An Empirical Research of Operations Management: The High Performance Manufacturing Project

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Objective of HPM Project

To comparatively analyze the requirements for competitive manufacturing and the linkages among various decisions, systems and practices in operations function, based on the data collected from manufacturing companies through questionnaires and the relevant measurement scales.
Examples of Questions

1. Is there any difference in operations strategies, systems, and practices among different industries, different types of companies, or different countries?

2. What requirements should be satisfied for the development of particular operations practice or system?

3. Does some particular practice contribute to the improvement of other practices, systems, or strategies and high competitive performance?
The 1st Round Data Collection

- **Preliminary Survey**
- **Years:** late 80’s
- **Regions:** US only
- **Industries:** machinery, electrical & electronics, and automobile
- **Respondents:** many people in the plant from plant manager to direct labor
- **Question items:** Both qualitative and quantitative environment, major products, organization, human resource, TQM, information systems, JIT, manufacturing strategy, technology development, improvement, and performance
Analytical Framework of HPM at the 2nd Round Data Collection

Organization
  Human Resource Management

Quality Management
  JIT Production Systems
  Information Systems

Technology Development
  Manufacturing Strategy

Competitive Performance
Outline of the 2nd Round Survey

- **Years:** 90’s
- **Regions:** Japan, US, UK, Germany, and Italy
- **Industries:** machinery, electrical & electronics, and automobile
- **Respondents:** 26 for each plant
  - plant manager, plant superintendent, plant research coordinator, plant accountant, human resource manager, inventory/purchasing manager, information systems manager, production control manager, process engineer, quality manager, supervisors and direct labor
- **Question items:** 2544 items, qualitative and quantitative
  - environment, major products, organization, human resource, TQM, information systems, JIT, manufacturing strategy, technology development, improvement, and performance
### Sample Size

<table>
<thead>
<tr>
<th>Country</th>
<th>Team Leader</th>
<th>Total Number of Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAPAN</td>
<td>Michiya Morita</td>
<td>46</td>
</tr>
<tr>
<td>US</td>
<td>Roger Schroeder</td>
<td>30</td>
</tr>
<tr>
<td>UK</td>
<td>Cris Voss</td>
<td>21</td>
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<tr>
<td>GERMANY</td>
<td>Peter Milling</td>
<td>33</td>
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<tr>
<td>ITALY</td>
<td>Roberto Filippini</td>
<td>34</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td></td>
<td><strong>164</strong></td>
</tr>
</tbody>
</table>
PART I

Analysis of Japanese Manufacturers
Data Collection in Japan

• 46 Japanese plants are included from machinery, electrical & electronics, and automobile industries.
• 32 world class plants and 14 randomly sampled plants
• Usually we visited each company three times:
  – Meet an executive to explain about the aim of this survey and ask him/her to cooperate
  – Receive responses and take a plant tour
  – Feed back the results to the company and discuss with managers and executives
Menu of Analysis

1. To Construct Measurement Scales
   – Validity
   – Reliability
   – Super-scales
   – Inter-industry and Inter-class Comparisons

2. Relationship between the Measurement Scales and Competitive Performance

3. Interrelationships among Operations Areas
Measurement Scales

• Construct measurement scales by using several question items
• Check Reliability by Cronbach’s Alpha
• Check Construct Validity by Confirmatory Factor Analysis
• Using individual level data set
• Construct Super Scales
• Using plant level data set
Measurement Scales for Organization

1. Centralization of authority
2. Commitment
3. Coordination of decision making
4. Pride in work
Measurement Scales for Human Resource

1. Documentation of shop floor procedure
2. Employee suggestions
3. Incentives for group performance
4. Recruiting and selection
5. Rewards/manufacturing coordination
6. Shop floor contact
7. Small group problem solving
8. Supervisory interaction facilitation
9. Task-related training for employees
10. Compensation for breath of skill
11. Manufacturing/human resources fit
12. Multi-functional employees
   – Stable employment intention
   – Management breadth of experience
Measurement Scales for Quality

1. Cleanliness and organization
2. Continuous improvement
3. Customer involvement
4. Customer satisfaction
5. Feedback
6. Maintenance
7. Process control
8. Quality in new products
9. Supplier quality involvement
10. Top management leadership for quality
   - Reward for quality
   - TQM link with customers
Measurement Scales for JIT

1. Daily schedule adherence
2. Equipment layout
3. Just-in-time delivery by suppliers
4. Just-in-time link with customers
5. Kanban
6. MRP adaptation to JIT
7. Repetitive nature of master schedule
8. Setup time reduction
9. Small lot size
   ● Accounting Adaptation to JIT Practices
   ● Co-Makership
   ● Pull System Support
Measurement Scales for IS

1. Accounting
2. Benefits of information systems
3. Coordination with corporation
4. Dynamic performance measures
5. External information: supplier quality control
6. Internal quality information
7. Manufacturing plans
8. Stability/predictability of short term production
   - Performance Feedback
Measurement Scales for Technology

1. Effective process implementation
2. Inter-functional design efforts
3. Product design simplicity
   - New Product Introduction Process
   - Working with Technology Suppliers
Measurement Scales for Manufacturing Strategy

1. Anticipation of New Technologies
2. Communication of Manufacturing Strategy
3. Distinctive Competence
4. Formal Strategic Planning
5. Functional Integration
7. Manufacturing Strategy Strength
8. Product Competitive Performance Comparison
9. Proprietary Equipment
   - Long-range orientation
Results of Measurement Analysis

- 4 measurement scales for organization
- 12 measurement scales for human resource
- 10 measurement scales for quality
- 9 measurement scales for JIT
- 8 measurement scales for IS
- 3 measurement scales for technology
- 9 measurement scales for strategy
- All super-scales are reliable and valid, which suggests the close relationships among relevant measurement scales.
Inter-industry and Inter-class Comparisons of Measurement Scales
Table 1-a Mean Values of Quality Management Scales by Industry

<table>
<thead>
<tr>
<th>Scales</th>
<th>Machinery</th>
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<th>F-value</th>
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</thead>
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<td>3.88</td>
<td>3.72</td>
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<tr>
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<td>4.12</td>
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<td>3.50</td>
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<tr>
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<td>3.58</td>
<td>3.77</td>
<td>1.17</td>
</tr>
<tr>
<td>Maintenance</td>
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<td>3.35</td>
<td>3.47</td>
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<tr>
<td>Process control</td>
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<td>3.72</td>
<td>3.84</td>
<td>1.24</td>
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<td>3.66</td>
<td>3.67</td>
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<tr>
<td>Supplier quality involvement</td>
<td>3.71</td>
<td>3.85</td>
<td>3.85</td>
<td>0.87</td>
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<tr>
<td>Top management leadership for quality</td>
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<td>Quality management super-scale</td>
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<td>3.77</td>
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<tr>
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Table 1-b Mean Values of Quality Management Scales by Class

<table>
<thead>
<tr>
<th>Scales</th>
<th>WCM</th>
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</thead>
<tbody>
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<td>Feedback</td>
<td>3.70</td>
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<tr>
<td>Maintenance</td>
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<tr>
<td>Rewards for quality</td>
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<td>Top management leadership for quality</td>
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<td>3.83</td>
<td>3.52</td>
<td>3.41**</td>
<td>3.73</td>
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</table>

** Sample size 32 14 46

** significant at 1% level by one-tailed test
* significant at 5% level by one-tailed test
Results for Quality Scales

• There are no major differences in quality management activities among three industries we investigated.

• WCM plants have more sophisticated quality management system than randomly sampled plants in terms of all measurement scales except Customer involvement.
### Table 2-a  Mean values of just-in-time production scales

<table>
<thead>
<tr>
<th>Scales</th>
<th>Machine</th>
<th>Electric</th>
<th>Auto</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily schedule adherence</td>
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<td>Equipment layout</td>
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<td>3.91</td>
<td>2.94</td>
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<tr>
<td>Just-in-time delivery by suppliers</td>
<td>3.37</td>
<td>3.42</td>
<td>3.78</td>
<td>5.63**</td>
</tr>
<tr>
<td>Just-in-time link with customers</td>
<td>3.38</td>
<td>3.37</td>
<td>3.87</td>
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<td>Kanban</td>
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<td>MRP adaptation to JIT</td>
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<tr>
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<td>3.32</td>
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<td>3.83*</td>
</tr>
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<td>Setup time reduction</td>
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<td>3.69</td>
<td>3.79</td>
<td>1.17</td>
</tr>
<tr>
<td>Small lot size</td>
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<td>JIT super-scale</td>
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</table>

** significant at 1% level by one-tailed test  
* significant at 5% level by one-tailed test
### Table 2-b  Mean values of just-in-time production scales

<table>
<thead>
<tr>
<th>Scales</th>
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<td>3.72</td>
</tr>
<tr>
<td>Just-in-time delivery by suppliers</td>
<td>3.61</td>
<td>3.32</td>
<td>2.34*</td>
<td>3.52</td>
</tr>
<tr>
<td>Just-in-time link with customers</td>
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<td>Kanban</td>
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<td>3.19</td>
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<td>Setup time reduction</td>
<td>3.79</td>
<td>3.45</td>
<td>3.15**</td>
<td>3.69</td>
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<td>Small lot size</td>
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<td>3.22</td>
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<td><strong>Sample size</strong></td>
<td>32</td>
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<td></td>
<td>46</td>
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</tbody>
</table>

** **significant at 1% level by one-tailed test  * significant at 5% level by one-tailed test
Results for JIT Scales

• There were major differences in just-in-time production systems among three industries.
  automobile > electric & electronics > machinery

• World class manufacturing plants have established more sophisticated just-in-time production systems than randomly sampled plants in terms of all the measurement scales except Small lot size.
<table>
<thead>
<tr>
<th>Scales</th>
<th>Machine</th>
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<tbody>
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<td>3.80</td>
<td>4.03*</td>
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<tr>
<td>Coordination with corporation</td>
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<td>3.39</td>
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<td>Dynamic performance measures</td>
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<td>3.42*</td>
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<td>Manufacturing plans</td>
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<tr>
<td>Stability/predictability of short term production</td>
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<td>3.53</td>
<td>3.78*</td>
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<tr>
<td>Information system super-scale</td>
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<td>3.69</td>
<td>3.76</td>
<td>4.65*</td>
</tr>
<tr>
<td>Sample size</td>
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** significant at 1% level by one-tailed test
* significant at 5% level by one-tailed test
<table>
<thead>
<tr>
<th>Scales</th>
<th>WCM</th>
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<td>3.64</td>
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<td>3.69</td>
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<td>3.90</td>
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<td>3.40</td>
<td>3.45**</td>
<td>3.63</td>
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<td>46</td>
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</tbody>
</table>

** significant at 1% level by one-tailed test
* significant at 5% level by one-tailed test
Results for IS Scales

• There found major differences in the utilization of production information systems among three industries, particularly for Coordination with Corporation, Internal Quality Information, Benefits of Information Systems, Stability/Predictability of Short Term Production, Dynamic Performance Measures, and Information System super-scale.

• On average, automobile plants are the most advanced, closely followed by electrical & electronics plants.

• WCM plants have more sophisticated information systems than randomly sampled plants do.
Table 4  Mean Values of Technology-Related Scales

<table>
<thead>
<tr>
<th>Scales</th>
<th>Machine</th>
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<tr>
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<td>3.88</td>
<td>3.81</td>
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<tr>
<td>Technology super-scale</td>
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<td>3.82</td>
<td>3.77</td>
<td>0.47</td>
</tr>
<tr>
<td>Sample size</td>
<td>15</td>
<td>16</td>
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</table>

Scales

<table>
<thead>
<tr>
<th>Scales</th>
<th>WCM</th>
<th>Random</th>
<th>t-value</th>
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<td>3.28</td>
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<td>3.85</td>
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<td>Technology super-scale</td>
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<td></td>
<td>46</td>
</tr>
</tbody>
</table>

** significant at 1% level by one-tailed test
* significant at 5% level by one-tailed test
Results for Technology Scales

• There were no major differences in technology development activities among three industries.

• WCM plants contribute to technology development more actively than non-WCM plants.
### Table 5-a  Mean Values of Manufacturing Strategy Scales by Industry

<table>
<thead>
<tr>
<th>Scales</th>
<th>Machine</th>
<th>Electric</th>
<th>Auto</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipation of new technologies</td>
<td>3.59</td>
<td>3.83</td>
<td>3.81</td>
<td>0.86</td>
</tr>
<tr>
<td>Communication of manufacturing strategy</td>
<td>3.52</td>
<td>3.59</td>
<td>3.73</td>
<td>1.12</td>
</tr>
<tr>
<td>Distinctive competence</td>
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### Table 5-b  Mean Values of Manufacturing Strategy Scales by Class

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<td>3.35</td>
<td>3.32**</td>
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<td>3.25</td>
<td>6.36**</td>
<td>3.74</td>
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<td>4.63**</td>
<td>3.95</td>
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<td>2.62**</td>
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<td>3.95</td>
<td>3.36</td>
<td>4.03**</td>
<td>3.77</td>
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<tr>
<td>Product competitive performance comparison</td>
<td>3.85</td>
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<td>5.21**</td>
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<td>4.27**</td>
<td>3.41</td>
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** significant at 1% level by one-tailed test
Results for Strategy Scales

• There are modestly significant differences in some measurement scales of manufacturing strategy among three industries.
  – Anticipation of New Technologies
  – Communication of Manufacturing Strategy
  – Manufacturing-Business Strategy Linkage
  – Manufacturing Strategy super-scale

• Automobile, and electrical & electronics plants are more advanced than machinery plants on average.

• World class manufacturers have more sophisticated operations strategy than randomly sampled manufacturing plants.
Which measurement scales are the most influential to Competitive Performance?

Which area is the most important for competitive performance?
Competitive Performance Indicators

- These indicators show plant management’s opinion on plant performance vis-à-vis global competition in quality, delivery, flexibility, and inventory turns.
- This is based on the subjective judgment by one plant manager.
- Objective performance measures have some difficulties at least for Japan.
Competitive Performance Indicators

1. Unit cost of manufacturing
2. Quality of product conformance
3. Delivery performance
4. Fast delivery
5. Flexibility to change product mix
6. Flexibility to change volume
7. Inventory turnover
8. Cycle time
9. Speed of new product introduction
10. Product capability and performance
11. Customer support and service
### Table 6  Super-Scales and Competitive Performance Indicators

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<tr>
<th></th>
<th>First canonical variable</th>
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<td><strong>Canonical correlation</strong></td>
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<td><strong>Likelihood ratio</strong></td>
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<td><strong>Redundancy index</strong></td>
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Correlations between super-scales and canonical variables of competitive performance indicators

<table>
<thead>
<tr>
<th>Super-scale</th>
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<td>Organization (OG)</td>
<td>0.4079</td>
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</tr>
<tr>
<td>Human resource (HR)</td>
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<td><strong>Just-in-time (JIT)</strong></td>
<td><strong>0.4888</strong></td>
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<tr>
<td>Quality (QM)</td>
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<td>Technology (TECH)</td>
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<td>Manufacturing strategy (MS)</td>
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Correlations between competitive performance indicators and canonical variables of super-scales

<table>
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<td>Quality of product conformance</td>
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<tr>
<td>Flexibility to change product mix</td>
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<td>Flexibility to change volume</td>
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<td>Inventory turnover</td>
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<td>Cycle time</td>
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<td>Speed of new product introduction</td>
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<td>Product capability and performance</td>
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<tr>
<td>Customer support and service</td>
<td>0.5439</td>
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</table>
Strength of Relationship with Competitive Performance

1. Manufacturing Strategy
2. Technology Development
3. Information Systems
4. Quality Management
5. Human Resources
6. Just-in-time Production
7. Organization
Quality Management and Performance Indicators

Customer Involvement
Cleanliness and Organization
Supplier Quality Involvement
Reward for Quality
Customer Satisfaction
Top Management Leadership for Quality

Quality of Product Conformance
Product Capability and Performance
Customer Support and Service
Speed of New Product Introduction
JIT Production and Performance Indicators

Equipment layout

Setup time reduction

Just-in-time delivery by suppliers

Kanban

Daily schedule adherence

Repetitive nature of master schedule

Cycle Time

Speed of New Product Introduction

Unit cost of manufacturing
Information Systems and Performance Indicators

External Information: Supplier Quality Control

Benefits of Information Systems

Stability/Predictability of Short Term Production

Accounting

Coordination with Corporation

Quality of Product Conformance

Cycle Time Unit Cost of Manufacturing

Inventory Turnover

Fast Delivery

Customer Support and Service

Speed of New Product Introduction

Benefits of Information Systems:
- External Information: Supplier Quality Control
- Stability/Predictability of Short Term Production
- Accounting
- Coordination with Corporation

Quality Indicators:
- Quality of Product Conformance
- Cycle Time Unit Cost of Manufacturing
- Inventory Turnover
- Fast Delivery
- Customer Support and Service
- Speed of New Product Introduction
Technology Development and Performance Indicators

**Effective Process Implementation**

**Product Design Simplicity**

**Inter-functional Design Efforts**

Inter-functional design efforts make a difference.

**Delivery Performance**

**Cycle Time**

**Speed of New Production Introduction**

**Customer Service and Support**
Manufacturing Strategy and Performance Indicators

- Distinctive Competence
- Manufacturing-Business Strategy Linkage
- Anticipation of new technologies
- Manufacturing Strategy Strength
- Product Competitive Performance Comparison
- Functional Integration

- Cycle Time
- Speed of New Product Introduction
- Fast Delivery
- Delivery Performance
- Inventory Turnover
- Flexibility to change product mix

Anticipation of new technologies
Requirements for and Consequences of the Operations Area

WHAT IS THE RELATIONSHIPS AMONG OPERATIONS AREAS?
### Table 7 Correlations between super-scales

<table>
<thead>
<tr>
<th></th>
<th>JIT</th>
<th>Organization</th>
<th>HR</th>
<th>QM</th>
<th>IS</th>
<th>Technology</th>
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All entries are significantly different from zero at 0.1% level by one-tailed test.
Requirements for Effective Quality Management

• Commitment (Organization)
• Coordination of Decision Making (Organization)
• Task-related Training for Employees (Human Resource Management)
• Small Group Problem Solving (Human resource Management)
• Multi-functional Employees (Human resource Management)
Requirements for Quality Management

1. Feedback
2. Maintenance
3. Process Control
4. Cleanliness and Organization
5. Supplier Quality Involvement
6. Reward for Quality
7. Commitment
8. Coordination of Decision Making
9. Task-related Training for Employees
10. Small Group Problem Solving
11. Multi-functional Employees
Impacts of Quality Management: Upon JIT and IS

• Just-in-time Delivery by Suppliers (JIT)
• Equipment Layout (JIT)
• Daily Schedule Adherence (JIT)
• Setup Time Reduction (JIT)
• MRP Adaptation to JIT (JIT)
• Repetitive Nature of Master Schedule (JIT)
• Benefit of Information Systems (IS)
• Stability/Predictability of Short Term Production (IS)
Impacts of Quality on JIT and IS

- Feedback
- Maintenance
- Process Control
- Supplier Quality Involvement
- Top Management Leadership for Quality

Benefits of Information Systems
- Stability/Predictability of Short Term Production

Just-in-time Delivery by Suppliers
- Equipment Layout
- Daily Schedule Adherence
- Setup Time Reduction
- MRP Adaptation to JIT
- Repetitive Nature of Master Schedule
Impacts of Quality Management: Upon Technology and Strategy

• Effective Process Implementation (Technology)
• Process Design Simplicity (Technology)
• Inter-functional Design Efforts (Technology)
• Distinctive Competence (Manufacturing Strategy)
• Anticipation of New Technologies (Manufacturing Strategy)
Impacts of Quality on Technology and Strategy

- Feedback
- Continuous Improvement
- Rewards for Quality
- Top Management Leadership for Quality
- Process Control
- Supplier Quality Involvement
- Maintenance

Effective Process Implementation
Product Design Efforts
Inter-functional Design Efforts

Anticipation of New Technologies
Distinctive Competence
Requirements for JIT Production

• Organization
  – Coordination of Decision Making; Commitment

• Human Resources
  – Supervisory interaction facilitation; Multi-functional employees;
    Small group problem solving; Recruiting and selection; Task-related
    training for employees; Documentation of shop floor procedure;
    Employee suggestions

• Quality Management
  – Maintenance

• Information System
  – Stability/predictability of short term production

• Manufacturing Strategy
  – Anticipation of new technologies; Communication of manufacturing
    strategy
Interrelation between JIT Production and Other Operations Management Areas

- Daily Schedule Adherence
- Equipment Layout
- Just-in-time Delivery by Suppliers
- MRP Adaptation to JIT
- Repetitive Nature of Master Schedule
- Setup Time Reduction
- Coordination of Decision Making Commitment
  - Supervisory interaction facilitation
    - Multi-functional employees
    - Small group problem solving
    - Recruiting and selection
    - Task-related training for employees
    - Documentation of shop floor procedure
    - Employee suggestions
- Maintenance
  - Stability / Predictability of Short Term Production
- Inter-functional Design Efforts
  - Communication of Manufacturing Strategy
  - Anticipation of New Technologies

TRƯỜNG ĐẠI HỌC KINH TẾ - ĐẠI HỌC QUỐC GIA HÀ NỘI
VNU University of Economics and Business
Impacts of Production Information Systems (1)

- MRP Adaptation to JIT (JIT)
- Daily Schedule Adherence (JIT)
- Equipment Layout (JIT)
- Just-in-time Delivery by Suppliers (JIT)
- Setup Time Reduction (JIT)
- Repetitive Nature of Master Schedule (JIT)
- Effective Process Implementation (Technology)
- Inter-functional Design Efforts (Technology)
IS

Benefits of Information Systems

Stability/Predictability of Short Term Production

Internal Quality Information

MRP Adaptation to JIT Daily Schedule Adherence Equipment Layout Just-in-time Delivery by Suppliers Setup Time Reduction Repetitive Nature of Master Schedule

Effective Process Implementation Inter-functional Design Efforts
Impacts of Production Information Systems upon Manufacturing Strategy

- Anticipation of New Technologies
- Functional Integration
- Manufacturing-Business Strategy Linkage
- Manufacturing Strategy Strength
- Distinctive Competence
- Communication of Manufacturing Strategy
- Formal Strategic Planning
IS

Benefits of Information Systems

Stability/Predictability of Short Term Production

Internal Quality Information

Accounting

Strategy

Anticipation of New Technologies

Functional Integration

Manufacturing-Business Strategy Linkage

Manufacturing Strategy Strength

Distinctive Competence

Communication of Manufacturing Strategy

Formal Strategic Planning
Prerequisites or Complements for Involvement in Technology Development (I)

- Task-related training for employees (HR)
- Small group problem solving (HR)
- Process control (QM)
- Reward for quality (QM)
- Supplier quality involvement (QM)
- Top management leadership for quality (QM)
Technology

- Effective Process Implementation
- Product Design Simplicity
- Inter-functional Design Efforts

- Technology-related Training for Employees
- Small Group Problem Solving
- Process Control
- Reward for Quality
- Supplier Quality Involvement
- Top Management Leadership for Quality

Inter-functional Design Efforts

Reward for Quality
Prerequisites or Complements for Involvement in Technology Development (II)

- Benefits of information systems (IS)
- Stability/predictability of short term production (IS)
- Anticipation of new technologies (MS)
- Distinctive competence (MS)
- Functional integration (MS)
- Manufacturing-business strategy linkage (MS)
- Manufacturing strategy strength (MS)
Requirements for Excellent Manufacturing Strategy

- **Organization**
  - Coordination of Decision Making; Commitment

- **Human Resource Management**
  - Supervisory Interaction Facilitation; Incentives for Group Performance

- **Just-in-time Production**
  - Equipment Layout; Setup Time Reduction; Daily Schedule Adherence; Just-in-time Delivery by Suppliers

- **Quality Management**
  - Top Management Leadership for Quality

- **Information System**
  - Benefits of Information Systems

- **Technology Development**
  - Effective Process Implementation
Requirements for Excellent Manufacturing Strategy

- Formal Strategic Planning
- Communication of Manufacturing Strategy
- Anticipation of New Technologies
- Distinctive Competence
- Functional Integration Manufacturing-Business Strategy Linkage

- Coordination of Decision Making Commitment
- Supervisory Interaction Facilitation Incentives for Group Performance
- Equipment Layout Setup Time Reduction Daily Schedule Adherence Just-in-time Delivery by Suppliers
- Top Management Leadership for Quality
- Benefits of IS Effective Process Implementation
PART II

An International Comparison Study on the Benefits of Production Information Systems
Analytical Framework

IT
- CAD
- CAE
- CAPP
- CNC/DNC
- FMS
- MRP
- LAN
- EDI
e tc.

Operation Systems
- Production planning
- Quality management
- Inventory management
- Cost management
- New product development etc.

Benefits of IS
- Manufacturing cost reduction
- Lead time reduction
- Increased flexibility
- Improved product quality
- Reduced new product introduction time etc.

Competitiveness
- Manufacturing cost
- Conformance quality
- Fast delivery
- Cycle time
- Speed of new product introduction
- Product capability and performance etc.
### Summary Table (I)

<table>
<thead>
<tr>
<th></th>
<th>Reduction in manufacturing cost</th>
<th>Decrease in inventories</th>
<th>Overall lead-time reduction</th>
<th>Improvement in on-time deliveries</th>
<th>Increased product-mix flexibility</th>
<th>Increased product-volume flexibility</th>
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</thead>
<tbody>
<tr>
<td>CAD</td>
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<td>S</td>
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<td>F</td>
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<td></td>
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<tr>
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<td>FJ</td>
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<td>Electronic linkage</td>
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<td>J</td>
<td></td>
<td></td>
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</tr>
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<td>Suppliers linked by EDI</td>
<td>J</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

The capital letters represent the initial of the sample nation where the coefficient is judged significantly different from zero at the 5% level by one-tailed t-test. F=5 countries pooled  G=Germany  I=Italy  J=Japan  K=United Kingdom  S=United States
The capital letters represent the initial of the sample nation where the coefficient is judged significantly different from zero at the 5% level by one-tailed t-test. F=5 countries pooled; G=Germany; I=Italy; J=Japan; K=United Kingdom; S=United States.
Conclusion (I)

1. There are considerable differences in the benefits of IS/IT utilization among countries.
   - Explanation power and significance are low for the US and German samples.

2. There are several ITs which do not necessarily show the hypothesized effects.
   - CAE -> reduced new product introduction time, improved product quality?
   - FMS, automated R/S -> overall lead time reduction, improvement in on-time deliveries?
   - JIT -> decrease in inventories?
Conclusion (II)

3. There are many unexpected or secondary effects of IS/IT utilization.

- LAN and EDI have various effects.
- Orders sent via EDI -> reduction in manufacturing cost, improved product quality
- Simulation tools -> improved customer service
- FMS, automated R/S, MRP, quality database -> increased product-volume flexibility
## Correlation analysis on the benefits of IS (I)

<table>
<thead>
<tr>
<th>Benefits of IS</th>
<th>Cost reduction</th>
<th>Inventory reduction</th>
<th>Overall lead-time reduction</th>
<th>Improved on-time deliveries</th>
<th>Flexibility to product mix change</th>
<th>Flexibility to volume change</th>
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</thead>
<tbody>
<tr>
<td>(Competitive performance)</td>
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</tr>
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<td>Manufacturing cost</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance quality</td>
<td>J</td>
<td>I</td>
<td>K</td>
<td>J</td>
<td>J</td>
<td>J</td>
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The capital letters represent the initial of the nation where significant correlations are detected at the 5% level by two-tailed test. G=Germany  I=Italy  J=Japan  K=United Kingdom  S=United States
# Correlation analysis on the benefits of IS (I)

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<td>G J K</td>
</tr>
</tbody>
</table>

The capital letters represent the initial of the nation where significant correlations are detected at the 5% level by two-tailed test. G=Germany  I=Italy  J=Japan  K=United Kingdom  S=United States
Conclusion (III)

4. There are considerable differences in the relationships between the benefits of production information systems and the competitive performance indicators among countries.
Conclusion (IV)

5. The benefits of production information systems do not necessarily connect with the improvement in competitive performance indicators.

- Cost reduction by utilizing production information systems does not contribute to the competitiveness in terms of manufacturing cost.
- Improved on-time deliveries by production information systems lead to the competitiveness in delivery performance for the Japanese sample only.
The Airport Book (?)

• Roger G. Schroeder, and Barbara B. Flynn (eds.)

• High Performance Manufacturing: Global Perspectives

• New York, NY: John Wiley & Sons, 2001
PART III

The third round data collection and analysis
Outline of the 3rd Round Survey

- **Years:** Started in 2002 in North Europe.

- **Regions:** Covers most industrial areas on the globe; Asia (Japan, and South Korea), North America (US, and Canada), and Europe (UK, Germany, Austria, Italy, Spain, Finland, Sweden, Norway, Denmark, and Switzerland)

- **Industries:** machinery, electrical & electronics, and automobile

- **Respondents:** 19 for each plant
  plant manager, plant superintendent, plant accounting manager, human resources manager, inventory manager, information systems manager, production control manager, process engineer, quality manager, member of product development team, supervisors, and direct labor
Question Items for the 3rd Round

- Question items are quantitative and qualitative

- **Environment**: Complexity of the Environment, Market Information, Plant Description, Plant Focus, and Unions

- **Supply Chain**: Coordination of plant activities, stability of demand, Supplier Lead Time, Supply Chain Planning, Trust-Based Relationship with Suppliers, Supply Chain Characteristics, Other supply Chain Scales and Items

- **Human resources**: Centralization of Authority, Commitment, cooperation, Coordination of Decision Making, Employee Suggestions – Implementation and Feedback, Fact-Based Management, Flatness of Organization Structure, Human Goodness, Management Breadth of Experience, Multi-Functional Employees, Recruiting and Selection, Rewards/Manufacturing Coordination, Shop Floor Contact, Small Group Problem Solving, Supervisory Interaction Facilitation, Task-Related Training for Employees, Compensation, Rewards and Incentives, Employee Absenteeism, Stable Employment, Suggestions, Training, Turnover
Question Items for the 3rd Round

- **Improvement**: Improvement Initiatives

- **Information Systems/Information Technology**: Application Areas, E-Business, E-Procurement, E-Sales, Expenses, Level of Customization, Product Configurator, Structure of Information

Question Items for the 3rd Round


• **Performance**: Accounting Data, Competitive Performance, Cost of Quality
Question Items for the 3rd Round


- **Total Productive Maintenance**: Autonomous Maintenance, Preventive Maintenance, Maintenance Support, Team-Based Maintenance, *Maintenance*
Question Items for the 3\textsuperscript{rd} Round


Number of Manufacturing Plants by Country

- **North Europe**: Finland collected data from 30 manufacturing plants, and Sweden collected data from 24 in 2003.
- **Japan**: Data from 35 plants was collected in 2003 and 2004.
- **USA**: Data collection from 29 plants was completed in early 2006.
- **Germany and Austria**: Germany and Austria completed data collection from 41 and 21 plants, respectively in early 2006.
- **Korea**: Data collection from around 31 plants was completed in early 2006.
- **Italy**: Data collection from 27 plants was completed in early 2007.
- **UK and Spain**: Data collection from 28 plants in Spain was completed in late 2008, but not in UK.
Who Participate in HPM Project?

- Roger Schroeder, University of Minnesota
- Barbara Flynn, Wake Forest University
- E. James Flynn, Wake Forest University
- Kimberly Bates, Trent University, Canada
- Debasish Mallick, University of Minnesota
- Kate McKone, Bobson College
- Rachna Shah, University of Minnesota
- Sohel Ahmad, Saint Cloud University
Who Participate in HPM Project?

• Chris Voss, London Business School, UK
• Kate Blackmon, Oxford University, UK
• Andrew & Margaret Taylor, Bradford University, UK
• Peter Milling, Mannheim University, Germany
• Frank Maier, International University, Germany
• Jörn-Henrik Thun, Mannheim University
• Roberto Filippini, Universita’ di Padova, Italy
• Cipriano Forza, Universita’ di Padova
• Andrea Vinelli, Universita’ di Padova
• Alberto Detoni, Universita’ di Udina, Italy
• Fabrizio Salvador, Instituto de Empresa, Spain
Who Participate in HPM Project?

- Michiya Morita, Gakushuin University, Japan
- Yoshiki Matsui, Yokohama National University
- Osam Sato, Tokyo Keizai University, Japan
- Hideaki Kitanaka, Takushoku University, Japan
- Atsuko Ebine, University of Tsukuba, Japan
- Tomoaki Shimada, Kobe University, Japan
- Yutaka Ueda, Seikei University, Japan
- Sadao Sakakibara, Kanagawa University, Japan
- Daesik Hur, Yonsei University, South Korea
- Tom Choi, Arizona State University, U.S.A.
- Jeong Wook Choi, Kookmin University, South Korea
Who Participate in HPM Project?

- Mikko Ketokivi, Helsinki University of Technology, Finland
- Virpi Turkulainen, Helsinki University of Technology
- Jussi Heikkila, Helsinki University of Technology
- Jan Olhager, Linkoping Institute of Technology
- Gerald Reiner, Vienna University, Austria
- Jose Machuca, Universidad de Sevilla, Spain
- Xiande Zhao, Chinese University of Hong Kong, China
- Baofeng Huo, Xi’an Jiaotong University, China
- and PhD students who are interested in the project.

We have joint meetings at DSI in November, POMS in May, EurOMA in June, or other occasions.
Analytical Framework of HPM at the 3\textsuperscript{rd} Round Data Collection

- Organization
  - Human Resource Management

- Quality Management
  - TPM
  - TOC
  - JIT Production

- Supply Chain Management

- Competitive Performance

- New Product Development
- Technology Development
- Manufacturing Strategy
PART IV

JIT Production in Japanese Companies
Objective

• To empirically discuss

1. what requirements should be satisfied for the development of JIT production systems

2. whether JIT production leads to improved practices in other operations management areas and high competitive performance based on the relevant measurement scales on just-in-time production and the data collected from manufacturing companies through questionnaires in 2003/2004 and mid 1990s.
Menu of Analysis

1. Measurement Scales for JIT production
2. Relationship between JIT production and Competitive Performance
3. Requirements for JIT production and the impacts of JIT production (interrelation between JIT production and other operations management areas)
Measurement Scales

1. Daily schedule adherence
2. Equipment layout
3. Just-in-time delivery by suppliers
4. Just-in-time link with customers
5. Kanban
6. Repetitive nature of master schedule
7. Setup time reduction
8. Small lot size
9. Synchronization of operations (new)
Daily schedule adherence (DSA)

assesses whether there is time for meeting each day’s schedule including catching up after stoppages for quality considerations or machine breakdown.
Equipment layout (EL)

• measures
  – use of manufacturing cells,
  – elimination of forklifts and long conveyers, and
  – use of smaller equipment designed for flexible floor layout,

• which are all associated with just-in-time manufacturing.
Just-in-time delivery by suppliers (JDS)

whether vendors have been integrated into production in terms of using kanban containers, making frequent or just-in-time delivery and quality certification.
Just-in-time link with customers (JLC)

assesses whether the plant has applied the just-in-time delivery concept and the pull system concept in the operational link with customers.
Kanban (KAN)

whether or not the plant has implemented the physical elements of a kanban/pull system.
Repetitive nature of master schedule (RMS) assesses use of small lot sizes, mixed model assembly, and level daily production schedule in the plant.
Setup time reduction (STR)

evaluates whether the plant is taking measures to reduce setup times and lower lot sizes in order to facilitate just-in-time production.
Small lot size (SLS)

whether or not the plant has moved towards producing in small batches as opposed to producing in large lots.
Synchronization of operations (SOP)

whether manufacturing capacities and workloads are well balanced within the plant and throughout the supply chain in order to keep total inventory minimal.
Results of Measurement Analysis

• Nine measurement scales are satisfactory in terms of reliability and validity.

• The super-scale, JIT, is also reliable and valid, which suggests the close relationships among nine measurement scales. The factor loading for SLS is marginal.
Competitive Performance Indicators

- These indicators show plant management’s opinion on plant performance vis-à-vis global competition in quality, delivery, flexibility, and inventory turns.
- This is based on the subjective judgment by one plant manager.
- Objective performance measures have some difficulties at least for Japan.
Competitive Performance Indicators

1. Unit cost of manufacturing
2. Quality of product conformance
3. Delivery performance
4. Fast delivery
5. Flexibility to change product mix
6. Flexibility to change volume
7. Inventory turnover
8. Cycle time
9. Speed of new product introduction
10. Product capability and performance
11. On time new product launch
12. Product innovativeness
13. Customer support and service
Super-Scales and Competitive Performance Indicators

Canonical correlation  0.9732
Likelihood ratio  0.00004  Significance  0.0715
Redundancy index: Super-scales  0.3816  Performance  0.1852

Correlations between super-scales and canonical variable of performance indicators

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Correlations between Performance indicators and canonical variable of super-scales

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Strength of Relationship with Competitive Performance

1. Supply Chain Management (new)
2. Just-in-time Production (6)
3. Total Preventive Maintenance (in QM)
4. Quality Management (4)
5. Manufacturing Strategy (1)
6. Technology Development (2)
7. Theory of Constraints (new)
8. Human Resource Management (5)
9. New Product Development (new)
JIT Production and Competitive Performance Indicators

First canonical correlation 0.9741 0.9212
Likelihood ratio 0.0001 0.0015 Significance 0.0157 0.2128
Redundancy index: JIT production 0.2915 0.2370 Performance 0.0268 0.1751

Correlations between JIT scales and canonical variable of performance indicators

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Correlations between performance indicators and canonical variable of JIT scales

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Strength of Relationship with Competitive Performance

- Equipment layout
- Setup time reduction
- Just-in-time delivery by suppliers
- Daily schedule adherence
- Synchronization of Operations

*Kanban* may facilitate fast delivery and inventory turnover.
JIT Production and Performance Indicators

- Equipment layout
- Setup time reduction
- Just-in-time delivery by suppliers
- Daily schedule adherence
- Synchronization of operations
- Kanban

- Unit cost of manufacturing
- Flexibility to change volume
- Speed of new product introduction
- On time new product launch
- Fast Delivery
- Inventory turnover
### Table 6  Correlations between super-scales

<table>
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All entries are significantly different from zero at 0.1% level by one-tailed test except the pairs between NPD and others.
JIT Production and Super-Scales

Canonical correlation 0.9329
Likelihood ratio 0.0113  Significance 0.0154
Redundancy index: JIT production 0.4355  Super-scales 0.4956

Correlations between JIT production scales and canonical variable of super-scales

- **Daily schedule adherence** 0.8423
- **Equipment layout** 0.7911
- **Just-in-time delivery by suppliers** 0.7033
- **Just-in-time link with customers** 0.7564
- **Kanban** 0.4097
- **Repetitive nature of master schedule** 0.7712
- **Setup time reduction** 0.7989
- **Small lot size** 0.2452
- **Synchronization of operations** 0.8164

Correlations between super-scales and canonical variable of JIT production scales

- **HR** 0.8446
- **TOC** 0.7068
- **QM** 0.7109
- **TPM** 0.8409
- **SCM** 0.8467
- **NPD** 0.2774
- **TECH** 0.7460
- **MS** 0.6837
JIT Production and Human Resource

Canonical correlation 0.9433
Likelihood ratio 0.0003 Significance 0.0369
Redundancy index: JIT production 0.3371 HR 0.3183

Correlations between JIT production scales and canonical variable of HR scales

**Daily schedule adherence** 0.6979
**Equipment layout** 0.6791
Just-in-time delivery by suppliers 0.5625
**Just-in-time link with customers** 0.7623
Kanban 0.3356
**Repetitive nature of master schedule** 0.7394
**Setup time reduction** 0.6810
Small lot size 0.3197
**Synchronization of operations** 0.6615

Correlations between HR scales and canonical variable of JIT production scales
Cooperation 0.5340 **Coordination of decision making** 0.8446
Employee suggestions 0.5940 Commitment 0.5756
Flatness of organization structure 0.1418 Human goodness 0.2347
Management breadth of experience 0.2830
Multi-functional employees 0.5978 **Recruiting and selection** 0.6630
**Supervisory interaction facilitation** 0.6939
**Small group problem solving** 0.7561 **Shop floor contact** 0.7205
Task-related training for employees 0.6050
Centralization of authority -0.1176
Rewards/manufacturing coordination 0.6239
JIT Production and TOC

Canonical correlation 0.8417
Likelihood ratio 0.1942 Significance 0.0004
Redundancy index: JIT production 0.3316 TOC 0.6414

Correlations between JIT production scales and canonical variable of TOC scales
Daily schedule adherence 0.6096
Equipment layout 0.7659
Just-in-time delivery by suppliers 0.6231
Just-in-time link with customers 0.6000
Kanban 0.3724
Repetitive nature of master schedule 0.6245
Setup time reduction 0.7695
Small lot size 0.0960
Synchronization of operations 0.7766

Correlations between TOC scales and canonical variable of JIT production scales
TOC philosophy 0.8417
Implementation of TOC 0.7567
JIT Production and Quality

Canonical correlation 0.9048
Likelihood ratio 0.0006  Significance 0.0061
Redundancy index: JIT production 0.3360  Quality scales 0.3437

Correlations between JIT production scales and canonical variable of quality scales

Daily schedule adherence 0.7494
Equipment layout 0.7654
Just-in-time delivery by suppliers 0.5690
Just-in-time link with customers 0.4860
Kanban 0.4094
Repetitive nature of master schedule 0.6288
Setup time reduction 0.7863
Small lot size 0.3826
Synchronization of operations 0.5927

Correlations between quality scales and canonical variable of JIT production scales

Cleanliness and organization 0.6324  Customer focus 0.1859
Customer involvement 0.4537  Customer satisfaction 0.6622
Organization-wide approach 0.5373  Prevention 0.3869
Process emphasis -0.1113  Feedback 0.6820
Process control 0.7513  Supplier quality involvement 0.5852
Top management leadership for quality 0.6087
TQM link with customers 0.4192  Supplier partnership 0.4917
JIT Production and TPM

Canonical correlation 0.9015
Likelihood ratio 0.0793 Significance 0.0012
Redundancy index: JIT production 0.4740 TPM scales 0.5668

Correlations between JIT production scales and canonical variable of TPM scales

- Daily schedule adherence 0.7560
- Equipment layout 0.7224
- Just-in-time delivery by suppliers 0.7242
- Just-in-time link with customers 0.7537
- Kanban 0.6299
- Repetitive nature of master schedule 0.7905
- Setup time reduction 0.7820
- Small lot size 0.1317
- Synchronization of operations 0.7648

Correlations between TPM scales and canonical variable of JIT production scales

- Autonomous Maintenance 0.2634
- Maintenance Support 0.7416
- Team Based Maintenance 0.8692
- Preventive Maintenance 0.7789
JIT Production and SCM

Canonical correlation 0.9240
Likelihood ratio 0.0498 Significance 0.0001
Redundancy index: JIT production 0.4565 SCM scales 0.4629

Correlations between JIT production scales and canonical variable of SCM scales

Daily schedule adherence 0.7902
Equipment layout 0.8230
Just-in-time delivery by suppliers 0.7576
Just-in-time link with customers 0.7724
Kanban 0.4603
Repetitive nature of master schedule 0.7250
Setup time reduction 0.8116
Small lot size 0.2287
Synchronization of operations 0.8589

Correlations between SCM scales and canonical variable of JIT production scales

Coordination of plant activities 0.7571
Stability of demand 0.4991
Supply chain planning 0.8164
JIT Production and NPD

Canonical correlation 0.8765
Likelihood ratio 0.0357 Significance 0.2565
Redundancy index: JIT production 0.1903 NPD scales 0.1046

Correlations between JIT production scales and canonical variable of NPD scales
Daily schedule adherence 0.5721
Equipment layout 0.2854
Just-in-time delivery by suppliers 0.5225
Just-in-time link with customers 0.3104
Kanban 0.4228
Repetitive nature of master schedule 0.4043
Setup time reduction 0.2788
Small lot size 0.5622
Synchronization of operations 0.4318

Correlations between NPD scales and canonical variable of JIT production scales
Customer Involvement -0.0580
Project Complexity -0.1007
Manufacturing Involvement in New Product Development 0.4469
Project Priority 0.1199
Team Rewards -0.3631
Team Spirit -0.0143
Supplier Involvement 0.4913
JIT Production and Technology

Canonical correlation 0.8818
Likelihood ratio 0.0761  Significance 0.0174
Redundancy index: JIT production 0.3865  TECH scales 0.3430

Correlations between JIT production scales and canonical variable of TECH scales

Daily schedule adherence 0.7896
Equipment layout 0.7847
Just-in-time delivery by suppliers 0.6440
Just-in-time link with customers 0.6038
Kanban 0.3860
Repetitive nature of master schedule 0.6986
Setup time reduction 0.8393
Small lot size 0.2784
Synchronization of operations 0.7669

Correlations between TECH scales and canonical variable of JIT production scales

Effective process implementation 0.8424
Inter-functional design efforts 0.7998
Mass customization 0.4868
Modularization of products 0.3769
New product introduction cooperation 0.3838
JIT Production and Mfg Strategy

Canonical correlation 0.9146
Likelihood ratio 0.0085  Significance 0.2430
Redundancy index: JIT production 0.2625  MS scales 0.2586

Correlations between JIT production scales and canonical variable of MS scales

**Daily schedule adherence** 0.7936
**Equipment layout** 0.6972
Just-in-time delivery by suppliers 0.4820
Just-in-time link with customers 0.5675
Kanban 0.2082
Repetitive nature of master schedule 0.4508
**Setup time reduction** 0.7581
Small lot size 0.0862
**Synchronization of operations** 0.7049

Correlations between MS scales and canonical variable of JIT production scales

Communication of manufacturing strategy 0.5985
Formal strategic planning 0.4398  Integration between functions 0.5812
Leadership for functional integration 0.5883
Manufacturing as a competitive resource 0.0156
**Unique practices** 0.7007  Proprietary equipment 0.4896
Achievement of functional integration 0.4913
Anticipation of new technologies 0.5936
Competitive intensity of industry 0.1629
Manufacturing-business strategy linkage 0.3814
Summary: Requirements for Excellent JIT

- **HR**
  - Coordination of decision making; Small group problem solving; Shop floor contact; Supervisory interaction facilitation; Recruiting and selection

- **TOC**
  - TOC philosophy; Implementation of TOC

- **Quality Management**
  - Process control; Feedback; (Customer satisfaction)

- **TPM**
  - Team Based Maintenance; Maintenance Support; Preventive Maintenance

- **SCM**
  - Supply chain planning; Coordination of plant activities

- **Technology development**
  - Effective process implementation; Inter-functional design efforts

- **Manufacturing Strategy (relation to JIT has been weakened?)**
  - (Unique practices)
# Interrelation between JIT Production and Other Operations Management Areas

<table>
<thead>
<tr>
<th>Daily Schedule Adherence</th>
<th>Coordination of Decision Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Layout</td>
<td>Small Group Problem Solving</td>
</tr>
<tr>
<td>Just-in-time Delivery by Suppliers</td>
<td>Shop Floor Contact</td>
</tr>
<tr>
<td>Just-in-time link with Customers</td>
<td>Supervisory Interaction Facilitation</td>
</tr>
<tr>
<td>Repetitive Nature of Master Schedule</td>
<td>Recruiting and Selection</td>
</tr>
<tr>
<td>Setup Time Reduction</td>
<td>TOC Philosophy</td>
</tr>
<tr>
<td>Synchronization of Operations</td>
<td>Implementation of TOC</td>
</tr>
<tr>
<td></td>
<td>Process Control</td>
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<td></td>
<td>Feedback</td>
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<td></td>
<td>Team Based Maintenance</td>
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<td></td>
<td>Maintenance Support</td>
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<td></td>
<td>Preventive Maintenance</td>
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<tr>
<td></td>
<td>Supply Chain Planning</td>
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<tr>
<td></td>
<td>Coordination of Plant Activities</td>
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<tr>
<td></td>
<td>Effective Process Implementation</td>
</tr>
<tr>
<td></td>
<td>Inter-Functional Design Efforts</td>
</tr>
</tbody>
</table>
PART V

International Comparison of Manufacturing Practices and Performance
Objective

• To empirically and comparatively discuss what are requirements for high performance manufacturing

• Based on the relevant measurement scales on HRM, TQM, TPM, JIT, SCM, NPD, technology development and manufacturing strategy, and performance indicators.

• Use survey data collected from manufacturing companies since 2002.
Menu of Analysis

1. Measurement Scales

2. Requirements for high performance manufacturing
Measurement Scales

1. Human Resource Management (HRM)
2. Quality Management (QM)
3. Total Productive Maintenance (TPM)
4. Just-in-Time Production (JIT)
5. Supply Chain Management (SCM)
6. New Product Development (NPD)
7. Technology Development (TD)
8. Manufacturing Strategy (MS)
Measurement Scales and Super Scales

1. Human Resource Management (HRM)
2. Quality Management (QM)
3. Total Productive Maintenance (TPM)
4. Just-in-Time Production (JIT)
5. Supply Chain Management (SCM)
6. New Product Development (NPD)
7. Technology Development (TD)
8. Manufacturing Strategy (MS)
Example of Measurement Scales: Supply Chain Management

1. Coordination of Plant Activities (CPA)
2. Stability of Demand (SOD)
3. Supply Chain Planning (SCP)
4. Supplier Lead Time (SLT)
5. Trust-Based Relationship with Suppliers (TBR)
Coordination of Plant Activities (CPA)

• measures the restriction of managerial decision making space due to corporate policies or action. It focuses on coordination between corporate and plant activities
Coordination of Plant Activities (CPA)

- Alpha = 0.723

- Purchasing of common materials is coordinated at the corporate level. (0.566)

- Our corporation implements ordering and stock management policies, on a global scale, in order to coordinate distribution. (0.704)

- Our corporation performs aggregate planning for plants, according to our global distribution needs. (0.673)

- Managerial innovations are transferred among plants within our corporation. (0.728)

- Our corporation transfers technological innovations and know-how between plants. (0.674)

- The choice of information systems standards and technologies for plants is coordinated at the corporate level. (0.555)
Stability of Demand (SOD)

• assesses whether manufacturing demands have been stabilized in cooperation with sales department in demand forecasting
Stability of Demand (SOD)

- Alpha=0.581
- Sales and manufacturing personnel communicate well with each other in this organization. (0.422)
- Manufacturing demands are stable in our firm. (0.861)
- Our inventory fluctuates more than planned. (deleted)
- Our total demand, across all products, is relatively stable. (0.868)
- We need better accuracy in our demand forecasts. (deleted)
Supply Chain Planning (SCP)

• evaluates whether the company has occupied a dominant position in planning and controlling the supply chain to customers
Supply Chain Planning (SCP)

- Alpha=0.764
- We actively plan supply chain activities. (0.740)
- We consider our customers’ forecasts in our supply chain planning. (0.632)
- We strive to manage each of our supply chains as a whole. (0.719)
- We monitor the performance of members of our supply chains, in order to adjust supply chain plans. (0.728)
- We gather indicators of supply chain performance. (0.764)
- We share our production plans with our suppliers. (deleted)
- Our customers do not have access to our production plans. (deleted)
Supplier Lead Time

• measures whether the company is taking measures to reduce supplier lead time and avoid excess inventory and stock-out risk
Supplier Lead Time

- Alpha=0.491
- We seek short lead times in the design of our supply chains. (0.776)
- We purchase in small lot sizes, to reduce supplier lead time. (0.529)
- When outsourcing, we consider supplier lead time as a greater priority than cost. (deleted)
- Our company strives to shorten supplier lead time, in order to avoid inventory and stock-outs. (0.819)
Trust-Based Relationship with Suppliers

• measures the level of belief in beneficial collaboration with suppliers
Trust-Based Relationship with Suppliers

• Alpha=0.710

• We are comfortable sharing problems with our suppliers. (0.737)

• In dealing with our suppliers, we are willing to change assumptions, in order to find more effective solutions. (0.669)

• We believe that cooperating with our suppliers is beneficial. (0.764)

• We emphasize openness of communications in collaborating with our suppliers. (0.776)
Results of Measurement Analysis for SCM

- Three measurement scales are satisfactory in terms of reliability and validity. Supplier Lead Time and Stability of Demand cannot pass the reliability test.
- The super-scale, SCM, is also reliable and valid, which suggests the close relationships among three measurement scales.
Super Scale for Supply Chain Management

1. Coordination of Plant Activities (CPA)
2. Stability of Demand (SOD)
3. Supply Chain Planning (SCP)
4. Supplier Lead Time (SLT)
5. Trust-Based Relationship with Suppliers (TBR)

- The average value of reliable and valid measurement scales, that is CPA, SCP and TBR.
Measurement Scales for HRM

1. Centralization of Authority (not used for HRM super-scale)
2. Commitment
3. Cooperation
4. Coordination of Decision Making
5. Employee Suggestions - Implementation and Feedback
6. Fact-Based Management
7. Flatness of Organization Structure
8. Human Goodness
9. Management Breadth of Experience
10. Multi-Functional Employees
11. Recruiting and Selection
12. Rewards/Manufacturing Coordination
13. Shop Floor Contact
14. Small Group Problem Solving
15. Supervisory Interaction Facilitation
16. Task-Related Training for Employees
Measurement Scales for TQM

1. Cleanliness and Organization
2. Continuous Improvement and Learning
3. Customer Focus
4. Customer Involvement
5. Customer Satisfaction
6. Feedback
7. Organization-Wide Approach
8. Prevention
9. Process Control
10. Process Emphasis
11. Supplier Partnership
12. Supplier Quality Improvement
13. Top Management Leadership for Quality
14. TQM Link with Customers
Measurement Scales for TPM

1. Autonomous Maintenance
2. Preventive Maintenance
3. Maintenance Support
4. Team-Based Maintenance
Measurement Scales for JIT

1. Daily Schedule Adherence
2. Equipment Layout
3. Just-in-Time Delivery by Suppliers
4. Just-in-Time Link with Customers
5. Kanban
6. Repetitive Nature of Master Schedule
7. Setup Time Reduction
8. Small Lot Sizes
9. Synchronization of Operations
10. Theory of Constraints
Measurement Scales for NPD

1. Customer Involvement
2. Organizational Consensus for New Product Concept
3. Manufacturing Involvement in New Product Development
4. Product Design Simplicity (alpha=0.517)
5. Project Complexity
6. Project Priority
7. Team Rewards
8. Team Spirit
9. Supplier Involvement
Measurement Scales for Technology Development

1. Effective Process Implementation
2. Environmental Turbulence (alpha=0.402)
3. Interfunctional Design Efforts
4. Mass Customization
5. Modularization of Products
6. New Product Introduction Cooperation
7. Sourcing Approaches for Mass Customization (alpha=0.458)
Measurement Scales for Manufacturing Strategy

1. Achievement of Functional Integration
2. Anticipation of New Technologies
3. Communication of Manufacturing Strategy (alpha=0.423)
4. Competitive Intensity of Industry (alpha=0.510)
5. Formal Strategic Planning
6. Integration Between Functions
7. Leadership for Functional Integration
8. Long-Range Orientation (alpha=0.419)
9. Long-Range Values (alpha=0.547)
10. Manufacturing as a Competitive Resource
11. Manufacturing-Business Strategy Linkage
12. Organizational Coordination of Functional Integration (alpha=0.545)
13. Proprietary Equipment
14. Unique Practices
Competitive Performance Indicators

• These indicators show plant management’s opinion on plant performance vis-à-vis global competition in quality, delivery, flexibility, and inventory turns.
• This is based on the subjective judgment by one plant manager.
• Objective performance measures have some difficulties.
Competitive Performance Indicators

1. Unit cost of manufacturing
2. Quality of product conformance
3. Delivery performance
4. Fast delivery
5. Flexibility to change product mix
6. Flexibility to change volume
7. Inventory turnover
8. Cycle time
9. Speed of new product introduction
10. Product capability and performance
11. On time new product launch
12. Product innovativeness
13. Customer support and service
### Super-Scales and Competitive Performance Indicators

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<thead>
<tr>
<th>Canonical correlation</th>
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<tr>
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<tr>
<td>Redundancy index</td>
<td>Super-scales 0.1524, Performance 0.1079</td>
</tr>
</tbody>
</table>

**Correlations between super-scales and canonical variable of performance indicators**

<table>
<thead>
<tr>
<th>Super-Scales</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRM</td>
<td>0.4657</td>
</tr>
<tr>
<td>TQM</td>
<td>0.3192</td>
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<tr>
<td>TPM</td>
<td>0.4233</td>
</tr>
<tr>
<td>JIT</td>
<td>0.4178</td>
</tr>
<tr>
<td>SCM</td>
<td>0.3929</td>
</tr>
<tr>
<td>NPD</td>
<td>0.1879</td>
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<tr>
<td>TECHNOLOGY</td>
<td>0.3924</td>
</tr>
<tr>
<td>STRATEGY</td>
<td>0.5526</td>
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**Correlations between Performance indicators and canonical variable of super-scales**

<table>
<thead>
<tr>
<th>Performance Indicator</th>
<th>Correlation</th>
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<tbody>
<tr>
<td>Unit cost of manufacturing</td>
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<tr>
<td>Quality of product conformance</td>
<td>0.3164</td>
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<tr>
<td><strong>Delivery performance</strong></td>
<td>0.4179</td>
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<tr>
<td>Fast delivery</td>
<td>0.2769</td>
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<tr>
<td>Flexibility to change product mix</td>
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<tr>
<td><strong>Flexibility to change volume</strong></td>
<td>0.4657</td>
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<tr>
<td>Inventory turnover</td>
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<tr>
<td>Cycle time</td>
<td>0.3497</td>
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<tr>
<td>Speed of new product introduction</td>
<td>0.2838</td>
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<tr>
<td>Product capability and performance</td>
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<tr>
<td>On time new product launch</td>
<td>0.3654</td>
</tr>
<tr>
<td>Product innovativeness</td>
<td>0.2754</td>
</tr>
<tr>
<td>Customer support and service</td>
<td>0.2239</td>
</tr>
</tbody>
</table>
Strength of Relationship with Competitive Performance

1. Manufacturing Strategy
2. Human Resource Management
3. Total Productive Maintenance
4. Just-in-time Production
5. Supply Chain Management
6. Technology Development
7. Total Quality Management
8. New Product Development

• Globally, but …
## Super-Scales and Competitive Performance Indicators

<table>
<thead>
<tr>
<th>Country</th>
<th>FIN</th>
<th>GER</th>
<th>ITL</th>
<th>JPN</th>
<th>AUTGER</th>
<th>EAST</th>
<th>WEST</th>
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<tr>
<td>canonical correlation</td>
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<td>0.99</td>
<td>0.98</td>
<td>0.74</td>
<td>0.86</td>
<td>0.66</td>
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<tr>
<td>Likelihood ratio</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.06</td>
<td>0.01</td>
<td>0.27</td>
</tr>
<tr>
<td>Significance</td>
<td>0.22</td>
<td>0.36</td>
<td>0.06</td>
<td>0.02</td>
<td>0.10</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Redundancy index: SCM</td>
<td>0.12</td>
<td>0.07</td>
<td>0.14</td>
<td>0.41</td>
<td>0.13</td>
<td>0.28</td>
<td>0.12</td>
</tr>
<tr>
<td>Redundancy index: Performance</td>
<td>0.10</td>
<td>0.06</td>
<td>0.08</td>
<td>0.16</td>
<td>0.06</td>
<td>0.20</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Correlations between SCM scales and canonical variable of performance indicators

| HRM          | 0.15 | 0.36 | -0.02 | 0.56 | 0.34 | 0.64 | 0.43 |
| TQM          | 0.17 | 0.37 | 0.07  | 0.87 | 0.37 | 0.55 | 0.23 |
| TPM          | -    | 0.18 | 0.16  | 0.38 | 0.72 | 0.27 | 0.54 |
| JIT          | 0.36 | 0.28 | 0.56  | 0.75 | 0.60 | 0.56 | 0.40 |
| SCM          | 0.35 | 0.15 | -0.20 | 0.68 | 0.40 | 0.45 | 0.38 |
| NPD          | 0.34 | 0.11 | 0.57  | 0.43 | 0.23 | 0.33 | 0.19 |
| TECHNOLOGY   | 0.54 | 0.16 | 0.16  | 0.65 | 0.28 | 0.72 | 0.24 |
| STRATEGY     | -    | 0.20 | 0.46  | 0.16 | 0.57 | 0.43 | 0.62 |

Correlations between performance indicators and canonical variable of SCM scales

| Unit cost of manufacturing | 0.20 | 0.40 | 0.10  | 0.09 | 0.42 | 0.46 | 0.31 |
| Quality of product conformance | 0.18 | 0.08 | 0.52  | 0.05 | 0.26 | 0.36 | 0.34 |
| Delivery performance       | -    | 0.22 | 0.44  | 0.24 | 0.39 | 0.41 | 0.21 |
| Fast delivery              | -    | 0.24 | 0.28  | -0.11| -0.06| 0.31 | 0.16 |
| Flexibility to change product mix | 0.37 | 0.19 | 0.31  | 0.10 | 0.19 | 0.44 | 0.26 |
| Flexibility to change volume | -   | 0.20 | 0.38  | -0.07| 0.22 | 0.32 | 0.71 |
| Inventory turnover         | 0.66 | 0.04 | 0.18  | 0.13 | 0.19 | 0.42 | 0.23 |
| Cycle time                 | 0.38 | -0.11| 0.46  | -0.10| 0.12 | 0.39 | 0.36 |
| Speed of new product intro | 0.36 | 0.11 | 0.30  | 0.09 | -0.08| 0.60 | 0.09 |
| Product capability and performance | 0.21 | 0.02 | 0.40  | -0.25| -0.10| 0.27 | 0.28 |
| On time new product launch | 0.32 | 0.10 | 0.23  | 0.21 | 0.08 | 0.60 | 0.20 |
| Product innovativeness     | 0.13 | -0.05| 0.33  | -0.12| -0.06| 0.30 | 0.19 |
| Customer support and service | -   | 0.14 | 0.18  | -0.06| -0.40| 0.08 | 0.39 |
Summary: Requirements for High Performance Manufacturing

- **Finland**
  - Technology -> Inventory turnover

- **Germany**
  - Strategy -> Unit cost of manufacturing, Delivery performance

- **Germany+Austria**
  - JIT -> Unit cost of manufacturing, Delivery performance

- **Italy**
  - JIT, NPD -> Quality, Cycle time, Product capability and performance

- **Japan**
  - Integration -> Delivery performance?

- **East (Japan+Korea)**
  - Integrative manufacturing

- **West (Austria+Finland+Germany+Italy+USA)**
  - Strategy-driven manufacturing -> Delivery, Flexibility
PART V

What are we doing?
The 4th Round Data Collection

• We have started to discuss about 4th round data collection since DSI 2005 in San Francisco and almost finalized the questionnaire at DSI 2010 in San Diego.
• We agreed to conduct the survey during 2011-12.
• Manufacturing plants in China including Taiwan, Singapore and Brazil would be involved in the 4th round.
  – Chinese University of Hong Kong
  – Xi’an Jiaotong University
  – National Chengchi University
  – National University of Singapore
  – Fundacao Getulio Vargas
• Vietnam is one of potential candidates for the data collection.
Questions for the 4th Round

- Adaptability
- Business Services
- Constraint Management
- Environment
- Human Resource Management
- Improvement
- IS/IT
- Lean/JIT
- Manufacturing Strategy
- New Product Development
- Performance
- Quality Management

- Supply Chain Management
- Sustainability
- Technology
- Total Productive Maintenance