The Effect of Setups in the Presence of Random Yield Loss

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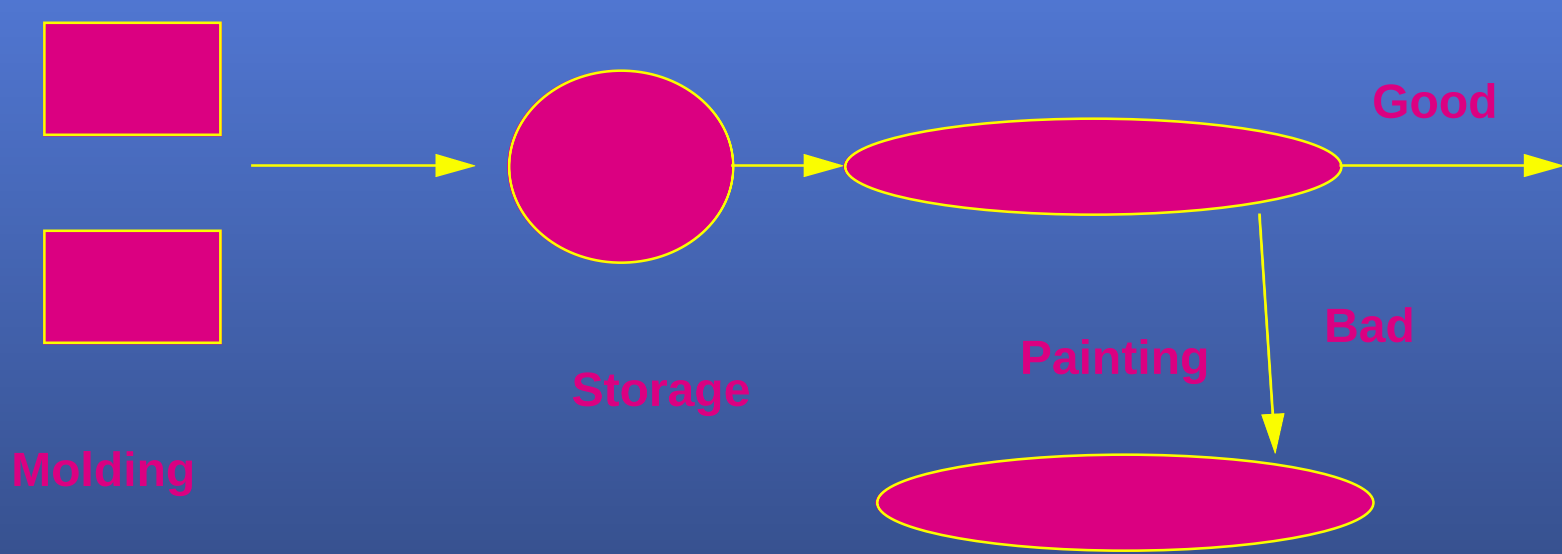
Outline

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

Motivation-Injection Molding Operations

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



Key Parameters

- Multiple products
- Multiple colors per part type
- Multiple periods
- Capacity constraints (with overtime)
- Fixed shipping times

Previous Results

- General Cases (Gerchak, Yano, Lee, etc.)
- General Results:
  - Convexity or quasi-convexity possible in many cases
  - Often can show minimum order point
  - Difficut to show specific optimal structure
  - Some non-order-up-to optimal policies

Key Uncertainties

- EFFECTIVE CAPACITY LIMITED BY
  - UNCERTAIN YIELDS - QUALITY LOSS
  - MACHINE BREAKDOWNS
  - VARIABLE PRODUCTION RATES
  - UNFORESEEN ORDERS
  - LACK OF MATERIAL/SUPPLIES
  - LOGISTICAL PROBLEMS
- GENERAL FRAMEWORK
  - BASIC OPTIMIZATION PROBLEM
  - MUST DEFINE OBJECTIVES
  - LOOK AT STRUCTURE

Short Term Model

- Risk
  - Unique to situation (not market)
  - Solved many times
  - Focus on expectation (all unique risk - diversifiable)
- Solution time
  - Must implement decisions
  - Real-time framework
  - Need for efficiency
- Coordination
  - Maintain consistency with long-term goals

GENERAL MULTISTAGE MODEL

- **FORMULATION:**

MIN $E[\sum_{t=1}^{T} f_t(x_t, x_{t+1})]$

s.t. $x_t \in X_t$

x_t nonanticipative

$P[h_t(x_t, x_{t+1}) \le 0] \ge a$ (chance constraint)

DEFINITIONS:

x_t - aggregate production

f_t - defines transition - only if resources available and includes subtraction of demand

DYNAMIC PROGRAMMING VIEW

- **STAGES: $t=1,\ldots,T$**
- **STATES: $x_t \to B_t x_t$ (or other transformation)**
- **VALUE FUNCTION:**
  - ∠ $\Psi_t(x_t) = E[\psi_t(x_t,\xi_t)]$ where
  - ∠ ξ_t is the random element and
  - ∠ $\psi_t(x_t,\xi_t) = \min f_t(x_t,x_{t+1},\xi_t) + \Psi_{t+1}(x_{t+1})$
  - s.t. $x_{t+1} \in X_{t+1t}(\xi_t)$ x_t given
- **ASSUMPTIONS:**
  - CONVEXITY (possible in many cases)
  - EARLY AND LATENESS PENALTIES

PRODUCTION SCHEDULING RESULTS

- **OPTIMALITY:**
  - CAN DEFINE OPTIMALITY CONDITIONS
  - DERIVE SUPPORTING PRICES
- **CYCLIC SCHEDULES:**
  - OPTIMAL IF STATIONARY OR CYCLIC DISTRIBUTIONS
  - MAY INDICATE KANBAN/CONWIP TYPE OPTIMALITY
- **TURNPIKE: (Birge/Dempster)**
  - FROM OTHER DISRUPTIONS:
  - RETURN TO OPTIMAL CYCLE
- **LEADS TO MATCH-UP FRAMEWORK**

Specific Models

- Simple Models
  - Single product
  - Single period
  - Unlimited overtime
- Policy Forms
  - Fixed order quantity (Q,r)
  - Order up to quantity (s,S)
  - Order to expectation
- Results
  - (s,S) type policies appear best in this group
  - No proof to date

Conclusions

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