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A HEDONIC STUDY OF AGRICULTURAL LAND RENT
IN SOUTHWESTERN ONTARIO

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1 Introduction

Land rent is defined as the difference between total revenue and total nonland production costs of a particular site. It is affected by prevailing output prices, nonland input prices, nonland input quantities, location of site relative to service centres and markets as well as site productivity. Land productivity is the result of prevailing climatic conditions, natural endowment of the soil and of such man made practices as improving land, causing deterioration, applying new technologies as well as employing various amounts of nonland inputs on land.

Since land is a heterogeneous input containing a variety of natural or man made physical characteristics, there is keen interest in examining their impact on land value. Several authors have statistically explored the contribution of factors determining the value of land (Downing, 1973; Jennings and Kletka, 1977; Chicoine, 1981; Miranowski and Hammes, 1984; Gardner and Barrows, 1985; King and Sinden, 1988; Palmquist, 1989; Palmquist and Danielson, 1989). The emphasis in empirical research has been on the effect of physical land features on land value rather than on land rent. Although physical features of the soil are expected to affect rent like they do land value, there remain other important features unique to tenancy. In addition to physical features of the soil, terms of the contract and characteristics of market participants are expected to influence rent.

In order to test the impact of the above mentioned variables on land rent, a hedonic price function is postulated for agricultural rents. Such a function yields implicit prices for the various characteristics determining land rent. Data for this study were gathered from a mailed questionnaire sent by the authors in 1989 to farmers in southwestern Ontario (Canada) who rented land in census year 1986. The response rate was 21 percent. Addresses were randomly selected and provided by Statistics Canada. The data refer to cropping year 1988. Only part owner-part tenant farmers were surveyed since, for other research purposes, the management ability of the farmer operating owned and rented land had to be identical. The majority of leased land in Ontario (84%) is rented by part owners. The studied area consists of the 12 adjoining counties in the most southwesterly part of the Province. This area contains cash crop, dairy, mixed, and specialty farms. Only fixed cash rent contracts are investigated. Seventy-two percent of the contracts in the area are fixed cash leases.

Information from a hedonic price function is important for several reasons. First, tenants and landlords entering into a contract need some kind of appraisal information to prepare bid and offer prices. As opposed to the usual process of ex ante farm land appraisal, which is predicated on subjective assessments of values of characteristics based on comparable cases, the implicit price approach instead yields ex post objective empirical estimates of the values of particular characteristics. Empirical estimates are useful as verification of values assigned by appraisers. Second, arguments persist that land productivity is not fully reflected in land prices and rents. Less productive and more erosive land is said to exchange at prices too high relative to land of higher quality, ceteris paribus. Inconclusive evidence on this issue has been reported by Erving and Mill (1985) and for not readily visible erosion by Gardner and Barrows (1985). A hedonic price function can reveal whether or not a relationship exists between land rent and certain land characteristics determining land quality, such as the drainage condition of the soil and the degree of erosion. However, absence of a statistically significant relationship is no proof of market failure. Land quality and rent are linked through productivity and production cost impacts. If a certain characteristic such as soil erosion has no effect on either productivity or production costs, no effect on rent is expected. Third, information on implicit prices is important for characteristics that can be manipulated. Implicit prices assist in making investment decisions.

The purpose of this study is to examine the effect on agricultural land rent of 1) soil and climate characteristics, 2) location, 3) land utilization, 4) contract terms, and 5) attributes of market participants. This is done by development and empirical estimation of a hedonic price model. Theory underlying the hedonic price function is explored. The data are then discussed and the model is presented with impact expectations of the various characteristics on land rent. This is followed by presenting model estimates and a discussion of the results. Finally, some pertinent implications are considered.

2 The Hedonic Price Function

The hedonic price function and the underlying production theory are predicated on the assumption that inputs are heterogeneous and that firms therefore employ the characteristics of such inputs. These characteristics rather than the inputs themselves become the arguments in a firm's production and profit functions.

The hedonic technique has been applied to heterogeneous inputs and outputs (for example, Ladd and Martin, 1976; Prescott and Puttock, 1990; Wilson, 1984; Veeman, 1987). As indicated, the technique has frequently been applied to land. The technique has also been used to estimate the value of nonmarket goods, such as outdoor recreation and pollution (Ridker and Henning, 1967; Deyak and Smith, 1978; McConnell, 1979; Adamowicz and Phillips, 1983).

The total contribution of a heterogeneous input such as land depends on both the number and the amount of the various characteristics provided. Total output therefore also depends on the total number and amount of characteristics (Ladd and Martin, 1976). The production function of a profit maximizing firm can therefore be depicted as:

$$q_y = f(v_{1y} \ldots v_{ny}) \tag{1}$$

q_y = quantity of output y (y = 1 ... Y); and

v_{jy} = the quantity of input characteristic j (j = 1 ... n) used in the production of commodity y.

The firm's profit function can be written as:

$$\pi = \sum_{y=1}^{Y} p_y f(v_{1y} \ldots v_{ny}) - \sum_{y=1}^{Y} \sum_{i=1}^{m} p_{xi} x_{iy} \tag{2}$$

where:

p_y = the price of commodity y

p_{xi} = the price of input x_i

x_{iy} = the quantity of market input i (i=1 ... m) used in the production of commodity y.

The first-order conditions for profit maximization are:

$$\frac{\partial \pi}{\partial x_i} = \sum_{y=1}^{Y} p_y \sum_{j=1}^{n} \frac{\partial f}{\partial v_{jy}} \frac{\partial v_{jy}}{\partial x_{iy}} - p_{xi} = 0, \quad i=1...m \tag{3}$$

Solving for p_{xi} gives:

$$p_{xi} = \sum_{y=1}^{Y} p_y \sum_{j=1}^{n} \frac{\partial f}{\partial v_{jy}} \frac{\partial v_{jy}}{\partial x_{iy}} \tag{4}$$

where:

$\frac{\partial v_{jy}}{\partial x_{iy}}$ = the marginal contribution of the ith input to the jth characteristic used in producing y; and

$\frac{\partial f}{\partial v_{jy}}$ = the marginal physical product of a unit of characteristic j in the production of y

The term $p_y \frac{\partial f}{\partial v_{jy}}$ is the marginal value product of characteristic j in the production of y. Over the range of variation in the data it is assumed that $\frac{\partial f}{\partial v_{jy}}$ is approximated by a constant α_{jy}. Equation (4) can then be written as:

$$p_{xi} = \sum_{y=1}^{Y} p_y \sum_{j=1}^{n} \alpha_{jy} \frac{\partial v_{jy}}{\partial x_{iy}} \tag{5}$$

Another assumption is that the quantity of characteristic j is proportional to the number of units of x_i; thus

$$\frac{\partial v_{jy}}{\partial x_{iy}} = V_{ji} = \frac{v_{jy}}{x_{iy}}$$

Let

$$p_y \sum_{j=1}^{n} a_{jy} = \sum_{j=1}^{n} \beta_j$$

then equation (5) can be written as:

$$p_{xi} = \sum_{j=1}^{n} \beta_j V_{ji} \tag{6}$$

Equation (6) is the hedonic price function where:

β_j = the marginal value product of the jth characteristic in the production of y, which is the marginal implicit value of a unit of characteristic j or the hedonic price of a unit of that characteristic.

V_{ji} = the amount of characteristic j per unit of input i.

Given data on per unit input prices p_{xi} and the amount of characteristics, j, per unit of input, i, regression analysis can be used to obtain estimates of β_j. For the production factor land the hedonic price function in equation (6) implies that the annual rent per unit of land is equal to the sum of marginal implicit prices, β_j, of each characteristic times the total quantity of each characteristic per unit of land, V_j.

Theory does not indicate the exact form of equation (6). Usually the best fitting functional form is used. Some economists have used a linear relationship, while others have utilized semilogarithmic or log-linear specifications.

The hedonic pricing method is based on several assumptions. The total area under investigation, in this case the 12 adjoining counties in southwestern Ontario, is considered a single market. In addition, landlords and tenants have adequate information on the characteristics of parcels, as well as of contracts and participants in the market, so that they have knowledge of all options available to them. Furthermore, the tenancy market is in equilibrium. The demand for land and contracts with specific levels of characteristics is equal to the supply of land and contracts with those attributes. The price clears the market for each bundle of characteristics. If the rental market is in equilibrium then each tenant acts to maximize profits given alternative land parcels and contracts. Finally, a large number of available parcels for rent exists having different characteristics from among which tenants may choose. This will allow tenants to choose a parcel and contract which will maximize profits (Miranowski and Hammes, 1984).

3 The Model and Data

The model determining rents of agricultural land as outlined here does not use the conventional demand and supply approach where land is considered to be a homogeneous commodity measured in divisible land units. The conventional approach uses a set of simultaneous equations to estimate rent. In actuality, land is transferred in indivisible units through various contracts. Both land and contracts are heterogeneous items, thus the homogeneity assumption underlying the single market is violated. Many markets exist with each submarket displaying identical characteristics. In this analysis each observation is a contract with indivisible land units and the concomitant price is the equilibrium rent in the pertinent submarket.

Agricultural land rent is affected by economic, physical, locational, and institutional factors. The data refer to a cross section of contracts in 1988 in which economic variables such as output and input prices as well as interest rates are assumed to be constant over all observations. Therefore, the model does not incorporate these economic variables. Their impact ends up in the constant term of the regression equation.

Given the macro economic climate, agricultural land rent is hypothesized to be a function of five groups of characteristics: 1) the physical properties of the land itself and climatic conditions; 2) the utilization of the site; 3) the location of the parcel relative to urban centres; 4) the content of the contract; 5) the participants in the markets.

3.1 Soil and Climate Characteristics

Land varies in physical properties. Soil texture, drainage, topography, erosion damage (loss of soil by water and wind), level of stoniness, damage due to periodic flooding, and depth to bedrock vary among parcels. Quality differences of these features are expressed in encumbrance points (Noble, 1977). This system was developed in the Department of Land Resource Science at the University of Guelph. The number of encumbrance points assigned to each feature of a particular parcel measures the degree of limitation of that feature for agricultural productivity. The minimum number of encumbrance points is zero, indicating no physical limitation, while the maximum value varies with the importance of the maximum limitation of that particular feature for agricultural use. For example, the maximum encumbrance points for drainage are 40, corresponding to very poor drainage (usually swamps or bogs), while the maximum points for erosion are 20, indicating severe erosion damage where all surface soil has been removed. Weighted average encumbrance points are calculated for each soil characteristic, the weight being the percentage of land in the contract having a particular limitation of that soil characteristic.

Seven soil characteristics are used in this analysis: soil texture, drainage condition, topography, erosion damage, stoniness, periodic flooding, and depth to bedrock. Five soil types are distinguished within soil texture. Loam and silt loam are considered to have no physical limitation for agricultural production, corresponding to zero encumbrance points. Sandy loam and clay loam have some limitations, corresponding to 5 points, while clay (15)[1] and sand (20) are considered more severe limitations for agricultural production. The drainage condition of soil is not considered to be a hazard for agricultural production if movement of air and water is unrestricted. The condition is fair (10) if some limitation for air and water movement exists, and poor (25) if water and air movement is restricted. Topography distinguishes several hazard intensities: level (0), 3 to 6% slopes (5), 7 to 12% slopes (10), and 13 to 20% slopes (20). Topography not only limits productivity because of erosion hazards but can lead to higher production costs per unit of land, both factors expected to exert downward pressure on rent. Erosion damage is reported as: no damage (0), and where considerable surface soil has been removed as moderately damaged (10). If all surface soil has been removed, the damage is severe (20). The

[1] Figures in brackets indicate encumbrance points for the respective soil feature.

degrees of stoniness are: stone-free (0), moderately stony (10), which indicates stone interference with cultivation of crops and use of machinery, and very stony (25), when too many stones are present for cultivation, but allowing suitability for pasture. Depth to bedrock is measured as: over 3 feet (0), 2 to 3 feet (20), 1 to 2 feet (40), and less than 1 foot (65). The summation of encumbrance points presents an indication of soil quality. The higher the encumbrance points, the poorer the soil quality and the lower the productivity of the soil. Hoffman (1971) found a statistically significant relationship between the aggregate encumbrance points for all soil features and yield of corn, barley and oats per unit of land. Our questionnaire provided descriptions detailing the above noted physical features of land, which farmers were asked to rate, relative to their land. A negative relationship is expected between rent and encumbrance points.

Climatic conditions are expected to have an important bearing on soil productivity and hence on rent. Climate is measured in terms of corn heat units (CHU). These are values based on the relationship between temperature and corn development (Brown, 1985). The system calculates a daily rate of corn development from average daily temperatures during the growing season. These daily rates are added over the entire growing season into CHUs. The higher the CHUs, the warmer the climate and the higher the soil productivity. As a result, rent is expected to be positively related to CHUs. CHUs in the area vary between 2300 and 3500.

3.2 **Land Utilization**

Land rent is affected by the kind of crops grown. Crop choice depends on various factors such as price, proximity to processing plants, soil conditions and climate. Two dummy variables are included to express land utilization. First, a dummy is assigned to contracts whose area occupies fifty-one percent or more in fruit and vegetables. Horticultural commodities are high value crops and land use on such farms is usually intensive, resulting in higher per unit land earnings than on land growing crops of lower value. To a great extent, specific soil characteristics and micro climate favourable for horticulture, but not captured by the included soil and climate variables in the model, as well as proximity to processing plants determine the location of horticultural production.

Second, among agricultural commodities a distinction can be made between crops with high and low gross margins. The gross margin is the difference between gross revenue and variable costs per unit of land, excepting rent. The gross margin must be shared by the operator in the form of wages and management allowance, by investment in the form of interest and depreciation allowance, and by land in the form of rent. Typical high gross margin crops include white and kidney beans, soybeans, tobacco, winter and spring wheat, corn grain, corn silage, and peanuts. A dummy is assigned when the contracted area contains 51% or more in such high gross margin crops. Observation shows that either the vast majority of the contracted area is occupied by high gross margin crops, or that the entire area is occupied by low gross margin crops.

Customarily, the kinds of commodities that tenants intend to grow is an important consideration during rent negotiation in the study area. Why this is so is not entirely clear. In certain instances tenants are limited in their crop choice. Certain soil characteristics and micro climate not captured by the variables included in the model may preclude cultivation of high gross margin crops. Moreover, soils susceptible to erosion or other forms of degradation may be better suited for low gross margin crops which can sustain productivity in the long run. Several high gross margin crops are highly erosion prone. Landlords may be better off negotiating a low gross margin cropping pattern with concomitant lower rents on land susceptible to erosion if land values are positively affected. Such negotiable terms are usually not explicitly included as restrictive covenants in the lease. In any case, due to the prevailing custom, rents in the study area are expected to be affected by land use instead of land use being affected by prevailing rents. Land utilisation by horticultural and high gross margin crops is expected to exert a positive influence on land rent.

3.3 Location

Net prices received and paid differ among farmers because of transportation costs. Locational advantage is expected to be reflected in land rents. For this study, the distance from the centre of the township in which the farm is located to the nearest population centre of 20,000 or more inhabitants is used as location variable. A negative relationship between distance and land rent is expected.

3.4 Contract Terms

A fourth group of characteristics relates to the contract. This consists of 1) the type of lease, either verbal or written, 2) the time period covering the lease, called lease duration, 3) any restrictive covenants and compensation clauses, and 4) parcel size.

Transactions in the market involve bilateral contracts between landlord and tenant. Transaction costs for information gathering, negotiation, legal consultation, monitoring, and enforcement differ among various contracts and parties. In addition, various contractual arrangements allow for different distributions of income variance among contracting parties (Cheung, 1969). For the purpose of this paper, both parties involved in contracting constitute a team. Each team is expected to reach an agreement that maximizes the sum of gains to both. In determining that sum, the concept of maximum bid price and minimum offer price is useful. The maximum bid price of prospective tenants is that which makes them as well off as they would be by not entering into agreement at all. In calculating the maximum bid price, prospective tenants will use opportunity costs of their resources. The minimum offer price of landlords is that which makes them as well off as they would be by utilizing the land in the next best alternative use (for example, either farming it personally or by hiring managers, or by selling). Tenants naturally would rather pay less than maximum bids but never more, and conversely, landlords would rather accept more than minimum offers, but never less. An increase in transaction costs as well as in income and/or asset value variance will decrease maximum bid prices and increase minimum offer prices. Teams are expected to choose that arrangement yielding the highest combined return to both