The Impact of Suburbanization on Agricultural Production Choices

1987

Rigoberto A. Lopez, Adesoji O. Adelaja, and Margaret S. Andrews

Assistant Professors, Department of Agricultural Economics and Marketing, Cook College, Rutgers University, New Brunswick, New Jersey 08903.

Selected paper presented at the American Agricultural Economics Association Meetings, East Lansing, Michigan, August 2-5, 1987

The authors are grateful to Timothy Taylor, Jim Seagraves, and Peter Barry for their helpful comments on a previous draft. The content of the paper, however, is the sole responsibility of the authors. Appreciation is extended to Claire Kuncewitch for her patience and efficient word processing assistance.

New Jersey Agricultural Experiment Station Publication No. J-02132-1-87, supported by state and U.S. Hatch Act funds.

The Impact of Suburbanization on Agricultural Production Choices

The process of suburbanization involves the tendency for the average residential household (or firm) to locate at an increasing distance from the city center.[1] This process, which is characteristic of many regions of the United States, has been accelerated in the postwar period by federal tax policies which subsidized single-family housing and state and local highway construction. As a result, housing and other infrastructural development have occurred in predominantly agricultural areas. Suburbanization has had a significant impact on the social and political environment of farmers at the urban fringe, however, relatively little is known about its economic impact on agriculture.

In recent years, the impact of suburbanization on agriculture has been highly debated both at the state and national levels. Despite evidence that the national supply of agricultural land is relatively unthreatened by direct pressures of suburban conversion (Fischel, Plaut, Gustafson and Bills), the use of public policies designed to retain land in agriculture and preserve the "right to farm" have increased, particularly at the state level.[2] Public sentiments are generally in favor of agricultural preservation with 45 state legislatures having enacted "right to farm" statutes, most of them since 1979 (Hand; Lapping et al.).

From an economic perspective, a major criticism of agricultural preservation measures is that they are based on limited information about the impacts of suburbanization on agricultural production and income (Gardner). Most studies that have indicated negative economic impacts have concentrated on partial effects such as the tendency for land to be idled in anticipation of conversion (Berry) or for land ownership patterns to change before conversion (Gustafson and Bills). A few studies show aggregate negative effects of suburbanization on productivity (Duncan; Andrews and Chetrick; Lopez and Munoz). Earlier investigations of Schultz's urban-industrial hypothesis, however, showed that farm incomes and productivity were highest near the centers of urban-industrial development (Katzman).

Given the contradictions in empirical evidence, the purpose of this paper is to develop a framework for estimating the consequences of suburban population growth on agriculture. The paper conceptualizes the various effects of suburbanization and utilizes a dual multiproduct profit function and a set of reduced form price equations to explore these effects for New Jersey. Empirical results provide information on the impact of suburbanization on agricultural production choices, prices and profits which is useful in understanding the structural changes that come about from suburbanization, and in addressing the "right to farm" and agricultural land preservation issues.

The Effects of Suburbanization

Suburban development has both direct and indirect effects on agriculture (Berry, Coughlin et al.). The direct impact of suburbanization is the conversion of land from farming to suburban uses. The indirect effects which result from mixing residential and agricultural uses of land can be categorized into regulatory, technical, speculative, and market effects (Andrews and Chetrick).

Regulatory effects are due to the decline in the political clout of the rural community. As suburbanization intensifies, agricultural and nonagricultural land use conflicts become more severe. This may lead to an increase in local ordinances designed to force farmers to internalize some of the negative externalities normally generated from agriculture. Ordinances that are common to suburban agricultural areas include regulation of livestock effluent discharge and pesticide usage, restrictive building codes, and controls on the density of livestock and poultry operations (Libby, Hunter).

Technical effects alter the technical efficiency of agricultural practices. According to Lisansky, vandalism is a major concern of farmers at the suburban fringe. The most common forms of vandalism include the destruction of crops and damage to farm equipment. This reduces technical efficiency in farming. The use of eminent domain to condemn land for public purposes breaks up farms and affects the efficiency of farm machinery use. Also, farmers must apply increasing management resources to obtain inputs when production agriculture becomes sparse relative to other industries and a "critical mass" of agricultural activity is lost (Derr et al.)

Speculative effects of suburbanization refer to distortions in agricultural production decisions due to development pressures. The opportunity cost of land increases as a result of the high demand for land by developers. Farmers may be reluctant to invest heavily in new technology as planning horizons are shortened by the possibility of selling their land. Land takes on the characteristics of a financial asset and its use as a productive input may be less responsive to current agricultural market conditions. This phenomenon, called the "impermanence syndrome," leads to a reluctance to maintain and replace farm machinery, drainage systems and other farm infrastructures.

The market effects occur because increased suburbanization brings farmers closer to their markets and thus reduces transportation costs. The locational advantages of suburban farmers make them more competitive in marketing their products and even allows direct marketing to consumers.

This may result in higher farm gate prices and lower input costs (Katzman). Furthermore, suburbanization affects the user cost of land mainly through property taxes, and capital gains from increased land value.

The net effect of suburbanization is expected to differ among alternative agricultural outputs and inputs due to regulatory differences and their degree of compatability with the suburban environment. Comprehensively measuring the impact of suburbanization on agriculture, therefore, requires an integrated framework that accounts for both the direct and indirect effects of suburbanization on alternative agricultural outputs and inputs. Such a framework is presented in the following section.

Conceptual Framework

Perhaps, the clearest methodological framework describing the rural/urban land conversion process was presented by R. Muth. This analysis, based on the principles of the von Thuenen location theory, suggests that land use patterns and the market price of land are established by relative rental gradients for urban and agricultural uses. Conversion of land into urban uses proceeds in concentric circles around a central city, and at the equilibrium boundary between urban and agricultural uses, relative rents of competing uses are equal. Policy changes that favor suburbanization (e.g., subsidized highway construction) and growing housing demand associated with population growth shift the urban and rural rent gradients so that the equilibrium boundary moves away from the city center.

In Muth's model, the market value of land is dominated by urban rent and land prices exceed agricultural use values only inside the urban/rural boundary. While speculation is not directly allowed for, it can be incorporated by recognizing that when shifts in the equilibrium boundary are expected, agents in the land market establish expectations about the conversion date and thus their planning horizon, for a particular parcel of land. Land speculation can cause the market value of agricultural land to rise above the agricultural use value before conversion if the expected urban rent at the conversion date discounted over the planning horizon exceeds the current agricultural rent. Although Muth's model is helpful in understanding the direct and speculative effects of suburbanization on agriculture, it excludes other important indirect effects. Further, the reliance of the Muth model on a single agricultural product limits its ability to fully capture effects on production choices, prices, and profits.

To illustrate the effects of suburbanization on agricultural production choices, consider the case where production possibilities of two outputs (Y_1 and Y_2) from a given amount of land are as depicted by curve H in Figure 1. With relative output prices depicted by P, the optimal production choice is at point a where Y_1^* and Y_2^* are produced. The direct effect of suburbanization would result in an inward shift of the agricultural production possibilities frontier as less land is available to agriculture. If the technical effects are more favorable to Y_2 relative to Y_1, the new curve will be skewed toward Y_2 so that the new optimal choice is at point b where the new product mix is biased towards Y_2 ($Y_2^{**}/Y_1^{**} > Y_2^*/Y_1^*$). If the market effects are such that the farm gate price of Y_2 is increased relative to the price of Y_1, the new optimal choice is at point c. Finally, if a local ordinance restricts the production of Y_1 so that $Y_1 \leq Y_1^{***}$, the constrained optimal choice is at point d which remains optimal for multiple relative prices.

A joint multiproduct, multifactor framework, is appropriate in evaluating the differential impact of suburbanization on various agricultural output and input decisions. Duality theory is particularly useful in examining theoretically consistent production choices in a multiproduct, multifactor framework. More specifically, the multiproduct profit function is appealing for investigating the impact of suburbanization on agriculture because it allows the estimation of the effects of nonchoice variables such as suburbanization on product supplies and input demands. Since the approach has been used extensively in examining production choices in the U.S. (Weaver, Shumway, and Antle), it allows a direct comparison of production choices in suburban agriculture to choices elsewhere.

The Economic Model

Consider the production decisions of firms in a multiproduct industry where the total number of production-related variables is s. The firms make quantity choices on n net outputs (Y_i) of which the first m are outputs produced ($Y_i > 0, i = 1, \cdots, m$) and the rest are variable inputs ($Y_i < 0, i = m+1, \cdots, n$). There are also fixed inputs ($Z_i, i = n+1, \cdots, r$) and other exogenous factors ($Z_i, i = r+1, \cdots, s$). Denote the expected nominal output prices and the input prices as $P_i(P_i > 0, i = 1, \cdots, m, m+1, \cdots, n)$, the expected profit as π, and let P_n be the numeraire price. The normalized expected prices of outputs and inputs can be defined as $p_i = P_i/P_n$ ($i = 1, \cdots, m, m+1, \cdots, n-1$) and the normalized variable profit as $\pi' = \pi/P_n$.

Under perfectly competitive conditions, a one-to-one (dual) relationship exists between the primal transformation function which relates outputs to inputs $g(Y, Z) = 0$, where Y is a vector of outputs and variable inputs, and Z is a vector of fixed inputs and other exogenous factors), and the dual normalized restricted profit function (Diewert, 1973; Lau, 1976). The normalized restricted profit function is expressed as

$$\pi' = \pi'(p, Z), \tag{1}$$

where p is a vector of the normalized prices of n-1 outputs and variable inputs. The profit function must be continuous; twice differentiable; convex; and monotonic in the normalized prices, the fixed inputs and the other exogenous factors. By applying Hotelling's lemma, a system of profit maximizing output supply and variable input demand functions (Y_i^*) is obtained as in Lau (1972)

$$\frac{\partial \pi'}{\partial p_i} = Y_i^*(p, Z), \ (i = 1, \cdots, n-1). \tag{2}$$

A condition required to generate a reasonable set of output supply and input demand equations is that the profit function is twice differentiable with respect to input and product prices (Diewert, 1973). Second or higher order Taylor's series approximations of the implicit function in equation (1) meet this requirement.

From equation (2), the total change in production choices from a change in the level of suburbanization is

$$\frac{dY_i^*}{dZ_s} = \sum_{j=1}^{n-1} \frac{\partial Y_i^*}{\partial p_j} \frac{dp_j}{dZ_s} + \sum_{j=r+1}^{s} \frac{\partial Y_i^*}{\partial Z_j} \frac{dZ_j}{dZ_s}, (i = 1, \cdots, n-1) \tag{3}$$

where Z_s is the element of Z which represents the level of suburbanization. The first term accounts for the effects of suburbanization through changes in agricultural prices. These price or market effects reflect shifts in the derived demand and supply of agricultural commodities and inputs that result from suburbanization.The second term embodies effects through other exogenous factors such as regulation, technology, and speculative pressures. Equation (2) can provide estimates of $\partial Y_i^*/\partial p_i$ and $\partial Y_i^*/\partial Z_j$ in equation (3). Estimates of the changes dp_i/dZ_s and dZ_j/dZ_s can be obtained from separate equations approximating the reduced form of a complete set of structural equations (e.g. demand and supply) for the effects of Z_s on p_j

and Z_j.

Econometric Procedures

The empirical framework utilized in this study involves a profit function and a set of reduced form equations. The profit function is a variant of the normalized quadratic profit function. More precisely, it is a restricted normalized cubic profit function (Stevenson), which is a truncated third-order Taylor series approximation of equation (1). This profit function can be expressed as

$$\begin{aligned}\pi' &= b_0 + \sum_{i=1}^{n-1} b_i p_i + \sum_{i=n+1}^{s} b_i Z_i + \frac{1}{2}\sum_{i=1}^{n-1}\sum_{j=1}^{n-1} b_{ij} p_i p_j + \\ &\quad \frac{1}{2}\sum_{i=n+1}^{s}\sum_{j=n+1}^{s} b_{ij} Z_i Z_j + \sum_{i=1}^{n-1}\sum_{j=n+1}^{s} b_{ij} p_i Z_j + \frac{1}{2}\sum_{i=1}^{n-1} \gamma_{is} p_i^2 Z_s,\end{aligned} \tag{4}$$

where b_0, b_i, b_{ij}, and γ_{is} are unknown parameters. In equation (4), γ_{is} represents the subset of the third order coefficients not restricted to zero. The coefficient γ_{is} allows direct measurement of the impact of suburbanization on price responsiveness.The application of Hotelling's lemma to equation (4) yields the following output supply and input demand equations with random error terms which include errors in optimization:

$$Y_i^* = b_i + \sum_{j=1}^{n-1} b_{ij} p_j + \sum_{j=n+1}^{s} b_{ij} Z_j + \gamma_{is} p_i Z_s + U_i, (i = 1, \cdots, n-1). \tag{5}$$

The error term (U_i) in each output supply and input demand equation is assumed to be independently and normally distributed with zero mean and non-zero variance-covariance matrix.

Since the profit function in equation (4) is normalized, it imposes homogeneity of degree zero in prices. The mixed second-order partial derivatives with respect to p and Z are indifferent to the order of differentiation. Thus, the symmetry conditions ($b_{ij} = b_{ji}$, for all i and j) can be imposed in order to reduce the number of parameters to be estimated.

The impact of suburbanization on prices and other exogenous variables in equation (5) is estimated using the following reduced form equations:

$$X_j = \lambda_{0j} + \lambda_{sj} Z_s + \sum_{k=1}^{K} \lambda_{kj} W_{kj} + \mu_j, \tag{6}$$

where $X_j = \{p_j, Z_j\}$; W_{kj} is a set of exogenous variables in the final reduced form; and μ_j are random disturbance terms.

Using equations (3), (5) and (6) for the *ith* choice variable, the total elasticity of production choice with respect to suburbanization (e_{is}) can be expressed as

$$e_{is} = \left[\frac{dY_i^*}{dZ_s}\right] \frac{Z_s}{Y_i^*} = \left[\left(\sum_{j=1}^{n-1} b_{ij}\lambda_{sj} + \gamma_{is} Z_s \lambda_{si}\right) + \left(\sum_{j=r+1}^{s} b_{ij}\lambda_{sj} + \gamma_{is} p_i \lambda_{si}\right)\right] \frac{Z_s}{Y^*}. \tag{7}$$

The expression in brackets represents the empirical form of equation (3). The first term captures the market effects of suburbanization while the second captures the regulatory, technical, and speculative pressures effects.

The total elasticity of revenue from (or cost of) the i^{th} choice variable with respect to the level of suburbanization, obtained as the sum of the effects on quantities and on prices is

$$R_{is} = \left[\frac{dp_i Y_i^*}{dZ_s}\right] \frac{Z_s}{p_i Y_i^*} = \left[p_i \frac{dY_i^*}{dZ_s} + Y_i^* \frac{dp_i}{dZ_s}\right] \frac{Z_s}{p_i Y_i^*} = e_{is} + f_{is}, \tag{8}$$

where f_{is} represents the flexibility of normalized price with respect to suburbanization. The total elasticity of profits with respect to the level of suburbanization is obtained as

$$R_s = \frac{d\pi'}{dZ_s} \frac{Z_s}{\pi'} = \frac{d\sum_{i=1}^{n-1} p_i Y_i^*}{dZ_s} \frac{Z_s}{\sum_{i=1}^{n-1} p_i Y_i^*} = \sum_{i=1}^{n-1} R_{is}. \tag{9}$$

Equations (6), (8) and (9) can be used, respectively, to evaluate the decomposed effects of suburbanization on prices, production choices, agricultural subsectoral profits, as well as the overall impact on farm profits.

Data and Estimation

The model was applied to aggregate time-series farm sector data for the state of New Jersey for the years 1949 to 1982.[4] Twenty-five farm commodities were grouped into four categories: vegetables, fruit, grain crops, and livestock. The variable inputs were divided into four categories: labor, capital, land and intermediate inputs. The intermediate input category included feed, seed, chemicals, fertilizer, and other miscellaneous inputs. The non-price exogenous variables included weather, technological change, suburbanization, and speculative pressure on land.

The sources of data included *Economic Indicators of the Farm Sector* (State Income and Balance Sheets, and Production Efficiency Statistics); *Agricultural Statistics* (U.S. Department of Agriculture); *New Jersey Agriculture* (New Jersey Department of Agriculture); and *Census of Population* (U.S. Department of Commerce). Annual data on input and product prices, expenditures on inputs, revenues from outputs, and population were obtained from these sources.

Quantity indexes were constructed for each product category via Fisher's Weak Factor Reversal Test. This was done by dividing revenues by Divisia price indexes constructed for each category.[5] The Tornquist discrete approximation to the Divisia price index was used to construct the price indexes from the prices and quantities of component products. The price and quantity of the intermediate input category were constructed in a similar manner. To obtain a measure of *expected* output prices, McCallum's instrumental variable approach to rational price expectations was used. The instruments used were lagged prices, a U.S. farm input price index and suburban population.[6]

Land input quantity was measured by land in production, and the quantity of capital and labor services were obtained by dividing expenditures by their respective prices. The price of labor was measured with the agricultural wage rate while the price of capital services was proxied with a state price index for petroleum products. Following Christensen and Jorgenson, the annual user cost ("price") of land is estimated as the annual opportunity cost of the land asset (real interest rate times the lagged average market value of land) *plus* property taxes per acre *minus* appreciation (measured as the change in average market value). Under this estimation procedure, capital gains on farmland reduce the cost of using land in agriculture while land taxes do the opposite.

A linear trend variable was used as a proxy for technological change. Weather effects for each output category were measured by the Stalling Index (the ratio of actual to expected yields based on a linear trend). An index of speculative pressure was estimated as the ratio of the average value of land in New Jersey to the U.S. average. Because the U.S. average land values approximate agricultural use values, this index indicates the extent to which suburban farmland values exceed the value dictated by potential agricultural revenues. Population in non-urban counties (those with less than 2,000 persons per square mile) was used as a proxy for the degree of suburbanization.[7]

The price of intermediate inputs was used as numeraire to normalize the expected product and input prices. The estimating system in equation (5) includes four product supply and three input demand equations. The set of explanatory variables in each choice equation included normalized expected output and input prices, an interaction term between own price and population, time, weather, non-urban population, and speculative pressure. The coefficients for weather in the livestock supply and all input demand equations were constrained to zero since weather is not expected to significantly affect them.

Equation (5) represents a system of non-simultaneous equations which could be estimated independently. However, given the symmetry restrictions, the iterative Zellner's seemingly unrelated procedure (IZEF) was used to estimate the equations jointly. IZEF estimates are considered to be more efficient than OLS estimates in the presence of contemporaneous correlation.

The system in equation (6) represents reduced forms for expected output prices, normalized input prices, and speculative index. To gain information, the price equations were estimated using nominal prices as dependent variables (Kang; Orcutt et al.).[8] An additional equation, therefore, had to be estimated for the numeraire. The estimation of expected output prices was described above. The equations for nominal input prices and speculative index were estimated jointly via IZEF. The instrumental variables used were suburban population, the lagged dependent variable, a U.S. index of prices received by farmers, and time. Parameter estimates of equation (6) associated with suburban population (λ_{sj}) were used in conjunction with estimated coefficients of equation (5) to measure the decomposed and total effects of suburbanization on agricultural prices, production choices and profits.

Empirical Results

The parameter estimates of the supply and demand functions corresponding to equation (5) are presented in Table 1. Of the 66 parameters estimated after the symmetry and other constraints were imposed, 42 were found to be significant at the $\alpha = .05$ level. All the own-price coefficients have the expected signs (own price coefficients have two components, an independent term and one associated with suburbanization). Partial elasticities of output supply and input demand, evaluated at mean values of the data, are reported in Table 2. Table 3 contains the estimated parameters corresponding to equation (6). These parameter estimates provided measures of the impact of suburbanization on prices and on the speculative pressure index. The estimates in Tables 1 through 3 were used to estimate the decomposed and total effects of suburbanization on prices, choices and profits as explained by equations (6), (7), (8) and (9). These results are presented in Table 4.

Statistical tests were conducted to determine if the profit function specification was valid. These included tests for non-jointness of the production technology, significance of the suburbanization variable, convexity and monotonicity. Following Shumway, the appropriate null hypothesis for overall non-jointness is that all mixed partial derivatives of the normalized profit function with respect to all product prices are zero. The test of non-jointness yielded a test statistic of 74.9 compared to a critical chi-square with 21 degrees of freedom at the $\alpha = .05$ level of 40.1. This led to the rejection of the non-jointness hypothesis and thus supported the multiproduct, multifactor profit function specification. To test the significance of suburbanization, the appropriate null hypothesis is $b_{ij} = 0$ (i = 1, 2,$\cdots$ n-1; j= suburbanization and speculative pressure). This test yielded a chi-square statistic of 145.8 compared to a critical chi-square with 21 degrees of freedom at the $\alpha = .05$ level of 40.1. Thus, the result of this test supported the significance of suburbanization as a determinant of output and input choices.

To test for convexity, the Jacobian matrix of the profit function was evaluated at mean population values. To test for monotonicity the predicted values of the product supply and input demand equations were examined if they were positive and negative at each annual observation. The estimated profit function was found to be convex and monotonic, and thus, well behaved.

Price Responsiveness in Suburban Agriculture

The estimated own-price elasticities of vegetables, fruits, grain crops and livestock in New Jersey are, respectively, 0.786, 0.683, 0.817, and 0.192 (Table 2). With the exception of the supply elasticity for livestock, these estimates are similar to those derived in other studies for other regions of the U.S. For example, Weaver estimated own-price elasticities of food grain and feed grain of 0.789 and 0.638 for South Dakota. Saez and Shumway also estimated own-price elasticities of supply of 0.889 and 0.369 for vegetables/fruits for the Texas/Oklahoma region and the Northern Plains. Weaver estimated own-price elasticity of livestock supply of 0.555 and 1.011 for North and South Dakota. These are higher than the estimated value of 0.192 for New Jersey.

On the input side, estimated partial own-price elasticities of labor, capital, and land are, respectively, -0.230, -0.636, and -0.010. In all cases, these were found to be more inelastic than those estimated for other regions. For example, Adelaja and Hoque estimated own price elasticity of demand for labor of -0.758 for West Virginia while Binswanger estimated -0.911 for the U.S. For capital, Weaver estimated own price elasticity of -1.656 for North

Dakota while Adelaja and Hoque estimated -1.172 for West Virginia. Based on different measurement of land prices, Antle and Binswanger estimated own price elasticities of demand for land of -0.181 and -2.225 for the U.S. The elasticity of demand with respect to speculative pressure was -0.332. Comparing this elasticity with the own price elasticity of demand for land, it is evident that programs which lower the user cost of land in agriculture through preferential taxation would only have a modest impact on land use. The effects of suburbanization on price responsiveness can be further evaluated with reference to the estimated coefficients for the interaction (own price x population) terms. These coefficients show that, except for grain crops and labor, farmers become less responsive to agricultural price signals as suburbanization intensifies.

The Effects of Suburbanization on Prices

The estimated parameters for the nominal prices and speculative index (equation (6)) are presented in Table 3. The effects of suburbanization on the numeraire, the price of intermediate inputs, was very small and insignificant. Based on this result, the impact of suburbanization on the numeraire was assumed to equal zero, and the price flexibilities (f_{is}) with respect to suburbanization and market effects reported in Table 4, were computed accordingly.[9] Thus, the estimated flexibilities and market effects in terms of normalized and nominal prices are the same.

Results in Table 3 suggest that suburbanization significantly increases farm-gate prices for all products, except livestock, but decreases the agricultural wage rates, the price of capital and the user cost of land. The insignificant estimate of the effect of suburbanization on livestock is probably due to the lack of opportunities for direct marketing. The negative effect of suburbanization on agricultural wages, although insignificant at the five percent level, is contrary to expectations. The estimated negative effect of suburbanization on capital suggests that suburban farmers have a locational advantage in purchasing capital. These results indicate that the user cost of land is reduced due to capital gains on farmland as suburbanization intensifies. Suburbanization was also found to strongly increase speculative pressures on land.

The Effects of Suburbanization on Output and Input Choices

The decomposed and total effects of suburbanization on choices (equation (7)), are presented in Table 4. The estimated total elasticities of choices for vegetables, fruit, grain crops and livestock are, respectively, 0.277, -2.607, -1.627, and -3.132. These elasticities suggest that vegetable production is encouraged by suburbanization while fruit, grain crops, and livestock are discouraged. Livestock production is discouraged the most followed by fruit production. The elasticities for labor, capital and land are, respectively, 1.397, -1.425, and -1.833. These elasticities suggest that suburbanization encourages labor use and discourages capital and land use, so that agriculture becomes more labor intensive.

The total elasticities of choice can be explained in terms of the decomposed effects. In general, technical and regulatory effects (associated with the population variable in Tables 1 and 2) are negative for all products but the effect is most severe in the case of livestock which is the most regulated product in suburban agriculture. Technical and regulatory effects on all inputs except labor are also negative. The positive effect on labor use may suggest that more labor resources are needed to obtain inputs ("critical mass") and to comply with regulations. It may also indicate that the productivity of labor is increased due to better education and training facilities in suburban areas. Speculative effects are negative for all products and all inputs except labor, reflecting a shorter planning horizon, premature idling of land and disinvestments in capital. Market effects, the impact of suburbanization on choices through changes in all prices, are positive for all products except for livestock where direct market opportunities are nonexistent. Market effects on all inputs, however, are negative, suggesting that price changes are such that the use of all inputs are discouraged.

Although the directions of change of the speculative effects and technical and regulatory effects are the same, the differences in magnitudes suggest that the speculative effects category captures those effects associated with the impermanence syndrome. For example, capital use is discouraged relatively more than land by speculation while the reverse is true for technical and regulatory effects. Thus, even though suburbanization overall tends to increase the capital/land ratio, the independent effect of speculation is to reduce it as would be expected by the impermanence syndrome.

The Effects of Suburbanization on Profits

Profit elasticities with respect to suburbanization by agricultural subsectors (R_{is} in Equation (8)) and by type of effect are presented in Table 4. Combining the impact of suburbanization on choices (e_{is}) and prices (f_{is}), subsectoral elasticities (R_{is}) show that the vegetable subsector is the only product subsector where revenues are increased by suburbanization. At the other extreme is livestock production where revenue losses are relatively the largest.

The clearest mechanism by which suburbanization benefits agricultural profits is via its effect on capital ($R_{is} = 1.645$) and land costs ($R_{is} = 5.799$).

In the case of capital, it is likely that this result reflects disinvestment as opposed to conventional capital cost savings. The result for land use is that suburbanization drives land away from agriculture as well as generates substantial capital gains.

In terms of effects, the predominant negative effect of suburbanization on agriculture is through technical and regulatory effects. The predominant positive effect is through changes in input and output prices ($f_{is} = 5.009$), especially the decline in the user cost of land ($f_{is} = -3.958$). Overall, the aggregate profit elasticity (R_s in Equation (9)) was 0.998.

Concluding Comments

The process of suburbanization significantly affects agriculture through direct (land conversion) and indirect (technical, regulatory, market price, and speculative) effects. Previous work has partially focused on these effects. A novel feature of this paper is the conceptualization and estimation of the decomposed and overall effects of suburbanization within an integrated economic framework. The empirical framework involved the use of a multiproduct profit function model, a system of reduced form price equations and New Jersey data. In general, the empirical findings are consistent with those of previous studies, in that both positive and negative effects were identified.

The direct effect of suburbanization through rural/urban land conversion was confirmed by its strong combined negative impact on land use. The impermanence syndrome hypothesis that capital investment is discouraged by land speculation was also confirmed. The estimated market price effects indicate that suburbanization increases the farm-gate prices for all commodities (except livestock) and reduces the procurement price of variable inputs. Technical, regulatory, and speculative effects were negative for all products and inputs, except labor. On the product side, vegetable production is the only subsector to benefit from suburbanization while livestock production is the most adversely affected. In summary, the impact of suburbanization on agriculture varies quite substantially across subsectors and by type of effects.

Policies aimed at preserving agriculture should take into account the differential impacts of suburbanization. As technical and regulatory effects were found the most detrimental, policies aimed at eliminating these effects such as "right to farm" statutes can potentially make a strong positive impact on suburban agriculture. Furthermore, "right to farm" policies can provide an incentive for participation in other farmland preservation policies such as agricultural zoning and districting. The results of this study confirm that the major benefit of suburbanization to farm profits is the reduction in land costs that accrue to farmland owners due to capital gains. Zoning and districting programs which involve limitations on future land development without compensation for losses in land value will not achieve widespread support and participation unless negative externalities of suburbanization are also addressed. Finally, the low responsiveness of land in agricultural production to its user cost suggests that preferential farmland tax assessment policies have a limited capacity to offset the conversion of land to non-farm uses.

Footnotes

1. The term suburbanization is used here to represent the set of forces involved in the movement of nonagricultural economic activities away from urban centers. Because urban boundaries frequently expand as activity becomes more dispersed, and because activities remain identified as urban in character even as they change geographic location, many writers refer to the same process as urbanization.

2. For a review of agricultural policy developments in the Northeast see Conklin et al. Although the Northeastern region acted earlier to enact farmland preservation measures, virtually all states now have some programs for farmland retention with preferential taxation of agricultural land being the most widespread. Statutes related to the "right to farm" provide some legal protection to farmers against private nuisance lawsuit and local government regulations and make public statements favoring agricultural land use (Lapping et al.)

3. The authors are indebted to one of *AJAE* reviewers for suggesting the incorporation of the impact of suburbanization on price responsiveness in the analysis.

4. New Jersey is an appropriate case study of agriculture in a suburbanizing environment. In the postwar period, New Jersey has been the most densely populated state in the nation and has lost over 50 percent of its agricultural land to suburban development. Most of the suburban growth has been outside the highly urbanized counties associated with the New York and Philadelphia metropolitan areas. According to the Office of Management and Budget, New Jersey is the only state where 100 percent of the land area is classified within

metropolitan statistical areas. All land area in the state is subject to municipal regulation.

5. Fisher's Weak Factor Reversal Test suggests that a dual relationship exists between the price index and the constructed quantity index which imposes the properties of the price index on the derived quantity index (Samuelson and Swamy). To obtain a superlative quantity index, a superlative price index such as the Divisia Price Index is required (Diewert, 1976). Diewert (1976) has shown that when the true functional form is unknown, such an index provides an approximation to the true index.

6. Consistent with the findings of Lopez (1986) on the nature of farmers' price expectations in the Northeast, it is assumed that the prices producers expect to receive are formed rationally as defined by Muth. McCallum shows that provided the final price expectation equation is free of autocorrelation, the use of instrumental variables provides consistent estimates with expectations of this type. The output price equations were estimated via Ordinary Least Squares. This technique yielded disturbances significantly free of autocorrelation at the five percent level of significance using the Durbin-h statistic test.

7. This measurement is justified based on patterns of change in population and land use. Over 97 percent of farmland in the state is located outside of urban counties and over 95 percent of the loss of agricultural land between 1954 and 1982 occurred in non-urban counties (*U.S. Census of Agriculture*). For the urban counties, population density in the four census years 1950, 1960, 1970, and 1980 averaged 3374, 3902, 4204, and 3966 persons per square mile, respectively. For

non-urban (i.e., suburban) counties it averaged 263, 371, 496 and 559. The coefficient of variation of population density in non-urban counties was 0.88, 0.88, 0.86, and 0.76. This suggests that changes in geographic dispersion of population were less important relative to increases in population density in suburban New Jersey in the post-war period. Several attempts to incorporate population dispersion into the suburbanization measure failed to improve results.

8. Applying the quotient rule,

$$\frac{dp_i}{dZ_s} = \frac{(dP_i/dZ_s)P_n - (P_n/dZ_s)P_i}{P_n^2}.$$

Using this result to compute the flexibility of a normalized price (f_{is}),

$$f_{is} = \frac{dp_i}{dZ_s}\frac{Z_s}{p_i} = \frac{dP_i}{dZ_s}\frac{Z_s}{P_i} - \frac{dP_n}{dZ_s}\frac{Z_s}{P_n} = F_{is} - F_{ns},$$

where F denotes flexibility of a nominal price. Although the results of using nominal prices are theoretically equivalent to using normalized prices directly, the indirect estimation procedure allow isolation of the impact of suburbanization on individual prices.

9. Recall footnote 8 and note that by assuming $dP_n/dZ_s = 0, dp_i/dZ_s = dP_i/dZ_s 1/P_n$ and $f_{is} = F_{is}$. The estimated nominal price flexiblity for intermediate inputs (F_{ns}) is - 0.082, but based on the above assumption, it was also set to zero for subsequent analysis. For comparison, equations (6) were also estimated using normalized prices. The estimated *direct* normalized price flexibilities, for vegetables, fruit, grain crops, and livestock were 0.47, 0.56, 0.27, and -0.01. The estimated *direct* normalized price flexibilities for labor, capital, and land were -0.10, -0.37, and -3.25.

Figure 1: Effects of Suburbanization on Production Possibilities, Prices and Optimal Output Choices

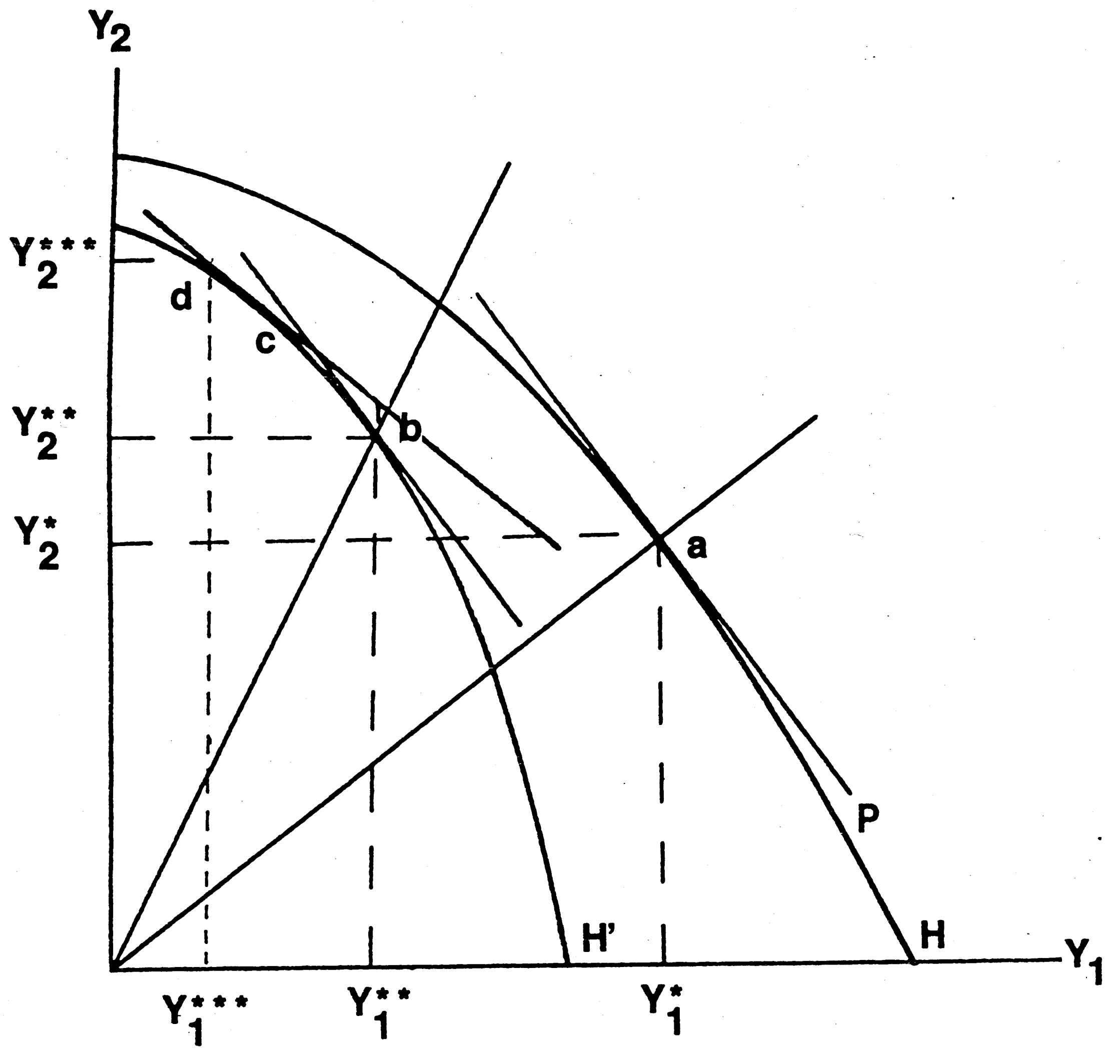

Table 1: Estimated Parameters of the Normalized Profit Function for New Jersey Agriculture

	Supply Equations				Demand Equations		
Variable	Vegetables	Fruits	Grain Crops	Livestock	Labor	Capital	Land
Intercept	237.833**	837.533	1373.151**	2083.561**	1125.670**	1694.857**	1284.810*
	(109.614)	(1100.146)	(137.834)	(529.748)	(194.552)	(114.422)	(58.453)
Normalized Prices:							
Vegetables	36.043**						
	(6.122)						
Fruit	-1.068	297.490**			(symmetrical)		
	(1.862)	(45.832)					
Grain Crops	-2.478**	1.651	-10.126**				
	(.961)	(1.585)	(.5372)				
Livestock	-.236	.431	-5.303**	42.016**			
	(1.910)	(5.087)	(1.868)	(12.280)			
Labor	.889	1.582	1.342*	-1.676	-1.253		
	(.990)	(3.161)	(.811)	(2.848)	(7.609)		
Capital	1.789**	-4.569**	-.884**	.380	1.579**	-17.953**	
	(.386)	(1.465)	(.335)	(1.091)	(.686)	(5.000)	
Land	.056	.494	-.340**	.527	-.416	-.016	-2.33**
	(.119)	(.782)	(.107)	(.382)	(.266)	(.118)	(1.16)
Own Price x Population:	-.892**	-8.437**	.570**	-1.266**	-.110	.388**	.063**
	(.145)	(1.117)	(.137)	(.399)	(.206)	(.128)	(.031)
Time	-38.282**	-8.737	20.502**	45.694**	-40.329**	-12.693**	14.723**
	(5.725)	(60.933)	(4.086)	(14.346)	(9.407)	(4.488)	(3.422)
Weather	5.428**	16.546**	3.120**	—	—	—	—
	(.508)	(3.401)	(.186)	(—)	(—)	(—)	(—)
Population	45.809**	172.453	-63.225**	-93.154**	60.742**	-44.067**	-35.346**
	(10.192)	(119.390)	(8.350)	(28.123)	(17.787)	(8.381)	(6.492)
Speculative Pressure	-40.668*	-1283.387**	-80.853**	-62.271	22.668	-91.818**	-60.972**
	(24.649)	(237.839)	(20.593)	(69.754)	(43.826)	(21.223)	(13.755)

Note : These results correspond to equation (5). Standard errors are in parentheses. Single and double asterisks indicate significance at the α=0.10 and 0.05 levels, respectively. For estimation purposes, input quantities were measured in negative units but for the sake of clarity, the estimated input coefficients are presented for input quantities in conventional (positive) units.

Table 2: Partial Product Supply and Input Demand Elasticities

	Elasticity with Respect to:										
	The Price of:										
Output or Input	Vege-tables	Fruit	Grain Crops	Live-stock	Labor	Capital	Land	Time	Weather	Popu-lation	Speculative Pressure
Vegetables	.786	-.090	-.246	-.025	.073	.158	.001	-.291	.828	-.054	-.210
Fruit	-.014	.683	.027	.008	.021	-.067	.001	-.011	.412	-2.169	-1.084
Grain Crops	-.239	.168	.817	-.707	.136	-.097	-.005	.193	.581	-1.430	-.516
Livestock	-.007	.013	-.198	.192	-.051	.012	.002	.128	—	-3.024	-.398
Labor	.050	.093	.096	-.132	-.230	-.088	-.003	-.192	—	1.537	.074
Capital	.173	-.471	-.111	.052	-.081	-.636	-.007	.106	—	-1.049	-.519
Land	.001	.0490	-.041	.070	-.036	-.036	-.012	.118	—	-1.633	-.332

Note: Elasticities are based on the estimated function parameters in Table 1 and mean values of the data.

Table 3: The Net Effects of Suburbanization on Prices and Speculative Pressure Index

Equation	Intercept	Population (λ_{sj})	Lagged Dependent Variable	Input Price Index	Output Price Index	Time	R^2
Expected Output Prices							
Vegetables	-52.680**	1.413**	.637**	.016*	—	—	.96
	(26.172)	(.626)	(.191)	(.009)	(—)	(—)	
Fruit	-25.993**	.88**	.125	.134**	—	—	.87
		(.440)	(.177)	(.034)	(—)	(—)	
Grain Crops	-22.907	.956**	.592**	.012	—	—	.86
	(16.632)	(.434)	(.215)	(.009)	(—)	(—)	
Livestock	3.255	.147	.817**	.021	—	—	.89
	(9.151)	(.310)	(.158)	(.029)	(—)	(—)	
Input Prices:							
Intermediate Inputs	.793	-.003	.520**	—	-.043**	.005**	.95
(numeraire)	(.588)	(.252)	(.095)	(—)	(.018)	(.001)	
Labor	19.258	-.347	.663**	—	.036**	.064	.93
	(25.793)	(.418)	(.121)	(—)	(.029)	(.089)	
Capital	73.402**	-.1.898**	.127**	—	.029**	.246**	.97
	(29.303)	(.544)	(.111)	(—)	(.034)	(.096)	
Land	31.164*	-1.500**	1.001**	—	—	.040**	.85
	(19.000)	(.098)	(.155)	(.—)	(—)	(.016)	
Speculative Pressure	-.070	.034**	.817**	—	—	-.0007**	.91
on Land	(.299)	(.017)	(.075)	(—)	(—)	(.0003)	

Note: These results correspond to equation (6). Prices were measured in nominal terms. Single and double asterisks indicate significance at the $\alpha = 0.10$ and 0.05 levels, respectively.

Table 4: Decomposed and Total Effects of Suburbanization

Choice Variables	Decomposed Elasticity of Choice: Market Price Effects	Technical/ Regulatory Effects	Speculative Pressure Effects	Total Elasticity of Choice (e_{is})	Flexibility of Price (f_{is})	Elasticity of Profits (R_{is})
Vegetables	.469	-.054	-.122	.293	.631	.923
Fruit	.253	-2.169	-.630	-2.545	.372	-2.173
Grain Crops	.078	-1.430	-.300	-1.652	.343	-1.309
Livestock	-.078	-3.024	-.031	-3.132	.049	-3.084
Labor	-.179	1.537	.043	1.400	-.597	-.802
Capital	-.007	-1.049	-.302	-1.358	-.287	1.645
Land	-.016	-1.633	-.193	-1.841	-3.958	5.799
Combined Effect on Profit Elasticity:	.924	-5.532	-.631	-5.239	6.237	.998

Note: These results correspond to equations (7), (8), and (9). The signs of the choice elasticities and price flexibilities of the inputs were reversed before computing the respective profit elasticities since they are associated with costs. Numbers may not add up exactly due to rounding errors.

REFERENCES

Adelaja, A. and A. Hoque "A Multi-Product Analysis of Energy Demand in Agricultural Subsectors." *Southern J. Agr. Econ.* 18(1986):51-63.

Andrews, M.S. and J. Chetrick. "Suburbanization, Agricultural Productivity, and Right-to-Farm." Paper presented at the National Conference on Sustaining Agriculture Near Cities, Boston, Massachusetts, November, 1986.

Antle, J.M. "The Structure of U.S. Agricultural Technology," 1910-1978. *Amer. J. Agr. Econ.* 66(1984):414-421.

Berry, D. "Effects of Urbanization on Agricultural Activities." *Growth and Change* 9(1978):2-8.

Binswanger, H.P., "The Measurement of Technical Change Biases with Many Factors of Production," *Amer. Econ. Rev.*, 64(1974):964-976.

Christensen, L.R. and D.W. Jorgenson. "The Measurement of U.S. Real Capital Input, 1929-1967." *Rev. Income and Wealth*, Series 15, No. 4 (1969): 293-320.

Conklin, H.E. et al. "Preserving Agriculture in the Urban Region." NE-90 Regional Research Project Report, Cornell University, New York Agr. Expt. Sta., 1980.

Coughlin, R.E. et al. *Saving the Garden: The Preservation of Farmland and Other Environmentally Valuable Land.* Philadelphia: Regional Science Research Institute, 1977.

Derr, D., L. Small, and P. Dhillon. "Criteria and Strategies for Maintaining Agriculture at the Local Level." *J. Soil and Water Conserv.* 32(1977):118-122.

Diewert, W.E. "Functional Forms for Profit and Transformation Functions." *J. Econ. Theory* 6(1973):284-376.

Diewert, W.E. "Exact and Superlative Index Numbers." *J. Econometrics* 4(1976):115-146.

Duncan, O.T. et al. *Metropolis and Region.* Baltimore: Johns Hopkins Press,1960.

Fischel, W.A. "Urbanization of Agricultural Lands: A Review of the National Agricultural Land Study." *Land Econ.* 58(1982):236-259.

Fisher, I. *The Making of Index Numbers*, Haughton-Mifflin, Boston, 1922.

Gardner, B.D. "The Economics of Agricultural Land Preservation." *Amer. J. Agric. Econ.* 59(1977):1027-36.

Gustafson, G.C. and N.L. Bills. "U.S. Cropland, Urbanization, and Landownership Patterns." AER-520. Economic Research Service, U.S. Department of Agriculture, November, 1984.

Hand, J.P. "Right-to-Farm Laws: Breaking New Ground in the Preservation of Farmland." *University of Pittsburgh Law Rev.* 45(1984): 289-350.

Hunter, J.M. "Summary and Conclusion of an Analysis of State Legislation Which Protects Agricultural Production from Undue Restriction by State or Lesser Government Units." Dept. of Agr. Econ., New Jersey Agr. Expt. Sta., SR 68, 1981.

Kang, H. "Univariate ARIMA Forecasts of Defined Variables." *J. Bus. Econ. Sta.* 4(1986):81-86.

Katzman, M.T. "The Von Thuenen Paradigm, the Industrial-Urban Hypothesis, and the Spatial Structure of Agriculture." *Amer. J. Agr. Econ.* 56(1974):683-96.

Lapping, M.B., G.E. Penfold and S. Macpherson. "Right-To-Farm Laws: Do They Resolve Land Use Conflicts?" *J. Soil and Water Conserv.* 26(1983): 465-67.

Lau, L.J. "A Characterization of the Normalized Restricted Profit Function." *J. Econ. Theory* 12(1976):131-163.

Lau, L.J. "Profit Functions of Technologies with Multiple Inputs and Outputs." *Rev. Econ. Statist.* 54(1972):281-289.

Libby, L.W. "Land Use Policy: Implications for Commercial Agriculture." *Amer. J. Agr. Econ* 55(1974):1143-1152.

Lisansky, J. "Farming in an Urbanizing Environment: Agricultural Land Use Conflicts and Right to Farm." *Human Org.* 45(1986): 363-371.

Lopez, R.A. "The Use of Composite Price Expectations in Supply Response Models." *Canadian J. Agr. Econ.* 34(1986): 455-474.

Lopez, R.A. and A.O. Munoz. "Supply Response in the Northeastern Fresh Tomato Market." *Northeastern J. Agr. Econ..* 16(1987): in press.

Lopez, R.E. "The Structure of Production and the Derived Demand for Inputs in Canadian Agriculture." *Amer. J. Agr. Econ.* 62(1980):38-45.

McCallum, B.T. "Rational Expectations and the Estimation of Econometric Models: An Alternative Procedure." *Int. Econ. Rev.* 17(1976):484-490.

Muth, J.F. "Rational Expectations and the Theory of Price Movements." *Econometrica* 29(1961): 315-335.

Muth, R.F. "Economic Change and Rural-Urban Land Conversions." *Econometrica* 29(1961):1-23.

New Jersey Department of Agriculture. *New Jersey Agricultural Statistics*. Various years.

Orcutt, G.H., H. H. Watts, and J.B. Edwards. "Data Aggregation and Information Loss." *Amer. Econ. Rev.* 58(1968):773-787.

Plaut, T.R. "Urban Expansion and the Loss of Farmland in the United States: Implications for the Future." *Amer. J. Agr. Econ.* 62(1980):537-542.

Saez, R.R. and C.R. Shumway. "Multiproduct Agricultural Supply Response and Input Demand Estimation in the United States: A Regional Profit Function Approach." Technical Report No. 85-3, Dept. of Ag. Econ., Texas A & M University, 1985.

Samuelson, P.A. and S. Swamy. "Invarient Economic Index Numbers Canonical Duality: Survey and Synthesis." *Amer. Econ. Rev.*, 64(1974):566-593.

Shumway, C.R. "Supply, Demand and Technology in a Multiproduct Industry: Texas Field Crops." *Amer. J. Agr. Econ.* 65(1983):748-760.

Stevenson, R. "Measuring Technological Bias." *Amer. Econ. Rev.* 70(1980):162-173.

U.S. Department of Agriculture. *Agricultural Statistics.* Annual.

U.S. Department of Agriculture. *Production and Efficiency Statistics.* Economic Indicators of the Farm Sector Series, Economic Research Service, 1983.

U.S. Department of Agriculture. *State Farm Income Statistics.* Economic Indicators of the Farm Sector Series, ESCS Statistical Bulletin 627, 1982.

U.S. Department of Commerce. Bureau of Census. *Census of Agriculture: New Jersey.* Washington, D.C. Various years.

U.S. Department of Commerce. Bureau of Census. *U.S. Census of Population.* Washington, D.C. Various years.

Weaver, R.D. "Multiple Input, Multiple Output Production Choices and Technology in the U.S. Wheat Region." *Amer. J. Agr. Econ.* 65(1983): 45-56.