Session 9: Maintenance & after sales service supply chains

Chair: Engin Topan

Ipek Dursun (Eindhoven University of Technology) - Data-driven spare parts recommendation for corrective maintenance of capital goods

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Corrective maintenance is an important part of after-sales product services. A service provider organizes a maintenance visit and a shipment of spare parts to a customer when a failure is reported. Our goal is to determine the set of parts that should be sent to a customer site when a failure is reported by a customer. Which parts are exactly needed is uncertain. The problem is motivated by previous research work on data-driven spare part recommendations. We assume that a probability estimate is provided for each set of spare parts by a predictive algorithm that analyzes historical data. We allow failure dependency between the parts. We aim to develop an optimal spare parts recommendation model based on these estimates by taking operational costs into account. Our problem can be classified as a *repair kit problem*. The resulting model is applicable for service providers in various industries, such as printing, agricultural, or healthcare equipment. We analyze the structure of the optimal policy analytically and generate practical insights for service providers.

Laurens Deprez (University of Luxembourg*) - Empirical Risk Assessment of Maintenance Costs under Full-service Contracts

Co-authors: Katrien Antonio, Robert Boute
*The contribution of this research was made when the presenter was at KU Leuven

We provide a data-driven framework to conduct a risk assessment, including data pre-processing, exploration, and statistical modeling, on a portfolio of full-service maintenance contracts. These contracts cover all maintenance-related costs for a fixed, upfront fee during a predetermined horizon. Charging each contract a price proportional to its risk prevents adverse selection by incentivizing low risk (i.e., maintenance-light) profiles to not renege on their agreements. We borrow techniques from non-life insurance pricing and tailor them to the setting of maintenance contracts to assess the risk and estimate the expected maintenance costs under a full-service contract. We apply the framework on a portfolio of about 5 000 full-service contracts of industrial equipment and show how a data-driven analysis based on contract and machine characteristics, or risk factors, supports a differentiated, risk-based break-even tariff plan. We employ generalized additive models (GAMs) to predict the risk factors' impact on the frequency (number of) and severity (cost) of maintenance interventions. GAMs are interpretable yet flexible statistical models that capture the effect of both continuous and categorical risk factors. Our predictive models quantify the impact of the contract and machine type, service history, and machine running hours on the contract cost. We additionally utilize the predictive cost distributions of our models to augment the break-even price with the appropriate risk margins to further protect against the inherently stochastic nature of the maintenance costs. The framework shows how maintenance intervention data can set up a differentiated tariff plan.

Engin Topan (University of Twente) - Operational spare parts planning in service control towers

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In this paper, we investigate a operational spare parts planning problem in a multi-item two-echelon distribution system, taking into account real-time supply information in the system. We consider a broad range of operational interventions, either reactive (to solve a shortage) or proactive (to avoid a shortage). We propose an integrated approach to determine the optimal timing and size of each intervention type to minimize the total downtime and shipment costs associated with interventions. Data from a leading original equipment manufacturer of high-tech systems is used to test the performance of our approach. We find that our integrated approach reduces total downtime considerably with a very limited increase in total shipment costs. Proactive emergency shipments contribute most to downtime reduction. The benefit of our approach is higher for high demand parts. Our approach is efficient enough to solve practical size problems. We also test the performance of a greedy heuristic, well-known approach in the literature. We find that the gap between the heuristic and the optimal solution is relatively large.