ECONSTOR Make Your Publications Visible.

A Service of

ZBW

Leibniz-Informationszentrum Wirtschaft Leibniz Information Centre for Economics

Wagner, Regina; Blecker, Thorsten

Conference Paper Material Requirements Planning under Phase-out Conditions

Provided in Cooperation with:

Hamburg University of Technology (TUHH), Institute of Business Logistics and General Management

Suggested Citation: Wagner, Regina; Blecker, Thorsten (2015) : Material Requirements Planning under Phase-out Conditions, In: Blecker, Thorsten Kersten, Wolfgang Ringle, Christian M. (Ed.): Operational Excellence in Logistics and Supply Chains: Optimization Methods, Data-driven Approaches and Security Insights. Proceedings of the Hamburg International Conference of Logistics (HICL), Vol. 22, ISBN 978-3-7375-4058-2, epubli GmbH, Berlin, pp. 73-95

This Version is available at: https://hdl.handle.net/10419/209282

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.



https://creativecommons.org/licenses/by-sa/4.0/

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.







Material Requirements Planning under Phase-out Conditions



ISSN (online): 2365-5070, ISSN (print): 2635-4430

Material Requirements Planning under Phase-out Conditions

Regina Wagner and Thorsten Blecker

In today's production environment with shortened product lifecycles, phase-outs, i.e. product elimination from production, become regular events. Badly planned phase-outs lead to high remaining stock levels after end of production, causing immense sunk costs. Previously performed 26 interviews revealed that this is a major challenge in current production (Grussenmeyer and Blecker, 2014; Grussenmeyer, Gencay and Blecker, 2014). Therefore, the objective of this paper is to develop a material requirements planning focusing on remaining stock induced costs during phase-out to plan optimal phase-out quantity and phase-out date. The research is conceptually driven and proposes an example of the methodology.

Keywords: Phase-Out, Product Elimination, Production Planning and Control, Remaining Stock Costs

1 Introduction

Shortened product life cycles are significant current trends of supply networks (Bakker, Wang, Huisman and den Hollander, 2014, p.10). They lead to frequent product changes in order to satisfy customer's demand (Slamanig, 2011, p.46).

Enabling successful product's ramp-ups requires production capacities availability. Since 80% of the new products are symmetrical replacements (Saunders and Jobber, 1988), companies use the old generation's production plant as well for the replacement's manufacturing, implying an equipment change. Thus, the old product needs to be eliminated in order to release the demanded production capacity (Vyas, 1993, p.68). Product elimination implementations mostly are realized as phase-outs (Avlonitis, 1983; Mitchell, Taylor and Tanyel, 1998; Baker and Hart, 2007), and their success depends on phase-out's process quality (Prigge, 2008). The need of having good phase-out processes is also described by practitioners (Holzhäuer and Riepl, 1996, p.49). Still, very few research deals with phase-out and its processes.

Phase-out can be described in a four-stage process, starting after product elimination decision-making. The two main stages are planning and implementation, framed by definition and finalization, describing the actual dealing with phase-out in the production department.

To successfully produce products, and therefore, as well to phase-out products, companies use production planning and control (PPC). Adopting this, especially the material requirements planning is a key issue in phase-out planning for not having any remaining stock after end of production (Holtsch, 2009; Hertrampf, 2012). To appropriately plan material requirements, this publication presents a methodology to estimate remaining stock costs.

The outline of this publication is as follows. After reviewing literature in chapter 2, equations to calculate remaining stock costs are elaborated in chapter 3. The following chapter 4 presents a phase-out example to demonstrate the methodology's functionalities. Chapter 5 summarizes the results.

2 Literature Review

Eliminating products from the company's portfolio is considered as an uninspiring and depressing task (Eckles, 1971, p.72) Nevertheless, in today's competitive environment, it is becoming more and more important (Prigge, 2008, p.100). After elimination decision-making, the implementation strategy needs to be determined (Avlonitis, Hart and Tzokas, 2000, p.54). From marketing point of view, five options are available, namely drop immediately, phase-out immediately, phase-out slowly, sell-out and drop from standard and re-introduce as special strategies (Baker and Hart, 2007, p.478).

2.1 Product Phase-Out

From a production point of view, only the phase-out strategies are interesting to investigate due to several reasons. The drop immediately strategy implies a direct machine stop, without any potential for improvement. The sell-out and drop strategy only induce marketing activities. In cases of plant sale, production does not change, while when product's rights are sold by ending production, a phase-out takes place. The situation is similar to the drop strategy. Even though the product might be re-introduced as a special after its normal end of production, it necessarily has to be phased-out before. Thus, this paper deals with the planned phase-out of a product.

In literature, product phase-out definitions are not clear. Apart from the fact that many authors use the term without defining it before (e.g. Inness, 1994; Holzhäuer and Riepl, 1996; Aurich, Naab and Barbian, 2005; Kotler and Armstrong, 2010) other definitions only include the production reduction from full capacity run to end of production (e.g. Kirsch and Buchholz, 2008; Ostertag, 2008; Scholz-Reiter, Baumbach and Krohne, 2008; Elbert, 2011) without considering any planning. Therefore, we define the product phase-out as "process, enabling companies to eliminate a product. The phase-out is subsequent to the phase-out decision and starts with the planning. The phase-out ends with the finalization after the end of production" (adopted from Grussenmeyer and Blecker, 2014, p.185).

Several authors assume a correlation between the market's decline phase and product phase-out (e.g. Aurich and Naab, 2006; Hertrampf, Nickel and Nyhuis, 2010) even though Avlonitis (1990, pp.55–60) detected that products are eliminated irrespective of their position in the product life cycle. Consequently, a phase-out may also take place at any time during the product's life.

2.2 Planning and Controlling Product Phase-Outs

Holtsch (2009, pp.54–60) described that previous publications do not deal with phase-out PPC. He then developed an 8-phase phase-out reference

process intending to give industry a guideline to plan and control phaseout (Figure 1).



Figure 1 Phase-out Control Process; Source: Holtsch (2009, p.62)

The phase-out PPC process presented by Holtsch is limited to phase-out induced remaining stock costs without referring to any further phase-out aspects. In addition, he does not follow any of the existing PPC models (e.g. Hornung, 1996; Hackstein, 1989; Lödding, 2005; Schuh, 2006) which he analyzed in his work. Holtsch (2009, p.111) only adds four activities to production plan generation and one function to make-or-buy decision-making to the Aachener PPS Modell (Aachen PPC Model Hornung 1996).

In his first process stage – phase-out decision-making – he aggregates requirements of different stakeholders without giving any elimination decision-making model on how to decide to phase-out, and without referring to any product elimination literature. For the second process stage – component identification – he develops a phase-out cube, with the three dimensions (ranging from N via O to P) phase-out coefficient, normative range of stock and normative stock value (as described in Holtsch (2009, p.74)). The cube's axes seem to have different relevance (e.g. NPO = neutral / OPN = dispositive adoption / PNO = phase-out relevant), where the phaseout coefficient is the main influence factor, but no justification is given. The third process stage is to calculate the expected remaining stock costs (inventory multiplied by unit costs) for all product components. This formula does not include multi-variant phase-outs where there might not only be one optimum phase-out day. At this stage, only unit costs are considered, i.e. remaining stock handling costs are entirely neglected. Furthermore, the amount of items or parts expected to become remaining stock is considered as input variable, obliging the companies themselves to develop calculation models. Process stages four and five summate all part's costs during phase-out (inventory costs, remaining stock costs, process costs, as well as income or losses from remaining stocks options) in addition to general phase-out management costs. In the sixths process stage, all options are then balanced to obtain the maximum profit. Process stage seven, i.e. phase-out control, is described as standard control loop without detailing any methodologies applicable. The author also describes how to perform multiphase-outs (subsequent or parallel) by adopting the control loop, but he does not include multi phase-outs into his planning process (Holtsch, 2009, pp.61–109). Therefore, it is necessary to develop a phaseout PPC model complying with specific phase-out objectives.

To close the first part of this gap, a methodology how to really calculate the expected remaining stock at end of production and its induced costs is presented in the following chapter.

3 Expected Remaining Stock

Material requirements planning can follow stochastic, deterministic and heuristic approaches. In general, stochastic models are applied for high

volume, low cost products, while deterministic models are used for high costs, low volume products. New products or products with unknown demand are calculated with heuristic models; which are therefore not relevant for phase-out. All models include decisions on production and inventory quantities and the identification of relevant costs, e.g. variable production costs, setup costs, and inventory costs. Similar to standard production planning, a phase-out plan is created in a rolling horizon fashion, to be updated after implementing the first decisions. The revised plan minimizes demand forecast and production uncertainties (Graves, 2001, p.730). Production planning figures are non-negative integers ($\in \mathbb{N}_0$).

The first planning step is to determine the amount of lots for every part j to be purchased during phase-out for producing all phase-out items i following the standard deterministic approach. The result then needs to be compared to existing contract limitations, e.g. lot sizes, which lacks in existing literature. For example. Hertrampf (2012) only reduces lot sizes by incorporating risk costs and Holtsch (2009) does not consider lot size limitations.

$$aPL_{jt} = \begin{cases} \left[\frac{\sum_{i=1}^{l} ar_{ij} \cdot \left[\frac{n_{it}}{LS_{it}} \right] \cdot LS_{it} - s_{jt-1} + sp_{jt}}{PLS_{jt}} \right] & if \quad n_{it} > 0 \qquad (1) \\ 0 & else \end{cases}$$

$$ar_{ij}, PLS_{jt} > 0$$

$$\forall i \in I, j \in J, t \in T$$

ao_{it} amount of items i ordered in period t [pcs]

aPL_{jt} amount of procurement lots of part j in period t [u/m]

ar_{ij} amount of part j required for item i [pcs/pcs]

LS_{it} production lot size of item i in period t [pcs/(u/m)]

n_{it} need of item i in period t [pcs], i.e. $ao_{it} - s_{it-1}$ [pcs]

PLS_{jt} procurement lot size of part j in period t [pcs/(u/m)]

 $Q_j(\tau)$ repair parts order quantity [pcs]

sp_{jt} spare parts need of part j in period t [pcs] (equation (2))

sit-1 stock of item i at the beginning of period t [pcs]

s_{jt-1} stock of part j at the beginning of period t [pcs]

subject to

$$Q_j(\tau) = \sum_{t=1}^{I} sp_{jt} \quad \forall j \in J$$
⁽²⁾

To determine the spare parts order quantity $Q_j(\tau)$ and the spare parts need sp_{jt}, please consult the publication of Sahyouni et al (2010, p.794) who present a deterministic optimization model.

Equation (1) calculates the ceiling of the necessary procurement lots of part j, i.e. the smallest integer greater or equal to the equation. The equation combines information of the quantity bill of materials with the existing demand subtracted by items i on stock. The division by the procurement lot size directly links the calculated need to procurement limitations. It is necessary to summate over all items i to obtain the parts' need for all phase-out items. For any situation where the amount of orders can already be covered by the stock on hand, the procurement lot size decreases to zero. Multiplying the amount of procurement lots with the lot size gives the stock level of part j, as given in equation (3).

$$s_{jt} = aPL_{jt} \cdot PLS_{jt} + s_{jt-1} \quad \forall j \in J, t \in T$$
(3)

- aPL_{jt} amount of procurement lots of part j in period t [u/m] (eq. (1))
- PLS_{jt} procurement lot size of part j in period t [pcs/(u/m)]
- s_{jt} stock of part j at end of period t [pcs]
- s_{jt-1} stock of part j at the beginning of period t [pcs]

The amount of stock serves to calculate the amount of lots that can be produced, taking now into account the given production lot size which is determined by the company and its suppliers. To do so, equation (4) divides the not-blocked stock of part j by the amount of parts j required to produce one item i and by the production lot size (part consumption). To not obtain half lots, the largest integer less than or equal to the equation is calculated (floor calculation), thus differing from the ceiling calculation in equation (1). The company needs enough parts procurement lots to produce (= rounding up), leading to a limited amount of item's production lots (= rounding).

$$aL_{ijt} = \left| \frac{s_{jt} - sp_{jt}}{LS_{it} \cdot ar_{ij}} \right| \quad \forall i \in I, j \in J, t \in T$$
(4)

$$ar_{ij}, LS_{it} > 0 \quad \forall i \in I, j \in J, t \in T$$

- aL_{ijt} amount of production lots of item i in period t with given part j [u/m]
- ar_{ij} amount of part j required for item i [pcs/pcs]

LS_{it} production lot size of item i in period t [pcs/(u/m)]

- s_{jt} stock of part j at end of period t [pcs] (eq. (3))
- sp_{jt} spare parts need of part j in period t [pcs] (eq. (2))

Since all different parts j have different procurement lot sizes and different consumptions per item i, equation (4) will provide several solutions for the amount of production lots for item i and period t; one value for every part j. To include all parts j given in the bill of materials to produce item i only the smallest number of lots as calculated in equation (4) may be produced with the given stock of materials. The necessary calculation is formulated in equation (5).

$$aLm_{it} = \min_{\substack{\to j \in J}} \{aL_{ijt}\} \quad \forall i \in I, t \in T$$
(5)

aLijt

amount of production lots of item i in period t with given part j [u/m] (eq. (4)) aLm_{it} minimum amount of production lots for item i in period t [u/m]

The expected item's i remaining stock needs to be calculated despite the fact that the calculation started with the initial amount of orders, due the rounding procedures in equation (1) and (4) leading to additional items i produced, that cannot be sold. Equation (6) calculates the item's i remaining stock, i.e. maximum amount of items i available at the end of period t (from stock or production), considering production and procurement lot size constraints leveraged by the amount of items ordered. When the time period t corresponds to the time between phase-out beginning and end of production, the amount of production lots times the production lot size is the phase-out quantity.

$$RS_{it} = aLm_{it} \cdot LS_{it} + s_{it-1} - ao_{it} \quad \forall i \in I, t \in T$$
(6)

- aLm_{it} minimum amount of production lots of item i in period t [u/m] (eq. (5))
- ao_{it} amount of items i ordered in period t [pcs]
- LS_{it} production lot size of item i in period t [pcs/m/u]
- sit-1 stock of item i at the beginning of period t (t-1) [pcs]
- RS_{it} remaining stock of item i at the end of period t [pcs]

In addition to the item's i remaining stock, the remaining stock amount of every part j is a set of stock balance constraints that equate the supply of all parts j in a period with its demand for producing item i. In any period t, a certain amount of parts is ordered, while others are already stocked. The available parts are then consumed to produce the item or to store them as spare parts. Due to the fact that normally more parts are procured than sold, stock remains (equation (7)).

$$RS_{jt} = s_{jt-1} - sp_{jt} + aPL_{jt} \cdot PLS_{jt} - \sum_{i=1}^{l} aLm_{it} \cdot ar_{ij} \cdot LS_{it} \quad \forall j$$

$$\in J, t \in T$$
(7)

- aLm_{it} minimum amount of production lots for item i in period t [u/m] (eq. (5))
- aPL_{jt} amount of procurement lots of part j in period t [u/m] (eq. (1))
- arij amount of part j required for item i [pcs/pcs]
- I number of phase-out items using part j
- LS_{it} production lot size of item i in period t [pcs/(u/m)]
- PLS_{jt} procurement lot size of part j in period t [pcs/(u/m)]
- RS_{jt} amount of remaining stocks of part j at the end of period t [pcs]
- s_{jt-1} stock of part j at the beginning of period t [pcs]
- sp_{jt} spare parts need of part j in period t [pcs] (eq. (2))

The calculated remaining stock from equation (7) is multiplied with the sum of the unit price per part j (i.e. the purchase price) and the remaining stock costs (equation (8)). The latter costs depend on the chosen remaining stock handling option chosen for part j (e.g. sale, recycle, or scrap). For sale situations where some income is generated, the cost is negative to reduce the expected remaining stock costs.

$$ecRS_{jt} = \begin{cases} RS_{jt}(pu_{jt} + cRS_{jt}) & if \quad RS_{jt} > 0 \quad \forall j \in J, t \in T \\ 0 & else \end{cases}$$
(8)

Source: Adopted from Hertrampf (2012, p.37)

- cRS_{jt} unit costs for the remaining stock handling option according to the existing remaining stock option of part j (Holtsch, 2009, p.95) [€/pcs]
- ecRS_{jt} expected remaining stock costs for remaining stock of part j at the end of period t [€]
- pu_{jt} unit price per part j in period t [€/pcs]
- RS_{jt} amount of remaining stocks of part j at the end of period t [pcs] (equation (7))

At this point it is reasonable to estimate a valuation at the part's replacement costs for pu_{jt}, for two reasons. First, following the first-in-first-out (FIFO) principle will in many situations reduce previous period's stock (s_{jt-1}) to zero. Second, planning periods should be relatively short so the difference between procurement costs of two subsequent periods is neglectible. For an entirely exact calculation, the procurement costs need to be discounted together with the storage costs that emerged by that date depending on the time every part j was bought (also not specified by Hertrampf (2012)).

The phase-out coefficient represents the usage degree of one part j in the phase-out item i and in other items I (Holtsch, 2009, p.74). A coefficient of less than one indicates a further use of part j in other items I and that any part's remaining stock can be "sold" to another product, thus, generating

a revenue the unit price to eliminate the part from calculation $pu_{jt} = -cRS_{jt}$. Those parts j do not create any loss for the remaining stock costs calculation. Equation (9) shows the phase-out coefficient.

$$cPO_j = \sum_{t=1}^{T} \frac{\sum_{i=1}^{I} (ar_{ij} \cdot ao_{it})}{\left(\sum_{l=1}^{L} ar_{lj} \cdot ao_{lt} + \sum_{i=1}^{I} ar_{ij} \cdot ao_{it}\right)} \quad \forall j \in J$$
(9)

$$ar_{lj}, ar_{ij} > 0 \quad \forall i \in I, j \in J, l \in L, t \in T$$

Source: Holtsch (2009, p.74)

ao _{it}	amount of phase-out items i ordered in period t [pcs]
aolt	amount of orders of alternative item I in period t [pcs]
ar _{ij}	amount of part j required for item i [pcs/pcs]
arıj	amount of part j required for item I [pcs/pcs]
cPOj	phase-out coefficient of part j [0;1]
I	number of phase-out items i
L	number of alternative use in other items I
Т	number of time periods until end of planning horizon

Parts j that might be used in next generation versions of item i might also be sold in future, which is not considered in equation (9). In those cases the expected remaining stock handling option would be storage and positive revenue after item's i end of production at the level of the unit price per part j. Similar to calculating the part's remaining stock costs in equation (8) also the remaining stock costs of the surplus items is calculated in equation (10), following an identical assumption. It is highly likely that companies sell remaining stock to at least obtain a lower-than-normal revenue (i.e. negative cRS_{it}), such as IBM who in 1998 generated a loss of \$1 billion due to excess PC inventory at their dealers which were sold at low special offer prices (Bulkeley, 1999).

 $ecRS_{it} = \begin{cases} RS_{it}(cp_{it} + cRS_{it}) & if \quad RS_{it} > 0 \quad \forall i \in I, t \in T \\ 0 & else \end{cases}$ (10)

Source: Adopted from Hertrampf (2012, p.37)

- cp_{it} unit cost of production for item i in period t [€/pcs] (in general: material procurement costs, manufacturing costs and related overhead)
- cRS_{it} unit costs for the remaining stock handling option of item i $[\mbox{\ensuremath{\varepsilon}}/\mbox{pcs}]$
- $\label{eq:rescaled} ecRS_{it} \quad expected remaining stock costs for remaining stock of item i at the end of period t [€]$
- RS_{it} amount of remaining stock of item i at the end of period t [pcs] (eq. (6))

Equation (11) gives the total expected remaining stock costs for all parts j and the phase-out item i for every period t over the planning horizon of T periods until end of production.

Concluding, equations (1) to (11) calculate the company's total remaining stock costs at the end of any period with a given amount of orders. For situations with only one phase-out item, the index i becomes 1.

$$tcRS_t = \sum_{i=1}^{I} ecRS_{it} + \sum_{j=1}^{J} ecRS_{jt} \quad \forall t \in T$$
(11)

- $ecRS_{it}$ expected remaining stock costs for remaining stock of item i at the end of period t [€] (equation (10))
- ecRS_{jt} expected remaining stock costs for remaining stock of part j at the end of period t [€] (equation (8))
- I number of phase-out items
- J number of parts
- tcRSt total remaining stock costs of all parts in period t [€]
- T number of time periods

4 Phase-out Example

To better understand the equations described above, this chapter offers an example to calculate remaining stock costs for one phase-out item i consisting of five parts j (j1-j5). Production lot sizes is $LS_{it} = 45$, and $s_{it-1} = 50$ items are already on stock. Let us assume the following further values:

Input variable	i1	i2	i3	i4	i5
ar _{ij}	1	2	3	4	5
PLS _{jt}	50	40	28	20	10
pu _{it}	3	2	58	17	31
cRS _{jt}	10	10	10	10	10
S _{it-1}	5	4	3	2	50

Table 1 Input Variables for Phase-Out Example

Table 2Amount of Items Ordered in Periods t1-t6

	t1	t2	t3	t4	t5	t6
a0 _{it}	75	10	25	54	43	77

Table 3Amount of Items Ordered in Periods t7-t12

	t7	t8	t9	t10	t11	t12
aOit	90	100	12	23	97	49



Figure 2 Expected Remaining Stock Costs per Period

Figure 2 shows a sample calculation of the expected remaining stock costs over 12 periods of the phase-out item i.

As given in the formulas above the remaining stock costs depends on the demand, the procurement and production lot sizes, the inventory at hand, as well as costs for remaining stock handling and procurement / production unit costs.

In the given example the company will need to pay ca. \leq 6.000 of remaining stock costs at the end of period t12, consisting out of \leq 4.200 for handling the remaining stock of the item itself and \leq 1.800 for handling the parts' remaining stock.

Figure 2 clearly shows that remaining stock costs differ strongly from period to period. The lowest amount may be achieved at the end of period t2; the highest amount needs to be paid at the end of period t7. The latter costs are more than twice times period t2 costs.

5 Summary and Conclusions

This research introduces a methodology to calculate expected remaining stock costs at end of production as add-on to material requirements planning within PPC. After a brief literature review, eleven equations are presented which serve to calculate first, the expected remaining stock quantity, and second, resulting costs. An example shows the methodology's functionalities.

This paper closes the gap in research by addressing the missing link of quantity and cost calculation in remaining stock investigations. By now, only costs were analyzed, expecting remaining stock quantity as given input.

Using the presented equations supports companies first of all in knowing the expected remaining stock costs level. In a further step companies may now decide basing on the new information to take different means for reducing the expected stock. One option is to end production earlier, i.e. to not meet the entire demand. In the example, period t2 is the month with least remaining stock costs. Yet, the company most probably will need to offer a penalty payment or a replacement product to the customer. This makes choosing period t2 less likely, but period t9 could then become interesting. But a further aspect changing the situation is that at the end no remaining stock of the item itself will be available (it is not reasonable to scrap remaining stock and pay penalty for unmet demand at the same time), so only the parts' remaining stock will be regarded, which would shift it to period t10 in the given example. Yet, also the amount to be paid for not meeting the demand needs to be considered, which consists of penalty costs and lost profit.

Alternatively, companies might try to reduce item's stock by selling them to a lower (cost-covering) price and to reduce part's stock by reducing procurement lot sizes where possible. Calculating appropriate lot size amounts is presented in Hertrampf's (2012) publication.

The next steps in research are therefore to include unmet demand (lost sales) and additional production runs to consume remaining parts into the methodology. Then, companies are enabled to thoroughly decide which remaining stock reduction measure is the most appropriate for their given situation.

References

- Aurich, J.C. and Naab, C., 2006. Organization of the run-out phase in production projects. Production Engineering, XIII(1), pp.153–156.
- Aurich, J.C., Naab, C. and Barbian, P., 2005. Systematisierung des Serienauslaufs in der Produktion. Zeitschrift f
 ür wirtschaftlichen Fabrikbetrieb, 100(5), pp.257– 260.
- Avlonitis, G.J., 1983. The product-elimination decision and strategies. Industrial Marketing Management, 12(1), pp.31–43.
- Avlonitis, G.J., 1990. 'Project Dropstrat': product elimination and the product life cycle concept. European Journal of Marketing, 24(9), pp.55–67.
- Avlonitis, G.J., Hart, S.J. and Tzokas, N.X., 2000. An analysis of product deletion scenarios. Journal of Product Innovation Management, 17(1), pp.41–56.
- Baker, M.J. and Hart, S., 2007. Product elimination. In: Product strategy and management, 2nd ed. Harlow u.a.: FT Prentice Hall, pp.440–525.
- Bakker, C., Wang, F., Huisman, J. and den Hollander, M., 2014. Products that go round: exploring product life extension through design. Journal of Cleaner Production, 69, pp.10–16.
- Bulkeley, W.M.B.S.R. of T.W.S., 1999. IBM discloses PC pretax loss of nearly \$1 billion last year. The Wall Street journal. 25 Mar.
- Eckles, R.W., 1971. Product line deletion and simplification: tough but necessary decisions. Business Horizons, 14(5), pp.71–74.
- Elbert, N., 2011. Auslaufmanagement in der Logistik Untersuchung der Pfadabhängigkeit im Produktlebenszyklus am Beispiel der Automobilindustrie. Veszprém, Ungarn.
- Graves, S.C., 2001. Manufacturing planning and control. In: P.M. Pardalos and M.G.C. Resende, eds., Handbook of applied optimization. New York, N.Y: Oxford University Press, pp.728–746.

- Grussenmeyer, R. and Blecker, T., 2014. Aligning Product Phase-Out with New Product Development. In: Grubbström, R.W.;Hinterhuber, H.H., (Eds): PrePrints, Volume 1. 18th International Working Seminar on Production Economics. Innsbruck, Austria, pp.183–194.
- Grussenmeyer, R., Gencay, S. and Blecker, T., 2014. Production Phase-out During Plant Shutdown. Proceedia CIRP, 19, pp.111–116.
- Hackstein, R., 1989. Produktionsplanung und -Steuerung (PPS): Ein Handbuch für die Betriebspraxis. Düsseldorf: VDI.
- Hertrampf, F., 2012. Auslaufmanagement in Produktionsnetzen. Berichte aus dem IPH. Garbsen, Germany: PZH.
- Hertrampf, F., Nickel, R. and Nyhuis, P., 2010. Efficient phase-out planning by alignment of lot sizes in supply chains. In: Proceedings. 43rd CIRP International Conference on Manufacturing Systems. Wien, pp.860–867.
- Holtsch, P., 2009. Planung und Steuerung von Produktionsausläufen in der Elektronikindustrie. Berichte aus dem IPH. Garbsen: PZH, Produktionstechn. Zentrum.
- Holzhäuer, R. and Riepl, K., 1996. Der 'geordnete' Produktauslauf. IO Management, 65(4), pp.49–50.
- Hornung, V., 1996. Aachener PPS-Modell: Das Aufgabenmodell. 4th ed. Sonderdruck 6/94. Aachen: Forschungsinstitut für Rationalisierung (FIR).
- Inness, J.G., 1994. Achieving successful product change: a handbook. Financial times. London, UK: Pitman.
- Kirsch, T. and Buchholz, W., 2008. An- und Auslaufmanagement logistische Herausforderungen am Anfang und Ende des Produktlebenszyklus. Industrie Management, 24(3), pp.45–48.
- Kotler, P. and Armstrong, G.M., 2010. Principles of marketing. 13th ed. Upper Saddle River, N.J: Pearson Education.
- Lödding, H., 2005. Verfahren der Fertigungssteuerung: Grundlagen, Beschreibung, Konfiguration. Berlin: Springer.
- Mitchell, M., Taylor, R. and Tanyel, F., 1998. Product elimination decisions: a comparison of American and British manufacturing firms. International Journal of Commerce and Management, 8(1), pp.8–27.

- Ostertag, R., 2008. Supply-Chain-Koordination im Auslauf in der Automobilindustrie. Wiesbaden: Gabler.
- Prigge, J.-K., 2008. Gestaltung und Auswirkungen von Produkteliminationen im Business-to-Business-Umfeld: eine empirische Betrachtung aus Anbieter- und Kundensicht. Wiesbaden: Gabler.
- Sahyouni, K., Savaskan, R.C. and Daskin, M.S., 2010. The effect of lifetime buys on warranty repair operations. Journal of the Operational Research Society, 61(5), pp.790–803.
- Saunders, J. and Jobber, D., 1988. An exploratory study of the management of product replacement. Journal of Marketing Management, 3(3), pp.344–351.
- Scholz-Reiter, B., Baumbach, B. and Krohne, F., 2008. Integriertes Auslaufmanagement - Anforderungen an ein zielorientiertes Kennzahlensystem zur effizienten Durchführung von Produktausläufen. Industrie Management, 24(5), pp.74–78.
- Schuh, G. ed., 2006. Produktionsplanung und -Steuerung: Grundlagen, Gestaltung und Konzepte. Berlin: Springer.
- Slamanig, M., 2011. Produktwechsel als Problem im Konzept der Mass Customization: theoretische Überlegungen und empirische Befunde. Wiesbaden: Gabler.
- Vyas, N.M., 1993. Industrial Product Elimination Decisions: Some Complex Issues. European Journal of Marketing, 27(4), pp.58–76.