JIT and Lean Operations

Outline

- Push-Pull Systems
- Global Company Profile: Toyota Motor Corporation
- Just-in-Time, the Toyota Production System, and Lean Operations
  - Eliminate Waste
  - Remove Variability
  - Improve Throughput
Outline – Continued

✓ Just-in-Time
  ✓ JIT Partnerships
  ✓ Concerns of Suppliers

✓ JIT Layout
  ✓ Distance Reduction
  ✓ Increased Flexibility
  ✓ Impact on Employees
  ✓ Reduced Space and Inventory

Outline – Continued

✓ JIT Inventory
  ✓ Reduce Variability
  ✓ Reduce Inventory
  ✓ Reduce Lot Sizes
  ✓ Reduce Setup Costs

✓ JIT Scheduling
  ✓ Level Schedules
  ✓ Kanban
Outline – Continued

✔ JIT Quality
✔ Toyota Production System
  ✔ Continuous Improvement
  ✔ Respect for People
  ✔ Standard Work Practices
✔ Lean Operations
  ✔ Building a Lean Organization
✔ Lean Operations in Services

Learning Objectives

When you complete this chapter you should be able to:

1. Define push-pull systems, just-in-time, TPS, and lean operations
2. Define the seven wastes and the 5 Ss
3. Explain JIT partnerships
4. Determine optimal setup time
Learning Objectives

When you complete this chapter you should be able to:

5. Define kanban
6. Compute the required number of kanbans
7. Explain the principles of the Toyota Production System

Push - Pull
A "push system" of production - distribution is one where replenishment of material items begins in advance of customer needs.
For a "push system" customer orders for materials are promised for delivery at a given future date, production is started at the first workstation of the production/distribution pipeline and pushed ahead to the next operation.

Work-in-process inventories are accumulated in the production - distribution pipeline in anticipation of shipping the completed order on the promised date.
SALES/PROD. PLAN

MPS

MRP

CRP

REALISTIC?

No

EXECUTE CRP

Yes

EXECUTE MRP

AVAILABLE TO PROMISE

Push is Computer Intensive !!!!!!!!!!!!

Pull
A "pull system" of production - distribution is one where customer demand activates production - distribution of the item.

For a "pull system" production and distribution activities are not performed in anticipation of customer actions. Customer orders initiate all production - distribution pipeline activities.
Pull systems are characterized as Just-in-Time Systems.

The logic of JIT is based on the concept that nothing will be ordered for replenishment until it is needed and need is created by the void left in a production - distribution pipeline when a product is pulled away or used.

In theory, when an item is sold to a customer the market "pulls" a replacement from the last position within the production - distribution pipeline. An order from this last pipeline position pulls a replacement unit from the next to last pipeline position to replace the pipeline void. Then an order from the next to last pipeline position pulls a unit from the third from last position to fill the void in the next to last position, and so on all the way back to the original release of materials at the beginning of the production - distribution pipeline.
In this way, total pipeline flow is equally maintained throughout the pipeline and if, as assumed, customer demand is smooth and continuous, total pipeline flow will be smooth and continuous and pipeline inventories are minimized.

In general, the philosophy of filling unit voids in the production - distribution pipeline defines the JIT goal of generating precisely the necessary units in the necessary quantities at the necessary time with zero \( p_c \).
Small Lot Sizes and Short Lead Times Between Supply Chain Links!!

JIT Demand-Pull Logic

Toyota Motor Corporation

- Largest vehicle manufacturer in the world with annual sales of over 9 million vehicles
- Success due to two techniques, JIT and TPS
- Continual problem solving is central to JIT
- Eliminating excess inventory makes problems immediately evident
Toyota Motor Corporation

- Central to TPS is a continuing effort to produce products under ideal conditions
- Respect for people is fundamental
- Small building but high levels of production
- Subassemblies are transferred to the assembly line on a JIT basis
- High quality and low assembly time per vehicle

Just-In-Time, TPS, and Lean Operations

- JIT is a philosophy of continuous and forced problem solving via a focus on throughput and reduced inventory
- TPS emphasizes continuous improvement, respect for people, and standard work practices
- Lean production supplies the customer with their exact wants when the customer wants it without waste
Just-In-Time, TPS, and Lean Operations

- JIT emphasizes forced problem solving
- TPS emphasizes employee learning and empowerment in an assembly-line environment
- Lean operations emphasize understanding the customer

Eliminate Waste

- Waste is anything that does not add value from the customer point of view
- Storage, inspection, delay, waiting in queues, and defective products do not add value and are 100% waste
Ohno’s Seven Wastes

- Overproduction
- Queues
- Transportation
- Inventory
- Motion
- Overprocessing
- Defective products

Eliminate Waste

- Other resources such as energy, water, and air are often wasted
- Efficient, ethical, and socially responsible production minimizes inputs, reduces waste
- Traditional “housekeeping” has been expanded to the 5 Ss
The 5 Ss

- **Sort/segregate** – when in doubt, throw it out
- **Simplify/straighten** – methods analysis tools
- **Shine/sweep** – clean daily
- **Standardize** – remove variations from processes
- **Sustain/self-discipline** – review work and recognize progress

**Two additional Ss**

- **Safety** – build in good practices
- **Support/maintenance** – reduce variability and unplanned downtime
Remove Variability

- **JIT systems require managers to reduce variability caused by both internal and external factors**
- **Variability is any deviation from the optimum process**
- **Inventory hides variability**
- **Less variability results in less waste**

Sources of Variability

1. **Incomplete or inaccurate drawings or specifications**
2. **Poor production processes resulting in incorrect quantities, late, or non-conforming units**
3. **Unknown customer demands**
Sources of Variability

1. Incomplete or inaccurate drawings or specifications

2. Poor production processes resulting in incorrect quantities, late, or non-conforming units

3. Unknown customer demands

Both JIT and inventory reduction are effective tools in identifying causes of variability.

Improve Throughput

- The time it takes to move an order from receipt to delivery
- The time between the arrival of raw materials and the shipping of the finished order is called manufacturing cycle time
- A pull system increases throughput
**Improve Throughput**

- By pulling material in small lots, inventory cushions are removed, exposing problems and emphasizing continual improvement
- Manufacturing cycle time is reduced
- Push systems dump orders on the downstream stations regardless of the need

**Just-In-Time (JIT)**

- Powerful strategy for improving operations
- Materials arrive where they are needed when they are needed
- Identifying problems and driving out waste reduces costs and variability and improves throughput
- Requires a meaningful buyer-supplier relationship
JIT and Competitive Advantage

JIT TECHNIQUES:

<table>
<thead>
<tr>
<th>Suppliers:</th>
<th>Few vendors; Supportive supplier relationships; Quality deliveries on time, directly to work areas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layout:</td>
<td>Work-cells; Group technology; Flexible machinery; Organized workplace; Reduced space for inventory.</td>
</tr>
<tr>
<td>Inventory:</td>
<td>Small lot sizes; Low setup time; Specialized parts bins</td>
</tr>
<tr>
<td>Scheduling:</td>
<td>Zero deviation from schedules; Level schedules; Suppliers informed of schedules; Kanban techniques</td>
</tr>
<tr>
<td>Preventive maintenance:</td>
<td>Scheduled; Daily routine; Operator involvement</td>
</tr>
<tr>
<td>Quality production:</td>
<td>Statistical process control; Quality suppliers; Quality within the firm</td>
</tr>
<tr>
<td>Employee empowerment:</td>
<td>Empowered and cross-trained employees; Training support; Few job classifications to ensure flexibility of employees</td>
</tr>
<tr>
<td>Commitment:</td>
<td>Support of management, employees, and suppliers</td>
</tr>
</tbody>
</table>

Figure 16.1

JIT and Competitive Advantage

WHICH RESULTS IN:

- Rapid throughput frees assets
- Quality improvement reduces waste
- Cost reduction adds pricing flexibility
- Variability reduction
- Rework reduction

WHICH WINS ORDERS BY:

- Faster response to the customer at lower cost and higher quality—A Competitive Advantage

Figure 16.1
**JIT Partnerships**

✓ **JIT partnerships exist when a supplier and purchaser work together to remove waste and drive down costs**

✓ **Four goals of JIT partnerships are:**
  - Removal of unnecessary activities
  - Removal of in-plant inventory
  - Removal of in-transit inventory
  - Improved quality and reliability

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**Figure 16.2**

**JIT Partnerships**

- **Suppliers**
  - Locate near buyer
  - Extend JIT techniques to their suppliers
  - Include packaging and routing details
  - Detail ID and routing labels
  - Focus on core competencies

- **Shipping**
  - Seek joint scheduling and shipping efficiencies
  - Consider third-party logistics
  - Use advance shipping notice (ASN)
  - Ship frequent small orders

- **Quantities**
  - Produce small lots
  - Deliver with little overage and underage
  - Meet mutually developed quality requirements
  - Produce with zero defects

- **Buyers**
  - Share customer preferences and demand forecasts
  - Minimize product specifications and encourage innovation
  - Support supplier innovation and price competitiveness
  - Develop long-term relationships
  - Focus on core competencies
  - Process orders with minimal paperwork (use EDI or Internet)

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**Mutual Understanding and Trust**
Concerns of Suppliers

- **Diversification** – ties to only one customer increases risk
- **Scheduling** – don’t believe customers can create a smooth schedule
- **Changes** – short lead times mean engineering or specification changes can create problems
- **Quality** – limited by capital budgets, processes, or technology
- **Lot sizes** – small lot sizes may transfer costs to suppliers

JIT Layout

Reduce waste due to movement

**JIT Layout Tactics**
- Build work cells for families of products
- Include a large number operations in a small area
- Minimize distance
- Design little space for inventory
- Improve employee communication
- Use poka-yoke devices
- Build flexible or movable equipment
- Cross-train workers to add flexibility

Table 16.1
Distance Reduction

- Large lots and long production lines with single-purpose machinery are being replaced by smaller flexible cells
- Often U-shaped for shorter paths and improved communication
- Often using group technology concepts

Increased Flexibility

- Cells designed to be rearranged as volume or designs change
- Applicable in office environments as well as production settings
- Facilitates both product and process improvement
Impact on Employees

- Employees are cross trained for flexibility and efficiency
- Improved communications facilitate the passing on of important information about the process
- With little or no inventory buffer, getting it right the first time is critical

Reduced Space and Inventory

- With reduced space, inventory must be in very small lots
- Units are always moving because there is no storage
Inventory

Inventory is at the minimum level necessary to keep operations running

JIT Inventory Tactics

Use a pull system to move inventory
Reduce lot sizes
Develop just-in-time delivery systems with suppliers
 Deliver directly to point of use
Perform to schedule
Reduce setup time
Use group technology

Table 16.2

Reduce Variability

![Diagram showing factors affecting inventory level](Figure 16.3)
Reduce Variability

Figure 16.3

Reduce Lot Sizes

Figure 16.4

- Inventory level
- Scrap
- Setup time
- Process downtime
- Quality problems
- Late deliveries

There are two scenarios:

1. **Q₁** When average order size = 200
   - Average inventory is 100

2. **Q₂** When average order size = 100
   - Average inventory is 50

Two graphs show changes in inventory over time.
Reduce Lot Sizes

☑ Ideal situation is to have lot sizes of one pulled from one process to the next
☑ Often not feasible
☑ Can use EOQ analysis to calculate desired setup time
☑ Two key changes necessary
  ☑ Improve material handling
  ☑ Reduce setup time

Lot Size Example

\[ D = \text{Annual demand} = 400,000 \text{ units} \]
\[ d = \text{Daily demand} = \frac{400,000}{250} = 1,600 \text{ per day} \]
\[ p = \text{Daily production rate} = 4,000 \text{ units} \]
\[ Q = \text{EOQ desired} = 400 \]
\[ H = \text{Holding cost} = $20 \text{ per unit} \]
\[ S = \text{Setup cost (to be determined)} \]

\[ Q = \sqrt{\frac{2DS}{H(1 \frac{d}{p})}} \quad Q^2 = \frac{2DS}{H(1 \frac{d}{p})} \]
\[ S = \frac{(Q^2)(H)(1 \frac{d}{p})}{2D} = \frac{(3,200,000)(0.6)}{800,000} = $2.40 \]

Setup time = $2.40/($30/hour) = 0.08 hr = 4.8 minutes
Reduce Setup Costs

- High setup costs encourage large lot sizes
- Reducing setup costs reduces lot size and reduces average inventory
- Setup time can be reduced through preparation prior to shutdown and changeover

Lower Setup Costs

Figure 16.5
Reduce Setup Times

Initial Setup Time

Step 1
Separate setup into preparation and actual setup, doing as much as possible while the machine/process is operating (save 30 minutes)

Step 2
Move material closer and improve material handling (save 20 minutes)

Step 3
Standardize and improve tooling (save 15 minutes)

Step 4
Use one-touch system to eliminate adjustments (save 10 minutes)

Step 5
Training operators and standardizing work procedures (save 2 minutes)

Step 6
Repeat cycle until subminute setup is achieved

JIT Scheduling

☑ Schedules must be communicated inside and outside the organization

☑ Level schedules
  ☑ Process frequent small batches
  ☑ Freezing the schedule helps stability

☑ Kanban
  ☑ Signals used in a pull system
Better scheduling improves performance

JIT Scheduling Tactics

- Communicate schedules to suppliers
- Make level schedules
- Freeze part of the schedule
- Perform to schedule
- Seek one-piece-make and one-piece move
- Eliminate waste
- Produce in small lots
- Use kanbans
- Make each operation produce a perfect part

Level Schedules

- Process frequent small batches rather than a few large batches
- Make and move small lots so the level schedule is economical
- “Jelly bean” scheduling
- Freezing the schedule closest to the due dates can improve performance
Scheduling Small Lots

JIT Level Material-Use Approach

A A B B B C A A B B B C

Large-Lot Approach

A A A A A B B B B B B B

Kanban

- Kanban is the Japanese word for card
- The card is an authorization for the next container of material to be produced
- A sequence of kanbans pulls material through the process
- Many different sorts of signals are used, but the system is still called a kanban
Kanban

1. User removes a standard sized container
2. Signal is seen by the producing department as authorization to replenish

Figure 16.8

Kanban

Figure 16.9
More Kanban

- When the producer and user are not in visual contact, a card can be used.
- When the producer and user are in visual contact, a light or flag or empty spot on the floor may be adequate.
- Since several components may be required, several different kanban techniques may be employed.

More Kanban

- Usually each card controls a specific quantity or parts.
- Multiple card systems may be used if there are several components or different lot sizes.
- In an MRP system, the schedule can be thought of as a build authorization and the kanban a type of pull system that initiates actual production.
More Kanban

- Kanban cards provide a direct control and limit on the amount of work-in-process between cells
- If there is an immediate storage area, a two-card system can be used with one card circulating between the user and storage area and the other between the storage area and the producer

The Number of Kanban Cards or Containers

- Need to know the lead time needed to produce a container of parts
- Need to know the amount of safety stock needed

\[
\text{Number of kanbans (containers)} = \frac{\text{Demand during lead time} + \text{Safety stock}}{\text{Size of container}}
\]
Number of Kanbans Example

Daily demand = 500 cakes
Production lead time = 2 days
(Wait time + Material handling time + Processing time)
Safety stock = 1/2 day
Container size = 250 cakes

Demand during lead time = 2 days x 500 cakes = 1,000

Number of kanbans = \( \frac{1,000 + 250}{250} = 5 \)

Advantages of Kanban

- Allow only limited amount of faulty or delayed material
- Problems are immediately evident
- Puts downward pressure on bad aspects of inventory
- Standardized containers reduce weight, disposal costs, wasted space, and labor
Quality

☑ Strong relationship
  ☑ JIT cuts the cost of obtaining good quality because JIT exposes poor quality
  ☑ Because lead times are shorter, quality problems are exposed sooner
  ☑ Better quality means fewer buffers and allows simpler JIT systems to be used

JIT Quality Tactics

Use statistical process control
Empower employees
Build fail-safe methods (poka-yoke, checklists, etc.)
Exposure poor quality with small lot JIT
Provide immediate feedback

Table 16.4
**Toyota Production System**

- **Continuous improvement**
  - Build an organizational culture and value system that stresses improvement of all processes
  - Part of everyone’s job
- **Respect for people**
  - People are treated as knowledge workers
  - Engage mental and physical capabilities
  - Empower employees

**Toyota Production System**

- **Standard work practice**
  - Work shall be completely specified as to content, sequence, timing, and outcome
  - Internal and external customer-supplier connection are direct
  - Product and service flows must be simple and direct
  - Any improvement must be made in accordance with the scientific method at the lowest possible level of the organization
Lean Operations

- Different from JIT in that it is externally focused on the customer
- Starts with understanding what the customer wants
- Optimize the entire process from the customer’s perspective

Building a Lean Organization

- Transitioning to a lean system can be difficult
- Lean systems tend to have the following attributes
  - Use JIT techniques
  - Build systems that help employees produce perfect parts
  - Reduce space requirements
Building a Lean Organization

- Develop partnerships with suppliers
- Educate suppliers
- Eliminate all but value-added activities
- Develop employees
- Make jobs challenging
- Build worker flexibility

JIT in Services

- The JIT techniques used in manufacturing are used in services
  - Suppliers
  - Layouts
  - Inventory
  - Scheduling