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Environmentally Adjusted Elasticity Measures

Saleem Shaik
Department of Agricultural Economics
P. O. Box 5187
Mississippi State University
Mississippi State, MS 39762
Phone: (662) 325-7992
Fax: (662) 325-6614
E-mail: shaik@agecon.msstate.edu

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Abstract

Here, using input, output and nitrogen pollution data related to one state, we propose to extend the elasticity concept to include environmental pollution treated as undesirable output to provide the environmentally adjusted elasticity measures for the period, 1936-1997 in a two-step procedure.

JEL classification: O3, C6, Q1

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Over the last two decades and particularly during the past decade the growing concern in the agricultural-environmental interaction has transformed the traditional examination of structural changes in agriculture to a broader social concept including non-market goods (environmental pollution). Agriculture has important effects on the natural environment: it can generate pollution that reduces the value of the environment for society; and the private market allocation of resources to agriculture generally excludes their use for recreational and other purposes. Because these "uses" of the environment are neither paid for nor priced in the market, the traditional analyses are incomplete (for details and survey refer to Bator; Mishan; and Baumol and Oates).

Researchers have addressed issues related to the abatement cost of environment pollution generated from agricultural production from the consumer side (Smith 1997) as well as the producer side accounting the total factor productivity for environmental pollution (Pittman, 1983, Oskam, 1991, Ball et al, 1994, and Shaik, 1998), and computing the green gross domestic product measures in the agriculture sector. The usefulness of estimating the extent (and price[1]) of environmental pollution is especially important given that the environmental pollution is currently disassociated from production decisions leading to the estimation of input and output elasticity measures excluding non-marketable goods (environmental pollution[2]). Also, agricultural policy analysis utilizes the traditional elasticities to examine the long-term changes in agriculture sector. With increasing evidence of pollution resulting from agriculture production and since the traditional elasticity measures do not represent the true measures, an important task is to estimate the environmentally adjusted elasticity measures to examine the long-term changes in agriculture.

Using input, output and nitrogen pollution data related to one state (Nebraska), we propose to extend the elasticity concept to estimate environmentally adjusted elasticity measures for the period, 1936-1997 based on variable profit function. In the variable profit function, the quantity and price (shadow price recovered from the linear

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[1] Identification and quantification of the extent of environmental pollution resulting from agricultural production is itself a difficult task and being a non-marketable good the price of environmental pollution cannot be directly observed. To overcome this impediment it is feasible to estimate the shadow price of environmental pollution drawing upon the relationship between the marginal products and price (marginal cost) from a production function.

[2] The equivalency of treating environmental pollution as undesirable output with weak disposability or as a normal input with strong disposability can be illustrated by an implicit production function, $F(Y,\ N,\ X) = 0$. Weak disposability refers to the ability to dispose of environmental pollution as an unwanted commodity at a positive private cost. Joint production of desirable output (Y) and environmental pollution (N) is assumed. Strong disposability refers to the ability to dispose of environmental pollution with no private cost. In general under the assumption of perfect competition, the first order conditions of the implicit function with respect to its elements are positive and equal to its prices (in our case, the first order derivatives are equal to the prices of environmental pollution). In addition if environmental pollution were treated as undesirable output with weak disposability, the firm would conceptually maximize profits with a negative shadow price ($\partial y / \partial N \ = \ -v$). The negative price reflects the inward bending of the transformation curve or backward bending of the input requirement set. Similarly, the firm would maximize profits with positive price ($\partial y / \partial x_{\ |N=x} = v_{N=x}$) of environmental pollution treated as a normal input with strong disposability.

programming approach by treating environmental pollution treated as undesirable output) of environmental pollution along with the system of output supply equations and fixed inputs equation are used to estimated the environmentally adjusted elasticity measures.

This paper has a three-fold contribution to the existing literature - 1) estimate the shadow price of environmental pollution using linear programming approach, 2) examine the effect of environmental pollution on output mix and factor, and 3) estimates the environmental adjusted elasticity measures based on cost and variable profit function. In the next section the econometric translog variable profit function along with the system of fixed input demand and output supply equations including environmental pollution are presented. Construction of Nebraska agriculture sector input, output and environmental data for the period, 1936-97 is detailed in the third section. Empirical application and results are presented in the fourth section followed by conclusions.

Theoretical Overview

Nonparametric Linear Programming Model

In agriculture sector one observes non-allocable input vector $x = (x_1, \ldots\ldots, x_n)$ used in the production of output $y = (y_1, \ldots\ldots, y_m)$, with corresponding price vectors $w = (w_1, \ldots\ldots, w_n)$ and $p = (p_1, \ldots\ldots, p_n)$. The price of nitrogen pollution treated as an undesirable output with weak disposability can be recovered from the dual values implicit in the piecewise linear programming constraint of the graph distance function.

The particular non-parametric measure considered here is one of Färe's hyperbolic graph productivity measures described in Färe, Grosskopf and Lovell, Chapter 8 section

3. To formally represent this measure, first partition the output vector into good outputs and bad outputs, $y = (y_g, y_b)$ and define the technology using the graph reference set satisfying constant returns to scale, strong disposability of good outputs and weak disposability of bad outputs:

$$(1) \qquad H^T(x^t, y_g^t, y_b^t)^{-1} = \max_{\theta, z} \{\theta : (\theta^{-1} x^t, \theta\, y_g^t, \theta^{-1} y_b^t) \in GR^T(x^t, y_g^t, y_b^t)\}$$

$$or$$

$$\begin{aligned} \max_{\theta, z} \theta \;\; s.t. \quad \theta\, y_g^t &\le Y_g z \qquad \text{where} \quad Y_g = (y_g^1, y_g^2, \ldots\ldots\ldots, y_g^T) \\ \theta^{-1} y_b^t &\ge Y_b z \qquad\qquad\quad Y_b = (y_b^1, y_b^2, \ldots\ldots\ldots, y_b^T) \\ \theta^{-1} x^t &\ge X z \qquad\qquad\quad X = (x^1, x^2, \ldots\ldots\ldots, x^T) \\ z &\ge 0 \end{aligned}$$

where z is a *Tx1* vector of intensity variables with $z \ge 0$ $\left(z = 1\right)$ identifying the constant (variable) return to scale boundaries of the reference set, and the equal sign on the second constraint indicates the weak disposability assumption on environmental pollution with a less (greater) than sign representing the strong disposability of desirable output (input).

The dual values implicit in the piecewise linear programming constraint from equation (1), equivalent to the producer shadow price, can be efficiently retrieved. More specifically, the producer shadow price of a bad output y_b, in terms of a good output y_g that must be given up, is the gradient of the technology frontier facet at the relevant point. That gradient is measured as the ratio of the shadow prices of the constraint row for the bad output and the constraint row for the good output, or

$$(2) \qquad r_{b,g} = \frac{\lambda_{y_b}}{\lambda_{y_g}}$$

where λ is the dual value of row in the programming solution above.

Nonlinear System of Input demand and Output Supply Equation Model

To examine the potential effects of environmental pollution on factor use patterns and output production mix and estimate the environmentally adjusted elasticity measures, we treat environmental pollution as an output with negative price in the variable profit maximization. The variable input demand functions, output supply functions and fixed input demand functions are derived from the variable profit function $\pi(p,x)$ .utilizing Shephard's lemma.

For estimation of the nonlinear system of equations, consider a firm with netputs (i.e., variable outputs and inputs) denoted by $y_i = (y_1, ..., y_I)$ (where y_i is positive for output and negative for variable input) and fixed inputs denoted as $x_j = (x_1, ..., x_J)$ and the corresponding price vectors represented as $p_i = (p_1, ..., p_I)$ and $w_j = (w_1, ..., w_J)$ respectively.

The translog variable profit function incorporating environmental pollution treated as an output with negative price, outputs, variable inputs and fixed inputs under Hicks neutral technical change satisfying the properties as defined in Diewert (1974) can be represented as:

$$(3) \quad \ln \pi(p,x) = \alpha + \sum_{i=1}^{I} \alpha_{i0} \ln p_i + \frac{1}{2} \sum_{i=1}^{I} \sum_{h=1}^{I} \alpha_{i,h} \ln p_i \ln p_h + \sum_{j=1}^{J} \beta_{j0} \ln x_j + \frac{1}{2} \sum_{j=1}^{J} \sum_{k=1}^{J} \beta_{j,k} \ln x_j \ln x_k + \frac{1}{2} \sum_{i=1}^{I} \sum_{j=1}^{J} \gamma_{i,j} \ln p_j \ln x_i + \varepsilon$$

where p refers to netputs (positive for outputs and negative for variable inputs). To ensure symmetry and homogeneity conditions, the following restrictions are required:

(4) $\alpha_{i,h} = \alpha_{h,i}$, $\beta_{j,k} = \beta_{k,j}$

and

(5) $\sum_{i=1}^{I} \alpha_{i0} = 1, \quad \sum_{h=1}^{I} \alpha_{i,h} = 0 \text{ for all } h \neq 0,$

$$\sum_{j=1}^{J} \beta_{j0} = 1, \quad \sum_{k=1}^{J} \beta_{j,k} = 0 \text{ for all } k \neq 0$$

The required share equations of netputs and fixed input variables can be derived using net profit (NP) $= \text{Revenue} - \text{Variable cost}$. Due to the use of net profit, the revenue (variable cost) shares should be positive (negative) and should sum to one. Similarly, the fixed cost shares are positive and should sum to one.

The logarithmic first order conditions of the cost function including environmental pollution treated as normal input with positive price given aggregate output provide the system of input demand functions for non-Hicks neutral technology:

(6) $$\frac{\partial \ln \pi}{\partial \ln p_i} = \frac{\partial \pi}{\partial p_i}\frac{p_i}{\pi} = \frac{y_i x_i}{\pi} = S_i = \alpha_{i0} + \sum_{h=1}^{12} \alpha_{i,h} \ln\left(w_i / w_{13}\right) + \sum_{j=1}^{2} \gamma_{i,j} \ln\left(x_j / x_3\right) + \varepsilon_i, \quad i = 1,\ldots,12$$

(7) $$\frac{\partial \ln \pi}{\partial \ln x_j} = \frac{\partial \pi}{\partial x_j}\frac{x_j}{\pi} = \frac{w_j x_j}{\pi} = R_j = \beta_{j0} + \sum_{k=1}^{2} \beta_{j,k} \ln\left(x_k / x_3\right) + \sum_{i=1}^{12} \gamma_{i,j} \ln\left(w_i / w_{13}\right) + \varepsilon_j, \quad j = 1,\ldots,2$$

where S_i is the share of netputs (output and variable inputs) and R_j is the share of the fixed input in the total cost of fixed inputs and ε_i and ε_j are the residuals of the netputs and fixed inputs.

Based on the parameter estimates of the shares equations the partial elasticity of variable netputs with respect to price for the netputs including environmental pollution can be computed from the coefficient estimate of the equation (6 and 7) respectively as:

$$(8a) \quad \varepsilon_{i,h} = S_h + \frac{\alpha_{i,h}}{S_i}, \qquad i = 1,.....13,\ i \neq h$$

$$(8b) \quad \varepsilon_{i,h} = S_i + \frac{\alpha_{i,i}}{S_i} - 1, \qquad i = 1,.....13$$

Similarly for computing the partial elasticity of fixed inputs with respect to quantity for the fixed inputs, S and α are replaced by R and β in equation 8a and b.

Nebraska Output, Input and Nitrogen Pollution Data

Outputs and Input Data

Nebraska agriculture aggregate Tornqvist-Theil input and output quantity index, and five dis-aggregate Tornqvist-Theil input price indices and six dis-aggregate Tornqvist-Theil output price indices for the period 1936-97 are constructed accounting for the quantity changes for this paper. An aggregate output quantity index and six output price indices – meat animals, poultry, dairy and other livestock, food grains, feed crops and vegetable and oil seeds are constructed from twenty-two commodities. Annual data on crop production (yield per acre times total harvested acres for each crop) and the crop prices received by farmers, and the quantity estimates (pounds of meat produced) of livestock and the average prices per pound of livestock were used in the construction of an output Tornqvist-Theil quantity index and five Tornqvist-Theil price indices.

Similarly an aggregate input quantity index, five input quantity and price indices –farm equipment, breeding livestock, farm real estate, farm labor and intermediate input price indices are constructed from twenty-five variables. An aggregate Tornqvist-Theil input quantity index and is constructed by aggregating twenty-five variables. Particular emphasis was given in the construction of farm equipment, *FE* (includes trucks, autos, tractors, other agriculture machinery), breeding livestock, *BLS* (cattle, hogs, sheep and lambs, horses and mules), farm real estate, *FRE* (non-irrigated crop land, irrigated crop land, pastures, building and structures), farm labor (hired and family labor) and intermediate inputs disaggregated into farm inputs (feed, seed and livestock), fertilizer and lime, pesticides, energy (fuel and electricity) and other intermediate inputs (interest and others) with different methods used in the construction of indexes for each group to account for quality changes (see Shaik for details). Also five Tornqvist-Theil input quantity indices were constructed and utilized in the construction of five implicit input price indices. The five implicit input price indices -farm equipment, breeding livestock, farm real estate, farm labor and intermediate inputs were calculated as the logarithmic difference between the rate of change in expenditures and the quantity index share for the five aggregate inputs.

Nitrogen Pollution Data

Nitrogen pollution quantity index is constructed based on the excess nitrogen from agriculture calculated from nutrient mass balance accounting - difference between nitrogen inputs (commercial fertilizer, animal manure, legume fixation) and nitrogen removed by harvested crops (Shaik). The excess nitrogen from agriculture calculated from nutrient mass balance accounting is identified as potential nitrogen pollution. A positive nitrogen mass balance in the form of residual nitrogen remaining in the soil may be dissipated as nitrogen contamination in groundwater, surface water or to atmosphere, a potential source of damage depending on the soil hydrologic and weather conditions. The National Research Council developed nitrogen and phosphate mass balances for cropland at the national level by aggregating nutrient inputs and withdrawals across all crops and nutrient sources.

Nitrogen pollution input (output) price index is constructed by utilizing the shadow price directly recovered from the dual values of the non-parametric linear programming approach, since price information is seldom available for non-marketable good like pollution. The shadow prices of the nitrogen pollution are recovered from the graph distance function (undesirable output with negative price) non-parametric linear programming approach. Specifically the shadow prices are retrieved as the gradient of the linear programming constraint of the distance function with respect to its elements. The ratio of the dual values (i.e., the gradients) of nitrogen pollution and desirable output implicit in piecewise linear programming constraint of the output distance function are the shadow prices of nitrogen pollution treated as an undesirable output (for details see Shaik and Perrin). The annual growth rates along with the four moments of the variables used in the estimation of nonlinear system of equations (equation 6and 7) is presented in Table 1.

Empirical Results

To examine the potential effects of environmental pollution on farm economic structure the system of variable input demand and output supply equations defined in equation (6 and 7) are estimated using Nebraska agriculture data for the period, 1937-1997. The nonlinear estimates along with probabilities from the share equations of the translog variable profit function imposing homogeneity and symmetry in system of outputs supply and variable input demand equations are presented in Table 2.

Under the null hypothesis, with degrees of freedom equal to number of restrictions, Hick neutral technical change is tested using the likelihood ratio test statistic[3]. The null hypothesis is examined by estimating system of input demand and output supply equations for an unrestricted (with technology, t included) and restricted model (without technology, t). With the likelihood ratio test we are unable to reject the Hicks neutral technical change at a 5% level of significance. The necessary and sufficient conditions for monotonicity are not violated.

The estimates from the system of variable input demand and output supply equations presented in Table 2 indicate poultry, other livestock, and oils and vegetables did not have a statistically significant effect on the environmental pollution for the period 1937-1997. Further the meat animals, food grains and feed crops had a negative and significant effect on environment pollution. While labor, farm based inputs (seed, feed and other livestock related), fertilizer, pesticide and energy (fuel and electricity) had a

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[3] The likelihood ratio test statistic is –2 [restricted model – (–unrestricted model)] and is chi-squared, with the degrees of freedom equal to the number of restrictions imposed.

positive and significant impact on nitrogen pollution. These results indicate with increased use of fertilizer and energy, nitrogen pollution will increase.

The traditional and environmentally adjusted measures are presented in Table 3. Signs on own partial elasticity measures are consistent with the exception of poultry, other livestock and food grains in the output mix with negative sign, and for labor, and farm based inputs in the input side with positive sign. Also, difference in the elasticity measures with and without environmental pollution in the estimation of shares equations seem to exist.

Overall the empirical state level analysis of Nebraska agriculture sector indicates potential impacts of nitrogen pollution on the farm economic structure. This is based on the estimation of input demand and the output supply functions accounting for premiums and indemnities. A more through investigation of the model as well as estimation procedure would provide clear and robust impacts due to crop insurance on factor use. Further simultaneous estimation of system of input demand and output supply equations along with the profit function would provide the detailed impact analysis of the potential impacts of pollution on the factor use as well as shifts in the crop production mix.

Conclusions

This paper examines the potential impacts of nitrogen pollution on Nebraska agriculture sector based on the system of fixed input demand and the system of output supply equations using a variable profit function for the time period 1937-1997. The likelihood ratio tests fail to accept the hypothesis of Hick-neutral technical change. So under Hicks-neutral technical change, the overall impacts of environmental pollution on agriculture sector based on the system of variable input demand and output supply equations even though indicate correct signs on the coefficient estimates, are not statistically significant. However, the traditional and environmental adjusted measures of elasticity seem to differ.

Further research needs to be explored on the consistency of estimate by testing for unit root/cointegration and accounting for unit roots if any; examine the impact of aggregation on shadow prices estimates from the linear programming and also in the estimation of system of equations.

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Table 1. Annual Growth Rates and Four Moments of the Variables for Nebraska Agriculture Sector, 1937-1997

Variable	Mean	Std Dev	Skewness	Kurtosis	Rate of Change
Price Index (1936=1.00)					
MeatAnimals	5.8492	0.6599	-0.3471	-0.7063	3.383
Poultry	5.049	0.2913	-0.4029	-0.9292	1.575
MiscLS	5.7359	0.6594	-0.0846	-1.0958	3.243
Foodgrains	5.254	0.4853	-0.5327	-0.0283	1.803
FeedCrops	5.1065	0.5199	-0.4023	-0.3989	1.838
VegOils	4.9974	0.5133	-0.065	-1.111	1.664
Nitrogen	5.5572	0.5658	-0.4393	-0.4907	2.747
Labor	6.2246	0.7203	-0.8275	0.3093	4.387
Fbinputs	5.6538	0.5894	-0.1055	-1.0062	3.005
Fertilizer	5.2807	0.4802	0.3364	-1.4871	2.244
Pesticide	5.5556	0.5161	-0.0962	-0.8276	2.880
Energy	5.7465	0.7606	0.3087	-1.3016	3.565
Others	5.7836	0.9431	0.2585	-1.4823	4.214
Quantity Index (1936=1.00)					
FE	5.6893	0.4307	-0.8369	0.2138	1.489
BLS	4.3948	0.0954	-0.1332	0.1917	-0.326
FRE	4.7009	0.0865	0.0986	-1.2476	0.320
Cost and Revenue Shares					
MeatAnimals	0.7103	3.472	-0.2581	0.511	1.272
Poultry	-0.0083	0.2731	-0.2461	3.4636	-1.841
MiscLS	-0.0646	0.7441	-2.1165	8.5181	-2.168
Foodgrains	-0.0688	0.8657	-0.7354	1.453	-1.379
FeedCrops	0.3996	3.1546	-0.4971	0.5912	2.339
VegOils	0.1944	0.4267	0.9009	2.6059	4.224
Nitrogen	1.3793	1.0633	0.1211	1.7385	0.590
Labor	-0.068	1.9013	0.3939	1.4285	0.231
Fbinputs	-0.8286	4.4192	0.4552	0.9524	1.813
Fertilizer	-0.1338	0.1981	-1.1552	3.339	10.827
Pesticide	-0.0526	0.0887	-2.1941	6.4356	7.832
Energy	-0.0918	0.4	0.5113	1.8802	1.350
Others	-0.3672	1.1641	-0.0197	2.3768	2.379
FE	0.1533	0.031	-0.9091	0.0068	0.938
BLS	0.0283	0.0168	1.7495	2.6428	-2.541
FRE	0.8184	0.021	-0.1598	-0.8995	0.022

Table 2. Parameter Estimates for a Translog Variable Profit Function for Nebraska Agriculture Sector, 1937-1997

		Intercept	Meat Animals	Poultry	Misc LS	Food grains	Feed Crops	Oils & Veg	Nitrogen
Meat Animals	Coefficeint	-6.9740	5.1193	0.5563	0.6882	1.6869	4.2734	0.1358	-2.0313
	Probt	<.0001	<.0001	<.0001	0.1013	<.0001	<.0001	0.4301	<.0001
Poultry	Coefficeint	-0.6537	**0.5563**	0.0313	0.2350	0.1620	0.3819	0.0021	-0.0909
	Probt	<.0001	**<.0001**	0.1858	0.0043	<.0001	<.0001	0.9473	0.1168
Misc LS	Coefficeint	-2.0821	**0.6882**	**0.2350**	0.5296	0.2809	-0.0078	0.1650	0.2595
	Probt	<.0001	**0.1013**	**0.0043**	0.1936	0.0010	0.9791	0.1989	0.2832
Food grains	Coefficeint	-1.3088	**1.6869**	**0.1620**	**0.2809**	0.4046	1.5440	0.2479	-0.3609
	Probt	0.0004	**<.0001**	**<.0001**	**0.0010**	<.0001	<.0001	<.0001	0.0003
Feed Crops	Coefficeint	-6.8169	**4.2734**	**0.3819**	**-0.0078**	**1.5440**	3.6359	-0.1309	-1.6601
	Probt	<.0001	**<.0001**	**<.0001**	**0.9791**	**<.0001**	<.0001	0.2636	<.0001
Oils & Veg	Coefficeint	-1.0862	**0.1358**	**0.0021**	**0.1650**	**0.2479**	**-0.1309**	-0.0176	0.0099
	Probt	<.0001	**0.4301**	**0.9473**	**0.1989**	**<.0001**	**0.2636**	0.8504	0.9181
Nitrogen	Coefficeint	1.9006	**-2.0313**	**-0.0909**	**0.2595**	**-0.3609**	**-1.6601**	**0.0099**	0.1383
	Probt	0.0023	**<.0001**	**0.1168**	**0.2832**	**0.0003**	**<.0001**	**0.9181**	0.6676
Labor	Coefficeint	3.4528	**-2.9640**	**-0.2518**	**-0.3414**	**-0.9387**	**-2.9540**	**-0.0521**	**0.8826**
	Probt	<.0001	**<.0001**	**<.0001**	**0.1448**	**<.0001**	**<.0001**	**0.5394**	**0.0003**
Fputs	Coefficeint	10.1923	**-5.4614**	**-0.5555**	**-0.5774**	**-2.2779**	**-3.6147**	**-0.3129**	**1.8815**
	Probt	<.0001	**<.0001**	**<.0001**	**0.2809**	**<.0001**	**<.0001**	**0.1651**	**<.0001**
Fertilizers,lime	Coefficeint	0.2531	**-0.3273**	**-0.0166**	**-0.0676**	**-0.0819**	**-0.3885**	**0.0494**	**0.3041**
	Probt	0.0014	**0.0135**	**0.4669**	**0.5435**	**0.0012**	**<.0001**	**0.2077**	**<.0001**
Pesticides	Coefficeint	0.1725	**-0.0351**	**-0.0031**	**-0.1251**	**-0.0373**	**-0.0040**	**0.0284**	**0.0497**
	Probt	<.0001	**0.4351**	**0.7433**	**0.0020**	**0.0003**	**0.8947**	**0.1246**	**0.0493**
Energy	Coefficeint	**0.9781**	**-0.4656**	**-0.0166**	**-0.3430**	**-0.1625**	**-0.3465**	**-0.1226**	**0.1723**
	Probt	<.0001	**<.0001**	**0.4669**	**<.0001**	**<.0001**	**<.0001**	**0.0001**	**0.0003**
Others	Coefficeint	2.9724	-0.1754	0.5657	0.3039	0.5329	0.2712	0.9975	1.4453
	Probt								
FE	Coefficeint	0.1117	0.0281	-0.0251	0.1158	0.0210	0.0417	-0.0346	0.0055
	Probt	<.0001	0.2351	0.0002	<.0001	0.0015	0.0081	0.0020	0.6439
BLS	Coefficeint	0.0982	**0.0171**	**-0.0075**	**0.0315**	**0.0046**	**0.0081**	**-0.0075**	**-0.0101**
	Probt								
FRE	Coefficeint	0.7901	-0.0452	0.0326	-0.1473	-0.0256	-0.0498	0.0421	0.0045
	Probt	<.0001	0.1453	0.0001	<.0001	0.0020	0.0143	0.0029	0.7746

Table 2 Continued

		Labor	Fputs	Fertilizers	Pesticides	Energy	Others	FE	BLS	FRE
Meat Animals	Coefficeint	-2.9640	-5.4614	-0.3273	-0.0351	-0.4656	-0.1754	-0.4055	6.7651	-5.3596
	Probt	<.0001	<.0001	0.0135	0.4351	<.0001		0.5187		0.0364
Poultry	Coefficeint	-0.2518	-0.5555	-0.0166	-0.0031	-0.1272	0.6763	-0.0385	1.5139	-0.4754
	Probt	<.0001	<.0001	0.4669	0.7433	<.0001		0.5984		0.1069
Misc LS	Coefficeint	-0.3414	-0.5774	-0.0676	-0.1251	-0.3430	0.3039	-0.0020	3.1851	-2.1831
	Probt	0.1448	0.2809	0.5435	0.0020	<.0001		0.9919		0.0051
Food grains	Coefficeint	-0.9387	-2.2779	-0.0819	-0.0373	-0.1625	0.5329	-0.1327	3.1453	-2.0126
	Probt	<.0001	<.0001	0.0012	0.0003	<.0001		0.5497		0.0303
Feed Crops	Coefficeint	-2.9540	-3.6147	-0.3885	-0.0040	-0.3465	0.2712	0.4615	6.4262	-5.8878
	Probt	<.0001	<.0001	<.0001	0.8947	<.0001		0.4177		0.0135
Oils & Veg	Coefficeint	-0.0521	-0.3129	0.0494	0.0284	-0.1226	0.9975	-0.2232	0.9862	0.2370
	Probt	0.5394	0.1651	0.2077	0.1246	0.0001		0.0001		0.1993
Nitrogen	Coefficeint	0.8826	1.8815	0.3041	0.0497	0.1723	1.4453	0.1153	-2.1766	3.0613
	Probt	0.0003	<.0001	<.0001	0.0493	0.0003		0.7568		0.0559
Labor	Coefficeint	1.6630	3.5899	0.1703	0.0466	0.2343	1.9151	-0.0170	-3.2835	4.3006
	Probt	<.0001	<.0001	0.0115	0.0634	<.0001		0.9688		0.0181
Fputs	Coefficeint	3.5899	4.6659	0.4190	0.0545	0.8784	2.3102	-0.0347	-6.0831	7.1177
	Probt	<.0001	0.0021	0.0135	0.3570	<.0001		0.9607		0.0131
Fertilizers,lime	Coefficeint	0.1703	0.4190	-0.0529	0.0049	-0.0002	0.9873	0.0240	1.1440	-0.1681
	Probt	0.0115	0.0135	0.1574	0.7676	0.9924		0.6369		0.3634
Pesticides	Coefficeint	0.0466	0.0545	0.0049	-0.0067	0.0438	0.9835	0.0551	1.1209	-0.1760
	Probt	0.0634	0.3570	0.7676	0.6642	0.0105		0.0037		0.0079
Energy	Coefficeint	0.2343	0.8784	-0.0002	0.0438	-0.1154	1.2434	0.0552	0.2929	0.6518
	Probt	<.0001	<.0001	0.9924	0.0105	0.0026		0.3575		0.0066
Others	Coefficeint	1.9151	2.3102	0.9873	0.9835	1.3541	-10.4912	1.1424	-2.0365	1.8941
	Probt									
FE	Coefficeint	-0.0288	-0.0639	0.0012	-0.0264	-0.0447	1.0100	0.0531	0.9652	-0.0183
	Probt	0.0120	0.0718	0.9221	0.0233	0.0012		<.0001		0.0782
BLS	Coefficeint	-0.0166	0.0314	0.0089	-0.0449	-0.0109	0.9958	-0.0348	1.0589	-0.0241
	Probt									
FRE	Coefficeint	0.0453	0.0324	-0.0102	0.0714	0.0555	0.9942	-0.0183	0.9759	0.0424
	Probt	0.0028	0.4650	0.5466	<.0001	0.0023		0.0782		0.0124

Table 3. Partial Elasticities for Nebraska Agriculture Sector, 1937-1997 at Mean of the Explanatory Variables.

	Meat Animals	Poultry	Misc LS	Food grains	Feed Crops	Oils & Veg	Nitrogen
With Environmental Pollution							
Meat Animals	6.917	0.775	0.961	2.367	6.008	0.183	-2.868
Poultry		-12.782	-28.536	-19.692	-46.329	-0.315	10.950
Misc LS			-9.264	-4.417	0.051	-2.624	-4.086
Food grains				-6.945	-22.027	-3.201	5.642
Feed Crops					3.263	-0.133	-3.960
Oils & Veg						0.470	1.430
Nitrogen							0.118
Labor							
Farm inputs							
Fertilizers							
Pesticides							
Energy							
Others							
FE							
BLS							
FRE							
Without Environmental Pollution							
Meat Animals	14.707	0.823	0.510	2.981	13.556	-3.418	
Poultry		-12.782	-56.922	-11.790	-34.410	-45.579	
Misc LS			11.644	3.550	-26.582	-4.907	
Food grains				-4.612	-31.694	-2.501	
Feed Crops					4.929	-6.155	
Oils & Veg						0.222	
Nitrogen							
Labor							
Farm inputs							
Fertilizers							
Pesticides							
Energy							
Others							
FE							
BLS							
FRE							

Table 3 Continued

	Labor	Fputs	Fertilizers	Pesticides	Energy	Others	FE	BLS	FRE
With Environmental Pollution									
Meat Animals	-4.181	-7.697	-0.469	-0.058	-0.664	-0.469			
Poultry	30.435	67.221	1.940	0.306	15.344	-81.989			
Misc LS	5.215	8.869	0.978	1.868	5.240	-4.774			
Food grains	14.034	33.485	1.589	0.942	2.760	-7.341			
Feed Crops	-7.198	-8.851	-0.778	0.184	-0.673	0.873			
Oils & Veg	1.112	-0.230	1.633	1.525	0.749	6.511			
Nitrogen	0.793	1.518	0.374	0.189	0.278	1.201			
Labor	9.999	23.441	1.139	0.332	1.557	12.518			
Farm inputs		163.862	15.621	2.744	31.852	82.433			
Fertilizers			-0.246	-0.062	-0.068	1.138			
Pesticides				-0.970	-1.472	-15.290			
Energy					-1.689	-1.634			
Others						-12.412			
FE							-2.062	-18.451	0.256
BLS								-12.628	-0.104
FRE									-1.483
Without Environmental Pollution									
Meat Animals	-7.563	-19.018	-1.061	0.661	-1.665	-1.061			
Poultry	30.274	123.095	-16.533	22.513	-17.631	-44.194			
Misc LS	24.954	1.535	1.427	-3.165	5.350	-18.008			
Food grains	14.217	37.094	6.580	-0.796	6.913	-8.744			
Feed Crops	-16.301	-35.204	-4.169	0.835	-2.534	3.012			
Oils & Veg	0.901	15.527	8.002	2.564	4.199	7.122			
Nitrogen									
Labor	24.810	57.573	5.572	-0.419	5.559	9.695			
Farm inputs		623.824	43.097	-13.682	32.510	48.572			
Fertilizers			0.434	-0.417	-0.075	0.336			
Pesticides				0.636	-2.034	-11.722			
Energy					-1.963	-1.882			
Others						-15.196			
FE							-2.628	-18.477	0.847
BLS								-12.823	0.106
FRE									-1.620