E-Supplement to Chapter 13 Inventory Management

Task E-13.1 ABC/XYZ analysis

An online retailer considers if it is useful to shorten the delivery time of selected products and to increase the inventory. We consider the following XYZ classification:

X	attract new customers through shorter delivery time
Y	delivery time is shorter than delivery times of our competitors / or we can still reduce our delivery time
Z	shorter delivery time do not make any difference

Initial data is given in Table E-13.1:

Table E-13.1. Initial data for ABC/XYZ analysis

Product	Amount	Gross margin (in $)	Delivery time (in days)	Delivery time competitor (in days)	Possible to attract to customers through shorter delivery times?
Books	1024	12,288	4	4	yes
CD	50	850	2	2	no
DVD	99	1,980	2	2	no
Blu-ray	192	2,304	2	2	yes
Poster	200	5,000	1	14	yes
Photo albums	195	2,925	7	7	no
Musical scores	99	1,188	21	14	no
Other sound carrier	30	510	14	14	no
∑	1889	27,045			

To find out for which products the online retailer has to reduce the delivery time and to increase the inventory we need to arrange the products by their gross margin (high → low) and cumulate them. Afterwards we calculate the percentage of the cumulated gross margin to classify the products in A-, B- and C-groups. We use the ratio 80:15:5 and get the following result:

Table E-13.2. Results for ABC/XYZ analysis

Product	Gross margin (in $)	Cumulated gross margin (in $)	% of cumulated gross margin	ABC	XYZ	Recommendation
Books	12,288	12,288	45,44%	A	X	increase inventory

Poster	5,000	17,288	63,92%	A	Y	
Photo albums	2,925	20,213	74,74%	A	Z	
Blu-ray	2,304	22,517	83,26%	B	X	increase inventory
DVD	1,980	24,497	90,58%	B	Z	
Musical scores	1,188	25,685	94,97%	B	Z	
CD	850	26,535	98,11%	C	Z	
Other sound carrier	510	27,045	100,00%	C	Z	

It can be observed that it is possible to attract new customers through shorter delivery time for books and blu-rays.

Task E-13.2 Dynamic lot-sizing models - Multi period problem

A bakery in London produces bread, pastry and pies for daily sales. Beyond that they are producing and selling pastry for events (e.g., opening ceremonies, balls, business lunches and more). The bakery has the following demand of flour (10kg bags) per month. Demand of flour depends on planned catering events per month.

Table E-13.3 Initial data for dynamic lot-sizing

Month t	1	2	3	4	5	6	7	8
Demand b_t	65	52	86	35	41	69	88	95

Flour orders take place at the beginning of each month and the flour is 2 days later available. Every order generates fixed cost *f* of €45 and there are holding costs c per 10kg bag per month of €0.8.

Calculate the amount of flour bags the bakery has to order per period. Find put which model leads to the cheapest total cost. Compare: Least Unit Cost heuristic, Silver-Meal heuristic and Wagner-Whitin model.

1. Least Unit Cost heuristic

$$K_{1,1}^{unit} = \frac{45}{65} \approx 0.69$$

$$K_{1,2}^{unit} = \frac{45 + 52 \times 0.8}{65 + 52} \approx 0.74$$

$$K_{2,2}^{unit} = \frac{45}{52} \approx 0.87$$

$$K_{2,3}^{unit} = \frac{45 + 86 \times 0.8}{52 + 86} \approx 0.82$$

$$K_{2,4}^{unit} = \frac{45 + 86 \times 0.8 + 35 \times 2 \times 0.8}{52 + 86 + 35} \approx 0.98$$

$$K_{4,4}^{unit} = \frac{45}{35} \approx 1.29$$

$$K_{4,5}^{unit} = \frac{45 + 41 \times 0.8}{35 + 41} \approx 1.02$$

$$K_{4,6}^{unit} = \frac{45 + 41 \times 0.8 + 69 \times 2 \times 0.8}{35 + 41 + 69} \approx 1.3$$

$$K_{6,6}^{unit} = \frac{45}{69} \approx 0.65$$

$$K_{6,7}^{unit} = \frac{45 + 88 \times 0.8}{69 + 88} \approx 0.74$$

$$K_{7,7}^{unit} = \frac{45}{88} \approx 0.51$$

$$K_{7,8}^{unit} = \frac{45 + 95 \times 0.8}{88 + 95} \approx 0.66$$

$$K_{8.8}^{unit} = \frac{45}{95} \approx 0.47$$

$q_1 = 65 \quad q_2 = 138 \quad q_3 = 0 \quad q_4 = 76 \quad q_5 = 0 \quad q_6 = 69 \quad q_7 = 88 \quad q_8 = 95$

$$K_{total}^{unit} = 6 \times 45 + (86 \times 0.8) + (41 \times 0.8) = €371.6$$

2. Silver-Meal heuristic

$$K_{1,1}^{period} = \frac{45}{1} = 45$$

$$K_{1,2}^{period} = \frac{45 + 52 \times 0.8}{2} = 43.3$$

$$K_{1,3}^{period} = \frac{45 + 52 \times 0.8 + 86 \times 2 \times 0.8}{3} \approx 74.73$$

$$K_{3,3}^{period} = \frac{45}{1} = 45$$

$$K_{3,4}^{period} = \frac{45 + 35 \times 0.8}{2} = 36.5$$

$$K_{3,5}^{period} = \frac{45 + 35 \times 0.8 + 41 \times 2 \times 0.8}{3} = 46.2$$

$$K_{5,5}^{period} = \frac{45}{1} = 45$$

$$K_{5,6}^{period} = \frac{45 + 69 \times 0.8}{2} = 50.1$$

$$K_{6,6}^{period} = \frac{45}{1} = 45$$

$$K_{6,7}^{period} = \frac{45 + 88 \times 0.8}{2} = 57.7$$

$$K_{7,7}^{period} = \frac{45}{1} = 45$$

$$K_{7,8}^{period} = \frac{45 + 95 \times 0.8}{2} = 60.5$$

$$K_{8,8}^{period} = \frac{45}{1} = 45$$

$q_1 = 117 \quad q_2 = 0 \quad q_3 = 121 \quad q_4 = 0 \quad q_5 = 41 \quad q_6 = 69 \quad q_7 = 88 \quad q_8 = 95$

$$K_{total}^{unit} = 6 \times 45 + (52 \times 0.8) + (35 \times 0.8) = €339.6$$

As we can see the Silver-Meal heuristic leads to lower total cost than the Least Unit Cost heuristic.

3. Wagner-Whitin model

Table E-13.4 Overview results Wagner-Whitin model

	Demand b_t							
	65	**52**	**86**	**35**	**41**	**69**	**88**	**95**
Period t	1	2	3	4	5	6	7	8
1	45	86.6	224.2					
2		90	158.8	214.8				
3			131.6	159.6	225.2			
4				176.6	209.4	319,8		
5					204.6	259.8	400.6	

6						249.6	320	472
7							294.6	370.6
8								**339.6**
$K_{\min}^{WW}$	45	86.6	131.6	159.6	204.6	249.6	294.6	339.6
q_t	$q_1 = 117$	$q_2 = 0$	$q_3 = 121$	$q_4 = 0$	$q_5 = 41$	$q_6 = 69$	$q_7 = 88$	$q_8 = 95$

$$K_{1,1}^{WW} = 45$$
$$K_{1,2}^{WW} = 45 + 52 \times 0.8 = 86.6$$
$$K_{1,3}^{WW} = 45 + 52 \times 0.8 + 86 \times 2 \times 0.8 = 224.2$$

$$K_{2,2}^{WW} = K_{1,1} + 45 = 90$$
$$K_{2,3}^{WW} = K_{1,1} + 45 + 86 \times 0.8 = 158.8$$
$$K_{2,4}^{WW} = K_{1,1} + 45 + 86 \times 0.8 + 35 \times 2 \times 0.8 = 214.8$$

$$K_{3,3}^{WW} = K_{1,2} + 45 = 131.6$$
$$K_{3,4}^{WW} = K_{1,2} + 45 + 35 \times 0.8 = 159.6$$
$$K_{3,5}^{WW} = K_{1,2} + 45 + 35 \times 0.8 + 41 \times 2 \times 0.8 = 225.2$$

$$K_{4,4}^{WW} = K_{3,3} + 45 = 176.6$$
$$K_{4,5}^{WW} = K_{3,3} + 45 + 41 \times 0.8 = 209.4$$
$$K_{4,6}^{WW} = K_{3,3} + 45 + 41 \times 0.8 + 69 \times 2 \times 0.8 = 319.8$$

$$K_{5,5}^{WW} = K_{3,4} + 45 = 204.6$$
$$K_{5,6}^{WW} = K_{3,4} + 45 + 69 \times 0.8 = 259.8$$
$$K_{5,7}^{WW} = K_{3,4} + 45 + 69 \times 0.8 + 88 \times 2 \times 0.8 = 400.6$$

$$K_{6,6}^{WW} = K_{5,5} + 45 = 249.6$$
$$K_{6,7}^{WW} = K_{5,5} + 45 + 88 \times 0.8 = 320$$
$$K_{6,8}^{WW} = K_{5,5} + 45 + 88 \times 0.8 + 95 \times 2 \times 0.8 = 472$$

$$K_{7,7}^{WW} = K_{6,6} + 45 = 294.6$$

$$K_{7,8}^{WW} = K_{6,6} + 45 + 95 \times 0.8 = 370.6$$

$$K_{8,8}^{WW} = K_{7,7} + 45 = 339.6$$

As you can see, Wagner-Whitin leads to the same order strategy like Silver-Meal heuristic. In this case we can say that €339.6 is the lowest possible applying these three methods.

Case ATP&CTP: LCD production chain in Taiwan

The LCD industry is relatively young and very dynamic. LCD manufacturers in Japan and Korea generate production schedules based mainly on product sales forecasts.

On the contrary, in Taiwan, LCD manufacturers supply assembled displays to original-equipment-manufacturers (OEM). Thus, customer satisfaction associated with the management of orders is extremely essential to LCD suppliers in Taiwan. An efficient and effective order fulfilment process enables firms to accurately estimate delivery dates and the available quantity of materials for a specific customer inquiry.

In order fulfilment processes, the available-to-promise (ATP) model provides a synchronized supply and capacity plan that represents actual and future availability of materials and capacity that can be utilized to accept new customer orders.
A typical LCD manufacturing process consists of three major stages, i.e. array, cell, and module as illustrated in Fig. E-13.1.

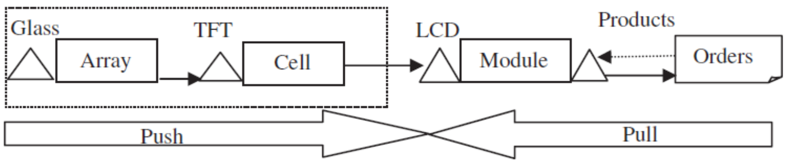

Fig. E-13.1. LCD manufacturing process (adopted from Tsai and Wang, 2009)

While array and cell manufacturing is a mass process in the push-framework similar to semiconductor manufacturing processes, the module production process is customer-oriented. Since module production is in the pull framework (i.e., the assemble-to-order (ATO) strategy), LCD manufacturers face fluctuating demand. In addition, order fulfilment processes in the LCD industry is complicated due to its special production network characteristics. In a module plant, cell glass panels passed from cell processes are assembled with all other necessary components, such as backlights which may be specifically chosen by customers. Manufacturing lines are categorized by different technology-related generation, i.e., panel size. In addition, a module plant is constrained by its capacity and generation limitation associated with manufacturing panels. Furthermore, array, cell and module manufacturing may be located at several facilities in different locations. The production chain of the LCD industry is a multi-tiered and multi-sited network as shown in Fig. E-13.2.

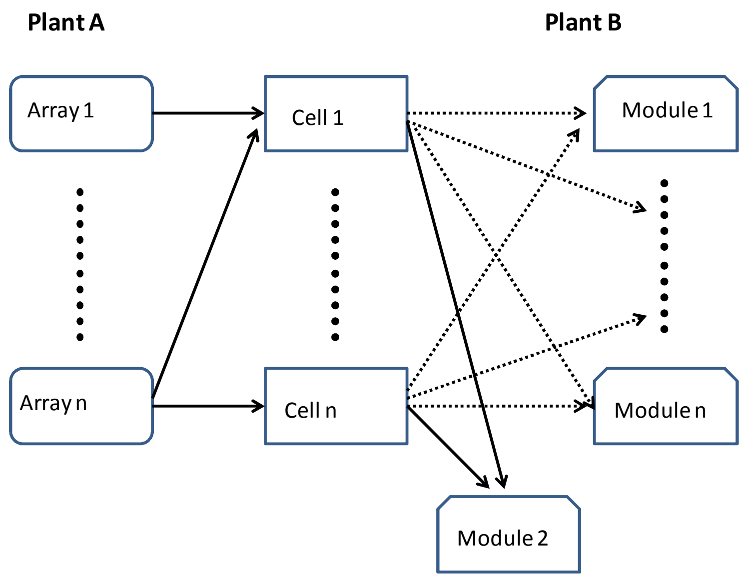

Fig. E-13.2. Supply network (adopted from Lin et al. 2010)

Array and cell processes are usually located in the same facility or in proximity due to similar production characteristics such as their technology-intensive and capital-intensive nature; however, module plants are generally located in different areas or countries because module assembly is a labour-intensive process that differs from the two other processes. For example, one leading LCD manufacturer, LG Philips, moved its module plants in 2007 to China to reduce costs.

Another feature of TFT-LCD manufacturing is the hierarchical structure of products. LCD products have several characteristic levels such as application, size, resolution, product model, etc., which results in alternative bill-of-materials (BOM) and product grade. The customer orders a specific product grade and chooses the BOMs.

The development of the ATP model for order fulfilment processes is based on a framework that considers several issues, including product grade, alternative BOMs, and production and transportation constraints in cell and module processes. In an ATO environment, due dates and quantity quotation are based on material and capacity availability. The order fulfilment process allows module plants to rapidly respond to order inquiries.

The following stakeholders are included in the ATP planning in the LCD supply chains: headquarters, distribution centres, and factories (see Fig. E-13.3).

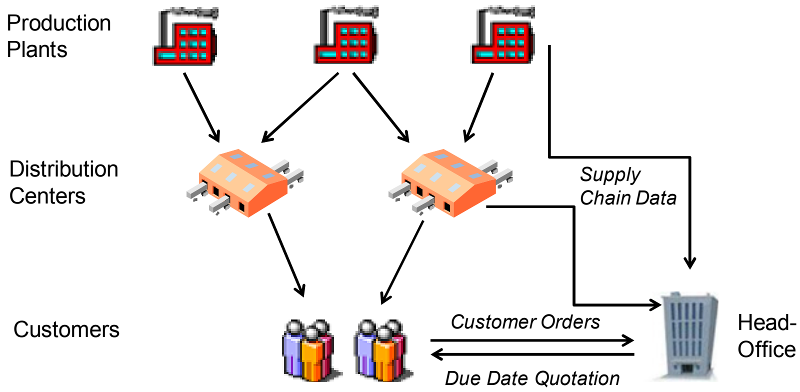

Fig. E-13.3. Stakeholders in the ATP process

Headquarters assembles all information about orders and confirms due delivery dates. Distribution Centres (DC) carry inventory status data. Factories calculate master production schedules, material inventory data, and material supply schedules (see Fig. E-13.4).

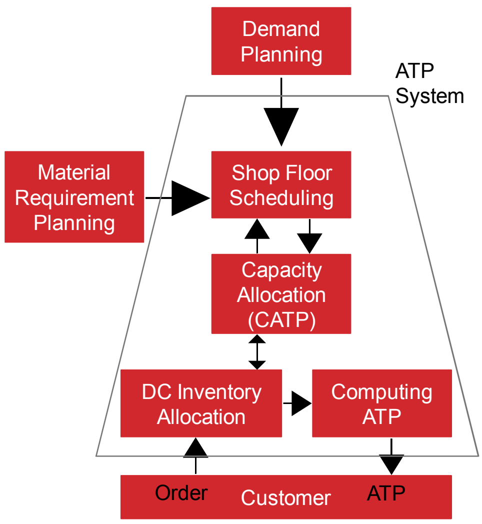

Fig. E-13.4. ATP-CTP process

The input data for the ATP model is order-related data such as quantity, location, transportation time, requested due date, and order priority. Based on costs associated with transportation and production, transportation constraints, and production capabilities, the ATP model returns the outputs of the available capacity to promise (CTP), the transportation schedule for shipments of cell glass panels from cell plants to module plants, the production schedule in module plants, and promised and unsatisfied orders. Module plants respond to customers based on the quantity a firm can deliver within a desired due date. If customers are unsatisfied with the quote and withdraw their order inquiry, the proposed ATP model releases the capacity dedicated to those order inquiries and updates the remaining capacity available-to-promise (CATP).

References

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Tsai K.M, Wang, S.C. (2009). Multi-site available-to-promise modeling for assemble-to-order manufacturing: An illustration on TFT-LCD manufacturing. *Int. J. Production Economics* 117:174–84.

Jeong, B., Sim, S.-B., Jeong, H.-S., Kim, S.-W.(2002). An available-to-promise system for TFT-LCD manufacturing in supply chain. *Computers & Industrial Engineering* 43:191–212.

Case Study: Papa John's Pizza

Papa John's is a pizza delivery company founded in 1983. Since then it has grown, with over 3,800 restaurants and 18,000 employees. The crucial issue in operations planning for Papa John's is to match demand and supply. The company needs to communicate demand to its suppliers timely and accurately. Especially when demand is forecasted to be particularly high, suppliers need to know ahead of time in order to deliver the necessary products.

In 2010, Papa John's became the official sponsor of the National Football League in the United States; and for the Super Bowl in 2011 its pizza was the official pizza. On the day of the Super Bowl, Papa John's sold over one million pizza pies. In order to be prepared for such peak events, supply chain coordination and information communication are essential.

The main issues for establishing efficient and responsive operations planning are the accuracy in managing inventory, better visibility of inbound and outbound products, and demand management especially for demand spikes. Because of the many suppliers and customers, along with uncertain demand, management information systems are needed at Papa John's to support operations managers.

Inventory optimization software assists them with the inventory planning, providing information about the optimal amount of products needed in order to prevent stock-outs. A new warehouse management system (WMS) and transportation management system (TMS) implemented new methods for picking up products and loading trucks. Papa John's went from manual warehouse management to pickers with headsets that guided them to the specific product. For example, for the Super Bowl event, Papa John's had to double their dispatches of deliveries. This was managed through a TMS. Typically, a TMS assesses inbound and outbound orders and suggests best vehicle routing solutions.

The changes allowed Papa John's to make not only improvement in the execution of their supply chain, but also resulted in great cost reduction. For example, storage costs reduced by 66.4%, inventory levels by 15.7%, inventory investment by 83.7%; and productivity, thanks to the WMS, increased by 9%. These changes make it possible for challenges such as those faced by the Super Bowl event to be managed so that companies could emulate its success story.

References

Hochfelder, Barry (2011), Papa John's Scores a Supply Chain Touchdown, *Supply & Demand Executive*, March: 16–17.

http://www.papajohns.com/about/index.shtm.

http://www.manh.com/about-us.

Case BIMBA ATP/CTP

Bimba Manufacturing is a US company, a manufacturer of automation actuators (cylinders used in a variety of industrial applications including medical processing, vegetable harvesting, and packaging and printing, to name but a few) that has long been known as an innovator. The company developed an ATP/CTP (available-to-promise/capable-to-promise) concept that allowed its distributors to access key production capacity and inventory information online which further established Bimba as an industry leader. The company has grown substantially since that time.

First, an *ATP Application* has been developed. This web application informs customers when a product can be shipped by Bimba. If a customer needs standard in-stock items, these products typically can be shipped at the day of request. If non-standard size actuators are requested, the system checks component availability and provides an ATP date (generally three to five days).

Second, *Quick Ship Application* to respond to emergency situations was developed. Bimba is able to manufacture and ship an actuator within 24 hours in many cases. The company reserves capacity to provide immediate turnaround for customers. The Quick Ship Inquiry application integrates requests by product line to accommodate emergency demand. For example if a customer needs five Flat Line actuators in 24 hours and the daily capacity of the production line is 13 actuators, Bimba still has the production capacity to create eight items more, so according to CTP they could accept customer emergency orders. The ATP/CTP resulted in six-figure cost savings and improved capabilities.

Reference
www.bimba.com.

Discussion questions

- What competitive advantages can you see for companies implementing ATP/CTP?
- Company A offers in the market a standard product, and many competitors exist. Company B has a unique position in the market (e.g., exceptional quality of products). For which company would the investment in ATP/CTP be more sensible?
- Can you see any obstacles in implementing ATP/CTP in the supply chain?

Case Study VMI

A supplier in a drugstore chain implemented a joint project with a drugstore retail network. In the result, the supplier is responsible for inventory and supply planning on the basis of inventory and demand data transmitted from the retail stores. This replaced a previous process where supplier processed the orders from the retail network.

Previously, the retailer's central warehouse managed demand and supply by replenishing from the supplier's logistics centre. The supplier could only react to the order, bundle and pick-up the order items. This caused shortages and bottle-necks in the case of large orders since the supplier's logistics centre was replenished daily from the production plants in order to reduce inventory. Demand and inventory data on the retail network side were not available for inventory planning at the supplier.

After the project implementation, production and inventory planning were improved. This cut production and inventory costs and allowed more flexible control assortment changes. The costs of higher service level on the supplier side were compensated through a reduction in the total process costs. Customer satisfaction has been increased and stock-outs have been reduced.

Questions:

a) What effects have been achieved in the project? How?
b) What is the name of the implemented concept?
c) Which methods of inventory management could be applied for this optimization?

Responses:

a) Production and inventory costs have been cut and control assortment changes became flexible on the basis of improved production and inventory planning. Customer satisfaction has been increased and stock-outs have been reduced on the basis of the data sharing between vendor and buyer.

b) This is VMI, since vendor takes responsibility for inventory management on the buyer side. The buyer provides inventory and demand information to the supplier.

c) For example: demand forecasting: exponential smoothing; safety stock: probability theory; order quantity planning: Silver-Meal heuristic

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Case Study VMI/CPFR

A department store has implemented modern distribution and planning processes to create transparency and flexibility in procurement logistics. First results are impressive: inventory has been drastically reduced along with maintaining the desired customer service level.

The department store activities are characterized by broad product portfolio which makes the company react quickly to demand fluctuations. The world economic crisis showed that sudden breakdowns in orders along with long lead times result in high inventory. This is very costly. The objective of optimization was to decrease sustainable inventory while maintaining the desired service level for more than 8,000 customers.

First, product portfolio was classified according to sales volumes and demand fluctuations. For each segment, the planning strategy and inventory control policy have been defined. The department store transmitted inventory and demand data to the suppliers who are now responsible for the inventory availability on the buyer side. Then the supplier decides on the optimal safety inventory placement in the supply chain. In addition, for each product an optimal safety stock level has been calculated.

A new information system is applied now which allows reduced ordering time. Previously, managers had to go through long Excel sheets; now everything happens within a few mouse clicks. Data and demand forecast quality have been improved. In addition, collaboration with suppliers has been improved.

Questions:

- What problem situation launched the project?
- Which objectives were addressed? What is the trade-off regarding these objectives?
- Which methods of inventory and demand management could be applied for this optimization?
- What are the advantages of the new information system? Which systems could be used in such a project?

Responses:

- Problem situation: to create transparency and flexibility in the procurement logistics.
- Objectives: inventory and service level; trade-off: Inventory creates costs but at the same time it can be used to increase supply chain flexibility.
- For example: demand forecasting: exponential smoothing; safety stock: probability theory
- Advantages: processing time reduction; data and demand forecast quality have been improved; collaboration with suppliers has been improved. Examples of information systems: ERP for data integration among different departments; APS for mathematical optimization along the supply chain; RFID and supply chain event management for good movement control; WMS for

Task EOQ

The operations manager of a company will realize if it implements the optimal inventory procurement decision. The following data are given:

q	100	150	200	250	300
Holding costs	486	729	972	1215	1458
Ordering costs	1944	1296	972	777.6	648
Total costs	2340	2025	1944	1992.6	2106

The inquiry in the procurement department revealed that at present order quantity equal 250. Is it optimal order quantity? If yes, why? If not, what is optimal order quantity?

Answer: EOQ=200 since at q=200 holding costs equals to ordering costs

E-Supplement to Chapter 13 Inventory Management

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To find out for which products the online retailer has to reduce the delivery time and to increase the inventory we need to arrange the products by their gross margin (high → low) and cumulate them. Afterwards we calculate the percentage of the cumulated gross margin to classify the products in A-, B- and C-groups. We use the ratio 80:15:5 and get the following result:

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Photo albums	2,925	20,213	74,74%	A	Z	
Blu-ray	2,304	22,517	83,26%	B	X	increase inventory
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Musical scores	1,188	25,685	94,97%	B	Z	
CD	850	26,535	98,11%	C	Z	
Other sound carrier	510	27,045	100,00%	C	Z	

It can be observed that it is possible to attract new customers through shorter delivery time for books and blu-rays.

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1. Least Unit Cost heuristic

$$K_{1,1}^{unit} = \frac{45}{65} \approx 0.69$$

$$K_{1,2}^{unit} = \frac{45 + 52 \times 0.8}{65 + 52} \approx 0.74$$

$$K_{2,2}^{unit} = \frac{45}{52} \approx 0.87$$

$$K_{2,3}^{unit} = \frac{45+86\times 0.8}{52+86} \approx 0.82$$

$$K_{2,4}^{unit} = \frac{45+86\times 0.8+35\times 2\times 0.8}{52+86+35} \approx 0.98$$

$$K_{4,4}^{unit} = \frac{45}{35} \approx 1.29$$

$$K_{4,5}^{unit} = \frac{45+41\times 0.8}{35+41} \approx 1.02$$

$$K_{4,6}^{unit} = \frac{45+41\times 0.8+69\times 2\times 0.8}{35+41+69} \approx 1.3$$

$$K_{6,6}^{unit} = \frac{45}{69} \approx 0.65$$

$$K_{6,7}^{unit} = \frac{45+88\times 0.8}{69+88} \approx 0.74$$

$$K_{7,7}^{unit} = \frac{45}{88} \approx 0.51$$

$$K_{7,8}^{unit} = \frac{45+95\times 0.8}{88+95} \approx 0.66$$

$$K_{8.8}^{unit} = \frac{45}{95} \approx 0.47$$

$q_1 = 65 \quad q_2 = 138 \quad q_3 = 0 \quad q_4 = 76 \quad q_5 = 0 \quad q_6 = 69 \quad q_7 = 88 \quad q_8 = 95$

$$K_{total}^{unit} = 6\times 45 + (86\times 0.8) + (41\times 0.8) = €371.6$$

2. Silver-Meal heuristic

$$K_{1,1}^{period} = \frac{45}{1} = 45$$

$$K_{1,2}^{period} = \frac{45+52\times 0.8}{2} = 43.3$$

$$K_{1,3}^{period} = \frac{45+52\times 0.8+86\times 2\times 0.8}{3} \approx 74.73$$

$$K_{3,3}^{period} = \frac{45}{1} = 45$$

$$K_{3,4}^{period} = \frac{45+35\times 0.8}{2} = 36.5$$

$$K_{3,5}^{period} = \frac{45+35\times0.8+41\times2\times0.8}{3} = 46.2$$

$$K_{5,5}^{period} = \frac{45}{1} = 45$$

$$K_{5,6}^{period} = \frac{45+69\times0.8}{2} = 50.1$$

$$K_{6,6}^{period} = \frac{45}{1} = 45$$

$$K_{6,7}^{period} = \frac{45+88\times0.8}{2} = 57.7$$

$$K_{7,7}^{period} = \frac{45}{1} = 45$$

$$K_{7,8}^{period} = \frac{45+95\times0.8}{2} = 60.5$$

$$K_{8,8}^{period} = \frac{45}{1} = 45$$

$q_1 = 117 \quad q_2 = 0 \quad q_3 = 121 \quad q_4 = 0 \quad q_5 = 41 \quad q_6 = 69 \quad q_7 = 88 \quad q_8 = 95$

$$K_{total}^{unit} = 6\times45 + (52\times0.8) + (35\times0.8) = €339.6$$

As we can see the Silver-Meal heuristic leads to lower total cost than the Least Unit Cost heuristic.

3. Wagner-Whitin model

Table E-13.4 Overview results Wagner-Whitin model

	Demand b_t							
	65	**52**	**86**	**35**	**41**	**69**	**88**	**95**
Period t	1	2	3	4	5	6	7	8
1	45	86.6	224.2					
2		90	158.8	214.8				
3			131.6	159.6	225.2			
4				176.6	209.4	319,8		
5					204.6	259.8	400.6	

6						249.6	320	472
7							294.6	370.6
8								**339.6**
$K_{\min}^{WW}$	45	86.6	131.6	159.6	204.6	249.6	294.6	339.6
q_t	$q_1 = 117$	$q_2 = 0$	$q_3 = 121$	$q_4 = 0$	$q_5 = 41$	$q_6 = 69$	$q_7 = 88$	$q_8 = 95$

$$K_{1,1}^{WW} = 45$$
$$K_{1,2}^{WW} = 45 + 52 \times 0.8 = 86.6$$
$$K_{1,3}^{WW} = 45 + 52 \times 0.8 + 86 \times 2 \times 0.8 = 224.2$$

$$K_{2,2}^{WW} = K_{1,1} + 45 = 90$$
$$K_{2,3}^{WW} = K_{1,1} + 45 + 86 \times 0.8 = 158.8$$
$$K_{2,4}^{WW} = K_{1,1} + 45 + 86 \times 0.8 + 35 \times 2 \times 0.8 = 214.8$$

$$K_{3,3}^{WW} = K_{1,2} + 45 = 131.6$$
$$K_{3,4}^{WW} = K_{1,2} + 45 + 35 \times 0.8 = 159.6$$
$$K_{3,5}^{WW} = K_{1,2} + 45 + 35 \times 0.8 + 41 \times 2 \times 0.8 = 225.2$$

$$K_{4,4}^{WW} = K_{3,3} + 45 = 176.6$$
$$K_{4,5}^{WW} = K_{3,3} + 45 + 41 \times 0.8 = 209.4$$
$$K_{4,6}^{WW} = K_{3,3} + 45 + 41 \times 0.8 + 69 \times 2 \times 0.8 = 319.8$$

$$K_{5,5}^{WW} = K_{3,4} + 45 = 204.6$$
$$K_{5,6}^{WW} = K_{3,4} + 45 + 69 \times 0.8 = 259.8$$
$$K_{5,7}^{WW} = K_{3,4} + 45 + 69 \times 0.8 + 88 \times 2 \times 0.8 = 400.6$$

$$K_{6,6}^{WW} = K_{5,5} + 45 = 249.6$$
$$K_{6,7}^{WW} = K_{5,5} + 45 + 88 \times 0.8 = 320$$
$$K_{6,8}^{WW} = K_{5,5} + 45 + 88 \times 0.8 + 95 \times 2 \times 0.8 = 472$$

$$K_{7,7}^{WW} = K_{6,6} + 45 = 294.6$$

$$K_{7,8}^{WW} = K_{6,6} + 45 + 95 \times 0.8 = 370.6$$

$$K_{8,8}^{WW} = K_{7,7} + 45 = 339.6$$

As you can see, Wagner-Whitin leads to the same order strategy like Silver-Meal heuristic. In this case we can say that €339.6 is the lowest possible applying these three methods.

Case ATP&CTP: LCD production chain in Taiwan

The LCD industry is relatively young and very dynamic. LCD manufacturers in Japan and Korea generate production schedules based mainly on product sales forecasts.

On the contrary, in Taiwan, LCD manufacturers supply assembled displays to original-equipment-manufacturers (OEM). Thus, customer satisfaction associated with the management of orders is extremely essential to LCD suppliers in Taiwan. An efficient and effective order fulfilment process enables firms to accurately estimate delivery dates and the available quantity of materials for a specific customer inquiry.

In order fulfilment processes, the available-to-promise (ATP) model provides a synchronized supply and capacity plan that represents actual and future availability of materials and capacity that can be utilized to accept new customer orders.
A typical LCD manufacturing process consists of three major stages, i.e. array, cell, and module as illustrated in Fig. E-13.1.

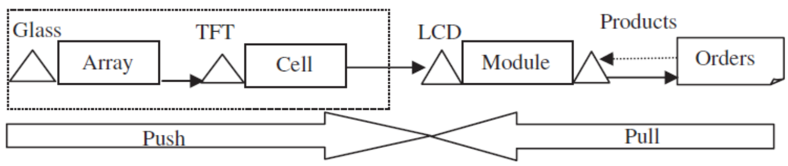

Fig. E-13.1. LCD manufacturing process (adopted from Tsai and Wang, 2009)

While array and cell manufacturing is a mass process in the push-framework similar to semiconductor manufacturing processes, the module production process is customer-oriented. Since module production is in the pull framework (i.e., the assemble-to-order (ATO) strategy), LCD manufacturers face fluctuating demand. In addition, order fulfilment processes in the LCD industry is complicated due to its special production network characteristics. In a module plant, cell glass panels passed from cell processes are assembled with all other necessary components, such as backlights which may be specifically chosen by customers. Manufacturing lines are categorized by different technology-related generation, i.e., panel size. In addition, a module plant is constrained by its capacity and generation limitation associated with manufacturing panels. Furthermore, array, cell and module manufacturing may be located at several facilities in different locations. The production chain of the LCD industry is a multi-tiered and multi-sited network as shown in Fig. E-13.2.

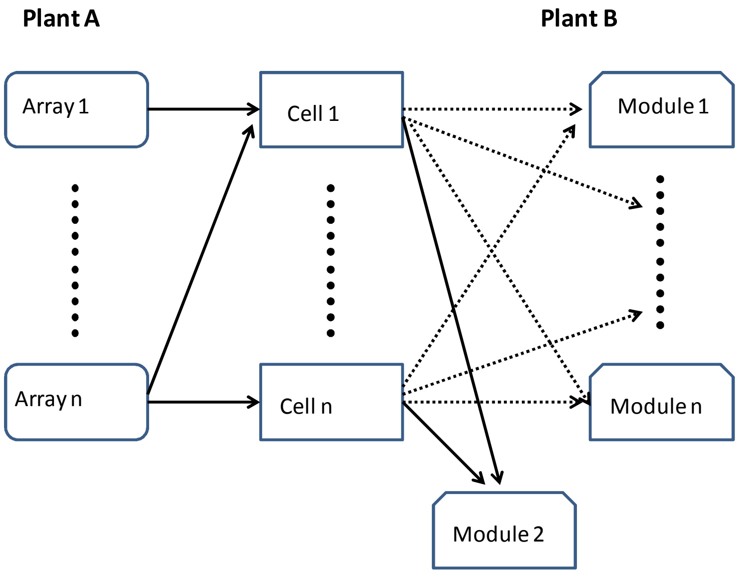

Fig. E-13.2. Supply network (adopted from Lin et al. 2010)

Array and cell processes are usually located in the same facility or in proximity due to similar production characteristics such as their technology-intensive and capital-intensive nature; however, module plants are generally located in different areas or countries because module assembly is a labour-intensive process that differs from the two other processes. For example, one leading LCD manufacturer, LG Philips, moved its module plants in 2007 to China to reduce costs.

Another feature of TFT-LCD manufacturing is the hierarchical structure of products. LCD products have several characteristic levels such as application, size, resolution, product model, etc., which results in alternative bill-of-materials (BOM) and product grade. The customer orders a specific product grade and chooses the BOMs.

The development of the ATP model for order fulfilment processes is based on a framework that considers several issues, including product grade, alternative BOMs, and production and transportation constraints in cell and module processes. In an ATO environment, due dates and quantity quotation are based on material and capacity availability. The order fulfilment process allows module plants to rapidly respond to order inquiries.

The following stakeholders are included in the ATP planning in the LCD supply chains: headquarters, distribution centres, and factories (see Fig. E-13.3).

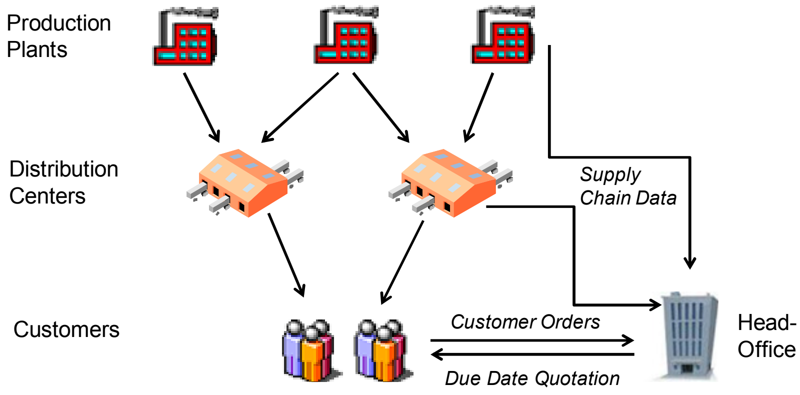

Fig. E-13.3. Stakeholders in the ATP process

Headquarters assembles all information about orders and confirms due delivery dates. Distribution Centres (DC) carry inventory status data. Factories calculate master production schedules, material inventory data, and material supply schedules (see Fig. E-13.4).

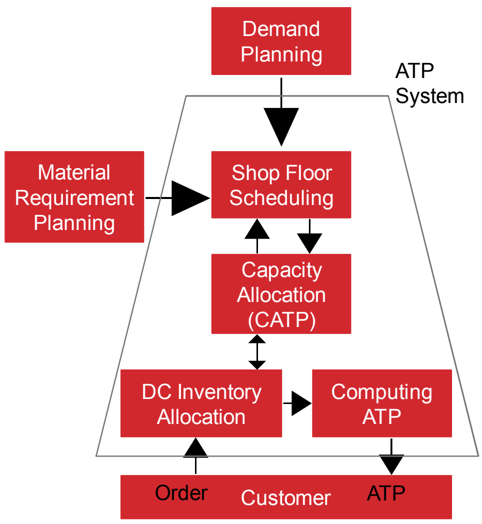

Fig. E-13.4. ATP-CTP process

The input data for the ATP model is order-related data such as quantity, location, transportation time, requested due date, and order priority. Based on costs associated with transportation and production, transportation constraints, and production capabilities, the ATP model returns the outputs of the available capacity to promise (CTP), the transportation schedule for shipments of cell glass panels from cell plants to module plants, the production schedule in module plants, and promised and unsatisfied orders. Module plants respond to customers based on the quantity a firm can deliver within a desired due date. If customers are unsatisfied with the quote and withdraw their order inquiry, the proposed ATP model releases the capacity dedicated to those order inquiries and updates the remaining capacity available-to-promise (CATP).

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Case Study: Papa John's Pizza

Papa John's is a pizza delivery company founded in 1983. Since then it has grown, with over 3,800 restaurants and 18,000 employees. The crucial issue in operations planning for Papa John's is to match demand and supply. The company needs to communicate demand to its suppliers timely and accurately. Especially when demand is forecasted to be particularly high, suppliers need to know ahead of time in order to deliver the necessary products.

In 2010, Papa John's became the official sponsor of the National Football League in the United States; and for the Super Bowl in 2011 its pizza was the official pizza. On the day of the Super Bowl, Papa John's sold over one million pizza pies. In order to be prepared for such peak events, supply chain coordination and information communication are essential.

The main issues for establishing efficient and responsive operations planning are the accuracy in managing inventory, better visibility of inbound and outbound products, and demand management especially for demand spikes. Because of the many suppliers and customers, along with uncertain demand, management information systems are needed at Papa John's to support operations managers.

Inventory optimization software assists them with the inventory planning, providing information about the optimal amount of products needed in order to prevent stock-outs. A new warehouse management system (WMS) and transportation management system (TMS) implemented new methods for picking up products and loading trucks. Papa John's went from manual warehouse management to pickers with headsets that guided them to the specific product. For example, for the Super Bowl event, Papa John's had to double their dispatches of deliveries. This was managed through a TMS. Typically, a TMS assesses inbound and outbound orders and suggests best vehicle routing solutions.

The changes allowed Papa John's to make not only improvement in the execution of their supply chain, but also resulted in great cost reduction. For example, storage costs reduced by 66.4%, inventory levels by 15.7%, inventory investment by 83.7%; and productivity, thanks to the WMS, increased by 9%. These changes make it possible for challenges such as those faced by the Super Bowl event to be managed so that companies could emulate its success story.

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http://www.papajohns.com/about/index.shtm.
http://www.manh.com/about-us.

Case BIMBA ATP/CTP

Bimba Manufacturing is a US company, a manufacturer of automation actuators (cylinders used in a variety of industrial applications including medical processing, vegetable harvesting, and packaging and printing, to name but a few) that has long been known as an innovator. The company developed an ATP/CTP (available-to-promise/capable-to-promise) concept that allowed its distributors to access key production capacity and inventory information online which further established Bimba as an industry leader. The company has grown substantially since that time.

First, an *ATP Application* has been developed. This web application informs customers when a product can be shipped by Bimba. If a customer needs standard in-stock items, these products typically can be shipped at the day of request. If non-standard size actuators are requested, the system checks component availability and provides an ATP date (generally three to five days).

Second, *Quick Ship Application* to respond to emergency situations was developed. Bimba is able to manufacture and ship an actuator within 24 hours in many cases. The company reserves capacity to provide immediate turnaround for customers. The Quick Ship Inquiry application integrates requests by product line to accommodate emergency demand. For example if a customer needs five Flat Line actuators in 24 hours and the daily capacity of the production line is 13 actuators, Bimba still has the production capacity to create eight items more, so according to CTP they could accept customer emergency orders. The ATP/CTP resulted in six-figure cost savings and improved capabilities.

Reference
www.bimba.com.

Discussion questions

- What competitive advantages can you see for companies implementing ATP/CTP?
- Company A offers in the market a standard product, and many competitors exist. Company B has a unique position in the market (e.g., exceptional quality of products). For which company would the investment in ATP/CTP be more sensible?
- Can you see any obstacles in implementing ATP/CTP in the supply chain?

Case Study VMI

A supplier in a drugstore chain implemented a joint project with a drugstore retail network. In the result, the supplier is responsible for inventory and supply planning on the basis of inventory and demand data transmitted from the retail stores. This replaced a previous process where supplier processed the orders from the retail network.

Previously, the retailer's central warehouse managed demand and supply by replenishing from the supplier's logistics centre. The supplier could only react to the order, bundle and pick-up the order items. This caused shortages and bottle-necks in the case of large orders since the supplier's logistics centre was replenished daily from the production plants in order to reduce inventory. Demand and inventory data on the retail network side were not available for inventory planning at the supplier.

After the project implementation, production and inventory planning were improved. This cut production and inventory costs and allowed more flexible control assortment changes. The costs of higher service level on the supplier side were compensated through a reduction in the total process costs. Customer satisfaction has been increased and stock-outs have been reduced.

Questions:

a) What effects have been achieved in the project? How?
b) What is the name of the implemented concept?
c) Which methods of inventory management could be applied for this optimization?

Responses:

a) Production and inventory costs have been cut and control assortment changes became flexible on the basis of improved production and inventory planning. Customer satisfaction has been increased and stock-outs have been reduced on the basis of the data sharing between vendor and buyer.

b) This is VMI, since vendor takes responsibility for inventory management on the buyer side. The buyer provides inventory and demand information to the supplier.

c) For example: demand forecasting: exponential smoothing; safety stock: probability theory; order quantity planning: Silver-Meal heuristic

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Case Study VMI/CPFR

A department store has implemented modern distribution and planning processes to create transparency and flexibility in procurement logistics. First results are impressive: inventory has been drastically reduced along with maintaining the desired customer service level.

The department store activities are characterized by broad product portfolio which makes the company react quickly to demand fluctuations. The world economic crisis showed that sudden breakdowns in orders along with long lead times result in high inventory. This is very costly. The objective of optimization was to decrease sustainable inventory while maintaining the desired service level for more than 8,000 customers.

First, product portfolio was classified according to sales volumes and demand fluctuations. For each segment, the planning strategy and inventory control policy have been defined. The department store transmitted inventory and demand data to the suppliers who are now responsible for the inventory availability on the buyer side. Then the supplier decides on the optimal safety inventory placement in the supply chain. In addition, for each product an optimal safety stock level has been calculated.

A new information system is applied now which allows reduced ordering time. Previously, managers had to go through long Excel sheets; now everything happens within a few mouse clicks. Data and demand forecast quality have been improved. In addition, collaboration with suppliers has been improved.

Questions:

- What problem situation launched the project?
- Which objectives were addressed? What is the trade-off regarding these objectives?
- Which methods of inventory and demand management could be applied for this optimization?
- What are the advantages of the new information system? Which systems could be used in such a project?

Responses:

- Problem situation: to create transparency and flexibility in the procurement logistics.
- Objectives: inventory and service level; trade-off: Inventory creates costs but at the same time it can be used to increase supply chain flexibility.
- For example: demand forecasting: exponential smoothing; safety stock: probability theory
- Advantages: processing time reduction; data and demand forecast quality have been improved; collaboration with suppliers has been improved. Examples of information systems: ERP for data integration among different departments; APS for mathematical optimization along the supply chain; RFID and supply chain event management for good movement control; WMS for

Task EOQ

The operations manager of a company will realize if it implements the optimal inventory procurement decision. The following data are given:

q	100	150	200	250	300
Holding costs	486	729	972	1215	1458
Ordering costs	1944	1296	972	777.6	648
Total costs	2340	2025	1944	1992.6	2106

The inquiry in the procurement department revealed that at present order quantity equal 250. Is it optimal order quantity? If yes, why? If not, what is optimal order quantity?

Answer: EOQ=200 since at q=200 holding costs equals the ordering costs