A DEA-PCA Sustainability Metric for Processing Vegetable Crops

Nicola Wille

Paul D. Mitchell

Fengxia Dong

Virginia M. Moore

Deana Knuteson

Jeffery Wyman

University of Wisconsin- Madison

nwille@wisc.edu

Selected Poster prepared for presentation at the Agricultural & Applied Economics Association's

2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014.

A DEA-PCA Sustainability Metric for Processing Vegetable Crops

Nicola Wille, Paul D. Mitchell, Fengxia Dong, Virginia M. Moore, Deana Knuteson and Jeffery Wyman, University of Wisconsin- Madison

Overview:

Sustainable agriculture is garnering renewed interest as more customers and retailers from both the U.S. and the world markets demand more sustainably sourced products and ingredients. Processed vegetables (canned and frozen) such as sweet corn and green beans face this same growing demand. To respond to this growing demand for sustainability data and programs, the Midwest Food Processors Association and the Wisconsin Potato and Vegetable Growers Association chose the National Initiative for Sustainable Agriculture (http://wisa.cals.wisc.edu/nisa) approach. This approach develops a farmer self-assessment survey that documents grower adoption of multiple sustainable practices, and then analyzes the data using data envelope analysis with principal components to develop a "sustainability score" for both individual growers and the industry as a whole.

Objective:

This study aims to describe the data analysis process for sustainability evaluation and illustrates its empirical application to Midwestern processed vegetable production, including its ability to be used upon large dimension, discrete and correlated variables and identify practices most improving the sustainability of individual growers and the industry as a whole.

Reference

Dong, F., P. Mitchell, and J. Colquhoun. 2013. *Measuring Farm Sustainability Using Data Envelope Analysis with Principal Components: The Case of the Wisconsin Cranberry*. Staff Paper No. 568, Dept. Ag. and Applied Econ., University of Wisconsin-Madison.

Methodology and Data:

The analysis used a non-negative Polychoric PCA and Common-Weight DEA approach developed by Dong, Mitchell, and Colquhoun (2013) to determine endogenously the weights for each best management practice, of which the corresponding variables can be discrete, correlated, and in large dimension. The final sustainability score was computed through common-weight DEA such that:

$$\text{Minimize } h(\omega_i, z_k, Z) = t\frac{1}{K}\sum_{k=1}^{K} z_k + (1-t)Z$$

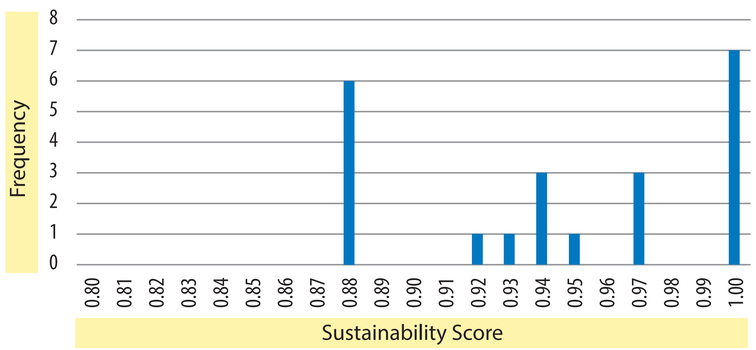
$$\text{subject to: } z_k = S_k - \sum_{i=1}^{I} \omega_i \tilde{x}_{ik} \ \forall k,\ Z - z_k \geq 0\ \forall k,\ z_k \geq 0\ \forall k,\ \omega_i > 0\ \forall i,\ Z \geq 0.$$

Where z_k is the deviation of common weight DEA score from the basic DEA score (S_k) for farm k; w_i is the common weight for the *ith* practice variable and Z is the maximum deviation over all farms $k = 1$ to K. The parameter $0 \leq t \leq 1$ determines the weight for the two parts of the objective function. The first constraint defines the deviation z_k, with the remaining constraints ensuring that deviations are non-negative ($z_k \geq 0$) and do not exceed the maximum deviation ($Z - z_k \geq 0$), that the maximum deviation is also non-negative ($Z \geq 0$), and that the common weights are strictly positive ($\omega_i > 0$). The final common-weight DEA scores are

$$\frac{1}{K}\sum_{k=1}^{K} Z_k$$

The data used in the analysis is from a survey of green bean and sweet corn growers in Illinois, Minnesota, and Wisconsin. The questions focus upon grower adoption of sustainable practices at the whole farm and the crop specific level. These practices include insect, pest, pathogen and weed management among others. The total sample consists of 107 growers; of these, 44 grow green beans and 67 grow sweet corn. Eight growers reported practices for both green beans and sweet corn.

Figure 1: Distribution of Green Bean Growers' Sustainability Scores



Results:

The data analysis generates a composite sustainability score for each individual farm. The distribution of the green bean growers' sustainability scores can be seen in Figure 1.

The calculated weights can indicate the importance of the practices upon the sustainability score. Some of the key practices from the crop specific analysis are presented below:

- Records were kept on the amount of water and/or energy used to irrigate the crop
- Potato, carrot or other crop that promotes green bean growth and development was planted the previous year
- Proper seed be preparation was completed with minimal tillage for planter

The three practices with largest weights for each crop assessed in this research along with their respective category and adoption rate by growers are presented in Table 1.

Table 1. Practices with largest weights with their respective category & adoption rate by growers.

Green bean practices	DEA-PCA Weight	Category	% of Current Adoption
Records were kept on the amount of water and/or energy used to irrigate the crop	0.049335	Production and Management	27.3%
Potato, carrot or other crop that promotes green bean growth and development was planted the previous year	0.051681	Production and Management	38.6%
Proper seed be preparation was completed with minimal tillage for planter	0.057168	Production and Management	77.3%

Implications:

The DEA-PCA metric used in the study can be used to establish a "sustainability score" for each grower. This allows growers to evaluate how sustainable they are comparing to their peers and identify the practices that can most improve their sustainability score. Industry associations can identify research and outreach needs in order to set goals and pursue industry-wide improvements. These characteristics have led to significant interest from farmers and industry associations, with programs to collect data and generate these sorts of sustainability metrics spreading to other crops and regions as a practical way to improve the sustainability of a range of cropping systems.