

# Lot-sizing with Start-up Times \*

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## Abstract

Many practical applications of lot-sizing and scheduling problems involve start-up times. Operations research literature contains but few studies of lot-sizing models that take start-up times explicitly into account. Here, we review some of these studies, discuss the models and their complexity, and we propose further models. We consider in particular a single-stage single-mode multi-item lot-sizing model with continuous set-ups and sequence independent start-up times, which we solve using an integer programming column generation algorithm and we develop a dynamic programming procedure for the single-item subproblem that treats the initial stock as a decision variable. We also use cutting planes developed by Constantino for the multi-item polyhedra. By combining column and cut generation, the lower bounds that we obtain before branching are on average less than 2% from an optimal solution. Our algorithm solves instances with 3 to 5 items and 24 periods in an average of 50 seconds on a modern workstation, and problems with 36 periods in an average of 750 seconds. Solutions guaranteed to be within 2% of optimality are obtained in less than 75% of these times.

**Keywords:** multi-item lot-sizing and scheduling problems, start-up times, branch-and-price, cutting planes, dynamic programming.

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