situations which a 3SLS would be asymptotically efficient, and has suggested instead that generalised method of moments (GMM) should be used to estimate the parameters in the hedonic price system. In addition, Cameron and Trivedi (2005) also demonstrate that GMM is more efficient than 2SLS/3SLS to address the identified endogeneity and non-linear functions underlying the hedonic price system. GMM also performs better when the model is over-identified, and under heteroskedasticity, a common problem in revealed data, especially when estimating system equations (Arellano and Bond, 1991). Following the theoretical model above, this paper applies GMM to a hedonic price function using consumer characteristics x_i^d as instruments to treat the endogenous product characteristics z.

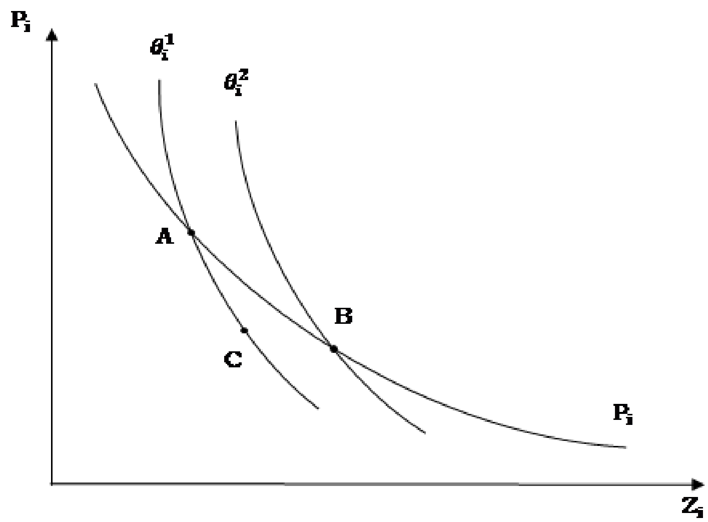

Figure 3: *Simultaneity in micro-data*

2.3 Hedonic price regression models

Kantar Worldpanel is a comprehensive panel-scanner dataset containing a substantial number of available variables which are expected to explain the variation in price. We are working with data that is representative of Great Britain's purchases (Northern Ireland data are not collected) and use all the recorded transactions of 2016. However, consumer characteristics are usually not taken into consideration in the main hedonic model, as previously discussed. In addition, consumers are assumed to be price-takers and their characteristics should not be able to change the price available to them in most cases. As explained in above, following Rosen (1974), most studies focus on the characteristics of the product (z). Considering z as the vector of all product characteristics (mostly discrete elements, e.g. chicken part, organic, retailer, etc.), the model includes dummies for special offer (γ_{i_t}) and region (η_r), and a vector for the month (δ_t).

Therefore, the household maximises utility by choosing a product with price p explained by:

$$ln(p_{irst}) = \alpha_1\delta_t + \alpha_2\gamma_{it} + \alpha_3\eta_r + \beta z_{is} + \epsilon_{irst} \tag{7}$$

Where: i, r, s and t are, respectively, item, region, store and time, and ϵ is the error term. Thus, δ varies with time, γ varies with item and time, η with region, and are specific to each item and store. The vector of characteristics allows to calculate utility by taking into account all of the information given, rather than looking at things one at a time. It is important to mention that t, in this case, will mostly explain seasonal variations, rather than capture wider shocks. For the latter, a larger annual panel data study would be required.

The appropriate functional form for hedonic method depends on the nature of the data used in the study. The predominant form used in the literature is the log-linear, but double-log is also used, as it facilitates the interpretation of results (Martínez-Garmendia, 2010 and Kim and Chung, 2011). Given that all explanatory variables are dichotomous, this study uses a semi-log function. The functional form will be applied in an OLS setting (model 1), in the first stage of the 2SLS (model 2) and in the GMM estimations (model 3). The last two attempt to address any bias from the simultaneity problem explained in section 2.2 (non-linearity), using socio-economic characteristics as instruments. As justified in section 2, the GMM estimation will be the main approach used in the estimations due to its ability to address endogeneity and heteroskedasticity, thus it will be the main source of results discussion.

The extended version of the model in equation (7) using GMM can be expressed as:

$$
\begin{aligned}
lnP_{irst} = \exp(&\beta_0 + \beta_1 Organic_{it} + \beta_2 FreedomFood_{it} + \beta_3 Offer_{it} + \beta_4 Branded_{it} \\
&+ \beta_5 BudgetLabel_{it} + \beta_6 Halal_{it} + \beta_7 Healthy_{it} + \sum_{j=2}^{7} \beta_j ChickenPart_{ijt} + \sum_{k=2}^{5} \beta_k Size \\
&+ \sum_{l=2}^{13} \beta_l Retailer_{ilt} + \sum_{m=2}^{7} \beta_m Region_{imt} + \sum_{n=2}^{12} \beta_n Month_{int} + \epsilon_{irst}) \quad (8)
\end{aligned}
$$

Where, in addition to the variables previously described, Organic represents organic label, Freedomfood represents the label for freedom food, Offer denotes any type of promotion, and Branded and BudgetLabel indicate external and own *low* price labels, respectively. Quality indicates products advertised as with superior quality (e.g. Tesco Finest, Asda Extra Special, etc.), Halal indicates halal chicken, and Healthy denotes the presence of a health label. From the remaining five types of dummy variables included in the model ChickenPart indicates the part sold (or whole chicken), Size indicates the package weight, Retailer the shop/supermarket (from 13 main companies), Region denotes the UK region, and Month represent the monthly dummies.

The exponential GMM format is widely used in applied work as alternative to linear regressions when the dependent variable uses log-transformed values. This avoids transformations from the original format for predicted values (Baum et al., 2003).

2.4 Choice of instruments

In the hedonic price literature there have been some few applications of instrumental variables approach to estimate coefficients of attributes of interest. Follain and Jimenez (1983) use as instruments predicted values of household income and household size, hence consumer characteristics. Gopalakrishnan et al. (2011) used spatial varying coastal geological features as instrument to estimate the amenity value of beach width, to coastal properties in a 2SLS estimation. Combris et al. (1997) have used sensory variables as instruments in a hedonic price estimation of attributes (notably, quality) of Bordeaux wine. All these studies have revealed a significant effect from the instrumental variables, despite the different endogeneity addressed across studies. The present paper uses socio-economic characteristics of households as instruments to treat the organic characteristic of chicken meat, as the variable of interest. For the socio-economic characteristics to be valid instruments, they have to be both exogenous and be relevant to the choice of the treated attribute.

There are a number of studies that confirm that socio-economic characteristics are relevant to organic food consumption, i.e. socio-economic characteristics drive the wtp for organic food. Griffith and Nesheim (2010) explore heterogeneity wtp for organic products across different family structures; Costanigro et al. (2012), Gschwandtner (2018), Yue et al. (2009); and Wong et al. (2010) are just few of the many studies that show the contribution of individuals' characteristics such income, age, gender, level of education, family structure, employment status, etc as on organic food consumption. The Kantar Wordlpanel dataset used in this study offers a number of household characteristics. These characteristics are not expected to explain the dependent variable (p), and are thus potentially exogenous to the price equation, while being relevant to preferences for organic consumption. We assume in this study that suppliers may not discriminate between individuals across their residual demand, thus consumers are likely to face the same price for the same item. By the same item, we mean the same combination of attributes, which includes chicken part, labels, package, etc., as well as retailer characteristics. However, the non-discriminatory assumption may not hold for some consumer characteristics available in the data, under certain circumstances.

The potential instruments present in the dataset, are investigated in the light of theoretical framework, data analysis, statistical tests (showed in section 4.3), and some intuition. The main variables under analysis were income, age, gender, BMI (body mass index) and variables derived from family structure. The rationale driving the choice of instruments is to evaluate whether suppliers would be able to use information about their customers as source of price discrimination. Retailers have access to socio-economic information about their local or average customer, and may use these as source of discrimination across different locations within regions. For example, Martínez-Garmendia (2010) used (endogenous) quantity in a hedonic price model to incorporate the volatility in prices across retailers and regions. Kahn and Lang (1988) used geographical location as a characteristic in one of the vectors in the first stage hedonic price model. In the case of this study, discrimination across regions is controlled using regional dummy variables.

From the dataset, BMI, Pre-family (dummy for young couple with no children), Young-family (dummy for family with youngest child aged below 5 years old), and Middle-family (dummy for family with youngest child aged between 5 and 9 years old) were tested as potential instruments. The first stage regressions (OLS and probit) are used to test the significance of consumers' characteristics for the choice for organic chicken. Table 1 (Appendices) shows results from the probit first-stage estimation[5], and indicates that the socio-economic characteristics are relevant ($p<0.1$) individually and combined. This is not trivial because the lower the correlation between the instrument and the instrumented variables, the larger is the bias of the IV estimators (thus it would be better to use OLS instead), despite the fact that a large number of observations may offset the effect of a small correlation (Wooldridge, 2010).

These variables, however, should ideally not be correlated with price, as previously explained. A simple correlation test in Table 2 (Appendices) indicates that, among the socio-economic variables, while all significantly correlated with the price, income and age have the highest correlation. Furthermore, when added to the baseline model (OLS), Female, Middle-family, and Older-family dummies are not significant, while Income, Age, Children, BMI (10% confidence), PreFamily (10% confidence), YoungFamily, and Retired are all significant in explaining variations in price. Although this does not prove that the former group of variables are exogenous (as the model includes endogenous variables which would bias the regressors), it is an indication of possible instruments.

Starting with BMI, several studies have indicated health as one of the main perceived attributes driving consumption of organic products. In the case of meat, it is related to the risk aversion to anti-biotic, hormones and other chemicals and potential manipulations used in the conventional counter-parts. In general it is presumed that individuals within the "healthy BMI range" are healthier and hence a positive correlation between this range and organic food consumption might be expected. In fact, it is also accepted that a causal relationship between the individual's diet and their health exists (West et al., 2002). Having a healthy and balanced diet is also more costly, thus considering that BMI is correlated with income - and can potentially influence price in the same manner - low cost retailers may target individuals with high BMI, which would imply that BMI is not a valid instrument. In fact, the correlation between BMI and price is one of the highest amongst the potential instruments as Table 2 reveals. Table 3 (Appendices) and Figure 4 show more

[5]Given that the choice for purchasing organic is dichotomous, Table 1 shows results from a probit regression. This might differ from the first stage of the simultaneous 2SLS and GMM regressions, but add extra robustness to the relevance test, as results from the probit estimation are more reliable in this case.

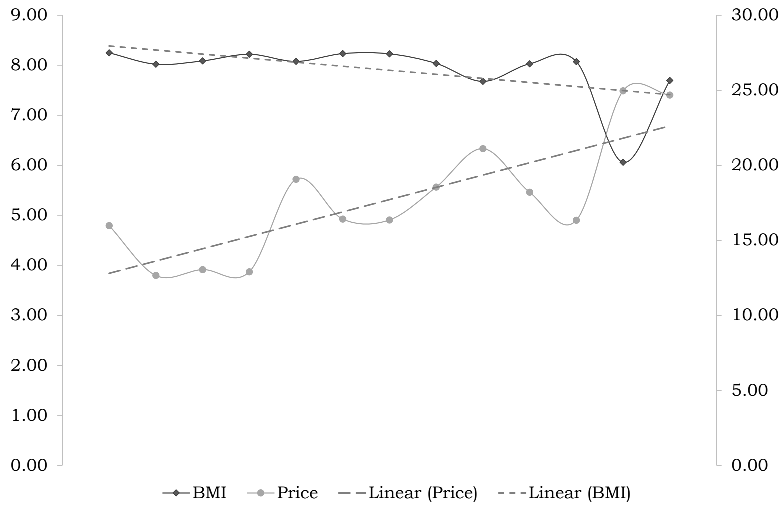

Figure 4: *Correlation BMI and Average Price: main retailers*

clearly the inverse correlation between largest suppliers' average price and average BMI of their consumers. Shoppers from cheaper retailers are suggested to have relatively higher BMI's. Thus, given such a correlation the variable is unlikely to be a valid instrument but will be tested anyway.

Within variables related to family structure, health remains a key factor for households with children. However, this is subject to affordability. Using a Bayesian inference method to estimate demand system for food in the UK, Tiffin and Arnoult (2010) have concluded that the presence of children in a household has a negative correlation with their dietary quality, e.g. fresh meat, fruit and vegetables. These households should be expected to demand attributes such as quality, taste and nutrition, but are subjected to their budget constraint. In fact, Maguire et al. (2004) show that parents are willing to pay a significant premium for the organic attribute of baby food, and meat has a positive effect on the premium, thus parents do seem to place value on *organic* meat. For young couples with no children, concerns about children's health would not play a part, but other factors such as higher affordability (given lower household size, thus higher grocery expenditure per head, ceteris parabus), aesthetic focus and higher exposure to social media may nudge them towards consumption for organic products. The latter may result in social compliance in line with motivators beyond own health, e.g. animal welfare, and positive attitude towards the environment. The main outcome from these musings is that household structures do influence individuals' choices of attributes associated with health and dietary quality of food. Thus, it is intuitive that they should influence the choice of organic, and can be used as instruments for the organic attribute in the GMM regression. The results of the instrumental variable tests are presented in section 4.3.

3 Data Description

The paper uses revealed (actual purchase entries) data in a hedonic price model in order to estimate the marginal effect of a list of attributes that determine the price of chicken, with emphasis on the organic attribute. Demand for chicken has increased consistently in the past decades, leading consumers to pay a premium for the characteristics they perceive as beneficial. Using scanned purchase information from UK households collected in 2016 by Kantar Worldpanel, this paper investigates the characteristics of the product, consumers and retailers that might have driven such a strong demand.

3.1 Chicken purchase data

The sample contains 336,970 chicken purchases from 26,658 UK representative households. The paper explores up to 40 variables containing product characteristics (chicken part, price, volume, packing, labelling, etc.), store information (e.g. retailer name, location), and socio-economic characteristics of the households, to investigate the heterogeneity across regions, education level, class, etc. Table 5 shows descriptive statistics. For representativeness, these should be compared to the ones of the usual chicken buyer, rather than the average characteristics of the UK population.

The average age of the household member responsible for the grocery shopping in the sample is 49 years old, 78% of which are female. Households have on average one child, and have an average gross income within category 4 (£30,000 to £39,999 per annum), which was above the national average income in 2016 (£26,300).

Family structure amongst households are fairly distributed, but highest proportion of households (18.6%) are "empty-nest", i.e. 45-65 years old with no children in the household, and the smallest number (10.2%) are "pre-family", i.e. below 45 years old with no children.

Table 5: *Sample socioeconomic description*

Variable	**Mean**	**sd**	**Median**	**Min**	**Max**
Age	49.250	13.680	48	18	95
Female	0.780	0.411	0	0	1
Income	4.210	1.960	5	1	8
Children	0.733	1.006	0	0	7
BMI	26.990	5.700	26	10	66
PreFamily	0.102	0.302	0	0	1
YoungFamily	0.175	0.380	0	0	1
MiddleFamily	0.123	0.328	0	0	1
OlderFamily	0.119	0.324	0	0	1
OlderDependents	0.153	0.360	0	0	1
EmptyNest	0.186	0.389	0	0	1
Retired	0.141	0.348	0	0	1
Scotland	0.075	0.263	0	0	1
Wales	0.046	0.210	0	0	1
North	0.256	0.437	0	0	1
Midlands	0.173	0.378	0	0	1
South	0.247	0.431	0	0	1
East	0.114	0.318	0	0	1
London	0.089	0.285	0	0	1

The regional distribution is as follows: North (25.6%), South (24.7%), Midlands (17.3%), East (11%), London (8.9%), Scotland (7.5%), and Wales (4.6%). Thus, above half of the chicken sold in the country are to attend demand in the North and South regions. Overall, these are similar to the regional population distribution in the UK, but not exactly. However, one should not expect the socio-economic distribution to match the national numbers very precisely, as the data only includes households from the panel that bought

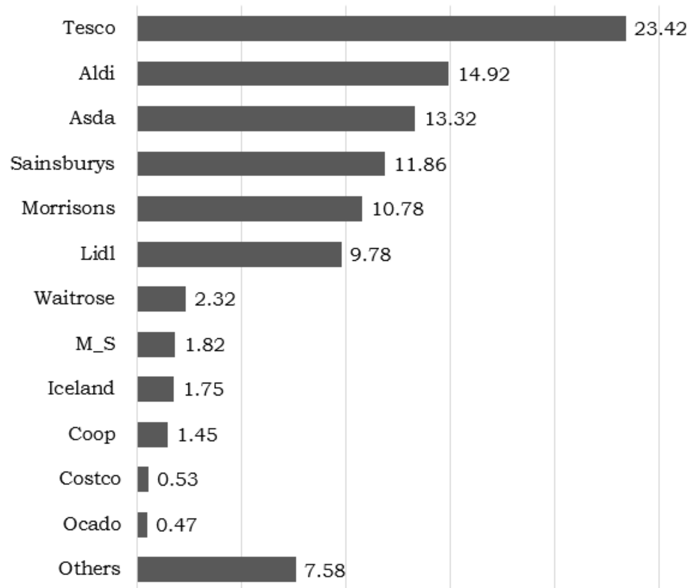

Figure 5: *Entry distribution by retailers (%)*

chicken at east once in 2016.

Table 6 in the Appendix illustrates the number of entries by region, and total expenditure, which are consistent with the representation of each region (average price paid per kilogram of chicken is relatively consistent across regions, ranging from £4.13 in Wales to £4.32 in London).

The data set has entries from 35 different retailers across the country. Figure 5 shows the distribution of chicken purchases by retailer in the UK. The sample indicates that approximately 23% chicken purchases in 2016 were made from Tesco, UK's largest grocery retailer. This is substantially larger than the second ranked Aldi, which has 15% of the market. The fact that Aldi ranks second and sells more broiler chicken than Asda, Sainsbury's and Morrisons might be surprising as these shops have substantially higher market shares. However, Aldi is a supermarket renowned for its good value for money and especially for the good taste of meat.

Table 7 in the Appendix shows the market shares of the retailers per region. For example, Tesco has 12.5% of market share in the East and 23% in the South region , whilst Aldi holds 1.7% in London.

The overall distribution in Figure 5 differs somewhat from the market shares of the supermarkets for all regions and all products in 2016, which were respectively Tesco (28.3%), Sainsbury's (16.8%), Asda (15.6%), Morrisons (10.9%), Aldi (6%), The Cooperative (6%), Waitrose (5.3%), Lidl (4.4), and Iceland (2.3%) according to Kantar Worldpanel (2018) because it contains just entries of chicken purchases and reflects consumers shopping preferences with respect to chicken (where Aldi is a favourite for example).

The data also allows for investigation of the market for each chicken part. As indicated in Table 8 (Appendices), the most popular chicken part in the UK is breast, formed by 48.81% of entries in the panel. Chicken breast is also associated with highest price, costing on average £6.67 pounds per kilo. Wings are the cheapest part sold, on average only £2.23/Kg.

3.2 Organic chicken market

The main interest of this research, the market for organic chicken is relatively more consolidated, with only eight sellers: Sainsbury's (40.4% of entries), Waitrose (25.3%), Tesco (15.3%), Morrisons (6.4%), Marks & Spencer (M&S) (5.9%), The Black Farmer (5.8%), Ocado (0.8%), and Asda (0.1%). Market shares in terms of expenditures by region are shown in Table 6 (Appendices) with the highest cumulatively percentage for South-East including London (45.23) followd by the North (25.76). Table 9 shows the average price including the bottom 1% (p1) and top 1% (p99) prices per retailer. It shows, for example, that Ocado is the most expensive on average across all price distributions, as it does not seem to sell low price products. The retailer only supplies thighs, which is the second most expensive chicken part. M&S, which usually is perceived as more expensive, interestingly has the lowest average price. However, 44% of its organic chicken sold was on offer, on average 56% cheaper than the original prices (the highest discount amongst the suppliers) and most of its organic chicken sold were legs, which are associated with relatively low price. Waitrose, UK's 'high-end supermarket' sells the most expensive organic chicken, as expected.

Table 9: *Price of organic chicken by retailers*

Retailer	N	mean	sum	p50	sd	p1	p10	p99
Sainsburys	759	10.82	8213.68	6.72	6.27	4.77	5.30	22.11
Waitrose	474	11.69	5541.50	9.32	5.85	4.72	5.75	23.87
Tesco	288	10.15	2923.19	10.00	2.15	5.81	6.94	13.60
Morrisons	121	9.30	1125.25	9.75	2.17	4.33	5.42	15.06
M&S	110	6.49	713.79	4.28	3.49	2.99	3.65	13.22
TheBlackFarmer	108	7.49	808.70	7.65	0.78	6.06	6.45	9.13
Ocado	15	16.74	251.08	16.65	1.38	14.19	15.81	20.83
Asda	2	11.44	22.87	11.44	0.59	11.02	11.02	11.85
TOTAL	1877	10.44	19,600.06	8.55	5.34	3.67	5.30	21.97

Table 10 shows the average prices paid for various organic chicken parts per supermarket.

M&S sells the most expensive organic whole chicken and the third most expensive organic chicken breast despite of being on average the cheapest. Conventional chicken is the cheapest at Asda, however, the supermarket has only very limited organic chicken sales, driving the average price for this product up. Table 10 also shows in bold in the parentheses which chicken part is sold most by the retailers. For example M&S sells mostly organic chicken legs, which is their cheapest organic chicken part and explains their overall low average. Sainsburys on the other hand sells mostly organic chicken breast which is the most expensive chicken part and explains their relatively high average. Ocado sells only tights, Asda only breast and TheBlackFarmer only legs in the organic range. The average cheapest organic whole chicken is sold at Waitrose, the cheapest breast at Morrisons, and the cheapest thighs at Sainsburys, suggesting a certain level of specialisation.

As illustrated in Tables 10 and 11 (Appendix) organic chicken breast is the most popular (37% of entries) and most expensive part. The part was bought on average for £15.44 per Kg. Note that it is generally sold in smaller packs (400g on average), thus the lower price perception consumers may have when buying might be a factor to consider. On the other hand, drumsticks and wings are the cheapest (sold only at Waitrose), and least popular chicken parts, though substantially more expensive than conventional counterparts.

The overall price distribution, the price distributions per supermarket and chicken part are illustrated in Figures 7 - 9 (Appendices). These figures show that the price paid for organic chicken, varies substantially across retailers. The price distributions per supermarket suggest that Waitrose and Sainsbury's offer the largest price variety, which is natural given their market shares, in contrast to Tesco and The Black Farmer.

Table 10: *Retail price by organic chicken parts (£/Kg)*

		Chicken Part					
Retail	Mean	Breast	Drum.	Legs	Thigh	Whole	Wings
Ocado	16.74				16.74		
					(15)		
Waitrose	11.69	19.49	7.69		11.38	6.01	5.78
		(121)	(17)		**(193)**	(128)	(15)
Asda	11.44	11.44					
		(2)					
Sainsburys	10.82	18.55		5.68	6.84	6.53	
		(279)		(163)	(135)	(182)	
Tesco	10.15	11.01		12.42	10.00	7.40	
		(155)		(41)	(10)	(82)	
Morrisons	9.30	10.04		4.97		6.90	
		(103)		(17)		(1)	
TheBlackFarmer	7.49			7.49			
				(108)			
M&S	6.49	11.65		3.85		7.87	
		(29)		**(65)**		(16)	
Sample Average	10.44	15.44	7.69	6.55	9.83	6.6	5.78
	(1877)	**(689)**	(17)	(394)	(353)	(409)	

Number of observations in parentheses
Numbers in bold represent the highest chicken part proportion

With regards to chicken parts, breast and thigh are the only ones who are associated with a wide price range.

Figure 6 below compares consumption of conventional versus organic chicken by region.

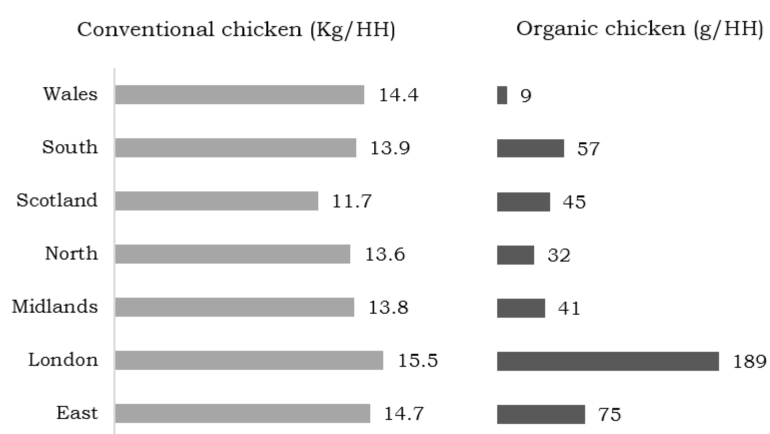

Figure 6: *Chicken consumption by region*

While the consumption of chicken in general appears relatively similar across regions the highest amount of organic chicken is consumed by far in London. The region that consumes least organic chicken is Wales. Consumption of organic chicken in London was 21 times the consumption in Wales. This should not be interpreted, however, as purely driven by consumer preferences or affordability, but also by availability of supply, which would require further investigation.

4 Regression results and discussion

4.1 Descriptive statistics of he variables used in the regressions

Table 12 shows descriptive statistics for the variables used in equation 8 including the main product characteristics (z) and dummies for promotion, region, and a monthly vector. On average, consumers paid £4.71 per kilogram and bought approximately 1 kg per purchase. Surprisingly, 45.3% of the items were on a type of offer, and 25.2% were budget label (retailer own low value item). Chicken breast is the most popular, forming 48.8% of the observations, and half chicken and wings are the least popular chicken parts. Only 1% of chicken sold was from a brand other than the retailers' own brand, and only 0.2% of entries had a 'healthy' label. Consumption across the months does not vary significantly, but July and August (summer in the UK) seem to be the months with lower chicken consumption, while in winter consumption appears to be relatively higher, with the exception of December, as substitutes (certainly turkey) may be more popular during end of year celebrations.

4.2 Regression Results

Most hedonic price studies involve OLS regressions as discussed. However, due to non-linear nature of the model, OLS leads to a biased and inconsistent estimates of parameters. For this reason two instruments derived from family structures (PreFamily and MiddleFamily) will be used in the 2SLS (used mainly for comparison) and GMM estimations. Their validity is shown in subsection 4.3 below. We use in all models the semi-log function form. Table 13 shows regression results from the OLS, 2SLS, and GMM estimations. The dependent variable is the natural log of the price paid per kilogram of chicken. The R-squared values for the OLS and 2SLS are high (84% and 68%, respectively), which indicates that the regressors are able to explain most variations in the (logged) price of chicken. However, the coefficient of Organic in the 2SLS model is substantially higher than OLS estimates (above five times), raising awareness about the validity of both sets of results. In fact, the organic coefficient in the 2SLS is also substantially higher than the GMM estimates. As explained, GMM estimations are considered the most reliable to effectively address the endogeneity and heteroscesdacity issues encountered in HP estimations. Nonetheless, the only other significant difference between 2SLS and GMM results are with regards to the parameters for "The Black Farmer", with 2SLS reporting a coefficient which is almost 5 times larger than one from the GMM, in absolute terms.

The coefficients in the GMM estimation indicate the change in price, when the attributes increase by one unit. As the model uses the exponential form of the explanatory variables, and the dependent variable is log transformed, the interpretation of the coefficients is straightforward, and represents the marginal effect of the respective variables on price. Therefore, the estimations for the marginal implicit prices were given by: MIP $= \frac{\partial p(z)}{\partial z_i} x \overline{P}$, where $\overline{P}$ is the sample mean price paid per kilogram of chicken (4.70 pounds). The MIPs are presented in the last column of the table.

The GMM estimations show that for the UK consumers the implicit marginal price for organic attribute per kilogram, holding all other factors constant, is £6.36, for freedom food £1.84, for quality £1.59, and halal £0.77. The implicit price consumers pay for a branded chicken product is £0.13 per kilogram, while the budget label gives a discount of £0.48. The coefficient for the 'healthy' variable is not significant in any regression which might seem surprising. Probably this has to do with what this label represents to the consumer and how it is presented and, another, better label it is required to elicit such an important

Table 12: *Descriptive statistics: main attributes*

Variable	Description	Mean	sd	Min	Max
Price	Price/Kg	4.706	2.459	0.100	27.676
LnPrice	Natural log of price/kg	1.412	0.533	-2.303	3.321
Freedom_Food	Freedom food label	0.006	0.077	0	1
Organic	Organic label	0.006	0.074	0	1
Size1	Package weight ¡ 400g	0.117	0.325	0	1
Size2	Weight 400-799g	0.323	0.468	0	1
Size3	Weight 800-1199g	0.223	0.417	0	1
Size4	Weight 1.200g-3000kg	0.334	0.472	0	1
Size5	Package weight > 3kg	0.002	0.049	0	1
Offer	Any type of offer	0.453	0.498	0	1
BudgetLabel	Budget/low cost label	0.252	0.434	0	1
Branded	Not retailer's brand	0.010	0.101	0	1
Quality	Retailer quality label	0.027	0.162	0	1
Healthy	Health label	0.000	0.015	0	1
Halal	Halal chicken	0.002	0.047	0	1
Breast	Part dummy	0.488	0.500	0	1
Drumsticks	Part dummy	0.033	0.179	0	1
Half	Part dummy	0.000	0.015	0	1
Legs	Part dummy	0.040	0.195	0	1
Thigh	Part dummy	0.108	0.310	0	1
Wings	Part dummy	0.015	0.123	0	1
Whole	Part dummy	0.314	0.464	0	1
Jan	Month dummy	0.081	0.273	0	1
Feb	Month dummy	0.083	0.277	0	1
Mar	Month dummy	0.097	0.296	0	1
Apr	Month dummy	0.083	0.276	0	1
May	Month dummy	0.080	0.272	0	1
Jun	Month dummy	0.098	0.297	0	1
Jul	Month dummy	0.074	0.261	0	1
Aug	Month dummy	0.071	0.257	0	1
Sep	Month dummy	0.097	0.297	0	1
Oct	Month dummy	0.078	0.269	0	1
Nov	Month dummy	0.081	0.273	0	1
Dec	Month dummy	0.076	0.264	0	1

Number of Obervations: 336,940

attribute. Chicken breast has an implicit marginal price of £2.38, the highest added value amongst all chicken parts, as expected. The other parts with positive implicit price are half chicken (£1.07) and thigh (£0.39), while all other have negative marginal effect, wings being associated with the lowest marginal implicit price (-£1.54).

The implicit marginal price decreases as package weight increases, smaller packages ($< 400g$) increasing the price by £0.49, and surprising, offers on average only contribute to a decrease of only 9 pence per kilogram of chicken. This indicates that, at least for chicken, retailers use offers as marketing strategy to influence consumers discount *perception* rather than actual price reduction.

Differently from the descriptive section, which show the average price paid for each product characteristics across sellers, the marginal implicit prices show how much individuals would pay for the shopping experience at that specific supplier, with all other attributes held constant. For example The Black Farmer has the highest average price probably due to its specialization on Organic. Once this is controlled for, it has the

Table 13: *Regression Results*

LnPrice	OLS		2SLS (IV)		GMM(IV)		MIP
Organic	0.718***	(0.007)	3.748***	(0.000)	1.353***	(0.104)	6.36
Freedom_Food	0.559***	(0.007)	0.626***	(0.000)	0.392***	(0.009)	1.84
Size1	0.350***	(0.013)	0.320***	(0.000)	0.200***	(0.011)	0.94
Size2	0.273***	(0.013)	0.257***	(0.000)	0.177***	(0.011)	0.83
Size3	0.145***	(0.013)	0.133***	(0.000)	0.102***	(0.011)	0.48
Size4	0.019	(0.013)	0.014	(0.000)	-0.014	(0.011)	-0.07
Offer	-0.064***	(0.001)	-0.035***	(0.050)	-0.020***	(0.004)	-0.09
Breast	0.705***	(0.008)	0.715***	(0.000)	0.507***	(0.009)	2.38
Drumsticks	-0.239***	(0.008)	-0.227***	(0.000)	-0.241***	(0.009)	-1.13
Half	0.119***	(0.032)	0.246***	(0.000)	0.227***	(0.027)	1.07
Legs	-0.161***	(0.008)	-0.215***	(0.001)	-0.195***	(0.011)	-0.92
Thigh	0.080***	(0.008)	0.072***	(0.000)	0.074***	(0.009)	0.35
Wings	-0.338***	(0.009)	-0.308***	(0.000)	-0.327***	(0.010)	-1.54
Whole	-0.010	(0.008)	-0.017**	(0.000)	-0.032***	(0.009)	-0.15
Branded	0.054***	(0.006)	0.041***	(0.000)	0.028***	(0.005)	0.13
BudgetLabel	-0.131***	(0.006)	-0.094***	(0.000)	-0.102***	(0.009)	-0.48
Quality	0.389***	(0.005)	0.491***	(0.000)	0.338***	(0.010)	1.59
Halal	0.231***	(0.014)	0.244***	(0.000)	0.164***	(0.011)	0.77
Healthy	0.020	(0.061)	0.051	(0.000)	-0.021	(0.029)	-0.10
Asda	0.046***	(0.002)	0.026***	(0.037)	0.013***	(0.003)	0.06
Aldi	-0.002	(0.006)	-0.047***	(0.000)	-0.013	(0.009)	-0.06
Lidl	0.007	(0.006)	-0.038***	(0.012)	-0.006	(0.009)	-0.03
Iceland	-0.103***	(0.003)	-0.132***	(0.000)	-0.105***	(0.005)	-0.49
Coop	0.160***	(0.003)	0.139***	(0.000)	0.089***	(0.003)	0.42
Costco	0.158***	(0.005)	0.154***	(0.000)	0.135***	(0.004)	0.63
Morrisons	0.115***	(0.002)	0.076***	(0.000)	0.048***	(0.005)	0.23
M_S	-0.066***	(0.007)	-0.230***	(0.000)	-0.130***	(0.016)	-0.61
Ocado	0.156***	(0.006)	0.109***	(0.000)	0.062***	(0.007)	0.29
Sainsburys	0.088***	(0.002)	0.013	(0.000)	0.003	(0.009)	0.01
Tesco	0.040***	(0.002)	0.007	(0.043)	0.001	(0.004)	0.00
TheBlackFarmer	0.290***	(0.013)	-2.675***	(0.000)	-0.580***	(0.097)	-2.73
Waitrose	0.384***	(0.004)	0.184***	(0.000)	0.107***	(0.021)	0.50
Scotland	0.002	(0.002)	-0.013***	(0.000)	-0.011***	(0.003)	-0.05
Wales	-0.016***	(0.002)	-0.013***	(0.000)	-0.008***	(0.002)	-0.04
North	-0.005***	(0.001)	-0.006***	(0.000)	-0.003**	(0.001)	-0.01
Midlands	-0.004***	(0.001)	-0.006***	(0.122)	-0.004***	(0.001)	-0.02
London	-0.007***	(0.002)	-0.033***	(0.000)	-0.025***	(0.004)	-0.12
East	-0.007***	(0.001)	-0.009***	(0.000)	-0.004***	(0.001)	-0.02
Constant	0.897***	(0.015)	0.912***	(0.000)	-0.047***	(0.014)	-0.22
Observations	336,940		336,940		336,940		
R-squared	0.839		0.676				

*Robust standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*
All models include monthly dummies

lowest marginal implicit price (-£2.73/kg). M&S (-£0.61) and Iceland (-£0.49) are associated with lowest implicit prices and Costco (£0.63) and Waitrose (£0.50) with the highest. Coop (£0.42) and Ocado (£0.29) are in the middle range.

Although statistically significant, there is no large variation in marginal implicit prices across regions, thus price differences in this case are mostly driven by product differentiation. Considering that the South of England is omitted due to collinearity, consumers in the North pay the highest implicit price, followed by the Midlands and East. London has the lowest MIP (-£0.12), whilst consumers in Scotland, with the highest average price (9% above national average), have a MIP of -0.05 (-1%) given all controls. Further heterogeneity is explored in section 4.4.

4.3 Instrumental Variable Tests

Table 14 shows results from statistical tests of the instruments, following the 2SLS and the GMM estimations. The adjusted R2 from the first-stage regression indicates the squared partial correlation between the endogenous regressor and the instruments only, which is usually low. For the endogeneity test of the organic attribute, this study applies the Wu-Hausman and the Durbin-Wu-Hausman, and C Difference-in-Sargan endogeneity test for the 2SLSL and GMM estimations, respectively. With 99% confidence, one can reject the null that Organic is exogenous, thus justifying the use of instrumental variables in the models.

Table 14 shows further the Angrist-pischke F-test for the validity of the instruments. This test shows when one endogeous variable (Organic) is weakly identified in the presence of multiple endogeous variables (which is possible for this study). The test statistic indicates that the instruments are valid, with F-statistics substantially above the threshold of 10 (or 23).

Table 14: *Instruments Validity*

Test	*2SLS*		*GMM*	
Endogeneity				
Durbin-Wu-Hausman x2-test	90.339	***		
Wu-Hausman F-test	90.377	***		
C Difference-in-Sargan			98.520	***
First stage regression				
Adjusted R2	0.088		0.088	
Angrist-Pischke F-statistic	35.663	***	35.663	***
Over-identification				
Wooldridge's robust Test	2.505			
Hansen's J x2-test			2.505	
P-value	0.114		0.280	

*** $p < 0.01$

Table 14 shows Wooldridge's Test for over-identification, given that the IV regression used robust estimations. This is required due to heteroscedasticy, a common problem in hedonic price regressions. The Hansen's J test is the alterntive for the GMM estimation. Over-identification occurs when the number of additional instruments (conditional to at leat one exogenous intrument) exceeds the number of endogenous variables. The test determines if the instruments are uncorrelated with with the error term. A significant test statistic indicates invalid instruments or model misspecification. The results indicate that the instruments pass the test in all models, hence we can reject the null of over-identification, and can conclude that the instruments are valid.

4.4 Heterogeneity

Heterogeneity across regions and chicken parts was identified through a series of regressions. In the GMM estimation, the socioeconomic characteristics x_i^d (Equation 11) include measured and unmeasured heterogeneity and shocks on preferences of households which should cause variation in wtp. In addition, spatial units (regions in the case of this study) have to be defined exogenously to rely on analysis of the variations across space (Helbich et al., 2014). The same applies to chicken parts, which are therefore treated as different products. Literature has explored various source of heterogeneity in organic price premia across different products and countries (ranging from -27% to 177%). Griffith and Nesheim (2010), who have applied a log-linear model to all grocery products in a basket of good, have also revealed a large amount of wtp heterogeneity across organic products in the UK (ranging from approximately -50% to 140%). Heterogeneity in chicken parts and regions is explored in this section by comparing GMM to OLS results in Tables 15 and 16 (Appendices).

For consistency, the same variables are incorporated as regressors, for chicken regions and parts. Similarly to the main model, variables derived from family structures were used. However, segmentation implied that different valid instruments were used across sub-samples. For regions, "Pre-family", "Young-family", "Middle-family", and number of adults were used, according to the strongest F-statistics. For chicken parts, "Older-family" was used as instrument in almost all models, with exception of legs, for which the strongest instrument has proved to be "Young-family".

Across regions, consumers in the North and East regions pay the highest premium for the organic attribute (above 150%), while households in Scotland pay only 35%. Price premia for the attribute 'Freedom Food' do not appear to vary significantly between regions (ranging from 27% to 43%), and there appears to be no substantial variation in the premia for the attribute 'Quality'. The latter is explained by the fact that most observations containing the quality attribute are associated with the retailer own brand label, which should be very consistent in most parts of the country. Consumers also seem to pay a higher premium for the attribute 'Halal' in the East and West, The marginal implicit price of the 'Budget Label' has the largest negative effect in Scotland, but values are relatively consistent between regions. Results also reveal that the marginal implicit values of the retailers vary across the country. The retailer marginal effect on price in London is the lowest for Aldi, Lidl, and M&S. The marginal effect is relatively higher in Scotland for Waitrose, in the Midlands Morrisons and Waitrose have the highest implicit prices, and in the North the main retailers have similar marginal implicit prices, apart from M&S, which is associated with a negative value. In contrast, log-linear OLS results show lower variation in the implicit vales of organic attribute across regions, ranging from 87% in Scotland to 120% in London.

Heterogeneity involving chicken parts confirms that the marginal effects of attributes do vary with the parts, as shown in Table 16[6]. The organic attribute has the highest marginal effect on all chicken parts, varying from 126% for legs to 298% for whole chicken. This indicates that consumers place lower aggregated value on the organic attributes when associated with parts of chicken, i.e. higher marginal value for organic chicken suppliers when the chicken is not cut into pieces, all other factors being equal.'Freedom Food' certification has the highest value for consumers of breast chicken and whole chicken (35% and 82%, respectively). A counter intuitive result is the negative effect of the attribute 'Quality' on drumsticks, despite its positive and significant high implicit value for all of the other chicken parts. Branded items have mixed average effect, but there is an indication that consumers prefer thighs and whole chicken associated with the retailers own label. As expected, 'Budget Label' has an negative and significant effect on implicit values, with the exception of breast and whole chicken. The 'Healthy' attribute was only available for chicken breast, and is as expected positive with a marginal effect of 13%. Consumers seem to place the highest value of 'Halal' attribute on thighs and legs, 37% and 11%, respectively. GMM results confirm that OLS is likely to under-estimate the marginal implicit prices of the organic attribute.

[6]Half chicken is not included in the table as there is no organic entry for the attribute in the sample.

5 Conclusions

This paper has elicited the implicit marginal effect of organic attibute of chicken meat in the UK using an instrumental variable approach in a hedonic pricing setting. The econometric limitations of the hedonic pricing model (HPM) derived from endogeneity issues pose great challenge to researchers and have rarely been addressed. They derive from various sources such as the simultaneous estimation of supply and demand, omitted variables, hedonic sorting or from the nonlinearity of the hedonic price function itself. Rosen (1974) argued in his original article that the attribute of interest in a HPM setting must be treated as endogenous, and the economic source of the endogeneity has been clarified by subsequent authors (see Kahn and Lang 1988 for a summary). And yet, very few studies have tried to address this endogenity empirically.

We address this limitation by instrumenting the organic attribute with two consumer characteristics related to family structure and the age of children.[7] Theoretically, consumer characteristics should be related to organic consumption but not influence the price of organic products. Empirically, the two instruments pass all the validity testes.

We show that when we use instruments, the value of the organic attribute is 2 to 5 times larger than without instruments, depending on the estimation method used (GMM or 2SLS). Because GMM appears to be the more appropriate method in the present case (see Wooldridge 1996) we rely on this estimation and an report an implicit marginal price of 135%, (equivalent to £6.36 per kilogram) for the organic attibute in chicken meat.

One of the main contributions of this paper is to demonstrate how socio-economic consumer characteristics can be used as valid instruments in applications of hedonic price models as they are both central drivers of the demand for the organic attribute and exogenous to the price function. The results show that the organic attribute contributes substantially to the marginal price of chicken across all types of chicken meat.

A reliable estimate of the marginal value of the organic attribute is a necessary first step for an accurate benefit–cost analysis of any policy decision related to organic products. It is especially important when related to meat where animal welfare aspects need to be further considered. And it is especially important at the present time in the UK when in the prospect of Brexit the agricultural policy is in the process of being reformed. To our knowledge, this paper is the first to incorporate an instrumental variable approach in order to isolate the value of the organic attribute for chicken meat in a hedonic pricing setting. We conclude that the organic attribute contributes to the value of chicken meat to a greater extent than previously believed. Our results suggest that the value of policy interventions via support of organic production benefit the UK consumer more than previously estimated. They point out to potential errors in hedonic settings and could have a significant impact on the long-run policy decisions. Measuring the value of the organic attribute without taking into consideration these errors might lead to a severe underestimation of its value to the UK consumer and might lead to misallocation of resources from the policy point of view. Organic production is a resource that generates value through various sources such as perceived better health and taste but also environmentally friendliness and higher animal welfare. Stated preference valuation techniques have been applied to estimate the value of this attribute using models that assume equilibrium market conditions. However, stated preference techniques usually suffer from hypothetical bias. Revealed preference valuation techniques applied to organic food usually involve HPM estimations but do not consider the endogeneity issues. Our analysis suggests that the organic attribute accounts for a much larger portion of chicken meat value than would be presumed if a correction for endogeneity would not have been in place. The economic

[7] 'PreFamily' (a dummy for a young couple with no children) and 'MiddleFamily' (a dummy for a family with children between 5-9 years old).

implications of organic production have received attention from resource economists only relative recently. Organic food products provide a series of benefits to consumers involving their direct use and their value to the environment and the society as a whole, and the present paper suggests a way how these can be estimated more accurately to be better suited for potential policy recommendations.

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Appendices

Table 1: *First stage regression of socio-economic characteristics (probit estimation)*

VARIABLES	Organic
Income	0.062***
	(0.005)
Female	0.024**
	(0.022)
BMI	-0.027***
	(0.002)
PreFamily	0.159**
	(0.042)
YoungFamily	0.204**
	(0.037)
MiddleFamily	0.294**
	(0.038)
OlderFamily	-0.024**
	(0.045)
EmptyNest	0.263**
	(0.038)
Retired	0.383**
	(0.039)
Constant	-2.289*
	(0.070)
Observations	238,860

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: *Correlation socio-economic variables with Price*

Variables	LnPrice	
Income	0.123	
Age	-0.099	
Female	0.009	
BMI	-0.047	
Retired	-0.053	
Children	0.020	
PreFamily	0.059	
YoungFamily	0.042	
MiddleFamily	-0.000	
OlderFamily	0.005	*All* $p < 0.01$

Table 3: *Correlation BMI with Retailers*

Variables	Cor BMI	Avrg Price	Avrg BMI
Asda	0.034	4.79	27.50
Aldi	-0.019	3.80	26.74
Lidl	-0.002	3.91	26.96
Iceland	0.009	3.87	27.40
Coop	-0.001	5.72	26.92
Costco	0.006	4.92	27.45
Morrisons	0.026	4.91	27.43
M&S	-0.005	5.56	26.79
Ocado	-0.017	6.33	25.59
Sainsburys	-0.015	5.46	26.76
Tesco	-0.008	4.90	26.91
TheBlackFarmer	-0.023	7.49	20.20
Waitrose	-0.036	7.40	25.65

Table 4: *Regression of socio-economic characteristics on Price*

LnPrice	Coef.	St.Err	t-value	p-value	Sig.
Income	0.007	0.000	31.59	0.000	***
Age	-0.001	0.000	-9.85	0.000	***
Female	0.001	0.001	1.32	0.188	
BMI	0.000	0.000	-1.27	0.203	
Retired	0.002	0.002	1.28	0.200	
Children	-0.002	0.001	-2.74	0.006	***
PreFamily	-0.015	0.002	-7.45	0.000	***
YoungFamily	-0.001	0.002	-0.47	0.636	
MiddleFamily	0.003	0.002	1.40	0.161	
OlderFamily	0.002	0.002	0.85	0.394	
Constant	1.207	0.018	67.23	0.000	***

R-Squared: 0.856

$***p < 0.01, **p < 0.05, *p < 0.1$

All variables from the baseline model were included

Table 6: *Sample entry distribution and total expenditure by region*

Region	Entries	Expenditure	Exp (%)	Mean	Median	sd
North	86,387	369,000.00	25.76	4.27	3.69	3.06
South	83,336	354,000.00	24.71	4.24	3.79	2.48
Midlands	58,134	243,000.00	16.96	4.19	3.70	2.78
East	38,403	165,000.00	11.52	4.30	3.78	2.77
London	29,958	129,000.00	9.00	4.32	3.67	3.50
Scotland	25,111	108,000.00	7.54	4.30	3.75	2.67
Wales	15,641	64,641.45	4.51	4.13	3.64	2.74
Total	336,970	1,432,641.45	100.00	4.25	3.75	2.85

Table 7: *Sample Distribution: Retail by region*

Retail	East	London	Midlands	North	Scotland	South	Wales
Tesco	12,491	7,037	12,021	14,987	5,018	23,400	3,952
Aldi	5,074	1,735	12,095	17,006	3,772	8,044	2,558
Asda	3,884	3,219	6,545	15,641	4,134	9,194	2,262
Sainsburys	4,874	5,872	6,544	7,124	1,729	12,928	899
Morrisons	3,530	1,871	7,329	11,770	3,421	6,877	1,535
Lidl	2,707	3,149	4,467	6,133	3,483	10,489	2,536
Waitrose	1,060	1,292	1,017	914	115	3,256	173
M&S	410	589	695	1,923	913	1,370	226
Iceland	602	1,015	788	1,508	412	1,158	406
Coop	676	218	951	1,055	545	1,251	187
Costco	230	251	199	420	190	426	56
Ocado	232	210	328	278	4	521	16
TheBlackFarmer	0	99	3	1	0	5	0
Others	2,633	3,401	5,152	7,627	1,375	4,417	835
Total (336,970)	38,403	29,958	58,134	86,387	25,111	83,336	15,641

Table 8: *Sample Distribution by Chicken Part*

SubProduct	Observations (purchases)	Share (%)	Mean (£/Kg)	Median (£/Kg)	sd
Breast	164,490	48.81	6.67	6.15	1.77
Whole	105,761	31.39	2.62	2.42	1.07
Thigh	36,378	10.80	3.74	3.00	1.85
Legs	13,310	3.95	2.69	2.43	1.11
Drumsticks	11,126	3.30	2.35	2.25	0.54
Wings	5,185	1.54	2.23	2.32	0.58
Others	649	0.19	2.82	2.49	1.22
Half	71	0.02	4.75	4.90	1.15
Total	336,970	100.00	4.71	5.20	2.47

Table 11: *Price comparison: organic vs conventional chicken parts*

	All Chicken Purchases			Organic Chicken		
SubProduct	Observations (purchases)	Share (%)	Mean (£/Kg)	Observ. (£/Kg)	Share (%)	Mean
Breast	164,490	48.81	6.67	689.00	15.44	36.71
Whole	105,761	31.39	2.62	409.00	6.60	21.79
Thigh	36,378	10.80	3.74	353.00	9.83	18.81
Legs	13,310	3.95	2.69	394.00	6.55	20.99
Drumsticks	11,126	3.30	2.35	17.00	7.69	0.91
Wings	5,185	1.54	2.23	15.00	5.78	0.80
Others	649	0.19	2.82	-	-	-
Half	71	0.02	4.75	-	-	-
Total	336,970	100.00	4.71	1877	10.44	100.00

Table 15: *GMM regression results: regions*

VARIABLES	Scotland		North		London		South		Midlands		East		Wales	
Method	GMM	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM	OLS
Instrument	P-Family		M-Family		M-Family		Y-Family		Adults		Y-Family			
F-statistic	90		138		106		22		90		32			
Organic	0.353***	0.628***	1.537***	0.637***	0.990***	0.790***	1.376***	0.712***	-0.158	0.683***	1.526***	0.780***	0.406***	0.723***
	-0.105	(0.022)	-0.166	(0.019)	-0.09	(0.014)	-0.176	(0.014)	-0.249	(0.020)	-0.229	(0.015)	(0.060)	(0.088)
Freedom_Food	0.273***	0.513***	0.357***	0.510***	0.433***	0.577***	0.374***	0.563***	0.381***	0.586***	0.420***	0.578***	0.347***	0.536***
	-0.014	(0.025)	-0.013	(0.019)	-0.014	(0.015)	-0.013	(0.011)	-0.012	(0.017)	-0.025	(0.018)	(0.026)	(0.045)
Offer	-0.041***	-0.077***	-0.028***	-0.069***	-0.011*	-0.054***	-0.022***	-0.065***	-0.052***	-0.067***	-0.012	-0.052***	-0.054***	-0.075***
	-0.004	(0.003)	-0.004	(0.002)	-0.006	(0.003)	-0.006	(0.002)	-0.002	(0.002)	-0.009	(0.003)	(0.003)	(0.004)
Branded	-0.011	-0.014	-0.018*	-0.018	0.105***	0.176***	0.017	0.052***	0.019	0.025	-0.012	-0.011	-0.068***	-0.105***
	-0.012	(0.020)	-0.011	(0.014)	-0.009	(0.010)	-0.013	(0.016)	-0.014	(0.020)	-0.017	(0.022)	(0.019)	(0.028)
BudgetLabel	-0.194***	-0.170***	-0.068***	-0.118***	-0.070***	-0.077***	-0.105***	-0.127***	-0.154***	-0.153***	-0.073***	-0.127***	-0.174***	-0.176***
	-0.03	(0.022)	-0.016	(0.011)	-0.02	(0.016)	-0.02	(0.015)	-0.015	(0.011)	-0.028	(0.016)	(0.027)	(0.020)
Quality	0.276***	0.396***	0.354***	0.349***	0.346***	0.401***	0.324***	0.401***	0.263***	0.367***	0.377***	0.436***	0.306***	0.410***
	-0.011	(0.017)	-0.022	(0.010)	-0.016	(0.015)	-0.013	(0.009)	-0.009	(0.011)	-0.021	(0.013)	(0.015)	(0.021)
Halal			0.247***	0.400***	0.102***	0.142***	0.184***	0.267***	0.094***	0.146***	0.393***	0.603***	0.406***	0.570***
			-0.034	(0.051)	-0.014	(0.019)	-0.022	(0.030)	-0.023	(0.034)	-0.144	(0.159)	(0.020)	(0.028)
Healthy			-0.081	-0.054	0.078*	0.167*			-0.016	0.062			-1.173***	-1.626***
			-0.072	(0.155)	-0.042	(0.091)			-0.043	(0.085)			(0.023)	(0.033)
Asda	0.036***	0.073***	0.019***	0.050***	0.006	0.035***	0.012***	0.043***	0.041***	0.060***	0.003	0.035***	0.006	0.016
	-0.005	(0.007)	-0.003	(0.003)	-0.005	(0.006)	-0.005	(0.004)	-0.003	(0.004)	-0.007	(0.005)	(0.008)	(0.010)
Aldi	0.077**	0.013	-0.039**	-0.003	-0.094***	-0.104***	-0.004	-0.002	0.051***	0.032***	-0.045	-0.009	0.046	0.018
	-0.03	(0.023)	-0.017	(0.011)	-0.021	(0.018)	-0.021	(0.015)	-0.015	(0.012)	-0.029	(0.017)	(0.029)	(0.022)
Lidl	0.093***	0.038*	-0.030*	0.006	-0.085***	-0.094***	0.001	0.007	0.061***	0.040***	-0.019	0.020	0.049*	0.023
	-0.03	(0.023)	-0.017	(0.011)	-0.021	(0.018)	-0.021	(0.015)	-0.015	(0.012)	-0.029	(0.017)	(0.029)	(0.023)
Iceland	-0.025**	-0.028*	-0.094***	-0.094***	-0.174***	-0.169***	-0.103***	-0.101***	-0.056***	-0.081***	-0.089***	-0.084***	-0.136***	-0.159***
	-0.01	(0.015)	-0.007	(0.006)	-0.01	(0.009)	-0.008	(0.007)	-0.007	(0.008)	-0.012	(0.009)	(0.014)	(0.015)
Coop	0.110***	0.203***	0.099***	0.173***	0.070***	0.126***	0.088***	0.146***	0.114***	0.169***	0.096***	0.172***	0.068***	0.088***
	-0.007	(0.011)	-0.005	(0.006)	-0.011	(0.016)	-0.006	(0.007)	-0.005	(0.007)	-0.01	(0.009)	(0.012)	(0.016)
Morrisons	0.070***	0.121***	0.046***	0.115***	0.029***	0.076***	0.059***	0.124***	0.101***	0.133***	0.060***	0.117***	0.066***	0.090***
	-0.006	(0.008)	-0.007	(0.003)	-0.008	(0.007)	-0.009	(0.005)	-0.004	(0.004)	-0.009	(0.006)	(0.009)	(0.011)
M&S	-0.040***	-0.057**	-0.170***	-0.039***	-0.115***	-0.041*	-0.089***	-0.038**	-0.028*	-0.086***	-0.185***	-0.107***	-0.129***	-0.211***
	-0.015	(0.023)	-0.035	(0.014)	-0.024	(0.022)	-0.022	(0.015)	-0.016	(0.019)	-0.044	(0.025)	(0.026)	(0.035)
Sainsburys	0.065***	0.128***	0.030***	0.096***	-0.012	0.057***	0.009	0.092***	0.066***	0.082***	-0.016	0.097***	0.016*	0.032***
	-0.009	(0.009)	-0.007	(0.003)	-0.011	(0.005)	-0.013	(0.004)	-0.005	(0.004)	-0.027	(0.005)	(0.009)	(0.011)
Tesco	0.018***	0.045***	0.012***	0.049***	-0.030***	-0.003	0.004	0.039***	0.039***	0.056***	0.008	0.046***	0.003	0.011
	-0.007	(0.008)	-0.004	(0.003)	-0.007	(0.006)	-0.006	(0.004)	-0.003	(0.004)	-0.009	(0.005)	(0.008)	(0.010)
Waitrose	0.252***	0.450***	0.078*	0.403***	0.048	0.322***	0.138***	0.401***	0.244***	0.370***	0.160***	0.388***	0.202***	0.312***
	-0.016	(0.027)	-0.042	(0.010)	-0.032	(0.011)	-0.03	(0.006)	-0.009	(0.010)	-0.029	(0.011)	(0.015)	(0.021)
Constant	-0.235***	0.680***	-0.041	0.916***	-0.022	0.942***	-0.029	0.880***	-0.037	0.955***	-0.114***	0.814***	-0.147***	0.812***
	-0.051	(0.067)	-0.027	(0.027)	-0.028	(0.033)	-0.04	(0.043)	-0.028	(0.033)	-0.039	(0.044)	(0.039)	(0.044)
Observations	25,109	25,109	86,380	86,380	29,952	29,952	83,328	83,328	58,130	58,130	38,400	38,400	15,641	15,641
R-squared		0.848		0.852		0.807		0.833		0.853		0.840		0.830

*Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; All models include chicken parts, package sizes and month dummies*

Table 16: *GMM regression results: parts*

VARIABLES	Breast		Drumsticks		Legs		Thigh		Wings		Whole	
Method	GMM	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM	OLS
Instrument	O-Family		O-Family		Y-Family		O-Family		O-Family		O-Family	
IV F-Statistics	38		11		21		35		12		15	
Organic	1.602***	0.652***	0.035	0.754***	1.260***	0.712***	2.766***	0.452***	1.580***	0.598***	2.978***	0.862***
	(0.032)	(0.006)	(2.107)	(0.030)	(0.070)	(0.011)	(0.112)	(0.018)	(0.467)	(0.032)	(0.062)	(0.010)
Freedom_Food	0.349***	0.679***			0.398***	0.326***	0.265***	-0.037			0.818***	0.648***
	(0.005)	(0.005)			(0.024)	(0.011)	(0.032)	(0.023)			(0.019)	(0.007)
Offer	0.006***	-0.057***	-0.039***	-0.035***	-0.090***	-0.154***	0.254***	0.111***	-0.113***	-0.113***	0.007	-0.090***
	(0.001)	(0.001)	(0.013)	(0.003)	(0.010)	(0.004)	(0.017)	(0.004)	(0.021)	(0.006)	(0.008)	(0.002)
Branded	0.059***	0.126***	0.122***	0.117***	0.397***	0.435***	-0.245***	-0.224***	0.213	0.315***	-0.040***	-0.026***
	(0.003)	(0.004)	(0.021)	(0.012)	(0.017)	(0.015)	(0.020)	(0.017)	(0.014)	(0.027)	(0.014)	(0.008)
BudgetLabel	0.098*	0.166***	-0.406***	0.230**	-0.212***	-0.285***	-0.217***	-0.051***	-0.229***	-0.171***	0.065***	-0.077***
	(0.053)	(0.055)	(0.007)	(0.115)	(0.021)	(0.009)	(0.009)	(0.009)	(0.010)	(0.007)	(0.011)	(0.013)
Quality	0.259***	0.374***	-0.111***	-0.113***	0.341***	0.273***	0.391***	0.508***	0.429***	0.349***	0.557***	0.456***
	(0.010)	(0.004)	(0.011)	(0.017)	(0.011)	(0.007)	(0.015)	(0.016)	(0.095)	(0.087)	(0.014)	(0.005)
Halal	0.047***	0.083***	0.038	0.038**	0.113***	0.095***	0.348***	0.357***	0.198***	0.220***	0.092**	-0.004
	(0.008)	(0.009)	(0.032)	(0.016)	(0.034)	(0.032)	(0.028)	(0.032)	(0.044)	(0.028)	(0.037)	(0.022)
Healthy	0.125***	0.181***										
	(0.028)	(0.019)										
Scotland	-0.022***	0.000	-0.027***	-0.026***	0.006	-0.013*	0.002	-0.017**	0.023	0.009	-0.020	0.023***
	(0.003)	(0.001)	(0.005)	(0.005)	(0.008)	(0.007)	(0.013)	(0.008)	(0.017)	(0.009)	(0.012)	(0.003)
Wales	-0.001	-0.014***	-0.025***	-0.025***	-0.011	-0.004	0.014	0.007	0.022	0.002	-0.004	-0.013***
	(0.002)	(0.002)	(0.006)	(0.006)	(0.011)	(0.008)	(0.014)	(0.008)	(0.019)	(0.010)	(0.007)	(0.003)
North	0.003**	-0.003***	-0.010***	-0.010***	-0.030***	-0.014***	0.013	-0.000	0.010	-0.003	-0.023***	-0.005***
	(0.001)	(0.001)	(0.004)	(0.003)	(0.007)	(0.004)	(0.012)	(0.005)	(0.015)	(0.006)	(0.006)	(0.002)
Midlands	0.000	-0.005***	-0.007	-0.008**	-0.032***	-0.015***	-0.042**	0.025***	0.002	-0.001	-0.013*	-0.003
	(0.002)	(0.001)	(0.004)	(0.004)	(0.008)	(0.005)	(0.019)	(0.005)	(0.013)	(0.006)	(0.007)	(0.002)
London	-0.030***	-0.014***	-0.003	-0.005	-0.047***	-0.014***	-0.086***	-0.016***	-0.002	0.000	-0.097***	0.005**
	(0.004)	(0.002)	(0.007)	(0.004)	(0.010)	(0.005)	(0.020)	(0.006)	(0.016)	(0.005)	(0.016)	(0.003)
East	-0.003	-0.007***	-0.003	-0.004	-0.052***	-0.009*	0.024*	-0.013**	0.012	0.004	-0.018*	0.004*
	(0.002)	(0.001)	(0.005)	(0.004)	(0.011)	(0.005)	(0.013)	(0.006)	(0.017)	(0.007)	(0.010)	(0.002)
Observations	164,462	164,462	11,126	11,126	13,310	13,310	36,377	36,377	5,185	5,185	105,760	105,760
R-squared		0.528		0.674		0.728		0.544		0.740		0.434

*Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; all regressions include main retailers, package size and month dummies*

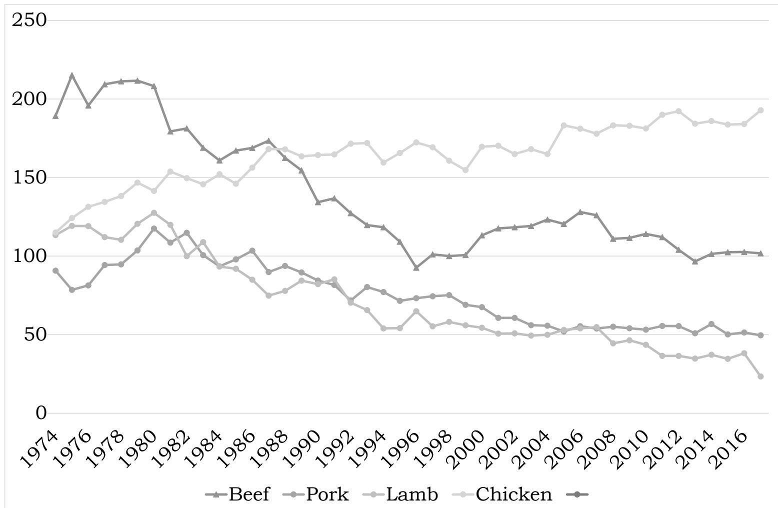

Figure 1: *Meat Consumption in the UK (g/person/week) - Source: Defra*

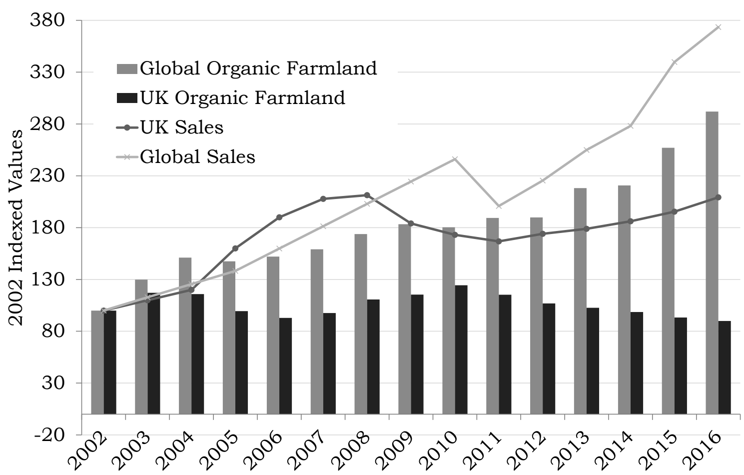

Figure 2: *Organic product: sales and farmland (2002 indexed values)*

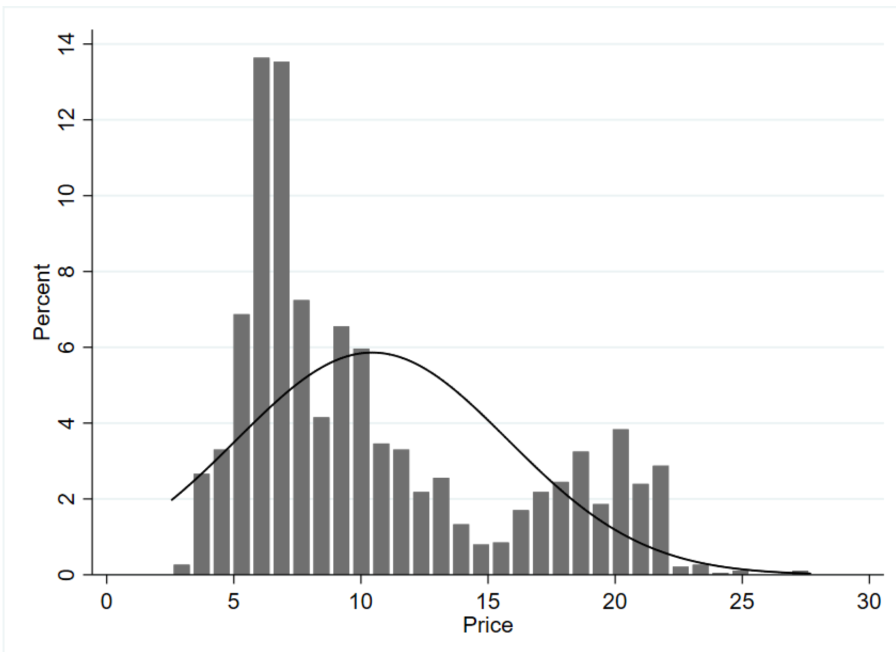

Figure 7: *Price Distribution: all retailers*

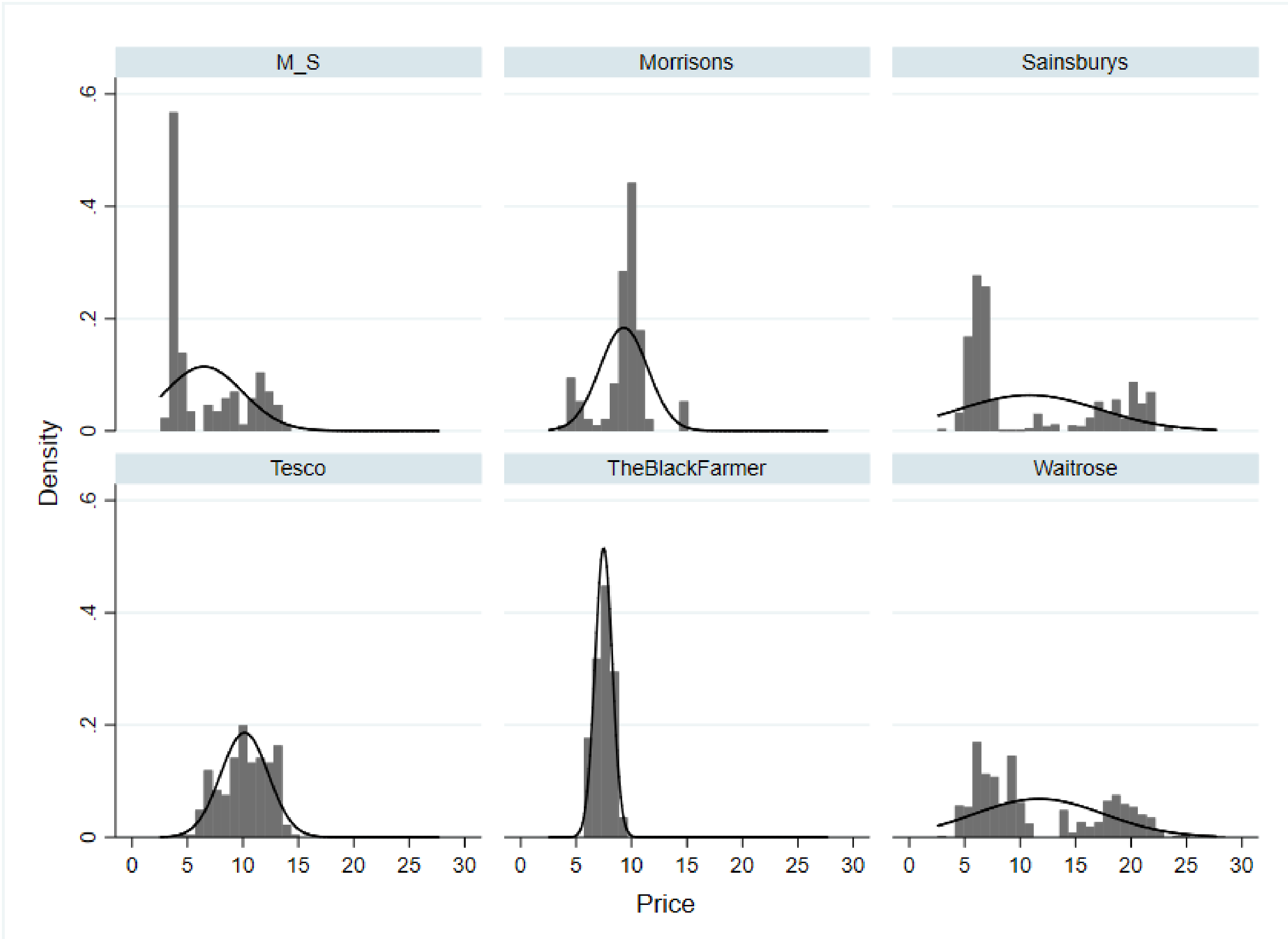

Figure 8: *Price Distribution by Retailer*

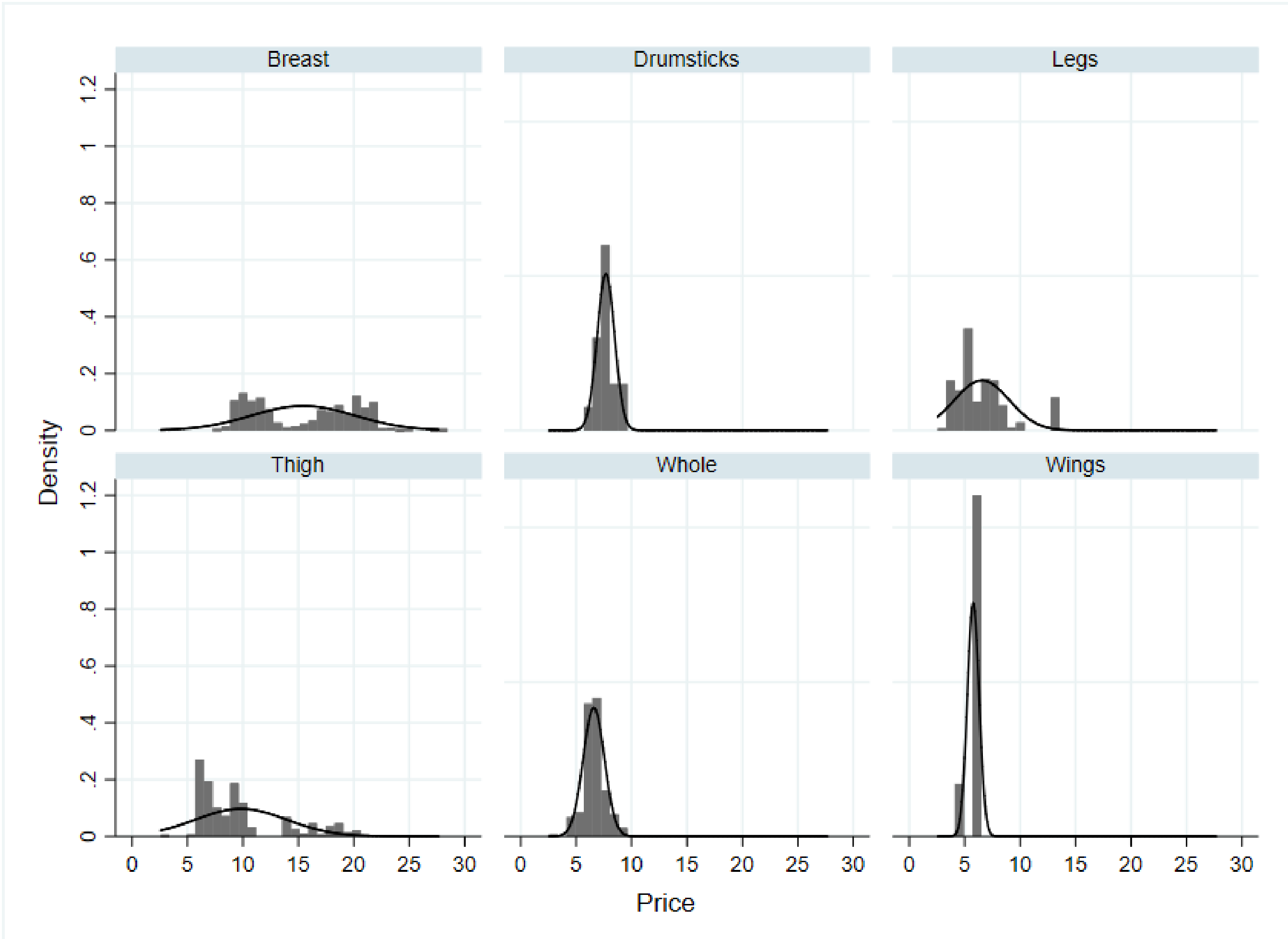

Figure 9: *Price distribution by parts*

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