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Labor Pains: Valuing Seasonal versus Year-Round Labor on Organic Farms

Luanne Lohr and Timothy A. Park

Although organic farm activities seem to demand year-round employees, seasonal workers dominate the organic labor market. We use the elasticity of complementarity to assess input substitutability and predict adjustments. Farm size and farm workers are complementary inputs. Incentives that encourage farmers to expand employment of year-round and seasonal workers raise the marginal product and rates of return to organic acreage in relative wage payments. A commitment to local sales reduces organic farm incomes. A shift to local sales leads to decreased use of seasonal workers but at higher wages, with smaller adjustments in the wages of year-round workers.

Key words: elasticity of complementarity, labor management, organic farming, returns to scale, seasonal workers

Introduction

Labor typically constitutes a higher level of variable input costs on organic than on non-organic crop farms. The complexity of following organic regulations, combined with greater reliance on technical production activities—such as mechanical tillage for weed control, a necessity to plant and manage cover crops off-season, and more hand harvesting and handling for fresh produce harvested closer to maturity—suggests a need for greater proficiency or more experience with organic systems. These special requirements can drive up wages and costs of finding and hiring labor in the organic sector.

In a review of organic-conventional comparison studies, Pimentel et al. (2005) report organic systems require on average 15% more labor than conventional systems. Further, organic labor needs are found to be more evenly distributed over the growing season and entail more activities in the off-season, arguing for more year-round employees on organic farms.

In 2001, 24% of all employees on organic farms worked year round, with more than 80% of year-round workers being farm family members (Walz, 2004). Among hired workers on organic farms, 5% were year-round employees and 95% were seasonal workers. In the conventional sector in 2001, 25% of hired workers self-identified as year-round labor, 60% claimed to be seasonal workers, and the remainder were unsure of their status (U.S. Department of Labor, 2005). Thus, hired labor is more likely to be seasonal in the organic sector than in the conventional sector, even though the labor requirements on organic farms suggest hiring year-round employees might improve profitability.

Luanne Lohr and Timothy A. Park are professors, both in the Department of Agricultural and Applied Economics, University of Georgia, Athens.

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Respondents to a 2002 survey of U.S. organic producers[1] rated high labor costs and the availability of labor as two of the most severe problems constraining production (Walz, 2004). Concerns about the availability and cost of labor were prevalent across all organic farm income groups, but were identified as a more significant constraint for female than for male farmers. A key question is whether organic farmers could raise their income by shifting toward more year-round hired labor. The average wage of conventional seasonal workers in 2001 was nearly one dollar (12%) lower than for year-round workers (U.S. Department of Labor, 2005). If the same condition holds for organic farms, the value added by year-round workers must be sufficient to compensate for the higher wages.

Our first objective is to identify factors that influence the marginal valuation of and demand for seasonal and year-round agricultural workers on organic farms. The Hicks elasticity of complementarity measures the effects of changes in relative input quantities on relative factor prices, and permits calculation of input substitutability. Downward pressure on wages could induce a change in the balance of year-round and seasonal labor on organic farms. The elasticities are calculated directly from a translog production function for U.S. organic farms.

Our second objective is to examine the influence of a unique characteristic of the organic farming sector—the prevalence of local marketing—and its effect on seasonal and year-round labor wages and employment. OFRF estimated that in 2001, 84% of the volume of flowers, herbs, and vegetables was sold within 500 miles of the farm, along with 63% of fruits and nuts, and 68% of grains and field crops (Walz, 2004). The local marketing channels included direct-to-consumer marketing as well as sales to wholesalers, retailers, and brokers. Local selling shortens the marketing chain, which may increase labor needs if farmers incur more handling and transportation costs.

The impetus for local selling arises from personal philosophy of farmers, lack of access to more distant markets, and the public interest in reducing total "food miles" to minimize the carbon footprint of a food system and provide consumers with benefits of locally grown food. A Leopold Center report from Iowa State University highlighted the benefits of local food systems and explicitly recommended that Iowa farmers, retailers, and food brokers attempt to market produce and meats locally and regionally (Pirog et al., 2001). The private sector has exploited both the local and organic marketing strategies. Whole Foods, the world's largest natural foods retailer, features its "Locally Grown" promise with a commitment to buy from organic producers within a seven-hour (approximately 400-mile) distance from the retail outlet (Whole Foods Market, 2006). Calculation of the Hicks elasticities of complementarity from a production function including this unique variable provides insight into how producers' incomes and labor use are affected when focusing on sales to local markets.

In the following sections, we define the elasticity of complementarity and its economic foundations and specify a translog production function to estimate a set of elasticities. We describe the OFRF data that we use and detail the empirical model development. Output

[1] The Fourth National Organic Farmers' Survey was the first survey of the Organic Farming Research Foundation (OFRF) to focus specifically on farmers' marketing activities and the only U.S. survey to do so. The 22-page questionnaire was mailed in April 2002 to 90% of all U.S. certified organic farmers, based on certifier records. Responses were returned by 1,034 farmers, representing an 18% response rate. The Social and Economic Sciences Research Center at Washington State University conducted a qualitative assessment of OFRF's survey methods, and concluded, "Overall OFRF has adhered to sound survey research methodology" (Walz, 2004, p. 14). The assessment suggested possible statistical issues with the response rate which may lead to nonresponse error, and survey complexity which may lead to measurement error. OFRF took account of these potential sources of error in presenting results, and subsequent analyses have indicated the data are representative of U.S. organic farmers. This response rate is comparable to the USDA's 2006 Agricultural Resource Management Survey (ARMS) of organic soybean production methods, which received responses from 26% of the sample of 907 organic soybean farmers selected in 15 states.

elasticities and returns-to-scale measures are presented to establish the theoretical validity of the Hicks elasticity of complementarity measure for organic farms. A measure of local sales is defined that can be implemented on available data from the OFRF survey and the model is applied to evaluate the impact of commitment to local sales on organic farm income. We conclude with a discussion of the implications of the findings and directions for future research.

Analysis of the Organic Farming Operation

Consider a farm operation facing perfectly competitive product and factor markets with a production function based on a vector of inputs **x** which are transformed into a measure of output described by the production function $y = F(\mathbf{x})$. The farm manager seeks to minimize cost for a given output level. The Hicks elasticity of complementarity measures the response of an input price to a change in the input quantity where the shift in factor price is chosen to keep marginal cost and quantities of other factors constant. The elasticity of complementarity, ρ_{ij}^H, is defined from the production function as:

$$(1) \qquad \rho_{ij}^H = \frac{F(\mathbf{x})F_{ij}(\mathbf{x})}{F_i(\mathbf{x})F_j(\mathbf{x})},$$

where $F_i(\mathbf{x}) = \partial F(\mathbf{x})/\partial x_i$, and $F_{ij}(\mathbf{x}) = \partial F^2(\mathbf{x})/\partial x_i\, \partial x_j = F_{ji}$. Inputs i and j are defined to be gross q-complements in the production of a variable output when ρ_{ij}^H is > 0, or when an increase in the quantity of input j increases the price (or marginal valuation) of input i. When ρ_{ij}^H is < 0, the inputs are gross q-substitutes. The Hicks elasticities measure the gross effects of changes in input quantities on input prices and include both substitution and output effects.

The translog production function specification follows the labor literature (Berger, 1983) in focusing on primary inputs of labor and materials (acreage in an agricultural framework):

$$(2) \qquad \ln(F) = \alpha_0 + \sum_i \alpha_i \ln(x_i) + \sum_q \delta_q \ln(x_q) + \frac{1}{2}\sum_i\sum_j \beta_{ij}\ln(x_i)\ln(x_j) + \frac{1}{2}\sum_q\sum_s \rho_{qs}\ln(z_q)\ln(z_s) + \sum_i\sum_q \gamma_{iq}\ln(x_i)\ln(z_q),$$

where **z** is a set of farm-level organizational and operational factors that influence performance, and $\beta_{ij} = \beta_{ji}$. The production function is homogeneous of degree θ in the set of variable inputs **x** if

$$\sum_i \alpha_i = \theta, \ \sum_j \beta_{ij} = 0\,\forall i, \ \text{and} \ \sum_i \gamma_{iq} = 0\,\forall q.$$

Constant returns to scale for the set of variable inputs in the specification is obtained when $\theta = 1$. The partial production elasticity of output for the ith factor is defined as:

$$(3) \qquad \varepsilon_i = \frac{\partial \ln(F)}{\partial \ln(x_i)} = \alpha_i + \sum_j \beta_{ij}\ln(x_j) + \sum_q \gamma_{iq}\ln(z_q),$$

and the elasticity of scale is the sum of the partial production elasticities for the variable inputs.

The Hicks elasticities examine how changes in the use of an input shift the marginal valuation of the input. A positive elasticity of complementarity between acreage and full-time workers indicates that additional acreage raises the marginal value of full-time labor. The farm hires more full-time workers. The Hicks elasticities can be computed from the translog production function as:

(4)
$$\rho_{ii}^{H} = \frac{\beta_{ii} + \varepsilon_i^2 - \varepsilon_i}{\varepsilon_i^2},$$
$$\rho_{ij}^{H} = \frac{\beta_{ij} + \varepsilon_i \varepsilon_j}{\varepsilon_i \varepsilon_j}.$$

Uncompensated quantity elasticities η_{ij}, or inverse price elasticities, are calculated along with the inverse output elasticities η_{iy} in the empirical results. The inverse price elasticities are expressed as:

(5)
$$\eta_{ii} = \frac{\beta_{ii}}{\varepsilon_i} - \frac{\sum_j \beta_{ij}}{\varepsilon} - 1,$$
$$\eta_{ij} = \frac{\beta_{ii}}{\varepsilon_i} - \frac{\sum_k \beta_{kj}}{\varepsilon}.$$

The inverse price elasticities measure the percentage change in price of a factor given a percentage change in the quantity of a factor. The inverse price elasticities show how an increase in the hiring of full-time labor changes the marginal valuation of that input. The uncompensated quantity elasticities account for both substitution and output effects.

The inverse output elasticities[2] from the translog model are given by:

(6)
$$\eta_{iy} = \frac{\sum_j \beta_{ii}}{\varepsilon \varepsilon_i} - \frac{\sum_k \sum_j \beta_{kj}}{\varepsilon^2} - \frac{1}{\varepsilon}.$$

The inverse output elasticities (or output flexibilities) show how the decision maker values marginal increases in the input as output expands. Theoretically, these elasticities should be negative for all inputs. As farm output increases, the marginal value of an additional full-time worker should decline. The inverse output elasticity shows which input prices are most responsive to a change in the level of output.

Empirical Model of the Organic Farm Operation

Nationally representative data from organic farms were obtained from the Fourth National Organic Farmers' Survey of all certified producers of record as of 2001, conducted by the Organic Farming Research Foundation (OFRF). Details of the history, methodology, and results of the OFRF survey can be found in Walz (2004). This survey focused specifically on organic marketing activities, yielding the data required to study the effect of the unique local selling variable on farm income and labor use. Our sample contains 799 observations, representing the major crop categories grown organically and in all regions in the United States

[2] The derivation of the inverse output elasticity and its form for the translog production function is presented in the appendix.

that produced organically in 2001. Table 1 presents the descriptions and summary statistics for variables in the model. Natural logs of the variables reported in table 1 were used in estimation where appropriate.

Dependent Variable

The production function for the *i*th producer is specified using a translog production function along with indicators of the operational and environmental constraints facing organic producers. The logarithm of total organic farming gross income (*INCOME*) is the dependent variable. Mean gross organic income for the surveyed farmers was $146,048.

Prominent applications that support the use of value measures (gross organic income) when estimating the production function include Dinar, Karagiannis, and Tzouvelekas (2007), Fraser and Horrace (2003), Olley and Pakes (1996), and Yang (1997). Mundlak (2001, p. 27) states that most studies in agriculture use output in the production function, whereas "production analysis in nonagriculture is conducted in terms of value added." Ackerberg et al. (2007) point out that inputs and outputs in the production function are measured in various ways depending on data availability. Labor inputs could be measured by labor expenses or in hours, and output also can be measured in either physical or monetary units, or replaced with a value-added measure.

The use of a revenue measure does not lead to biased estimates of the coefficients in the production function. Mairesse and Jaumandreu (2005, p. 658) conclude that "estimating the production function or the revenue function (i.e., whether output is deflated by individual prices or not) makes little difference for the results when they rely mainly on a cross-sectional dimension." Our preferred specification has the benefit of controlling for farm-level effects such as organic farming experience, education, and cropping decisions.

The use of value measures in the production function has been extensively discussed in the production economics literature. As noted by Griliches and Mairesse (1998), typically nominal sales rather than quantity measures of output are available. They enumerate potential problems with value measures, but the limitations arise primarily when firms have market power. Their explicit conclusion is that if output prices are random and exogenous to the firm (firms operate as perfect competitors), then the error term would not be correlated with the observed inputs. We believe the assumption of no market power in pricing the organic output is appropriate.

The price premiums attributable to organic farming make gross income a useful measure of performance. Most studies evaluating competitiveness of organic systems with conventional systems find smaller acreages, lower yields, and higher labor costs may be offset by modest price premiums (McBride and Green, 2008). Gross income is a simple, direct measure of farm performance that accounts for the diversity of up to 30 different marketed crops per farm. A traditional production function using yield as a dependent variable would require calculation of a complicated metric to express multiple crop yields as a single variable, and is not consistent with decision-making models of organic farmers.

The economic motivation of this paper is to understand how changes in factor use influence relative input prices. A dual approach based on the revenue functions does not provide estimates of the Hicks measures. The Hicks elasticity of complementarity measures the effects of changes in relative input quantities (such as increased labor on organic farms) on relative factor prices and is derived directly from the estimation of a production function.

Table 1. Variable Descriptions and Summary Statistics (*N* = 799 farms)

Variable	Description	Mean	Std. Dev.
INCOME	Total gross organic farming income (1,000s US$)	146.048	607.488
LABYRRD	Year-round labor: managers, full-time employees, and part-time employees	2.60	5.46
LABSEAS	Seasonal labor: full-time and part-time employees	5.14	23.64
LABRTOT	Total labor: year-round and seasonal employees	7.74	26.33
ACRE	Acreage farmed organically (1 to 13,000 acres)	192.38	673.47
TRANMIXD	Farmer originally a conventional producer, now farms organic and conventional acres [a]	15.8	36.5
CORPPART	Farm operation is organized as a nonfamily partnership, corporation, or cooperative [a]	5.0	21.7
PARTTIME	Operator is part-time farmer [a]	31.4	46.4
FEMALE	Farm operator is female [a]	21.8	40.6
SOMEHS	Attended some high school [a]	5.0	21.2
GRADHS	Graduated from high school [a]	43.0	49.5
GRADCOL	Graduated from college or university [a]	35.0	47.7
GRADDEG	Obtained a graduate degree [a]	18.0	38.3
YRSORG	Years as an organic farmer (0 to 60 years)	12.11	9.38
PCTVEG	Share of total organic acreage in vegetable crops [a]	27.5	40.2
PCTFIELD	Share of total organic acreage in field crops [a]	50.3	47.2
PCTFRUT	Share of total organic acreage in fruit, nut, and tree crops [a]	22.2	39.1
LOCSELL	All organic products sold within 500 miles of farm operation (from 0 to 4 product categories):	0.87	0.77
	► 0 product categories sold entirely within 500 miles [a]	33	
	► 1 product category sold entirely within 500 miles	50	
	► 2 product categories sold entirely within 500 miles	13	
	► 3 product categories sold entirely within 500 miles	3	
	► 4 product categories sold entirely within 500 miles	1	
WEST	Farm is in SARE Region 1 [a]	28.6	45.2
NORCENT	Farm is in SARE Region 2 [a]	40.3	49.1
SOUTH	Farm is in SARE Region 3 [a]	5.7	23.2
NOREAST	Farm is in SARE Region 4 [a]	25.4	43.6

[a] Numbers are percentages in each category.

The revenue function summarizes the behavior of the producer deciding on the output mix that maximizes revenue given prices for inputs and outputs. The arguments of the revenue function are output prices and inputs. Duality relations generate output supply functions that also depend on output prices and inputs. The elasticities from the revenue function demonstrate how changes in output prices influence output supplied. The approach does not yield elasticity of complementarity measures relating changes in input quantities to changes in relative factor prices. The OFRF survey lacks data on output or input prices at the farm level, which are needed to apply the revenue function.

Diversification is a hallmark of organic farming. Vegetable crops and herbs were grown by about 28% of the farmers in the sample, with a typical crop mix of at least four different vegetable crops. Fruit, nut, and tree crops were produced by approximately 21% of the sample, with a lower degree of diversification averaging about two crops in this category. Field crops were the predominant production category, with 51% of farmers allocating acreage across an average of two field crops.

Production Inputs

The two inputs given in equation (2) are labor and acreage, which are under the control of the producer and can be changed annually depending on the planned output for that season. The labor input is represented by year-round workers (*LABYRRD*) and seasonal farm employees (*LABSEAS*). The average farm in the sample used two year-round and five seasonal paid employees. The majority of organic farm operations (52%) relied on both year-round and seasonal workers, with 34% of farmers hiring only seasonal workers and 15% using only year-round workers. Employment of both year-round and seasonal farm workers is more closely correlated with farm income than is farm size, and the relationship is even stronger for organic farms with higher incomes (over $99,000).

The mean farm size in the sample was about 192 acres, with the largest farm in the sample operating 13,000 acres. Organic farm size is most closely related to production of field crops with a correlation coefficient of 0.91, followed by vegetable production at 0.21. By contrast, farm income is more closely influenced by vegetable production and fruit, nut, and tree crop production with correlations of 0.61 and 0.32, respectively. Larger farms are typically operated as diverse enterprises and tend to include both field crop production and vegetable production.

The fixed effects in our example are farm and regional factors that influence the ability of the farmer to respond optimally to production constraints. Under the U.S. organic regulation, farmers may certify as organic less acreage than they farm, resulting in the possibility of parallel organic and conventional systems being managed by the same operator. Conventional producers are expected to have more familiarity with farm labor markets and contacts with extension advisors if they previously used or currently use conventional production methods. To account for this type of contact and experience with agribusinesses and rural-based service industries among organic producers, we combine two dimensions of farmer experience—parallel farming and transitional farming. Transition farmers were originally conventional producers who later converted some or all of their farms to organic production. The set of farmers who transitioned to organic farming while also maintaining mixed farming operations (*TRANMIXD*) accounts for about 16% of our sample.

A business structure variable indicates whether the farm was organized as a nonfamily partnership, corporation, or farm cooperative (*CORPPART*), and is suggestive of the flexibility accorded the farmer in implementing management decisions. Organic farms in this category tend to hire both more year-round labor and seasonal labor than family farms (sole proprietors, partnerships, or corporations), averaging about 5.5 year-round and 10.3 seasonal workers. On average, family farms hire 2.6 year-round and 5.1 seasonal workers. These comparisons do not control for farm size. About 31% of the organic producers were engaged in farming on a part-time basis (*PARTTIME*).

The USDA has placed increasing emphasis on research and technical assistance responding to the management concerns of female farmers. Farms operated by women represent a growing segment of U.S. farms, accounting for 9% in 2004, an increase of 58% from 1978 (Hoppe et al., 2007). Female farmers (*FEMALE*) account for 22% of the U.S. organic farms in our sample.

The specification includes two variables that measure the human capital of the organic farmer. The highest level of formal education of the farm operator was available from the OFRF survey. The four education categories indicated whether the organic producer had attended some high school (*SOMEHS*), graduated from high school (*GRADHS*), graduated from college (*GRADCOL*), or attained a graduate degree (*GRADDEG*). The number of years the farmer was certified as organic (*YRSORG*) may also influence production outcomes. Farmers who have more experience in organic farming may be more efficient at matching inputs to farm needs. This hypothesis is supported by Foster and Rosenzweig (1995, p. 1205) who found that experience effects augment the "ability of farmers to make appropriate decisions about input use for new technologies."

The impacts of cropping choices are represented by the acreage allocations across three categories. The categories correspond to information collected from the OFRF survey and include the percentage of certified organic acreage in field crops such as grains, alfalfa, or other field crops (*PCTFIELD*), fruit, nut, or tree crops (*PCTFRUT*), or vegetable crops (*PCTVEG*).

Indicator variables representing the four Sustainable Agriculture Research and Education (SARE) regions are included in the model. These regions reflect the USDA's demarcation of sustainable agriculture extension-research support. A dichotomous variable was created for each region, equal to one if the respondent's farm was in that region, and zero otherwise. Overall, 29% of farmers were in the SARE 1 region (*WEST*), 40% in the SARE 2 region (*NORCENT*), 6% in the SARE 3 region (*SOUTH*), and 25% in the SARE 4 region (*NOREAST*).

The *WEST* region has historically received the strongest institutional support for organic agriculture and is home to two of the nation's oldest organic farm and certifying organizations—California Certified Organic Farmers and Oregon Tilth. California enacted the first state law to define organic foods in 1982. California and Washington were among the first extension services to conduct outreach and applied research on organic agricultural systems using teams of extensionists rather than individuals. Thus, the locality-specific research needed for successful organic farming emerged sooner in the West than in the other regions.

Marketing Strategies of Organic Farmers

We develop an indicator of the farmer's sales to local markets and examine how this variable influences both farm performance and farm-level employment outcomes. The local selling indicator (*LOCSELL*) measures the number of commodity categories in which the producer sold all output within 500 miles of the farm. The variable is based on sales information for organic products across four broad commodity groups as recorded in the OFRF survey: (*a*) vegetables, including herbs, floriculture, mushrooms, and honey; (*b*) fruit, nut, and tree products; (*c*) grains and field crop products; and (*d*) livestock products.

In the survey, producers were first queried about their sales across three broad market categories—direct-to-consumer outlets, direct-to-retail sales, and wholesale markets. Producers provided information on markets used to sell organic products as well as the location of organic buyers. Respondents indicated the volume of organic products sold in markets located within 500 miles of the farm, organic products sold nationally, and products sold for export. For each commodity group, we identified producers who sold all their output within 500 miles of the farm.

Consider a producer who sold all of the vegetable outputs within 500 miles of the farm and some portion of other organic products was sold to more distant buyers. The local selling indicator (*LOCSELL*) has a value of one for this producer. Over 68% of producers sold their entire production of at least one commodity category within 500 miles of their farm. For convenience, we refer to these farmers as locally committed organic farmers. Sales in local markets are emphasized by both male and female farmers; 66% of males and 72% of females have a positive local selling indicator.

Organic farmers who diversify their sales outlets beyond local sources for all their products and record a zero score on the local selling indicator have significantly higher organic incomes, operate larger farms, and hire more farm labor than those who sell products closer to their farms (*LOCSELL* is positive). Organic farm income for locally committed producers is about 42% of the income reported by farmers who do not fully commit any of their products to local outlets.

Local sales commitments are significant across all major crop categories reported in the OFRF survey. For farmers who concentrate more than 50% of their acreage in vegetables, over 75% sell all of one product category within 500 miles of the farm. Organic farmers primarily engaged in fruit and nut production show the lowest commitment to local markets. Still, over 50% of primary fruit and nut producers have a positive value for the *LOCSELL* variable.

Estimation Results

Coefficient estimates and asymptotic standard errors based on heteroskedasticity robust standard errors for the translog production function are presented in table 2. Random shocks that influence output are assumed to be related to acts of nature such as weather, pest and weed infestations, and yield variability, which are endemic to organic production. As argued by Zellner, Kmenta, and Dreze (1966), when producers maximize expected profit rather than ex post profit, the error terms for inputs can be assumed to be driven by human error and managerial misjudgments which should be unrelated to the error term in the production function. Grant and Hamermesh (1981) and Kim (2000) estimate the production function and cost share equations as a system of equations using a seemingly unrelated regression approach.

We conducted a Hausman exogeneity test of the labor inputs and the local selling decision that could plausibly be adjusted during the growing season in response to factors known by the farmer but unobserved by the econometrician. The instruments chosen are correlated with the labor decisions and reflect long-term organic production and marketing strategies that are not influenced by the random shocks of the error term. The decision to sell 100% of a

Table 2. Translog Production Function for U.S. Organic Farmers (*N* = 799 farms)

Param.	Variable	Estimate	Param.	Variable	Estimate
α_0	Constant	8.953*** (35.221)	γ_3	*PARTTIME*	−0.701*** (−7.890)
α_1	ln(*LABYRRD*)	0.252*** (2.943)	γ_4	*FEMALE*	0.217** (2.383)
α_2	ln(*LABSEAS*)	0.114 (1.543)	γ_5	*GRADHS*	−0.182 (−1.115)
α_3	ln(*ACRE*)	0.064 (0.893)	γ_6	*GRADCOL*	0.307* (1.852)
β_{11}	ln(*LABYRRD*)^2	0.050 (0.880)	γ_7	*GRADDEG*	0.012 (0.067)
β_{22}	ln(*LABSEAS*)^2	−0.048 (−0.743)	γ_8	ln(*YRSORG*)	0.197*** (3.822)
β_{33}	ln(*ACRE*)^2	0.051*** (2.785)	γ_9	*PCTVEG*	0.042 (0.311)
β_{12}	ln(*LABYYRD*∗*LABSEAS*)	0.082* (1.696)	γ_{10}	*PCTFIELD*	−0.264* (−1.861)
β_{13}	ln(*LABYRRD*∗*ACRE*)	0.035 (1.458)	γ_{11}	*LOCSELL*	−0.145*** (−3.108)
β_{23}	ln(*LABSEAS*∗*ACRE*)	0.010 (0.450)	γ_{12}	*WEST*	0.115 (1.116)
γ_1	*TRANMIXD*	−0.054 (−0.444)	γ_{13}	*SOUTH*	−0.326** (−2.339)
γ_2	*CORPPART*	0.416** (1.987)	γ_{14}	*NOREAST*	0.064 (0.672)
$R^2 = 0.55$					

Notes: Single, double, and triple asterisks (*,**,***) denote asymptotic *t*-values with significance at α = 0.10, 0.05, and 0.01, respectively. Heteroskedasticity robust standard errors are used in calculating *t*-values.

commodity through local markets represents a long-term plan of the producer and can be considered as predetermined in the econometric model. The farmer must exhibit knowledge of the local market, develop a business plan, and create appropriate marketing aids. These decisions require extensive planning and should not be highly influenced by short-term production shocks.

The instruments included the farmer's involvement in value-added production activities, the farmer's reported expansion in demand for his or her organic production, and the change in average prices received for organic products from last year along with the marketing aids used by the producer in selling through local outlets (such as farm events and demonstrations, local promotional efforts, featured product samples, and in-store demonstrations). The exogeneity hypothesis for the labor inputs and local selling decision was not rejected. The test statistic confirms that endogeneity is not a significant factor in the specification of the production function, as the calculated χ^2 value of 14.37 was below the critical χ^2_8 value of 15.51 at the 5% significance level.

In the estimated model, the coefficient estimates for the natural logs of the inputs may be converted to output elasticities, calculated by taking the derivatives of the estimated model with respect to the logarithms of each input measure. The output elasticities measure the change in the value of organic farm production due to a specified change in the use of an input. The resulting output elasticities indicate that a 1% increase in the use of year-round labor raises the value of organic production by about 0.46%. The output elasticity for seasonal labor is slightly smaller at 0.16%, and both measures are statistically significant. Higher input levels lead to increased organic production value, ensuring the monotonocity condition for the production function is met for each input (year-round and seasonal labor and organic acreage). Concavity of the production function requires that the Hessian matrix based on the parameter estimates be negative semidefinite, and this condition is satisfied.

The calculated returns-to-scale measure is 0.89 which is not significantly different than one, implying essentially constant returns to scale for the set of variable inputs (acreage, year-round and seasonal employees). The production function for organic farms does not reject the constant returns-to-scale restriction, indicating the Hicks elasticity of complementarity is a theoretically valid measure to examine input substitution patterns for these organic farms.

The output elasticities for labor and acreage were evaluated for farms in four acreage size percentiles (0–25th, 26th–50th, 51st–75th, and 75th–100th). The estimated scale elasticity increases with the size of the farm, moving from decreasing returns to scale for smaller farms to increasing returns to scale for those farms with the most organic acreage. Producers with farms exceeding 120 acres show slightly increasing returns to scale.

The estimated coefficient on part-time farming status reveals these farmers have incomes which are approximately 50% lower than full-time farmers, using Kennedy's (1981) procedure to measure the impact of a dichotomous variable on the logarithm of value added. The majority of part-time organic farmers (about 76%) report that less than 25% of their net household income originates from organic farm production. Organic farm incomes are 24% higher for male farmers. Farms organized as a nonfamily partnership, corporation, or farm cooperative (*CORPPART*) achieve significantly higher organic farm incomes than other farms.

An important result from the production function shows producers who focus on local sales (*LOCSELL* is positive) achieve farm incomes 14% lower than other producers. Empirically, a commitment to local sales is found to be associated with lower farm incomes—an impact which has not been considered in policy suggestions that farmers expand their supply to local markets.

Corporate or nonfamily partnerships who sell locally apparently are taking advantage of better marketing strategies in their operations. The incomes of these organic farmers are 37% higher than other farmers. One clear performance indicator distinguishing the corporations or nonfamily partnerships is that they are better able to manage labor, as the majority of these farmers report no problems in hiring employees for production or marketing in their OFRF survey responses. In addition, these operations use a wider variety of marketing programs targeted to local sales outlets, including farm events and demonstrations, local advertising and promotional efforts, product samples, in-store demonstrations, and the use of organic certification labels and seals. Cooperative extension marketing specialists and growers associations could examine these operations to learn what strategies they employ.

More than 74% of the organic producers who graduated from college participate in local selling—the highest level of participation across the education categories. The incomes of the college-educated farmers are 36% higher compared to farms where the manager did not graduate from high school. College-educated farmers selling locally do not experience an income drop when engaged in local selling, but instead achieve incomes 21% higher relative to their counterparts lacking a high school education.

As noted, the average farm size is lower for farmers with a local sales component, and the workforce of year-round and seasonal employees on these farms is also smaller. The Hicks elasticities discussed below are instructive in measuring adjustments in input valuations for farmers demonstrating a commitment to marketing through local channels.

Input Adjustments on Organic Farms

Tables 3 and 4 record the elasticities of complementarity and elasticities of factor prices with respect to changes in quantities. The elasticities are calculated at the mean values of the explanatory variables. We focus on the elasticities that are statistically significant. All the Hicks elasticities are statistically significant. Inverse output elasticities are reported in table 4.

The elasticities of factor prices with respect to the quantity of the same input are negative and significant in all cases, as required for a well-behaved production function. A positive elasticity between organic acres and both types of employees indicates that as farm size increases, the marginal value of labor rises and managers hire more of these employees; these inputs are *q*-complements. Year-round employees are relatively more complementary with farm size and have a larger elasticity of factor price with respect to farm size than seasonal employees. The Hicks elasticity of complementarity estimates (ρ_{ij}^{H}) are 1.256 for year-round employees and 1.195 for seasonal employees, while the η_{ij} estimates are 0.174 and 0.157 for the respective employee groups.

The Hicks elasticities can be used to assess farm-level employment effects associated with sales to local markets. Recall, organic producers who specialize in local sales (*LOCSELL* is positive) operate smaller farms compared to national sales producers. Smaller farm sizes imply that the marginal value of seasonal labor decreases, and hires of these workers decline since the factors are *q*-complements.

Organic farms with a local sales emphasis employ fewer total workers, and hires of both year-round and seasonal workers are smaller in comparison to other farm operators. The use of seasonal workers is about 50% lower, while the demand for year-round workers is 40% smaller when farms engage in local sales. Employment of both year-round and seasonal workers declines with increased emphasis on local sales due to smaller farm sizes. Policies or incentives that promote a shift to local sales by organic farmers would lead to decreased use of seasonal workers and higher wages for these workers according to the Hicks measures. Adjustments in the wages of year-round workers show greater changes if organic farmers emphasized local sales.

An important result is that the own-elasticity of complementarity for the number of seasonal employees is negative and significant, while the cross-elasticity between seasonal employees and year-round employees is positive and statistically significant. This finding suggests that increased reliance on year-round employees raises the marginal valuation of seasonal workers. The organic farmer hires more seasonal labor to produce a given level of output.

Negative own-quantity elasticities reveal organic farmers are willing to pay less for added quantities of the input. The inverse price elasticity for organic acreage means that a 1% increase in acreage decreases the price of additional acreage by 0.72% while increasing the marginal value of productivity (MVP), or the marginal revenue product, for seasonal

Table 3. Estimated Hicks Elasticities of Complementarity

	With Respect to Quantity of:		
Marginal Value of Productivity	Acres	Year-Round Employees	Seasonal Employees
Acres	−0.153*** (−6.430)		
Year-Round Employees	1.256*** (7.484)	−0.200*** (−3.457)	
Seasonal Employees	1.195*** (2.942)	1.961*** (3.065)	−0.192** (−2.064)

Notes: Single, double, and triple asterisks (*,**,***) denote asymptotic t-values with significance at $\alpha = 0.10$, 0.05, and 0.01, respectively. Elasticities are evaluated at sample means of explanatory variables.

Table 4. Estimated Uncompensated Inverse Price Elasticities and Output Elasticities

	With Respect to Quantity of:			
Marginal Value of Productivity	Acres	Year-Round Employees	Seasonal Employees	Output Elasticity
Acres	−0.720*** (−8.728)	0.301*** (3.117)	0.081 (1.230)	−1.212*** (−7.219)
Year-Round Employees	0.174*** (2.235)	−0.720*** (−3.748)	0.215 (1.504)	−1.156*** (−7.856)
Seasonal Employees	0.157 (1.089)	0.640* (1.718)	−1.223*** (−3.306)	−2.904** (−1.938)

Notes: Single, double, and triple asterisks (*,**,***) denote asymptotic t-values with significance at $\alpha = 0.10$, 0.05, and 0.01, respectively. Elasticities are evaluated at sample means of explanatory variables.

employees. The price of seasonal employees is the most responsive input to a change in its own quantity, indicating that an increase in the number of seasonal workers hired results in wage declines of about 1.22%. The expanded use of seasonal employees leads to decreased valuation of year-round workers and reduced employment opportunities for these workers.

As indicated by the negative signs for the estimated inverse output elasticities, with the expansion of the value of organic farm production, the farm operation places a lower value on additional units of the input. Increases in organic farm income have similar effects across each of the inputs. Wages for seasonal employees are the most responsive to changes in the level of organic farm income.

Discussion and Conclusions

This study presents results from a production function analysis of U.S. organic crop farms, using a unique national data set from the Organic Farming Research Foundation (OFRF). We emphasize returns to scale and elasticities of complementarity using a flexible functional form, linking these measures to farm-level characteristics and local marketing initiatives. The results confirm that the Hicks elasticity of complementarity is an appropriate measure to assess input substitutability for organic producers since the production function exhibits constant returns to scale.

The decision to hire and train year-round versus seasonal workers is properly examined using the Hicks elasticity of complementarity. Farm size and both types of farm workers are complementary inputs. Incentives that encourage farmers to expand employment of year-round and seasonal workers will raise the marginal product, and in turn, rates of return to organic acreage. Labor training programs designed to reduce costs incurred by farmers could encourage both higher wages and more year-round hiring. In the conventional sector, year-round employment is strongly correlated with length of time working for the same employer (U.S. Department of Labor, 2005). Long-term year-round workers may have positive effects on both farm income and the rural economy.

The Hicks measure is useful in assessing farm-level employment effects associated with sales to local markets. Organic farmers who specialize in local sales operate smaller farms compared to producers who sell across a diversified set of local, national, and export markets. A commitment to local sales leads to lower farm incomes—a side effect which has been overlooked in the emphasis on expanding organic sales to local markets. Employment of both year-round and seasonal workers declines with increased emphasis on local sales. Policies or incentives promoting a shift to local sales by organic farmers would lead to decreased use of seasonal workers and higher wages for these workers according to the Hicks measures. The increased demand for "locally grown" foods will have a detrimental effect on average farm income and labor unless larger farms participate in this marketing option.

Our findings demonstrate that distinguishing between year-round and seasonal employees is critical in understanding labor demand and evaluating worker flows and labor market adjustments of organic farms. The National Agricultural Statistics Service (NASS) links hiring trends for farmworkers and wage rates for hired workers to shifts in crop acreage across regions, suggesting the NASS model could be improved by incorporating an expanded set of cropping choices at the farm level and decisions to sell in specific marketing channels. This type of information is collected in the OFRF survey.

The elasticity of complementarity has other applications in the organic sector. The impact of an incentive to encourage the supply of capital or hire specific types of workers depends on the Hicks elasticity. Seidman (1989) shows that a tax incentive to stimulate the use of capital benefits low-skilled labor if the two inputs are complements according to the Hicks elasticity, highlighting the empirical relevance of this measure. The Environmental Quality Incentives Program (EQIP), reauthorized in the Farm Security and Rural Investment Act of 2002, provides incentive payments and cost-shares to install or implement structural and management practices on eligible agricultural land. Over 20% of organic farmers participate in programs such as EQIP, and the effects of these programs on relative factor prices for organic acreage and on-farm employment are appropriately analyzed using the production framework proposed here.

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Appendix: Derivation of the Inverse Output Elasticity and Its Form for the Translog Production Function

Beginning with a partial differentiation of equation (14) from Kim (2000) with respect to x_j and reformatting results in elasticity terms to yield:

$$b_i(\mathbf{x}) = [a_i(\mathbf{x}), \mathbf{x}],$$

$$\frac{\partial \ln(b_i)}{\partial \ln(x_j)} = \frac{\partial \ln(a_i)}{\partial \ln(x_j)} + \frac{\partial \ln(a_i)}{\partial \ln(y)} \frac{\partial \ln(y)}{\partial \ln(x_j)},$$

$$\eta_{ij} = \eta_{ij}^c + \varepsilon_j \eta_{iy},$$

$$\eta_{ij} = \eta_{ij}^c + S_j \varepsilon \eta_{iy}.$$

Zero degree homogeneity of the inverse demands implies:

$$\eta_{ij} = \eta_{ij}^c + S_j \varepsilon \eta_{iy},$$

$$\sum_j \eta_{ij} = \sum_j \eta_{ij}^c + \sum_j S_j \varepsilon \eta_{iy},$$

$$\sum_j \eta_{ij}^c = 0, \quad \sum_j S_j = 1,$$

$$\sum_j \eta_{ij} = \varepsilon \eta_{iy} \Rightarrow \eta_{iy} = \frac{\sum_j \eta_{ij}}{\varepsilon}.$$

Uncompensated quantity elasticities η_{ij}, or inverse price elasticities, are calculated along with the inverse output elasticities, η_{iy}, in the empirical results. The inverse price elasticities are expressed as:

$$\sum_j \eta_{ij} = \frac{\sum_j \beta_{ij}}{\varepsilon_i} - \frac{\sum_j \sum_k \beta_{kj}}{\varepsilon} - 1,$$

$$\eta_{iy} = \frac{\sum_j \eta_{ij}}{\varepsilon},$$

$$\sum_j \eta_{iy} = \frac{\sum_j \beta_{ij}}{\varepsilon \varepsilon_i} - \frac{\sum_j \sum_k \beta_{kj}}{\varepsilon \varepsilon} - \frac{1}{\varepsilon}.$$