Measurement vs Reporting

Levers to Improve Management of Commons[1]

Saeed P. Langarudi, Carlos Silva, and Alexander Fernald

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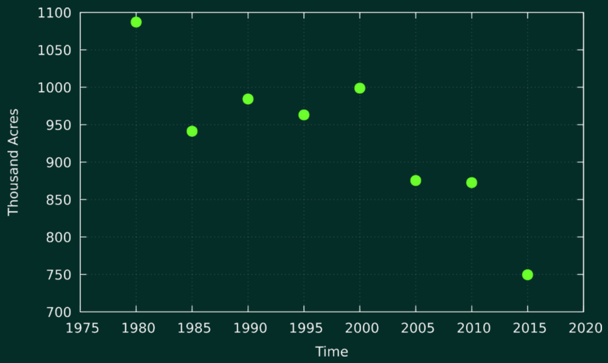
[1] 2021. System Dynamics Review, 37(1), 72-92.

It costs to measure and report!

NM water use data measured every 5 years and reported with ~4 years delay



Example data – irrigated acreage in New Mexico, 1980-2015 [Magnuson et al., 2019, tab. 3.2].

- Latest data point could get as old as 9 years!

Questions

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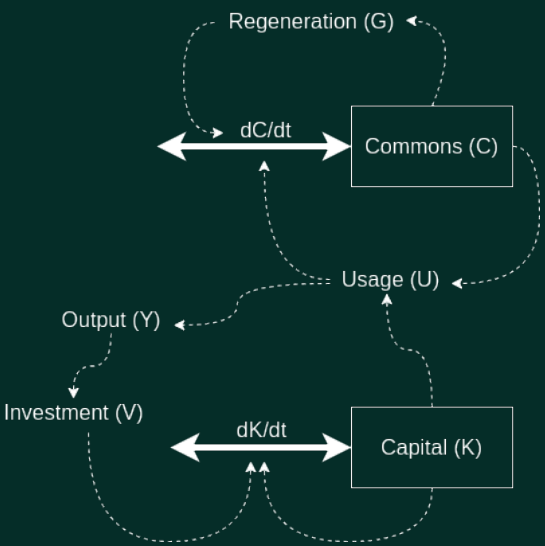
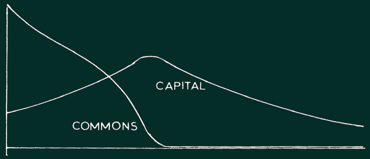
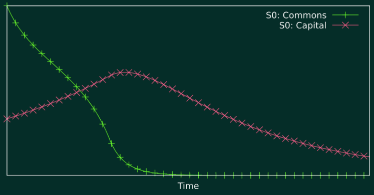
  - Added delays deteriorate misperceptions and undermine management performance [Moxnes, 1998, Moxnes, 2004].
- Where should the limited resources be invested to enhance behavior?

Base model [Anderson, 1974]



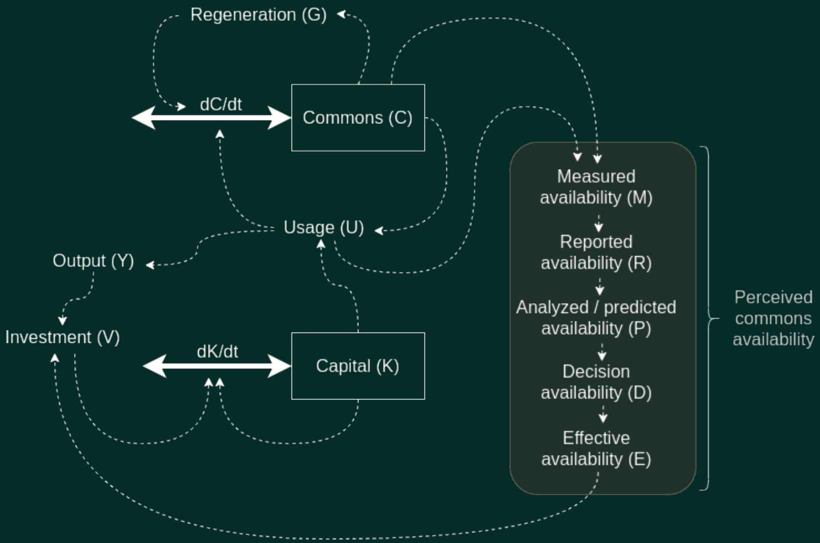


Original simulation [Fig. 3.a]

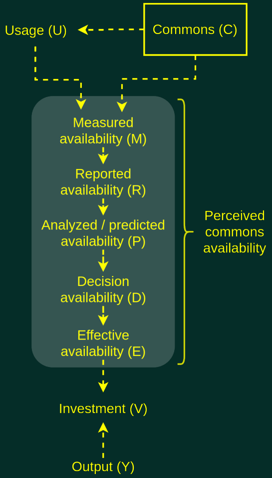


Replicated simulation

Extended model



Information perception



- $M_t = \frac{C_t}{U_t} \div \frac{C_0}{U_0}$

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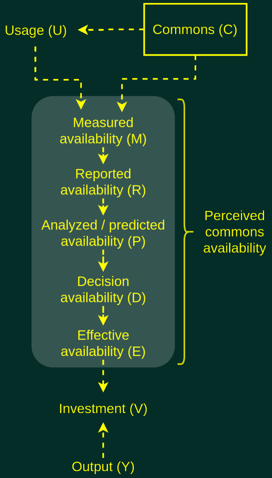

- $M_t = \frac{C_t}{U_t} \div \frac{C_0}{U_0}$
- $R_t = \begin{cases} M_{\max(0,t-\frac{\rho}{\mathrm{d}t})}, \frac{\rho}{\mathrm{d}t} \in \mathbb{Z} & \text{if } t \bmod \omega = 0 \\ R_{t-dt} & \text{otherwise} \end{cases}$

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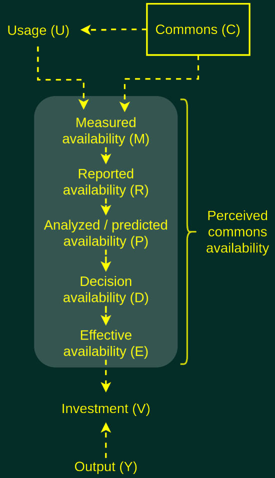

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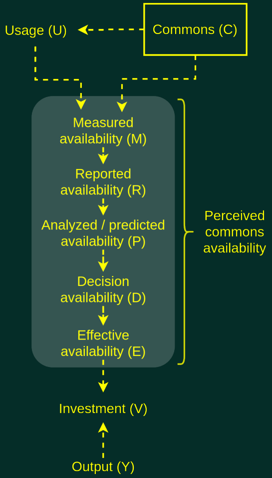

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- $P_t = R_t$
- $D_t = P_t$

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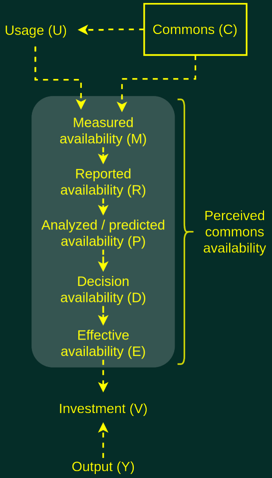

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- $D_t = P_t$
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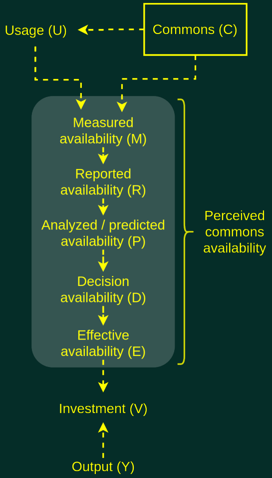
Information perception



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- $P_t = R_t$
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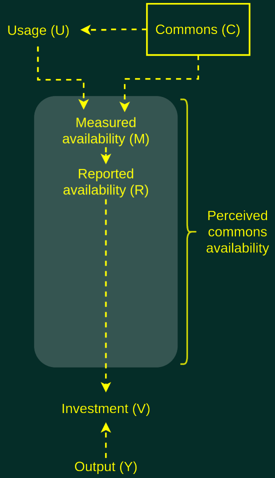
- $V_t = \delta Y_t E_t$

Partial information perception



- $M_t = \frac{C_t}{U_t} \div \frac{C_0}{U_0}$
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- ~~$P_t = R_t$~~
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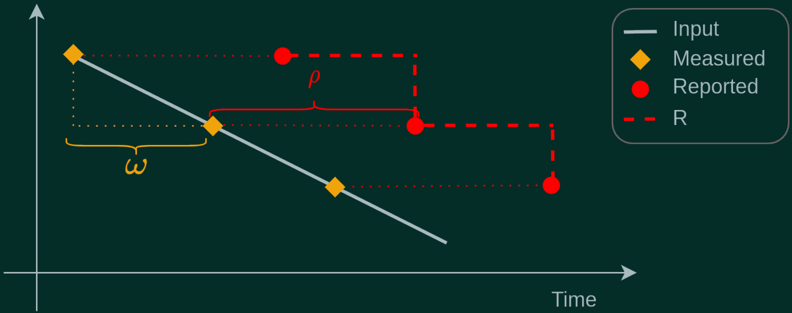
Reported availability (R_t)

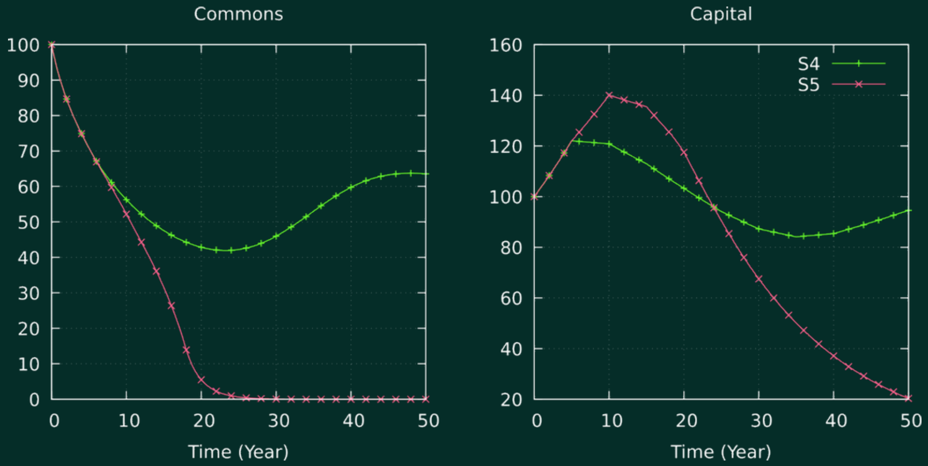
$$R_t = \begin{cases} M_{\max(0, t-\frac{\rho}{dt})}, \frac{\rho}{dt} \in \mathbb{Z} & \text{if } t \bmod \omega = 0 \\ R_{t-dt} & \text{otherwise} \end{cases}$$



Measurement interval (ω), reporting delay (ρ)

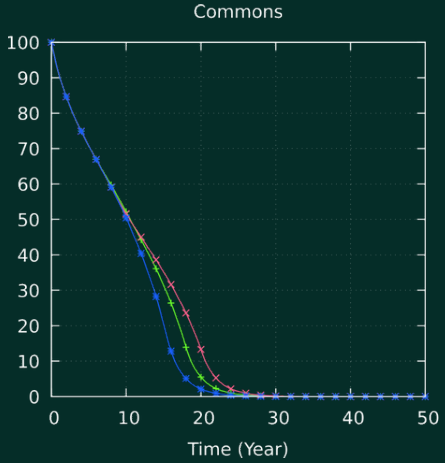
Measurement and reporting bias

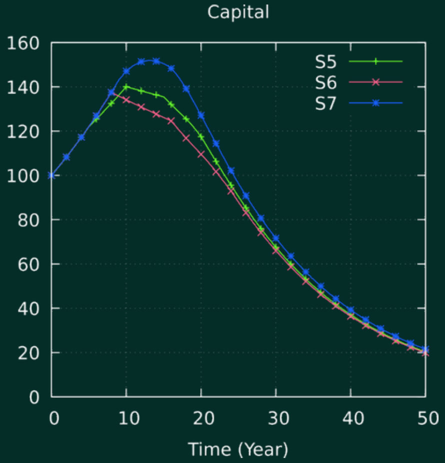
- S4: $\omega + \rho = 5$
- S5: $\omega + \rho = 9$



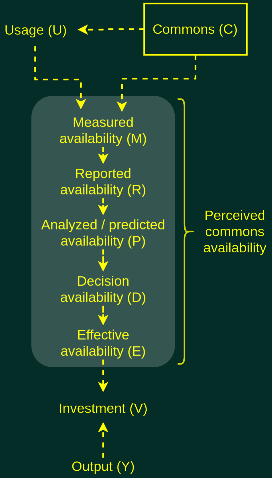
More measurement vs faster reporting

- S6: $\omega = 8, \rho = 1$ (faster reporting)
- S7: $\omega = 1, \rho = 8$ (more measurement)





Results are robust!



- $E_t = \frac{1}{\psi} \int (D_t - E_t)$
- $D_t = 1 - \dfrac{1 - P_t}{(P_t + 1)^{\zeta}}$
- $P_t = R_t \left(1 + \varphi \dfrac{R_t - Q_t}{\kappa Q_t}\right)$
- $Q_t = \frac{1}{\kappa} \int (R_t - Q_t)$
  - Q: historical average of reported availability (R)

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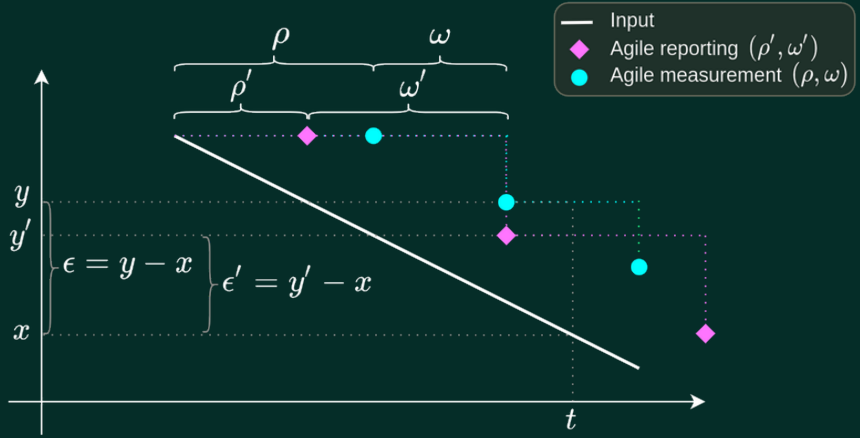
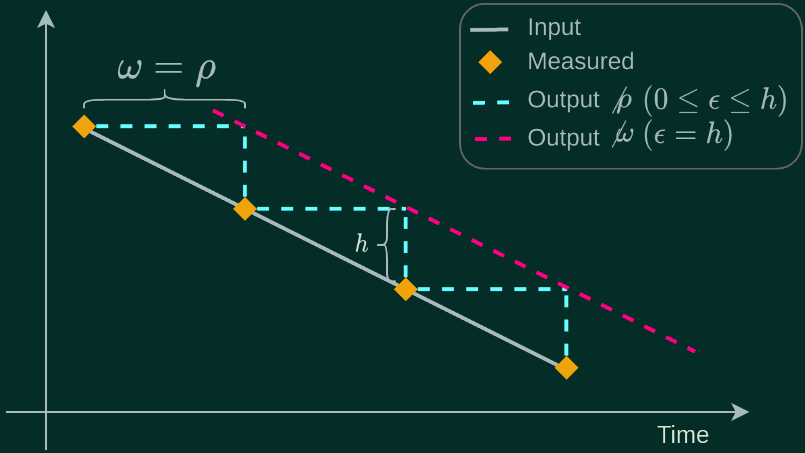
Why faster reporting pays off better?



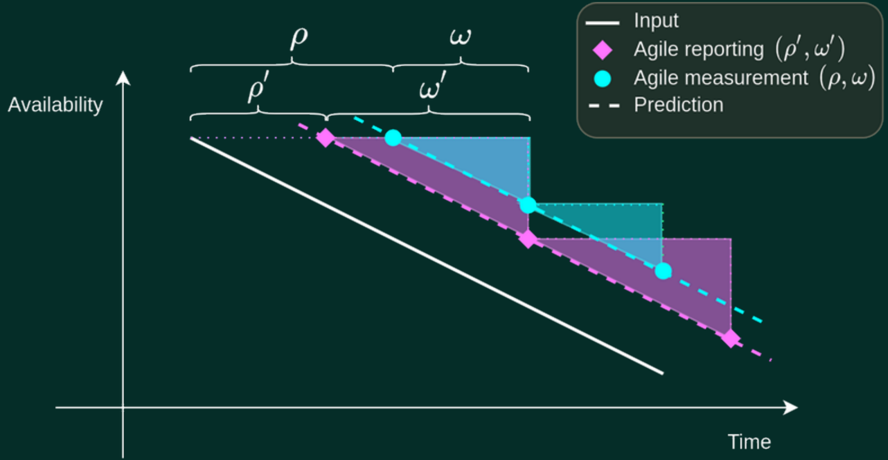
Faster reporting generates less perception error than more measurement; measurement interval (ω), reporting delay (ρ)

Extreme case example



Measurement interval (ω), reporting delay (ρ)

Effect of forecasting



Forecasting has a greater impact in a system with a relatively quicker reporting; measurement interval (ω), reporting delay (ρ)

Conclusion

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- Oscillatory systems need flexible resource allocation switching priority between measurement and reporting depending on the trends.
- Forecasting is more effective in a system that has relatively faster reporting.
- Results remain robust under relaxed assumptions.

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Thank You!