Production System

Traditional Production System

Competitive Product Space

- A representation of the firm’s product portfolio in the four dimensional space: $Q$, $C$, $Var.$, $Res.$

 Variety

 $B$ - Another firm: expensive and customized products.

 $A$ - One firm: low cost and standardized products

 Responsiveness

 Cost Efficiency ($1/cost$)
Strategic Positioning

- Defines those positions that the firm wants to occupy in its competitive product space. The current position, direction, and goal position.

```
Responsiveness

High       Low

Price

B

A
```

Manufacturing System Typology

- Manufacturing system are classified in different ways:

  - Process positioning strategy
    - based on production process

  - Product positioning strategy
    - Based on the interaction with the consumer
### Manufacturing System Typology

- **Typology 1**
  - Evaluates based on how production process is physically arranged in a factory
  - Depicts how the product flow is processed

- **Typology 2**
  - Evaluates the interaction between producer and consumer on how the order is being sent and received (Consumer Order Decoupling Point)
  - Depicts how the inventory is maintained

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### Typology 1

- Process Architecture refers to
  - **Physical layout** of resources
  - **Flexibility** of resources

- Most process architectures fall somewhere on the continuum between job shop and flow shop
Process Architectures: Job Shop

Product 1 → A → B → Product 2
Product 1 → C → D → Product 2

Output

Job Shop

- Functional layout or Process layout:
  - similar resources in the same department.
  - Ex. all press machines are located in stamping department

- Ex. Bakeries, law firms, emergency rooms, repair shops.
Job Shop Characteristics

- low volume, high variety customized products
- flexible resources
- skilled human resources
- jumbled work flows
- high material handling
- large of inventories
- long flow time
- highly structured information system
- high cost per unit of product but low investment

Process Architectures: Flow Shop

Input

Output

Product 1

Product 2
Flow Shop

- **Product layout or line layout:**
  - Resources are arranged according to the sequence of the operations.
  - Usually requires duplication (and investment) of a resource pool; dedication of resources.

- **Discrete flow shop:**
  - assembly line

- **Continuous flow shop:**
  - beverage, chemical plant, process plant.

Flow Shop Characteristics

- high standardization, high speed
- low material handling
- short flow time
- low unit-processing costs
- high investment cost; needs mass production.
- special purpose equipment, and low skilled labor prevent flexibility

<table>
<thead>
<tr>
<th>Process Flexibility</th>
<th>Product Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Low Standardization, Commodity Products</td>
</tr>
<tr>
<td></td>
<td>High Volume, Many Products</td>
</tr>
<tr>
<td>High</td>
<td>Low Standardization, One of a kind</td>
</tr>
<tr>
<td></td>
<td>Low Volume</td>
</tr>
</tbody>
</table>

- **JOB SHOP** (Commercial Printer, Architecture firm)
- **BATCH** (Heavy Equipment, Auto Repair)
- **FLOW SHOP** (Auto Assembly, Car lubrication shop)
- **CONTINUOUS FLOW** (Oil Refinery)

Oppportunity Costs
Out-of-pocket Costs

A similar graph can be prepared to show the relationship between process flexibility and cost, or process flexibility and response time, but not for quality.

<table>
<thead>
<tr>
<th></th>
<th>Low Volume One of a Kind</th>
<th>Multiple Products, Low Volume</th>
<th>Few Major Products, Higher Volume</th>
<th>High Volume, High Standardization</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Job Shop</td>
<td>Boutique Restaurant</td>
<td></td>
<td></td>
<td>Flexibility (High) Unit Cost (High)</td>
</tr>
<tr>
<td>II. Batch</td>
<td>Heavy Equipment Coffee Shop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Assembly Line</td>
<td>Automobile Assembly Mc Donald</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV. Continuous Flow</td>
<td>Sugar Refinery</td>
<td></td>
<td></td>
<td>Flexibility (Low) Unit Cost (Low)</td>
</tr>
</tbody>
</table>

ABOVE THE DIAGONAL

- Flexibility/Variety is Higher
- Costs are Higher
- OK with low volume markets
- OK when high customization is necessary
- Threats:
  - A competitor can undercut you
  - Risky when high volume can be stimulated through price competition
Costs are lower
- Automation is higher
- Greater investment

Threats:
- Greater market risk – what do you do with an automated highly specialized plant when demand decreases?
- Competition may match costs with greater product variety.

Characteristics of Processes: Job Shop vs. Batch vs. Flow Shop

<table>
<thead>
<tr>
<th>Type of Process</th>
<th>Product Volume</th>
<th>Specialized Equipment</th>
<th>Product Variety</th>
<th>Machine Setup Frequency</th>
<th>Labor Skills</th>
<th>Variable Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Shop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Shop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Most processes fall somewhere on the continuum between Job Shop and Flow Shop
Characteristics of Processes: Job Shop vs. Batch vs. Flow Shop

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Job Shop</th>
<th>Repetitive</th>
<th>Line</th>
<th>Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process speed</td>
<td>Varies</td>
<td>Slow</td>
<td>Moderate</td>
<td>Fast</td>
</tr>
<tr>
<td>Labor content</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Labor skill level</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Order quantity</td>
<td>Very small</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Unit quantity cost</td>
<td>Very large</td>
<td>Large</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Routing variations</td>
<td>Very high</td>
<td>High</td>
<td>None</td>
<td>Low</td>
</tr>
<tr>
<td>Product options</td>
<td>Low</td>
<td>Low</td>
<td>None</td>
<td>Very high</td>
</tr>
<tr>
<td>Design component</td>
<td>Very large</td>
<td>Large</td>
<td>Very small</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

All manufacturing falls on this continuum.

Typology 2

- **ETO -> MTO-> ATO-> MTS**
### Tipologi Sistem Manufaktur

<table>
<thead>
<tr>
<th>ASPECT</th>
<th>MTS</th>
<th>ATO</th>
<th>MTO</th>
<th>ETO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface between manufacturer and customer</td>
<td>Less interface</td>
<td>Sales dept.</td>
<td>Engineering and sales Dept.</td>
<td>Engineering Dept.</td>
</tr>
<tr>
<td>Delivery time</td>
<td>Short</td>
<td>Medium</td>
<td>Variable</td>
<td>Variable</td>
</tr>
<tr>
<td>Production Volume</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>Product variety</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>Delivery order estimate</td>
<td>Based on stock availability of finish product</td>
<td>Based on stock availability of component and sub-assembly product</td>
<td>Based on availability of production capacity</td>
<td>Based on availability of engineering and production capacity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>MTS</th>
<th>ATO</th>
<th>MTO</th>
<th>ETO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit in Master Production Schedule</td>
<td>Sales unit</td>
<td>Major components</td>
<td>End products</td>
<td>End products</td>
</tr>
<tr>
<td>Assembly schedule</td>
<td>MPS dependent</td>
<td>Consumer dependent</td>
<td>Covers most of the assembly operation</td>
<td>Covers all of the assembly operations</td>
</tr>
<tr>
<td>Structure of Bill of Material</td>
<td>Standard BOM</td>
<td>Planning BOMs are used</td>
<td>Unique BOM for each customer order</td>
<td>Unique BOM for each customer order</td>
</tr>
</tbody>
</table>
### Tipologi Sistem Manufaktur

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<th>ATO</th>
<th>MTO</th>
<th>ETO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basis for production planning</td>
<td>Forecasting</td>
<td>Forecasting and backlog</td>
<td>Backlog and customer order</td>
<td>Customer order</td>
</tr>
<tr>
<td>Handling of uncertainty (demand)</td>
<td>Safety stock</td>
<td>Over planning of component and sub-assembling</td>
<td>Little uncertainty exist</td>
<td>No handling</td>
</tr>
</tbody>
</table>

### The Problem of Manufacturing...

- Getting the right material and physical resources together at the right place and at the right time to meet the customer’s requirements.

- Desired features, On time delivery, High Quality, at the best price…
Breaking down the problem...

- Getting the material needed…
- Having enough inventory of material to support production
- Not having too much inventory and extra costs…

The name of the game...

- Material Requirement Planning
  - Inventory control -> MRP -> MRP II -> ERP

- Just in Time
  - Toyota Production System
  - Synchronous Mfg.

- Lean Manufacturing
  - Lean Production
  - Agile manufacturing

- Computer Integrated Manufacturing
  - Computer Aided Design
  - Computer Aided Manufacturing
  - Computer Aided … etc.
What can you expect in the real world?

- It may not be as easy as you think!
- Continual changes