CT561: Systems Modelling & Simulation

Lecture 6: Information Delays and the Stock Management Structure

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Information Delays

- Many delays exist in channels of information feedback (Sterman 2000)
  - Measurement or perception of a variable
  - Updating beliefs or forecasts
- For example:
  - How many orders might our company receive next week?
  - Can we build this into our stock and flow model?

Structure of information delays

- Cannot be modeled with the same structure as material delays (where material is conserved)
- Simplest information delay and one of the most widely used models of belief adjustment and forecasting is *exponential smoothing* or *adaptive expectations*
- Key idea: the belief gradually adjusts to the most recent value of the variable (negative feedback)

Exponential Smoothing

- A raw data sequence is often represented by $\{x_t\}$ beginning at time t = 0.
- The output of the exponential smoothing algorithm is commonly written as $\{s_t\}$, *which may be regarded as the best estimate of what the next value of x will be*.
- When the sequence of observations begins at time t = 0, the simplest form of exponential smoothing is given by the equations:

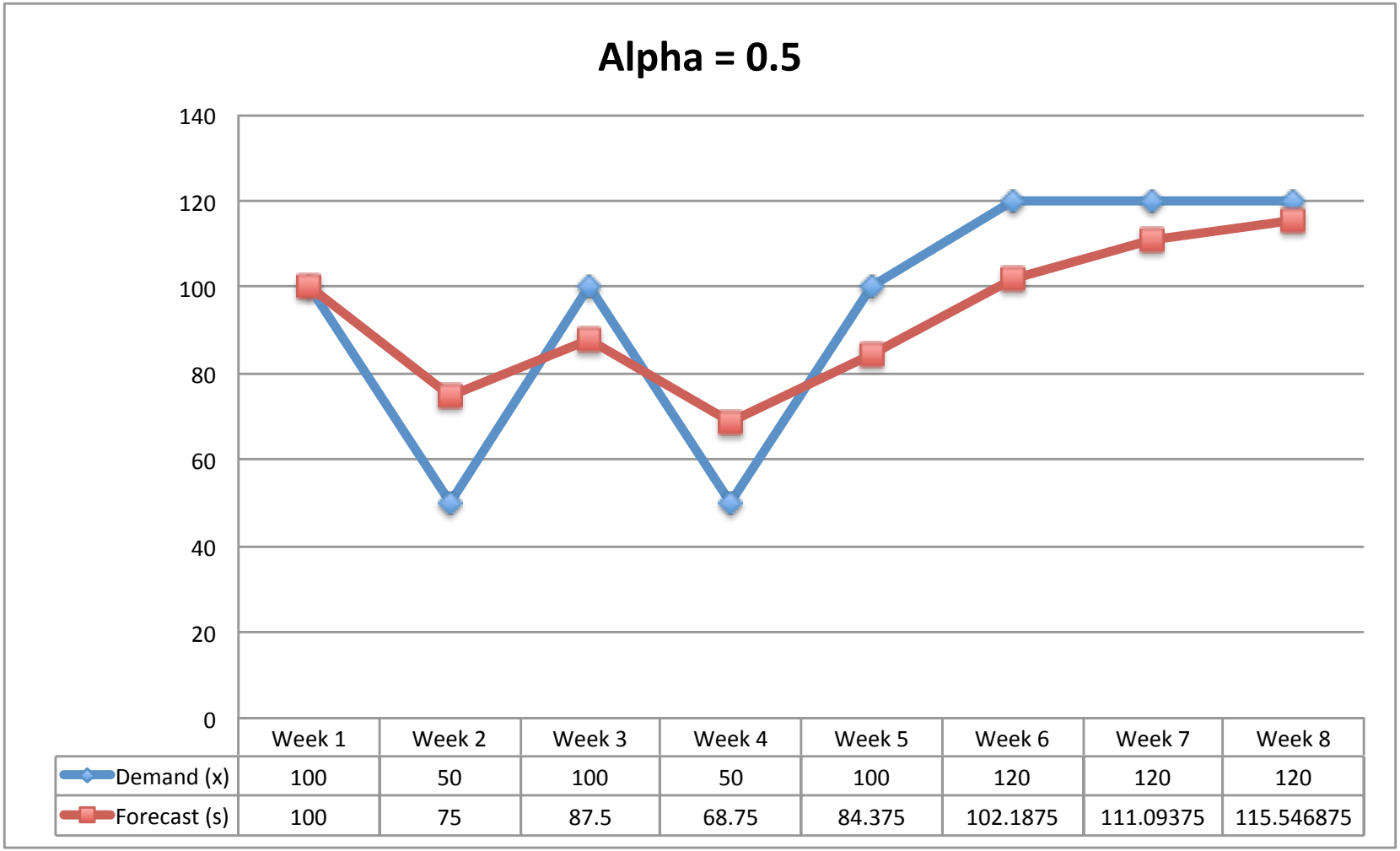
$$s_o = x_0$$

$$s_t = \alpha x_t + (1 - \alpha)\, s_{t-1} \quad 0 \leq \alpha \leq 1$$

where α is a smoothing constant

https://en.wikipedia.org/wiki/Exponential_smoothing

$$s_o = x_0$$
$$s_t = \alpha x_t + (1 - \alpha)\, s_{t-1} \quad 0 \le \alpha \le 1$$



	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Demand (x)	100	50	100	50	100	120	120	120
Forecast (s)	100	75	87.5	68.75	84.375	102.1875	111.09375	115.546875

In System Dynamics Models

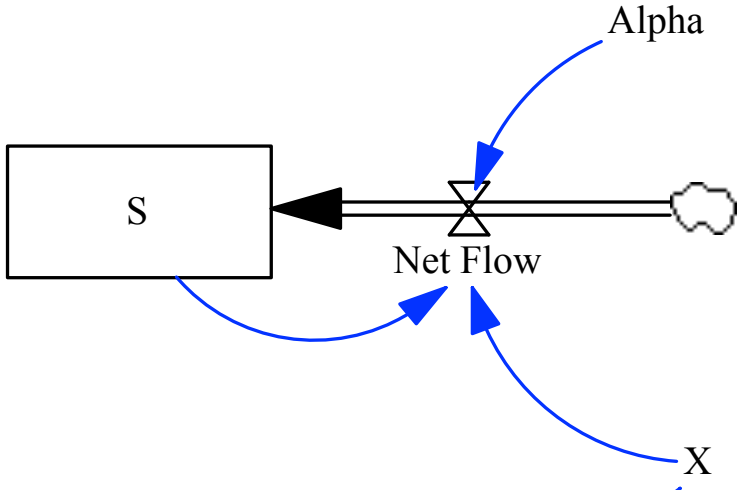
- What can we expect the future value of a key flow to be?
  - Expected quit rate (software company)
  - Expected customer demand (retailer)
- Can exponential smoothing be represented as a stock and flow structure?

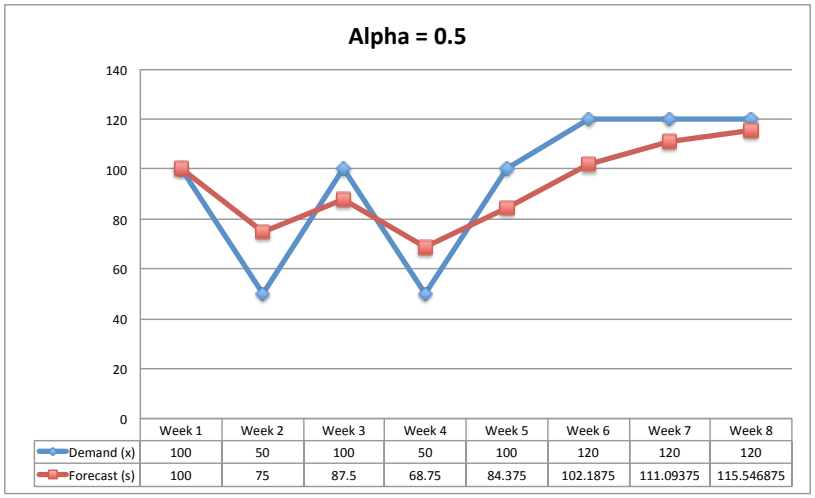
Exploring the exponential smoothing equation: *The forecast value is a stock.*

$$s_t = \alpha x_t + (1 - \alpha)\, s_{t-1}$$

$$s_t = \alpha x_t + s_{t-1} - \alpha\, s_{t-1}$$

$$s_t = s_{t-1} + \alpha\,(x_t - s_{t-1})$$



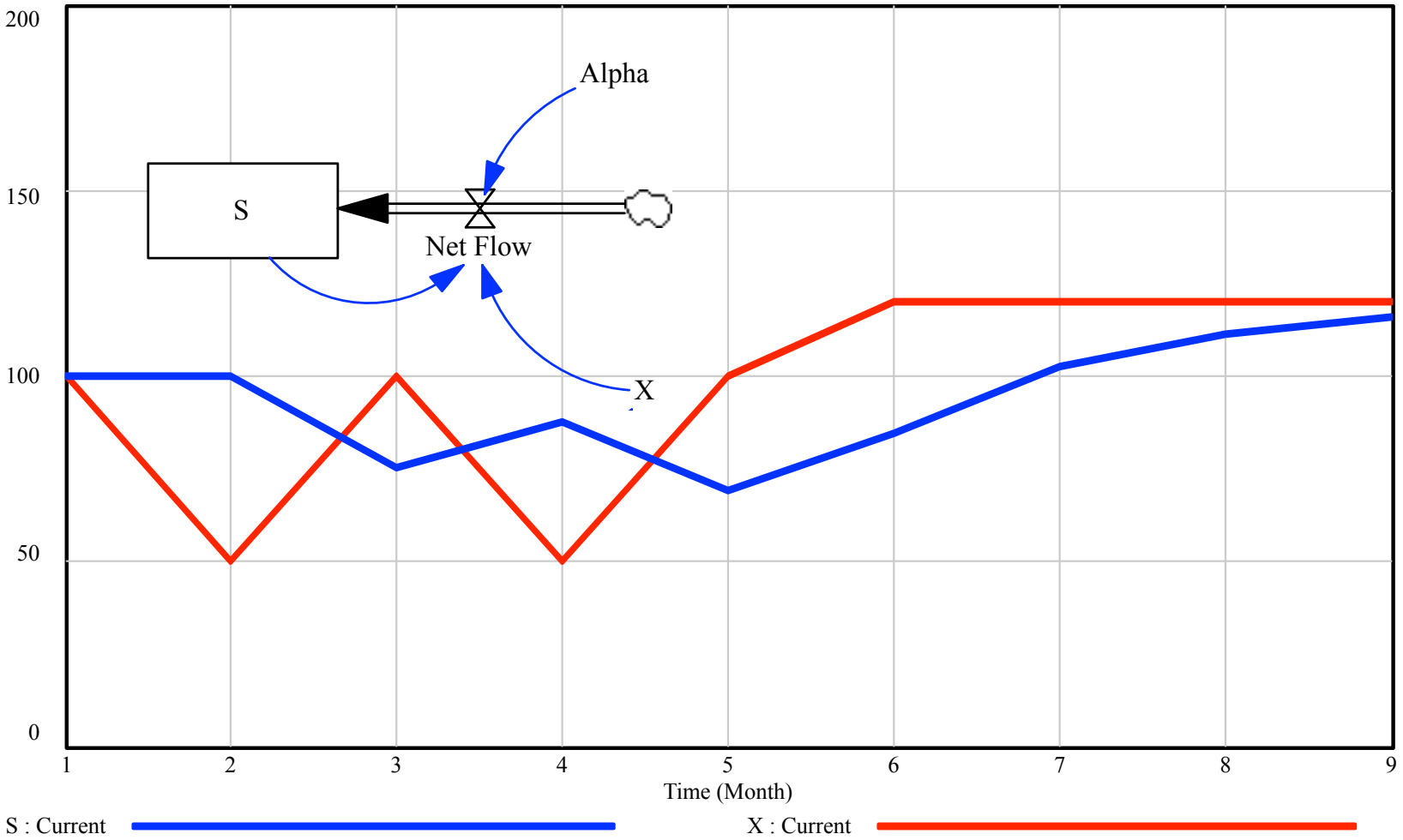


Alpha = 0.5

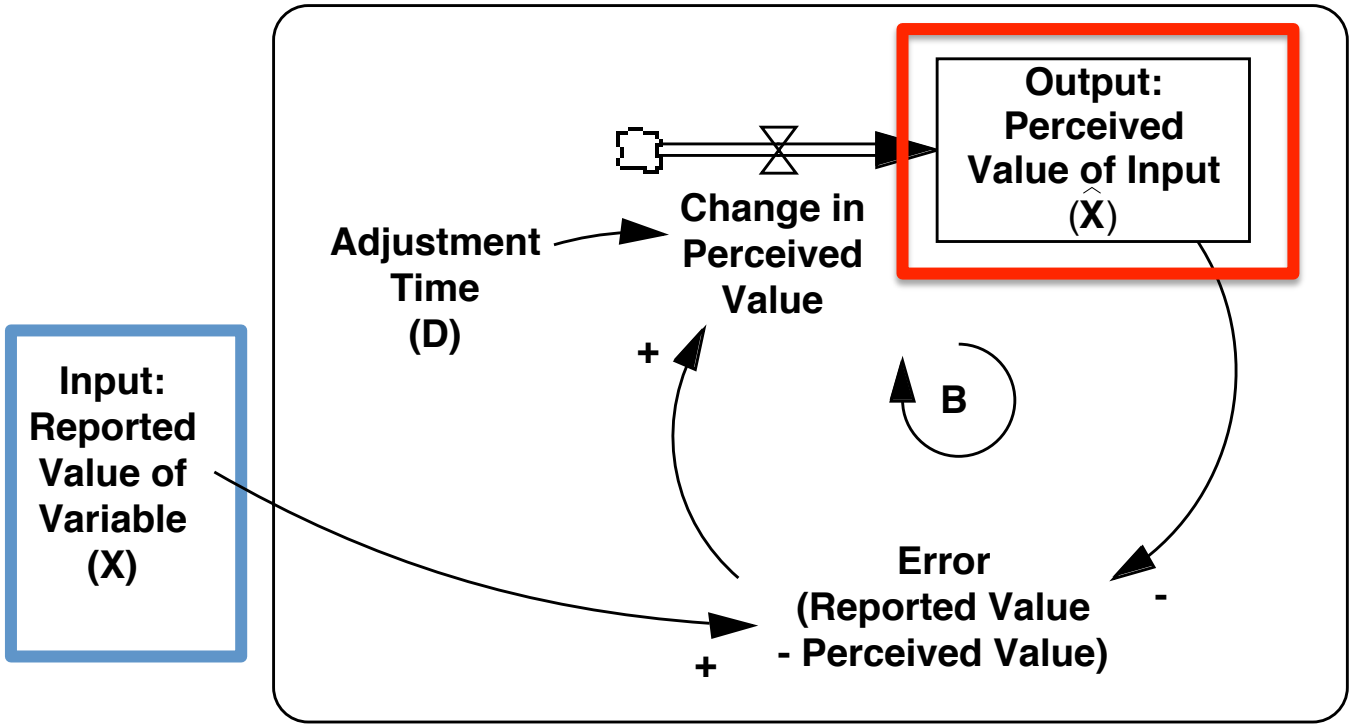
Net Flow = (X - S) * Alpha

S = INTEG(Net Flow , 100)

Results of Stock and Flow



Information Delay Stock and Flow Model (D = 1 /α)



Sterman 2000
Business Dynamics

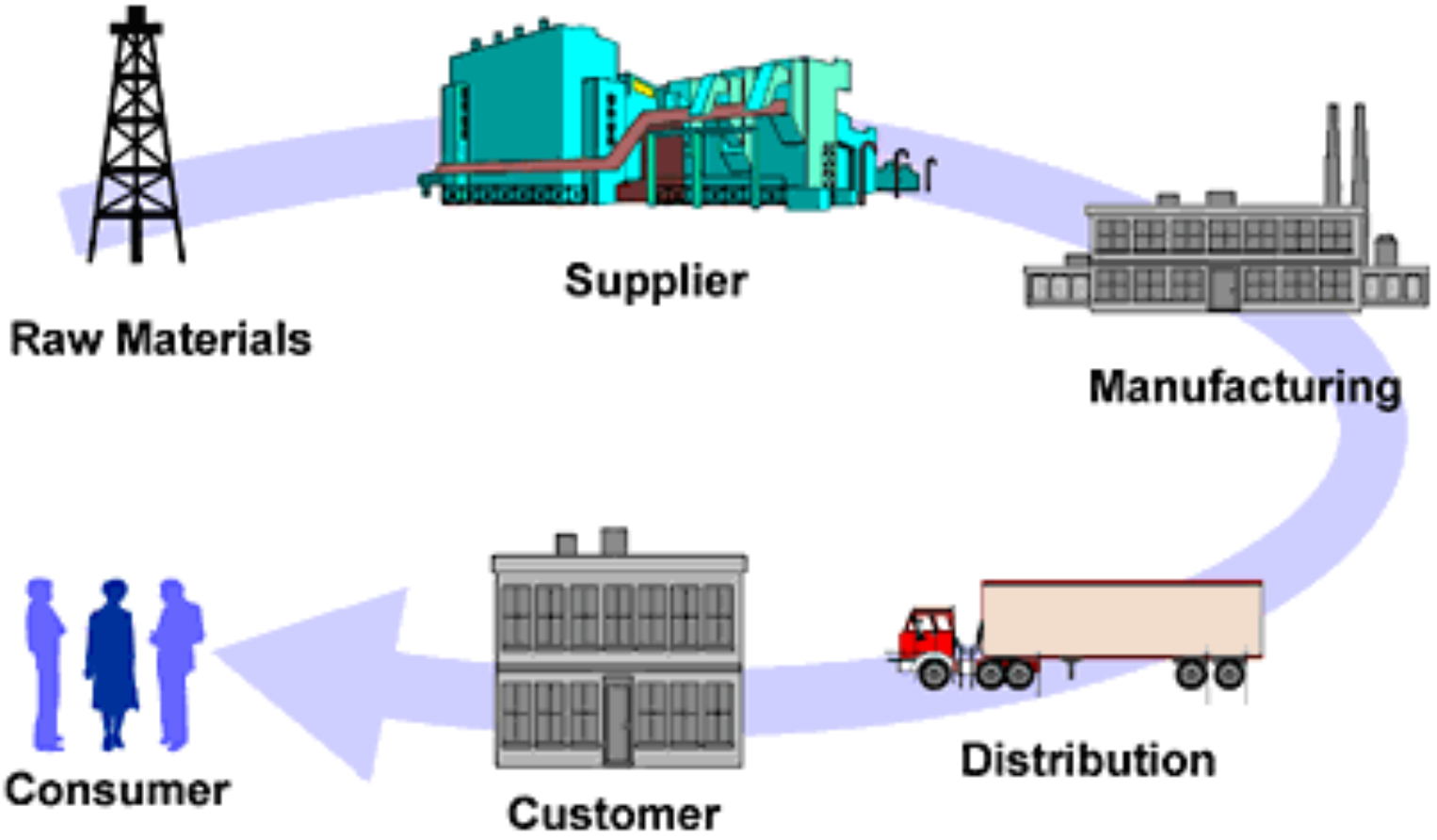
$\hat{X}$ = INTEGRAL(Change in Perceived Value, $\hat{X}(0)$)

Change in Perceived Value = Error/D = $(X - \hat{X})/D$

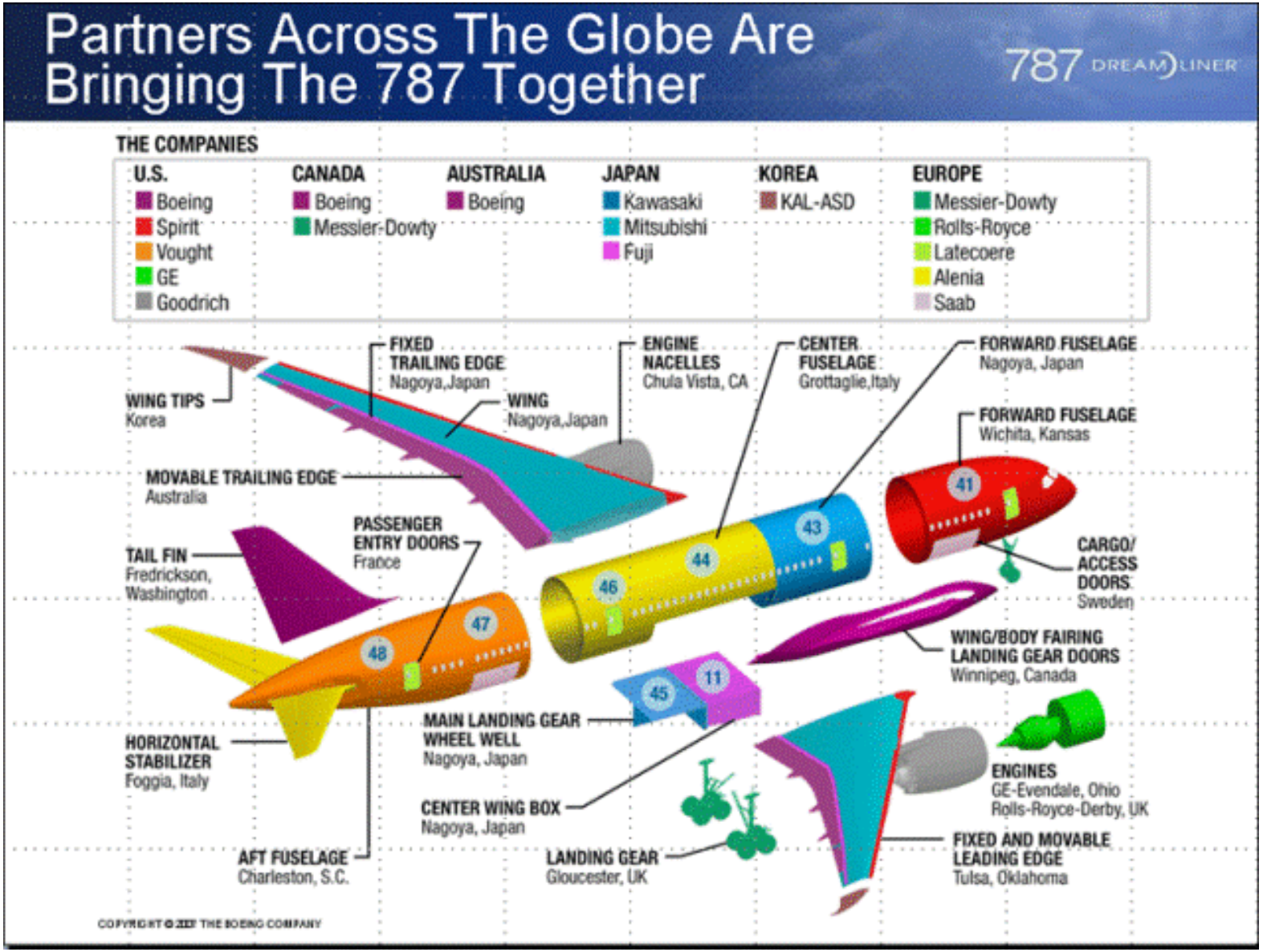
Challenge 6.1

- Construct a stock and flow model of students progressing through a University (one stock).
- Extend this to formulate an expectation of how many students will enrol in the future

The Stock Management Structure



http://www.brightonsbm.com/news/sup ply-chain/



http://supply-chain-data-mgmt.blogspot.ie/2012/10/the-size-of-boeings-supply.html

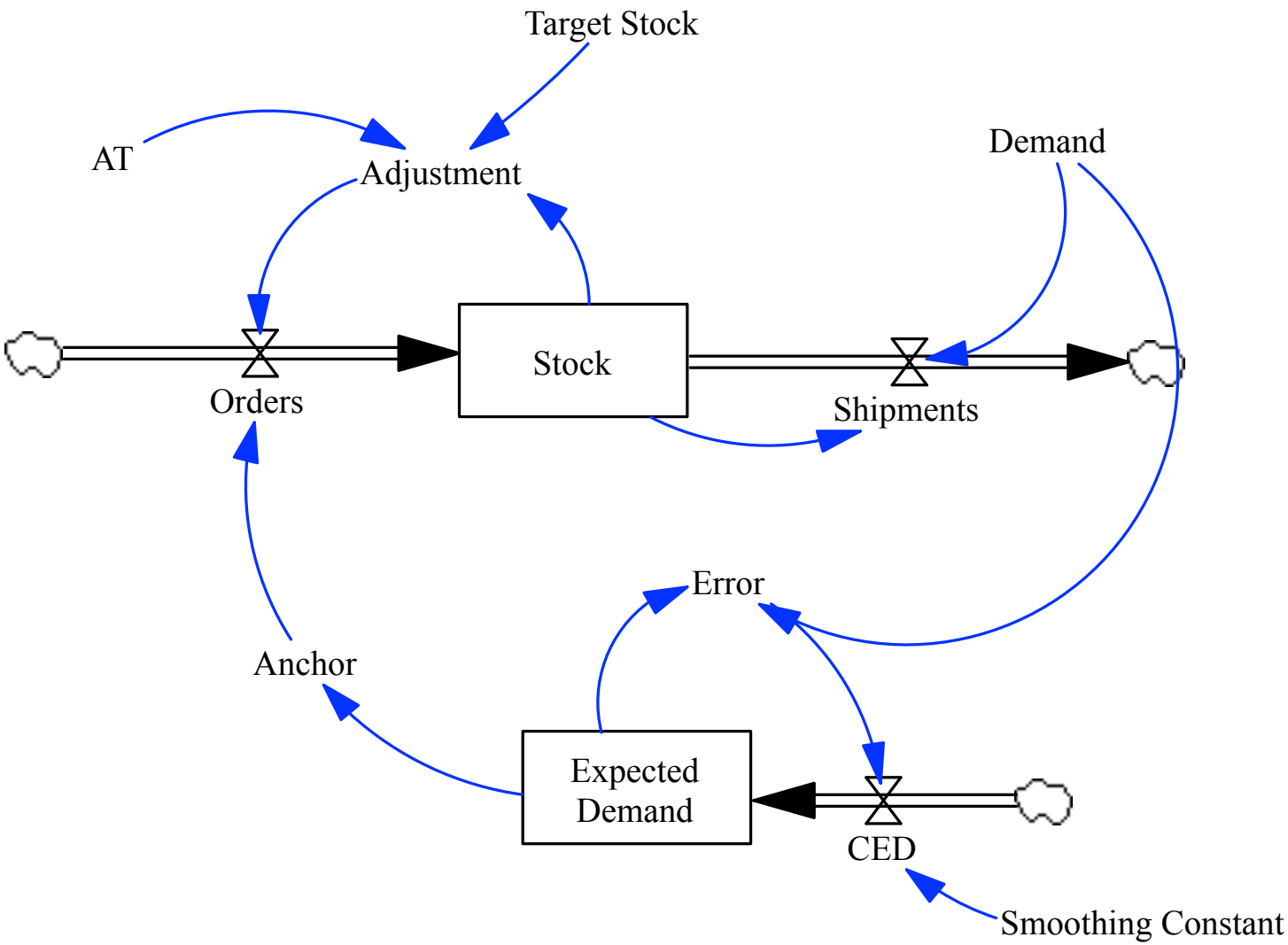
Rules for managing a stock

(1) Managers should replace expected losses from the stock **(the anchor**)

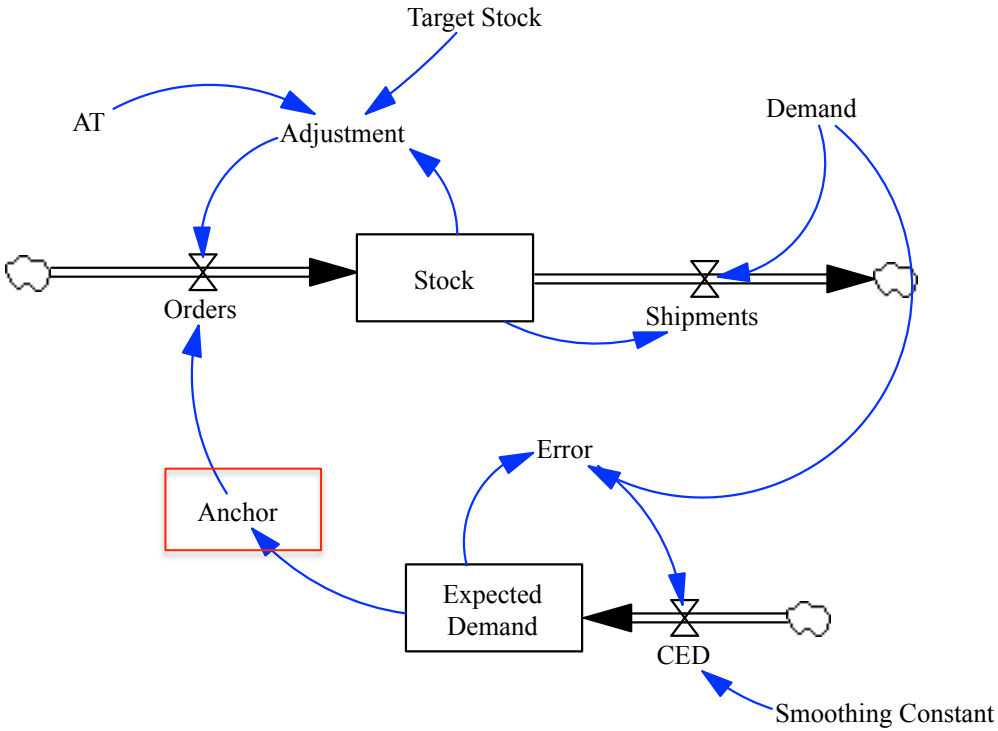
(2) Managers should reduce the discrepancy between the desired and actual stock **(the Adjustment).** Acquire:

- more than the expected losses when the stock is less that the desired,
- less than the expected losses when there is a surplus.

The Stock and Flow Model



Stock Management: The anchor



Anchor=Expected Demand

Expected Demand= INTEG (CED, 100)

CED=Error/Smoothing Constant

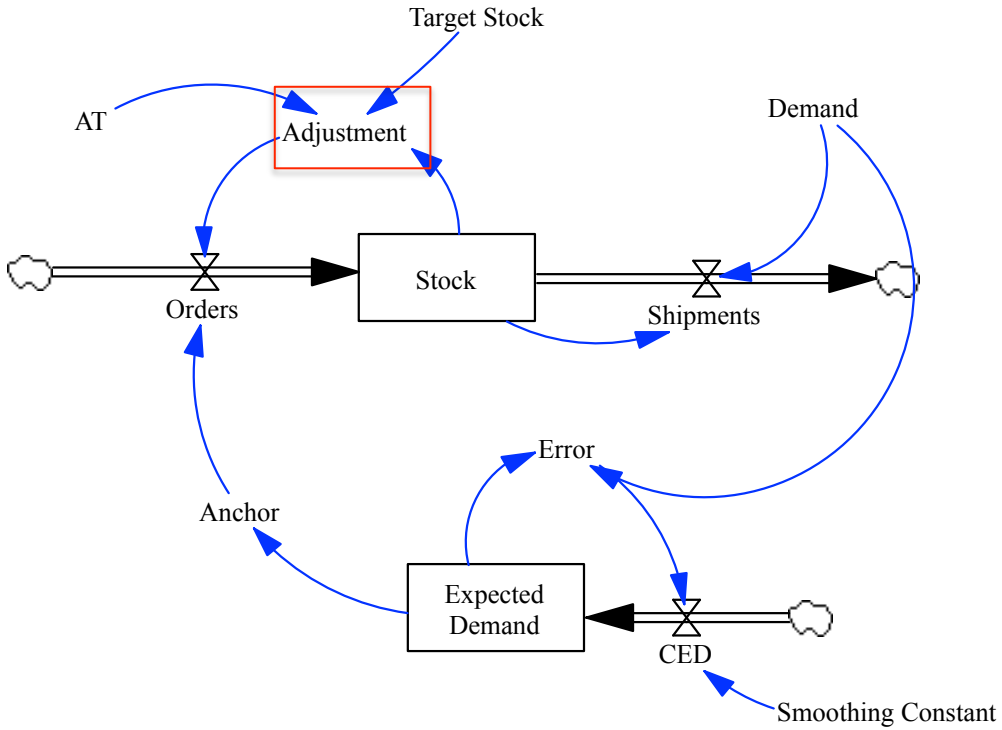
Error=Demand-Expected Demand

Smoothing Constant= 2

Demand=100+Step(100,10)-Step(150,20)

Managers should replace expected losses from the stock

Stock Management: The adjustment



Adjustment = (Target Stock-Stock)/AT

Target Stock=400

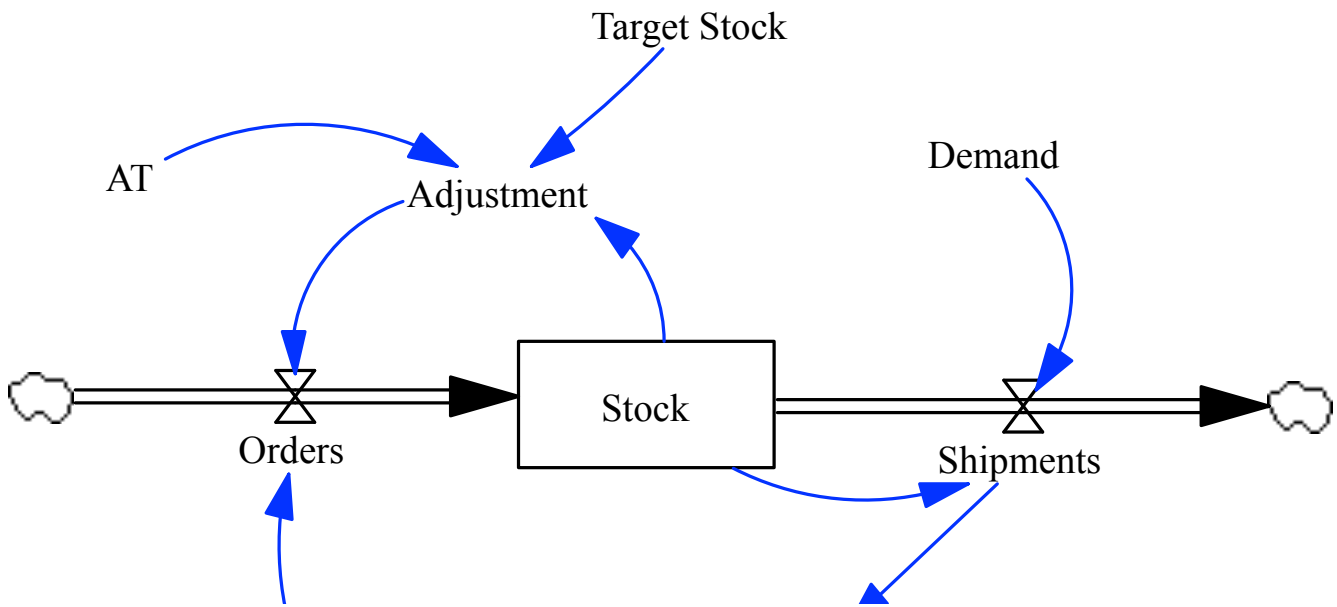
AT=1

Stock= INTEG (Orders-Shipments, 400)

Orders=max(0,Anchor+Adjustment)

Managers should reduce the discrepancy between the desired and actual stock

Inventory Management: The adjustment



Adjustment=(Target Stock-Stock)/AT

AT=3

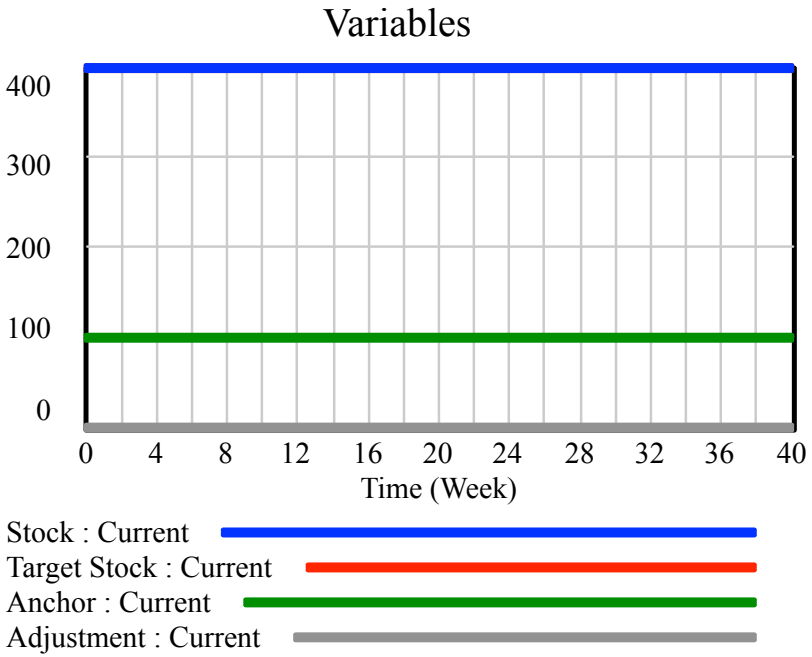
Demand=10+Step(10,20)

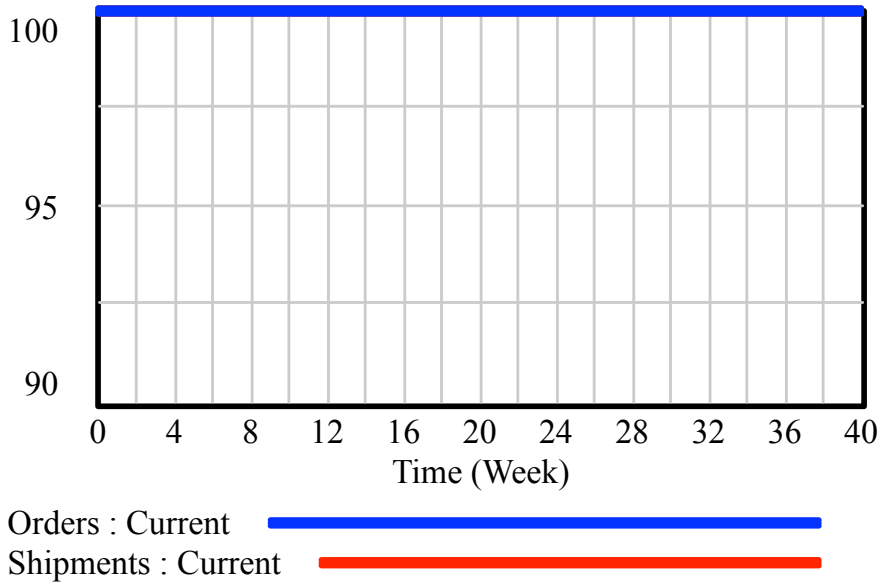
Shipments=min(Demand,Stock)

Stock= INTEG (Orders-Shipments, 50)

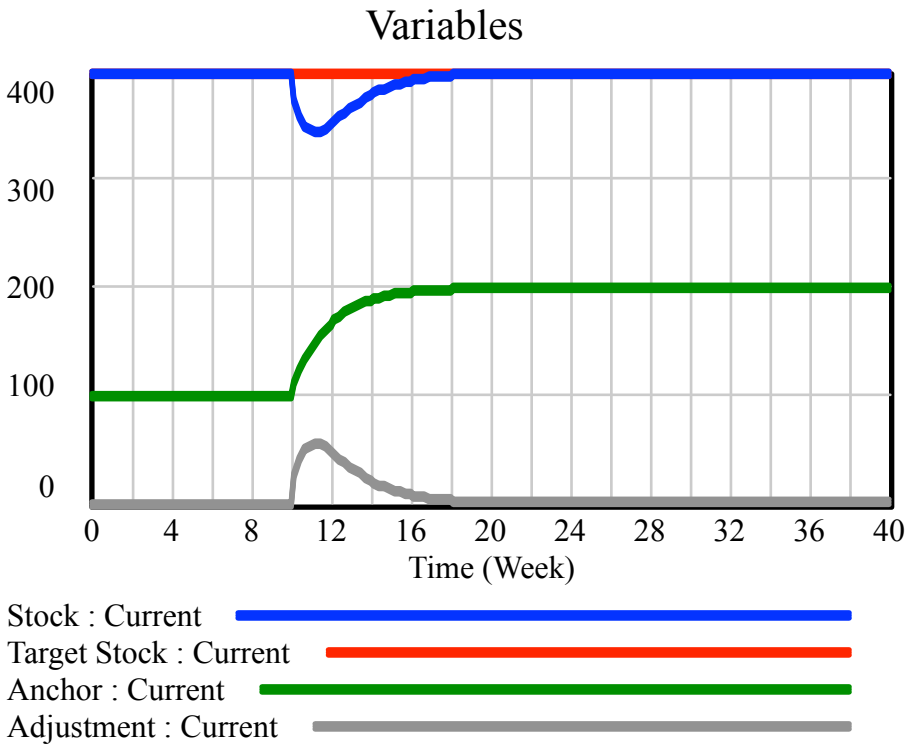
Target Stock=50

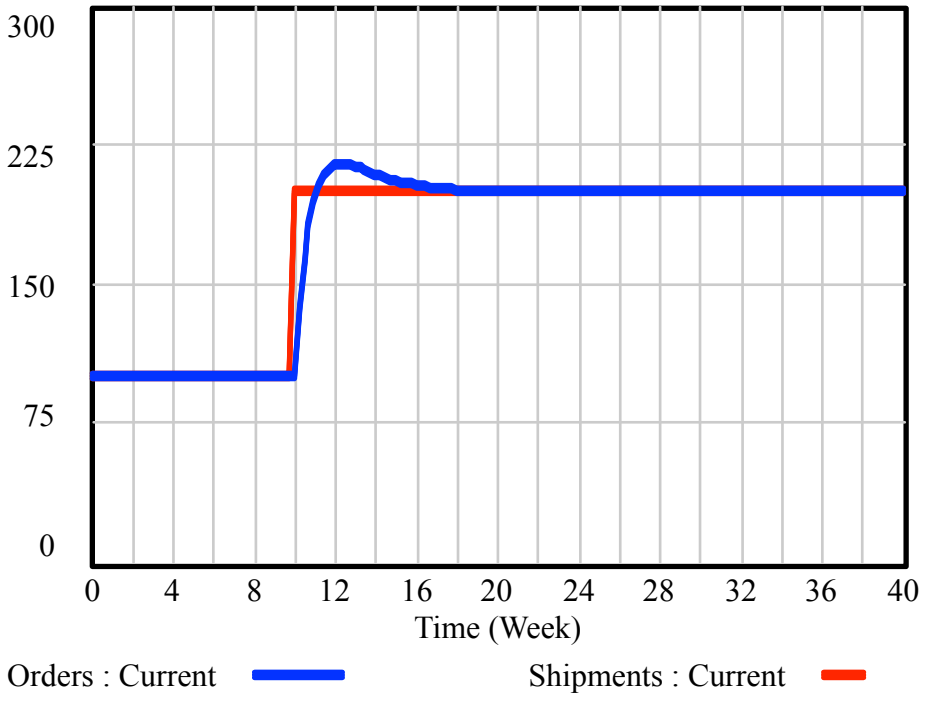
Equilibrium



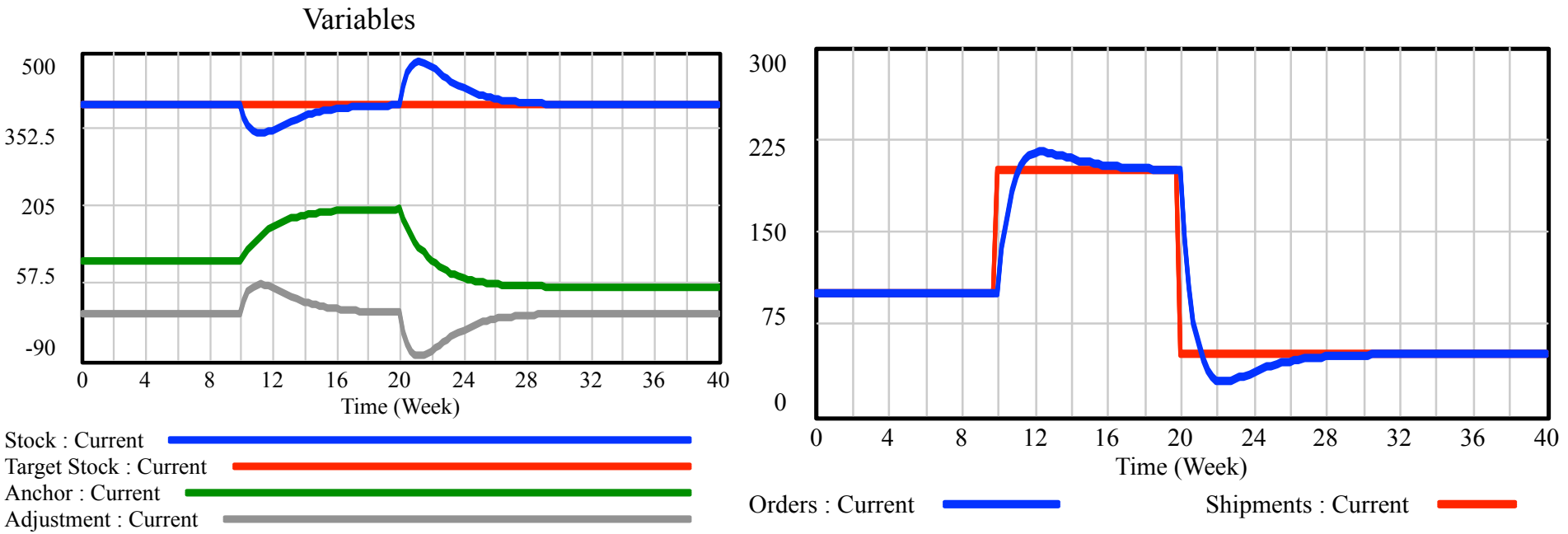


Demand = 100+Step(100,10)





Demand = 100+Step(100,10) – Step(150,20)



Challenge 6.2

For a software organization, the desired number of programmers is one per €100,000 of expected revenue per year. Based on this, construct a stock and flow model of staff recruitment (using the Stock Management Structure) that takes the following into consideration:

There are three kinds of programmer: Rookie, Experienced and Expert.

All hires are done at the Rookie level, and programmers progress from there with an average delay of 50 weeks for rookies, and a delay of 150 weeks before experienced become expert.

On average, there is attrition from each programmer category. This is 5% for Rookies, 2% for Experienced and 1% for Expert.