Market Models of Security Investments with Shared Spectrum [2]

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SPECTRUMX

BACKGROUND

Security is a critical concern in shared spectrum environments, where attacks can degrade service and influence market interactions between competing service providers (SPs).

Hence, SPs can be incentivied to make investments in security, in either competitive or collaborative way.

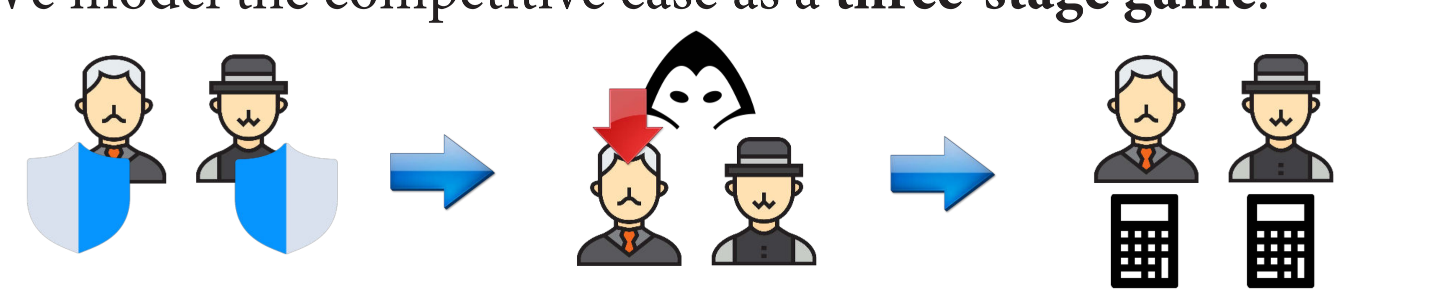
RESEARCH QUESTION

We aim to examine the market implications of attacks and investments. In our research, we endeavor to address:

- What constitutes an SP's **optimal strategy**?
- How do attacks and investments affect the **market dynamics**?
- What are the distinctions between **competitive** and **collaborative** cases?

METHODS AND MATERIALS

- Based on our previous work in [1], which shows the attacker has incentive to **attack only one SP** for better gain.
- We assume the licensed shared bandwidth with **intermittent availability**.
- We model the competitive case as a **three-stage game**:



First Stage the two SPs decide the investment levels.

Second Stage the attacker decides how to attack.

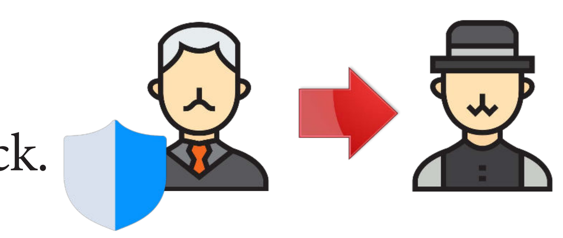
Third Stage the SPs decide on the quantity of consumers to serve.

- We model the collaborative case as an optimization problem.

RESULTS

The investments have two potential influences:

Protect itself against the attack.



Switch the attack to the other.

Competitive case:

- Each SP minimizes its revenue loss plus investment cost, as a function of investment level and attack power:

$$\min_{I_i} R_{i,loss}(I_i, q_i) := \Delta R_i + C_i(I_i)$$

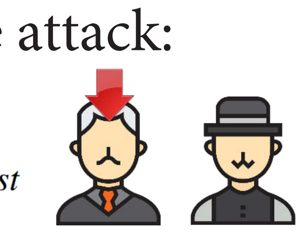
- Let $I_{i,best}$ be the optimal investment for SP i if it is attacked. The investment level of an SP to switch the attack is:

$$I_{i,sw}(I_{-i}) = \max\left(0, 1 - M_{i,\text{switch}}(1 - I_{-i})\right)$$

where $M_{i,\text{switch}}$ is a constant related to bandwidth amount.

- Suppose SP1 is initially targeted, the **following are possible equilibria**:
  - SP1 cannot switch the attack:

$$I_1 = I_{1,best} \qquad I_2 = 0$$



  - When SP2 invests $I_{2,best}$, SP1 can switch the attack:

$$I_1 = I_{1,sw}(I_{2,best}) \qquad I_2 = I_{2,best}$$

- **Other combinations are not equilibria**, i.e., there will not be an equilibrium in which one SP would invest higher than its optimal level when the other decides to switch.

Collaborative case:

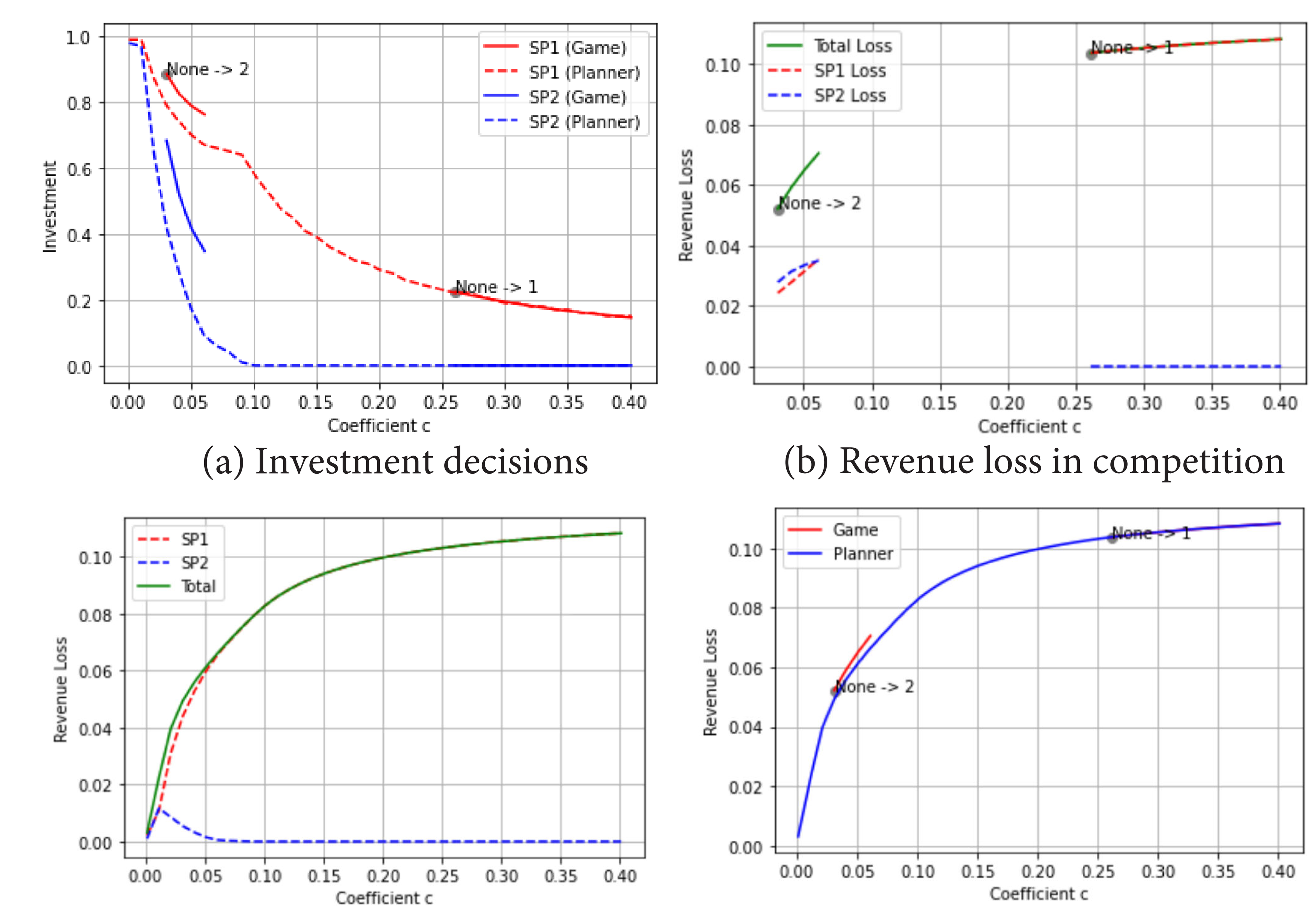
- A social planner seeks to solve:

$$\min_{I_1, I_2} \sum_i R_{i,loss}$$

- Can be solved as a mixed-integer non-linear program.

Key Results:

- Competition can result in **no equilibrium** and **over-investment** in security compared to that of a social planner.



(a) Investment decisions (b) Revenue loss in competition

(c) Revenue loss for planner (d)Revenue loss comapre

Fig.1 Equilibrium Outcome
(for linear cost function with coefficient c)

Future Work:

- Consider other spectrum sharing models, e.g. open access models, and other attack models.
- Extend to sequential competition.

ACKNOWLEDGEMENT

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REFERENCES

[1]Z. Xie, R. A. Berry, “Market Models of Spectrum Attacks with Shared Spectrum”, WiOpt 2023

[2]Z. Xie, R. A. Berry, “Market Models of Spectrum Attacks with Shared Spectrum”, DySPAN 2024