Decision Making for Different Types of Variation in a Manufacturing System

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Decision Making for Different Types of Variation in a Manufacturing System

Abstract
Common cause variation: Natural part of the process; Acting on process.

Special cause variation: From external sources; searching and mitigating causes.

Disciplines
Industrial Engineering | Industrial Technology | Manufacturing | Other Operations Research, Systems Engineering and Industrial Engineering

Comments
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Decision Making for Different Types of Variation in a Manufacturing System
Xue Lei  Cameron MacKenzie  Caroline Krejci
Iowa State University (IMSE)
The University of Texas at Arlington
Common cause variation

• Natural part of the process
• Acting on process

Special cause variation

• From external sources
• Searching and mitigating causes
Motivation

Common cause

Special cause

Variation of manufacturing process

Decision making

Correct

Improve system performance

Wrong

Degrade system performance

Variation of manufacturing process

Decision making

Correct

Improve system performance
Research goals

- Analyze and quantify how common cause variation and special cause variation impact system performance
- Simulate how human operators may
  - Interpret causes of variation
  - Make decisions to reduce causes of variation
- Quantify impact of decision making
  - If human operators correctly interpret variation
  - If human operations incorrectly interpret variation
Simulation of manufacturing system

Interaction within the decision team

Queue length for each station

Manufacturing system

Daily throughput of system

Cue

Instruction

Recommendation

Shared mental model
Simulate decision making

- How should each station operator give recommendations to the production manager?

- How should the production manager make decisions based on the recommendations and give the cues?

-Recongition-primed decision (RPD) model

Modified RPD model for station’s operator

Elementary data from environment → Experience knowledge base (EKB)

Similarity measure

More data → Yes

System out of control

No

Yes → Make recommendation

Station’s operator
Experience Knowledge Base (EKB)

Control chart of queue length for station 1

Control chart of daily throughput

Station’s operator

Production Manager
Simulation

• Simulate manufacturing system (40 days) → control chart parameters
  • Daily throughput
  • Queue length for each station
• Use simulation to analyze how performance metrics change
  • If production team attempts to reduce common cause variation
  • If special cause variation is introduced
  • If production team misinterprets cause of variation (future work)
Common cause and special cause variation

• Actions to reduce common cause variation
  • Change mean process time of station’s machines
  • Reduce variation of process time of station’s machines
  • Change mix of arriving jobs
• Special cause variation problems
  • Forklifts move more slowly
  • Machine breaks down
• Actions for special cause variation: identify system problem and fix problem
## Change mix of 3 job types

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<tr>
<th></th>
<th>Mean</th>
<th>STD</th>
<th>1↑ 2↓ 3↓</th>
<th>1↓ 2↑ 3↓</th>
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<td>↑ (≤ 3)</td>
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Decrease one station’s process time, increase another station’s process time

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<th>III</th>
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<td><strong>Daily throughput</strong></td>
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<td>STD</td>
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<td><strong>Queue length of station 1</strong></td>
<td>Mean</td>
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<td>STD</td>
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<td>≈</td>
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<tr>
<td><strong>Queue length of station 2</strong></td>
<td>Mean</td>
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<td>≈</td>
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<tr>
<td></td>
<td>STD</td>
<td>↑ (&lt; 1)</td>
<td>≈</td>
</tr>
<tr>
<td><strong>Queue length of station 3</strong></td>
<td>Mean</td>
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<td>↓</td>
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<td>STD</td>
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<tr>
<td><strong>Queue length of station 4</strong></td>
<td>Mean</td>
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<tr>
<td><strong>Queue length of station 5</strong></td>
<td>Mean</td>
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<tr>
<td></td>
<td>STD</td>
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<td>≈</td>
</tr>
</tbody>
</table>
Special cause variation: Machine breakdowns

Station 1 machine breakdown

Station 5 machine breakdown
Special cause variation: Machine breakdowns

Station 2 machine breakdown

Station 3 machine breakdown
Special cause variation: Machine breakdowns

![Graph showing Station 4 machine breakdown over days with daily throughput on the y-axis and days on the x-axis.](image)
Special cause variation: Forklift trucks move more slowly

![Graphs showing daily throughput over different speeds](image-url)
Preliminary contributions

- Recognition-primed decision making model applied to manufacturing system
  - Embed interplay among decision team within the shared mental model
  - Represent knowledge base of experts through control charts
- The importance of distinguishing common cause variation and special cause variation

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