Multiproduct Production Choices and Policy Response

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A restricted profit function model of California agriculture is specified and estimated subject to prior information provided by economic theory. Symmetry, homogeneity, and convexity of the profit function are maintained in the estimation. Parameter estimates and elasticities are presented for four input and 10 output equations. Tests of the hypotheses of nonjointness in inputs and Hicks-neutral technical change in variable inputs and outputs are rejected. The impacts of decoupling agricultural program payments are examined.

Key words: decoupling, multiproduct profit function, policy response.

Frequently of great concern in U.S. farm policy debates is the supply responsiveness of major agricultural commodities (especially those being produced under provisions of existing farm programs) to changing economic and political conditions. Although the object of considerable empirical research, much uncertainty remains about supply responsiveness (both direct and indirect) and about the impacts of that responsiveness on input markets. If we are to anticipate the geographic distribution of benefits and costs from changes in government policies, it is important that analysis be highly disaggregated geographically. If we are to anticipate the distribution among various types of producers, such as those producing different combinations of commodities, it is important that the analysis also be commodity specific.

Data limitations frequently restrict the extent of feasible geographic and output-input disaggregation. Reliance on economic theory and modestly restrictive assumptions about the technology (such as twice-continuous differentiability) can sometimes help by permitting some reduction in the number of parameters requiring estimation. Such reliance, however, can also increase the complexity of the required estimation methods (e.g., some implications of the maintained hypotheses may require imposition of nonlinear inequality constraints during estimation). Nevertheless, maintenance of the theory increases the potential for detailed analysis of production relationships, especially those relationships sensitive to changes in the economic and political environments.

Recent empirical studies of agricultural supply response have generally assumed the behavioral objective of profit maximization and employed duality theory to estimate systems of output supply and input demand equations (e.g., Lopez; Ball; Huffman and Evenson; Shumway and Alexander; Weaver). Some analysts (e.g., Ball; Shumway and Alexander) have reported estimates of supply and demand relationships that are consistent with the neoclassical theory of the profit-maximizing firm (i.e., the estimated supply and demand equations are homogeneous of degree zero in prices and monotonic, and the Hessian of the profit function is positive semidefinite assuring that the profit function is, at least locally, convex in prices).[1] Indeed, Ball makes a strong argument that convexity, if not satisfied, must be

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[1] For examples of nonconvex, locally convex, and globally convex sets of estimates, see Shumway; Ball; and Shumway and Alexander, respectively.

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maintained during estimation or the use of duality theory in the model specification is not valid.

The objective of this article is to present a highly disaggregated, static model of agricultural supply response for an important and diverse agricultural state, California. Estimates of own- and cross-price elasticities of supply and demand that are consistent with economic theory will be presented, as will tests regarding functional structure and technological change. The impact on output supplies and input demands of decoupling government farm commodity payments from farm production will also be assessed.

Model Description

This study employs a restricted profit function as the vehicle for multiple output supply and input demand estimation. The agricultural sector in the state of California is modeled as though it were a competitive firm assuming (*a*) exogeneity of output and variable input prices facing the state and (*b*) the existence of a twice-continuously differentiable concave aggregate state-level production function.[2] The indirect restricted profit function is modeled using a normalized quadratic functional form (Lau; Shumway). The normalized quadratic is self-dual and imposes linear homogeneity in prices. It is a locally flexible functional form and as such does not impose arbitrary restrictions on substitution elasticities or returns to scale. The normalized quadratic does not restrict the underlying production technology to be homogeneous, homothetic, or nonjoint.[3] It is also capable of satisfying curvature properties globally.

Following the "netput" convention (output quantities are measured as positive while variable input quantities are measured negatively), the normalized quadratic can be written as:

$$(1) \qquad \bar{\Pi} = b_0 + C\bar{P} + .5\bar{P}'D\bar{P},$$

where $\bar{\Pi}$ is profit divided by price of netput 1; $\bar{P} = [\bar{p}_2, \ldots, \bar{p}_m, x_{m+1}, \ldots, x_n]$ is the vector of normalized prices ($\bar{p}_i = p_i/p_1$) of the variable netputs and quantities of fixed inputs and related exogenous variables ($x_{m+1}, \ldots, x_n$); b_0 is the intercept; and C and D are parameter matrices. By the envelope theorem (Silberberg), the first derivatives of this function with respect to normalized prices give output supply and input demand equations that are linear in the vector of normalized prices and other exogenous variables:

$$(2) \qquad x_{it} = c_i + \sum_{j=2}^{m} d_{ij}\bar{p}_{jt} + \sum_{j=m+1}^{n} d_{ij}x_{jt}, \quad i = 2, \ldots, m$$

where t is time.

The numeraire (netput 1) demand equation can also be derived via the envelope theorem. It is quadratic in normalized prices and other exogenous variables:[4]

$$(3) \qquad x_{1t} = b_0 + \sum_{i=m+1}^{n} c_i x_{it} - .5 \sum_{i=2}^{m} \sum_{j=2}^{m} d_{ij}\bar{p}_{it}\bar{p}_{jt} + .5 \sum_{i=m+1}^{n} \sum_{j=m+1}^{n} d_{ij}x_{it}x_{jt}.$$

Parameters were estimated for a system of 14 stacked supply and demand equations (2) and (3). Symmetry of cross-partial derivatives was maintained in stacking the system. Homogeneity was maintained through normalization. Monotonicity was not maintained but was checked at each observation. Error terms were assumed to be additive, independently and identically distributed with mean zero and a constant contemporaneous covariance matrix. The econometric estimation was carried out by constrained nonlinear least squares using a Cholesky factorization to maintain convexity (Lau). A reduced-gradient, nonlinear programming procedure (Talpaz, Alexander, and Shumway) employing the MINOS version 5.1 algorithm (Murtagh and Saunders) was used

[2] Although the differentiability hypothesis has not been formally tested, Lim found complete nonparametric consistency with the rest of the maintained joint hypothesis, for the period 1956–82, when measurement errors of less than 1% perturbed these data.

[3] Like all second-order Taylor-series expansions (Dorfman, Kling, and Sexton), the normalized quadratic does not impose cross-effect restrictions on comparative statics at a point, but it does impose other restrictions. For example, the normalized quadratic profit function maintains the joint hypothesis of a quasi-homothetic technology and, except for the numeraire, strongly separable output supplies and input demands. However, the normalized quadratic is more "separability flexible" than is the translog (Pope and Hallam, p. 265).

[4] Because the numeraire demand equation is quadratic and the other supply and demand equations are linear, a change in numeraire netput changes the model specification. Using 1951–82 data for each of the 10 U.S. Department of Agriculture (USDA) farm production regions, Gottret found that technology test conclusions did not change but own-price elasticities were sensitive to choice of numeraire.

to obtain the parameter estimates consistent with economic theory.

The restricted profit function (1) was not included in the system of estimation equations. The numeraire equation (3) was included in the estimations, but the interactions among fixed factors were not estimated due to the high degree of collinearity that resulted from their inclusions.[5] Because profit in any period is a linear combination of outputs and inputs, profit can be determined exactly from equations (2) and (3).

Data

Annual data for the period 1951–82 were used in the profit function estimations. The exogenous variables in the profit function included output price expectations, observed prices of the variable inputs, quantities of fixed inputs, government policy variables, weather variables, and time.

Historical cash prices were examined in an effort to develop quasi-rational expectations of market prices for outputs. Nerlove suggested that producer price expectations can be successfully modeled using univariate or small multivariate times-series models to generate minimum mean-squared error predictions of subsequent cash prices (Nerlove; Nerlove, Grether, and Carvalho). Each output price series (or price index series) was examined in order to identify univariate ARIMA specifications. In each case the appropriate univariate specification as indicated by the autocorrelation, partial autocorrelation, and final prediction error statistics was an ARIMA (0, 1, 0) or random walk. Based on this result, one-period lags of output prices were used as expectations of the current period's market price.

Government policies designed to control supplies of agricultural commodities were included in the form of effective diversion payments, effective support prices, and in the case of sugar beets, effective direct payments. These were constructed in a manner similar to Houck et al. following McIntosh. Effective diversion payments appeared in the individual commodity supply equations only; cross-commodity effects of diversion payments were not examined. The direct payment for sugar beets was a dollar-per-net-ton payment made directly to producers with no accompanying acreage restrictions. It was, therefore, treated in the same manner as a diversion payment but with the opposite expected effect. The data used to construct the effective diversion payment, support price, and direct payment variables were obtained from *Commodity Fact Sheets* (USDA 1972–82) and *Situation* reports (USDA 1949–84d, h) and from Cochrane and Ryan.

The effective support prices were incorporated in the specifications of expected output prices for the grain crops, sugar beets, and cotton following a procedure developed by Romain. Some previous studies have incorporated support prices in a "higher of effective support price or expected market price" framework (Shumway; Shumway and Alexander). It is quite probable that the announced government programs affect production decisions even when the effective support price is less than the expected market price. Romain's procedure gives some weight to effective support price in every period, with the amount of the weight depending on the relative magnitude of market price expectations, effective support prices, and loan rates (Duffy, Richardson, and Wohlgenant).

Temperature and precipitation variables for critical planting and growing months were included in each of the crop supply equations. The weather data were from Weiss, Whittington, and Teigen and were monthly state averages of precipitation and temperature measurements, weighted by acreage of harvested cropland. The temperature variable included in the model was measured as the average of the month immediately preceding typical spring or fall planting dates plus the following month. The precipitation variable was the total for the first three months of the growing season. Time was included as a proxy for disembodied technological change.

The inputs treated as fixed in a single production period (season) were family labor, service flows from capital stocks, and land. The quantities of unpaid family (and operator) labor were measured as hours worked per year. Data sources included *Farm Labor* (USDA 1949–84c) for the period 1965–80, and unpublished USDA data for 1951–64, with extrapolations for 1981–82. Service flows from capital stocks were a weighted aggregate mea-

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[5] Failure to estimate these interaction terms destroys the flexibility of the functional form in the fixed factors.

sure of depreciation and real interest charges (calculated at current replacement costs) for various capital items including service structures, farm trucks, farm automobiles, tractors, and other equipment. Data sources included *Agricultural Prices* (USDA 1949–84a), *State Farm Income and Balance Sheet Statistics* (USDA 1949–84g), and unpublished USDA data. The land input was measured total number of acres of land in farms. Data sources were various issues of *Agricultural Statistics* (USDA 1949–84b). Both Statistical Reporting Service and Agricultural Census data were utilized. No input allocation data were obtained.

Quantity and market price data for the outputs and variable inputs were obtained from various issues of the sources already cited and from *Statistical Annual: Chicago Board of Trade*; *Field Crop Production, Disposition, and Value* (U.S. Economics, Statistics, and Cooperatives Service); *Meat Animals Production, Disposition, and Income* (USDA 1949–84e); *Wheat Situation* (USDA 1949–84h); and *Seed Crops* (USDA 1949–84f). See Evenson for further details.

Ten output supply equations were estimated. The supply equations were corn-sorghum, barley-wheat-oats, sugar beets, cotton, rice, fruits, vegetables, other crops, dairy and poultry, and meat animals. The grains were aggregated in the respective categories according to similarities in cultural practices and government commodity policies for the individual crops. The vegetables aggregate included tomatoes, potatoes, lettuce, onions, and other vegetables. The fruits aggregate included apples, oranges, grapefruit, grapes, and other fruits. The meat animals category included cattle and calves, hogs and pigs, and sheep and lambs. The dairy and poultry aggregate included chickens, turkeys, eggs, and milk. "Other crops" included all agricultural products that were not specifically accounted for in the other commodity equations. All aggregates were constructed using the Tornqvist index (Chambers, p. 233).

The four variable inputs included machinery operating inputs (i.e., fuel; lubricants; repairs to machinery, equipment, and buildings), fertilizer, hired labor, and miscellaneous inputs. The miscellaneous inputs category included all inputs not specifically accounted for in the other three variable inputs or in the fixed inputs, e.g., items such as pesticides, seed, feed, and products used on the farms where they were grown.[6] The price index of hired labor was used as the numeraire.

Empirical Results

The system of output supply and input demand equations was estimated by nonlinear least squares while maintaining symmetry, convexity, and linear homogeneity of the profit function in prices. Convexity was tested using the approximation test developed in Shumway, Alexander, and Talpaz (p. 54). This property was not rejected at the .05 level (F statistic of .734 with a critical value of $F^{.05}_{181,267} = 1.248$). Monotonicity was not imposed, but was not violated at any observation.

The empirical estimates are reported along with their asymptotic standard errors in table 1. As might be expected in a model of this scope, a relatively small proportion (30%) of the estimated parameters were significant at the .05 level. High collinearity among exogenous variables inflates the standard errors of the parameter estimates. Nevertheless, a majority of the own-price parameters, all of which had the expected sign because of the maintenance of convexity in the estimation, were significant.

Technology Tests

Agricultural production is characterized by firms that produce more than one type of output. The assumption that decisions regarding the production of one commodity can be made independently of other commodities is, therefore, questionable. If the production of each commodity for a multiproduct firm is independent of the other production activities, then its production is said to be nonjoint in inputs. Input nonjointness implies that the multiproduct profit function is the sum of its single-product counterparts and permits substantial analytic simplification in economic modeling. If production decisions on one output are independent of those made on all other outputs,

[6] The miscellaneous inputs category is an aggregate of several inputs. Separability of the production function in a subset is a sufficient condition for consistent aggregation of elements in that subset. Although we have not conducted tests for separability in the miscellaneous inputs category, Lim failed to reject separability in materials by nonparametric test using California data for the period 1956–82. His materials category included each of the inputs aggregated into miscellaneous inputs plus fertilizer.

then economic models of output supply do not require estimation of response parameters to any alternative output prices. This simplification is justified whether the supply function for each output includes the total quantity of the fixed input as an independent variable or only the quantity allocated to its production. Short-run nonjointness is indicated for the normalized restricted profit function if and only if all cross-output-price terms in each supply equation are zero. Short-run nonjointness in inputs was tested subject to homogeneity, symmetry, and convexity (table 2) and was rejected at the .01 level of significance (i.e., $d_{ij} = 0$ for all $i \neq j$, i and j outputs).

Hicks-neutral technical change was jointly tested, both globally and locally, for variable inputs and outputs. Technical change is indirectly Hicks neutral in variable inputs and outputs if all ratios of variable input demands and output supplies are independent of time (Lau). That is,

$$d_{i18}x_j - d_{j18}x_i = 0 \tag{4}$$

and

$$c_{18}x_j - d_{j18}x_1 = 0 \qquad \text{for all } i, j = 2, \ldots, 14,$$

where d_{i18} is the coefficient for the interaction of the ith commodity and time (x_{18}). Technical change is globally indirectly Hicks neutral if all parameters in (4) are zero, but such restrictions also render a technology which is devoid of technical change. Global indirect Hicks-neutral technical change (or really absence of technical change) was soundly rejected at the .01 level of significance (table 2).

Technical change is locally indirectly Hicks neutral in variable inputs and outputs at a given data point if each restriction in (4) is satisfied at that point. This hypothesis was tested independently at the 1982 observation and at the means of all observations. Local Hicks-neutral technical change was rejected at both data points (table 2).

None of the technology test results justify further analytic simplification from the model specification in equations (2) and (3). To attempt to explain California output supply of each of the 10 outputs over the 1951–82 period without including alternative output price variables would result in model misspecification as would attempts to explain optimal output ratios and input ratios without including time or another proxy variable for technology.

Parameter Estimates

Estimation of the model subject to the curvature constraints ensures that all estimated own-price parameters were positive (table 1). Therefore, all estimated own-price elasticities of supply (demand) were positive (negative). One input demand equation (miscellaneous inputs) had a significant (.05 level) own-price parameter. All but two own-price supply parameters (corn-sorghum and vegetables) were significant.

Significant complementary relationships were evident in the input demands between one or more of the variable inputs and each of the fixed inputs (family labor, capital, and land). A significant supplementary input demand relationship was evident between total fertilizer use and land.

Significant complementary relationships affected supplies of barley-wheat-oats, corn-sorghum, cotton, fruits, vegetables, other crops, and meat animals. Significant competitive relationships affected supplies of barley-wheat-oats, cotton, rice, other crops, and meat animals. This evidence of both competitive and complementary input demand and output supply relationships is consistent with the findings for other geographic entities of Antle; Lopez; and Shumway and Alexander but contrary to Ball's results. The output supply results suggest that both technical interrelationships and constraints on allocatable fixed inputs cause short-run joint production in agriculture.

Table 3 presents the elasticities of supply and demand and their standard errors computed from the convex parameter estimates calculated at the data means. The input demand functions were all price inelastic. Estimated own-price elasticities of demand ranged from −.858 for hired labor to −.070 for fertilizer. With the exception of the barley-wheat-oats aggregate, sugar beets, and rice, estimated own-price elasticities of supply were also inelastic. The own-price elasticities of supply ranged from 1.723 for rice to .165 for vegetables.

Elasticities of supply with respect to government diversion payments at the data means are reported in table 4 for the corn-sorghum and barley-wheat-oats aggregates, sugar beets, and cotton. Only own-commodity effects of diversion payments were estimated. Of the four response parameters estimated, three had the expected sign (corn-sorghum, sugar beets, and

Table 1. Parameter Estimates

Variable[a]	Negative of Input Demand Equations			
	Hired Labor[b]	Machinery Operating Inputs	Fertilizer	Miscellaneous Inputs
Intercept	0.2633 (0.1983)	0.2239 (0.2482)	−0.5116 (0.2735)	1.1472* (0.4391)
Normalized Prices				
Machinery Operating Inputs		0.1275 (0.1982)	Symmetric	
Fertilizer		−0.0376 (0.1769)	0.0762 (0.2066)	
Miscellaneous Inputs		−0.0390 (0.1452)	0.1933 (0.1649)	0.8730* (0.2435)
Corn-Sorghum		0.0060 (0.0568)	−0.0423 (0.0631)	−0.0617 (0.0841)
Barley-Wheat-Oats		−0.1100 (0.0668)	−0.0201 (0.0707)	−0.1762* (0.0784)
Sugar Beets		0.0003 (0.0016)	−0.0001 (0.0018)	−0.007 (0.0024)
Cotton		0.0621 (0.0904)	0.0027 (0.1018)	−0.0668 (0.1446)
Rice		0.0091 (0.0059)	−0.0030 (0.0066)	−0.0134 (0.0098)
Fruits		−0.0733 (0.0586)	−0.0435 (0.0636)	−0.2170* (0.0915)
Vegetables		−0.0380 (0.0708)	0.0356 (0.0780)	−0.0236 (0.1047)
Other Crops		0.0350 (0.1383)	−0.0306 (0.1529)	−0.1406 (0.2128)
Dairy-Poultry		−0.0560 (0.0847)	0.0725 (0.0926)	0.1634 (0.1080)
Meat Animals		−0.0407 (0.0470)	−0.0261 (0.0519)	−0.2563* (0.0695)
Family Labor	0.5805 (0.4131)	−0.7207 (0.5671)	−0.2059 (0.6123)	−1.9225* (0.8756)
Land	−35.3853* (15.8142)	12.5259 (19.9702)	30.5349 (21.9242)	−79.8633* (34.7524)
Capital	26.9891 (32.5892)	−199.8640* (44.9725)	58.9861 (48.9306)	−217.2888* (74.8141)
Year	−0.0030* (0.0015)	−0.0018 (0.0020)	−0.0063* (0.0022)	−0.0267* (0.0033)

Table 1. Continued

	Output Supply Equations									
Variable[a]	Corn-Sorghum	Barley-Wheat-Oats	Sugar Beets	Cotton	Rice	Fruits	Vegetables	Other Crops	Dairy-Poultry	Meat Animals
Intercept	−0.1606	−0.1303	−0.0037	−0.8708	0.1223*	1.9257*	0.4925	0.1534	−0.5125*	−0.1851
	(0.2216)	(0.1807)	(0.0098)	(0.6540)	(0.0621)	(0.6553)	(0.3399)	(0.9157)	(0.2431)	(0.2805)
Normalized Prices										
Corn-Sorghum	0.0343									
	(0.0570)									
Barley-Wheat-Oats	0.0211	0.1798*				Symmetric				
	(0.0332)	(0.0533)								
Sugar Beets	−0.0001	0.0014	0.0002*							
	(0.0011)	(0.0010)	(0.00006)							
Cotton	−0.0284	−0.1290	−0.0062*	0.9004*						
	(0.0899)	(0.0672)	(0.0026)	(0.2171)						
Rice	−0.0020	−0.0103*	0.0002	−0.0129	0.0035*					
	(0.0045)	(0.0040)	(0.0002)	(0.0109)	(0.0012)					
Fruits	0.0197	0.0697	−0.0014	0.1527	0.0054	0.5596*				
	(0.0392)	(0.0372)	(0.0017)	(0.1035)	(0.0078)	(0.1133)				
Vegetables	−0.0345	0.0115	−0.0009	−0.0074	0.0061	0.0463	0.1589			
	(0.0452)	(0.0456)	(0.0016)	(0.0982)	(0.0072)	(0.0612)	(0.0893)			
Other Crops	0.0173	0.0289	−0.0036	0.6375*	−0.0377*	−0.1625	−0.1004	0.9000*		
	(0.0947)	(0.0893)	(0.0035)	(0.2058)	(0.0155)	(0.1389)	(0.1408)	(0.3765)		
Dairy-Poultry	−0.0358	0.0301	0.0009	−0.0887	−0.0073	−0.0426	−0.0760	−0.0267	0.2259*	
	(0.0468)	(0.0515)	(0.0014)	(0.0836)	(0.0054)	(0.0562)	(0.0628)	(0.1205)	(0.0977)	
Meat Animals	−0.0007	0.0971*	−0.0005	−0.1823*	0.0079	0.1141*	0.0846	−0.1652	−0.0052	0.2073*
	(0.0311)	(0.0289)	(0.0012)	(0.0798)	(0.0055)	(0.0507)	(0.0455)	(0.0961)	(0.0397)	(0.0514)
Family Labor	0.1613	0.5952	0.0062	2.4493*	0.1075	−0.0994	0.6449	−3.1515*	0.6469	0.0486
	(0.3986)	(0.3665)	(0.0168)	(1.0040)	(0.1013)	(1.0779)	(0.6082)	(1.4813)	(0.5102)	(0.4931)
Land	17.3838	−1.5400	0.4045	−47.2079	−10.7094*	−125.3725*	−57.6019*	−19.1618	33.0563	38.8557
	(18.4235)	(13.9256)	(0.7504)	(46.5721)	(4.6845)	(49.1758)	(25.7334)	(68.9736)	(19.3431)	(22.2752)
Capital	−11.1130	20.5059	−0.9746	284.8308*	10.3993	−92.9579	3.1382	515.8187*	130.2619*	−67.8748
	(31.9847)	(29.9661)	(1.5396)	(88.2941)	(9.8153)	(100.7634)	(50.9556)	(140.2409)	(42.2599)	(44.0886)
Year	0.0014	0.0032*	0.00007	0.0105*	−0.00009	0.0161*	0.0160*	−0.0171*	0.0145*	0.0054*
	(0.0015)	(0.0013)	(0.00007)	(0.0040)	(0.0004)	(0.0044)	(0.0024)	(0.0059)	(0.0018)	(0.0019)

Table 1. Continued

	Output Supply Equations									
Variable[a]	Corn-Sorghum	Barley-Wheat-Oats	Sugar Beets	Cotton	Rice	Fruits	Vegetables	Other Crops	Dairy-Poultry	Meat Animals
Effect. Div. Pay.	−0.0257 (0.0366)	0.0575 (0.0345)	0.00005 (0.0001)	−2.7683* (1.1308)	–	–	–	–	–	–
Precipitation	−0.0011 (0.0010)	−0.0005 (0.009)	−0.0001* (0.00004)	0.0005 (0.0037)	0.0005 (0.0003)	−0.0035* (0.0018)	0.00002 (0.0009)	0.0004 (0.0046)	–	–
Temperature	0.0005 (0.0009)	0.0012 (0.0008)	0.00004 (0.00004)	0.0088* (0.0037)	−0.0005 (0.0003)	−0.0078* (0.0038)	0.0024 (0.0021)	−0.0026 (0.0045)	–	–

Note: Standard errors are in parentheses. MSE = 1.300 with 267 degrees of freedom. An asterisk indicates significance at the .05 level.

[a] Hired labor price was used to normalize all other prices and profit. Price indexes for 1977 = 1.000; quantity indexes are expenditures or receipts (in $ million) divided by the price indexes. Squared and interaction terms for the fixed inputs were not included in the estimation due to collinearity problems.

[b] Hired labor was the numeraire netput. All price parameters estimated for the linear supply and demand equation system are constrained to apply to the quadratic price variables in this equation. Compare text equations (2) and (3).

cotton). The 90% confidence limits for the elasticities were calculated using the Taylor-series approach as suggested by Dorfman, Kling, and Sexton. The only diversion payment elasticity significantly different from zero was for cotton.

Short-Run Impacts of Decoupling

Current government policies are often blamed for creating a price structure that results in agricultural commodity surpluses and makes exports uncompetitive without subsidies. In an effort to overcome these difficulties one policy option debated for the 1990 Farm Bill was "decoupling" (Boschwitz; Grennes). Decoupling would provide to farmers direct payments that are tied to historical base acreage and yield, while eliminating acreage restrictions. Decoupled program payments, therefore, would provide to farmers income support that is independent of what or how much is produced. The central idea behind decoupling is to allow the market, rather than government acreage restrictions and deficiency payments, to influence farmers' production decisions.

As used in the various debates, decoupling is not always a well-defined concept. For example, industry entry and exit decisions by farmers are seldom addressed in the discussions. Since entry and exit are only of concern in considering long-run effects, we will also ignore the issue in our examination of possible short-run impacts. By assumption, our model regards producers as risk-neutral profit maximizers and does not explicitly treat the risk-bias effects of current programs. While this may appear to be a serious abstraction of reality, recent nonparametric tests suggest that the risk-neutral profit-maximizing hypothesis does not seriously depart from observed state-level data. For example, Lim found that measurement errors averaging less than 1% in California annual quantity data for the period 1956–82 would have been sufficient for complete consistency with this hypothesis.

The predicted impact of decoupling government farm commodity payments from production was examined by computing the percent change in the quantity of each input demanded and output supplied due to the proposed withdrawal of paid diversion programs, price supports, and associated acreage restrictions (table 5). The total impact of decoupling on an output supply or input demand depends both on the elasticities with respect to diversion payments and all expected prices and on the magnitude of changes in each of those variables.

Table 2. Chi-Squared Statistics for Hypotheses Tests

Hypothesis	Calculated Value	Degrees of Freedom	Critical Value $\alpha = .01$
Nonjointness	110.44	45	69.954
Indirect Hicks-Neutral Technical Change, Variable Inputs and Outputs:			
Global	288.03	14	29.141
Local[a] (1982)	45.04	12	26.217
(mean)	44.17	12	26.217

[a] The local test was performed at both the 1982 observation and the data means.

The predicted impacts of withdrawing supports, diversion payments, and associated acreage restrictions along with their 90% confidence limits were calculated at the data means. The predicted impacts of decoupling were found to be significantly different from zero for miscellaneous inputs, the barley-wheat-oats aggregate, cotton, the fruits aggregate, and the dairy-poultry aggregate. The magnitude of the predicted impact was greater from withdrawing price supports than from withdrawing diversion payments with their associated conditions for three of the four commodities receiving diversion payments. The greatest expected impacts would be a 17% decrease in sugar beet production and a 14% increase in rice production (neither significant). Other major expected changes (11–13%) would occur in the production of cotton (increase), corn-sorghum (increase, but not significant), and barley-wheat-oats (decrease). Expected demand would increase for hired labor, fertilizer, and miscellaneous inputs and would decrease for machinery operating inputs, but only the change in miscellaneous inputs was significant. Overall expected production would increase for six outputs and decrease for four. Of all inputs and outputs, nine quantities could be expected to change by less than 5%, and five by more than 10%. Of the five estimated impacts found to be significantly different from zero, three were positive (miscellaneous inputs, cotton, and fruit) and two were negative (barley-wheat-oats and dairy-poultry).

Although our model is among the most detailed in terms of output disaggregation of ex-

Table 3. Output Supply and Input Demand Elasticities for California, Data Means

	Elasticity with Respect to the Price of					
Output or Input	Hired Labor	Machinery Operating Inputs	Fertilizer	Miscellaneous Inputs	Corn-Sorghum	Barley-Wheat-Oats
Hired Labor	−0.858	−0.116	0.052	0.048	−0.094	0.058
	(1.591)	(0.304)	(0.131)	(0.361)	(0.180)	(0.171)
Machinery Operating Inputs	−0.335	−0.417	0.051	0.1200	−0.019	0.348
	(0.664)	(0.657)	(0.242)	(0.473)	(0.185)	(0.457)
Fertilizer	0.255	0.088	−0.070	−0.445	0.098	0.046
	(0.339)	(0.416)	(0.205)	(0.419)	(0.151)	(0.161)
Miscellaneous Inputs	0.027	0.024	−0.049	−0.522	0.037	0.104
	(0.230)	(0.089)	(0.045)	(0.226)	(0.052)	(0.058)
Corn-Sorghum	1.448	0.104	−0.305	−1.044	0.584	0.352
	(2.152)	(0.981)	(0.471)	(1.482)	(0.998)	(1.495)
Barley-Wheat-Oats	−0.330	−0.685	−0.052	−1.077	0.130	1.083
	(0.831)	(0.455)	(0.185)	(0.559)	(0.402)	(0.432)
Sugar Beets	0.287	0.068	−0.012	−0.164	−0.035	0.334
	(0.620)	(0.384)	(0.180)	(0.247)	(0.261)	(0.255)
Cotton	−0.575	0.084	0.002	−0.089	−0.038	−0.169
	(0.441)	(0.126)	(0.058)	(0.195)	(0.121)	(0.106)
Rice	1.171	0.620	−0.085	−0.892	−0.134	−0.677
	(1.660)	(0.481)	(0.191)	(0.758)	(0.307)	(0.393)
Fruits	−0.317	−0.068	−0.017	−0.197	0.018	0.062
	(0.256)	(0.061)	(0.026)	(0.118)	(0.037)	(0.042)
Vegetables	−0.073	−0.041	0.016	−0.025	−0.037	0.012
	(0.169)	(0.079)	(0.036)	(0.112)	(0.041)	(0.048)
Other Crops	−0.273	0.041	−0.015	−0.160	0.020	0.032
	(0.451)	(0.161)	(0.074)	(0.248)	(0.109)	(0.095)
Dairy-Poultry	−0.140	−0.053	0.029	0.152	−0.033	0.028
	(0.139)	(0.081)	(0.037)	(0.108)	(0.045)	(0.048)
Meat Animals	0.037	−0.089	−0.021	−0.480	−0.0019	0.179
	(0.191)	(0.091)	(0.042)	(0.150)	(0.060)	(0.060)

Note: Standard errors in parentheses were calculated using the Taylor-series method as suggested by Dorfman, Kling, and Sexton.

isting dual models, it is still a highly aggregated and very general empirical model. Because of the model's generality and the fact that it does not adequately capture all the important nuances of specific commodity programs, it is capable of examining only very broad implications of policy changes such as decoupling. Nevertheless, it is apparent from this analysis that any major policy change, such as decoupling program benefits from production levels, would have substantial impacts on production patterns. While some of the results are surrounded by large confidence intervals, the prospect of substantial reallocation of inputs among the various commodities portends important new uncertainties to agribusiness firms as well as to agricultural producers. Needed processing capacity and stocks of specific inputs could change markedly under a new policy scenario. Because of the possibility of such major changes, government policy formulation aimed partially at reducing risk has the potential to introduce important new uncer-

Table 4. Supply Elasticities with Respect to Diversion Payments

Commodity	Elasticity	90% Confidence Limits[a]
Corn-Sorghum	−.0991	−.3401, .1418
Barley-Wheat-Oats	.0292	−.0023, .0606
Sugar Beets[b]	.0561	−.1310, .2431
Cotton	−.0272	−.0031, −.0513

Note: The elasticities were calculated at the data means.
[a] Confidence limits were calculated by the Taylor-series method.
[b] The sugar beet payments were a dollar-per-net-ton direct payment. These payments were made in order to stabilize domestic prices, provide benefits to growers, and achieve desired labor reforms. These payments were treated like diversion payments in the econometric model, but unlike the diversion payments, the expected sign is positive.

Table 3. Continued

Elasticity with Respect to the Price of							
Sugar Beets	Cotton	Rice	Fruits	Vegetables	Other Crops	Dairy-Poultry	Meat Animals
−0.032	0.203	−0.143	0.356	0.073	0.254	0.173	−0.025
(0.266)	(0.513)	(0.422)	(0.789)	(0.183)	(0.947)	(0.391)	(0.111)
−0.022	−0.086	−0.217	0.220	0.119	−0.109	0.189	0.153
(0.123)	(0.126)	(0.150)	(0.184)	(0.223)	(0.432)	(0.289)	(0.181)
0.006	−0.003	0.051	0.093	−0.079	0.068	−0.175	0.070
(0.099)	(0.101)	(0.114)	(0.142)	(0.177)	(0.216)	(0.234)	(0.143)
0.010	0.017	0.059	0.121	0.014	0.082	−0.103	0.180
(0.015)	(0.038)	(0.048)	(0.065)	(0.061)	(0.126)	(0.076)	(0.077)
−0.060	−0.207	−0.250	0.312	−0.568	0.284	−0.637	−0.014
(0.447)	(0.659)	(0.572)	(0.632)	(0.619)	(1.559)	(0.869)	(0.617)
0.212	−0.339	−0.467	0.398	0.068	0.172	0.193	0.696
(0.157)	(0.198)	(0.220)	(0.238)	(0.272)	(0.500)	(0.334)	(0.278)
1.152	−0.626	0.266	−0.214	−0.212	−0.817	0.214	−0.141
(0.500)	(0.333)	(0.366)	(0.387)	(0.372)	(0.843)	(0.080)	(0.334)
−0.198	0.515	−0.127	0.190	−0.010	0.823	−0.124	−0.284
(0.108)	(0.219)	(0.116)	(0.145)	(0.127)	(0.392)	(0.125)	(0.159)
0.244	−0.369	1.723	0.334	0.394	−2.432	−0.510	0.613
(0.348)	(0.350)	(0.953)	(0.506)	(0.496)	(1.454)	(0.437)	(0.505)
−0.031	0.060	0.036	0.476	0.041	−0.143	−0.041	0.122
(0.039)	(0.048)	(0.055)	(0.222)	(0.057)	(0.137)	(0.056)	(0.074)
−0.024	−0.003	0.048	0.046	0.165	−0.104	−0.085	0.106
(0.042)	(0.045)	(0.060)	(0.064)	(0.116)	(0.152)	(0.079)	(0.072)
−0.098	0.313	−0.318	−0.173	−0.111	0.996	−0.032	−0.221
(0.100)	(0.140)	(0.164)	(0.157)	(0.160)	(0.518)	(0.145)	(0.145)
0.013	−0.035	−0.050	−0.037	−0.069	−0.024	0.220	−0.006
(0.006)	(0.035)	(0.039)	(0.050)	(0.059)	(0.109)	(0.111)	(0.043)
−0.023	−0.147	0.109	0.200	0.154	−0.300	−0.010	0.455
(0.054)	(0.068)	(0.078)	(0.094)	(0.086)	(0.181)	(0.078)	(0.133)

Table 5. Impacts of Decoupling on California Agriculture, Data Means

	Predicted Quantity Change by Withdrawing:			
Output or Input	Price Supports	Diversion Payments	Total	90% Confidence Limits[a]
	%			
Hired Labor	−2.01	—	2.01	−28.95, 32.97
Machinery Operating Inputs	−4.22	—	−4.22	−12.10, 3.66
Fertilizer	2.98	—	2.98	−3.17, 9.13
Miscellaneous Inputs	3.14	—	3.14	0.93, 5.37
Corn-Sorghum	2.13	9.91	12.04	−26.26, 50.38
Barley-Wheat-Oats	−7.87	−2.91	−10.87	−21.12, −0.44
Sugar Beets	−11.06	−5.61	−16.67	−41.07, 7.73
Cotton	10.73	2.72	13.45	6.78, 20.23
Rice	14.33	—	14.33	−7.36, 36.02
Fruits	3.28	—	3.28	0.86, 5.70
Vegetables	0.27	—	0.27	−2.44, 2.98
Other Crops	3.74	—	3.74	−3.00, 10.48
Dairy-Poultry	−2.37	—	−2.37	−4.38, −0.36
Meat Animals	−0.82	—	−0.82	−4.60, 2.96

[a] Confidence limits were calculated by the Taylor-series method.

tainties into agricultural production and its assorted communities and support industries.

Summary and Conclusions

The theory of the competitive industry was maintained in the econometric estimation of output supply and input demand equations for California agriculture reported in this article. Symmetry, homogeneity, and convexity of the profit function were maintained in the estimation. Monotonicity was not maintained but was satisfied by all equations at all observations. Curvature of the normalized quadratic profit function was maintained using a Cholesky factorization procedure and nonlinear least squares.

A geographically specific model with a high degree of commodity disaggregation was developed and estimated. Short-run nonjointness in inputs was rejected. Indirect Hicks-neutral technical change was rejected, both globally and locally, for outputs and variable inputs, indicating that relative input utilization and output production were nonconstant over the period studied.

The examination of the effects of decoupling government farm commodity payments from production levels revealed a substantial impact on a few commodities. All inputs and outputs would be affected, five significantly. Of the significant impacts, the outputs of cotton and barley-wheat-oats were expected to change the most, +13% and −11%, respectively.

Previous studies have documented the geographical diversity of supply response by regions. Regional differences in supply response have important implications for formulation of agricultural commodity policies and prediction of the effects of changing economic conditions. Further research efforts should be directed at developing additional state-level models in order to more accurately reflect these geographical differences. In addition, the estimation of individual commodity supply equations, rather than aggregate categories, for commodities produced under government programs is important for providing commodity-specific information for formulating future policies.

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