$$\boxed{P} \rightleftharpoons \boxed{F} \rightleftharpoons \boxed{B}$$

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$$\frac{dA}{dt} = \underline{\underline{K}} A + Q\, C_p(t)$$

$$\begin{bmatrix} \dot{F} \\ \dot{B} \end{bmatrix} = \begin{bmatrix} -k_2 - k_3 & k_4 \\ k_3 & -k_4 \end{bmatrix} \begin{bmatrix} F \\ B \end{bmatrix} + \begin{bmatrix} K_1 \\ 0 \end{bmatrix} C_p$$

$$A(t) = U_n' A = [1\ 1] \begin{bmatrix} F \\ B \end{bmatrix} = F + B$$

integrate both sides

$$A = \underline{\underline{K}} \int \underline{A}\, dt + \underline{Q} \int C_p(t)\, dt$$

$$\underbrace{\underline{\underline{K}}^{-1} A}_{\text{column vector}} = \int A\, dt + \underline{\underline{K}}^{-1} \underline{Q} \int C_p\, dt$$

Sum components on both sides.

$$U_n' \underline{\underline{K}}^{-1} A = U_n' \int A\, dt + U_n' \underline{\underline{K}}^{-1} Q \int C_p\, dt$$

rearrange.

$$U_n' \int A\, dt = -U_n' \underline{\underline{K}}^{-1} Q \int C_p\, dt + U_n' K^{-1} A$$

in Logan terminology $ROI(t) = U_n' A + V_p C_p$

so $\int ROI\, dt = \int U_n' A\, dt + V_p \int C_p\, dt$

$$\int U_n' A\, dt = \int ROI\, dt - V_p \int C_p\, dt.$$

substitute ...

Substitute for $\int U_n' \cancel{A}\, dt$ and move V_p to right (2)

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$$\int ROI\, dt = \left(-U_n' \underline{\underline{K}}^{-1} Q + V_p\right) \int C_p\, dt + U_n' \underline{\underline{K}}^{-1} A$$

divide by $U_n' A + V_p C_p = ROI(t)$

$$\frac{\int_0^T ROI(t)\, dt}{ROI(T)} = \left(-U_n' \underline{\underline{K}}^{-1} Q + V_p\right) \frac{\int_0^T C_p(t)\, dt}{ROI(T)} + \frac{U_n' \underline{\underline{K}}^{-1} A}{U_n' A + V_p C_p}$$

for $t > t^*$

$$\frac{U_n' \underline{\underline{K}}^{-1} A}{U_n' A + V_p C_p}$$ is constant.

occurs when $\frac{A}{C_p} = R$ const.

Show paper difference

assume $U_n' A + V_p C_p \propto C_p$ after t^*

$$= U_n' \begin{bmatrix} R_1 \\ R_2 \\ \vdots \end{bmatrix} C_p + V_p C_p$$

$$\equiv R_0 \cdot C_p$$

divide both side by C_p instead of ROI

so $\therefore$ Where $C_p =$

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Zhou divides by $C_p(T)$

$$\frac{\int_0^T ROI(t)\,dt}{C_p(T)} = \left(\cancel{\ }U_n' \underline{\underline{K}}^{-1} Q + V_p\right) \frac{\int C_p(t)\,dt}{C_p(T)} + \frac{U_n' \underline{\underline{K}}^{-1} A}{C_p}$$

but he assumes that $A = \begin{bmatrix} F \\ B \\ \vdots \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \end{bmatrix} C_p$

or .. $\cancel{\frac{A}{C_p} = \begin{bmatrix} R_1 \\ R_2 \end{bmatrix}}$ $\underline{R} = \begin{bmatrix} R_1 \\ R_2 \end{bmatrix}$

$$\Rightarrow \frac{\int ROI(t)\,dt}{C_p(T)} = \left(-U_n' \underline{\underline{K}} Q + V_p\right) \frac{\int C_p(t)\,dt}{C_p(T)} + U_n' \underline{\underline{K}}^{-1} \underline{R}$$

So where did $\begin{bmatrix} R_1 \\ R_2 \end{bmatrix}$ go in y, mx terms?

doesn't matter as long as we plot

$$\frac{\int_0^T ROI(t)\,dt}{C_p(T)} \quad vs \quad \frac{\int C_p(t)\,dt}{C_p(T)}$$

only thing that changes on plot is intercept.

Questions.

1. why less noise than Logan plot. ?

2. What about 'validating approp conditions' is different from Logan plot.

3. Why didn't Zhou say that Logan had proposed this eqn in 2003.

(She thought t^* would be later and thus x-out more data)