RECONFIGURING LOGISTICS SYSTEMS THROUGH POSTPONEMENT STRATEGIES

by

Remko I. Van Hoek
Erasmus University Rotterdam

Harry R. Commandeur
University of Ghent and Erasmus University Rotterdam

and

Bart Vos
University of Tilburg

Postponement strategies can be applied to form, time, and place. Form postponement means that companies delay production, assembly, or even design until after customer orders have been received, which increases the ability to fine tune products to specific customer wishes. Time and place or logistics postponement means that the forward movement of goods is delayed as long as possible in the chain of operations, and goods are kept in storage at central locations in the distribution chain.[1]

Postponement strategies are not new. The principle was introduced in 1950,[2] and the roots can be traced to the late 1920s,[3] but use has been increasing recently. Based on a survey of 3,693 companies, the Council of Logistics Management indicates that a shift towards postponement is taking place in the international business world.[4] More than 40 per cent of North American and nearly 50 per cent of European respondents employ postponement strategies more often today than five years ago. Only 24.4 per cent and 16.2 per cent of respondents, respectively, indicated that their use of these strategies has not increased. Morehouse and Bowersox predict that by 2005 more than half of all inventory in food supply chains will be retained in a semiprocessed state at manufacturing locations, waiting for final manufacturing or packaging to meet customers' specifications.[5] An increasing number of European industrial companies are implementing postponed manufacturing systems. These combine the three areas of postponement: customization of products (form postponement) is delayed until goods are ordered (time postponement) and have reached the international distribution chain, frequently followed by direct delivery to retailers or customers (place postponement). This system allows companies to separate the customization of products from the primary or basic manufacturing of standard products or generic modules. This separation frees primary manufacturing to focus

more on large economical runs, while secondary or final manufacturing can be focused on responding to customer wishes. Thus, this system simultaneously enhances customer service and efficiency.[6]

Despite the potential (or theoretical) attractiveness and the increasing application of postponement strategies, little is known about their implementation.[7] In a previous survey manufacturers reported great difficulty with providing product modification or customization while in the logistics system. Improvements in this area have significant potential for improving distribution service quality and making firms more responsive to customers.[8] This study contributes to the practical knowledge of postponed manufacturing and offers some clarification as to why a highly attractive principle hardly has been applied to date. This clarification is to be used as a basis for further research.

TOWARD NETWORK ORGANIZATIONS

A number of developments are fostering and reinforcing the key shifts taking place in the design of international supply chains. First, markets have become more transparent and less fragmented owing to the gradual removal of barriers to trade and foreign direct investment. European unification is an example. Trade within the European Union has become more liberalized with the elimination of barriers in transportation, border control, fiscal policies, law, and finance.[9] These efforts enhance the possibility for companies to rationalize their European manufacturing and logistics structures and move away from strong nation-based geographical structures.[10]

Second, demand is becoming increasingly variable and uncertain in time and place, and even after Europe 1992 there are still differences in local culture, demand, and taste. As a result, companies are urged to increase their responsiveness to customers while simultaneously achieving cost efficiency. A move from mass production and marketing systems toward mass customization may be required.[11]

Third, advances in information technology are enabling companies to achieve a degree of control in international supply chains which could not be envisioned only a short time ago.[12] Advanced information systems tend to reduce the transaction costs associated with the control of international flow of goods and enable rapid response to customer orders. As a result, modern information technologies can now "orchestrate" the revolution of operations from a push to a pull system required for postponement.[13]

Coordinating technologies can also help create a totally new context for management decisions. Many authors point to the enabling role of coordinating technologies in organizational reconfiguration. The sharing of information across the supply chain can allow companies to move from a product, functional, or departmental organization to an organization oriented toward processes (such as the product development process, the brand management process, and the supply chain management process).[14] According to Achrol,[15] strategy has been rooted in functional approaches, but with windows of opportunity becoming narrower and more transitory in turbulent markets, new forms are required. In turbulent environments advantages of vertical control may be offset by inflexibility and inertia. In that respect coordinating technologies can help replace the formal, slow moving hierarchical command and control organization with an informal, fluid, and organically evolving, electronically connected network organization, integrated across organizational boundaries.[16]

A number of key characteristics of network organizations are:

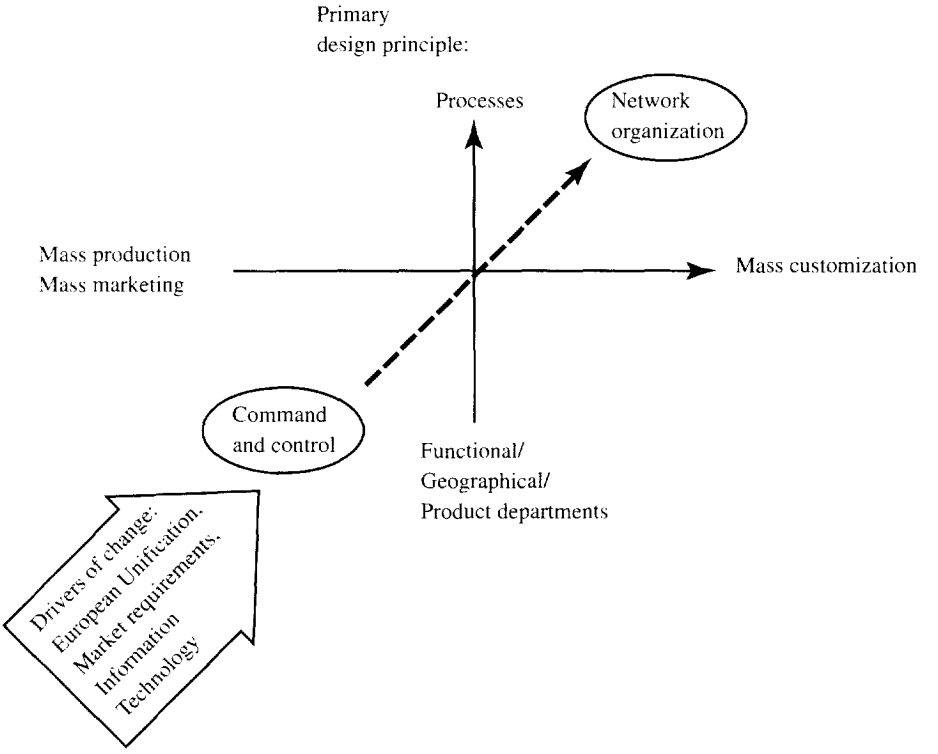
- Traditional formal structures and organizational units can be disintegrated while coordinating technologies allow integrated management[17] which allows both decentralization and centralization to be more easily combined within one operating system;[18]
- Multiple specialized organizational units and companies are in a constantly changing configuration of relations based on core competencies, not on hierarchical position, in order to assure the performance levels needed in today's competitive battle;[19]
- Increasing availability of information can make logistics increasingly transparent;[20]
- Network organizations can compete on all three dimensions of global competition as identified by Bartlett and Ghoshal: global efficiency, local responsiveness, and worldwide learning.[21]

Of course, this list is only a selection of those characteristics of network organizations most relevant to logistics.

Figure 1 displays the shift toward network organizations, indicated by the arrow starting at the traditional quadrant of the command and control hierarchy. The top left and bottom right quadrants are less common combinations in most businesses. In the top left would be some traditional process industries, and in the bottom right would be make-to-order industries, such as construction.

FIGURE 1

FROM A COMMAND AND CONTROL HIERARCHY TO A NETWORK ORGANIZATION



The implementation of postponement strategies may be key to the creation of a network organization through the decoupling of primary *(centralized)*, manufacturing and secondary *(decentralized)*, manufacturing in a *transparent* operating system in which *outside suppliers* (vendors, main suppliers, and so forth) can directly supply secondary manufacturing operations. Furthermore, postponed manufacturing can create the ability to mass customize products.

POSTPONED MANUFACTURING IN THE CONTEXT OF MASS CUSTOMIZATION

Mass customization aims at customizing goods and services at the cost-efficiency levels of mass production. Like postponement, mass customization of products can occur at various points along the value chain from design and fabrication to delivery and sales,[22] and it does not necessarily have to involve the logistics function. There are five methods for achieving mass customization: (1) Create products and services that are customizable by customers (involving the design phase); (2) Modularize components to customize end-products and services (for example postponed manufacturing, involving the design, manufacturing, and distribution phase); (3) Provide quick response throughout the value chain (involving the distribution phase); (4) Customize services around standard products or services (involving the distribution and sales phase); and (5) Provide point-of-delivery customization (involving the sales phase).[23] Methods 2 to 4 involve the logistics function. Further methods to create cost-efficient customization in the logistics system are accommodating special logistics service requests, offering logistics support to sales and marketing incentive programs, offering customized logistics service levels.[24]

Postponed manufacturing is thus one method for achieving mass customization that involves the logistics function. Companies can choose to implement other methods. The choice may be based on the applicability of the various methods, which varies among industries. Not all products and processes may accommodate postponement. In the chemical industry, for example, many processes do not allow the seperation of processing into a primary and a secondary phase. Table 1 identifies a number of operating characteristics that can help determine the viability of postponed manufacturing. A modular product design, common in electronics and increasingly in the automotive industry, for instance, allows for the rapid final manufacturing of customized products at low processing costs. A high product cube or weight increase through final manufacturing, as in the soft drink industry, favors postponement for reasons of reduced transportation and inventory carrying costs.

TABLE 1

FACTORS FAVORING POSTPONED MANUFACTURING APPLICATIONS

Factor	Effect of postponement
Technology & process characteristics	
—Feasible to decouple primary and postponed operations	(a precondition)
—Limited complexity of customizing operations	—Limited loss of economies of scale through postponement
—Modular product design	—Rapid final manufacturing at low processing costs
—Sourcing from multiple locations	—Direct bulk shipments of modules

TABLE 1 (CONT'D)

Factor	Effect of postponement
Product characteristics	
—High commonality of modules	—Lowered inventory levels and reduced risk of obsolete inventories
—Specific formulation of products	—Improved customization
—Specific peripherals	—Improved customization
—High value density of products	—Reduced pipeline expenses and inventory carrying costs
—Product cube and/or weight increases through customization	—Reduced transportation and inventory carrying costs
Market characteristics	
—Short product life cycle	—Reduced risk of obsolete inventories
—High sales fluctuations	—Reduced inventory levels
—Short and reliable lead times required	—Improved delivery service
—Price competition	—Lowered cost levels
—Varied markets and customers	—Improved targeting, segmentation, and positioning of products and sales

Sources Table 1: Same reference as notes 3, 28 to Cooper, and 46; and Remko I. van Hoek and Harry R. Commandeur, "Het verVAL van de Logistiek," *Handboek Logistiek* (Alphen a/d Rijn: Samsom Bedrijfsinformatie, 1995).

QUESTION DEVELOPMENT

Two questions are posed in this study. First, what factors can enhance the application of postponed manufacturing? Second, what factors are bottlenecks in the implementation of postponed manufacturing? The relevant literature in each area is discussed below.

What Factors Can Enhance the Application of Postponed Manufacturing?

To gain more understanding of postponement, it is relevant to explore enhancing factors. Deregulation in Europe and information technology may be enabling factors. Market requirements also may drive the increasing application of postponement. The enhancement of postponement within a company often requires a reconfiguration of the existing operating base.

O'Laughlin and others recommend a four-step framework for the reconfiguration of European logistics systems: visioning, logistics strategic analyses, logistics planning, and management of change.[25] This framework will be used here, as it was specifically designed for the reconfiguration of European operating bases, which is the context of this research.

Visioning. A vision of the required reconfiguration is expected to be a crucial starting point for successful change. O'Laughlin and others point to three characteristics that mark processes leading to well-defined visions in anticipation of (future) customer wishes: (1) a champion in senior management ranks, (2) a total supply chain perspective and (3) a formalized logistics strategy planning process.

Bowersox and others identified a relation between the logistics flexibility required for postponed manufacturing (flexibility in accommodating special customer requirements, product modification while in the logistics system) and characteristics of formalization.[26] Correlations where identified between flexibility and the availability of a mission statement, a strategic plan, and the number of years logistics is formally organized. No correlation was observed between flexibility and the title level of the logistics executive and the participation of the executive in strategic planning. Accordingly, the perspective and penetration of logistics thinking (or championship) in senior management ranks and the perception of logistics competency as a strategic resource at all ranks may be more important. Companies in Europe are upgrading and broadening the scope of logistics from the internal flow of goods to the coordination of internal and external relations and flows of goods and information.[27]

Logistics Strategic Analyses. After the visioning stage, the logistics strategy has to be formulated within the framework of both the corporate and the business unit or division strategy. O'Laughlin and others identify four levels of decision making in the strategy formulation process: (1) customer service requirements; (2) logistics strategy; (3) logistics functions; and (4) implementation. They state that the required overall customer service level has to top the list of priorities in this process. At the second level the focus turns toward the analyses of how best to organize the supply chain to meet the required customer service levels. In that respect, three levels of integration in the supply chain are identified: internal integration (internal logistics), channel integration (cross-functional and cross-organizational process integration), and geographical integration (cross-border integration). A variance can be observed in the level of integration to which companies across industries have progressed. One manager of Digital Equipment involved in the implementation of a new system that allows for the on-line, real-time measurement of operations and performance recently told us: "We are starting off implementing the system within our own department. Other functions and third parties may follow later but that is not yet planned." This manager had not yet progressed beyond the stage of internal integration. Even though variance exists, the general trend observed by O'Laughlin and others is toward more integration, rationalization, and consolidation of logistics operations. This is consistent with the findings of other European studies.[28]

At the third level, various functional areas of logistics will be involved in balancing service and costs at a tactical/operational level. Despite the importance of the overall customer service level, costs obviously are a concern, too. In designing supply chains, costs and service consequences are key topics.[29] In fact, one reason why little is known about the implementation of postponement may be that it is difficult to estimate the costs of such strategies.

The logistics information systems infrastructure is also a key factor in implementation. According to Achrol,[30] a full-disclosure information technology that is directly wired to the pulse of the mar-

ket and that has the flexibility to react to market signals with a customized and immediate response is at the heart of the network organization. The research of Bowersox and others shows correlations between the flexibility required for postponed manufacturing and technology variables, such as the availability of soft- and hardware systems, EDI links, and accurate and timely information.[31] Tight control over the supply chain is an important prerequisite for postponement strategies.[32] Bowersox and others identified a correlation between the flexibility required for postponed manufacturing and various performance measurement variables.[33] The control required for postponed manufacturing can be achieved through coordinating technologies linking operations to suppliers and customers through EDI and better control of in-house activities.[34]

Logistics Planning. In this step the reconfiguration is stipulated and planned. Network organizations are expected to be able to adjust structures and processes fluidly and rapidly.[35]

Management of Change. In this step the actual reconfiguration takes place. O'Laughlin and others expect this to result in a shift of the logistics manager's job (1) from a country to a pan-European orientation, (2) from in-country distribution to the coordination of multiple flows across country borders and within local markets and, (3) from an emphasis on trading off costs and service to an emphasis on balancing costs and service. Management of change is expected to be the most critical success factor of all. This brings us to the second question.

What Factors are Bottlenecks in the Implementation of Postponed Manufacturing?

Research by Daugherty and others shows how managers experience problems with the modification of products in the logistics system.[36] This may be one reason why postponed manufacturing applications are still in an infancy stage. These factors may be as relevant to the practical knowledge of postponed manufacturing as the enhancing factors.

Despite the universal challenge to create the flexibility of build-to-order manufacturing while retaining economy-of-scale benefits and to tailor offerings to specific customer wishes while maintaining low costs there is, of course, no such thing as a universal solution. And there is no single recipe for consolidation of logistics systems in Europe.[37] The balance between efficiency and responsiveness can vary per organizational unit, per business function, and even per activity.[38] Even if companies are evolving in the same direction and the organization design resulting from a reconfiguration may be comparable, the change process itself may vary among companies. Ghoshal and Nohria conclude that the reconfiguration process can vary significantly depending on circumstances in the operating environment.[39] Factors that can be expected to influence the change process are a company's starting point and its heritage.

A company's starting point influences the focus of the change process. Postponed manufacturing strategies may be adopted not only because of flexibility requirements but also because of the need to combine global efficiency with local responsiveness capabilities, as identified by Bartlett and Ghoshal.[40] Global efficiency can be enhanced through consolidation of activities in large-scale, upstream operations. Local responsiveness can be enhanced through the decentralization of activi-

ties in downstream postponed manufacturing operations. In finding the balance between efficiency and responsiveness, a very globally efficient company may be focused on reconfiguring its operating base to enhance local responsiveness capabilities. In contrast, a company with a dominant local responsiveness capability may be focused on enhancing the global efficiency of its operating base.

The administrative heritage or history of an organization can be expected to play a critical role. Despite the importance of enabling factors, the organization's history and existing operating practices may cause a bottleneck in the change process. Reconfiguring the operating base often involves changing people. A change management plan should be realistic in estimating how quickly the organization can accept change,[41] and the plan should be designed to meet human criteria as well as more economic considerations.[42] This is illustrated by the following quotation from a European IBM manager, based on his experience with centralizing inventory and control over spare parts: "During the years that we worked on this project I spent all of my travel budget meeting local executives, reasoning for changes, and calming their fear of losing responsibilities and jobs." According to Garvin,[43] reconfiguration efforts should not ignore management processes. Like operating processes, these have to be changed, too.

This touches upon what may be a blind spot of European managers—the importance of an overall international supply chain perspective. The need for accurate management of manufacturing-logistics and marketing interfaces is likely to be a bottleneck in achieving the potential benefits of postponement strategies. At an operating level, the implementation of postponed manufacturing systems requires cross-functional marketing-manufacturing-logistics integration in the supply chain as final manufacturing and marketing activities (dealer delivery, order-driven customization, special promotions, and so on) are being moved into the distribution channel. At a managerial level, lagging supply chain integration, for example, will result in responsible managers relying on others to implement postponement programs.

METHOD

According to Yin,[44] "what" questions can be answered by exploratory research with the goal of developing a basis for further research. This study is part of the first phase of a broader project on postponement that hopes to make use of the benefits of triangulation, that is: off setting the weaknesses of some methods by the strengths of other methods.[45]

Exploratory case studies of four companies employing postponed manufacturing operations in Europe were prepared. The companies represent four different industries: software (SW), biotechnology (BT), transport equipment for industrial use (TE), and telecom business devices (BD). The first two are U.S.-based companies, the other two are European. Companies from different continents and industries are expected to have differences in organizational heritage and starting positions and different industry-specific characteristics. These are expected to influence both the need for global efficiency and/or local responsiveness capabilities and postponement strategies in the international supply chain, the difference also should contribute to an overall perspective on the research questions.

The researchers worked within each company for a number of months, following a standardized set of research questions and procedures in order to maximize the ability to compare cases. The process consisted of in-depth interviews (held at various levels in the company hierarchy), desk and file research, and cost and quantitative studies of marketing, logistics, and manufacturing strategies and coordination.

CASE STUDY RESULTS

A summary of the relevant case data based upon O'Laughlin's framework is presented in Table 2. The primary objective for each company in implementing postponement was to improve customer responsiveness of the international supply chain in a cost-efficient manner. By reconfiguring existing operations or adding new ones, the companies aimed at improving their performance for customers in terms of both service levels and costs. The change process, however, differed among companies.

TABLE 2

CASE STUDY DATA

	SW	BT	TE	BD
Reconfiguration:	Creation of a European sourcing system for components and a downstream third-party final manufacturing operation	Decentralization of operations from USA to Europe and creation of national stocking points	Central outsourcing of final manufacturing and inventory centralization	Centralization of European operations from a country level to continental and global level and integration of process
1. Visioning				
Top management involvement	Yes	Yes	Yes	Yes
Total supply chain perspective	Yes	Yes	Yes, but not really future oriented	Limited; battles with local barons
Formalized logistics plan	Yes	No	No	Not at first
2. Strategic planning				
Customer service first	Yes	Yes, but regulation second	Yes	Yes
Internal integration	Yes	Yes	Yes	Yes
Channel integration	Yes	Yes	Yes	Limited
Geographical integration	No	No	Yes	Yes

TABLE 2 (CONT'D)

CASE STUDY DATA

	SW	BT	TE	BD
Regulatory drivers	No	Earlier market introduction in Europe, national stocking and testing	No	Demonopolizing of national telecom companies enabling centralization
Information technology-infrastructure:				
With suppliers	Not formalized	E-mail / fax	EDI from an internally integrated system	Not formalized
With customers	EDI	Fax / phone	EDI from an internally integrated system	EDI
Internal	Statistical control of third party	Inventory control system	Electronical control of third party from headquarters	Logistics planning module
3. Logistics planning				
Time frame of change	6 months	Very short	3 years	3 years and ongoing
Approach of change process	Turnkey, instant adjustments through outsourcing	Almost intuitive decision making	Stepwise	Country and stepwise intensive process with fall backs, more a social-political battle than an economic rational turnaround
4. Manage change				
Heritage/ starting point	Global efficiency	Global efficiency	Local responsiveness	Local responsiveness
Adoption of postponed manufacturing contributes to	Global efficiency and local responsiveness	Global efficiency and local responsiveness	Local responsiveness and global efficiency	Local responsiveness and global efficiency
Pan-European orientation	Yes	Limited by national regulation	Yes	Slowly increasing
Cross-border and local flows	Yes	Yes	Yes	Yes
Balanced costs and service	Less rework, reduced risk of obsolescence, more customization and higher (direct) delivery performance	Product localization within a 24-hour delivery zone, some pipeline costs savings	Efficient supply and reduced inventory expenses, improved lead time	Efficiency in sourcing, pipeline and inventory costs, more accurate delivery and wider assortment

SW is a relatively young U.S.-based company that manufactures and markets graphic software packages. It started supplying the European market in 1989, for which it had to build a European operating base to increase local responsiveness. SW began to source components from European suppliers. The mother company selected a third-party logistics service provider for transportation and final manufacturing of software packages, customized for the various European markets. Outsourcing enabled SW to start supplying European customers rapidly and make almost instantaneous adjustments to its operating base. SW's global efficiency starting point can still be found in R&D: software is developed at the U.S. headquarters, and mastercopies are sent to Europe for duplication. The headquarter company remains responsible for activities like supplier selection and inventory control.

BT is a young U.S. based company that applies biotechnology to develop, produce, and sell health care products. The decision to locate in Europe and to establish national stocking points was driven by regulatory, product approval requirements, different in each country, and a need for responsiveness to customers. Marketing and selling biotechnology products requires regulatory approvals. An approval can be obtained more rapidly in Europe than in the U.S., especially if a company applies for approval from a European operating base and manufactures products in Europe. Differences in national regulation still exist, even after Europe 1992, which means that national stocking points with national quality assurance are still required as well as specific processing procedures, despite the fact that the physical product is homogeneous. Furthermore, a high and rapid product availability (replenishment within 24 to 48 hours and total reliability) is demanded by customers. The European organization consists of one plant that finishes base products, received from the U.S. manufacturing base, into country-specific products and distributes them to national stocking points. Since BT's products are of high value, these demands can be met from one point in Europe using express or courier services, thus saving on inventory costs. The actual reconfiguration of the operating system involved establising a downstream manufacturing plant and stocking points, to add local responsiveness to the existing capability of global efficiency. This reconfiguration took place within a very short time, with decisions made almost intuitively on the basis of top management commitment to product approval and availability.

TE is a European manufacturer of fully customized transport equipment for industrial use. Facing increasing difficulties in efficiently meeting its customers' requirements for fast and reliable lead times, TE was pushed to reconfigure its manufacturing and logistics operations. Final manufacturing was postponed from the factory in northern Europe to a third-party distribution center located centrally in Europe. The distribution center became an extension of the assembly line in northern Europe, allowing TE to ship standard components from its factory to the postponed manufacturing operation. The distribution center's location in the market has reduced distance to customers, allowing TE to improve its performance on lead times at acceptable outbound pipeline costs. A second step of the reconfiguration consisted of centralizing parts inventories from national sales organizations to the postponed manufacturing operation to enhance efficiency and the ability to assure reliable delivery through improved transport and inventory planning. Furthermore the formerly disintegrated sup-

ply chain is now electronically integrated into one operating system, which allows TE to control and manage suppliers, customer orders, and the third-party service supplier from its headquarters.

The structure of the European manufacturer of business telecommunication devices (BD) was dominated by local companies with a large degree of operating autonomy. In order to meet the demands of monopolistic national telecommunication companies in Europe, it had been necessary to build a strong local presence and an ability to design products to national specifications. Increasing competition put pressure on prices, and forced BD to increase its supply chain efficiency. Demonopolization and privatization of national telecommunication companies enabled BD to reconfigure its operating base to become more (globally) efficient. A central location in Europe was established to perform customizing, final assembly, testing, and repair of business telecom devices for the entire west European market. These activities were previously executed decentrally by the various local companies in European countries. Local companies remained responsible for marketing, sales, and after-sales service. In this reconfiguration process the existing structures hampered the change process; many local companies where unwilling to sacrifice autonomy for integral supply chain improvements at first. The change process was conducted stepwise, one local company at a time, and took more than three years.

CASE COMPARISON

As mentioned before, customer service came first in the reconfiguration of all companies, although regulatory requirements were a second major concern in BT's case. All companies have a sense of urgency regarding market requirements; the customer-specific character of TE's and BD's finished products make almost every customer order unique.

The case results confirm the variance in the level to which integration has progressed for companies in different industries. BT and SW did not move into the stage of geographical integration because their reconfiguration was oriented downstream, with the movement of final manufacturing operations into the European marketplace. Despite the fact that BD has progressed to the level of geographical integration within Europe, this process is staggered because channel integration is limited. Upstream difficulties with a main supplier caused delays in shipments of finished products to customers. This reduced delivery performance and negatively affected the trust of downstream local companies in the performance of BD's postponed manufacturing operation. In turn this caused a fallback in the implementation of the postponement strategy. SW and TE's channel integration involved extensive alignment with third parties and specialist companies.

The influence of regulation is especially apparent in the case of BT, although it is in contrast with the expected deregulation. In BD's case the regulatory effect of state-owned telecommunication companies has decreased because of demonopolization, enabling the establishment of postponed manufacturing operations.

The case results also show how information technology can be used in organizational revolutions to help create a new context for management and strategic decision making. TE (the transport equipment manufacturer) especially makes the most notable use of an advanced information technology (IT) infrastructure. Although these infrastructures vary from one case to another, the use of IT is universal and is an important factor in the implementation of postponement strategies.

Factors Favoring Postponed Manufacturing

A summary of relevant operational characteristics per case, used to establish the feasibility of postponed manufacturing, is presented in Table 3. The shaded scores printed do not confirm the theoretically anticipated values (as presented in Table 1).

TABLE 3

OPERATING CHARACTERISTICS

	SW	BT	TE	BD
Technology & process				
Decoupling feasible?	Yes	Yes	Yes	Yes
Complexity of customization	Low	Low	Moderate	Moderate
Modular product design	Yes	No; one base product that is purificated and packed	Yes	Yes
Sourcing from multiple locations?	Yes (USA and Europe)	No (postponement from one plant)	No (postponement from one plant)	Yes (global)
Product characteristics				
Specific formulation	Low	No	High	High
Specific pheriperals	Yes	Yes (packaging)	Yes	Yes
Commonality of components	High	High	High	High
Value density	High: $100.000/m3	High: $80.000/m3	Moderate: $20.000/m3	Moderate: $20.000/m3

TABLE 3 (CONT'D)

	SW	BT	TE	BD
Volume changes	+350%	+10%	+5%	+0-25%
Market				
Life cycle	1 year	Biological; 1.5 year	Regular small changes	Regular new releases
Sales fluctuation	High	Limited	High	High
Required lead times	< 1 week	24-48 hours, 100% reliability	1-2 weeks	2-3 weeks
Price competition	Yes	No	Limited	Yes
Varied markets	Yes	No	Yes	Yes

SW's case is straightforward in the sense that almost all operational characteristics favor postponed manufacturing. It does not make economic sense to ship high-value, voluminous, and heavy packages from the U.S. to various European markets. By establishing a European customizing center, SW avoids high transportation and inventory costs and is able to realize short, reliable lead times. The specific nature of a software package is not so much the result of its content but rather of peripherals, such as country-specific documentation. SW's assembly process, merely combining discs and peripherals, is low in complexity, which facilitates the postponement of assembly into the distribution channel.

BT's product has a homogeneous biological structure, sourced from one manufacturing plant in the U.S. Customization merely consists of packing the product in specific boxes; sales, markets, and prices are rather stable. Very rapid and reliable delivery performance is required, however. This, together with specific testing and manufacturing procedures, highly favors postponed manufacturing.

TE's postponed manufacturing center is actually an extension of the assembly line in northern Europe. Therefore, this case is not characterized by multiple sourcing; generic components are solely supplied by the manufacturing base. In contrast with SW's case, the complexity of TE's assembly process is much greater than the regular activities of the logistics service provider. Still, the advantages of postponed manufacturing outweigh the additional processing costs associated with this complexity. The central location allows TE to improve its performance on lead times to customers at acceptable outbound pipeline costs.

In BD's new structure, global and European suppliers deliver directly to the postponed manufacturing operation rather than to the various local companies. Direct sourcing from multiple locations contributes to increased efficiency by reducing transportation and inventory costs, provided that the processes between the organizational units involved are properly integrated. The high complexity of BD's final assembly process is primarily caused by the specific equipment and qualified

labor needed in the testing of customized telecom devices. Proper testing facilities are a prerequisite to assure high quality.

Table 3 also shows that the volume increase in both TE's and BD's assembly process is very modest. Previous research findings emphasized savings in transportation costs due to shipping less voluminous unassembled products in form postponement strategies.[46] Yet, this was clearly not a dominant consideration, compared to pipeline and inventory costs, in the reconfiguration process of TE and BD.

The Logistics Planning and Change Process

The starting points differ among cases and as a result the orientation of the change process differs. BT and SW were predominantly globally efficient before the reconfiguration. Enhancing local responsiveness capabilities required the downstream positioning of operations. BD, on the contrary, was predominantly locally responsive and in order to increase overall efficiency in its European operating base, it had to consolidate management, operations, and sourcing.

Administrative heritage, or the history of a company's operating base, appears to have a substantial effect on the implementation of postponed manufacturing. It influences the way the change process is designed and the way it progresses. Our research suggests a deviation between relatively young, and older companies with an existing and well established organization in Europe. Younger organizations (BT and SW) almost instantly and intuitively reconfigured their operating base, not hindered by existing structures or an operating heritage in Europe. Companies with a history of strong local autonomy may find it difficult to implement organizational change that represents a radical departure from the established paradigm. Within BD, traditional organization structures have been a barrier in the implementation of postponed manufacturing. After three years the reconfiguration process of BD is still in progress. It is being conducted stepwise by each local company involving intensive negotiations and discussions. Although economic arguments are important, of course, political and social issues are key items as well. Sometimes these cause additional delays and fallbacks in abandoning the long-established heritage of local autonomy. Severe resistance from organizational units and national barons causes lengthy change processes with occasional fallbacks.

In the original work of Bartlett and Ghoshal,[47] a deviation in change processes was expected not only among companies with different starting points and heritage but also among companies from different home countries. In our research, however, the deviation is not so much between European or U.S. companies as between young companies and older companies with a well-established organization in Europe.

As a result of the reconfiguration, the jobs of logisticians in the case companies were largely altered, as expected. Both cross-border and local flows of goods and information increased. Furthermore, costs optimization within service requirements are key issues. The pan-European orientation of managers is limited in some cases, however. Recall the example of BD, in which supply problems generated a slip of performance and a loss of trust among organizational units. This lack of supply chain integration explains the falling behind of cross-functional or even cross-organizational channel integration in cases.

The simultaneous cost and service performance improvement can only be realized if the international supply chain is integrated. In turbulent markets, integration within functional areas is no longer enough; channel integration, together with cross-border global and local integration of flows is key. Despite the availability of enabling technologies and European unification to facilitate this integration, many organizations are still reluctant to implement fundamental changes in their supply chains. Reasons for postponed manufacturing applications remaining in an infancy stage start at step 1 of the reconfiguration process: a lack of total supply chain perspective. Also, formalized logistics plans and planning processes are not available in-depth. During our research we experienced great difficulty in collecting proper costs and operational performance data in those companies without formalized logistics plans. Because of prevailing local autonomy, measurement systems were different and inconsistent among countries and operations.

Contribution of Postponement to the Formation of Network Organizations

Relevant consequences of the postponed manufacturing applications for the move toward network organization are indicated in Table 4. A general effect of the applications is the mass customization of products. The combination of upstream, speculative primary manufacturing of generic components and modules with downstream, instantaneously postponed secondary manufacturing and (direct) delivery results in cost-efficient customization in these technology-process-product-market combinations. As expected information technology can help create a management context in which postponement and speculation can be more easily combined within one operating system.

TABLE 4

EFFECT OF POSTPONEMENT ON THE FORMATION OF NETWORK ORGANIZATIONS

	SW	BT	TE	BD
Mass customization	Improved responsiveness and customization without cost increase			
Disintegration and integration within one operating system	Yes	Yes	Yes	Yes
Transparency of logistics	High	High	Moderate	Limited
Extensive use of specialized companies	Yes	No, because of testing and processing regulation	Yes	No; focus on in-house change
Fluid and rapid reconfiguration of structures	Yes	Yes, but limited by regulation	No	No

Despite variations among cases, both disintegration and integration tendencies can be observed within all operating systems, combined with an urge to create local responsiveness and global efficiency simultaneously. At TE, for example, the implementation of a postponement strategy meant that the customer ordering function, final manufacturing, and some operations management had to be moved downstream to increase responsiveness, while (parts) inventories were centralized to enhance efficiency. Mostly, however, the integration is merely internal and geographical/physical. The reintegration in network organizations as mentioned by La Londe and Powers,[48] however, is fundamentally different from these primary integration tendencies. In the shift toward a network organization, a first action is to use disintegration and (internal, channel, and geographical) integration in the reconfiguration of operations and channels to create the primary capabilities efficiency and responsiveness. Having created a modern logistics system layout, a secondary action can be to install a formal command and control hierarchy. An alternative, as suggested by La Londe and Powers, is to take another turn into the IT-enabled virtual reintegration and create a control system based on networking, not ownership. A higher level reintegration of specialized companies, markets, and suppliers, allows for responsiveness not only in operational processes but also in reconfiguring structures and management processes on a constant base, depending on market requirements. In turbulent markets, vertical reintegration might be a step back, whereas virtual reintegration is a more effective step forward.

Due to a lack of modern supply chain vision and heritage problems, however, the case companies still have a long way to go toward the creation of network organizations, despite the contribution of postponement strategies. As a result, logistics is not very transparent, especially in the cases in which the change process took more time. A clean-sheet approach might have resulted in more transparency in TE's case than did the stepwise evolution. An outcome of the heritage of local autonomy in BD's case is IT systems developed autonomously in every country that are incompatible with systems in other countries. These system difficulties and the social/political battle that required compromises in some stages of the change process resulted in pan-European flows of goods and information with some exceptions and variances on a national basis. In our research, just getting the picture of the current logistics system together took days and consultations with various managers.

Internal integration problems within BD result in a limited use of specialist outside suppliers, while testing and processing regulation in BT's case limit the room for cooperation with third parties. These regulatory issues also limit the ability of BT to fluidly and organically develop an informal structure as expected in network organizations. TE's structures do not evolve fluidly but stepwise. BD's change process does not reflect fluid structures. In that respect, ultimately it is not the enabling technologies that create flexibility but the people who work with it at the level of individual factories.[49]

CONCLUSION AND FURTHER RESEARCH

Our cases reveal how market circumstances require the implementation of postponement strategies and how advances in IT and European unification enable that implementation. The experiences of the case companies demonstrate that it is by no means easy to reap the anticipated benefits of such strategies. Both strategic and operating characteristics influence the feasibility of postponement.

In targeting the anticipated benefits of postponement, a framework for the reconfiguration of European logistics systems such as that of O'Laughlin and others, can be applied. Most items and issues in their framework are relevant in the experience of our case companies. In most instances the management of change will be the key challenge of the reconfiguration process. In addition to the items in the O'Laughlin framework, our research reveals how the change process is organized and progresses differently depending on the starting points of companies and the organization's heritage. Bottlenecks may occur in the very first step of the process, the visioning stage. An organization's heritage of local autonomy in Europe often results in a lack of integral supply chain perspective and a limited formalization of logistics strategy planning. As a result of the latter, operational approaches to reconfiguration prevail, and postponement applications are still in the infancy stage.

Postponement strategies contribute to the creation of mass customized products and a number of network operating circumstances. A wider implementation of postponement and the creation of fluidly evolving networks, however, will require an integrated supply chain vision and strategic logistics planning. Apart from operational processes, management processes need to be changed as well.

The case study research method seriously limits the ability to generalize results. More case studies in different industries are being conducted to get a better perspective on cross-industry and cross-company variations in applicability of postponement and in the range of possible postponed manufacturing applications. As a second stream, calculation modeling is being used to gain more insight into the financial effect of postponement on operating costs and on the role of specific operating characteristics. These insights are difficult to generate on the basis of individual case studies only, especially because it appeared difficult for case companies to estimate accurately the costs/benefits of postponed manufacturing systems. Furthermore, a survey is being conducted to help build statistical generalizations on the extent to which companies have actually implemented postponement in the context of operational feasibility and organizational reconfiguration. It is hoped this triangulation of research methods will enable us to add to the body of knowledge on postponement and bring the theoretical benefits of postponement introduced in the 1950s and 60s a step closer to the practice of international business.

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ABOUT THE AUTHORS

Remko I. van Hoek is assistant professor, Department of Marketing Management, faculty of Economics, Erasmus University Rotterdam, the Netherlands. The research in this article is part of his dissertation.

Harry R. Commandeur is professor of marketing, University of Ghent, Vlerick School of Management, Belgium and assistant professor, Department of Marketing Management, faculty of Economics, Erasmus University Rotterdam, the Netherlands.

Bart Vos is assistant professor of organization and strategy, Tilburg University, the Netherlands. He received his Ph.D in international manufacturing and logistics from Eindhoven University of Technology.