Chapter 15 Objectives

1. Describe the basic features of lean manufacturing.
2. Describe lean accounting.
3. Discuss and define productive efficiency and partial productivity measurement.
4. Explain what total productivity measurement is, and describe its advantages.
Lean Manufacturing

• **Lean Manufacturing**: an approach designed to eliminate waste and maximize customer value

• Characterized by
  • Delivering the right product
  • In the right quantity
  • With the right quality (zero defects)
  • At the exact time the customer needs it
  • At the lowest possible cost

• Lean manufacturing systems allow managers to eliminate waste, reduce costs and become more efficient.
Promised Benefits Include:

- Reduced lead times
- Improved quality
- Improved on time deliveries
- Less inventory
- Less space
- Less human effort
- Lower costs
- Increased profitability

Lean Manufacturing

Objective 1
Lean Manufacturing

Five principles of lean thinking:

1) Precisely specify value by each particular product
2) Identify the ‘value stream’ for each
3) Make value flow without interruption
4) Let the customer pull value from the producer
5) Pursue perfection
Lean Manufacturing

• Value Stream
  • Made up of all activities – value-added and non-value added - required to bring a product group or service from its starting point to a finished product in the hands of the customer
  • Activities can be
    • Value added
    • Non-value added
      • Activities avoidable in the short run
      • Activities unavoidable in the short run due to current technology or production methods

• Types of value streams
  • Order fulfillment
  • New product value stream
  • Sales and marketing value stream

Objective 1
Lean Manufacturing

Lean Manufacturing uses a demand pull system.

The objective of lean manufacturing is to eliminate waste by producing a product only when it is needed and only in the quantities demanded by customers – thus, demand pulls products through the manufacturing process.
Lean Manufacturing

**Waste** is anything customers do not value.

Major sources of waste include:
- Defective products
- Overproduction of goods not needed
- Inventories of goods awaiting further processing or consumption
- Unnecessary processing
- Unnecessary movement of people
- Unnecessary transport of goods
- Waiting
- The design of goods and services that do not meet the needs of the customer
Lean Manufacturing

Order Fulfillment Value Stream—Robert AutoParts

- Sales
- Order Entry
- Scheduling
- Purchasing
- Packaging and Shipping
  - Cellular Manufacturing
  - Support Activities
  - Production Planning
- Billing Customer
  - Collecting Cash and Receivables
  - Post-Sales Services
Lean Manufacturing

Identifying value streams

• Two-dimensional matrix
  – Activities/processes on one dimension
  – Products on the second dimension

<table>
<thead>
<tr>
<th>Wheel Model</th>
<th>Order Entry</th>
<th>Production Planning</th>
<th>Purchasing</th>
<th>Aluminum Cell&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Steel Cell&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Stress Testing&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Packaging &amp; Shipping</th>
<th>Invoicing</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>B</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>C</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>D</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Lean Manufacturing

Value flow

• Reduced setup/changeover times
  – Reduces waste due to *move time* and *wait time*
  – Production in smaller batches and in greater variety
  – Decreases time to produce

• Cellular manufacturing
  – **Cells** contain all the operations in close proximity that are needed to produce a family of products
  – Chosen over departmental structure because it reduces lead time, decreases product cost, improves quality, and increases on-time delivery
Lean Manufacturing

Panel A: Current Departmental Layout—Model A Aluminum Wheel Production

Given batch size = 10 units

<table>
<thead>
<tr>
<th>Process Time</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Machining</td>
<td>50 minutes</td>
</tr>
<tr>
<td>Casting</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Painting</td>
<td>40 minutes</td>
</tr>
<tr>
<td>Finishing</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Total Processing</td>
<td>150 minutes</td>
</tr>
<tr>
<td>Move and Wait Time</td>
<td>40 minutes</td>
</tr>
<tr>
<td>Total Batch Time</td>
<td>190 minutes</td>
</tr>
</tbody>
</table>

Color Code:

Blue: Value-added process time
Red: Non-value-added move and pre-process wait time
Lean Manufacturing

The cell can produce 12 units per hour (60 min/hr ÷ 5 min/unit).

The production rate is controlled by the slowest activity in the cell.

The cycle time of operation is the number of minutes it takes an operation to process one unit of a product = 5 min.

<table>
<thead>
<tr>
<th>Processing Time (ten units)</th>
<th>Elapsed Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Unit</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Second Unit</td>
<td>20 minutes (processing begins five minutes after the first)</td>
</tr>
<tr>
<td>Tenth Unit</td>
<td>60 minutes (total processing time)</td>
</tr>
</tbody>
</table>

Time saved over traditional manufacturing: 150 minutes − 60 minutes = 90 minutes
Lean Manufacturing

Pull Value

• Lean manufacturing uses a demand-pull system, where the production is triggered by the customer order

• Eliminates waste by producing a product only when it is needed and only in the quantities demanded by customers
  – No production takes place until a signal from a succeeding process indicates a need to produce.
Lean Manufacturing

Pursue Perfection

• Identify and eliminate sources of waste
• Employee empowerment
• Total quality control
• Inventory management
• Activity-based management
Lean Accounting

• Accounting practice should closely follow changes in the operation of a business
• Traditional cost management systems may not work well in the lean environment. Changes in structural and procedural activities for lean manufacturing change
  – Product-costing
  – Operational control
Lean Accounting

Traceability of Overhead Costs

• In a lean environment, many overhead costs assigned to products using either driver tracing or allocation are now directly traceable to products.

• Increasing directly traceable costs yields increased accuracy of product costing
# Lean Accounting

## Multiple Products

<table>
<thead>
<tr>
<th></th>
<th>Materials</th>
<th>Salaries/Wages</th>
<th>Machining</th>
<th>Other</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Order Processing</strong></td>
<td>$12,000</td>
<td></td>
<td></td>
<td></td>
<td>$12,000</td>
</tr>
<tr>
<td><strong>Production Planning</strong></td>
<td>24,000</td>
<td></td>
<td></td>
<td></td>
<td>24,000</td>
</tr>
<tr>
<td><strong>Purchasing</strong></td>
<td>18,000</td>
<td></td>
<td></td>
<td></td>
<td>18,000</td>
</tr>
<tr>
<td><strong>Stamping</strong></td>
<td>$250,000</td>
<td>25,000</td>
<td>$19,000</td>
<td>$12,000</td>
<td>306,000</td>
</tr>
<tr>
<td><strong>Welding</strong></td>
<td>100,000</td>
<td>28,000</td>
<td>23,000</td>
<td>8,000</td>
<td>159,000</td>
</tr>
<tr>
<td><strong>Cladding</strong></td>
<td>60,000</td>
<td></td>
<td></td>
<td></td>
<td>60,000</td>
</tr>
<tr>
<td><strong>Testing</strong></td>
<td></td>
<td>7,000</td>
<td></td>
<td></td>
<td>7,000</td>
</tr>
<tr>
<td><strong>Packaging and Shipping</strong></td>
<td></td>
<td>6,000</td>
<td></td>
<td></td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Invoicing</strong></td>
<td></td>
<td>8,000</td>
<td></td>
<td></td>
<td>8,000</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>$410,000</td>
<td>$128,000</td>
<td>$42,000</td>
<td>$20,000</td>
<td>$600,000</td>
</tr>
</tbody>
</table>
Lean Accounting

Value Stream Reporting

• Costs are collected and reported by value stream.
• Each value stream is treated as a standalone business unit.
• The income statement should reflect the profit/loss by each value stream.
 Lean Accounting

**Robert AutoParts Profit and Loss Statement**

<table>
<thead>
<tr>
<th></th>
<th>Aluminum Stream</th>
<th>Steel Stream</th>
<th>Sustaining Costs</th>
<th>Plant Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>$700,000</td>
<td>$1,500,000</td>
<td></td>
<td>$2,200,000</td>
</tr>
<tr>
<td>Material costs</td>
<td>(280,000)</td>
<td>(410,000)</td>
<td>(690,000)</td>
<td></td>
</tr>
<tr>
<td>Conversion costs</td>
<td>(70,000)</td>
<td>(190,000)</td>
<td>(260,000)</td>
<td></td>
</tr>
<tr>
<td>Value stream profit</td>
<td>$350,000</td>
<td>$900,000</td>
<td></td>
<td>$1,250,000</td>
</tr>
<tr>
<td>Value stream ROS</td>
<td>50%</td>
<td>60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee costs</td>
<td></td>
<td></td>
<td>($40,000)</td>
<td>(40,000)</td>
</tr>
<tr>
<td>Other expenses</td>
<td></td>
<td></td>
<td>(30,000)</td>
<td>(30,000)</td>
</tr>
<tr>
<td>Change in inventory:</td>
<td></td>
<td></td>
<td></td>
<td>(500,000)</td>
</tr>
<tr>
<td>Current less prior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant gross profit</td>
<td>$680,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant ROS</td>
<td></td>
<td></td>
<td></td>
<td>31%</td>
</tr>
</tbody>
</table>

**aROS = Return on Sales = Profit ÷ Sales**

- Costs outside the value streams (sustaining costs) are reported in a separate column.
- To avoid distorting the current week’s performance, inventory reductions are reported separately from the value stream contributions.
Productive Efficiency

**Productivity** is concerned with producing output efficiently, and it specifically addresses the relationship of output and the inputs used to produce the output.
Productive Efficiency

Technical Efficiency

Technical efficiency improvement occurs when less inputs are used to produce the same output or more output is produced using the same input.
Productive Efficiency

Allocative Efficiency:
Of the two combinations that produce the same output, the least costly combination would be chosen.

**EXHIBIT 15-2**

Allocative Efficiency

*Technically Efficient Combination I: Total Cost of Inputs = $20,000,000*

- Labor:
  - [3 figures]  
  - $ [3 figures]

- Capital:
  - [3 figures]

*Output:*
- [5 cars]

---

*Technically Efficient Combination II: Total Cost of Inputs = $25,000,000*

- Labor:
  - [2 figures]  
  - $ [3 figures]

- Capital:
  - [4 figures]

*Output:*
- [5 cars]
Productive Efficiency

- **Partial Productivity Measure**: Measuring productivity for one input at a time
  - **Productivity ratio** = output/input
- **Operational Productivity Measure**: Partial measure where both input and output are expressed in physical terms
- **Financial Productivity Measure**: Partial measure where both input and output are expressed in dollars
## Total Productivity Measurement

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of frames produced</td>
<td>240,000</td>
<td>250,000</td>
</tr>
<tr>
<td>Labor hours used</td>
<td>60,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Materials used (lbs.)</td>
<td>1,200,000</td>
<td>1,300,000</td>
</tr>
</tbody>
</table>

### Partial Operational Productivity Ratios

<table>
<thead>
<tr>
<th></th>
<th>2012 Profile</th>
<th>2013 Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor productivity ratio</td>
<td>4.000</td>
<td>5.000</td>
</tr>
<tr>
<td>Material productivity ratio</td>
<td>0.200</td>
<td>0.192</td>
</tr>
</tbody>
</table>

### Productivity Measurement: Profile Analysis with Trade-Offs

1. \( \frac{240,000}{60,000} \)
2. \( \frac{250,000}{50,000} \)
3. \( \frac{240,000}{1,200,000} \)
4. \( \frac{250,000}{1,300,000} \)
Total Productivity Measurement

- **Profit-Linkage Rule**: For the current period, calculate the cost of the inputs that would have been used in the absence of any productivity change, and compare this cost with the cost of the inputs actually used. The difference in costs is the amount by which profits changed because of productivity changes.

  To compute the inputs that would have been used \((PQ)\), use the following formula:

  \[ PQ = \frac{\text{Current period output}}{\text{base period productivity ratio}} \]
### Total Productivity Measurement

<table>
<thead>
<tr>
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<tr>
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<td>250,000</td>
</tr>
<tr>
<td>Labor hours used</td>
<td>60,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Materials used (lbs.)</td>
<td>1,200,000</td>
<td>1,300,000</td>
</tr>
<tr>
<td>Unit selling price (frames)</td>
<td>$30</td>
<td>$30</td>
</tr>
<tr>
<td>Wages per labor hour</td>
<td>$15</td>
<td>$15</td>
</tr>
<tr>
<td>Cost per pound of material</td>
<td>$3</td>
<td>$3.50</td>
</tr>
</tbody>
</table>
Total Productivity Measurement

PQ (labor) = \( \frac{250,000}{4} = 62,500 \) hrs.
PQ (materials) = \( \frac{250,000}{0.2} = 1,250,000 \) lbs.

Cost of labor: \( (62,500 \times $15) \) $937,500
Cost of materials: \( (1,250,000 \times $3.50) \) $4,375,000
Total PQ cost $5,312,500

The actual cost of inputs:
Cost of labor: \( (50,000 \times $15) \) $750,000
Cost of materials: \( (1,300,000 \times $3.50) \) $4,550,000
Total current cost $5,300,000
Profit-linked effect = Total PQ cost – Total current cost

= $5,312,500 – $5,300,000

= $12,500 increase in profits

*The net effect of the process change was favorable. Profits increased $12,500 because of productivity changes.*
## Total Productivity Measurement

<table>
<thead>
<tr>
<th>Input</th>
<th>(1) $PQ^*$</th>
<th>(2) $PQ \times P$</th>
<th>(3) $AQ$</th>
<th>(4) $AQ \times P$</th>
<th>(2) - (4) $(PQ \times P) - (AQ \times P)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>62,500</td>
<td>$937,500$</td>
<td>50,000</td>
<td>$750,000$</td>
<td>$187,500$</td>
</tr>
<tr>
<td>Materials</td>
<td>1,250,000</td>
<td>4,375,000</td>
<td>1,300,000</td>
<td>4,550,000</td>
<td>(175,000)</td>
</tr>
</tbody>
</table>

\[
\text{Labor: } \frac{250,000}{4} \\
\text{Materials: } \frac{250,000}{0.2}
\]
**Total Productivity Measurement**

Price Recovery = Total Profit Change – Profit-linked Component

Productivity Change

Total Profit Change = Profit in 2010 – Profit in 2009

Profit in 2010 = 250,000x$30 – 50,000x$15 – 1,300,000x$3.50 = $2,200,000

Profit in 2009 = 240,000x$30 – 60,000x$15 – 1,200,000x$3.00 = $2,700,000

Price Recovery = -$500,000 – 12,500 = -$512,500

*The net effect of the Price Recovery was unfavorable. Profits would have decreased by $512,500 if productivity had not increased.*
# Measuring Changes in Activity and Process Efficiency

**Activity Example: Purchasing**

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of purchase orders</td>
<td>200,000</td>
<td>240,000</td>
</tr>
<tr>
<td>Material used (lbs.)</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Labor used (number of workers)</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Cost per pound of material</td>
<td>$1</td>
<td>$0.80</td>
</tr>
<tr>
<td>Cost (salary) per worker</td>
<td>$30,000</td>
<td>$33,000</td>
</tr>
</tbody>
</table>
# Measuring Changes in Activity and Process Efficiency

## Activity Productivity Analysis Illustrated

### Profile Analysis

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>4</td>
<td>4.8</td>
</tr>
<tr>
<td>Labor</td>
<td>5,000</td>
<td>8,000</td>
</tr>
</tbody>
</table>

## Profit-Linked Productivity Measurement

<table>
<thead>
<tr>
<th>Input</th>
<th>(1) (PQ^*)</th>
<th>(2) (PQ \times P)</th>
<th>(3) (AQ)</th>
<th>(4) (AQ \times P)</th>
<th>((2) - (4))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>60,000</td>
<td>$48,000</td>
<td>50,000</td>
<td>$40,000</td>
<td>$8,000</td>
</tr>
<tr>
<td>Labor</td>
<td>48</td>
<td>1,584,000</td>
<td>30</td>
<td>990,000</td>
<td>594,000</td>
</tr>
</tbody>
</table>

\(\sum\) Materials: 240,000 ÷ 4

\(\sum\) Labor: 240,000 ÷ 5,000
Team Project

(5 pts) Proposal Overview: Company Well Defined & Product Characteristics Clear

(10 pts) Customer Expectations and Alternative Solutions Clearly Considered

(30 pts) Cost Management Principles and Techniques Clear & Fully Utilized

(35 pts) Analysis with Assumptions Complete & Calculations Accurate

(20 pts) Costs & Benefits with Sustainability Impacts Clearly Stated & Investment Justified