ECE 100: Introduction to Engineering Design

Project No. 1 Description

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Some Course Business Items…

- Please submit your Modeling Assignment No. 3 and retrieve the graded Modeling Assignment No. 2 from your team folder.
- *Mean: 80.9; Max: 105, Min: 43.* I still need to grade the extra credit. Per Mike Pew, this are some reasons why individuals lost credit:
  - Negative inventory costs
  - Labeling, organization and identification of graphs
  - Not reading the assignment handout, or at least not close enough and as a result not answering any or all of the questions as requested or otherwise not doing the assignment correctly
  - Having insanely high bounds (several million dollars) for the surface plots so as to render them useless and not picking useful inputs for the table.

Project No. 1

- Upper management at Sparky Computer, Inc. (SC) is well aware of your team's expertise in engineering modeling and simulation and has hired your services to study its current inventory management practices (based on the use of EOQ-style approaches) and advise on improvements and modifications. In particular, Sparky Computer is opting to license technology from two PID control system vendors (IMC, Inc. and ACME) and wishes to determine the following:
  - whether the replacement of the existing EOQ policies with PID ones has merit,
  - which one of the two PID control vendors offers the most suitable technology, and
  - which specific product model within that vendor's suite of offerings represents the best buy.

IMC, Inc. Tuning Rules

$$u(t) = K_c e(t) + \frac{K_c}{\tau_I}\int_0^t e(t')dt' + K_c \tau_D \frac{de}{dt} - \tau_F \frac{du}{dt}$$

Model		K_c	τ_I	τ_D	τ_F
BRONZE	$\beta = \theta$	$\frac{2\lambda+\beta}{(\lambda+\beta)^2}$	$2\lambda + \beta$	-	-
SILVER	$\beta = \theta/2$ $\tau = \theta/2$	$\frac{\beta+2\lambda+\tau}{(\beta+\lambda)^2}$	$\beta + 2\lambda + \tau$	$\frac{\tau(\beta+2\lambda)}{\beta+2\lambda+\tau}$	-
GOLD	$\beta = \theta$	$\frac{2(\beta+\lambda)}{2\beta^2+4\beta\lambda+\lambda^2}$	$2(\beta + \lambda)$	-	$\frac{\beta\lambda^2}{2\beta^2+4\beta\lambda+\lambda^2}$
PLATINUM (Level Two)	$\beta = \theta$	$\frac{2(\beta+\lambda)}{2\beta^2+\lambda^2}$	$2(\beta + \lambda)$	$\frac{2\beta\lambda}{\beta+\lambda}$	$\frac{\beta\lambda^2+4\beta^2\lambda}{2\beta^2+\lambda^2}$

Table 1: IMC, Inc. PID Controller Tuning Rules. θ represents the order fulfillment time.

ACME, Inc. Tuning Rules

$$u(t) = K_c e(t) + \frac{K_c}{\tau_I}\int_0^t e(t')dt' + K_c \tau_D \frac{de}{dt}$$

Model	K_c	τ_I	τ_D	τ_F
BRONZE	0.2	20	-	-
SILVER	$0.9/\theta$	3.3θ	-	-
GOLD	$(10+\theta)/100$	$10+\theta$	$10\theta/(10+\theta)$	-
PLATINUM	$1.2/\theta$	3.3θ	0.5θ	-

Table 2: ACME® PID Controller Tuning Rules

Discrete-Time PID Control (As Before)

$$O(k) = O(k-1) + K_1 e(k) + K_2 e(k-1) + K_3 e(k-2) + K_4 \Delta O(k-1)$$

$$O(k) = O(k-1) + \overbrace{\frac{TK_c}{\tau_F + T}\left(1 + \frac{T}{\tau_I} + \frac{\tau_D}{T}\right)}^{K_1} e(k)$$

$$-\overbrace{\frac{TK_c}{\tau_F + T}\left(1 + \frac{2\tau_D}{T}\right)}^{K_2} e(k-1) + \overbrace{\frac{K_c \tau_D}{\tau_F + T}}^{K_3} e(k-2) + \overbrace{\frac{\tau_F}{\tau_F + T}}^{K_4} \overbrace{(O(k-1) - O(k-2))}^{\Delta O(k-1)}$$

T is the "sampling time" or review period; please keep at 1 (day) for this exercise.

To this end, SC's management is interested in receiving *demonstrated* answers to the following questions:

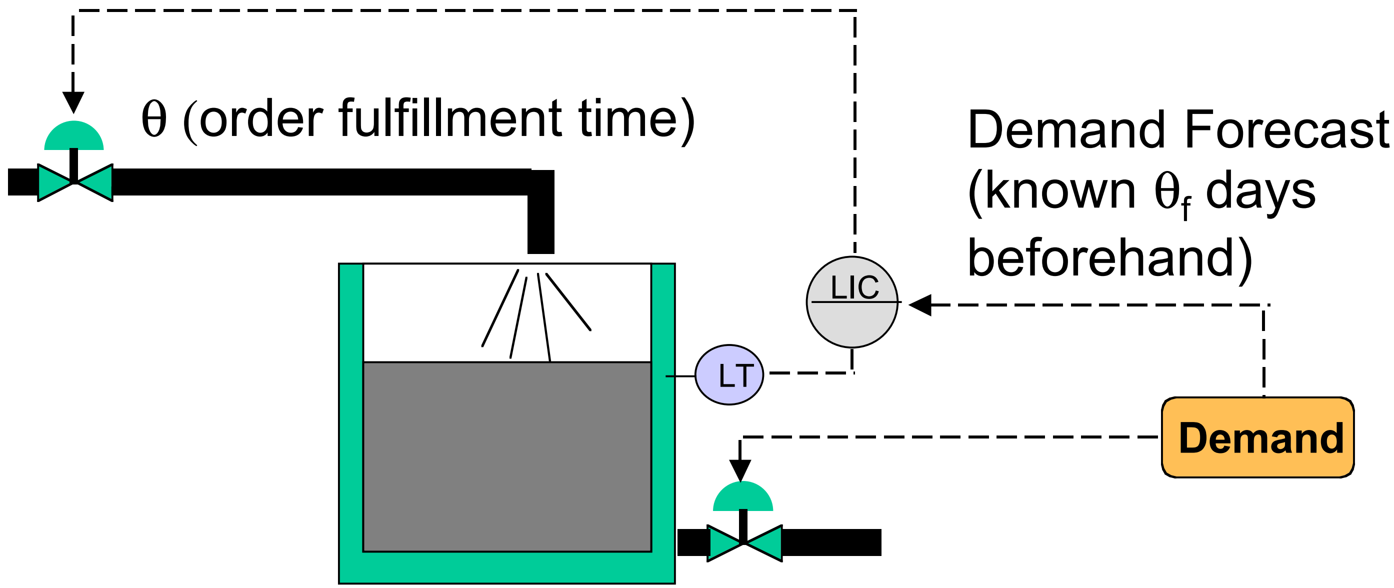
1. How do standard EOQ policies (tested under conditions that involve both stochastic and deterministic demand variations) compare with PID-type decision policies?

2. How can the design and adjustable parameters in the PID decision policies (e.g., lambda and initial net stock) be "tuned"/selectd to minimize total costs over 60 days while avoiding the bullwhip effect"?

3. How can the PID policies be modified to take advantage of a 5 day ahead demand forecast? The forecast consists of anticipated knowledge (five days prior) of the deterministic demand.

4. How robust are the decision policies per item 3 to erroneous information? Specifically consider the effect of error in the demand forecast.

Some thoughts on using forecasts



Meet demand (with forecast given θ_f days beforehand) for a node with θ day order fulfillment time.

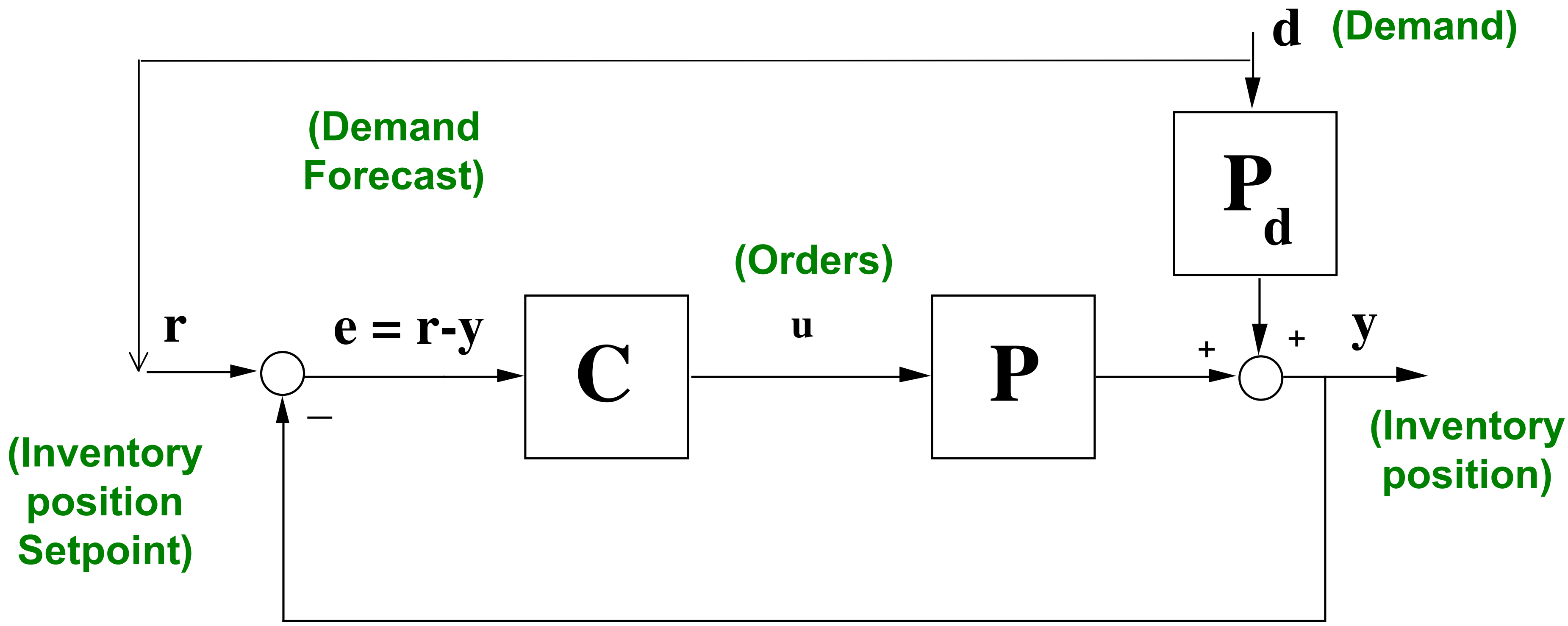
Some thoughts on using forecasts (cont.)

- Feedforward-only decision policy (implemented on Graphical/Animated Spreadsheet)
  - Extremely simple:

    O(k) = Baseline Demand + Forecasted Demand Change (3 days prior)

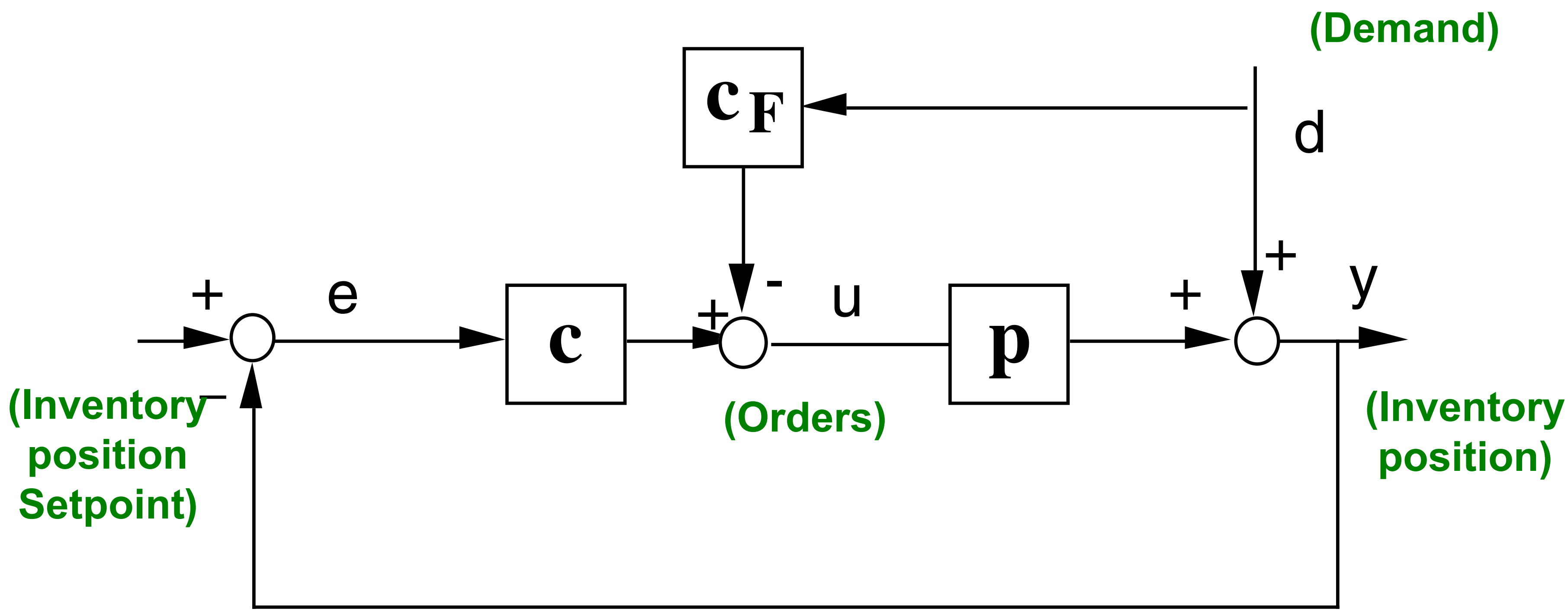
  - Works well when forecast is "accurate"; breaks down under biased forecast scenarios.
- Forecast-adjusted setpoint in feedback-only control (please evaluate)
  - retains existing PID decision policy
  - changes inventory position setpoint when forecast warrants it
- Combined feedback/feedforward control (do for "wow" credit)

Forecast-Adjusted Setpoint



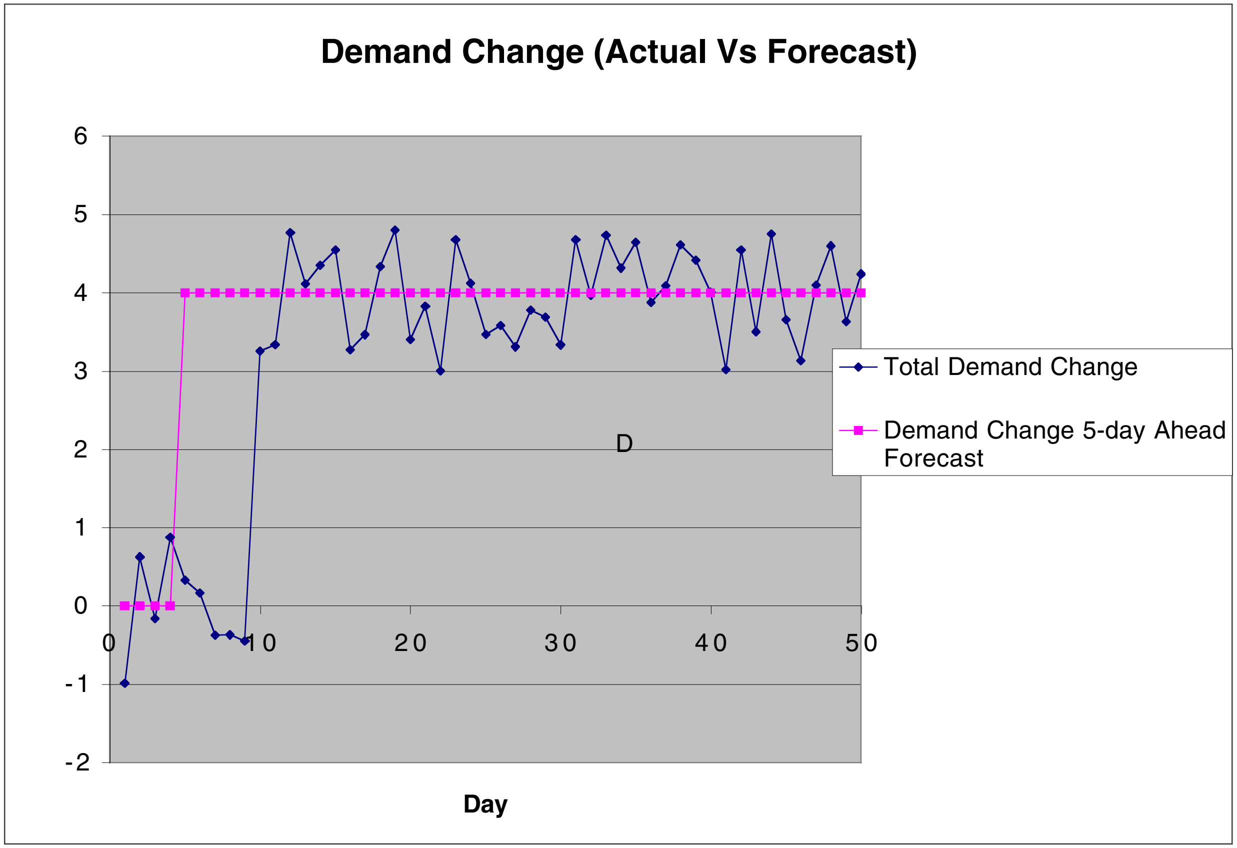
C = Controller
P = Process “Transfer Function”
Pd = Disturbance “Transfer Function”

Combined Feedback-Feedforward Control

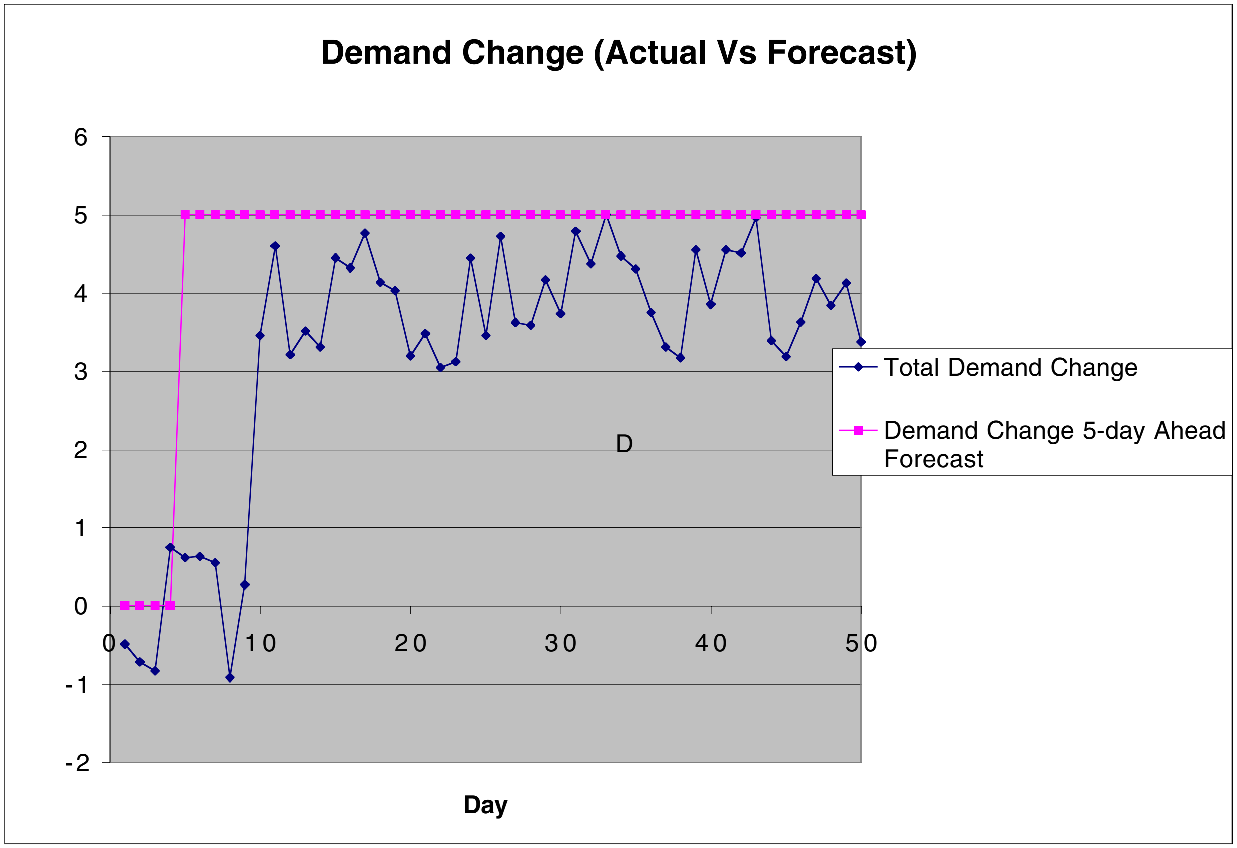


Challenge lies in coordinating the feedback and feedforward orders
"Two degree of freedom" control is desirable…

Demand Change vs Forecast (Stochastic Gain = 2, Zero Forecast Error)



Demand Change vs Forecast (Stochastic Gain = 2, +25% Forecast Error)



Project No. 1 Point Breakdown

- Total Number of Points: 245:
  - 50 pts for Modeling Assignment No. 4; i.e. spreadsheets associated with
    - IMC, Inc. and ACME-brand decision policy implementations
    - Enhanced policies using demand forecasts
  - 125 pts for Project Report and Group Summary
  - 50 pts for Project Presentation
  - 20 pts for Team Process Check

Upcoming Class Sessions

- Tuesday, March 25.
  - Sheila Young, Engineering Librarian, will be presenting to the class.
- Thursday, March 27.
  - Presentation on Presentations
- Thursday, April 3.
  - Project No. 1 Reports are due
- Tuesday, April 8.
  - Team Project Presentations.