Space Debris and Collision Risk in the Orbital Commons

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Motivation

Research questions

What do we know?

Framework

- Satellite and debris accumulation,

$$S_{t+1} = S_t(1 - L(S_t, D_t)) + X_t$$
$$D_{t+1} = D_t(1 - \delta) + G(S_t, D_t) + \mu_L X_t$$

- Discrete time dynamic optimization: launch today if discounted stream of satellite returns starting tomorrow is larger than the launch cost
- Perfect competition, constant returns, immortality, and open access
- We compare open access to a sole owner of the entire fleet
- Kessler syndrome is occurring if $\kappa(D_t) > 0$, where

$$\kappa(D_t) = -\delta D_t + G(0, D_t)$$
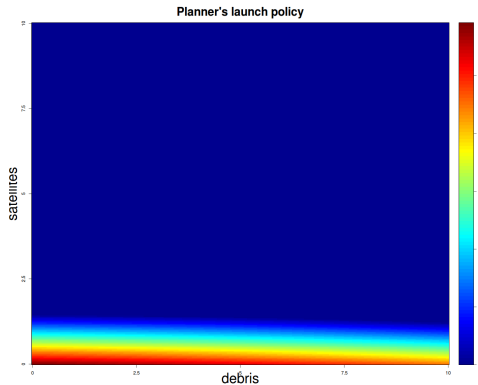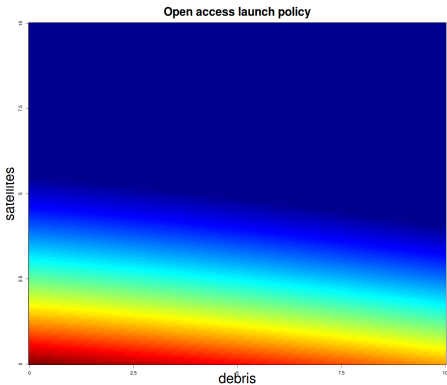
A firm's problem

Words

Equilibrium condition

The fleet owner's problem

Words

Optimality condition

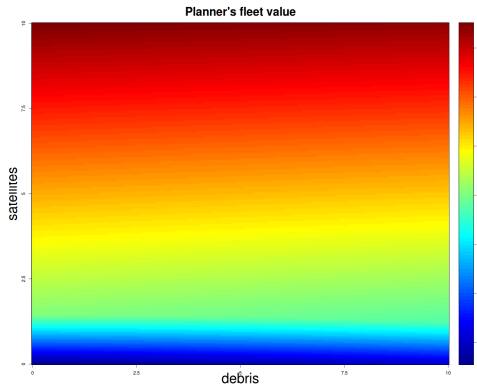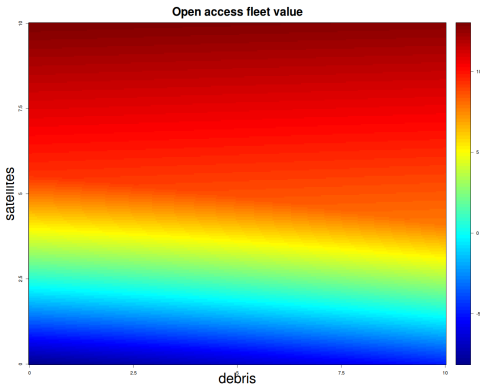# Open access and optimal incentives to reduce congestion

Open access firms respond to risk, but not optimally: they don't
internalize the risks their own satellites pose

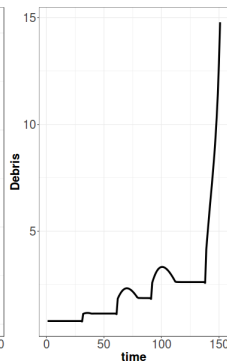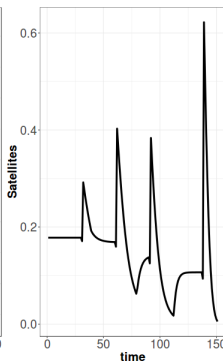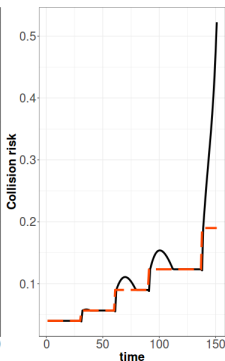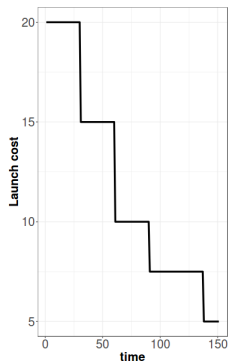# Open access and optimal incentives to reduce congestion

Open access fleets are too large and not as valuable; higher debris stocks are costlier

Lower costs and Kessler syndrome under open access

Proposition 10

All else equal, sustained decreases in launch costs will eventually cause Kessler syndrome

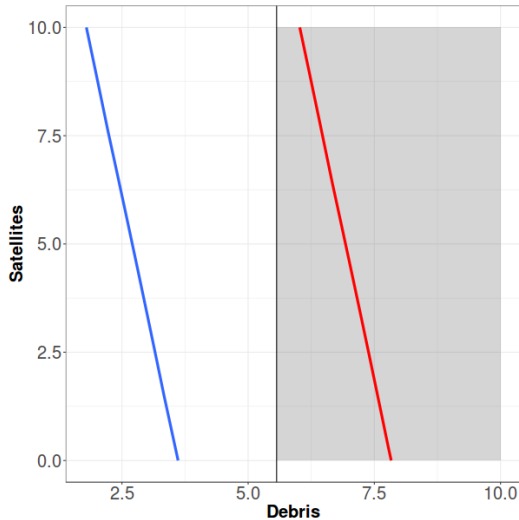# Lower costs and Kessler syndrome under open access

Open access: Launch until
        risk = excess return

Launch cost ↓
    ⟹ excess return ↑
    ⟹ eqm set shifts →
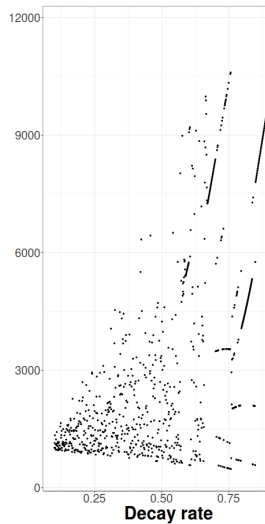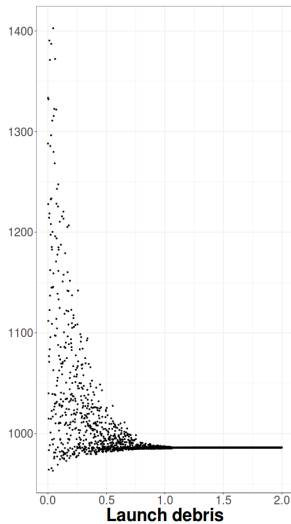
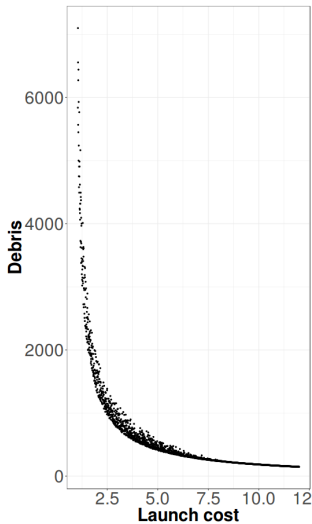Eqm set will eventually be
pushed to Kessler region

Open access dynamics: instability

../images/decay_increase_1.png

Open access dynamics: instability

Orbit management is an economic problem

1. Launch rates and debris are endogenous
   - Modeling debris with exogenous launch is looking at the symptoms and ignoring the cause
2. Open access is an inefficient way to manage orbits
   - Not just debris, too many satellites
3. Congestion creates incentives to limit debris growth, but not enough
   - Open access can cause Kessler syndrome in LEO

Thank you!

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