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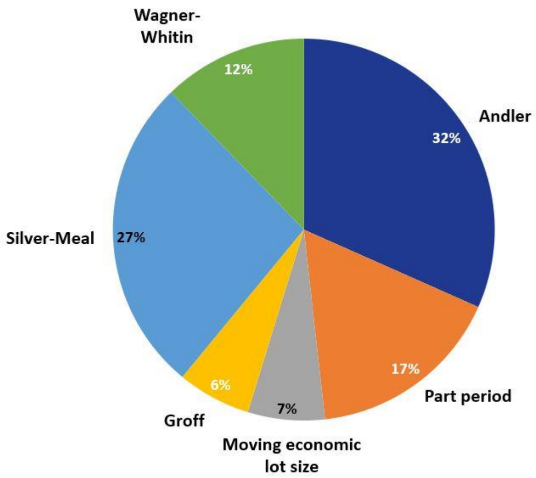

Lot size optimization

as an essential component of supply chain optimization

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Lot size optimization as an essential component of supply chain optimization

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Economic lot-sizing procedures for the total cost reduction of warehousing and procurement or setup costs offer a large, mostly unused potential for cost reduction. In practice, users see the major problem all in the determination of input costs. The real challenge yet is usually overlooked. In order to fully exploit the potential, users must be familiar with the principles and limits of the economic batch sizing methods and know which pitfalls have to be avoided.

Goals of the lot-sizing procedures

Economic lot-sizing procedures aim to minimise the total costs for a given article, consisting of inventory costs on the one hand and procurement costs for purchased articles or set-up costs for in-house production articles on the other. This optimises a small, essential component within the entire supply chain that is often overlooked in practice.

Larger batch sizes in procurement or production lead to higher inventories and thus higher warehousing costs. These generally rise in proportion to the batch size, while the ordering costs or set-up costs - generally referred to as batch initiation costs - fall in inverse proportion.

A simple example:

If the same absolute transport costs are incurred for a part for lot size x as well as for lot size 2x, then with twice as many parts ordered, each part only bears half the transport costs.

If certain costs rise in proportion to the batch size and others fall in inverse proportion to the batch size, then there must be a minimum total cost at a certain batch size (cf. Fig. 1).

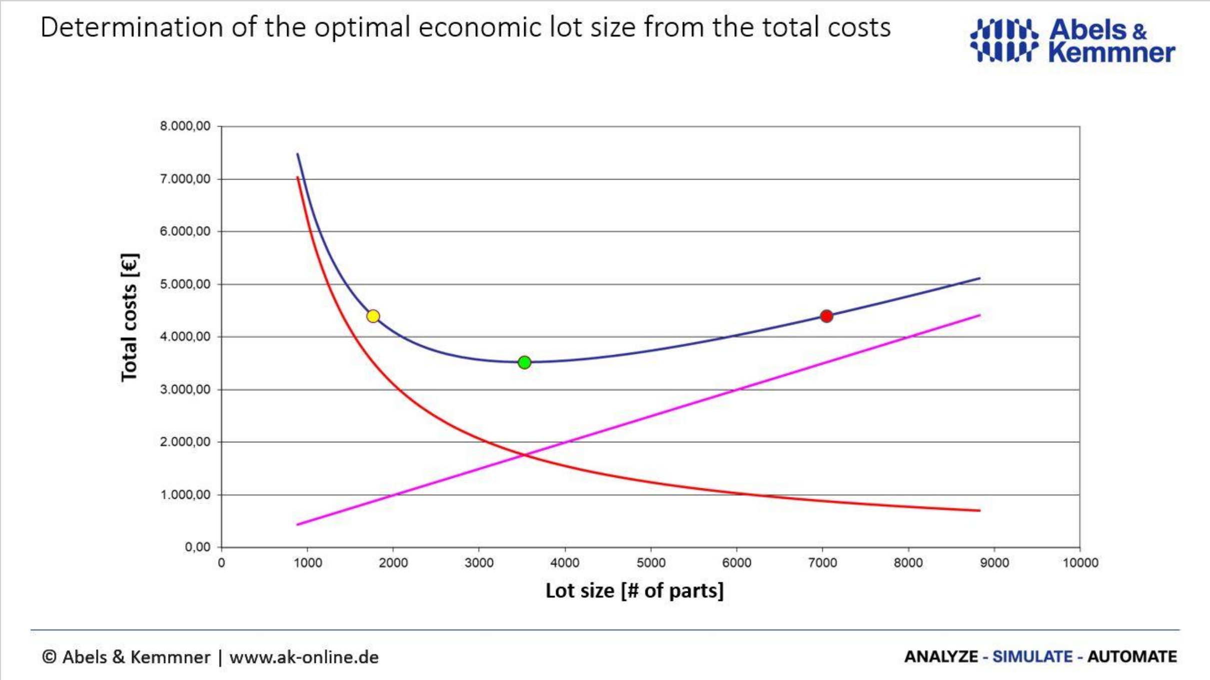

Fig. 1: Lot size optimisation tries to find the cost optimum from inventory carrying and lot initiation costs

The classic economic batch sizing methods

One of the first to recognise the connection between inventory costs and batch circulation costs was Kurt Andler. He developed a formula for calculating an economic lot size in 1929. The Andler formula is still widely used today. In calculating the optimal lot size, Andler assumed that the total required quantity of an article in a planning horizon, e.g. one year, is known. From inventory costs on the one hand and procurement costs on the other, the formula now derives the lot size with which orders should always be placed. Since the lot size remains constant over the planning period, this is also referred to as a static economic lot-sizing procedure.

In practice, however, production or order requirements are rarely evenly distributed over the planning horizon. Rather, they follow one another irregularly and vary in size (Fig. 2). The decisive answer to how to determine economic lot sizes for "dynamic" requirements was given by two Americans as early as 1958. Mr Wagner and Mr Whitin developed an economic lot-sizing procedure with which dynamic lot sizes could be calculated. This mathematical solution takes into account that with the decision on a first lot size in the planning horizon, the leeway for the design of the subsequent lot sizes is automatically limited. The Wagner-Whitin method determines a sequence of lots with different sizes and different time intervals that minimises the total costs. The result is a scientifically precise answer to the question of the right lot sizes for single-stage, single-product production without capacity limitations.

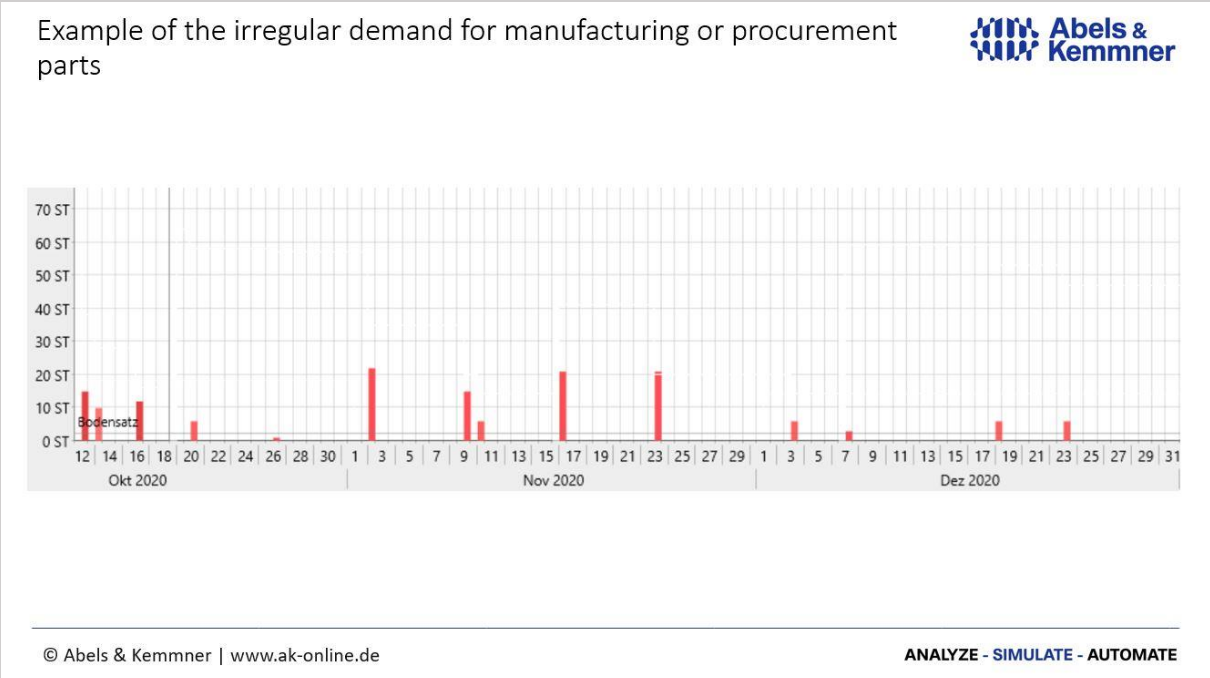

Fig. 2: Lot size optimisation tries to find the cost optimum from inventory carrying and lot initiation costs

The Wagner-Whitin method was too complex to be used by hand or with the calculating machines of the time. Thus, in the course of the following years, approximation methods were developed which, at the expense of theoretical accuracy, could manage with little computational and storage capacity. In 1968, for example, the Part Period method and the moving economic lot size method were introduced, in 1973 the Silver-Meal method and in 1979 the Groff method, both named after their developers, followed. These are the "classic" economic lot-sizing procedures offered in many ERP systems. In addition, there are a large number of other methods for determining optimal lot sizes that have not yet found much resonance in practice.

All approximation methods work according to the "grubbing principle". If material has to be reordered or remanufactured, the procedures check how many future requirements should already be ordered now to keep the total costs over this period as low as possible. Thus, when an order is placed, future requirements are "grubbed". For the next order, a new grubbing process starts and so on.

As indicated above, the grubbing approach does not lead to the lowest total costs in the planning horizon. However, empirical simulations, that we carry out in many of our consultancy projects, show that the advantage of the Wagner-Whitin method is only effective for some of the items in practice, as the demand quantities and their distribution change continuously over the course of the planning horizon. However, relying on the approximation methods instead of Wagner-Whitin unfortunately does not lead to more correct economic lot sizes. All approximation methods are based on different cost considerations and therefore often arrive at different values for the economic lot size. The deviations can be very significant (Fig. 3).

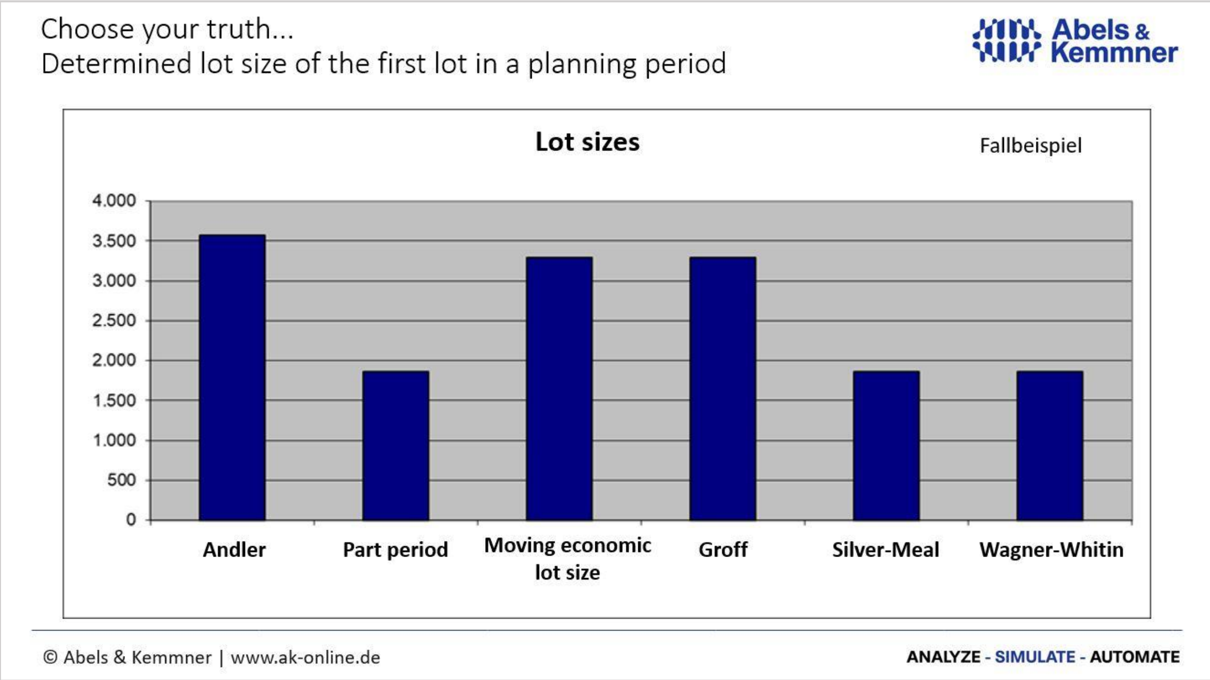

Fig. 3: Results of different economic lot sizing methods for the same demand time series

The “one” correct economic lot-sizing procedure does not exist

If different economic lot-sizing methods lead to significantly different lot sizes, the question arises, which method is closest to the "truth". It is not necessary to hit the economic lot size exactly; getting close enough to the correct value, would be enough. Unfortunately, practical experience proves that none of the lot-sizing formulas calculates sufficiently accurately to rely on a single economic lot-sizing procedure for all cases.

Fig. 4 shows a case study of the cost changes that would result over all production items if one of the six most common economic lot-sizing procedures were consistently applied to all items. Regardless of which of the lot-sizing procedures is used, the total costs would increase in all cases!

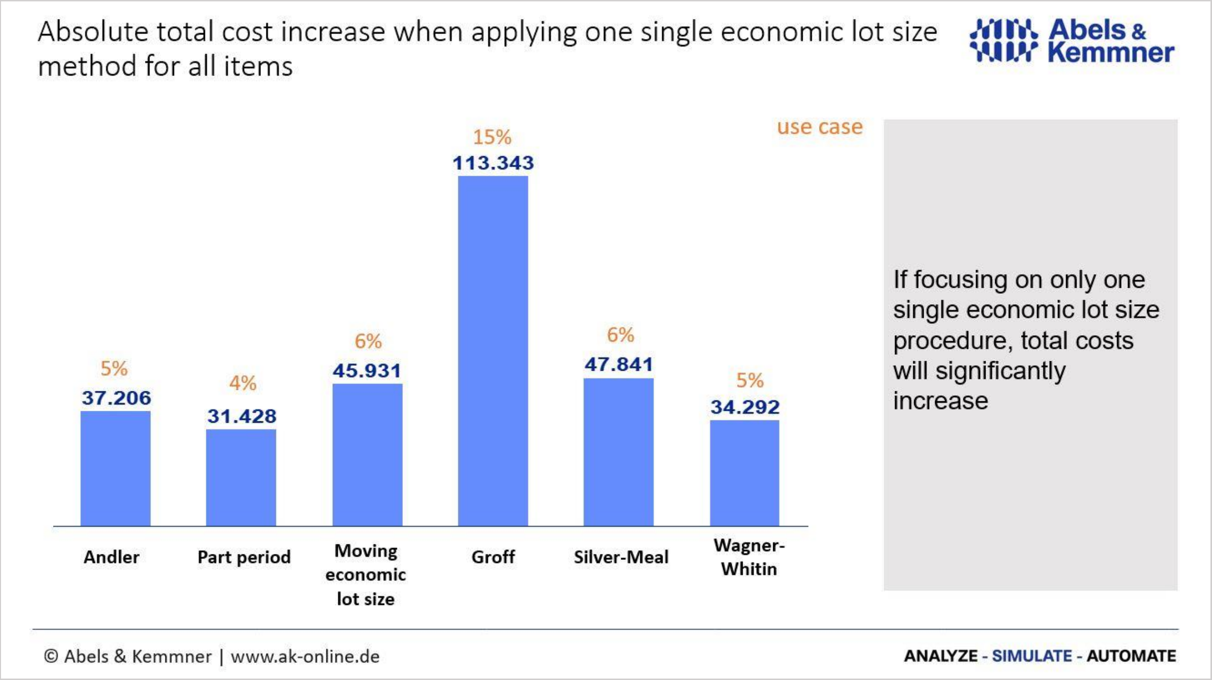

Fig. 4: If the economic lot sizes of all items are calculated with a single economic lot-sizing procedure, overall costs will increase; no matter which of the procedures is applied.

In practice, this effect is mostly unknown, although it is the biggest problem in the application of economic lot-sizing procedures. Unfortunately, it is not possible to recognise the cost-increase effect shown with the usual on-board tools in practice. This requires a more powerful approach, an empirical simulation.

How to find the best economic batch sizing method by simulation

We carried out the above presented analyses with the help of the softwaretool **DISKOVER**.

DISKOVER is an ERP optimisation system that can be used, among other things, to automatically update and maintain the scheduling parameters of an ERP system. The system adjusts the scheduling parameters in such a way that the most economical scheduling proposals are generated. To find the most economical parameter settings, DISKOVER applies a simulation function with which the economic effect of different parameters can be determined on the basis of empirical values from the past.

This simulation approach can also be used to determine for each article the economic lot-sizing procedure that leads to the lowest total costs. In the use case from which the above figures originate, it was possible to reduce the sum of the annual stockholding and lot initiation costs (=total costs) by more than €200,000, corresponding to 22% of the total costs before lot sizing optimisation.

Fig. 5 shows how often which of the various economic lot-sizing procedures was identified as optimal in the analysis example.

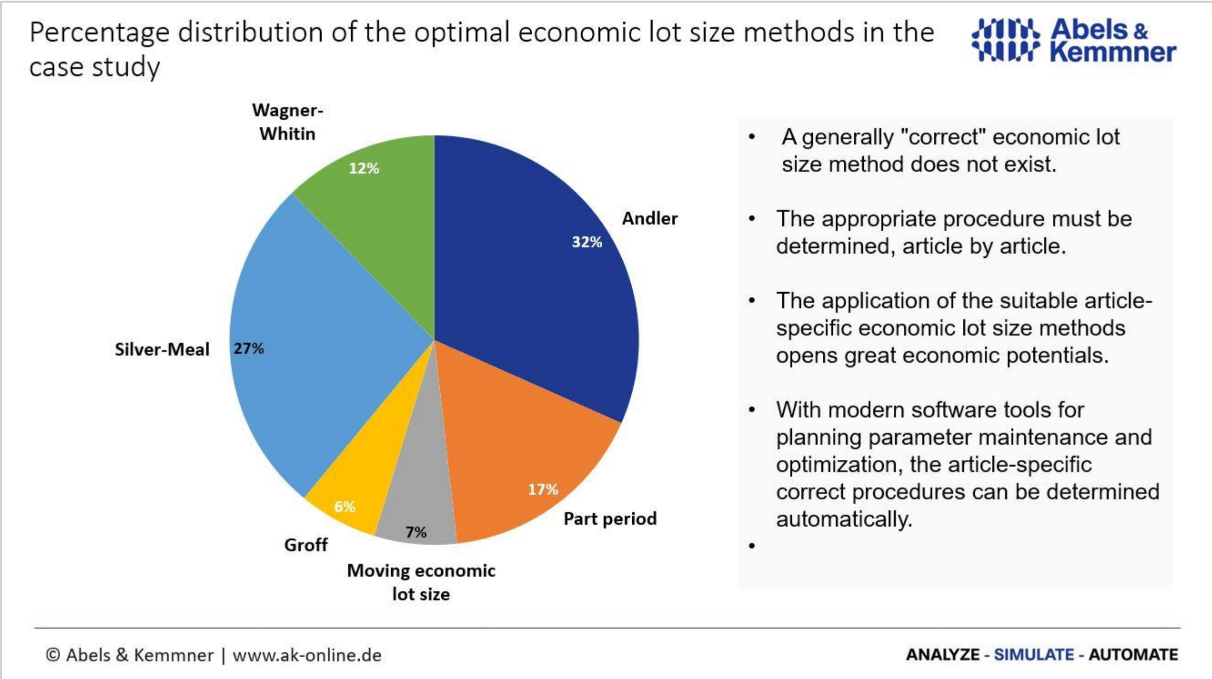

Fig 5: Percentage distribution of optimal economic lot-sizing procedures in an analysis project

The considerable cost saving potentials can easily and automatically be raised with modern software modules for optimising scheduling parameters, such as **DISKOVER**.

Don't be afraid of determining the costs when calculation economic lot sizes

While in practice almost nobody cares about the danger of incorrect economic lot-sizing procedures, there is much discussion about how to arrive at correct input costs for lot-sizing.

In general, two oppositely reacting types of costs are to be considered in economic lot-sizing procedures: on the one hand, the inventory costs and, on the other hand, the lot initiation costs, i.e. the procurement costs in the case of purchased articles or the set-up costs in the case of in-house production articles.

These two costs represent the two sensitive input variables for the calculation of economic lot sizes. In practice, the correct determination of these costs is usually seen as the greatest obstacle to the application of economic lot-sizing procedures. However, the issue of costs is less challenging than commonly feared.

Which costs are to be taken into account

Warehousing costs are made up of a whole range of cost types. In addition to the interest on capital employed, this also includes other, ofter much larger kinds of costs. These are mainly: costs for wear and tear, loss and breakage, transport and handling within the warehouse, storage and depreciation as well as warehouse management and insurance.

Procurement costs include all costs in the procurement process, especially ordering costs, quantity discounts, additional costs for unfavourable order quantities, transport, insurance and packaging costs and, if applicable, incoming goods and quality inspection costs. Accordingly, set-up costs in in-house production can also include more than just the costs for set-up. Order processing costs, cleaning costs and quality inspection costs, for example, might occur here too.

It is not possible to determine precise costs for every material number in every process. Usually, when considering inventory carrying costs and lot initiation costs, imputed values are used, which represent average values at least over a group of articles, sometimes over all articles. This normally leads to acceptable results.

Only variable costs count

It is important when considering costs that not the full costs but only the variable costs may be considered; an error that is frequently encountered in practice. Lot initiation costs or components of inventory carrying cost rates, which are independent of the lot sizing decision, play no role in determining the economic lot size.

Let's take the machine hourly rate as an example, which is often used to calculate set-up costs. A large part of the machine hourly rate consists of the depreciation costs, allocated to each hour of the budgeted equipment runtime. However, the depreciation costs do not increase proportionally with each hour of production of the equipment under consideration. Rather, they are incurred in full, so to speak, in the first second of the new business year. Whether work is done on this equipment once a year or five days a week does not change anything relevant about the depreciation costs.

Also inaccurate costs may lead to the proximity of the economic batch size

Fortunately, it is not necessary to set up a scientific research project to determine the costs. The effects of even significant deviations of the lot initiation costs or the inventory carrying cost rate from the "real" values usually do not lead to correspondingly large deviations in the determined optimal lot sizes.

Fig. 6 shows an example of how the optimal lot size changes if the calculation of the inventory carrying cost rate or the set-up costs is +/- 20% off the "real" values. If the inventory carrying cost rate were 20% too low, the calculation would result in an optimal lot size of 87 pieces compared to the "real" 77 pieces. On the "real" total cost curve, a batch size of 87 pieces would not lead to a serious shift in total costs compared to 77 pieces.

Furthermore, our experience shows that the average lot sizes applied prior to an economic lot size optimisation are significantly further away from the respective optimal lot sizes than the lot sizes resulting from imprecise cost values.

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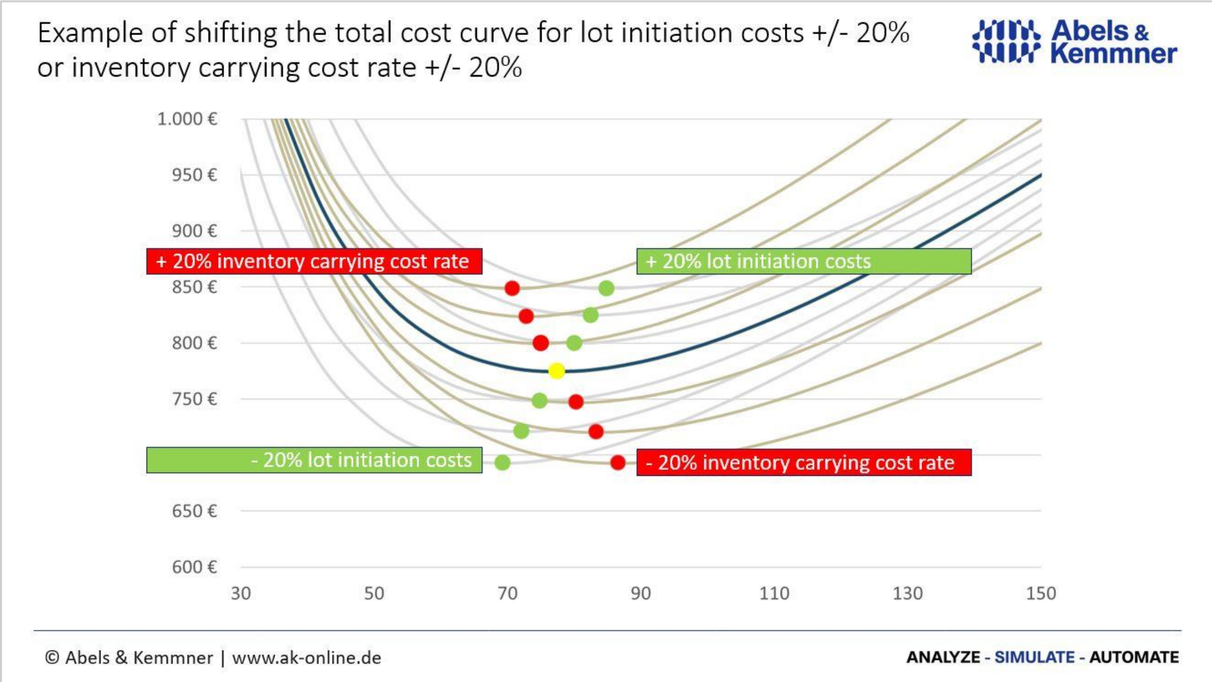

Fig. 6: Example of the shift in the total cost curve with lot initiation costs +/- 20% or inventory carrying rate +/- 20%.

Capacity limits must be checked

Once the most economical lot-sizing procedure has been identified for each article, the input costs have been determined with some degree of accuracy and economic lot sizes have been calculated for the articles under consideration, there is possibly still a small pitfall to be overcome.

All classical economic lot-sizing procedures consider single-stage, single-product production without capacity limitation. Neither are lot size dependencies between different storage levels considered, nor is production capacity, which may not be sufficient to produce all articles in the determined economic lot sizes. The lot-size dependencies between different storage levels can mostly be ignored in the dynamic situation in practice, not so the production capacities.

If economic lot sizes are to be calculated not only for a few in-house production items, but for a wide range, it is important to check whether the available production capacities are exceeded when applying the economic lot sizes. If lot size optimisation leads to significantly reduced production lot sizes, retooling has to be done more frequently and thus production capacity is occupied by retooling and can no longer be used for the production of parts. If the ERP system is able to determine the future capacity load from planned requirements, resulting production orders and applicable routings, such a bottleneck effects can easily be identified.

In such a case, an EPEI (every part every nterval) or a rhythm wheel calculation can be used to determine a batch size mix of the various production parts that fits to the existing production capacities. Powerful software tools for optimising scheduling parameters, such as DISKOVER, which has already been mentioned in the previous blog posts, can also carry out such capacity checks, trigger the possibly necessary EPEI calculation and enlarge the economic batch sizes adequately.

The digitalisation of supply chain management, makes economic lot size calculation a routine process

The determination of economic lot sizes is an essential component of optimising supply chain management. There are only few reasons not the use economic lot sizes.

However, digital tools of modern supply chain management are required to simply, consistently and reliably tap the cost reduction potential of economic lot sizes.

The costs of such tools are more than offset by the potential savings.

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