Demand forecasting constitutes a crucial element of logistics planning, determines the overall logistics cost and can also create a competitive advantage of the whole supply chain. However, in spite of the fact that forecast errors are often directly built in logistics cost functions, whose minimization may lead to diversified functionals of demand, logistics planners are mainly concerned with maximizing the precision of mean value forecasts. In this project, we take a different route and directly connect the forecasting process (encompassing forecast computation and forecast evaluation) with the functional of demand used as the decision level in logistics planning and the corresponding forecast loss function. Our project aims at supplementing the stream of research attempting to mitigate the widely discussed problem of the inconsistency between demand forecasting and stock control, which are often treated separately from each other.

The forecasting strategy considered here assumes that the decision maker follows the so-called service level approach, i.e., instead of minimizing the total logistics cost, he/she formulates a certain service level target. In the project, the service level will be measured by several concepts summarized under the common name fill rate, with a special focus on the so-called short-term fill rate, which is extensively used in service level agreements. Additionally, we plan to also consider the long-term fill rate and the gamma service level. These service measures will be applied to several inventory models, whose detailed specifications will depend on the inventory systems of enterprises examined in the project. It is assumed, however, that at least two different inventory systems will be analyzed. Whenever necessary, we plan to advance the statistical theory of inventory forecasting. In particular, to the best of our knowledge, the concept of the short-term fill rate has never been discussed within the framework of the decision-theoretic forecasting. The same also applies to the concept of the gamma service level. In the project we would like to fill in this gap.

The way a service level constraint is solved in practice depends on the available knowledge concerning the distribution of demand (or forecast errors of demand). If the shape of the distribution is known, the practitioner only requires to use appropriate formulas for decision levels, although, to achieve the target service level, some authors advise a sort of a small sample adjustment of safety factors or even using nonparametric techniques. On the other hand, in the case of unknown distributional shapes, there are several options to follow. One among them is the robust distribution free approach which protects against the worst-case scenario and which requires that the mean and variance of the distribution of demand are known. Another is the empirical strategy based on the empirical distribution function and the sample average approximation, which is gaining more interest nowadays due to the availability of large datasets. Other options to follow make use of kernel density estimation or the bootstrap technique.

The project’s main aim is to check the usefulness of machine learning methods and observation-driven models in inventory forecasting under real-life scenarios. This goal inscribes into the broader discussion concerning the place of computer-intensive data-driven methods in business forecasting. The machine learning methods examined here will be, among others, neural networks (including deep learning networks), regression trees, random forests and gradient boosting. In the project, we would like to adjust these approaches for the purpose of forecasting the functionals of demand of interest here and the use of the direct M-estimation strategy. On the other hand, the observation-driven models will encompass such constructions as uni- and multivariate generalizations of exponential smoothing models and uni- and multivariate generalized autoregressive score models. Some new models will also be introduced. We will examine the performance in inventory forecasting of the M-estimation of such models enabling a direct computation of decision levels vis-à-vis the standard approach assuming that the distribution of demand (or forecast errors of demand) is known and the approach based on nonparametric density estimation. This examination will be based on real data and real-life inventory systems and will encompass studies utilizing univariate time series as well as multivariate data. We expect that these studies will provide practical recommendations concerning the usefulness of the machine learning and observation-driven models in business forecasting and advance our knowledge about eligible practical implementations of an inventory forecasting system. As a by product, we also plan to develop a system of accuracy measures for inventory forecasting and new tests of forecast optimality. Furthermore, we will also systematize and discuss the different approaches to inventory forecasting and touch upon the question of computing hierarchical forecasts under service level requirements. It is also worth adding that before running empirical studies, we will also use simulation techniques to validate the different concepts and methods and to justify the use of the direct forecasting approach based on M-estimation.