Endogenizing Sustainability in U.S. Corn Production: A Cost Function Analysis

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Selected Poster prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Joint Annual Meeting, San Francisco, CA, July 26-28.

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Introduction

As basic and essential units in agricultural production, farms interact directly with surrounding ecological and environmental systems. Therefore the sustainability of their activities is crucial to achieving national and global agricultural sustainability. Various methods have been proposed for evaluating farm sustainability (e.g., Dong et al. 2015; Van Passel and Meul 2012), with many studies examining factors that influence farm sustainability, focusing on farm characteristics, farmer demographics, and related external factors. Importantly, farm sustainability in the current studies is treated as an exogenous choice in the production procedure (e.g., Gòmez-Limón and Sanchez-Fernandez 2010; Reig-Martínez et al. 2011). However, adoption of sustainable production practices is a key part of production procedure, so that adoption of sustainable practices is endogenous in farm production.

Objectives

This study develops a method for specifying and estimating a cost function in the presence of endogenous sustainable practice adoption. We use this method to estimate the impact of sustainable practice adoption on farm cost structure, as well as to identify the mechanism by which production factors decide farm sustainability level and to conduct analysis of related policies.

Methods and Data

The cost function is derived by choosing inputs to minimize the cost to produce output quantity y and to achieve sustainability level S, given input prices w_i (i = labor, seed, land, fertilizer, and pesticide). Empirically, a trans-logarithmic functional form is specified for the cost function:

$$\ln(C) = \alpha_0 + \alpha_1 \ln y + \frac{1}{2}\alpha_{11}(\ln y)^2 + \sum_{i=1}^{m} \beta_i \ln w_i + \sum_{i=1}^{m} \gamma_{yi} \ln y \ln w_i + \frac{1}{2}\sum_{i=1}^{m}\sum_{k=1}^{m} \beta_{ik} \ln(w_i)\ln(w_k) + \delta_s \ln S + \frac{1}{2}\delta_{ss}(\ln S)^2 + \delta_{ys} \ln y \ln S + \sum_{i=1}^{m} \delta_{si} \ln S \ln w_i$$

$$\text{cost share}: CS_i = \beta_i + \sum_{k=1}^{m} \beta_{ik} \ln w_k + \gamma_{yi} \ln y + \delta_{si} \ln S$$

With constraints:

$$\beta_{ik} = \beta_{ki}, \sum_{i=1}^{m} \beta_i = 1, \sum_{i=1}^{m} \gamma_{yi} = 0, \sum_{i=1}^{m} \beta_{ik} = 0, \sum_{i=1}^{m} \delta_{si} = 0$$

The cost elasticity of sustainability is calculated as

$$\frac{\partial \ln C}{\partial \ln S} = \delta_s + \delta_{ss} \ln S + \delta_{ys} \ln y + \sum_{i=1}^{m} \delta_{si} \ln w_i$$

The data used in this study are from 2010 Agricultural Resource Management Survey (ARMS) Phase II Corn Production Practices and Cost Reports and Phase III Corn Costs and Returns Report. There are totally 1,496 observations used in the analysis after deleting those with missing values. The sustainability score *S* is calculated using non-negative PCA-common weight DEA method developed by Dong, Mitchell, and Colquhoun (2015) and is scaled to range between 0 and 100.

Results and Discussion

The cost and cost share functions are estimated using nonlinear seemingly unrelated regression method with above constraints imposed. The cost elasticity of sustainability is evaluated at the means of variables and its standard error is calculated by delta method.

item	estimation	std. err
S	-0.100	0.101
S×S	0.060**	0.024
S×Output	-0.007	0.008
S×Wage	-0.017***	0.004
S×Seed price	0.005*	0.003
S×Rent	0.001	0.003
S×Fertilizer price	-0.002	0.006
S×Pesticide price	0.013***	0.004
Elasticy of S	0.037**	0.017

Note: *, **, *** indicates statistical significance at 10%, 5% and 1%, respectively.

The estimated results suggest that production cost will increase if a farm improves its sustainability. Moreover, the estimated interaction parameters between sustainability and input prices show that if wage rate increases, holding everything else fixed, the marginal cost of sustainability will decrease, implying that higher sustainability level is labor saving (e.g., no-till/conservation tillage). In the meantime, marginal cost of sustainability will increase if seed and pesticide prices increase.

Conclusions

Adopting sustainable agricultural practices is costly to farmers. Without price premium, increased sale, or subsidies, farmers may be reluctant to adopt more sustainable practices in the short run. Although making the adoption of sustainable practices mandatory is able to force farmers to do so, they may suffer economic losses.

Reference

Dong, F., P. Mitchell, and J. Colquhoun, 2015. Measuring Farm Sustainability Using Data Envelope Analysis with Principal Components: The Case of Wisconsin Cranberry. *Journal of Environmental Management* 147:175-183.