Production and inventory planning in Procter & Gamble's snacks business

Established in 1837, The Procter & Gamble Company began as a small, family operated soap and candle company in Cincinnati, Ohio, USA. Today, P&G markets more than 250 brands - including Pampers, Tide, Ariel, Always, Pantene, Bounty, Pringles, Folgers, Charmin, Iams, Actonel, Olay and Clairol - to more than five billion consumers in 160 countries. Last year, P&G invested over $1.7 billion in research and development at 19 technical centers and nearly 100 universities around the world.

Problem/opportunity

This case is a multi-period production and inventory planning model originating in our Snacks business. It includes capacity constraints, minimum lot sizes and particular product changeover restrictions.
The business objective is to keep inventory as low as possible, while maintaining product availability.
Out-of-stocks must be avoided 'at all cost'.

The line produces ~ 50 products (stock-keeping units, or SKUs), which belong to 6 product families (flavors). Capacity is limited, and not far in excess of average demand. Day-to-day demand is fluctuating; on top there are 2 seasonal peaks. The chart (next page) illustrates the variability of demand as a ratio to available capacity.

Due to the nature of the production process, capacity must be 100% utilized, or planned to be shut down for a prolonged period. Production is scheduled in multiples of full shifts (8 hrs each). The process is continuous (24´7), with the exception of planned maintenance periods. Depending on the SKU, a minimum batch corresponds to a few days up to several months of shipments.

Flavors broadly fall into 2 groups: 'A' and 'B'. The production process requires that a run of a non-A flavor is followed by at least one run of A, i.e., a B-to-B flavor-to-flavor changeover needs to pass through A. There is no need for modeling changeover times or costs explicitly.

Given the business objective of responsiveness to demand, one would like to plan short runs per flavor, with many changeovers. Such a policy would eventually result in excess inventory of flavor A SKUs - a clearly undesirable result.

Why was this problem/opportunity selected?

While the production process looks (deceptively) simple, this model is typical for a class of mixed-integer production planning problems with a high number of planning periods. The solution of the linear relaxation of these problems generally is a very weak starting point for the branch and bound process, which takes unacceptably long to provide near-optimal solutions, let alone prove optimality.

Due to the fluctuating demands, the planning horizon is at least 2 weeks, and preferably one month. The number of planning periods is therefore roughly 30 days ´ 3 shifts/day = 90 shifts.

Description of technical solution

This problem was initially formulated as a classical mixed-integer problem, solved with XpressMP.
The first step was to reformulate this as a discrete lot sizing problem with backlogging (DLSB). Indeed, with planning periods defined as 1 shift, only one product is produced in a 'bucket', and production must run during a whole shift.

Research at CORE resulted in strong cutting planes, which result in (near-) integer LP relaxations. Branch and bound time is typically reduced to less than one minute - on some data sets even less than 15 seconds to proven optimality. This represents a speed-up of over 50 times compared to the initial formulation.

Benefits

The discrete optimization model has been integrated in an in-house built production planning tool and the results have been validated by the production planners. After some fine-tuning of the objective function coefficients, results were excellent : improved customer service at equal or lower inventories, less disruptions (expediting / schedule changes) in the operation. Planners' productivity increased significantly, as a complete planning cycle (including, among others, data transfers, checks on materials availability and warehouse status) now takes less than 2 hours, versus 4-5 hours previously, and requires much fewer revisions.

Results from the tool have been used to evaluate and suggest changes to the production process in order to further reduce inventories and changeover costs.

We have successfully re-applied the discretization methods in other production planning applications - often solving problems with 100 or more planning periods to optimality in very acceptable times, using the standard version of Xpress-MP.
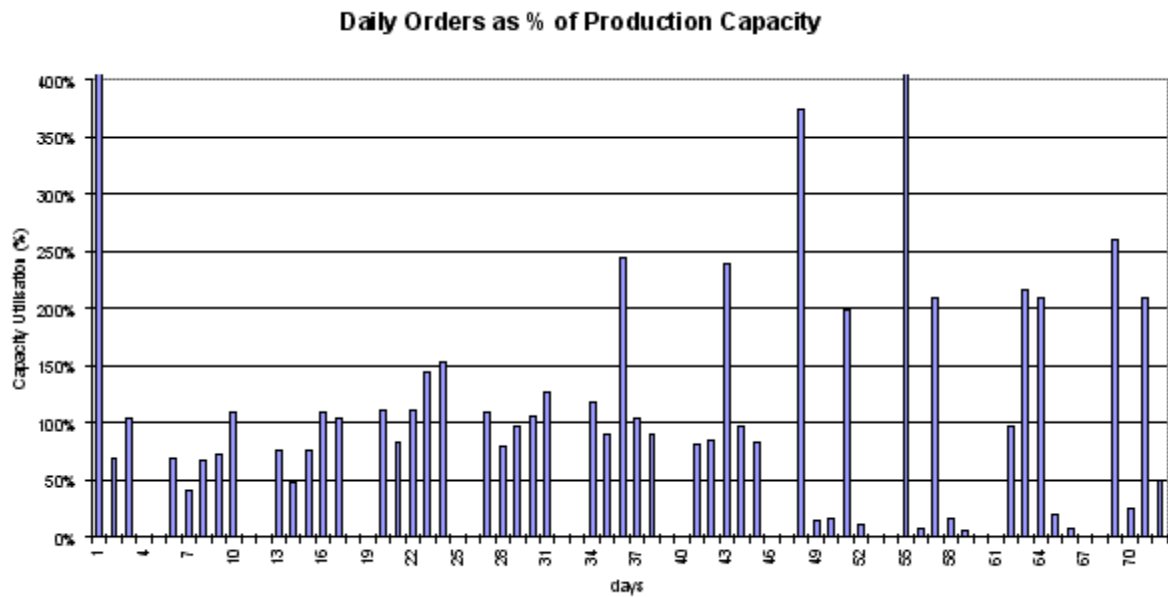

Chart showing variability of demand as a ratio to production capacity

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