Harvest Risk and the Possible Application of Semantic Modeling

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Gathering the harvest represents a complex managerial problem for agricultural cooperatives involved in harvesting and processing operations: balancing the risk of overinvestment with the risk of underproduction. The rate to harvest crops and the corresponding capital investment are critical strategic decisions in situations where poor weather conditions present a risk of crop loss.

This common problem in agriculture requires the application of mathematical models to calculate risk. An article that recently appeared in *Manufacturing & Service Operations Management* puts forth a method to calculate Harvest Risk for Concord grapes. The title of the article is "Controlling the Risk for an Agricultural Harvest" authored by S.J. Allen and E.W. Schuster.

Mostly grown in the Northern US, Concord grapes are a hardy variety known for exceptional flavor. However, like all agricultural crops, grapes are susceptible to frost damage during fall harvesting operations. Therefore, the goal is to harvest all of the grapes before a fall frost terminates operations.

The research article written by Allen and Schuster presents a case study of the Concord grape harvest and the development a mathematical model to control Harvest Risk by finding the optimal harvest and processing rate. Since it is impossible to predict in advance exactly when a frost will occur, it becomes important to employ various risk models to determine the best rate to process grapes. The model involves differentiation of a joint probability distribution that represents risks associated with the length of the harvest season and the size of the crop. This approach is becoming popular as a means of dealing with complex problems involving operational and supply chain risk.

Allen and Schuster note that Harvest Risk is an under researched in agriculture. During the course of model formulation, they conducted an extensive literature review and found that there were no similar models for calculating Harvest Risk. This prompted a search for risk models used outside of agriculture to address the problem of a one-time event such as determining the correct lot size for perishable items like newspapers. In many ways, the Harvest Risk problem is similar to making purchases of highly seasonable items like fashion goods. With fashion merchandise, there are risks of ordering too much or too little. Either case can result in significant financial loss.

Likewise, the grape harvest represents a one-time event where harvesting too rapidly implies too much investment in equipment. Harvesting too slowly means an increased probability of losing crop because of a frost. These types of tradeoffs are very important for a variety of business and agricultural problems.

Looking outside a discipline to find mathematical models that might have relevant application is a time consuming task. Allen and Schuster have noted that their line of research for the Harvest Risk problem dates over eight years. Most development and application of mathematical models occurs in highly specialized domains where researchers and managers have large amounts of specific knowledge but very little general knowledge about other disciplines. It takes years to accomplish meaningful research will realistic application.

One of the important technologies under development as part of *The Data Project*, **Semantic Modeling,** helps to solve this problem. Semantic Modeling allows for rapid application of models to data regardless of the domain where the model was originally developed. In essence, Semantic Modeling allows for the free flow of models over a network in much the same way that the Internet facilitates the free flow of information through interconnected web pages. Simply stated, Semantic Modeling is an advanced form of connective technology. Using this technology, modelers can quickly search for models from other disciplines that might solve the problem at hand. The approach also allows for recombining elements of different models from different disciplines to form new models.

In addition, semantic modeling aids in integrating various data sets. For example, the Harvest Risk model developed by Allen and Schuster relies on a point estimate of temperatures for a specific grape growing region. Differences in elevation and other physical and environmental factors can result in significant temperature variation within a small area. When a frost hits a growing region, it is seldom evenly distributed.

Semantic Modeling has the capability of integrating various data sets to get a detailed view of the temperature characteristics for a region. For example,

data from the US Geological Service could be integrated into the Harvest Risk model to account for differences in elevation for a specific growing area. This would give a much more accurate picture of what proportion of the Concord crop is susceptible to frost because of being located in lower elevations where cool air tens to accumulate. Sometimes a few feet in elevation can make a big difference in frost damage. Other data from the National Oceanic and Atmospheric Administration (NOAA) could also provide details on surface temperature variation within a growing region. Combining these data sets creates a more robust model that provides an accurate representation of Harvest Risk on a spatial basis.

The Harvest Risk model also has applications outside of agriculture. Project management, inventory management for fashion goods, and the optimal ordering policies for short life cycle high technology items are also practical problems that can be addressed using elements of the Harvest Risk model. Semantic Modeling will play an important role in linking models from a wide number of different disciplines to an array of different problems in business.

Allen and Schuster reported that the application of the Harvest Risk model to the operations of one agricultural cooperative resulted in millions of dollars in cost avoidance. Using the Semantic Modeling technology being developed by through *The Data Project*, how many other businesses out side of agriculture might experience similar savings?

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