The Effect of Setups in the Presence of Random Yield Loss

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Outline

- Optimal Policy Structure
- Convexity Results
- General Formulation
- Previous Results
- Motivation - Plastics Plant
Motivation-Injection Molding

Operations

Plant Characteristics

- Injection molded parts
- AS/RS
- Painting with substantial yield loss

Good

Bad
Key Parameters

- Multiple products
- Multiple colors per part type
- Multiple periods
- Capacity constraints (with overtime)
- Fixed shipping times
Some non-order-up-to optimal policies

- Convexity or quasi-convexity possible in many cases
- Often can show minimum order point
- Difficult to show specific optimal structure

General Results:

- General Cases (Gerchak, Yan, Lee, etc.)

Previous Results
Key Uncertainties

- Look at Structure
- Must define objectives
- Basic optimization problem

General Framework

- Logistic problems
- Lack of material/supplies
- Unforeseen orders
- Variable production rates
- Machine breakdowns
- Uncertain yields
- Quality loss

Effective Capacity Limited By
Short Term Model

- **Risk**
  - Unique to situation (not market
  - Solved many times
  - Unique to situation (not market)

- **Solution Time**
  - Focus on expectation (all unique risk - diversifiable)
  - Solved many times

- **Coordination**
  - Need for efficiency
  - Real-time framework
  - Must implement decisions

- **Solution Time**
  - Focus on expectation (all unique risk - diversifiable)
  - Solved many times
  - Unique to situation (not market)
GENERAL MULTISTAGE MODEL

FORMULATION:

\[ \min \ E \left[ \sum_{t=1}^{T} f_t(x_t, x_{t+1}) \right] \]

s.t. \[ x_t \in \mathcal{X}_t \]

\[ x_t \text{ nonanticipative} \]

\[ \mathbb{P} \left[ h_t(x_t, x_{t+1}) \leq 0 \right] \geq a \text{ (chance constraint)} \]

DEFINITIONS:

- \( x_t \) - aggregate production
- \( f_t \) - defines transition - only if resources available and includes subtraction of demand
- \( \mathcal{X}_t \) - aggregate production

MODEL

GENERAL MULTISTAGE
DYNAMIC PROGRAMMING VIEW

- EARLY AND LATENESS PENALTIES
- CONVEXITY (possible in many cases)

ASSUMPTIONS:

- CONVEXITY: \( (x_{i+1})^T y_{i+1} x_{i+1} \) is the random element and \( y \) is the random element
- EARLY AND LATENESS PENALTIES

VALUE FUNCTION:

\[
E[x] = \min \left\{ (x_{i+1})^T y_{i+1} x_{i+1} \right\}
\]

STAGES: \( \{T, \ldots, 1\} \)

STATES: \( x \rightarrow B(x) \) (or other transformation)
PRODUCTION SCHEDULING

RESULTS

• LEADS TO MATCH-UP FRAMEWORK
  – RETURN TO OPTIMAL CYCLE
  – FROM OTHER DISRUPTIONS:
    TURNPIKE: (Birge/Dempster)
  – MAY INDICATE KANBAN/CONWIP TYPE OPTIMALITY
  – OPTIMAL IF STATIONARY OR CYCLIC DISTRIBUTIONS

• CYCLIC SCHEDULES:
  – DERIVE SUPPORTING PRICES
  – CAN DEFINE OPTIMALITY CONDITIONS

• OPTIMALITY:
  – CAN DEFINE OPTIMALITY CONDITIONS
Specific Models

• Simple Models
  – Single product
  – Single period
  – Unlimited overtime

• Policy Forms
  – Order to expectation
  – Order up to quantity (s, S)
  – Fixed order quantity (Q,r)

Results

– (s,S) type policies appear best in this group
– No proof to date

Simple Models
Conclusions

• Common situations with setups and random yields
• General models possible with some convexity results
• Policy structure for general case unclear