European Review of Agricultural Economics Vol **27 (4)** (2000) pp. 519–532

A hedonic analysis of agricultural land prices in England and Wales

David Maddison

University College London and University of East Anglia, UK

Received April 1999; final version received August 2000

Summary

With the hedonic approach, farmland price differentials are held to be indicative of underlying productivity differences. Data characterising over 400 separate transactions in farmland in England and Wales in 1994 are analysed, and the marginal value of particular farmland characteristics is computed. The analysis indicates that climate, soil quality and elevation are all important characteristics, in addition to the structural attributes of farmland. It is found that landowners are unable to costlessly 'repackage' their land and that regulated tenancies halve farm values. Some doubt is cast on the accuracy of professional valuations performed by land agents.

Keywords: hedonic prices, farmland values, England and Wales

JEL classification: Q12, Q24

1. Introduction

The value of land derives from its use, and anything that affects the productivity of land will be reflected in its purchase price. In principle, therefore, land prices contain information on the value that farmers place on various characteristics of the land. Using the 'hedonic' approach described below, price differentials associated with particular characteristics can be used to measure the productive value of those characteristics.

The hedonic approach has already been employed by Miranowski and Hammes (1984) to determine the implicit prices for soil characteristics in Iowa. Brown and Barrows (1985) and Ervin and Mill (1985) have used the hedonic technique to measure the impact of soil erosion on farmland productivity. Palmquist and Danielson (1989) have applied the technique to measure the value of erosion control and drainage. More recently, Mendelsohn *et al.* (1994), Dinar *et al.* (1998) and Evenson and Alves (1998) have used the hedonic technique to measure the impact of climate on agricultural productivity in the United States, India and Brazil, respectively.

This paper uses the hedonic technique to measure the productivity of farmland characteristics in England and Wales. Apart from the geographical domain of its application, what distinguishes this analysis is the fact that it deals with the price of individual plots of agricultural land over a large geographical area. Previous applications have dealt with the price of individual plots within a small geographical area and have not therefore been able to investigate the productivity impacts of characteristics such as climate that vary over large distances. Other applications have examined variation in land prices over large geographical areas but have used county averages for the returns to land along with county averages for climate, elevation and soil quality.

The remainder of the paper is organised as follows. Section 2 summarises the hedonic technique and explores the theoretical basis for placing restrictions upon the functional form of the hedonic price equation. In Section 3 the data on farm sales in England and Wales used to estimate the hedonic price equation are discussed. In Section 4 the hedonic price equation is estimated, and in Section 5 the values of various farmland characteristics are computed and the results discussed. Section 6 concludes.

2. The hedonic technique

Although widely used in other fields, the hedonic technique may be unfamiliar to many agricultural economists. Before proceeding to the empirical implementation of the hedonic technique it may therefore be useful to present a brief summary of the technique.[1]

Different plots of agricultural land possess different characteristics. Some of these characteristics, such as soil quality and climate, cannot be altered. These are dubbed non-produced characteristics. Other features of the land (such as the number of buildings) can be changed. These are termed structural attributes. The price of land (P) is functionally dependent upon its characteristics (q) both structural and non-produced. This relationship is represented by the hedonic price equation $P = (q_1, q_2, \ldots, q_n)$. It is assumed that no individual is able to influence the position of the hedonic price equation. None the less, the hedonic price schedule is determined by the interaction of many buyers and sellers, and adjusts to eliminate excess supply and demand for each type of land.

Palmquist (1989) shows how to derive the farmer's bid function for a plot of land. This bid function will be a function of the characteristics of the land, the price of inputs and outputs as well as a vector of farmer-specific skills. In equilibrium, the partial derivative with respect to the characteristics of the land of the farmer's bid function must equal the derivative of the hedonic price equation. Otherwise, the farmer could increase profits by using land with more or less of particular characteristics. In addition, the zero-profit constraint means that the farmer's total bid for a plot of land must equal the rental price.

If all farmers had identical skills, then the functional form of the hedonic price equation would correspond to the (common) bid function for each characteristic. If, on the other hand, the productive skill of each farmer

1 For a more extensive theoretical discussion of the hedonic technique as applied to farmland, see Palmquist (1989).

differs, then a farmer's marginal willingness to pay for particular characteristics can be inferred from the locational choice of the farmer. In this case, identification of the bid function itself requires the analyst to observe how a given farmer's locational choice changes in different markets. This is seldom attempted as it would typically require information from different time periods as well as characteristics of the farmers themselves (see Palmquist (1989) for more details).

Estimating additional benefits arising from changes in the characteristics of farmland is easy or not depending upon whether these changes affect few or many sites. If changes affect only a few plots, the owners of these plots would enjoy a capital gain whose magnitude is easy to calculate given the hedonic price schedule. If a change in the characteristics of land simultaneously affects many plots, then the hedonic price schedule may itself move. Even in this case, it is still possible to approximate the ensuing change in economic welfare and in some cases the resulting measures are exact (see Palmquist (1989) for more details). All welfare measures depend, however, on the assumption of unchanged input and output prices and are therefore partial equilibrium in nature.

Underpinning the hedonic technique is the assumption that farmers are perfectly informed about the characteristics of different tracts of land. Given that the costs of acquiring information concerning particular tracts of land are low, relative to the costs of purchasing land, this seems plausible. It also assumes that there is a unified market for land. This too is plausible enough given that most agricultural crops are traded on national markets and this would tend to integrate land markets. It should be noted that the hedonic model is normally developed in terms of prices prevailing in the rental market. In practice, however, there are typically better data on sales rather than on the rental market. In this case, the approach must be modified to account for the flow of future benefits associated with the uses and characteristics of the land. Typically, this is achieved by annuitising the observed price differentials.

The question of what constitutes the appropriate functional form of the hedonic land price schedule is typically viewed as being solely an empirical question. Parsons (1990) shows, however, that there are in fact theoretical reasons for preferring particular functional forms. Parsons argues that the price of non-produced characteristics such as climate increases proportionately with farm size, that the hedonic price function should be additively separable in terms of the structural attributes of the land, and that the price per acre should be independent of the quantity of land.

The logic of these conditions is obvious. For example, if the price per acre[2] were found to depend on the number of acres or the price of non-produced characteristics were not proportional to plot size then it would mean that profits could be earned from either dividing or combining plots of land. Likewise, the price function should be additively separable in structural

2 1 hectare = 2.47 acres (approximately).

characteristics, as it is always possible to buy an undeveloped plot and build on it at a cost that is (usually) independent of either the size of the plot or the non-produced characteristics.

The assumptions underpinning these theoretical restrictions are nothing more than the assumption of perfect competition in the market for land and attributes as well as zero transaction costs (so that the number of sales does not itself enter as an argument in the seller's profit function). If, however, transaction and bargaining costs form a significant cost, then land cannot be costlessly repackaged, and plots of different sizes that are otherwise identical may well be sold for different unit costs. It seems, therefore, preferable that the values attached to particular characteristics should be inferred from a model whose functional form is based solely on a goodness-of-fit criterion. Certainly, this is the route most other researchers have followed.

3. The dataset

The empirical analysis draws on data on land transactions in England and Wales taken from *Farmland Market* (1994). This journal contains a county-by-county record of over 400 transactions in farmland during the first 6 months of 1994.[3] The journal records the location, acreage and whether the property sold has vacant possession, along with other important details concerning dwellings and other buildings included in the sale. Some of this farmland was sold by public auction although 63 per cent of the transactions were by private treaty. Whenever a farm was sold by private treaty, the only available indicator of its worth was the professional valuation, whereas when a farm was sold by auction the actual sale price was available.

The *Ordnance Survey Gazetteer of Great Britain* (Ordnance Survey, 1992) was used to determine the grid reference location of the individual properties from the given address either to a named farm or to the nearest named settlement. It was possible to include a set of land quality variables in the dataset by indirectly utilising the 5-km grid square *Agricultural Land Classification of England and Wales* (Ministry of Agriculture, Fisheries and Food, 1988). This classifies land into one of seven grades according to the extent to which its physical characteristics impose long-term limitations on agricultural use. This grading system does not, it is claimed, necessarily reflect the current economic value of the land, although it is almost invariably taken that grade 1 land is the best, as there are few limitations to its use. Grade 7 is either urban land or, as is the case here, land that was not surveyed. The principal physical factors included in the grading system are those relating to the site (gradient, micro-relief and flood risk) and soil (texture, structure, depth and stoniness). Although the soil quality data have the form of a single variable taking the integer values 1–7, the information is incorporated into our statistical analysis by means of six dummy variables.

3 Agents voluntarily submit details of sales to the journal and it is generally considered that the land prices in *Farmland Market* exceed those given in official statistics.

Table 1. Definition of variables in the dataset

Variable	Definition
PRICE/ACRE	Price per acre (£)
ACRES	Number of acres
PRIVATE	Dummy variable; =1 if the property was sold by private treaty, = 0 otherwise
BEDROOMS	Number of bedrooms in dwellings where specified
COTTAGES	Dwellings for which the number of bedrooms is not specified
MILK	Milk quota offered with the property (1000 l)
POSSESS	Dummy variable; =1 if the property has vacant possession, = 0 otherwise
POPDEN	Persons per square kilometre measured at the county level
SOIL*j*	Dummy variable; =1 if land is officially classified as grade j, = 0 otherwise; $j = 1, \ldots, 6$
FD_SUMMER	30-year average number of frost days April–September
FD_WINTER	30-year average number of frost days October–March
TEMP_SUMMER	30-year average temperature April–September (°C)
TEMP_WINTER	30-year average temperature October–March (°C)
WIND_SUMMER	30-year average wind speed April–September (m/s)
WIND_WINTER	30-year average wind speed October–March (m/s)
PRECIP_SUMMER	30-year average precipitation April–September (mm)
PRECIP_WINTER	30-year average precipitation October–March (mm)
SUN_SUMMER	30-year average hours of sunshine April–September
SUN_WINTER	30-year average hours of sunshine October–March
REH_SUMMER	30-year average relative humidity April–September (percentage)
REH_WINTER	30-year average relative humidity October–March (percentage)
ALT	Average elevation above sea level (m)
WALES	Dummy variable; =1 for farms located in Wales, = 0 otherwise

Source: see text.

Climate variables are calculated on a 10-km grid square basis.[4] A number of summertime (April–September) and wintertime (October–March) 30-year climate averages (1961–1990) are included. Also recorded are the population density of the county in which the farm is located, the average elevation of the farm and a dummy variable indicating whether the farm is situated in Wales or England. The purpose of this dummy variable is to test for the geographical segmentation of the market for farmland. The information currently contained in the dataset is described in Table 1, and a statistical summary is given in the Appendix (Table A1).

4 These were provided by the Climate Research Unit of the University of East Anglia under the auspices of the TIGER initiative.

The relevance and expected impact on land values of some of the recorded variables may need further explanation. First, many of the farms or land were sold together with other assets of worth. Virtually all farmsteads have large farmhouses attached to them and often labourers' cottages or holiday homes. Although they do not contribute to the productivity of the land, these structures add to the asset value of the farm and hence to its purchase price. Therefore, it is necessary to control for them in the regression analysis. Usually the number of bedrooms is recorded only for the main farmhouse. Hence one can distinguish between dwellings of known and unknown size. By contrast, farm buildings are not consistently recorded in the source and are consequently excluded from the dataset; this represents an unfortunate closure on the information available. Milk quotas permit a farmer to sell up to a given volume of milk without paying the milk superlevy. Milk quota is thus of considerable value to dairy farmers and is sometimes sold along with the farm.[5] Farm equipment and livestock are, by contrast, usually sold separately. Nowadays in England and Wales only a very few farms are sold as tenanted property. Tenanted property is highly regulated in England and Wales and it seems likely that the regulations governing tenanted property reduce the value of such property in the eyes of an institutional investor.[6] The dataset thus records whether a property has vacant possession or is sold as a regulated tenancy.

4. Empirical analysis and results

A hedonic price equation was specified taking price per acre as the dependent variable to reduce possible problems associated with heteroscedasticity. Initially, the set of regressors included the linear and quadratic values of all the independent non-binary variables.[7] This allows the marginal effect of changes in the level of the variables to differ. Furthermore, as the equation combines both professional valuations and actual sale price data the equation was augmented by a set of additional regressors multiplied by the dummy variable PRIVATE indicating whether the professional valuation or the actual sale price was used.[8]

5 Two observations included in the dataset merit comment. These are observations for which the number of bedrooms is very large (43 bedrooms) and the price per acre is very high (£32,500 per acre). The first observation is of a farm with a very large house attached to it and several labourers' cottages. The number of bedrooms is recorded for each of these labourers' cottages so they are coded as extra bedrooms rather than mere cottages. The second is for a very small farm (11 acres) but with a large farmhouse and a relatively large amount of milk quota attached to it (300,000 l). This pushes up the price per acre. There is nothing else that is unusual about either of these properties.

6 Most tenants and their successors have security of tenure for up to three generations.

7 It should be noted that the variables describing the structural attributes of land were divided by the number of acres. This is because the dependent variable is in terms of price per acre and, in principle, structural attributes should enter the hedonic price function additively (see Parsons, 1990). Dividing the structural attributes by the number of acres does indeed substantially improve the fit of the hedonic price equation.

8 In the dataset the number of farms sold by private treaty is 254 and the number of farms sold by auction is 149. Two farms were broken up and sold partly by auction and partly by private treaty.

A linear functional form has an important defect in that the marginal effect of characteristics is independent of the level of any other characteristic, implying, for example, that the value of climate is independent of soil quality. A commonly chosen procedure, therefore, is to conduct a limited Box–Cox search in which the linear model, the semilog model, the log–linear model and the inverse semilog model are compared. Using the method described by Maddala (1977), it was found that the semilog model was more likely to have generated the observed data. It was, however, observed that the RESET test for functional form was still not passed and after some experimentation it was determined that a term in acres cubed needed to be added to the regression equation.

For the purposes of presentation the equation was re-estimated dropping the statistically insignificant higher-order terms and the statistically insignificant interaction terms involving the dummy variable PRIVATE.[9] The resulting equation is shown in Table 2. The model succeeds in explaining 65 per cent of the variation in the log of PRICE/ACRE. Tests for functional form and heteroscedasticity are not significant. The test for non-normality is, however, statistically significant, indicating that, whereas the OLS estimator is still consistent, the reported *t*-statistics have only asymptotic justification.[10]

5. Discussion

Holding the characteristics of farmland at their sample means and varying plot size results in the relationship between price per acre and farm size described by Figure 1. On the face of it, this implies that there are potential profits to be made from repackaging parcels of land into smaller or larger plots. An alternative explanation is that this is a reflection of significant transaction costs. Transaction costs might prevent a farmer from either dividing his or her land or combining his or her land with land from someone else to form a plot with a higher value per acre. Figure 1 suggests that these transaction costs must be substantial. The most valuable plots of farmland appear to be in excess of 1000 acres in size and this may be indicative of the minimum efficient scale for agricultural production.

Originally, many hedonic studies were conducted using professional valuations rather than sale price data.[11] Here the combination of actual market data and professional valuations makes it possible to test whether the slopes and intercept of the model differ depending on which of the two price measures is employed. Judging by the significance of the variables PRIVATE and PRIVATE × BEDROOMS/ACRES, it seems that professional valuations

9 In the case of the variable ALT, the linear term was insignificant and so was dropped instead.

10 More specifically, the distribution of the OLS residuals is symmetric but has a kurtosis less than that expected for the normal distribution.

11 The majority of hedonic studies use opinion-based data rather than actual sale price data. For a recent hedonic land price study using only professional valuations coupled with an attempt to assess their adequacy, see Roka and Palmquist (1997).

Table 2. The hedonic price equation

Variable	Coefficient	*t*-statistic
Intercept	8.862	2.90
ACRES	-0.169×10^{-3}	−4.73
$ACRES^2$	0.254×10^{-5}	3.95
$ACRES^3$	-0.807×10^{-9}	−3.16
PRIVATE	−0.152	−2.89
PRIVATE × BEDROOMS/ACRE	5.769	3.84
COTTAGES/ACRE	34.251	4.59
$(COTTAGES/ACRE)^2$	−195.284	−4.59
BEDROOMS/ACRE	12.152	8.23
$(BEDROOMS/ACRE)^2$	−44.453	−6.17
MILK/ACRE	0.109	5.21
POPDEN	0.301×10^{-3}	2.11
POSSESS	0.722	4.69
SOIL1	0.066	0.45
SOIL2	0.167	1.92
SOIL3	0.108	1.52
SOIL4	0.588×10^{-2}	0.07
SOIL5	−0.179	−1.36
SOIL6	0.156	1.69
FD_SUMMER	−0.046	−1.69
FD_WINTER	0.020	2.36
TEMP_SUMMER	−0.494	−2.30
TEMP_WINTER	0.194	1.20
PRECIP_SUMMER	-0.509×10^{-3}	−0.53
PRECIP_WINTER	0.636×10^{-3}	1.12
SUN_SUMMER	0.469×10^{-3}	0.25
SUN_WINTER	−0.170	−0.44
REH_SUMMER	−0.105	−2.23
REH_WINTER	0.043	1.03
WIND_SUMMER	0.499	1.51
WIND_WINTER	−0.334	−1.88
ALT^2	-0.686×10^{-5}	−3.17
WALES	0.018	0.13
Number of observations		405
Adjusted *R*-squared		0.620
Fisher test for zero slopes		$F_{32,372} = 21.62^{***}$
Breusch Pagan test for heteroscedasticity		$\chi^2_{32} = 36.10$
Ramsey's RESET(2) test for functional form		$t_{371} = 1.58$
Jarque Bera test for normality		$\chi^2_2 = 50.43^{***}$

Dependent variable = log (PRICE/ACRE)

*** Significant at the 1 per cent level.

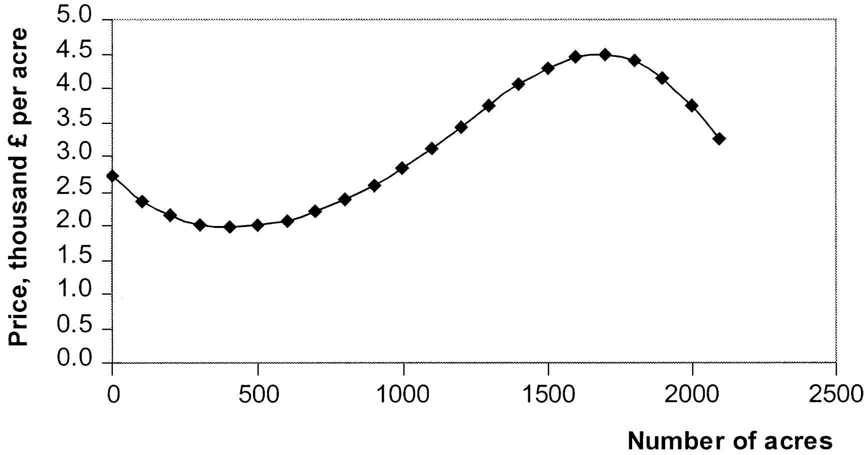

Figure 1. The effect of plot size on price per acre.

generally underestimated the value of farmland but overestimated the value attached to additional living accommodation.

Turning to the characteristics of the farmland itself, as one would expect, structural attributes are important determinants of the price per acre. Milk production quota per acre, cottages per acre and the number of bedrooms per acre are all highly significant. The implicit valuations of an additional bedroom, an additional cottage and additional quota for 1000 l of milk are shown in Table 3. All the implicit prices in Table 3 reflect the valuations of purchasers rather than professional valuation experts. These valuations, moreover, refer to a farmer who has chosen to locate at a site corresponding to the sample averages. These implicit prices are not annuitised.

Moving to the non-produced characteristics of farmland, the coefficient on the variable describing population density of the county in which the farm is located is statistically significant. This may provide support for the hypothesis that distance to market is an important characteristic of farmland. Alternatively, it may be that farmland is being bought on the assumption that permission will be granted for the construction of houses and that population density serves as a proxy for the potential profits from realising such ambitions. It might even be that population density captures the effect of excluded amenities such as distance to the local school or the availability of off-farm work for members of the farmer's family.

The coefficient on the variable indicating vacant possession is both positive and significant, illustrating that regulations governing tenancies hold rents beneath market values and reduce the value of the property to investors. The same property sold with vacant possession fetches more than twice the price of tenanted property.

The land quality grading system appears to play an uncertain role. Given the way that the grades are commonly presented in a sales prospectus one might have anticipated that the coefficients on these variables would decline

Table 3. The implicit price of farmland characteristics (evaluated at sample means)

Characteristic	Price
Bedrooms	£24,175.96/bedroom
Cottages	£82,154.90/cottage
Milk quotas	£247.60/1000 l
Characteristic	**Price per acre**
Population density	£0.68/person/km^2
Vacant possession (relative to tenanted)	£1,181.54
Soil grade 1 (relative to soil grade 7)	£142.24
Soil grade 2 (relative to soil grade 7)	£375.44
Soil grade 3 (relative to soil grade 7)	£236.95
Soil grade 4 (relative to soil grade 7)	£12.23
Soil grade 5 (relative to soil grade 7)	−£341.79
Soil grade 6 (relative to soil grade 7)	£351.79
Frost days (summer)	−£100.88/frost day
Frost days (winter)	£46.40/frost day
Temperature (summer)	−£883.78/°C
Temperature (winter)	£485.45/°C
Wind speed (summer)	£1,466.98/m/s
Wind speed (winter)	−£642.62/m/s
Precipitation (summer)	−£1.15/mm
Precipitation (winter)	£1.44/mm
Sunshine (summer)	£1.06/h
Sunshine (winter)	−£3.84/h
Relative humidity (summer)	−£226.67/percentage point
Relative humidity (winter)	£98.72/percentage point
Altitude	−£3.68/m
Wales	£41.27

Source: see text.
It should be noted that in the first half of 1994 £1 = ECU 1.309 (Central Statistical Office, 1995).

as land quality moves from grade 1 to grade 6. In fact, however, whereas the value of land declines as one moves from grades 2 to 5, grade 1 farmland is not the one valued most highly of all. The most valuable land appears to be grade 2 farmland, closely followed by grade 6. This highlights the fact that the grading system uses physical rather than economic criterion with which to classify land (see above). Only two of the land quality variables are significant at the 10 per cent level of significance. However, what these tests check for is whether the implicit value of land grades 1–6 is statistically different from that of land grade 7. By contrast, the hypothesis that the implicit values of land graded 2 and land graded 5 are equal can be rejected at the 1 per cent level of significance.[12]

Three of the climate variables appear to have a statistically significant impact on farm prices at the 5 per cent significance level (the number of frost days in wintertime, summertime temperatures and relative humidity during the summer). The fact that an increase in the number of frost days during winter increases land values can be explained by the fact that a cold snap during wintertime kills pests and vermin and is to the benefit of agricultural production.[13] Similarly, high relative humidity may have a detrimental impact on farmland prices insofar as it encourages diseases such as mildew. Average wind speed during the winter months and the number of frost days during the summer are statistically significant at the 10 per cent level.

The average elevation of the farmland appears to exert a negative and highly significant effect on farmland prices. This is a finding that also emerges from other hedonic studies. The explanation usually offered is that higher elevations imply a greater diurnal variation in temperatures and that this is detrimental to agricultural production. Whether a farm is located in Wales or England does not appear to be important, although one could argue that with only 12 Welsh farms this hardly constitutes a compelling test for geographical segmentation of the market for farmland.

Finally, it is important to remember that the implicit prices in Table 3 reflect only the willingness to pay of the 'typical' farmer for marginal changes in the level of climate variables. The value to society of marginal changes in the level of these characteristics may be very different. This is because the price of agricultural output (and therefore land values) is artificially inflated and distorted by the Common Agricultural Policy. It is also possible that direct payments to particular farms become capitalised into land values. In principle, these payments are like characteristics of the land and should be treated as such by including them in the hedonic price equation (see, e.g. Barnard *et al.*, 1997). Unfortunately, the dataset used in this analysis does not include details of direct payments to farms. The implication of this is that some of the characteristics identified by the analysis as being important may not be inherently productive at all, except insofar as they tend to attract direct payments.[14]

6. Conclusions

This paper has employed the hedonic technique to calculate the value of marginal changes in the characteristics of farmland in England and Wales.

12 Using the variance–covariance matrix of the parameter estimates and calculating the standard error of the parameter SOIL2 – SOIL5. Dividing the parameter estimate by the standard error results in a *t*-statistic of 2.63.

13 There is a lugubrious old saying in Eastern England: 'A warm winter makes for a fat graveyard'.

14 An example of this is the support given to hill farmers. The UK has a long tradition of giving specific aid to hill farmers, initially on a national basis, and, since 1975, under EU legislation. Eligible areas cover all the main hill and upland areas in the north, west and south west of the UK, and account for about half of the total agricultural land area (12 per cent in England). It is likely that these payments conceal the true extent to which greater elevation inhibits agricultural activity.

The results uphold the findings of earlier analyses conducted in the United States. As one would expect, structural attributes are very important determinants of farmland prices. Population density is also important, although it is not clear whether this is because distance to market matters or is a result of other factors. Implicit values for soil quality and climate are embedded in farmland prices and there is evidence that measures of climatic extremes such as frost days can improve the fit of the hedonic price regression. Average elevation significantly reduces farm values. The paper also demonstrates that professional valuations provide a biased indicator of the sale price because surveyors place too much value on the number of bedrooms and not enough on the other characteristics. Finally, the analysis indicates that tenanted farms are sold for significantly less than similar farmsteads with vacant possession and that farmland cannot be costlessly repackaged in the sense that the size of a plot exerts a significant influence on the price per acre. Future work might usefully examine the extent to which direct payments to farmers are capitalised into land prices.

Acknowledgements

The Centre for Social and Economic Research on the Global Environment (CSERGE) is a designated research centre of the UK Economic and Social Research Council (ESRC). The author would like to acknowledge helpful comments made on an earlier version of this paper by David Pearce, Kim Swales, Peter Pearson and four anonymous referees. Particular thanks are due to Ana Oliveira for help with the collection of the data. The usual disclaimer applies.

References

Barnard, C., Whittaker, G., Westenbarger, D. and Ahearn, M. (1997). Evidence of capitalisation of direct government payments into US cropland values. *American Journal of Agricultural Economics* 79: 1642–1650.

Brown, K. and Barrows, R. (1985). The impact of soil conservation investments on land prices. *American Journal of Agricultural Economics* 67: 943–947.

Central Statistical Office (1995). *Economic Trends*, 495. London: HMSO.

Dinar, A., Mendelsohn, R., Evenson, R., Parikh, J., Sanghi, A., Kumar, K., McKinsey, J. and Lonergan, S. (1998). *Measuring the Impact of Climate Change on Indian Agriculture*. World Bank Technical Paper No. 402. Washington, DC: The World Bank.

Ervin, D. and Mill, J. (1985). Agricultural land markets and soil erosion: policy relevance and conceptual issues. *American Journal of Agricultural Economics* 67: 938–942.

Evenson, R. and Alves, D. (1998). Technology, climate change, productivity and land use in Brazilian agriculture. *Planejemento e Politicas Publicas* 18: 223–258.

Maddala, G. (1977). *Econometrics*. Singapore: McGraw–Hill.

Mendelsohn, R., Nordhaus, W. and Shaw, D. (1994). The impact of global warming on agriculture: a ricardian analysis. *American Economic Review* 84: 753–771.

Ministry of Agriculture, Fisheries and Food (1988). *Agricultural Land Classification of England and Wales—Revised Guidelines and Criteria for Grading the Quality of Agricultural Land*. London: HMSO.

Miranowski, J. and Hammes, B. (1984). Implicit prices of soil characteristics for farmland in Iowa. *American Journal of Agricultural Economics* 66: 745–749.

Ordnance Survey (1992). *The Ordnance Survey Gazetteer of Great Britain*. London: Macmillan.

Palmquist, R. (1989). Land as a differentiated factor of production: a hedonic model and its implications for welfare measurement. *Land Economics* 65: 23–28.

Palmquist, R. and Danielson, L. (1989). A hedonic study of the effects of erosion control and drainage on farmland values. *American Journal of Agricultural Economics* 71: 55–62.

Parsons, G. (1990). Hedonic prices and public goods: an argument for weighting locational attributes in hedonic regressions by lot size. *Journal of Urban Economics* 27: 308–321.

Roka, F. and Palmquist, R. (1997). Examining the use of national databases in a hedonic analysis of regional farmland values. *American Journal of Agricultural Economics* 75: 1651–1656.

Appendix

Table A1. Statistical summary of variables used

Variable	Mean	SD	Minimum	Maximum
PRICE/ACRE	2,641.55	2,345.91	176.06	32,545.46
ACRES	130.07	207.36	7.00	2,090.00
PRIVATE	0.63	0.48	0.00	1.00
BEDROOMS	2.27	3.78	0.00	43.00
COTTAGES	0.25	1.34	0.00	16.00
MILK	15.79	84.41	0.00	738.44
POSSESS	0.98	0.13	0.00	1.00
POPDEN	261.719	167.34	24.00	1,033.00
SOIL1	0.02	0.15	0.00	1.00
SOIL2	0.13	0.34	0.00	1.00
SOIL3	0.45	0.50	0.00	1.00
SOIL4	0.18	0.39	0.00	1.00
SOIL5	0.03	0.17	0.00	1.00
SOIL6	0.10	0.30	0.00	1.00
FD_SUMMER	19.66	4.18	7.10	29.90
FD_WINTER	82.91	13.57	42.90	111.20
TEMP_SUMMER	12.71	0.68	10.07	13.90
TEMP_WINTER	5.71	0.73	3.17	8.08
WIND_SUMMER	4.40	0.28	3.92	5.40
WIND_WINTER	5.20	0.58	4.22	7.15
PRECIP_SUMMER	387.94	91.65	274.10	754.30
PRECIP_WINTER	495.88	177.53	262.70	1,143.80
SUN_SUMMER	1,031.62	76.14	861.90	1,224.00
SUN_WINTER	431.65	34.61	342.50	517.70
REH_SUMMER	82.32	2.09	77.52	87.30
REH_WINTER	89.63	1.56	85.22	94.07
ALT	117.91	75.38	31.00	359.00
WALES	0.03	0.17	0.00	1.00

Source: see text.
Number of observations was 405.

Corresponding author: David Maddison, Centre for Social and Economic Research on the Global Environment, University College London, and University of East Anglia. E-mail: d.maddison@ucl.ac.uk