Sales and operations planning for product rollovers with finite production capacities

Abstract

A product rollover takes place if a product generation is replaced by a successor version. The successful introduction of new products to the market is a key driver for the financial success of companies. This applies in particular to industries which are characterized by short product life cycles such as semiconductor, consumer electronics, and fashion. Depending on the decision about the product offering, the literature distinguishes between single- and dual-product rollovers. According to the classical single rollover strategy, only one product generation is sold at a time, i.e., the company stops selling the old generation once the new generation is introduced to the market. In contrast, the dual rollover strategy allows for a transition period during which both product generations are sold simultaneously.

The scientific literature on selecting optimal product rollover strategies has so far focused on capturing sales and marketing aspects. Covered market features include product cannibalization, product announcements, and strategic customers as well as competition with other companies.

A common assumption in the literature is that the sales volume is not constrained by production capacities. In practice, production capacities are often limited during the introduction of new product generations. This can be due to shared capacity with the production of the old product generation, new production processes, or a limited supply of raw materials and components. The operations management literature that considers finite capacity, focuses either only on the introduction of new products without a predecessor or assumes a given rollover strategy.

We contribute to the literature by generalizing the results for rollover strategies to the case where the production capacity is limited. This requires the differentiation between sales and
production rollover strategies because production and sales are not necessarily aligned. We focus on the question how the presence of limited production capacities drives the selection of rollover strategies and the underlying optimal decisions on production, sales, and price.

We propose a deterministic two-period model of a company that maximizes the profit, given as revenue from sales of both product generations reduced by variable production and inventory holding costs. The company decides about the amounts of old and new product to be produced and to be sold in each period as well as the resulting inventory level. These decisions also determine the chosen rollover strategy. It is further assumed that the new product can be produced only in the second period because its development has not been completed in the first period. The prices for the old product in the first period and the new product in the second period are considered given by a competitive market. However, the company can decide to offer discounts for the old product in the second period to stimulate sales.

We use a vertical demand model to capture assortment based substitution, e.g., potential buyers of the new product may decide to buy the old product if both generations are sold simultaneously. By using a fluid approach the model also captures stock-out based substitution. It occurs, if a customer who planned to buy the new (old) product buys the old (new) product instead because of a stock out of the new (old) product. Typically, not all customers are willing to substitute. Hence a share of the demand may also be lost.

It is further assumed that the old and the new product are produced with a shared and finite production capacity, e.g., assembled on the same assembly line. The capacity consumption of the new product and its variable production cost may be different from the old product.

The problem is formalized as a non-linear integer program. We provide explicit solutions for the unlimited capacity case and closed form solutions for given rollover strategies for the finite capacity case with customers that are unwilling to substitute in case of stock outs. Numerical results are obtained for the general setting. These are obtained from a linearized MIP formulation, for a given discount. Because the profit is not concave in the discount, an exhaustive search on the interval $[0, 1]$ is performed to determine the optimal discount decision.
The model yields the following insights regarding the impact of finite production capacity on the choice of optimal product rollover strategies and their underlying decisions.

- We show that for finite production capacity a dual sales rollover in combination with a single production rollover can be optimal. It uses inventory of the old product to free capacity for the new product in the second period. In contrast, we show that sales and production rollover strategies are always aligned in the case of unlimited capacity such that unnecessary inventory holing costs are avoided.

- Finite capacity drives firms to select dual sales and production rollovers instead of single rollovers.

- Increasing capacity consumption by the new product increases the use of dual sales and production rollovers.

- Decreasing willingness to substitute in case of stock-outs can cause the postponement of the introduction of the new product.

- The consideration of finite capacity can lead to increased discounts for the older product, i.e., a lower price.

- The lost profit from selecting rollover strategies based on an unlimited capacity model for a finite capacity setting increases in the difference of the quality between product generations.

Finally, future extensions to a monopolistic setting and the consideration of stochasticity are discussed.