Susanne Wiedenmann: Supply Planning for Processors of Agricultural Raw Materials

Renewable resources from agriculture have the potential to be an attractive alternative source of raw materials for industry. Their efficient use is important, since acreage for cultivation is limited. For such applications, supply planning can pose specific problems for processors of raw materials, because many crops are only seasonally available. Harvest quality and quantity as well as sales prices on commodity markets are uncertain at the time of decision.

In this work, an approach for decision support based on stochastic programming is being developed to optimize supply planning of processors of agricultural raw materials under consideration of industrial requirements for material use. The potential for innovative products based on raw materials from oil crops is explored and the example of processing linseed is used to illustrate possible applications as well as the structure and availability of past data for supply planning.

Based on these findings, an initial supply planning problem of a processor of agricultural raw materials is modeled. Risk mitigation approaches as keeping safety stock, supplier diversification and hedging with tradeable or non-tradeable contracts are investigated.

Quantitative methods for handling uncertain data are reviewed and their data requirements are compared with the available data structures. Stochastic programming is selected for the development of optimization models that maximize the expected profit of the processor of agricultural raw materials. A basic two-stage stochastic program with recourse is developed to adequately model the temporal structure of information availability and the value of flexibility provided by the optional supply. Several modifications of the basic model are implemented for decision situations that are derived from the basic problem. The basic model and its modifications are validated with realistic data on linseed and a numerical analysis is carried out. The effect of using different sets of past data as probability distributions of the commodity market price on the first-stage decisions and the profit of the basic model are tested.

Based on these findings, decision support for the supply planning of a seed company is developed in an industrial case study. The company needs to consider uncertain harvest quantity, purchase price and carry-over inventory levels from the previous period. The results of the case study demonstrate that the developed decision support based on stochastic programming can improve the state-of-the-art in supply planning of the company that processes agricultural raw materials.

Conclusions on the work are drawn and an outlook on further research concerning the models, the methodology and other applications is provided. Other applications of stochastic programming on supply planning with renewable resources from agriculture are possible, as there is a multitude of other tactical decisions where uncertain parameters can be described with probability distributions. Further modifications of the models are possible to consider more or different actors, periods, other processes or decisions. Several other fields of application for stochastic programming on planning processes are possible for different actors in supply chains utilizing renewable resources.