A hedonic price model of the Paris carcase lamb market

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Summary

Based on a lamb carcase classification and pricing exercise in the Paris wholesale market at Rungis an equation was estimated which regresses prices on farm-based and factory-based quality aspects and on country of origin of the carcases. The revenue foregone per carcase by each supplying country, because of divergence from the optimal quality is quantified and allocated to particular quality attributes. For all countries quality improvement would yield substantial increased revenue. Supplying countries other than France suffer a substantial country-of-origin discount which is not justified on quality considerations. Further research is necessary on this phenomenon.

1. Introduction

A hedonic price function is a regression of the observed price of a commodity against its quality attributes (Lucas, 1975). It can be extended to include non-quality attributes such as brands and countries of origin. At a given point in time it can identify not just which factors are important in determining the price of a commodity but also how important each factor is and the consistency of its relationship with price. These are usually important informational inputs in the decision-making process of farmers, processors and policy-makers. Using the estimates of such relationships in conjunction with the differences which exist on average in the explanatory variables of the model as between countries of origin, it is possible to quantify how much, in money terms, commodities from one country are gaining or losing relative to the optimum for that market and relative to similar commodities in the market which have been supplied by other countries. This is an issue of very great interest to farmers, who because of the relative weakness of their position in the food industry, usually end up as the

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recipients of any shortfalls in the price performance of products at market level. Using this type of analysis it is possible to pinpoint the origins of such shortfall e.g. farm level, factory level or other. It thus clarifies by whom remedial action should be taken and provides one with estimates of the possible value gains to be had from such actions, thereby enabling reliable esimates of cost-effectiveness or cost-benefit to be made.

Early work in this area which was mostly in the non-agricultural sectors was done by Adelman and Griliches (1961); Dean and Depodwin (1961); Dhrymes (1967); and Gavett (1967). A publication by Ladd in 1978 reviewed much of the work done up to that time. Agricultural applications of hedonic price modelling have been made by O'Connell (1981); Ethridge and Davis (1982) and Brorsen, Grant and Rister (1984).

2. Methodology

The exercise reported on in this article relates to lamb carcases and was undertaken in the Paris meat market at Rungis in March and June 1985. Since the exercise was done at wholesale level, only carcase-quality aspects were measured. Meat- or eating-quality aspects were not assessed directly and are reflected in the exercise only insofar as they are related to the carcase characteristics which were measured. The carcase-quality characteristics which were measured were, weight, conformation, fat level, colour of fat, colour of lean, dampness/dryness of carcase, dirt on carcase, blisters in the fat covering of the carcase, bruise marks on carcase, presence of long pieces of string on carcase, and standard of butchery. In addition, the date of the exercise was noted as were the areas of origin of the lamb. Carcase-quality characteristics were chosen after consultation with a group of market traders.

A formal sampling procedure was not adopted because of the constantly variable supply situation with regard to both the volume of lamb handled by particular wholesalers and the area of origin of the lamb. The procedure adopted was to obtain a sample of lamb from each area of origin which was as large as the circumstances permitted at each market visit. This objective was greatly facilitated by the total co-operation of Rungis wholesalers whose willing assistance is gratefully acknowledged. Apart from having to travel to Paris without any precise foreknowledge of the supply situation that would pertain when one arrived, there was also the problem that having arrived at the market the supply position was constantly shifting, with truckloads of lamb being unloaded and brought into the market, while almost simultaneously, lamb was being sold and taken out of the market. In addition, one was in constant danger of being battered to death by 400 kg Charolais carcases which were hurtling along the overhead rails at a high rate of knots. These problems are mentioned to illustrate the difficulties and indeed dangers of engaging in this type of market research and as a riposte to those researchers in the so-called 'hard' sciences who carry out their research in very controlled environments – often in comfortable laboratories – and who have the nerve to allude to economics and marketing in a derisory fashion as belonging to the 'soft' sciences.

Apart from weight, all the quality characteristics were measured subjectively. Conformation and fat levels were measured using the EC classification system with conformation measured on the EUROP scale and fat on the 1 to 5 scale. On the conformation scale, E represents maximum conformation and P minimum conformation. For computational purposes the conformation classes EUROP were coded 5, 4, 3, 2, 1 respectively. On the fat scale, a carcase scoring 1 would be virtually devoid of fat while a carcase of fat level 5 would be extremely fat. Colour of fat and colour of lean were each measured on a three-point scale with 2 representing normal colour. In the case of fat, a score of 1 represented a creamy white fat colour and 3 represented yellow fat. In the case of lean colour a score of 1 represented a lighter red than normal while 3 represented dark red muscle. Butchery standard was also measured on a three-point scale. A score of 2 represented acceptable commercial butchery, 1 represented excellent butchery exemplified by no torn fat and very careful trimming while 3 represented bad butchery exemplified by torn subcutaneous fat and careless or over-severe trimming. The following five characteristics i.e. dampness/dryness of carcase, dirt, blisters, presence of long string and bruising were all measured on a 0, 1 dummy variable basis. The following were each scored as 0, dry carcase, clean, unblistered, no long string and no bruising. Their opposites were scored as 1. Two of the above five characteristics, namely blisters and bruising, were found on the basis of an F-test to have no significant effect on price and were omitted from the analysis. The remaining three, together with butchery standard, were included in a single 'presentation' index. This approach helped to reduce multicollinearity problems and had the additional benefit of increasing the degrees of freedom. The weighting given to each approximated to $b_i/\Sigma b_i$, where b_i was the coefficient of the variable when included individually in the equation.

An attempt was also made to measure approximate slaughter age, but scoring on this variable was found to be very highly correlated with lean colour, and, from a statistical and practical point of view, it was decided to drop the age variable. As a result, the coefficient for lean colour can be interpreted as an age effect, with a light red muscle colour denoting younger lamb and darker muscle colour denoting older lamb. Very old 'lamb' is not desired at any time and suffers a price penalty in the market. Younger or spring lamb – for which there is a price premium – is particularly noticeable in the January-March period when it contrasts with the preponderant hogget lamb of the previous season.

Most of the measurements were subjective and were therefore subject to error. To minimise possible error, the measurements were carried out by a highly trained classifier from the Irish Department of Agriculture.

3. Data

From the data in Table 1 it can be seen that French lamb is unique in two respects; it is the lightest and the most highly priced. Its conformation is good, although second in this sample to English lamb. The sample sizes for English, Scottish and Welsh lamb are, however, too small to place much confidence in them as representing their true average positions. Very little lamb from these origins was on sale in Rungis at the time the field work for this study was being done. Surprisingly, French lamb is not the leanest, being outdone in this regard by lamb from the Irish Republic, England and Wales. Twenty-eight percent of lamb from the Republic of Ireland was 'damp' or 'sweaty'. Likewise, a substantial proportion of French lamb was damp while none of the English, Scottish or

Table 1. *Characteristics of Rungis lamb carcases 1985*

	French	Irish Republic	English	Scottish	Welsh
Number of carcases	192	186	26	36	30
Average weight (Kg)	17.9	19.3	18.4	19.1	18.8
Average conformation	3.3	2.6	3.8	3.2	3.0
Average fat	3.4	3.1	3.0	3.5	3.0
Average dampness/dryness	0.18	0.28	0.0	0.0	0.0
Average blister score	0.00	0.07	0.0	0.0	0.0
Average dirt score	0.02	0.09	0.0	0.0	0.0
Average bruising score	0.00	0.10	0.0	0.04	0.0
Average string score	0.06	0.74	0.0	0.0	0.0
Average butchery score	1.85	2.05	2.0	1.6	1.0
Average fat colour	2.04	2.00	2.0	2.0	2.0
Average lean colour	1.41	1.50	1.30	2.0	2.0
Average ex-Rungis price. Ff/Kg	30.83	25.2	22.7	28.5	28.5

Welsh lambs in this sample had this characteristic. The figures for the succeeding five presentational characteristics may likewise be read as percentages e.g. 2% of French lamb was dirty as was 9% from the Irish Republic. An extraordinary 74% of Irish Republic lamb had string of about half of three-quarters of a metre attached. A score of 2 for each denotes average butchery, average fat colour and average lean colour. The Welsh, the Scottish and the French had better than average butchering; the English scored average figures in this respect and the Irish Republic slightly below average. There was little difference in fat colour scores across countries of origins, but all lamb was judged to have either average or better than average lean colour.

4. Hedonic price equation

An attempt was made to explain price variation by regressing the quality measurements on ex-wholesale prices. Table 2 below shows the means, coefficient of variation, minima and maxima of the variables used in estimating equations. Equations incorporating linear and non-linear relationships between price and carcase quality measurements were estimated. With the exception of the weight variable, the choice of equation form was based on an F-test using a 1% level of significance. In the case of weight it would have been equally valid to use a linear or a quadratic form based on the F-test. However, the quadratic form was used because of widespread interest in the issue of the optimum weight for this market. The quadratic form allows one to calculate this optimum and the price penalties incurred for diverging from it.

Table 2. *Means and variations of sample measurements*

	Mean	Coefficient of variation (%)	Minimum	Maximum
Price (Ff/Kg)	27.8	14.0	17.0	39.0
Weight (Kgs)	18.8	14.0	12.4	28.0
Conformation	3.0	27.0	1.0	5.0
Fat	3.3	28.0	1.0	5.0
Dampness	20.5	-	0.0	1.0
Blisters	2.9	-	0.0	1.0
Dirt	4.1	-	0.0	1.0
Bruising	3.7	-	0.0	1.0
String	37.7	-	0.0	1.0
Butchery	1.9	-	1.0	3.0
Fat colour	2.0	-	1.0	3.0
Lean colour	1.5	-	1.0	3.0
J1[a]	32.0	-	-	-
J2[a]	43.0	-	-	-

[a] The percentages of the sample taken in the two June 1985 market visits. The remainder, i.e. 25%, was taken in the March 1985 visit.

The equation giving the best degree of fit is presented in tabular form in Table 3 below. This equation explains 78% of the variation in price and is therefore fairly satisfactory in that regard. There were no unduly serious problems with regard to multicollinearity or autocorrelation in the equation as presented in Table 3. A quadratic form best described the relationship between price and weight and between price and fat. It is therefore possible to derive an optimum level of weight and fat as follows:

$$\frac{\text{d Price}}{\text{d Weight}} = 0.967 - 2\,(0.026)\,Wt = 0$$

Table 3. *Price effects of physical characteristics, areas of origin and times of market visits*

Characteristic	Change	*t*-ratio	Effect on price in terms of Ff/Kg
Carcase weight[a]		4.3	+ 0.967
(Carcase weight)^2		4.9	- 0.026
Conformation	Increase of 1 class	13.4	+ 1.873
Fat		5.7	+ 3.209
(Fat)^2		6.3	- 0.581
Presentation index[b]	Increase of 1 unit	9.8	- 3.904
Fat colour	Increase of 1 unit	5.6	- 1.846
Lean colour	Increase of 1 unit	4.8	- 0.963
Country-of-origin effect relative to French lamb	Irish Republic	13.1	- 3.219
	English	6.4	- 4.986
	Scottish	7.2	- 3.266
	Welsh	6.7	- 4.422
Time of market visit relative to visit of March 25th	June 3rd	4.2	- 1.375
	June 4th	1.9	- 0.583
Intercept	-	8.9	21.222

a For the variables with quadratic terms, the price effect of an increase of 1 unit depends on the level of the variable at which it takes place. Thus a weight movement from 18 to 20 Kg is associated with a drop in price of [(18 × 0.967) – (324 × 0.026)] – [(20 × 0.967) – (400 × 0.026)] = 0.05 Ff/Kg whereas a movement from 23 to 25 Kg is associated with a drop in price of 0.56 Ff/Kg. Likewise an increase in fat from Class 3 to Class 4 is associated with a price reduction of 2.02 Ff/Kg.

b The weighting in this index was 0.45 each for the dampness and butchery variables and 0.05 each for the dirt and string variables. It could vary from + 0.45 for a carcase which was excellently butchered and had no dampness, dirt or string to + 1.90 for a carcase which was badly butchered and was damp, dirty and had string attached.

since the second derivative is negative, the weight which maximises price = 18.6 Kg.

$$\frac{\text{d Price}}{\text{d Fat}} = 3.209 - 2(0.581)\ \text{Fat} = 0$$

since the second derivate is negative, the fat class which maximises price is 2.8.

The price penalties incurred with divergences from the optimal weight and fat are presented in Table 4 below.

These effects are additive, so that a 15 Kg carcase of fat class 1 would suffer a price penalty on these issues relative to the optimum of 2.14 Ff/Kg, while a carcase of 27 Kg and fat class 5 would suffer a penalty of 4.76 Ff/Kg.

From the information contained in Table 3 it is possible to describe in fairly precise terms the optimal carcase type for this market. As already calculated, it

Table 4. *Price penalties for diverging from optimal weight and fat levels Ff/Kg*

	15Kg	18Kg	18.6Kg	21Kg	24Kg	27Kg
	0.34	0.01	0.00	0.15	0.76	1.84
Fat classes						
	1	2	2.8	3	4	5
	1.80	0.33	0.00	0.03	0.89	2.92

should be 18.6 Kg in weight and should score 2.8 in fat covering. It should score 0.45 for presentation which means that the carcase should not be damp or sweaty; it should be very well butchered and, less importantly, it should not be dirty or have long strings attached. It should have maximum conformation, i.e. a conformation score of 5, a creamy-white fat colour and light-red muscle colour, that is, it should score 1.0 on each of these. Finally, from the point of view of making top price it should be French lamb, because imported lamb suffers a price discount of 3 to 5 Ff/Kg which is not accounted for by any of the factors measured in this exercise.

Insofar as lamb from any particular area of origin diverges in quality from the market optimum it will suffer a reduction in price, the amount of the reduction being determined by the amount of that quality divergence multiplied by the price effect of unit divergence, as presented in Table 3 above. It is possible therefore to quantify how much revenue lamb from each country of origin is foregoing – and for what reasons – by not producing the optimal product for the market. The first step is to calculate quality divergence from the optimal for each country. This is done in Table 5. The second step is to multiply this divergence by the price effect of unit divergence. This is done in Table 6.

As can be seen in Table 6, the revenue foregone by not reaching the optimal lamb carcase quality, ranges from 6.21 Ff/Kg for English lamb to 9.43 Ff/Kg for Irish lamb. Lamb from all origins loses a relatively small amount of potential revenue because of non-optimal fat and lean colour and negligible amounts of potential revenue because of non-optimal weight. For all countries, the loss of potential revenue because of sub-optimal conformation is substantial. Sub-optimal fat colour is another source of fairly substantial potential revenue loss for all countries as is sub-optimal presentation, with the exception of Welsh lamb which, in this sample, suffered no loss whatever on the issue of presentation.

The figures for revenue foregone for quality reasons are in total quite substantial for every country. They prompt the question as to whether these levels of extra revenue could be realised by a country which supplied lamb which was optimal in every way, as described earlier. The answer, unfortunately, is likely to be no. The equation coefficients presented in Table 3 are estimates of the premium/penalty system operative in the market, given the supply/demand position at that time. There are two aspects of change in supply/demand that are worthy of consideration. The first relates to a change in the supply/demand position for lamb given no change in the quality position. Farmers are well aware that when supply increases, then in general, factories become rather choosey and tend to put more structure into their prices, paying premia for better quality and penalties for poorer quality although probably, in the farmers' opinion, with the emphasis more on the penalty side. Conversely when supply decreases, factories are less choosey and put less structure into their prices, the overriding objective being to obtain throughput. Any system of price premia and penalties therefore can change with changing supply/demand conditions, and those presented in Table 3 are applicable given the particular state of the market balance when the samples for this study were obtained.

The second, and from the point of view of this study, the more relevant aspect of supply/demand that should be considered relates to quality characteristics. It may not be inappropriate to hypothesise the existence of supply and demand schedules for quality characteristics. In a similar vein, supply and demand curves have been hypothesised for marketing services and attempts have been made to estimate them (Baron, 1977). There may exist a distinct demand curve for say, conformation, in the Paris lamb market. If, in an effort to maximise revenue from lamb exports, the suppliers of lamb into that market decided to maximise the conformation of all their lamb supplies, then even with no increase in tonnage of lamb supplied it is probable that the price premium for extra conformation would be less than that presented in Table 3. How much less the premium would be would depend on the size of the shift in the supply schedule for conformation and on the price elasticity of the demand schedule for conformation. These are both very much matters for speculation and will not be pursued here. The purpose here is simply to make the point that the coefficients for price premia and penalties used here are valid for the market conditions in which they were obtained but not necessarily for other market conditions. In particular, premia for quality would probably be less in the context of an improvement in the overall quality position even with no change in tonnage of lamb supplied.

Table 5. *Quality divergence from market optimum by country of origin*

	Market optimum	Optimum-Av. French	Optimum-Av. Irish Rep.	Opt.-Av. English	Opt.-Av. Scottish	Opt.-Av. Welsh
Weight (Kg)	18.6	0.7	-0.7	0.2	-0.5	-0.2
(Weight)^2	346.0	25.6	-26.5	7.4	-18.8	-7.4
Conformation	5.0	1.7	2.4	1.2	1.8	2.0
Fat	2.8	-0.6	-0.3	-0.2	-0.7	-0.2
(Fat)^2	7.8	-3.8	-1.8	-1.2	-4.5	-1.2
Fat colour	1.0	-1.04	-1.0	-1.0	-1.0	-1.0
Lean colour	1.0	-0.41	-0.50	-0.3	-1.0	-1.0
Presentation	0.45	-0.47	-0.60	-0.45	-0.28	-0.0

Table 6. *Quantification and explanation of foregone revenue by country of origin (Ff/Kg)*

Characteristic	Quality divergence from optimum X price effect of one unit change or divergence in quality [*Note*: '+' sign denotes revenue foregone]									
	France		Irish Republic		England		Scotland		Wales	
Weight	+0.68		-0.68		+0.19		-0.48		-0.19	
(Weight)²	-0.67		+0.69		-0.19		+0.49		+0.19	
Net weight		+0.01		+0.01		0.00		+0.01		0.00
Conformation		+3.18		+4.50		+2.25		+3.37		+3.75
Fat	-1.93		-0.96		-0.64		-2.25		-0.64	
(Fat)²	+2.21		+1.05		+0.70		+2.61		+0.70	
Net fat		+0.28		+0.09		+0.06		+0.36		+0.06
Fat colour		+1.92		+1.85		+1.85		+1.85		+1.85
Lean colour		+0.39		+0.48		+0.29		+0.96		+0.96
Presentation		+1.83		+2.50		+1.76		+1.09		0.00
Revenue foregone by not reaching market optimal quality		7.61		+9.43		+6.21		+7.64		+6.62
Revenue foregone by not reaching French quality		0.00		1.82		(1.40)[a]		0.03		(0.99)[a]
Revenue foregone due to country-of-origin effect		0.00		3.22		4.99		3.27		4.42

[a] These are premia which English and Welsh lamb should have made relative to French on quality considerations alone

The final topic to be discussed here is the country-of-origin effect. This is negative and consistent for all imported lamb. It is a price penalty suffered by imported lamb which is not justified by reference to the quality characteristics measured in this study. In the case of English and Welsh lamb one must add to this the premium which they should have received for superior quality. The situation could arise because of errors in measurement or because of an omitted variable or variables. The possibility of measurement error arises because most of the measurements were subjective. However, to explain the country-of-origin effect in this way, it would be necessary to argue that the measurement error applied disproportionately either to imported lamb or to French lamb because this result would be unlikely if it applied equally to both. This is an implausible explanation, especially since the same highly trained classifier was used for all the classification work.

With regard to the second of the two possible explanations mentioned above, namely an omitted variable or variables, it can be said that all imported lamb is less fresh than domestically produced lamb. There is therefore less time flexibility in its subsequent marketing than there is for French lamb. The price discounting of imported lamb might therefore be a form of insurance against the possibility of it losing consumer attractiveness and hence losing value. In the author's opinion this would be a very remote possibility, and hence it should not be the basis for discounting of imported lamb much less discounting of the magnitude found in this study. However, this issue cannot be resolved by discussions or argument, but by empirical work relating to the commercial value systems of retail butchers and others who buy lamb in Rungis for sale to the final consumer.

Finally, there is another possible explanation of the country or origin effect, and it is one which has received some attention in the literature. It relates to the possible existence of separate demand functions for imported and domestically produced commodities which are otherwise homogeneous. It appears from the literature that the idea of a separate demand curve for products differentiated by place of production was first conceived and developed by analysts who were trying to estimate inter-country trade models.

Work has been done in this area by Stent (1967); Armington (1969); Colman and Miah (1973); and Grennes, Johnson and Thursby (1978). Stent undertook his work specifically to try to prove the validity or otherwise of conflicting claims which appeared in the Report of the Committee of Inquiry into Fatstock and Carcase Meat Marketing and Distribution (1964) and which were as follows: 'Some witnesses have claimed that fluctuations in supplies of imported meat have been responsible for changes in prices for home-produced meat. On the other hand, the Imported Meat Trade Association has stated that the dominant factor in determining prices for home-produced meat is the supply of that meat.' The work of Armington, Colman and Miah was similar to that of Stent. All were primarily concerned with trying to estimate own-price flexibilities (slopes of demand curves) and cross-price elasticities of demand for home-produced and imported products. They estimated these using time series data. The emphasis here, however, is less concerned with slopes of demand curves and more with their relative positions and with explaining why, at a given point in time, imported produce of a given quality makes a substantially lower price than domestic produce of the same quality. In addressing this issue, time-series analysis of the type referred to above would play a part in estimating the statistical characteristics of demand functions for domestic and imported lamb in France, but more would be required. It would be necessary to go beyond statistical demand estimation so as to identify the factors underlying the existence of separate demand functions for domestic and imported lamb. Grennes, Johnson and Thursby discuss four reasons why buyers might distinguish products by place of production. Of the four, their second point is of most relevance here. It relates to what they call national factors which might operate even where products are intrinsically homogeneous. They suggest that traders may employ political considerations in their business transactions. They also state 'Importers .... may prefer to diversify their purchases among suppliers for security reasons. If a country relies heavily on imports for its supply of a good, it may want to minimize the probability of restricted supply by diversifying its purchases.' This latter hypothesis would seem to be a sounder one than the previous (political considerations) one, and is in line with the reasoning of O'Connell et al. (1981) in their discussion consequent on finding a substantial and consistent negative country-of-origin effect on Irish beef-selling at wholesale level in the U.K. Traders may judge the probabilities of supply disruption to be greater, the further removed suppliers are from the market, and particularly so when overseas suppliers are involved. This consideration may develop into an implicit but important element of the attitude of buyers, which underlies their demand. It may form part of the explanation as to why, at a given point in time, imported produce of a given quality makes a substantially lower price than domestic produce of the same quality. There may, of course, be other reasons as well.

This is a complex but highly relevant area for further applied research. The result of the statistical analysis of this study, which showed differential pricing far in excess of what is warranted for purely quality reasons, suggests that even with a product which is homogeneous in quality terms there is not a single demand function for lamb in the Paris market. There are, it seems, separate demands and separate market segments. Ascertaining the statistical and market characteristics of these and the commercial attitudes and value systems which give rise to them would increase our understanding of how this and other markets work, and might provide the information which exporters into this and other markets could use to recoup at least some of the substantial revenue which they are currently foregoing.

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