The rediscovery of postponement preparing for the next millennium mass customized supply chain
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THE REDISCOVERY OF POSTPONEMENT
PREPARING FOR THE NEXT MILLENIUM
MASS CUSTOMIZED SUPPLY CHAIN

Abstract
This paper reviews available work on postponement based upon the notion that there is a growing
attention for the concept in research and practice. This is driven by the move towards mass
customization in supply chains. There is however, a lacking integration and cross-fertilization between
research(areas). This fragmentation implies that new work has a reduced impact on knowledge
creation. This paper develops an integrated categorization of available publications and identifies
white gaps in knowledge. Challenges for content and method of research in the new supply chain
context are formulated to support more robust and integrated research into the next millenium.

Key-words: Literature review, postponement, supply chain

1. Introduction

As markets become more turbulent, product life cycles shorten, both product variety and
complexity increases and customer demands escalate, windows of opportunity become narrower and
more transitory and companies have to seriously consider manufacturing and marketing to individual
customers, as opposed to mass markets. As a result frame-breaking strategies become a necessity
(Achrol, 1991). Mass customization is frequently presented as a strategy that matches this ambition to
customize. Its popularity in the international business community is significant. This is not so
surprising as it aims to combine agile customization of products with lean production efficiency within
one supply chain (Anderson and Narus, 1995; Kahn, 1998). It breaks with the dilemma that one has to
choose between low volume – high variety and high volume – low variety (Gilmore and Pine, 1997;
Kotha, 1995).

With mass customization coming to the forefront of international supply chains, as a
managerial response to increasing market turbulence, postponement is given consistent mention as one
of the central features of the emerging organization forms. Oleson (1998) points at the need to shift
from make to inventory to make to order, in order to enable agile responsiveness to customers. Lampel
and Mintzberg (1996) observe a general trend towards a combination of standardized design,
standardized fabrication and customized assembly and distribution. Whereas Pine (1993) identified
customized final assembly of products from generic modules as the best option for achieving mass
customization option. What these points reflect is the system of combining speculative supply and
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fabrication with postponed assembly and delivery. This reflects the 1980 (!) perspective from Bowersox et. al. (1980) at innovative ways to improve productivity in (marketing) channel structures; 1. the postponement of customer-specific product assembly, combined with 2. rapid delivery directly to the customer instead of through multiple echelons of speculative inventory, and 3. non-stock-holding dealers that order from distribution centers (Bowersox et al. 1980).

Also Feitzinger and Lee (1997) explicitate the role of postponed manufacturing in making mass customization happen (“Mass customization at HP, the power of postponement”). Dittman, VP of Whirlpool, furthermore, highlighted the managerial interest in using postponement in adopting mass customization:

"The strategic intent to strive for mass customization is one thing, the process and systems to accomplish it are another. The journey towards this vision of a true pull environment (postponement) will no doubt be evolutionary, far from linear. [...] A relation with strategy is a prerequisite for global leverage."

It may be well known to the academic audience that postponement theory dates back to the founding article of Bucklin in 1965. In a personal conversation with the author Prof. Bucklin stated:

"Postponement was introduced in the 1960s but look at all the speculative inventory that is still stored in the channel."

Does the growing stream of recent publications on postponement in various disciplines (see for example: Feitzinger and Lee, 1997 in strategy; Garg and Tang, 1997 in operations research; Pagh and Cooper, 1998 in logistics), taken together with the stated interest of managers, reflect that after a 30 years incubation period the principle is finally actively integrated in managerial practice and academic research? The consistent reference to the value of postponement within logistics strategy and capability development by Bowersox et al. (1980, 1992, 1995) and the work on postponement continued and published in the 1980s by Zinn (1988, 1990) suggest the opposite for academic research. Postponement is not new on the research agenda as indicated by important journal publications over the last two decades, including logistics, marketing and operations. The well known case examples of companies that have grown (Dell, see Magretta, 1998) and flourished (HP, see Feitzinger and Lee, 1997) based upon postponement, also suggest the opposite regarding managerial practice; postponement is not new in conceptualization, nor in application by innovative companies. Perhaps we should rather interpretate the growing interest in, and application of, postponement as a rediscovery of the concept. The question then becomes: "what is new and what has changed".

Apparently the market has changed. The need for mass customization and agility is driven by market circumstances. It may be that, as part of the answer to the demanding market and business environment, postponement is becoming a requirement in today’s business-world, instead of just another concept to consider. What is new may also be the organizational context of supply chain
management that enables the application of postponement. Whereas traditionally mass production might not have favored postponement, the new format of supply chain management might do so. Indeed, mass production focuses on large batches and economies of standardization, not customization of single products. Supply chain management on the contrary, places the customer central to its efforts, thus raising the relevance of postponement.

If we are indeed going through a rediscovery of postponement in research, we need to ask ourselves two more questions: "What do we already know and what do we need to learn about postponement in the new business environment and organizational context that we did not already know?" Unless we build on from where knowledge creation had already brought us and contribute to a better understanding of the "rules of the new game", the rediscovery of postponement may rapidly turn out to be a fad.

This is especially relevant because, in spite of the recent attention, insights in postponement still appear to be somewhat underutilized. Most authors reference the founding work by Bucklin but more recent publications are less often referenced, and apparently, these publications have a reduced impact on the theory development. Furthermore, postponement research is not well integrated across disciplines, whereas a thorough review that organizes and summarizes research is lacking. As a result it is unclear what exactly has been learned from research and what unresolved questions remain. The purpose of this paper is to address this concern by providing such a review. This paper reviews literature on postponement available to date and published in academic journals or books with the aim of comparing and categorizing existing knowledge. Publications on postponement originate from a wide field of operations management, including operations research, logistics, marketing and since recently even strategic management. The categorization is than used to identify gaps in research and knowledge as an input to the further rediscovery of postponement.

2. Elements of the categorization

Both content and method of study can be used in a categorization of available literature. Starting with content, table 1 lists a number of publications that recently added to the understanding of postponement by adding elements to the way postponement is defined and approached. This section not only introduces publications but also summarizes relevant elements of its contribution. The categorization developed in this paper is method and content driven by nature.

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1 Textbooks such as Bowersox and Closs (1996) and Stern et al. (1995) also mention postponement but are not included in the review; within the function of a textbook these publications explain the basics of postponement but do not present new research and findings.

2 This list of publications is far from complete, the complete list of available publications will be provided starting in table 2 and further on throughout the paper. The objective of table 1 is to provide insight into the elements included in the definition of postponement as a research subject.
2.1. Elements of postponement study and definition

Initially, postponement was applied in the distribution sphere only, involving the delay of the forward movement of inventories (of finished goods) in the channel. Bucklin (1965) dealt with the questions of where in the channel inventory should be positioned (upstream waiting for customer orders, or downstream in anticipation of future customer orders) and which player (supplier or customer) should carry the inventory. The time and place utility of a product, the traditional utilities provided by the logistics function, are impacted by this type of postponement. In addition, a third utility has been added to the postponement concept: a product's form/function utility. Apart from the postponed forward shipment of goods (time postponement) and maintaining goods at central locations in the channel (place postponement) Zinn and Bowersox (1988) summed up manufacturing activities that can be postponed (labeling, packaging, assembly/manufacturing). Postponing these tasks implies that products are finalized in response to customer orders and then shipped to that same customer. Thus, the notion of postponed manufacturing covers not only time and place postponement; it also includes customizing the form and function utility of a product. Postponed manufacturing thus is a cross-functional operating system in which final manufacturing activities are positioned in the distribution channel and performed in response to market signals. This cross-functional nature of the concept explains the relevance of postponement to a wide range of research streams, as mentioned before.

Christopher (1992) further expanded the prevailing approach by pointing at the role of geographical scale levels in postponement applications. He also demonstrated how postponed manufacturing works at a European scale. The relevance of operating at a particular geographical scale, broader than one market region - including the European, Asian or North American market - is also shown in the case of Hewlett Packard which is described by Lee et al. (1993). Cooper (1993) expanded the scale level at which activities may be postponed to include the position in the chain where postponement applications (similar to those mentioned by Zinn and Bowersox, 1988) are found. In particular, Cooper (1993) sums up the options: time postponement operated in the factory; packaging postponement separated from the factory in a downstream regional warehouse; or postponed manufacturing separated from the factory in midstream central warehouses.

2.2. Methods of study and theoretical contributions

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Bowersox and Closs (1996) defined time postponement as delaying the forward movement of goods until customer orders are received (delaying the determination of time utility), place postponement as the storage of goods at central locations in the channel until customer orders are received (delaying the determination of place utility) and form postponement and as delaying product finalization until customer orders are received (delaying the determination of form/function utility). Van Hoek et al (1998) explain that postponed manufacturing combines these three basic forms within one operating system; product finalization and shipment of goods is delayed until customer orders are received and operated from a central location in the channel.
Table 2 categorizes publications according to the method of study. Four methods are used (naturally in relation to the purpose of study). As explained, Bucklin (1965) established the theoretical principle in the distribution channel, centering around inventory positioning, determining the amount of time and place postponement based upon total storage costs. Shapiro (1984) listed a further set of possible degrees of postponement applications, from no postponement (decentral stock of finished goods maintained) to time and place postponement (central stocks of finished goods stored) to form postponement throughout the channel (work in progress stored). This is the foundation under the approach of the Lampel and Mintzberg (1996) categorization of supply chains, ranging from no customization through customized distribution, assembly, fabrication to full customization in the chain (even though the authors did not reference the Shapiro (1984) article). Also its the first clue to the relevance of a supply chain-wide approach of postponement.

Zinn and Levy (1988) further developed the theoretical perspective on postponement by developing theoretical notions and propositions for empirical research, on top of those developed by Bucklin (1965). To date these propositions have not been tested in published papers, only some of the Bucklin propositions have been tested implicitly. Based upon a conceptualization of the application of postponement in marketing channels. Zinn and Levy (1988) remark that the assumption of integral cost minimization in the chain (used by Bucklin, 1965) implies that the theory holds less value in channels where an individual player can use powerplay to force inventory load onto another player’s shoulders and minimize their own costs. This is particularly evident in chains with bilateral governance and not overly intensive inter-channel competition, in which players take a short-run perspective. It is also evident in high-risk product channels with unified governance, where companies may choose not to vertically integrate and thereby seek to avoid risks. In short, an integral supply chain perspective among players in the supply chain is expected to be a prerequisite for the viability of postponement.

In addition to the focus on integral cost minimization, the Bucklin (1965) model also focuses on the role of time and place postponement in positioning inventories and designing direct or intermediate channels, which holds a relation with the supply chain structure. There is a difference between the impact of time and place postponement, as included in Bucklin (1965) and form postponement as included in latter publications. Time and place postponement pushes/maintains inventories upstream, from national and regional stocking points to international warehouses, until customer orders have been received. Form postponement, on the other hand, often pushes manufacturing activities downstream, from global manufacturing locations into international distribution channels, so that they can be performed closer to the customer. The implementation of postponed manufacturing may involve both a downstream positioning of manufacturing activities and the upstream centralization of inventories. Christopher (1992 & 1998) offered a geographical categorization of activities in the supply chain, from globally coordinated to localized activities. Product finalization is positioned at an intermediate level in the chain, centralized on a continental
level, where centralized inventories are also positioned. Furthermore, he includes postponement in the list of future directions for supply chain management, which further highlights the (practical) relevance of further postponement research.

Pagh and Cooper (1998) published the most recent theoretical work on postponement. They provided a categorization of postponement applications in the mid- to downstream stages of the supply chain only. The categorization is a reworked version of the applications mentioned in Zinn and Bowersox (1988) and Cooper (1993). Cooper (1993) in turn, referenced Zinn and Bowersox (1988) for the postponement applications he developed, stating that his naming was different but that the applications are essentially the same. Pagh and Cooper (1998) also reflect upon the role of factors in the operating environment of companies that influence the feasibility and selection of a particular postponement application. This approach is similar to, and some of the factors used are the same as in Zinn and Bowersox (1988), Cooper (1993), and van Hoek et al. (1998). Pagh and Cooper (1998) thus, essentially, developed an overview of known applications and factors in the implementation of postponement. This overview really brings us at the point in knowledge creation where we can move on to creating new insights in new applications and operating approaches. We will return to this challenge after a review of other methods and specific issues studied.

2.2.1. Case studies

Case studies published as case examples (Cooper, 1993) as single in-depth case studies (Feitzinger and Lee, 1997 (HP); van Hoek, 1997 (wine producer)) or 4 to 8 cases (van Hoek et al. 1998; van Hoek 1998 I) center around practical experience of companies in trading off and in implementing postponement. These papers provide in-depth insights of cost and benefits assessments made factors of relevance in that assessment and the process of change management involved in implementation. Cooper (1993) developed a categorization of four types of mid-to downstream postponement applications, based upon different combinations of operating characteristics that favor certain types of postponement applications. He lists examples of companies fitting in that categorization. Based upon a single case van Hoek (1997) expanded the categorization into a framework of four categorizations, based upon technological, process, product and market operating characteristics that do, or do not, favor specific postponement applications. The applications included are similar to those in Cooper (1993). Feitzinger and Lee (1997) use HP as a case study as in the other Lee publications on postponement. These other Lee-works use a different method for a more detailed assessment of operations research-rules in assessing the feasibility of postponement. Van Hoek et. al. (1998) provide a cross case comparison of postponement practices to offer further analytical generalization.

Statistical and mathematical generalizations are generated based upon the final two methods used: modeling and surveys.
2.2.2. Modelling

Zinn followed the reasoning from one of the six propositions developed that centered around the role of value of goods in favoring postponement. In two publications (1988 and 1990) he further developed this line of reasoning using a simulation model and developing heuristics on postponement. Findings indicate the role of operation conditions such as volume and value in achieving lowest logistics costs with postponement. The lowest cost approach also follows the original Bucklin model; but the modeling significantly leverages the original model to a higher level of understanding. Time and place postponement from the original model are supplemented with form postponement applications. Lee et al. (1993, in an operations research journal) simulate a postponed manufacturing supply chain. In the simulation postponed manufacturing is compared to a supply chain with manufacturing integrated in the factory. The simulation is however, limited almost exclusively to inventory levels. They state that transportation issues (less bulky transport of generic modules), the need to develop a local supply base (location factors, local sourcing) and other non-quantifiable factors - e.g., the increased marketability of locally assembled products, which is relevant for marketing - warrant further study. An indication of the fragmentation of available material is found in the publication of Lee et al. (1993). Their article has the same focus as the study published by Zinn (1990) in a logistics journal. The latter article estimates the inventory savings resulting from postponed manufacturing as well as the operating characteristics that influence these savings. They come up with quite comparable results, including the role of commonality and product variety. But the study by Lee et al. (1993) does not include a reference to Zinn (1990) and does some overlapping work.

Garg and Tang (1997) study two products, pc's and hairdryers, and developed insights relevant to adopting postponement early, mid-/ upstream in the chain or late, downstream. This works from the point that a company has actually selected postponement as a supply chain concept to be implemented. Case studies, mentioned in the previous section, indicate that companies trade-off specific postponement options against supply chain options without postponement. Thus the trade-off studied in Garg and Tang (1997) tends to be integrated with the fundamental trade-off of postponement in configuring the supply chain.

2.2.3. Surveys

One of the rare empirically tested research models on postponement was developed by Dröge et al. (1995). It concerns the impact of form postponement on organizational structure. Organization structure is studied in terms of formal control, horizontal and vertical differentiation, and size. The approach of Dröge et al. (1995) is comparable to that used by Bowersox et al. (1992). In the latter
survey, organizational characteristics are linked to logistics organizational capabilities. Although postponement is not specifically mentioned, related strategies are, such as product modification while in the logistics system or flexibility in responding to specific customer requests. These strategies are linked to the availability of formalized logistics and a strategic plan. The findings do highlight a number of items relevant for the implementation path (used, for example, in the selection of a framework for case studies, as outlined in the appendix).

Whereas Bowersox et al. (1992) do not explicitly measure postponement, Dröge et al. (1995) measured postponement by asking about the percentage of goods made to order. Neither publication developed a comprehensive measure of postponement applications that would reflect the various applications, as can be found in practice and other sources that point at assemble, configure, pack, label and ship to order applications. So, really there is no construct or scale for postponement along the chain, other than the first attempt from van Hoek (1998 II) which uses postponement throughout the supply chain (from engineering and purchasing all the way through manufacturing, down to distribution) as a dependent variable explained by factors such as operating characteristics. (selected from other papers mentioned) IT-applications (mentioned in Bowersox et al. 1992) and market characteristics. This provides a first statistical generalization using factors from prior case studies and modeling studies. Also, its the first study to include postponement applications along the entire supply chain, not just in final manufacturing and distribution/mid- and downstream. We will return to this point in the gap-analysis following the literature categorization. But, firstly we will identify specific focus areas in the studies under review to develop a more comprehensive overview of content contribution of studies and start conceptualizing integrated overview.

3. Specific elements of study

3.1. Element 1: Customization

Lampel and Mintzberg (1996) refer to the relation of their continuum between standardization (make-to-forecast) and customization (make-to-order) within the trend towards the mass customization. They state that if there is one dominant move along their continuum of supply chains, it is towards intermediate positions of make to order and assemble to order situations. In such situations, companies combine the efficiency of mass production in speculative upstream manufacturing of semifinished goods and modules with downstream customization in order to achieve customization without cost penalty. While Lampel and Mintzberg (1996) relate the customer order decoupling point to mass customization, Morehouse and Bowersox (1995) relate postponement to mass customization. Therefore, it seems relevant to include the principle to include the principle of mass customization in the framework being developed here.
Postponement applications can be expected to contribute to the mass customization of goods and services. In postponed manufacturing applications for example, the customization of products at an intermediate level in the supply chain (after customer orders have been received) allows for the combination of rapid and reliable delivery with improved responsiveness to customer wishes. Local variations in taste and product formulation can be integrated in the process if driven by orders. In addition, improved customer responsiveness does not have to take place at the expense of efficiency levels. In postponed manufacturing, customization of products can be separated from the speculative manufacturing of basic materials. The separation frees primary manufacturing to focus on large economic runs of standard products or generic components and modules.

A list of methods for achieving mass customization of goods can be compiled on the basis of Pine (1993) and Daugherty et al. (1992). That list includes seven methods:

1. Create products and services that are customizable by customers (involving the design function); for example, self-fitting clothing, bake-off products.
2. Modularize components to customize finished products and services (involving the manufacturing, distribution, marketing function, and the product design).
3. Provide quick response throughout the value chain (involving the design, manufacturing, distribution, and marketing function).
4. Customize services around standard products or services (involving the distribution and marketing function).
5. Provide point-of-delivery customization (involving the marketing function); for example, adjusting clothes in the store.
6. Offer logistics support to sales and marketing incentive programs (involving the distribution function); for example, assembly of promotion displays, shelf management to assure availability.
7. Offer customized logistics service levels (involving the distribution function); for example, regionally targeted distribution service levels.

The functional areas involved in the particular methods shown in parentheses are based on Pine (1993) and Daugherty et al. (1992). Like the customer order decoupling point (CODP) and postponement, mass customization can occur at various positions in the chain.

As mentioned, Pine (1993, p.196) states that customizing products from standardized modules (method 2) is the best option for achieving mass customization. This method reflects assembly to order situations and postponed manufacturing. Time and place postponement is reflected in method 7, the offering of customized logistics services. Postponed packaging in a regional warehouse is reflected in method 6, which calls for relatively easy finalization of products in warehouses. Method 5, providing point of sale customization, is related to CODP 7 positioned in the retail channel. Neither method 1, 4

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4 The point in the supply chain that distinguishes between push and pull/order-driven operations.
including customizability in the product design, nor method 3, providing quick response throughout the chain, is related to a specific CODP or postponement application. Quick response is said to be possible along the entire chain. Pine (1993) is not explicit about the product design being made to order or not. The offering of customized services around standardized products (method 4) is the same as method 7, though it is not limited to logistics services. This also makes it difficult to position method 4 anywhere along the chain.

Figure 1 specifies methods for achieving mass customization that can be directly related to a particular CODP and/or postponement application (applications from Zinn and Bowersox, 1988; Cooper, 1993). The postponed manufacturing segment is shown between bars. That segment unites a specific CODP position and a method for achieving mass customization. Several issues can be deducted from figure 1. Firstly, postponement applications listed here (and studied in literature) appear mostly at midstream or downstream positions in the supply chain, as opposed to upstream speculation or forecast-driven activities. Furthermore, apart from a number of methods that can occur anywhere along the chain, the methods for achieving mass customization included in figure 1 are also most likely to be applied at midstream or downstream positions in the chain. These linked positions in the supply chain can be related to the basic principle underlying the effectiveness and efficiency of both mass customization and postponed manufacturing. That principle is the inclusion of upstream speculative/mass manufacturing driven by forecasts and intermediate or downstream postponed/customizing manufacturing and service activities within one supply chain structure.

Table 3 lists the three mass customization, the CODP and postponement, based upon specification of customization, as found in the literature. Methods for mass customization specify activities and functions involved in customization. The CODP specifies the position in the chain where the customization occurs. Furthermore, the CODP indicates the extent to which operations are pull/order-driven by customization versus push/forecast-driven by standardization. It also reveals which functions are involved in the customization, reasoning that all functional activities positioned downstream of the CODP play a role in customization. Postponement combines these specifications, integrating both principles into one operating system.

To further illustrate the link between postponement and customization, table 4 indicates the contribution that postponed manufacturing, used as an example application of postponement before, makes to the global marketing planning matrix, as developed by Quelch and Hoff (1986, p.61). Promotion and product positioning is not included in the set of relevant segments. It was excluded even though customization in the logistics system can be achieved by supporting special promotion campaigns and despite the fact that positioning can be affected by building customer displays. The direct impact of postponement is on customer service. That means achieving differentiated and customized customer service at a competitive price level. Table 4 also has an explicit geographical element, to which we will return latter on.
Companies can choose not to implement postponement. That decision may be based on variations in the applicability of postponement. Not all products and processes may accommodate postponement. In the chemical and processing industry, for example, many processes are not amenable to separate in a primary and a secondary phase. Seperation along those lines is required for postponing final manufacturing.

As an overview, a list of operating characteristics relevant to assess the viability of postponed manufacturing has been compiled by van Hoek et al. (1998), partly based upon Zinn and Bowersox (1988) and Cooper (1993), see table 5. The basic rationale is that operating characteristics favoring either postponement or speculation represent forces relevant to the structuring of supply chains. This reasoning ties in with the focus of one of the hypotheses formulated by Bucklin (1965). That particular hypothesis focuses on the role of operating characteristics. It posits that heavy, bulky, and inexpensive (low value density) products are likely to flow through channels with more intermediate, speculative inventories than products with the opposite characteristics.

In classifying postponement applications, Cooper (1993) uses three product characteristics: branding, formulation, and peripherals. He also recognized the importance of primary product characteristics. As an example, products can have a global branding and homogeneous formulation, whereas peripherals (including documentation and packaging) vary between markets. In that situation, final manufacturing is most likely structured as a deferred/regional packaging system. Zinn and Bowersox (1988) also assess the viability of various levels of postponement with the operating characteristics of brands (one or more), product variety, and unit value. But they also use fluctuations in sales and variation in package size/cube increase through final manufacturing. A cube increase through final manufacturing results in additional transportation volume and storage space needs. As a means to save on those expenses, final manufacturing can be postponed.

Further factors from table 5 will be briefly explained below. The complexity of customization operations is relevant in the sense that postponing final manufacturing would otherwise result in a (too) strong loss of economies of scale and long processing times. That, in turn, creates the risk of not meeting lead-time restrictions. The complexity of automobile manufacturing is the reason why Kotha (1995) expects that mass customization in the automotive industry will be limited to mixing some modules. He does not expect it to include customization at a component level. Both cost and service considerations do not allow for postponed manufacturing in these situations. The technological content refers to changeover times and processing times. Limited flexibility and a high technological content will result in lengthy process cycles and long changeover times. That will make postponement unfavorable under lead time and processing costs restrictions (the competitive bar).

The possibility to decouple primary and secondary manufacturing is a precondition for the implementation of postponed manufacturing. Olhager (1994) assumed that production systems that
cannot be decoupled have to be run either fully order-driven or fully forecast-driven. In this respect, they are unlike the combination of an order- and a forecast-driven activities in postponement. Also, the underlying production system has to allow for final manufacturing within acceptable lead times. Postponement allows for direct sourcing of modules used in the final manufacturing, from multiple regions, instead of indirect sourcing through many echelons. The commonality is also related to the principle of design for logistics. Zinn (1990) draws attention to the principle of risk pooling. He stated that the number of modules may be smaller than the number of finished products through commonality. Storing modules in stead of finished products pools inventory risks across a smaller number of SKUs. In this situation, Zinn (1990) attributes inventory savings through postponement to two factors. The first is the size of the assortment and the variation in demand for finished products which can be supplier from a limited number of modules. The second is the demand for modules, which is negatively related, allowing for effective risk pooling of generic modules. When modules used in the final manufacturing are interchangeable with a product’s inventory levels and risks of obsolete inventories are lower. Kotka (1995) explained how competitors of National Pen - companies that did not implement postponed manufacturing - had to raise inventory levels to accommodate customization demands from customers. In the mean time, National Pen could provide almost unlimited customization from a relatively small base of modules and components. Product variety through differences in formulation, peripherals, or packaging, if included in products, can be created in the postponed manufacturing operation. Thereby, postponement would allow for improved customization.

Short life cycles and fashion cycles of finished products generate inventory risks. Postponing final manufacturing lowers that risk, especially if components have a high commonality and can be used in other products. Sales fluctuations and variations in sales volume and frequency create inventory complexities. Speculative inventories will have to be prepared to accommodate all volumes, frequencies, and combinations of products. When the final manufacturing can be performed within a limited timeframe, the postponed manufacturing operation can continue to assure competitive lead times. In fact, the improved responsiveness may save on back orders, increasing the overall delivery reliability. In general, the ability to respond to individual customer wishes with specific product features or other adaptations is enhanced by following a “sense and respond” approach.

Having listed the factors mentioned in literature, the review also indicates how factors have been added to the list throughout years of study and how some factors have received continued attention (such as value) in multiple studies, whereas others have not. Two things can be further pointed out, firstly, the aim of studies listed in this section is assessing the feasibility and viability of postponement applications mid- and downstream in the supply chain. This is approached as a cost minimization effort. We have pointed out however that, postponement fits within mass customization and agility efforts and how the customer-focused approach brings new relevance and interest to postponement. As a result, cost minimization and feasibility study has not lost relevance but will now
come second to the first order issue, that of raising customer responsiveness. Secondly, these studies, like the literature in general, tends to concentrate on mid-, to downstream applications in the supply chain. As pointed out in figure 2, operating characteristics such as volume and variety in progress also hold relevance when postponement application are leveraged throughout the entire supply chain and is applied in both purchasing and manufacturing. In the figure postponement is also applied in purchasing, lowering volume and further delaying variety creation (and the early asset commitment) on top of achievements in postponed manufacturing and distribution.

3.3. Element III: Geographical reconfiguration involved in the implementation of postponement

European researchers starting with Cooper (1993), pointed at the differences in geographical level of operating postponement applications. The variance is from the national level for deferred packaging, to the European/continental level for postponed manufacturing (in Cooper, 1993). Christopher (19925) pointed at the continental level of operating for postponed manufacturing whereas other activities may be localized or globalized. Van Hoek (1998 I) explicitly looked at the process of geographical repositioning and reconfiguring involved in the evolution towards, and implementation of, postponement. A link with international strategy is established in studying cases. This leads to the indication that the nature, timetable and focus of the reconfiguration process differ depending on organizational heritage. Thus: the resulting geographical structure and scale levels of operating may be comparable and as projected by Cooper and Christopher. The change process may differ however, and the reconfiguration may be wider than merely the mid- to downstream stages are involved.

Introducing the link between postponement and international strategies, in particular globalization or localization of activities along the supply chain (recall the citation from Ditmann), to the relation between postponement and the CODP/Lampel and Mintzberg customization continuum, introduced in the previous section, the categorization in figure 3 can be developed. The figure projects the continuum of supply chains (standardization versus customization) from Lampel and Mintzberg in, the established, relation to the CODP positions. A relation between globalization and standardization can be assumed, as can a relation between localization and customization. Customization through postponement may require localization of processes and activities, as mentioned before. The other way around, standardization might allow globalization and the achievement of further scale economies in that process. These items are therefore combined on the axes of figure 3. As a result, the sections of the box reflect standardization, customization, or a balance; concomitantly, they reflect globalization, localization, or a balance. The same also implies the geographical scale level at which activities are performed. This can be clarified using the operations from the supply chain as a second vertical axis.

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5 Christopher (1992) is released as a revised second edition in 1998, without significant changes in the references to postponement. Given the chronological structure of the review we continue to mention 1992 when referencing this work.
In postponed manufacturing applications for example, R&D and primary production may be operated at a global scale level; these activities may be more or less standardized. Distribution and service may be operated on a customer-specific and local basis while final manufacturing is operated at an intermediate level, balancing standardization and customization (in accordance with the structure suggested by Christopher, 1992). In other supply chains, almost the entire chain may be operated customer-specific and locally. It will most likely be found in engineering to order situations and in full customization chains. At the other extreme, chains may be fully globalized and standardized in shipment to order situations and in segmented standardization chains.

Having included the spatial dimension in the postponement conceptualization, we are really adding a dimension to the temporal/time-dimension used in the original Bucklin model (1965). For this purpose, postponement applications can be projected against each other to assess differences in the postponement - speculation balance along the time and spatial dimension. These applications are juxtaposed in table 6. The table responds to a challenge put forward by Heskett in 1966 that time and spatial dimension need to be integrated in logistic system design. A challenge to which research had not responded yet, according to Ballou (1995). Figure 4 expands the original Bucklin model with the spatial dimension of postponement applications as a second horizontal axis, complementary to the time dimension introduced by Bucklin (1965).

Next, postponement and speculation costs can be projected for a case study and traded off. Bucklin (1965) used inventory costs to operationalize postponement and speculation costs. Taking a wider supply chain approach, postponement and speculation costs can be operationalized using the cost curves for materials, transport, inventory, and handling from Christopher’s (1992) cost model. Inventory and materials costs, for example, favor postponement of operations for capital in progress considerations. Transportation costs may favor speculative large volume shipments instead of flexible, frequent direct deliveries practiced under a postponement operating system. And handling costs favor standardized, large-scale operations for economies of scale considerations instead of flexible postponed pull operating systems. These conditions lead to a total operating costs curve for the cost minimization within a certain service window for a responsive operating system.

In using the total cost approach, it is also possible to compare calculated total costs of supply chain structures with and without postponement applications, at various positions along the temporal and the spatial dimension. For example, deferred packaging has a relatively short lead time, resulting from localized packaging and distribution operations. Thus, it can be positioned to the left of the horizontal axis. In postponed manufacturing applications, on the other hand, final manufacturing is operated at an international level, which may result in slightly longer lead times. The bars in figure 5 reflect total costs. Of course, operating costs derived from the Christopher (1992) model can be projected in a decomposed manner. It then becomes clear that the applications are particular “points” along the curves derived from the original Christopher and Bucklin models.
An operating structure can be selected to satisfy a required service window and a required level of responsiveness. For example, if required lead times are very short, it is not possible to perform final manufacturing activities in a postponed manufacturing structure due to the lead-time penalties resulting from the final manufacturing that has to be performed after an order has been received. The deferred packaging structure may be favorable, due to the limited scope of form postponement, allowing for short cycle times. When, on the other hand, acceptable lead times are very long postponed manufacturing will also lose some of its appeal. At this level, large-scale continuous manufacturing can be performed within the lead time. This model adds to the reasoning put forth by Bucklin (1965) which said that lead-time requirements are not the only important factors determining the amount of speculation needed. He also emphasized the role of spatial considerations and the required level of customization that can be achieved with operating systems.

Apart from explaining the selection of a particular application, the framework can be helpful in the analysis of the impact of variations in operating characteristics on cost levels. A high value of a product, for example, favors postponement. The deferred packaging structure in the above example becomes more expensive (the break-even point shifts to the left implying that the bundled manufacturing structure becomes more favorable). The higher expense is due to local inventories and earlier commitment of products. In contrast, the increase in costs of the bundled manufacturing structure is lower. The reason is that this structure favors inventory costs through inventory consolidation and the postponement of inventory commitment.

With respect to the point on the relevance of cost modeling, it should be noted here that the original Bucklin model, as well as this extension, should first of all fit the customer responsiveness strategy. In other words: the structures evaluated should not be selected for cost expectations firstly, but based upon their fit within the strategy.

3.4. Element IV: Change management

The case studies on the implementation of postponement (Feitzinger and Lee 1997, van Hoek 1997 & 1998) center largely around the managerial process from feasibility study to the actual implementation of postponement. Central to this is the change management process (of course best studied integral and throughout the process using qualitative research). O’Laughlin et al. (1993) state that proper change management in logistic reconfiguration programs may be the single most critical success factor to such programs (van Hoek et al. 1998 use the O’Laughlin change management action plan as a framework for studying the implementation of postponement).

Table 7 lists factors mentioned to be relevant in the change management process in literature, following the environment - strategy - structure - performance contingency framework. First of all, Dröge et al. (1995) pointed out the importance of IT as a driver of organizational change and its role in enabling postponement through speeding up customer information and making it transparent in the
chain (contributing to customer responsiveness). Secondly, van Hoek et al. 1998 have identified deregulation as a second driver of supply chain reconfiguration. It can be expected that deregulation enables companies to establish postponement operations in major markets, while globalizing primary production in stead of duplicating factories nationally. The notion that a trade relation is imperative to the supply chain structure (Dröge et al. 1995) explains that market turbulence is a relevant third driver of the growing attention for postponement. In international markets a general move towards customization of products on a cost-effective basis is accompanied by residual differences in local markets. These differences require the localization of strategies, products, and operations, all favoring postponement. ICT and deregulation are thus expected to be enablers of postponement applications. Market turbulence is expected to be the new demanding context in which postponement can prove to be an effective solution. The reason why postponement is receiving growing attention might be that the operating environment did not facilitate or require postponement in the past, whereas it now does.

Apart from the new technologies and the new market context new organizational forms are also expected to influence the application of postponement. In particular literature points at geographic restructuring within the service window and the role of operating characteristics in favoring or disfavoring postponement. The organizational heritage finally, may resort a moderating impact on structure development, through its impact on time-line, structure and nature of the change process.

Ultimately, the implementation of postponement, within the proper operational and strategic context, should affect performance levels. The literature is predominantly concerned with improvements in operational (cost-) performance, with a slight concentration on logistics costs (see Lee et al. 1993 and Zinn, 1990).

4. Integral categorization of literature

Having specified available contributions to insights in postponement in terms of:

- postponement types covered (time, place and form postponement),
- methods of study,
- amount of customization/activities postponed,
- the segments in the supply chain covered,
- coverage of operating characteristics, spatial restructuring/level of operating and
- the role of change management,

table 8 lists publications reviewed chronologically and characterizes publications based upon these items.

Inspection of the table validates the lacking integration of studies. Methods used do not reflect integrated efforts or a structured progress of knowledge creation. Such progress would start with theorizing, qualitative research and than move onward to mathematical and statistical generalizations. The development of the literature did start with the conceptual Bucklin article, founding theory, but
than progressed into modeling, back to conceptualization, cases and surveys. Of course knowledge development can to some extend be iterative as new factors to consider are added in time or the concepts is altered following intermediate findings. Still the body of literature displays a fragmentation across various fields. While elements such as operating characteristics are relevant for various fields, there is not a lot of (explicit) cross-referencing and fertilization. Within the context of a rediscovery and repositioning of the concept, within the new market and business environment, specific gaps can be identified that deserve attention, as specified in the following section.

5. Challenges to the rediscovery of postponement

Based upon a review of table 8 two elements appear central to a successful rediscovery of postponement. Firstly: integrating the lessons learned in previous research in reconceptualizing. The challenge becomes to fill the gaps in table 8 and available knowledge from various areas and to capture the new dynamics of the concept. Secondly, we may need to improve methodological robustness. Having noted the iterative knowledge development in this area, integration of methods within a more structured or comprehensive study plan seems valuable and needed. We will generate suggestions, or challenges to research, starting with the new focus, that of postponement in the supply chain, instead of in the marketing or distribution channel only.

5.1. Challenge 1: Postponement as a supply chain concept

Figure 6 presents the focus area in the supply chain of the studies reviewed here. Secondly, it positions them in terms of methods used. This vertical axis is merely aimed at structuring study areas and is not intended to suggest a hierarchy in methods (as methods should predominantly fit a research question). In time research questions may advance towards more structured, qualitative generalizing and testing methods (we will return to this point in the method challenge section).

Whereas Bucklin (1965) focussed his founding article on downstream distribution only (time and place postponement) studies have rapidly started including form postponement in the midstream final manufacturing stage of the chain. Most recent publications have claimed a supply chain approach of postponement (Feitzinger and Lee, 1997 for example) but their content does not go beyond that of Zinn’s work in the 1980’s and does not reflect an integrated study of postponement applications throughout the entire supply chain. Van Hoek (1998 II) provided a first attempt to measure postponement applications along the Lampel and Mintzberg (1996) continuum, throughout the supply chain. This study started right away with statistical generalization of postponement as a supply chain construct but more in-depth empirical insights in levels and points of application along the supply chain may deserve further conceptualization (as targeted in figure 2, by example).
5.2. Challenge 2: Integrating related supply chain concepts

In developing a supply chain-wide scope of the postponement concept research will not only identify relations among streams of research on postponement but may also experience cross-fertilization with related concepts such as just in time manufacturing and supply, vendor managed inventory, efficient consumer response and its quick response distribution techniques. These may fit very well within a supply chain conceptualization of postponement and in fact even prove to be related to the Bowersox et al. (1980) projection of future channel structures. Not only is quick response included as one of the methods for achieving mass customization bringing it in relation to postponement, ECR also involves order driven distribution, directly to the customer in the retail channel, from centralized warehouses. This fits time and place postponement. Vendor managed inventory involves time postponement upstream but not necessary place postponement as inventories of parts are stored at the customer facility and transferred in ownership when components are needed in production. JIT goes beyond that by adding upstream form postponement to time postponement. Supplies are manufactured and shipped to order under this approach. JIT may neither involve place postponement as doorstep plants are commonly used for JIT operations. This may prove an interesting extension of postponement studies in the mid-to downstream stages of the supply chain. Zinn and Bowersox (1988) stated that, in this segment of the supply chain, time postponement is always combined with place postponement. Apparently, this is not the situation in the upstream stages of the supply chain. Adding related concepts into the postponement research might add conceptual richness to the concept, through cross-fertilization of research within the expanded focus area in the supply chain.

5.3. Challenge 3: Postponement in the globalizing supply chain

Having mentioned place postponement as an area of enrichment we also touch upon the spatial dimension of postponement. Bowersox et al. (1995) included postponement as one of the elements in constructing a model for World Class Logistics and assessed application rates of postponement as a whole (not at specific point in the supply chains) in different continents, thus relating it to the globalization of supply chains. Based upon case studies, van Hoek (1998 I) studied reconfiguration practices in-depth and identified differences in globalization approaches and reconfiguration process between companies from different continents. Even if the ultimately targeted World Class Logistics model is more or less comparable across companies in different regions of the world (an universal answer, as argued by Bowersox et al. 1995) the process of getting there by no means is. The importance of change management/moderating variables and market/operating variables (table 7) in the construction of postponement applications may prove a nuance to the universality of the World Class Logistics cross-country and cross-continent empirical assessment. It has been stated by experts...
such Mr. Van der Hoop (with a long standing practical global business experience, as well as a research experience, by example from participating in the above mentioned World Class Logistics project) that postponement is most (or more relevant) in the European market-place give the remaining (even after deregulation) differences in language, culture, and consumer behavior across the many countries in a relatively small geographical area.

5.4. Challenge 4: Postponement in the customized supply chain

Having mentioned differences in consumer behavior, we returned to the relevance of postponement in achieving customization. Having pointed at the limitations in existing feasibility models and operating characteristics used, we need to re-conceptualize these models. Probably, this should go far beyond listing a set of relevant individual market characteristics as done in table 5. Figure 7 for example, presents a starting point in categorizing customer preferences, heterogeneity and behavior (exact performance requirements). This is based upon a marketing study of relevant customization approaches in turbulent markets. Especially in the customized products postponement might play a role. Fitting postponement concept development with this approach may elevate the input from traditional marketing channel studies to postponement knowledge (something also called for by Stern et al. 1995). Figure 7 also represents an attempt to integrate single variables into a decision framework and go beyond listings of variables, as initially attempted by, for example, Cooper (1993), Pagh and Cooper (1998) and table 5.

5.5. Challenge 5: Methodological upgrading: Triangulation of postponement

In order to integrate findings from the various studies into a coherent research plan, triangulation is a viable methodological approach. Not only is triangulation a proper method for mixing qualitative and quantitative methods in a coherent approach, it also leads to robust findings and potentially, to cross-method synergies (Jick, 1979). Mentzer and Flint (1997) state that triangulation is the single best method for research in logistics, an area central in postponement research.

Triangulation does require a comprehensive, coherent and carefully integrated research design. The benefits though, include the upgrading of research to a more advanced and richer methodological level, off-setting the lack single method findings, and potentially adding to the richness of findings by filling gaps in available knowledge.

As an example, one particular research proposal that would benefit from triangulation is shown in figure 8. It starts with the ex ante assessment of postponement applications in the supply chain, using figure 4 for developing and evaluating supply chain structures within an integrated framework. Developing customer based and customization oriented measures, in addition to cost measures and modeling of supply chains, will be a challenge in this part of the study. These measures...
should go beyond lead times and delivery reliability previously used (Lee et al. 1993 and Zinn and Bowersox, 1988). Any customer will want his order fulfilled fast and reliable. Customization however, might include functionalities, product specifications, and the degree of customer defined components selection.

A second step could then be to study the implementation of selected supply chain structures. Change management, adjustment of organization characteristics (for example those from Dröge et al. 1995) and the required geographical reconfiguration (using for example figure 3) throughout the implementation process, are relevant elements to consider in this part of the study. Given the comprehensiveness of these elements and the, potentially, long time period covered by implementation processes (disfavoring a single measure moment) a case study method might be favorable here.

The final element in the triangulation framework might be an ex post evaluation of performance improvements and achievements following the implementation process. A survey of multiple plants within the global supply chain or within industries might be a valid method here. Generalizations on points and degree of applications along supply chain can be developed in relation to market operating circumstances and contingencies. In order to close the loop these findings can be input to new postponement and supply chain initiatives.

6. A final word

In this paper we have tried to categorize available literature on postponement systematically. In that process we have found that the recent growth in publications reflects a rediscovery of postponement, driven by market turbulence within the supply chain organizational context and in relation to customization efforts. In order to contribute to the knowledge components of the global, agile or customized supply chain, through postponement, challenges for upgrading and repositioning content and method of research have been presented. We hope this can facilitate a migration of knowledge and practice to (finally?) start benefiting from realizing postponement applications into the next millennium. As a common business practice, not an old theoretical notion or a practice of a limited number of frame-breaking companies.

We have intentionally not called this final section "Conclusion" as we feel that with the now rapidly growing body of work on postponement, knowledge and insights are progressing. The work initiated and in progress, as well as, the challenges put forward here, not only indicate that we are not in the stage of reaching conclusions on the field and concept as a whole. To some extend we hope that the literature review presented here will soon be outdated by the publication of new findings, contributing to the future of operations. Hopefully, the (re-)conceptualizations and research approaches suggested here will facilitate the rediscovery of postponement, involving the leveraging of lessons learned. With a progression of the state of knowledge creation surely new research questions will be put forward and pieces of the puzzle will be added. We anxiously await them.
References


Table 1: Elements of postponement definitions available in the literature

<table>
<thead>
<tr>
<th>Source</th>
<th>Elements included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucklin, 1965</td>
<td>Type of postponement; time and place postponement</td>
</tr>
<tr>
<td>Zinn and Bowersox, 1988</td>
<td>Type of postponement, Activities postponed</td>
</tr>
<tr>
<td>Christopher, 1992</td>
<td>Geographical level of operating, Activities postponed</td>
</tr>
<tr>
<td>Cooper, 1993</td>
<td>Position in the supply chain, Geographical level of operating, Activities postponed</td>
</tr>
</tbody>
</table>

Table 2: Methods of study in postponement literature

<table>
<thead>
<tr>
<th>Method</th>
<th>Publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases and examples</td>
<td>Feitzinger and Lee (1997); Cooper (1993); van Hoek (1997); van Hoek et al. (1998); van Hoek (1998 I)</td>
</tr>
<tr>
<td>Simulation/calculation</td>
<td>Zinn and Bowersox (1988); Zinn (1990); Lee et al. (1993); Garg and Tang (1997)</td>
</tr>
<tr>
<td>Survey</td>
<td>Dröge et al. (1995); Bowersox et al. (1992 &amp; 1995); van Hoek (1998 II)</td>
</tr>
</tbody>
</table>

Table 3: Specifications of the customization offered by three principles

<table>
<thead>
<tr>
<th>Principle</th>
<th>Specification of customization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods for achieving mass customization</td>
<td>Activities and functions involved in customization</td>
</tr>
<tr>
<td>CODP</td>
<td>Position of customization in the chain, level of customization, functions involved</td>
</tr>
<tr>
<td>Postponement</td>
<td>Position of customization in the chain, level of customization, activities and functions involved in customization</td>
</tr>
</tbody>
</table>

Figure 1: Postponement definition framework
Table 4 Postponed manufacturing in the global marketing planning matrix

<table>
<thead>
<tr>
<th>Business Function</th>
<th>Research &amp; Development</th>
<th>Finance &amp; Accounting</th>
<th>Manufacturing</th>
<th>Logistics</th>
<th>Marketing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing mix elements/activities</td>
<td>Product design</td>
<td>Brand name</td>
<td>Product positioning</td>
<td>Packaging</td>
<td>Advertising</td>
</tr>
</tbody>
</table>

| Countries | Region 1 Country A | Region 2 Country B | Region 3 Country C | Region 4 Country D |

Source: Adapted from Quelch and Hoff, 1986

Table 5 Operating characteristics relevant for postponement

<table>
<thead>
<tr>
<th>Factor</th>
<th>Impact of postponement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technological characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>- Limited complexity of final manufacturing operation</td>
<td>Limited loss of economies of scale through postponement and short processing times</td>
</tr>
<tr>
<td>- Limited complexity of technological content in final manufacturing</td>
<td>Short set-up and changeover times, short processing times</td>
</tr>
<tr>
<td>- Modularity</td>
<td>Rapid final manufacturing at low processing costs, increased possibility to adjust products to markets</td>
</tr>
<tr>
<td><strong>Process characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>- Possible to decouple primary and secondary production system</td>
<td>(a technical precondition and needed for manufacturing within the lead time)</td>
</tr>
<tr>
<td>- Limited complexity of final manufacturing process</td>
<td>Short set-up and changeover times, short processing times</td>
</tr>
<tr>
<td>- Sourcing from multiple locations</td>
<td>Direct bulk shipments of modules</td>
</tr>
<tr>
<td><strong>Product characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>- High commonality of modules</td>
<td>Lowered inventory levels and reduced risk of obsolete inventories</td>
</tr>
<tr>
<td>- Product variety; specific formulation of products</td>
<td>Improved customization possible</td>
</tr>
<tr>
<td>- Product variety; specific peripherals/packaging</td>
<td>Improved customization possible</td>
</tr>
<tr>
<td>- High value density/unit value of products</td>
<td>Reduced pipeline expenses and inventory carrying costs</td>
</tr>
<tr>
<td>- Products cube and/or weight increases through customization/final manufacturing</td>
<td>Reduced transportation and inventory carrying costs</td>
</tr>
<tr>
<td><strong>Market characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>- Short product life cycles/fashion cycles</td>
<td>Reduced risk of obsolete inventories</td>
</tr>
<tr>
<td>- High sales fluctuations</td>
<td>Reduced inventory levels and risk of obsolete inventories</td>
</tr>
<tr>
<td>- Short and reliable lead-times required</td>
<td>Improved delivery service</td>
</tr>
<tr>
<td>- Price competition</td>
<td>Lowered cost levels</td>
</tr>
<tr>
<td>- Varied and (physically) fragmented markets</td>
<td>Improved targeting, segmentation, and positioning of products and sales</td>
</tr>
</tbody>
</table>

Source: van Hoek et al. (1998)
Figure 2 Postponement in the supply chain

Product numbers in progress and volume

Stage: Purchasing/Primary manufacturing Final manufacturing Distribution

Inputs Modules Outputs
Normal situation
Postponement

Globalization and standardization
High Low
Global, Standardization International, Balance Local, Customized
Low
Localization and customization

Operations:
Design
Purchasing
Primary production
Final manufacturing
Inventory
Distribution
Service

CODP:
Shipment Assembly Production Engineering
to order to order to order to order
Segmented Customized Tailored Full
standardization standardization customization customization

Postponed manufacturing

Figure 3 Postponement and globalization versus localization
Table 6 Postponement applications in relation to the spatial and temporal dimension of the supply chain

<table>
<thead>
<tr>
<th>Time postponement/Unicentric manufacturing</th>
<th>(Sensitivity to) Postponement costs</th>
<th>(Sensitivity to) Speculation costs</th>
<th>Time dimension</th>
<th>Geographical level at which postponement is applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time and form postponement in the factory/Bundled manufacturing</td>
<td>high, resulting in low levels of postponement</td>
<td>low, resulting in high levels of speculation</td>
<td>longer lead times (weeks) expected when more expensive transportation is used</td>
<td>global scale level of operating</td>
</tr>
<tr>
<td>Postponed manufacturing/Deferred assembly</td>
<td>medium</td>
<td>medium</td>
<td>medium lead times (2-4 days)</td>
<td>international/continental scale level of operating</td>
</tr>
<tr>
<td>Time and form postponement from the distribution channel/Deferred packaging</td>
<td>high</td>
<td>low</td>
<td>short lead times (1-2 days)</td>
<td>national and regional scale level of operating</td>
</tr>
</tbody>
</table>

Figure 4 Total cost framework in relation to a temporal and a spatial dimension
Figure 5 Impact of value density increase on viability of postponement applications.
<table>
<thead>
<tr>
<th>Factor relevant to the implementation of postponement</th>
<th>Key references</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environment</strong></td>
<td></td>
</tr>
<tr>
<td>ICT as an enabler</td>
<td>Dröge et al. (1995); Bowersox et al. (1992)</td>
</tr>
<tr>
<td>Deregulation as an enabler</td>
<td>Van Hoek et al. (1998)</td>
</tr>
<tr>
<td>Market turbulence as a driver</td>
<td>Dröge et al. (1995); Feitzinger and Lee (1997); van Hoek et al. (1998)</td>
</tr>
<tr>
<td><strong>Strategy and structure</strong></td>
<td></td>
</tr>
<tr>
<td>Geographical restructuring required for the</td>
<td>Christopher (1992); van Hoek (1998 I)</td>
</tr>
<tr>
<td>implementation</td>
<td></td>
</tr>
<tr>
<td>Operational characteristics should favor postponed</td>
<td>Bucklin (1965); Cooper (1993); Zinn and Bowersox (1988); van Hoek (1997); Garg and Tang (1997)</td>
</tr>
<tr>
<td>manufacturing</td>
<td></td>
</tr>
<tr>
<td>Organizational heritage influences the structure and</td>
<td>Bowersox et al. (1992); van Hoek et al. (1998)</td>
</tr>
<tr>
<td>timetable of change process</td>
<td></td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td></td>
</tr>
<tr>
<td>Performance improvements realized through the</td>
<td>Lee et al. (1993); Zinn and Bowersox (1988); Zinn (1990); Feitzinger and Lee (1997); Garg and Tang (1997)</td>
</tr>
<tr>
<td>implementation of postponement</td>
<td></td>
</tr>
<tr>
<td>Publication</td>
<td>Method: Theoretical/ Conceptual</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>1 Bucklin (1965)</td>
<td>Yes</td>
</tr>
<tr>
<td>2 Shapiro (1984)</td>
<td>Yes</td>
</tr>
<tr>
<td>3 Zinn and Bowersox (1988)</td>
<td>Yes</td>
</tr>
<tr>
<td>4 Zinn and Levy (1988)</td>
<td>Yes</td>
</tr>
<tr>
<td>5 Zinn (1990)</td>
<td>Yes</td>
</tr>
<tr>
<td>6 Christopher (1992, 1998)</td>
<td>Yes</td>
</tr>
<tr>
<td>7 Bowersox et al. (1992)</td>
<td>Yes</td>
</tr>
<tr>
<td>8 Cooper (1993)</td>
<td>Yes</td>
</tr>
<tr>
<td>9 Lee et al. (1993)</td>
<td>Yes</td>
</tr>
<tr>
<td>10 Bowersox et al./CLM (1995)</td>
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<tr>
<td>11 Dröge et al. (1995)</td>
<td>Yes</td>
</tr>
<tr>
<td>12 Morehouse and Bowersox (1995)</td>
<td>Yes</td>
</tr>
<tr>
<td>13 Van Hoek (1997)</td>
<td>Yes</td>
</tr>
<tr>
<td>14 Feitzinger and Lee (1997)</td>
<td>Yes</td>
</tr>
<tr>
<td>16 Van Hoek et al. (1998)</td>
<td>Yes</td>
</tr>
<tr>
<td>17 Van Hoek (1998 I)</td>
<td>Yes</td>
</tr>
<tr>
<td>18 Pagh and Cooper (1998)</td>
<td>Yes</td>
</tr>
<tr>
<td>19 Van Hoek (1998 II)</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Figure 6 Publications along the supply chain

Method of study
Survey
Cases
Model
Concept

Upstream (sourcing, components) Midstream (finished goods) Downstream (distribution)

Supply chain

NB Publication 10 not specified due to unclear supply chain position
Figure 7 Customization approaches in the supply chain

<table>
<thead>
<tr>
<th>Exact Performance</th>
<th>Preference heterogeneity</th>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td><strong>Convenience goods</strong></td>
<td>Tissues, dairy products, soft-drinks</td>
<td>Shopping goods</td>
</tr>
<tr>
<td></td>
<td>Assortment variety:</td>
<td>Small-range standard</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td><strong>Functional goods</strong></td>
<td>Tailored suits, vitamins, medicines</td>
<td>Specialty goods</td>
</tr>
<tr>
<td></td>
<td>Assortment variety:</td>
<td>Small-range customized</td>
<td></td>
</tr>
</tbody>
</table>
Ex ante modeling of supply chain options
Research-question: "What can be the benefits of postponement in the (customized) supply chain?"

Ex post survey of performance achievement
Research-question: "Where, to what extend and with what success is postponement applied?"

Case study of implementation
Research-question: "How is postponement implemented in a global supply chain?"