CT561: Systems Modelling & Simulation

Lecture 8: Stock Management

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https://github.com/JimDuggan/SDMR

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Recap

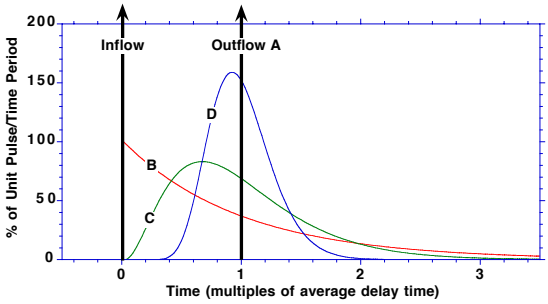
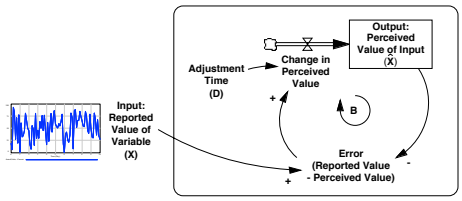


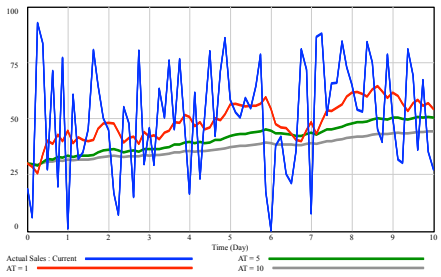
Figure 11-2 Some distributions of the outflow from a delay

The input I all cases is a unit pulse at time zero. Outflow A is a pipeline delay in which all items arrive together exactly 1 delay time after they enter.

Outflow distributions B-D exhibit different degrees of variation in processing times for individual items so some arrive before and some after the average delay time. In all cases the average delay time is the same and the areas under each distribution are equal.



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



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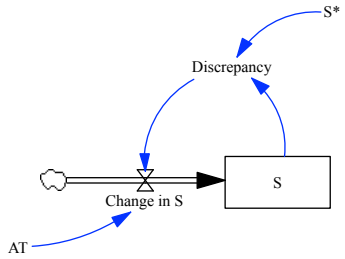
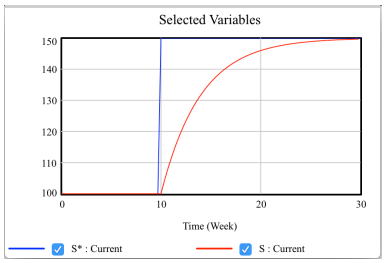
A familiar structure…

- Managers often seek to adjust the state of the system until it equals a goal or desired state.
- The simplest form of this negative feedback is
  - R_I = Discrepancy/AT = (S^* - S)/AT





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Observations on Goal Adjustment

- "**Desired** minus **actual** over **adjustment time**" is the classic linear negative feedback system. (Sterman 2000).
- Examples:
  - **Change in Price** = (Competitor Price – Price)/Price Adjustment Time
  - **Heat Loss from Building** = (Outside Temperature – Inside Temperature)/Temperature Adjustment Time
  - **Net Hiring Rate** = (Desired Labour – Labour)/Hiring Delay
- However, what happens if there is an outflow to the stock?

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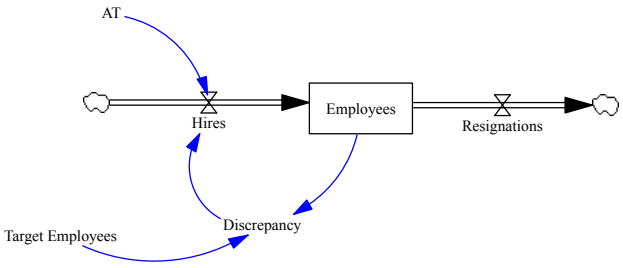
Model behaviour over time?



AT = 2

Discrepancy = Target Employees - Employees

Employees = INTEG(Hires - Resignations , 100)

Hires = Discrepancy / AT

Resignations = {0,10,50}

Target Employees = 100 + step (50, 6)

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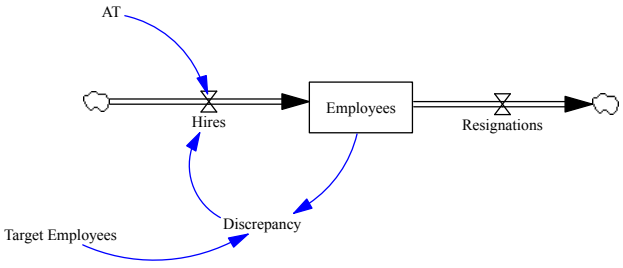
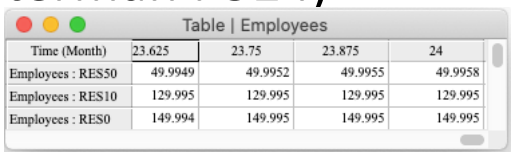
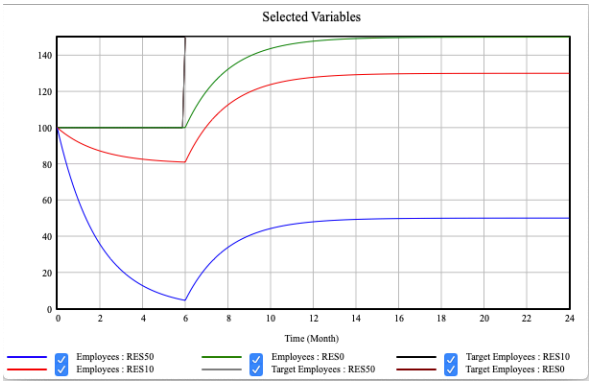
Steady State Error (Sterman P524)







When will the stock be in equilibrium?

When Hires == Resignations

$(E^* - E)/AT = R$
$(E^* - E) = R * AT$
$E = E^* - R * AT$

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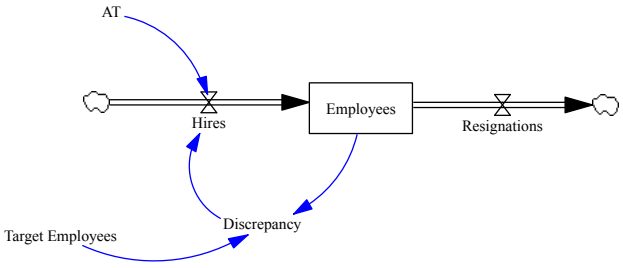
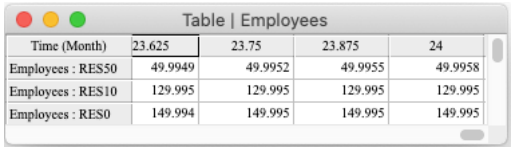
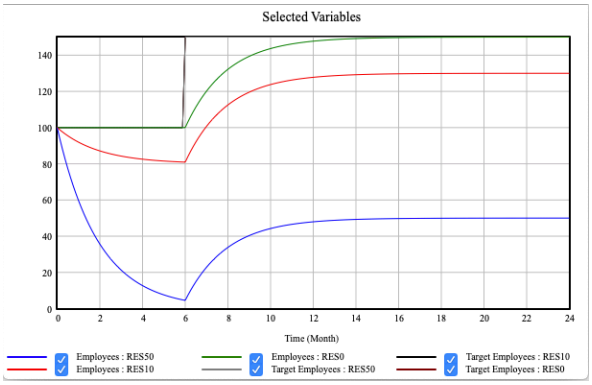
Steady State Error (Sterman P524)







$E = E^* - R * AT$

E^*	R	AT	E
150	0	2	150
150	10	2	130
150	50	2	50

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Challenge 8.1

- Explore the steady state error in Vensim
- Confirm the equation $E = E^* - R * AT$

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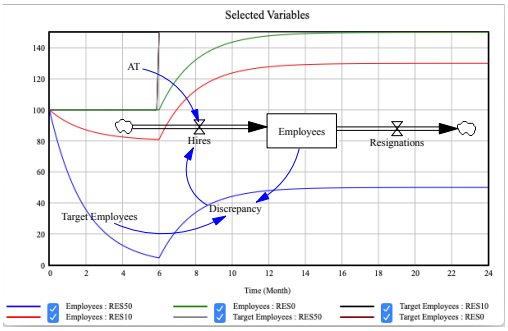
How to Manage?

$E = E^* - R * AT$

E^*	R	AT	E
150	0	2	150
150	10	2	130
150	50	2	50



- Where there is an outflow, the equilibrium will be less than the goal
- The larger the outflow, the greater the equilibrium shortfall will be
- To manage this, we need to account for the expected outflow to prevent this steady state error
- This is can be achieved using the stock management structure

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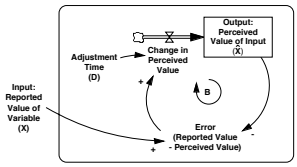
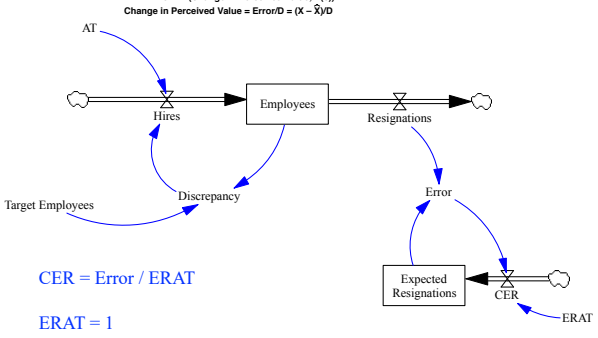
Add Expected Losses



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



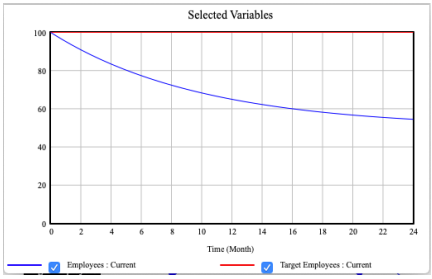
CER = Error / ERAT

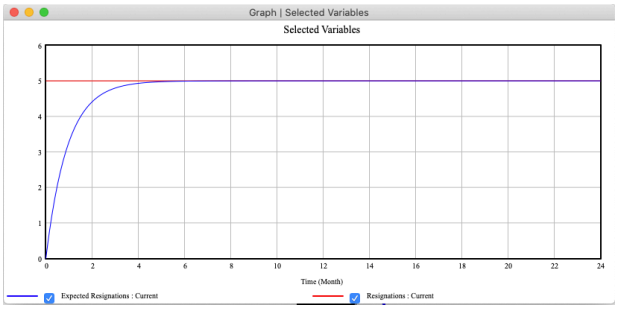
ERAT = 1

Error = Resignations - Expected Resignations

Expected Resignations = INTEG(CER , 0)

Resignations = 5





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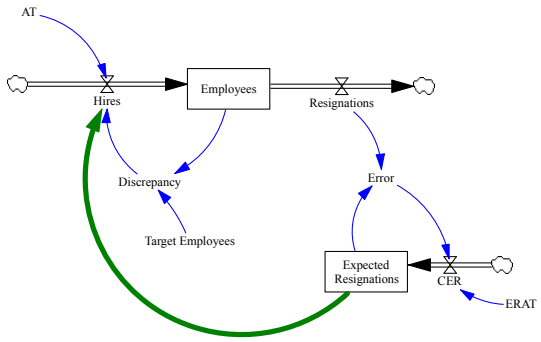
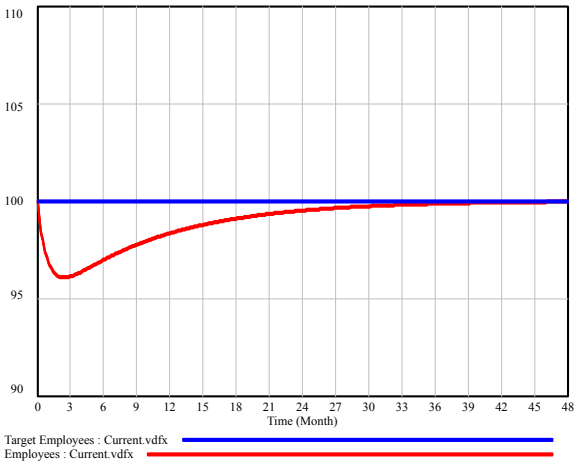
Account for this in the inflow – Stock reaches its goal

Stock Management Structure



Hires=max(0,**Expected Resignations**+Discrepancy/AT)



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Challenge 8.2

- Explore the steady state solution in Vensim
- Show that the state reaches the goal in steady state

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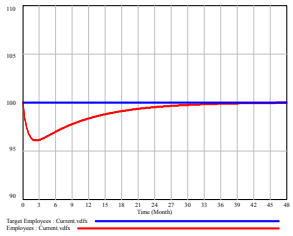
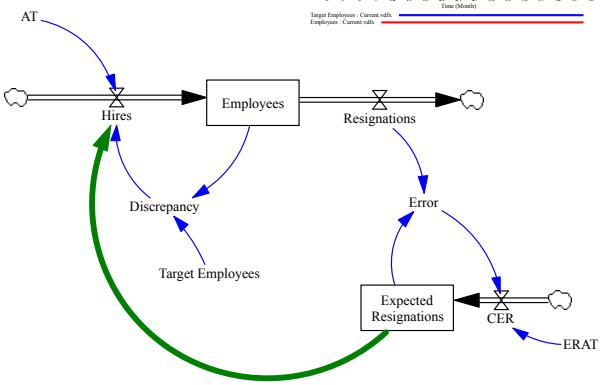
Rules for managing a stock
Anchor and *Adjustment*



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



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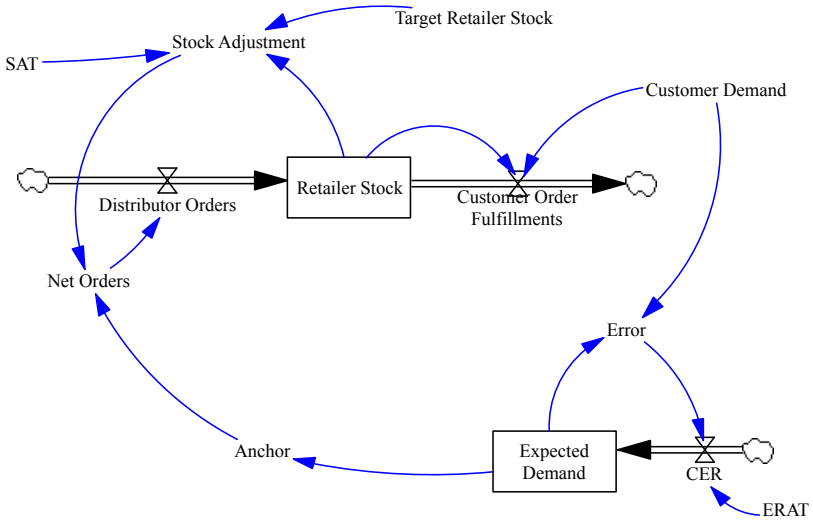
The Stock and Flow Model



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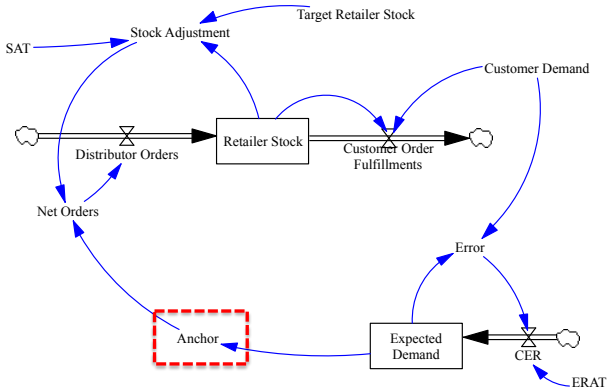
Stock Management: The anchor



Anchor=Expected Demand

CER=Error/ERAT

Customer Demand=100+step(100,30)-step(150,60)

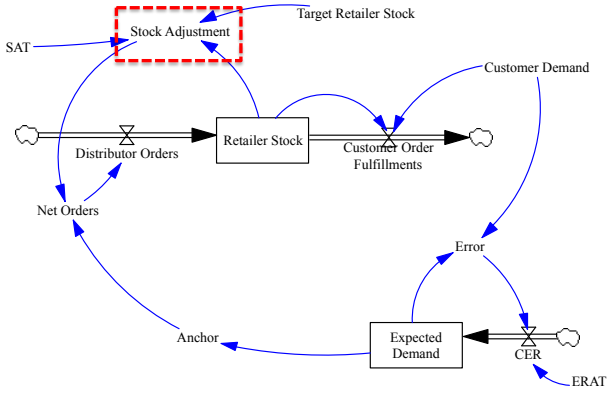
ERAT=5

Error=Customer Demand-Expected Demand

Expected Demand= INTEG (CER,100)

Managers should replace expected losses from the stock

Stock Management: The adjustment



SAT=3

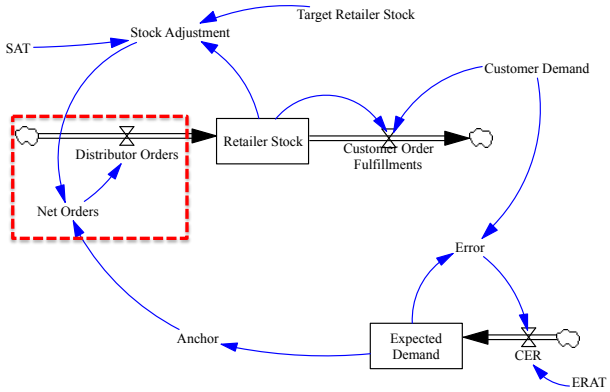
Stock Adjustment= (Target Retailer Stock-Retailer Stock)/SAT

Target Retailer Stock=400

Retailer Stock= INTEG (Distributor Orders-Customer Order Fulfillments, 400)

Managers should reduce the discrepancy between the desired and actual stock

Stock Management: Decision Rule

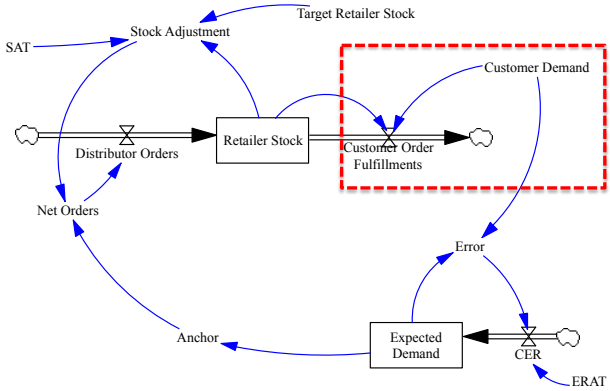


Distributor Orders= max(0,Net Orders)

Net Orders =Anchor + Stock Adjustment

The ordering amount requested for each time (non-negative)

Stock Management: Order Fulfillment

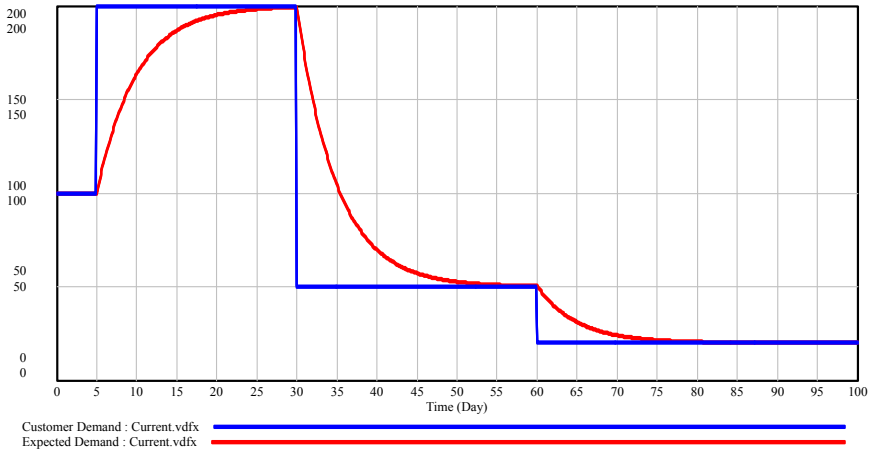


Customer Demand=
100+step(100,5)-step(150,30)-step(30,60)

Customer Order Fulfillments=
min(Customer Demand,Retailer Stock)

Order fulfilment fulfils all demand, constrained by the stock availability

Demand and Expected Demand



Expected demand is driven by actual demand (information smoothing)

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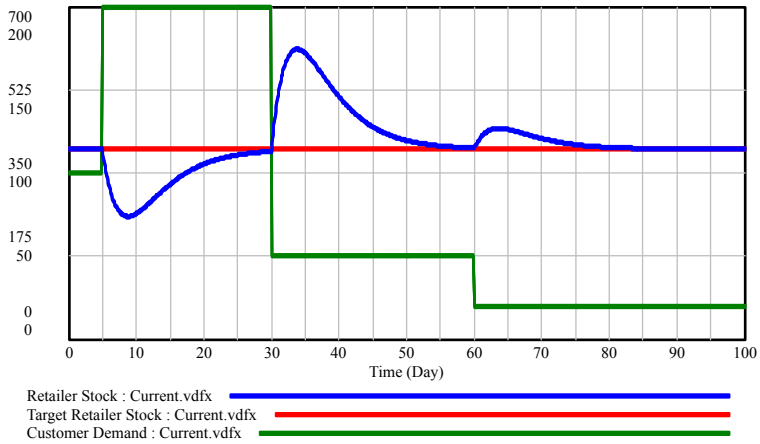
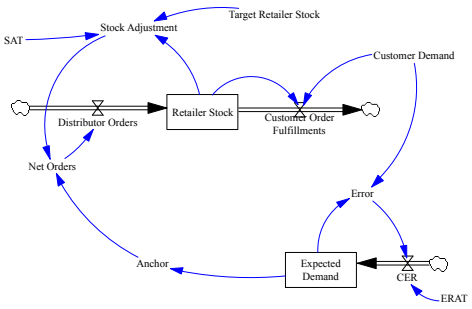
Stock and Target Stock





1. *Step in demand leads to a reduction in stock – Reduction leads to increased adjustment*
2. *Reduction in demand leads to surplus in stock, which then declines to target level*

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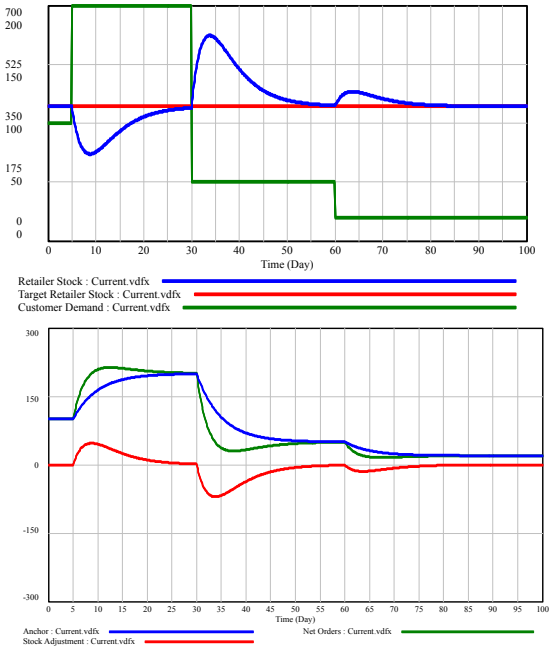
Anchor, Adjustment and Net Orders

1. *Adjustment is positive with a stock deficit compared to target.*
2. *Adjustment is negative with a stock surplus compared to target*
3. *Anchor always approaches true demand (it is expected demand)*
4. *Net orders are the sum of anchor plus adjustment*
5. *Stock reaches its target value*



Summary: ***Anchor*** and ***Adjustment***

- Managers should replace <u>expected losses</u> from the stock **(the anchor)**
- Managers should <u>reduce the discrepancy</u> between the desired and actual stock **(the Adjustment).** Acquire:
  - more than the expected losses when the stock is less that the desired,
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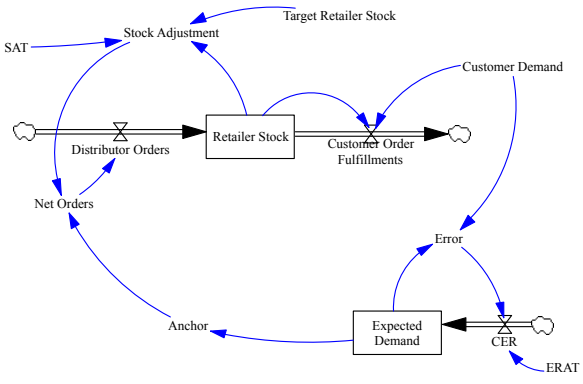

Challenge 8.1

Use the stock management structure to build a stock and flow model (with equations) of employee hiring and progression through a software organisation (assume that only Rookies are hired).

There are two kinds of employees: (1) Rookies who are hired and (2) Experienced, who transition from Rookies after a first order time delay of 150. The Rookie quit rate is 10%, and the Experienced quit rate is normally 5%.

Discuss how different values for the hiring adjustment time would impact the number of Rookies in the organisation.

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Challenge 8.2

7. Formulate equations for the following description:

   The number of rookies in the organisation impacts the quit rate of experienced employees. If the number of rookies exceeds a reference value of 30%, the quit rate will rise, and if it falls below the reference value, the quit rate will fall.

   The normal quit rate is 5%. The overall quit rate has a maximum value of 10%, and a minimum value of 3%.

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