approach permits the direct quantitative incorporation of risks and uncertainties within strategic auction bids, we contribute to an enhanced strategic bidding optimization and comprehensive methodological support for project developers in competitive renewable energy auctions.

3 - Financial Issues in Setting Optimal Product Life cycle Policy

Arik Sadeh, Cristina Feniser

Many variables and type of considerations are involved in the question of when to stop marketing a given product and to initiate another lifecycle for that product. In this study financial aspects are addressed and modeled. The aspects of the consumers with respect to their motivation to replace a product is taken in consideration. The role of technology and the R&D period are considered as well. The financial criterion for success is to maximize the discounted net cash flow or the equivalent annuity stream for a given period of time, e.g. a year, a decade etc. The initiation of another cycle is independent of when the current cycle terminates, but is functionally related to its length. Managerial and operational constraints are included, as well as market share constraints. The problem is solved for various functional forms. The resulting rules are expressed in managerial terms, for example, as a function of peak of cash flow, cumulative cash flow, level of cash flow, and the length of the R&D period. Some numerical examples for all cases are provided to illustrate the rules resulting from the models.

■ WC-18

Wednesday, 14:00-15:40 - 1j. Geneva

Supply chain network design

Stream: Supply Chain Management
Invited session

Chair: *Jean-Sébastien Tancrez*

1 - Reverse logistic network for fiber reinforced plastic waste from wind power plants

Valentin Sommer, Grit Walther

Achieving a resource efficient Europe is one of the flagship initiatives pursued within the EU Strategy 2020 program. Herein, the key concept is to establish circular economies. Among other measures, this requires the analysis of waste streams, the development of feasible technical recycling processes, and the installation of collection and recycling infrastructures. Herein, challenges exist with regard to amount and quality of future waste streams and applicable recycling techniques. Regarding the quality of the waste stream, composite materials often require the development of advanced (and costly) separation techniques in order to allow for recycling. With regard to the quantity of waste streams, high-volume or high-mass innovative products provide challenges as little information is available during the sales period of these products on total market size, speed of market penetration, technical lifetime and product replacement strategies. Rotor blades from wind power plants constructed with fiber reinforced plastics even combine these challenges, i.e. composite materials are used in an innovative product. Thus, technical challenges of the composite materials have to be tackled as well as challenges regarding the expected amounts of the future waste stream. Against this background, we aim at developing a strategic planning approach for the design of appropriate recycling infrastructures for fiber reinforced plastics from rotor blades of wind power plants regarding potential recycling techniques with their expected costs and achievable recycling targets. We develop a multiperiod MILP accounting for technology, capacity and location decisions for the recycling of these rotor blades. The model is applied to a case study containing a detailed data set of expected fiber reinforced plastic waste masses from wind power plants, as well as information on established and potential recycling techniques. Scenario and sensitivity analyzes are conducted with regard to influencing parameters, i.e. targeted recycling quotas and expected annual amount and composition of the waste stream. From these analyses, recommendations are derived for legal decision makers and investors.

2 - A stochastic approach to the cooperative carrier facility location problem

Lotte Verdonck, Patrick Beullens

Fierce competition and declining profit margins often force transport companies to adopt a collaborative mind-set. Cooperating with fellow carriers can provide efficiency increasing strategies which are not available under an internal company focus. Due to its practical importance, collaborative logistics has developed into an active and growing research domain. Existing studies mainly focus on collaborative transport in order to increase the efficiency of vehicle fleet operations. Instead of optimising joint transport operations, carriers may also cooperate by sharing warehouses or distribution centres (DCs). In Verdonck et al. (2016), the cooperative carrier facility location problem is discussed. By jointly deciding on two types of decisions, namely, first which DCs to open, and, second how to allocate the quantity of product flows in the distribution network, partnering companies aim to minimise their total logistics cost. In addition, the carriers have to decide on a suitable distribution of the collaborative benefits while ensuring stability of the coalition. The majority of studies on collaborative logistics assume deterministic problem settings. Very few studies address how horizontal collaboration between carriers can work in a stochastic environment. As such, our research work investigates approaches to the stochastic optimisation of the cooperative carrier facility location problem. We can draw on past research on the facility location problem under uncertainty, but the context of horizontal carrier collaboration introduces additional challenges with respect to the assessment and sharing of risks, and the robustness of coalition stability.

Verdonck L, Beullens P, Caris A, Ramaekers K, Janssens G (2016) Analysis of collaborative savings and cost allocation techniques for the cooperative carrier facility location problem. Journal of the Operational Research Society 67(6):853-871

3 - Capacity formulations for a multi-period network design problem

Roland Braune

This contribution is based on a multi-period network design problem for strategic-tactical planning of material flows between plant locations of a manufacturing company. Transport capacities on edges can be allocated in integer multiples of a base capacity that corresponds to a single truck load. The number of truck loads that can be moved between two nodes in the network depends on the driving time. A single truck may serve multiple connections during a time period which usually corresponds to a working day. The total number of trips is limited by the truck's temporal availability (typically 8 hours per day), but it can be extended by renting additional trucks at (high) fixed costs. The network nodes allow for the limited storage of goods over time and impose handling capacity constraints on both inbound and outbound flows.

The pure design part of the problem under consideration exhibits strong similarities to the network loading problem which has already been studied extensively in the scientific literature. However, the dynamic multi-period nature of the overall problem in combination with admissible intermediate storage of commodities and various additional custom constraints has not been specifically addressed so far. In essence, the transfer of selected valid inequalities that have initially been designed for mixed-integer programming (MIP) formulations in the context of network loading represents the core of this contribution. The focus, in particular, is on cutset and multicut (e.g., spanning tree) inequalities, involving design variables only. The key idea is to obtain a so-called capacity formulation of the problem by "projecting out" any flow-related decision variables. The final purpose is to embed these valid inequalities into a Benders decomposition approach in which the master problem solely contains design variables. Further conceivable application scenarios comprise Benders-and-cut or Branch-and-cut approaches in general. The motivation for employing this kind of approaches arises from the intractability of the original MIP formulation, primarily resulting from long planning horizons and a huge number of commodities.

A time-expanded formulation of the original multi-period problem serves as the basis for installing those valid inequalities. Precisely speaking, cutsets are defined in a multi-layer fashion, potentially involving multiple "copies" of a link, each of which connects the same pair of nodes in different time periods. In other words, cutsets are "spanned" across predefined time intervals, depending on the respective commodities' first supply and latest demand dates. The effects of the added cuts are analyzed using both synthetic (randomly generated) and real-world benchmark problem instances. Preliminary experiments provide strong evidence for a successful and efficient strengthening of the respective LP formulation, in comparison to the relaxation of the original MIP.

4 - Multi-echelon supply chain network design with transportation mode selection, product outsourcing and single-assignment requirements

Teresa Melo, Maria Cortinhal, Maria João Lopes