A DEA-PCA Sustainability Metric for Processing Vegetable Crops

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Overview:
The DEA-PCA Sustainability Metric for Processing Vegetable Crops
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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:

\[ \text{Minimize} \quad h(a_i, z_i, Z) = \frac{1}{K} \sum_{k=1}^{K} Z_k + (1-t)Z \]

subject to: \[ z_i = S_k - \sum_{k=1}^{K} w_k Z_k \forall k, \quad Z - z_i \geq 0 \forall k, \quad z_i \geq 0 \forall k, \quad a_i > 0 \forall i, \quad Z \geq 0. \]

Where \( z_i \) is the deviation of common weight DEA score from the basic DEA score (\( S_k \)) for farm \( k \); \( w_k \) is the common weight for the \( i \)th practice variable and \( Z \) is the maximum deviation over all farms \( k = I \) 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 \( z_i \), with the remaining constraints ensuring that deviations are non-negative (\( z_i \geq 0 \)) and do not exceed the maximum deviation \( (Z - z_i > 0) \), that the maximum deviation is also non-negative \( (Z \geq 0) \), and that the common weights are strictly positive \( (a_i > 0) \). The final common-weight DEA scores are

\[ \frac{1}{K} \sum_{k=1}^{K} Z_k \]

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.

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.