



Learning Objectives for This Chapter

- Push and pull views of the supply chain
- Mass customization and modularization
- Order penetration point and postponement
- Basic production strategies in the supply chain
- Analysis of order penetration point location

6.1 Introductory Case-Study DELL vs. Lenovo

Dell

The company Dell was founded in 1984 by Michael Dell, who was 19 at the time. Starting off with only \$1000 in start-up capital borrowed from Dell's father, the company opened its first subsidiary in the UK only 3 years later. In 1995, Dell became a global company and in 2001 was named the No. 1 computer systems provider. What is it about Dell that makes it so special?

Dell is well known for its direct-sales model and its ATO or “assemble to order” approach. This means manufacturing and delivering individual PCs configured to particular customer specifications. Instead of pre-assembling a complete PC, Michael Dell created a SC where inventories of components are held in a few central locations, and as customer's placed their orders a Dell computer is assembled exactly to the customer's requirements. Distribution and shipping are made direct to the

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customer. Standard components are offered and customers can choose the particular features they want to add to the technical device. Strong customer focus is an important part of the direct model. The online channel has proven very effective for the sale of computer hardware, and by 2009 represented about half of the sales in this category. In 2007, Dell expanded its sales channels and started to sell PCs through retail stores.

Most of Dell's suppliers come from Asian countries, such as Japan (RAM chips), Taiwan (monitors), and Singapore (disk devices). All components are then delivered to manufacturing plants, for example in Austin, Texas (Fig. 6.1).

Using the ATO strategy, cycle times are reduced and inventory expenses are kept at a low level, as not all varieties of products need to be stored, but only the standardized versions. In addition, assembly is easy because the features that can be chosen are independent from the outer appearance of the device. So Dell can offer high-quality products at comparatively low prices.

The customer is able to choose between what type of processor, software, or storage they want in their device. However, the touch and feel experience of the device is lacking and Dell has little presence in retail stores. Customers might miss the presence of a sales expert during the purchasing process. Dell tried to overcome this obstacle by offering hotlines and live chat with sales representatives on their website.

Such a system allowed Dell to create a more flexible SC and ensure efficiency. The lead time was initially 4–6 weeks. With the ATO model, a PC could be fully assembled in 1–2 days, and the customer would receive the order by the end of the week. This significantly reduces inventory holding costs incurred during shipping and improves customer satisfaction. With this strategy, Dell usually holds inventory

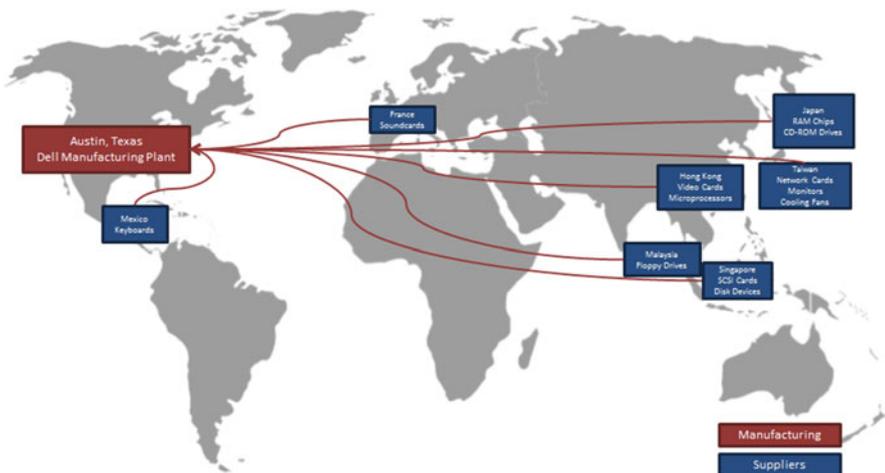


Fig. 6.1 DELL's supply chain

for less than 4 days. By using a postponement assembly strategy, Dell is able to generate cash much faster and reinvest this cash into improving their SC model.

Even though Dell was a so-called rule-maker when they introduced the direct model, market changes forced the company to rethink its strategy. The model was mainly meant for mass production of personal computers for business customers. However, today most sales are generated by laptops for end customers.

“We discovered that only one in four of our customers were using the direct model anymore,” says William Hutchinson, Dell’s vice president of global logistics. While the direct model worked phenomenally well when Dell was aiming for a largely mature customer base, its customers today are as likely to be from emerging markets with immature infrastructures.

In autumn 2013, the company went from being a public company to a private one so that there could be more flexibility in decision making. Future product lines are now storage, networking (e.g. Dropbox), and cloud computing. For storage media, the direct model no longer applies as there is little or no reasonable adaption to the product necessary. Hence, in this product area it is difficult for Dell to gain a competitive advantage. Most likely, producing via a make-to-stock (MTS) strategy would be more reasonable. Additionally, with increasing demand, the risk of stock-outs due to low inventory is also increasing. Moreover, some customers are demanding more than low prices. To improve the approach to these high-end customers, Dell will implement a “premium product line”. In the future, Dell will most likely have a hybrid strategy and use both MTO (make-to-order) and ATO.

Lenovo

The Lenovo brand appeared in 2004, but the company has a much longer history, starting in Beijing in 1984 as the New Technology Development Company (NTD Co.) of the Institute of Computing Technology (ICT) of the Chinese Academy of Sciences (CAS). In 1988, the company was expanded into Hong Kong and grew into the largest PC company in China. In 2004, it changed its name to Lenovo, and in 2005 it acquired the former IBM Personal Computing Division. Currently, Lenovo is one of the world’s largest PC manufacturers. It has more than 33,000 employees in over 60 countries and operates in more than 160 countries worldwide.

A global SC at Lenovo was established in accordance with functional, geographic, and “internal customers” dimensions. In order to increase customer service in major markets, Lenovo established “strongholds” in Europe, America, Singapore, and Shenzhen, China to provide customers with business and financial services (see Fig. 6.2).

Lenovo’s SC includes raw material procurement, production in three locations (Beijing, Shanghai, Huiyang), product distribution, transportation, warehousing (outsourcing), and payment. Lenovo’s inventory cycle is now within 10 days, and the cash cycle can be achieved within 10–20 days. These performance indicators contribute to relatively high profits for Lenovo China.

In October 2005, Lenovo announced a new organizational structure, composed of production, marketing, and logistics. Lenovo bases product development and marketing in Hong Kong. This enables Lenovo’s technical staff to receive timely market

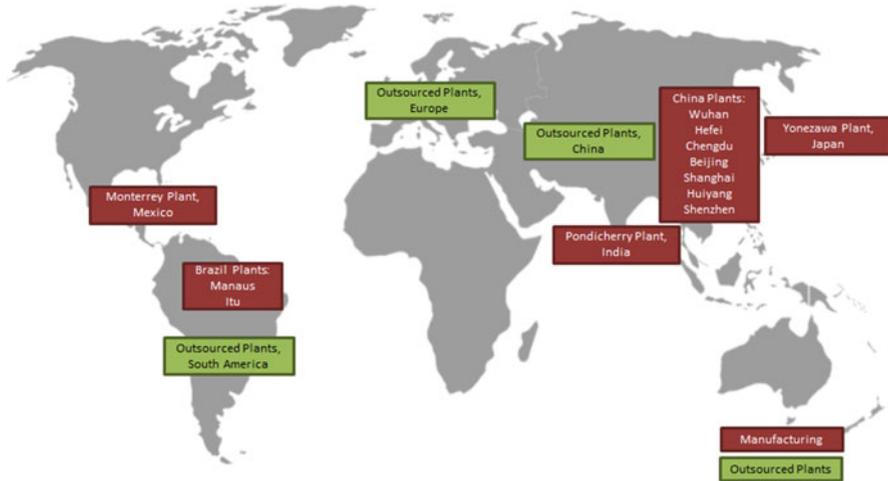


Fig. 6.2 Lenovo's supply chain

and technical information and understand the progress of market and technical factors. This also shortens the company's product development cycle and company products can keep up with international trends.

Production is mainly organized in Shenzhen and other production area in mainland China. The labor costs and price of real estate in mainland China are much lower than in Hong Kong. Locating the production processes on the Chinese mainland helps reduce manufacturing costs. In addition to Lenovo's own investment in the construction of production factories in Shenzhen and other places, Lenovo also develops cooperative relations with other domestic manufacturers.

In procurement and inventory management, Lenovo integrates procurement, production, distribution, and logistics into a unified system with over 300 suppliers. In addition, the company has more than 5000 customer channels in China. Purchase of raw materials such as monitors, hard drives, video cards, and even chassies and other parts are typically organized in collaboration with suppliers in Taiwan, which is a world supply centers for IT components.

In production and inventory management, Lenovo takes a combination of MTS with a large margin of safety, and MTO production with a relatively low safety stock of finished goods to cover demand for only a couple of days. In mainland China, Lenovo's suppliers operate warehouses near Shanghai, Beijing, and Huiyang so that these three factories can receive deliveries faster. Recently, Lenovo opened production facilities in the United States to improve the relationship with its business customers and to be able to offer more flexible support.

Lenovo also uses a VMI purchasing pattern. In accordance with Lenovo's VMI project, its inventory manager, BAX Global Freight Logistics Ltd, as third-party logistics, is responsible for inventory control. The third-party logistics company is responsible for replenishing the production line at the right time with right items in

the right quantity. VMI relies on sharing information between suppliers, third-party logistics, and Lenovo, and ensures timely delivery of materials needed for production. VMI brings considerable benefits to production and inventory management at Lenovo. First, its internal business processes are streamlined. Second, it places the inventory closer to production and enhances the elasticity of supply and better responds to changes in market demand. Third, it improves inventory liquidity. Fourth, through visual inventory management, Lenovo can monitor suppliers' delivery capabilities online. Eventually, it will accelerate Lenovo's logistics, shortens lead times, and ensures timely delivery of the materials required for production: since the Lenovo SC is shortened, costs are reduced and flexibility is enhanced.

In the distribution phase, Lenovo and partners form a closer relationship, with timely information sharing and precise and efficient integration of operations. Lenovo's distribution channels are distributors, agents, distributors of contract, and distributors of non-contract. Lenovo subdivides functions of different channels and uses two channel systems, i.e. one for home computers and one for business computers. Due to their different target customers, distributors can establish good relationships with their customers, which is helpful in opening up the market while avoiding strong competition among themselves. Lenovo adheres to the secondary distribution system, namely a maximum of two levels between Lenovo and consumers, because excessive levels would reduce the efficiency of operations and increase Lenovo's management costs. Lenovo has adopted a selective distribution strategy. On the one hand, Lenovo can reach markets through the distributors. On the other hand, by selecting and training core agents and distributors, Lenovo is able to provide users with better solutions. Through the development of secondary channels, Lenovo flattens the structure of its distribution channel. Direct shipments are organized for MTO production. As with Dell products, customers are able to order Lenovo's products online, but without any adaption tailored to customers.

To manage the complexity of the SC, Lenovo uses an ERP system from SAP. ERP helps Lenovo to run effective SC execution. By monitoring huge amounts of SC data in real time, Lenovo has access to more accurate information, helping to enable fast decision making, facilitating a responsive SC, and improving logistical efficiency. It also provides end-to-end visibility of the entire global SC, and increases transparency and efficiency with real-time access across the SC.

Discussion

1. Identify the basic stages in the value chain which are described in this case study.
2. Explain the interconnections between the production and distribution strategies at Dell and Lenovo.
3. Compare MTO and MTS strategies.
4. Describe the advantages and possible limitation of VMI at Lenovo.

6.2 Postponement and Modularization

6.2.1 Problem: Mass Production or Product Customization

Henry Ford said: “A customer can have a car painted any color that he wants so long as it is black”. Until the 1970s, mass production dominated the industries and markets. The advantages were low unit costs because of rare machine setups, large batch material ordering, and use of standard technologies and materials. Since the 1980s, customers have played a more and more important role in the SC. Products become individual and customized. This flexibility creates competitive advantages, but is also costly. Machines should be set up frequently, lot-sizes in manufacturing and procurement become smaller, and the variety of technologies and materials rise.

In this context, the problem is to determine the right *production strategy* for the SC in order to combine the advantages of mass production and customization.

6.2.2 Principles: Postponement and Modularization

In an era of a customer-oriented product individualization and global competition, companies are struggling to find ways to improve responsiveness without holding huge finished goods inventories. Postponement and modularization are useful tools in this regard.

The *postponement* concept was first introduced in literature by Alderson (1950), where it was observed that products tend to become differentiated as they approach the point of purchase; later this concept was further developed by Bucklin (1965). In addition to postponed forward shipment of goods (time postponement) and maintaining goods at a central location in the channel (place postponement), certain manufacturing activities can also be postponed (Van Hoek 2001). Although this differentiation improves marketability, the manufacturability of the products becomes more complex.

Van Hoek (2001) defines *postponement* as “an organizational concept whereby some of the activities in the SC are not performed until customer orders are received”. Postponement is especially useful for:

- Significant number of variants of an end product with an uncertain split of demand on variants.
- Delivery time requested by customers must allow value-adding steps after receipt of customer orders (or reliable demand forecast).

Differentiation of a generic product into a specific end-product is shifted closer to the consumer by postponing identity changes, such as assembly or packaging, until the last possible SC location. This allows safety stock to be held as one generic product instead of multiple specific end-products. Especially in cases where the split of demand into specific end-products is uncertain, postponement with its risk pooling effect leads to a lower safety stock requirement and a lower risk of

obsolescence of end-products. Furthermore, as less value has been added to the generic product than to the specific end-product, *less capital* is bound in each stocked unit.

The concept of *modularization* implies a product design approach whereby the product is assembled from a set of standardized constituent units. It provides opportunities for exploiting economies of scope and scale from a product design perspective. The key issue here is to design efficient linkage mechanisms in the constituent units so that any required combination can be conveniently assembled.

Baldwin and Clark (1997) describe modularity as “building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole”. The ideas of the integration the product and process modularity have been extensively investigated in the *mass customization* approach.

Ernst and Kamrad (2000) introduced a conceptual framework for evaluating different SC structures in the context of modularization and postponement. In the analysis, modularization is linked to postponement. The paper introduces taxonomy and develops a corresponding framework for the characterization of four SC structures, defined according to the combined levels of modularization and postponement: rigid, postponed, modularized, and flexible.

6.2.3 Examples of Postponement Strategies

Asian Paints (Shah 2009)

Asian Paints is an Indian paint manufacturing firm that has employed a postponement strategy in its emulsions product category. Asian Paints offers four emulsion brands. In turn, each brand offers 150–250 shades. Offering a wide variety of color shades is essential in the emulsions market. An emulsion comprises a “base” and a combination of “stainers”. The base provides the functional aspects while the stainers provide the required shade. The base accounts for 99% of the final emulsion volume. A wide range of shades is developed using just 10 stainers. At Asian Paints, the mixing of the base and the stainers, also known as “tinting”, is carried out at the various sales points (SPs) distributed across the country. On average, there is one SP for every 400 retailers. At the retailer point, the customer chooses from a range of 150–250 shades.

The retailer immediately forwards this order to the SP. The effective time for tinting is about 10 min. The customer collects the shade of her choice within 1–2 days of placing her order. Except for certain fast-moving shades, the inventory at the SP is mainly bases and stainers. The SPs order these periodically from their designated regional distribution centers (RDCs). The factory warehouses replenish the RDC inventories periodically. The periodicity of ordering depends on the demand volumes. The RDC lead times (factory to RDC) are in the range of 2 weeks to 1 month while the SP lead times (RDC to SP) are in the range of 1–2 days. Thus, the delivery period would be close to a month if the tinting operation took place at the factory itself. Tinting is a low-technology operation due to low capital expenditure and simplicity. The delayed differentiation due to postponement

of the tinting operation has reduced the inventory levels drastically. Customer service is high because of the reduced delivery period. Forecasting errors are also considerably reduced. There is no loss of scale economies as a result of the postponement. Being a simple operation, product quality is not diluted because operations were transferred from the factory to the SPs.

Asian Paints revolutionized the postponement concept in the Indian paint industry. Asian Paints has been offering substantially higher numbers of shades and maintains its finished goods inventories at about 60% of the industry average. This has helped them to maintain profitability consistently higher than the industry average, and has probably contributed to increased market share over a period of time.

Automotive Industry (Appelfeller and Buchholz 2011; Kagermann et al. 2011)

Modular design is an important method for controlling and reducing complexity. Using identical components and modules significantly reduces diversity and complexity. Limited, accurate, and defined components and modules, which are assembled to create individualized final products, result in outward diversity and inward standardization. In the automotive industry this approach has become known as a *platform strategy* which can be used within or across product lines or brands.

From the customer's perspective, postponement means being able to specify requirements as late as possible in the production process. Vehicle manufacturers are particularly well known for this practice. For example, BMW customers are able to modify their personalized vehicle up to 5 days before assembly begins. In turn, a gearbox or seat supplier has to defer production until the precise requirements are known.

While the implementation costs are significant, postponement in combination with JIT has many benefits:

- Lower inventory costs for finished goods, but also for raw materials and work in process (WIP);
- Lower risk of product obsolescence;
- Simpler forecasting and greater responsiveness;
- Customized products can deliver competitive advantages, such as time to market, as well as command a price premium.

If a company shifts final assembly to a time and location close to the customer in time or space, it can supply more personalized solutions and avoid make-to-stock production, while still realizing economies of scale.

A good example of successful implementation of the postponement strategy is the automobile manufacturer Toyota (Belson 2011). Building brands such as Toyota, Lexus, and Scion in its own factories in Japan, Toyota afterwards ships the cars with the aim of selling them internationally. Toyota employs port facilities, e.g. a 98-acre operation at Newark's port is a scaled-down assembly plant. Cars, destined for sale from Virginia to Maine, are modified at the Newark port according to a customer's special request at very short notice.

A range of so-called port-installed options can result in 21 different models. The average length of time spent at Toyota's facility is 8 days for the up to 12,500 vehicles arriving by ship at any one time. Between 2 and 6 days are required for the necessary adjustments and it takes on average another 1.9 days for a car, once completed, to leave the facility.

By completing the modifications within 8 days and allowing the customer the possibility to adjust his/her order in regard to the car's configuration—including satellite radios, tires, rims, bumper protectors, body mouldings, and a variety of exterior items—until 2 days before the car arrives in Newark, Toyota achieves better customer service and higher customer satisfaction. In addition, having established a close relationship with suppliers and only ordering daily the accessories needed for the next 2 days, the facility has reduced its just-in-time inventory by 70% within the last 4 years.

IKEA (Cheng et al. 2010; Kagermann et al. 2011)

With production in 41 different units worldwide, IKEA controls a SC for approximately 9500 finished products. The "Range Strategy & Product Development Supply Chain" group is in charge of handling the SC as smoothly and efficiently as possible. IKEA developed the concept of "design for logistics" (DFL). DFL focuses on the design of the product not only according to customer requirements, but also to ensure efficient handling and transportation. This results in more efficient stocking of items and the so-called flatpack approach, in which most items are packaged in flat, easy to handle packages. IKEA ultimately aims for a 75% fill rate for its trucks. Due to vertical integration, IKEA produces "make-to-stock", which means they follow a push strategy. This strategy comes with many advantages on the one hand, but also with some risks on the other. For one, the "make-to-stock" approach requires accurate forecasting of demand to manage the trade-offs between costs (transportation cost/inventory cost) and service level (availability of items). Therefore, IKEA is engaging in risk when pooling activities such as:

- postponement (last step of the SC is the assembling of the product by the customer)
- material standardization (uniform screws, planks, colors, techniques)
- inventory pooling (at warehouse or in store)
- product pooling (similar kinds of products).

IKEA has taken the concept of manufacturing postponement to an extremely high level: final assembly of many furniture items occurs in people's houses. The company works closely with its suppliers to source and design attractive furniture that can be location-neutral and flat-packed whenever possible, making its products acceptable in many countries while keeping transportation and warehousing costs low. All products in IKEA retail stores are kept in a semi-finished form (flat packs) and are assembled by customers or deliverymen after home delivery. In this way, truckload capacities can be better utilized and configurations can be easily made at customer locations.

6.3 Push–Pull Views and Order Penetration Point

The push/pull view of the SC divides SC processes into two categories based on whether they are executed in response to a customer order (downstream SC) or in anticipation of customer orders (make-to-stock, upstream SC). Pull processes are initiated in response to a customer order. The pull advantages are responsiveness, and a high degree of customer-oriented product individualization. Push processes are initiated and performed in anticipation of customer orders. The advantages of this are economy of scale (low manufacturing and transportation costs), flexibility (high level of inventory), and short supply times.

This view is very useful when considering strategic decisions related to SC design, because it forces a more global consideration of SC processes as they relate to the customer.

The main idea behind postponement is to delay product differentiation at a point closer to the customer. This point is also known as the order penetration point (OPP) (see Fig. 6.3).

In the case of a customer inquiry or order, the goods can be delivered from a general inventory holding unit (trajectory α) or customized according to the inquiry or order (trajectory β). Upstream of the OPP, the processes are designed to be lean. Downstream the processes are designed to be agile.

Three categories are primary relevant to the OPP location:

- Delay of product differentiation—postponement,
- Design and developing standard or generic configurable products that can be customized quickly—product modularization,
- Implementation of specific collaboration strategies, inventory strategies, buffers, etc. to fulfil service level objectives—agility.

In practice, a selected postponement strategy determines the OPP location. The further upstream the OPP is located in the SC, the more manufacturing and logistics activities are postponed. In general, the aim is to postpone manufacturing and logistics as much as possible and maintain high customer service standards.

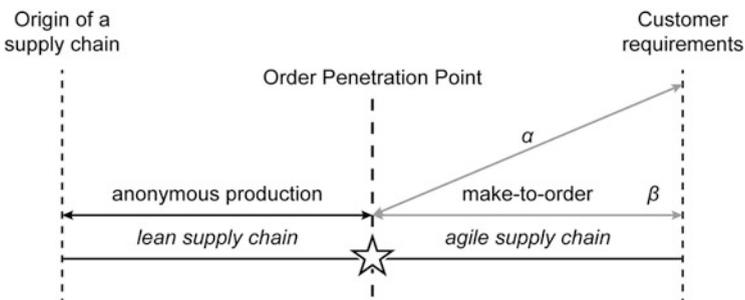


Fig. 6.3 Order penetration point

The OPP location is dependent on a number of factors.

Factor 1. Costs of inventory holding. This factor has been highlighted in literature as one of the most important for analyzing postponement strategies.

Factor 2. Costs of modularization. High costs of modularization are the main drawback of postponements.

Factor 3. Costs of information systems installation and running. However, the introduction of new IT costs a lot of money.

Factor 4. Costs of replenishment. Practical case studies, i.e. of DELL, point to the conclusion that SC responsiveness highly depends on the speed of replenishment of customer-individualized product units.

OPP location depends on products.

Factor 1. How many variants of a product are possible?

Factor 2. What is customized (product, batch sizes, and package)?

Factor 3. Which parts of the products can be customized from a technological point of view?

Factor 4. Which parts of the products can be modularized from technological point of view?

Factor 5. Price of products

Factor 6. What is the concurrent situation in the industry?

Factor 7. SC cycle for a product

Factor 8. Customization cycle of a product

Factor 9. Where is strategic inventory held?

OPP location depends on customers.

Factor 1. Who launches orders (individual consumer, organization, retail, or wholesaler)?

Factor 2. Who launches the customization (individual consumer or organization)?

Factor 3. Who is the end customer (individual consumer or organization)?

Factor 4. Number of customers

Factor 5. Which contracts are used?

OPP location depends on suppliers.

Factor 1. How many alternative suppliers are available?

Factor 2. Possibility of strategic alliances under and with the suppliers

Factor 3. What contracts are used?

6.4 Selection of a Production Strategy

We already know the principles of postponement, push/pull views, and OPP. Now we can integrate this knowledge and consider several production strategies.

6.4.1 Types of Production Strategies

With pull processes, execution is initiated in response to a customer order. With push processes, execution is initiated in anticipation of customer orders. Therefore, at the

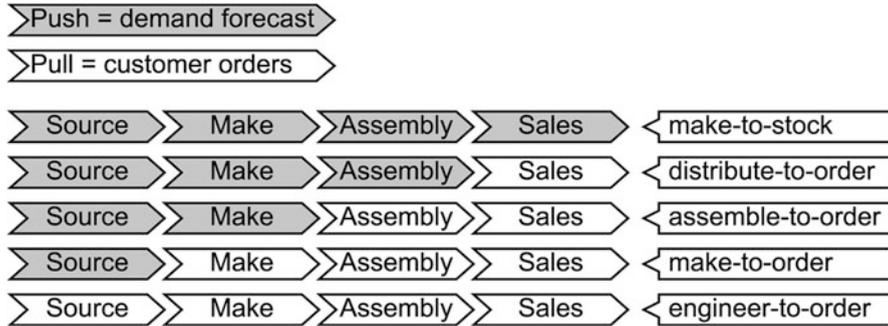


Fig. 6.4 Production strategies in the supply chain

time of execution of a pull process, customer demand is known with certainty, whereas at the time of execution of a push process, demand is not known and must be forecasted (see Fig. 6.4).

The push/pull boundary is the place of the OPP that separates push processes from pull processes. A product is kept as long as possible in a generic state. Differentiation of the generic product into a specific end-product is shifted closer to the consumer by postponing identity changes, such as assembly or packaging, until the last possible SC location. According to the placement of the OPP, the following *production strategies* can be determined:

- Make-to-stock (MTS)
- Distribute-to-order (DTO)/Configure-to-order (CTO)
- Assemble-to-order (ATO)
- Make-to-order (MTO)
- Engineer-to-order (ETO).

A *make-to-stock strategy* is typical for mass production of standard products like sugar, socks, etc. MTS advantages are low unit production costs and higher capacity utilization because of scale effect and quantity flexibility regarding demand fluctuations resulting from product standardization. Disadvantages of MTS are higher inventory and lower production flexibility.

Distribute-to-order (or *configure-to-order*) strategies allow a small degree of customer individualization. It might have customer-specific packaging (as in the pharmaceutical industry) or some individual items added to a standard manufactured product. Advantages of DTO are higher flexibility regarding product structure and lower inventory.

Assemble-to-order presumes a higher degree of product individualization which happens directly within the manufacturing. A typical example of ATO is car manufacturing or DELL in the electronics industry. Assembly is performed individually for each customer from a set of standard modules. Advantages and shortcomings of the ATO are similar to the DTO/CTO, but with higher investments in the process, product flexibility, and lower inventory.

A *make-to-order* strategy is similar to ATO, but presumes also a possibility of customer individualization at the module/component level. This means that not only the final assembly from some standard modules can be individualized, but also that the modules and components can be manufactured individually for each particular customer. MTO can be recommended for customer-specific products with fluctuating demand. Advantages and shortcomings of MTO are similar to ATO, but with even higher investments in flexibility and lower inventory.

Engineer-to-order has the highest degree of customer individualization. An example is the production of an Airbus 380 or a house building where the customer is involved in the engineering and production processes right from the beginning and can select not only individual components, but also materials and designs. ETO is reasonable for complex products of high value where customer individualization is crucial.

In practice, hybrid production strategies, e.g., MTO-ETO are frequently encountered (Jordan and Graves 1995; Alp and Tan 2008; Zschorn et al. 2017).

Case Study Airbus: Production Strategy and Strategic Supplier Collaboration with the Help of AirSupply

Taking aircraft manufacturing at Airbus as an example, the following case study describes how Airbus implements the ETO production strategy and collaborates with its suppliers using AirSupply. Each time an Airbus aircraft is made, it is the result of assembling a multitude of parts representing a very large volume of orders. And what's true for the Airbus assembly line is true for the whole aerospace industry where not only aircraft, but also helicopters and satellites are built. Parts for manufacturing come from multiple suppliers from all over the world. Most of them are quite complex and need to fulfill the highest quality standards. Every time delay can cause very high costs.

It is essential that all suppliers involved in the manufacture of aircraft have real-time visibility of the progress of demand and inventory to adapt to fluctuations and changes in customer requirements. In such a case, it is essential for customers and suppliers to have a common tool that will enable them to better collaborate and to gain visibility over demand as well as inventory.

In January 2009, EADS decided to initiate the development of a specific Aerospace & Defense industry solution to replace the current company individual SCM solution. EADS is one of the leading Aerospace & Defense companies worldwide. The range of products includes aircraft from Airbus, helicopters from Eurocopter, and satellites from the Astrium division. Each aircraft is practically one of a kind. One of the reasons why commercial aircrafts are all configured differently is that the ordering airlines want to differentiate themselves from their competitors. The easiest way for passengers to spot these differences is by looking at the seats and entertainment systems.

With 75%, the value added by external suppliers in aircraft manufacturing is relatively high. A single long-range aircraft is made up of around four million individual parts, supplied by companies from many countries. Even at the final assembly line, workers put together components originating from at least four

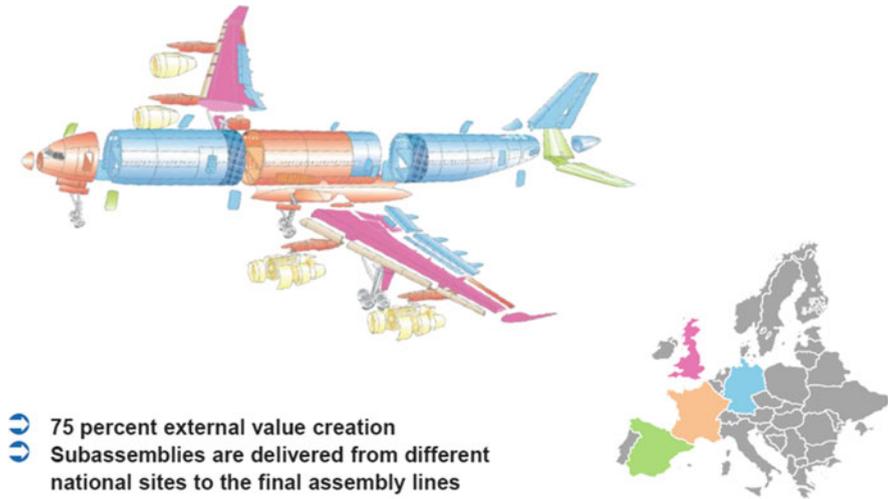


Fig. 6.5 Modular production strategy (based on SupplyOn)

different countries: fuselage sections and the vertical stabilizers come from Germany, the cockpit and central fuselage section from France, the wings from England, and the horizontal stabilizers from Spain (see Fig. 6.5).

Where the engines come from depends on the customer's preference. The task is made even more complex by the generous length of time Airbus gives its customers to submit their final wishes. Including lead time, manufacturing takes around 2 years, and Airbus accepts customer change requests up to as late as 6 months before delivery (see Fig. 6.6).

Collaboration with suppliers begins only a few months after the order has been received. This is normal for the aerospace industry and is very different to the automotive industry, for example. Delivery dates are coordinated with suppliers at weekly intervals, on both the capacity planning and order levels. The production of components begins before the date on which the customer is able to request the last modifications. Final assembly takes around 1 month. This intensive process of coordination with suppliers is managed via AirSupply.

How does the collaboration look like in concrete terms? The first step is calculating future demands via the Airbus ERP system. This always takes place on the weekend. On the following Monday, the Airbus Order Officer checks the generated demand planning (see Fig. 6.7).

The next step is the approval of the requirements planning and transmission to the suppliers via AirSupply. The supplier now checks whether he can provide what is needed by Airbus. If the answer is yes, he sends his confirmation. If the answer is no, he can use AirSupply to propose alternative quantities and delivery dates. The Order Officer at Airbus then checks the supplier's proposal and accepts it. The collaboration process has now been successfully completed and the data is transferred back to the ERP system at Airbus.

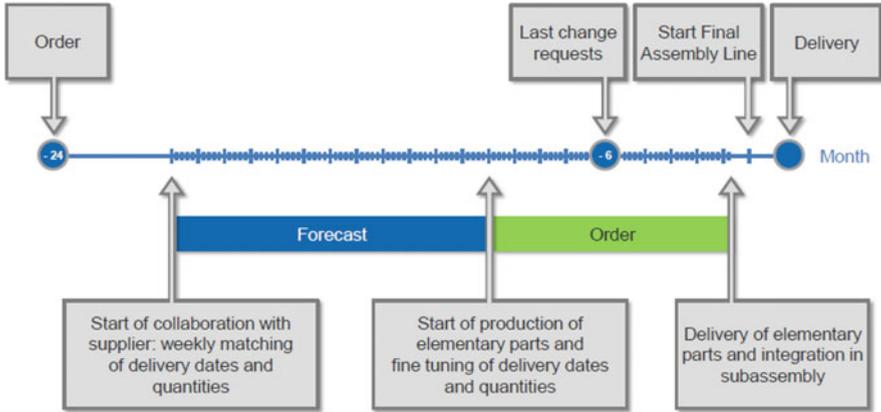


Fig. 6.6 Intense collaboration with suppliers throughout the whole production process of an aircraft

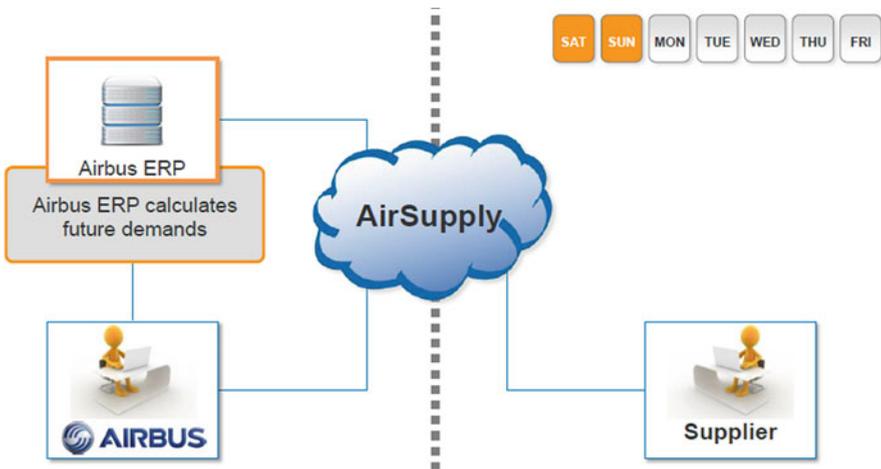


Fig. 6.7 Start of supplier collaboration

It is evident that it would not have been possible to conduct this process by exchanging messages in a conventional EDI format. The rules required to logically represent this collaboration are not provided by classical ERP systems. This is why the entire set of logical rules governing collaboration has been moved to the cloud.

The ERP systems simply process the results of the collaboration. From the system architecture perspective, the solution is embedded in SupplyOn's cloud infrastructure. This is made up of central components that control registration of companies and users. At the current time, around 8000 companies from over 70 countries are using SupplyOn's solutions.

One of the most remarkable aspects of this project was that it created a solution for the entire European Aerospace & Defence industry and not only for the EADS group. To make this possible, the French aerospace industries association GIFAS formed the BoostAeroSpace initiative. SupplyOn designed the solution together with the lead partner EADS, and the companies Dassault Aviation, Safran, and Thales. Up to 150 people were involved in the project in its most intensive phases, with a total of around 10,000 working days. After completion of design, development, and the pilot phase, the solution went live at the end of 2011. Shortly after, the integration of the suppliers began.

The strategic goal of EADS and Airbus is to maintain the competitiveness of the European Aerospace & Defense industry in the long term. They are convinced that this can best be achieved by creating a common industry solution together with further leading companies in this sector. It was EADS's ambitious goal to build the best Aerospace & Defense industry SCM solution worldwide. This applies to the functionality of the solution as well as to the underlying business model. EADS and BoostAeroSpace opted for SupplyOn as their implementation and operating partner due to its successful track record with a cloud-based solutions for the automotive industry. Once AirSupply is deployed at EADS, BoostAeroSpace partners, and further customers, it will establish itself as the industry standard.

Discussion

1. What benefits of AirSupply for supplier collaboration can you identify?
2. Describe the advantages and risks of an ETO (engineer-to-order) production strategy.

In summary, the basic trade-off in selecting the right production strategy is between investments in flexibility and reduction of costs due to the scale effects or inventory reduction. Total flexibility, inventory, and unit costs should be balanced with customer satisfaction and service level. One possible approach to perform such an analysis is presented in the next section.

6.4.2 Method: Lost-Sales Analysis

This task investigates the issue of how to determine what the right production strategy and OPP location is in the SC. In the proposed model, we consider two strategies:

- MTS and delivering from a general inventory holding unit and
- introducing the agile MTO part downstream from the general inventory holding unit.

We assume that the introduction of the agile part of the SC downstream from the OPP leads to an increase in both flexibility and costs. As such, we propose a “lost-sales” based treatment of the OPP location determination: the OPP location can be determined by a comparison of the financial results of the two strategies (with and without OPP). With regard to this treatment, a quantitative estimation of the OPP location can be found by relating the above-mentioned strategies to each other, i.e., an OPP location index can be calculated at different stages of the SC according to the model (6.1) (Ivanova et al. 2015):

$$D = \frac{R_a \cdot k_a - (C_u^a + C_d^a + P^a + L^a)}{R - (C + k \cdot P + k \cdot L)} \rightarrow \max[t_0; T] \quad (6.1)$$

where

D is the index to characterize the efficiency of the OPP location,

R is the revenue in case of make-to-stock,

R_a is the revenue when agility is introduced downstream from the general inventory holding unit,

C are the SC costs in case of make-to-stock,

C_u^a are the SC costs upstream from the OPP when agility is introduced,

C_d^a are the SC costs downstream from the OPP when agility is introduced,

P are penalties of not-fulfilled contracts in case of make-to-stock,

P^a are penalties of not-fulfilled contracts when agility is introduced,

L are losses of rejected customer’s inquiries in case of make-to-stock,

L^a are losses of rejected customer’s inquiries when agility is introduced,

k, k_a are correcting coefficients to take into account future increases in sales due to an increase in responsiveness when agility is introduced, and

t is instants of time within the whole SC cycle $[t_0; T]$.

Different OPP locations can be investigated and the best one with the maximum value $D > 1$ is selected on the basis of the formula (6.1).

Task 6.1 Selection of an OPP Location

We consider a SC where four potential OPP locations correspond to the following strategies: MTO—Make-to-Order, ATO—Assembly-to-Order, CTO—Configure-to-Order, and MTS—Make-to-Stock (Fig. 6.8).

The following data is considered (Table 6.1):

Calculate the indexes D and propose the OPP location. $D_{\max} = 6.65$ and corresponds to the OPP at $t = 4$.

Recommend a manufacturing strategy! We recommend selecting the MTS strategy as there is no need for any OPP in this SC.

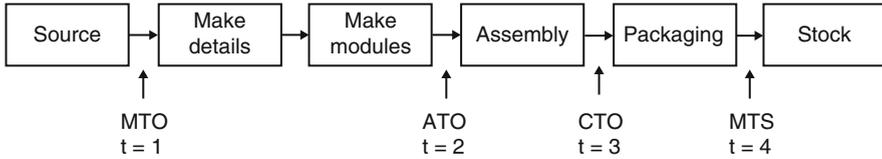


Fig. 6.8 Alternative OPP locations

Table 6.1 Comparison of OPP locations in the SC

t	1	2	3	4
R ^a	160	180	200	220
R	220	220	220	220
C _u ^a	40	40	40	40
C _d ^a	160	160	160	160
C	192	192	192	192
P ^a	3.5	3.5	3.5	3.5
P	7	7	7	7
L ^a	2.5	2.5	2.5	2.5
L	11.2	11.2	11.2	11.2
k _a , k	1.15	1.15	1.15	1.15
D	-3.111739745	0.141442716	3.394625177	6.647807638

Explain the push/pull view of the processes within a SC.

The push/pull view of the SC divides SC processes into two categories based on whether they are executed in response to a customer order or in anticipation of customer orders. Pull processes are initiated in response to a customer order. Push processes are initiated and performed in anticipation of customer orders. The push/pull boundary separates push processes from pull processes.

Explain the basic trade-off between responsiveness and efficiency of SCs in terms of inventory. The fundamental trade-off when making inventory decisions is between responsiveness and efficiency. Increasing inventory will generally make the SC more responsive to the customer. This choice, however, comes at a cost as added inventory decreases efficiency. Therefore, a SC manager can use inventory as a driver for reaching a targeted level of responsiveness and efficiency according to their the competitive strategy.

Explain the meaning of the coefficients k! k, k_a are correcting coefficients which account for future increases in sales due to the increase in responsiveness when agility is introduced.

6.5 Key Points

Customers play more and more important roles in the SC. Products have become individual and customized. This flexibility creates competitive advantages, but is also costly. The right production strategy in the SC combines the advantages of efficient mass production and responsive product customization. The push/pull view of the SC divides SC processes into downstream (production in response to a customer order) and upstream (production in anticipation of customer orders). Pull processes are initiated in response to a customer order. The advantages of the downstream are responsiveness, and a high degree of customer-oriented product individualization. Push processes are initiated and performed in anticipation of customer orders. The advantages of the upstream are economy of scale and flexibility (high level of inventory and short supply times).

The first element of a production strategy from the push-pull point of view is postponement, which is an organizational concept whereby some of the activities in the SC are not performed until customer orders are received. Postponement is especially useful when there are many variants of an end product with an uncertain split of demand on variants. In addition, delivery time requested by customers must allow value-adding steps after receipt of customer orders (or forecast).

The second element of a production strategy is OPP, which separates the push and pull parts of the SC. In practice, the selected postponement strategy determines the OPP location. The further upstream the OPP is located in the SC, the more manufacturing and logistics activities are postponed. In general, the aim is to postpone manufacturing and logistics as much as possible while maintaining high customer service standards.

According to the placement of the OPP, the following production strategies can be determined:

- Make-to-stock (MTS)
- Distribute-to-order (DTO)/Configure-to-order (CTO)
- Assemble-to-order (ATO)
- Make-to-order (MTO)
- Engineer-to-order (ETO)

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Bibliography

- Alderson W (1950) Marketing efficiency and the principle of postponement. *Cost Profit Outlook* 3 (4):15–18
- Alp O, Tan T (2008) Tactical capacity management under capacity flexibility. *IIE Trans* 40:221–237

- Appelfeller W, Buchholz W (2011) *Supplier relationship management: strategie, organisation und IT des modernen Beschaffungsmanagements*, 2nd edn. Gabler, Wiesbaden
- Baldwin CY, Clark KB (1997) Managing in the age of modularity. *Harv Bus Rev* 75:84–93
- Belson K (23 Sep 2011) Far from the factory, adding final touches. *The New York Times*. http://www.nytimes.com/2011/09/25/automobiles/far-from-the-factory-adding-final-touches.html?pagewanted=all&_r=0. Accessed 10 May 2014
- Bucklin LP (1965) Postponement, speculation, and the structure of distribution channels. *J Mark Res* 2:26–31
- Cheng TCE, Li J, Wan CLJ, Wang S (2010) Postponement strategies in supply chain management. *International series in operations research and management science*, vol 143. Springer, New York
- Ernst R, Kamrad B (2000) Evaluation of supply chain structures through modularization and postponement. *Eur J Oper Res* 124(3):495–510
- Gunasekaran A, Laib K-H, Cheng TCE (2008) Responsive supply chain: a competitive strategy in a networked economy. *Omega* 36(4):549–564
- Ivanova M, Kaeschel J, Ivanov D (2015) Analysis of the order recovery point location in the supply chain. *Int J Integr Supply Manage* 9(4):329–342
- Jordan WC, Graves SC (1995) On the principles of the benefits of manufacturing process flexibility. *Manag Sci* 41:577–594
- Kagermann H, Osterle H, Jordan JM (2011) *IT-driven business models: global case studies in transformation*. Wiley, Hoboken
- Olhager J (2003) Strategic positioning of the order penetration point. *Int J Prod Econ* 85(3):319–329
- Shah J (2009) *Supply chain management: text and cases*. Pearson, Chennai
- van Hoek RI (2001) The rediscovery of postponement a literature review and directions for research. *J Oper Manag* 19(2):161–184
- Zschorn L, Müller S, Ivanov D (2017) Capacity planning on key work stations in a hybrid MTO-ETO production system: a case-study on Siemens AG. *Int J Invent Res* 4(2/3):214–232

Reference for Sect. 6.1

- Chopra S, Meindl P (2012) *Supply chain management: strategy, planning, and operations*, 5th edn. Pearson, London
- CNN (2013) <http://edition.cnn.com/video/data/2.0/video/business/2013/12/13/world-biz--dell-brian-gladden.cnn.html>
- Dell (2014) <http://www.dell.com>
- Global Integrated Supply Chain System (2006) Successful cases of SCM in China. <http://tinyurl.com/p8rhuh8>
- Hirsh L (2007) <http://www.ecommercetimes.com/story/18779.html>
<http://www.it-times.de/news/nachricht/datum/2013/06/07/lenovo-eroeffnet-werkshallen-in-den-usa/>
- San Juan R (2013) <http://www.gaebler.com/Dell-Direct-Model-to-Success.htm>
- Slack N, Brandon-Jones A, Johnston R (2011) *Essentials of operations management*. Pearson, London
- Supply Chain Council (2012) Inside Lenovo's hybrid supply chain strategy. http://supply-chain.org/f/Zapko-Inside_Lenovos_Hybrid_Supply_Chain_Strategy.pdf
www.lenovo.com