

Sharing of Fire Fighting Resources

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Joint work with Kate Larson and Rob Mcalpine

Resource Sharing

- Increasing demand for resource sharing
 - Changing climate trends
 - Tighter budget
 - Expanding urban interface
- Sharing essential in meeting challenges during emergencies



Our Work

- Interviews with agencies
 - British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Parks Canada, CIFFC
- Game theoretic model for resource sharing



Benefits of Sharing

- **Training** and **experience** for crews
- **Networking** within community
- **Morale** for crew and positive press
- Returning past **favors**
- Justifies **spending**



Deciding to Import

- **Forecast** essential
 - Outlook range from 4-5 days, to 10-14 days
- Crew **fatigue** (some provinces)
- Costs not a factor



- **Internal logistics** sometimes a barrier to importing
- **Informal calls** to CIFFC enables preplanning

Smaller Agencies and Exporting

- Logistics of assembling larger teams more challenging
- Assembling **regional teams** beneficial for smaller agencies
- Prefer **shorter commitments** to mitigate risk
 - Early release for crews when possible



Larger Agencies and Exporting

- Long term **fatigue** an issue for frequently exported crews
- Larger agencies tend to **evaluate** CIFFC requests
 - Prefer concrete assignments over speculative requests
- Smaller agencies take requests on **face value**



Other Considerations

- Equipment
- Aircraft
- Helicopters





Overall Thoughts

- **Standardization** of equipment and training
- Expanded training opportunity and information flow
- Helped build national fire **community**

- No interest in changing CIFFC significantly
- Vastly superior to systems in other countries
- Strong resistance against centralizing resources



Improvements

- Facilitate better understanding of how requests are prioritized
- Exchange of **Type 2** crews
- Encourage assembling **regional teams**
- Standardization of information systems and technology transfer

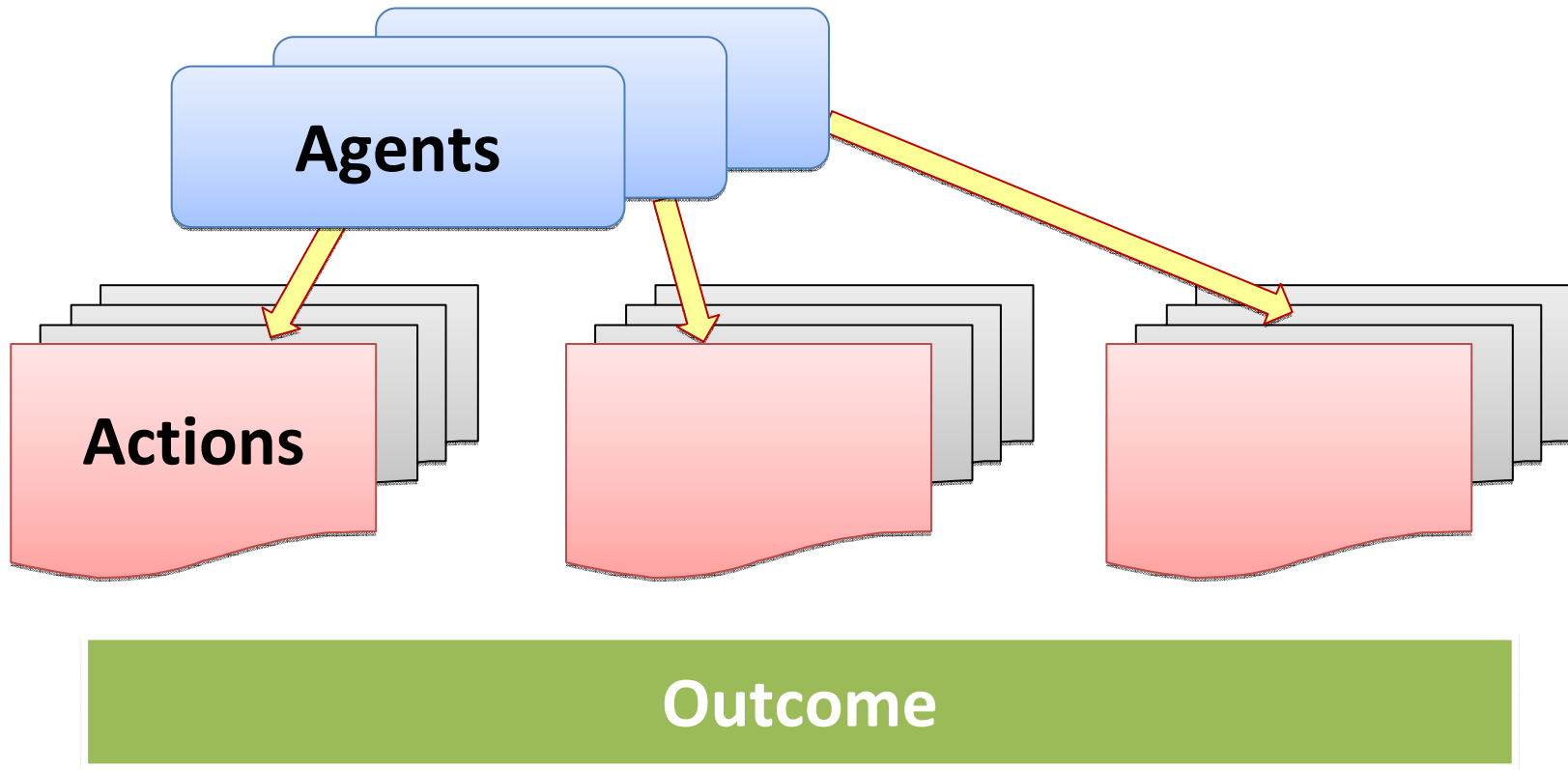


Process

- Daily report used as **rough indicator** of availability
- Prefer resources to come from **single** agency
- **Discourages “fishing expeditions”**
 - Unfair burden on lending agencies
- Delays can cause domino effect



Game Theory



Utilities



Payoff (\$)

El Farol Bar



Sante Fe
Population 100



El Farol Bar



Home

El Farol Bar



Sante Fe

Population 100



El Farol Bar

Max Capacity 40



Home

El Farol Bar

Agents

Community of 100

Actions



Bar



Home

Outcome

Utilities

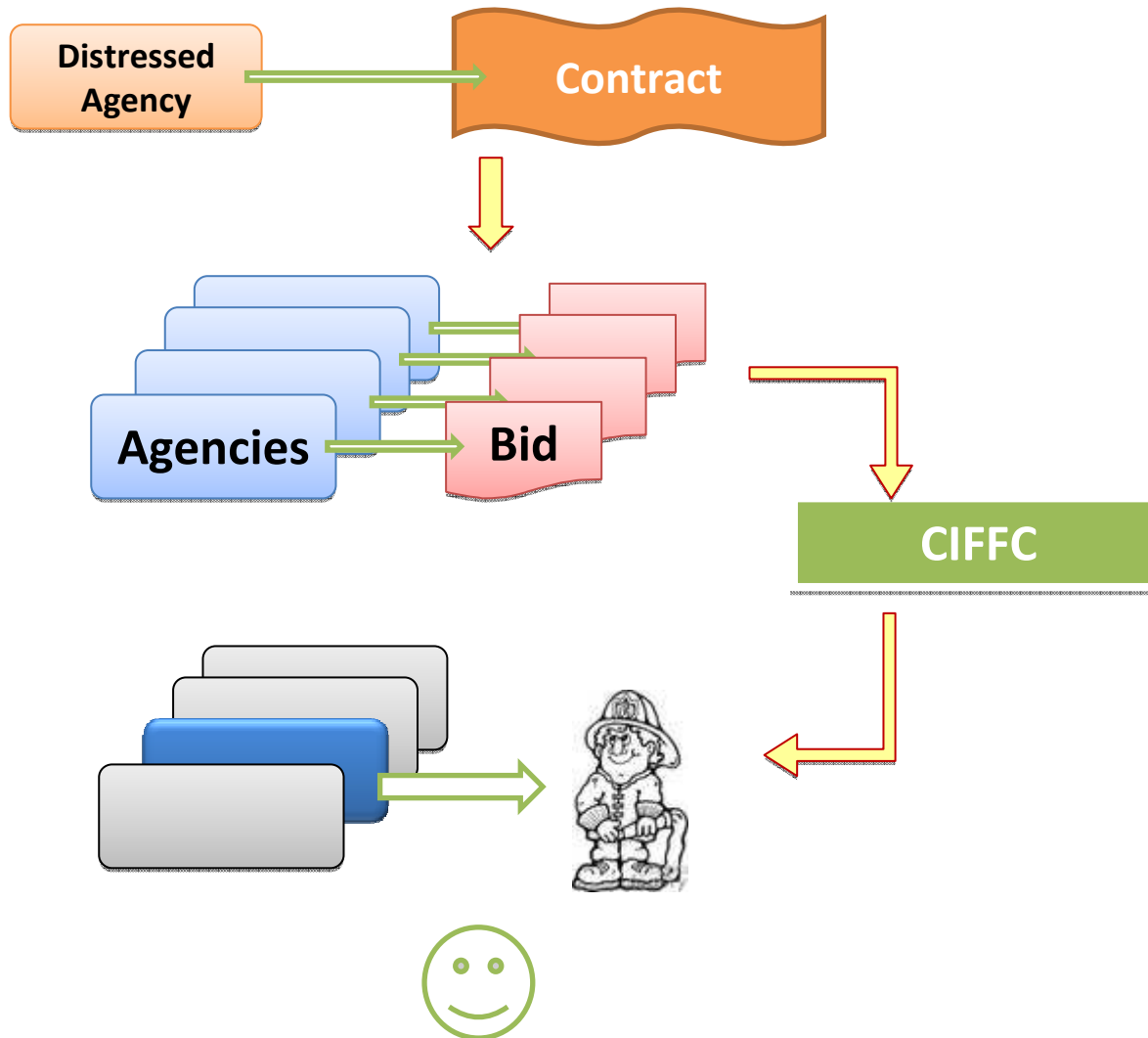
40+ @ Bar



< 40 @ Bar



Resource Sharing Model



Agency Utility

Bid

Non-exporting

Exporting Agency



+ Social Goodwill

+ Cost Benefit

- Added Fire Risk

- Search Cost

- Search Cost

Utility

Utility

Expected Utility

Bid

Non-exporting

Exporting Agency



+ Social Goodwill

+ Cost Benefit

- Added Fire Risk

- Search Cost

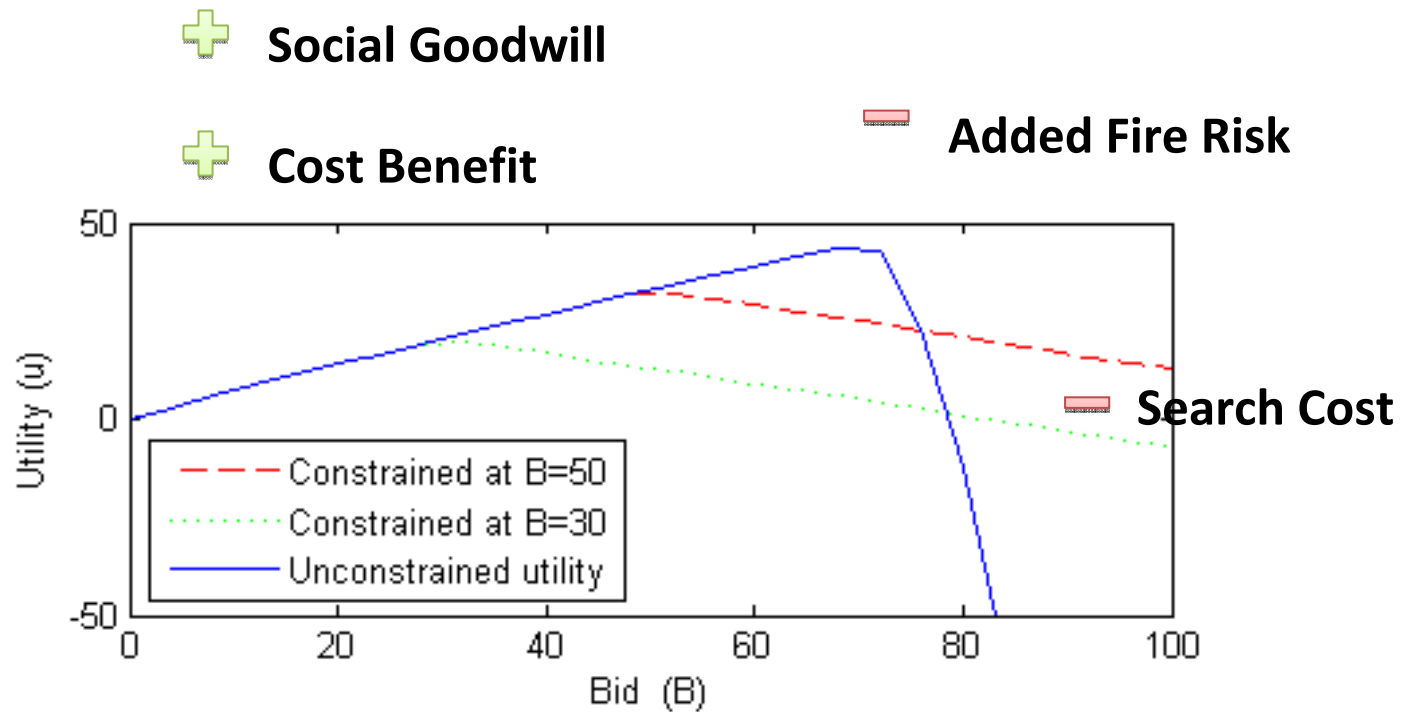
- Search Cost

× Chance

× Chance

Expected Utility

Expected Utility



Selection Process

Simplified version:

1. Agencies **prioritized** by distance (or other criteria)
2. Closest agency with **bid \geq contract** fills it
3. Fill **partial** bids in order of priority



Selection Process

Position in priority queue

=> Probability distribution on available contract



Knowledge of preferences of **other agents** very useful!

Conclusions

- **Strong support** for CIFFC
- Strategizing in **effort** towards guaranteeing resource availability
- Selection process **key**



~ **FIN** ~

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<https://cs.uwaterloo.ca/research/tr/2012/CS-2012-11.pdf>



El Farol Bar

Agents

Actions

Outcome

40+ @ Bar

< 40 @ Bar

Optional Symmetric Strategy

Community of 100



Bar



Home

Utilities



40%

Randomize

60%

Other Considerations

Equipment

- Varies by time of year

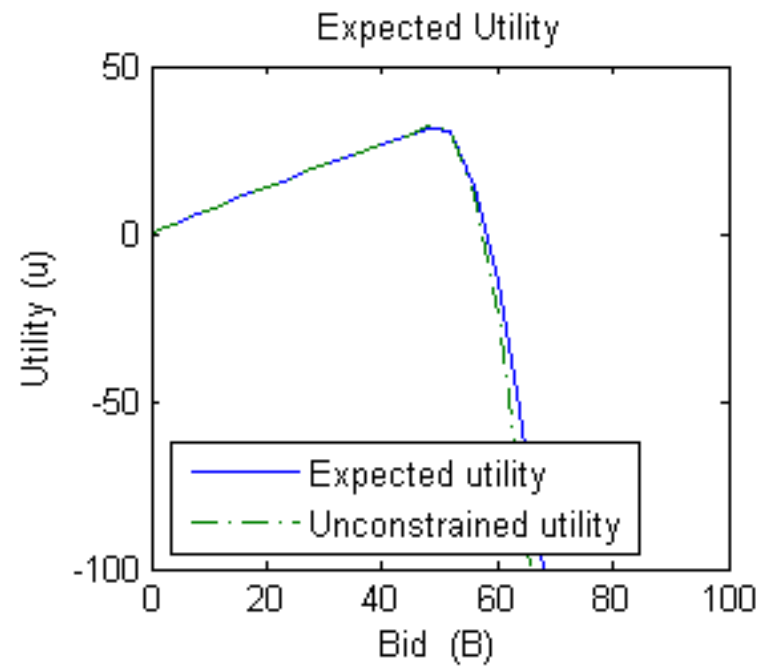
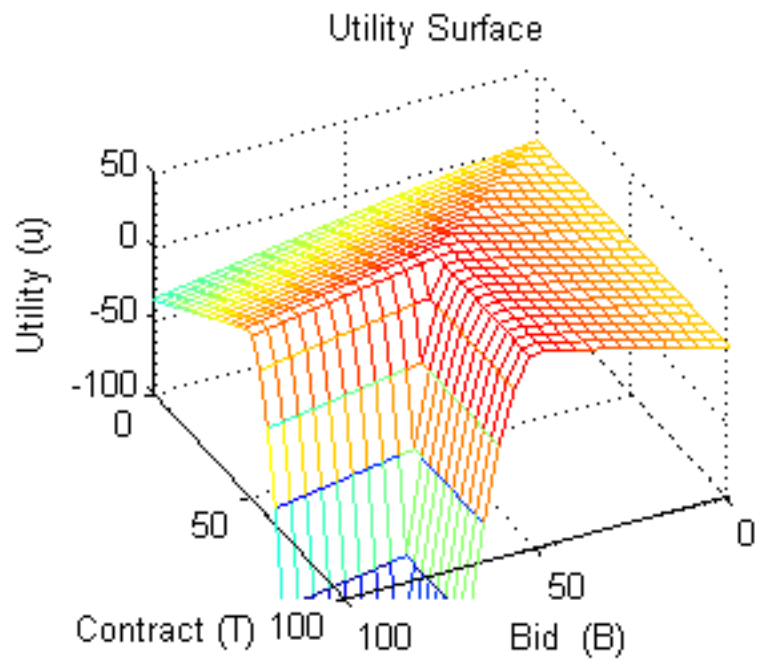
Aircraft

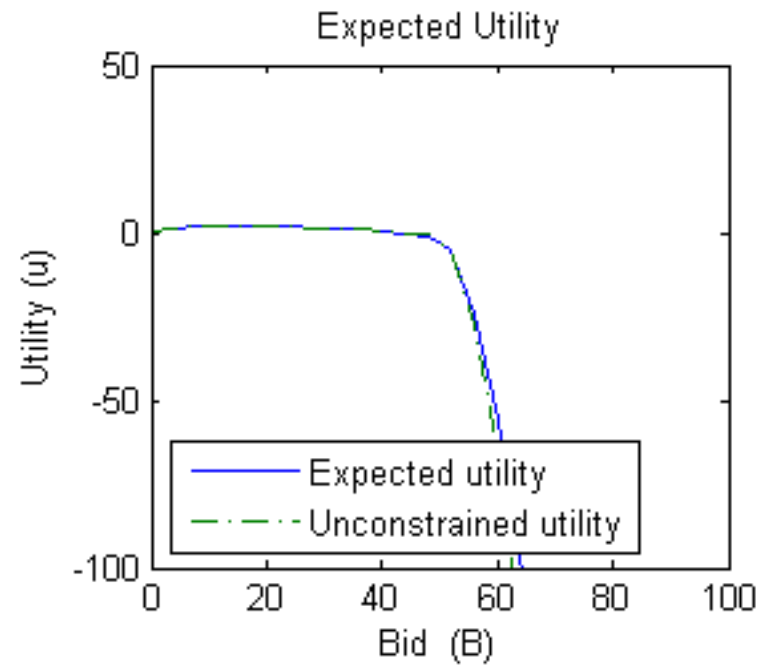
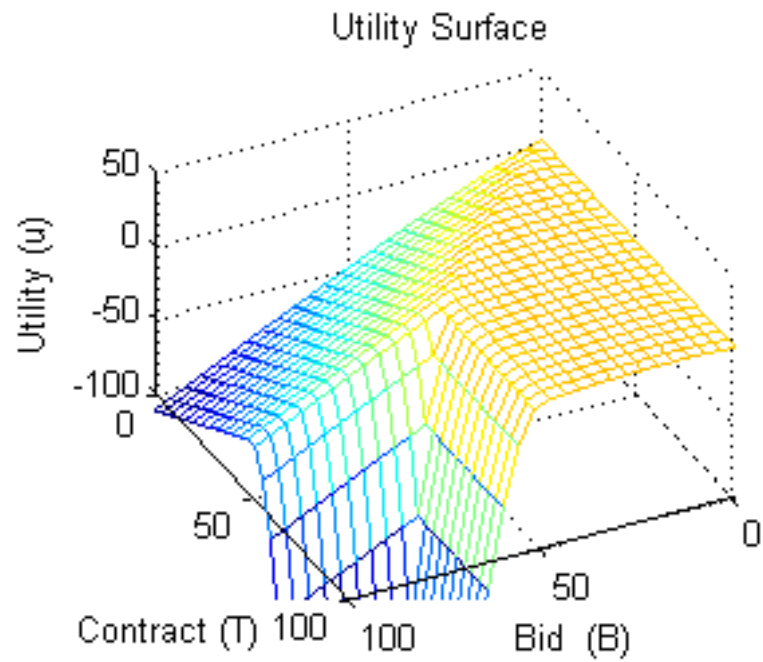
- Easy decision due to mobility

Helicopters

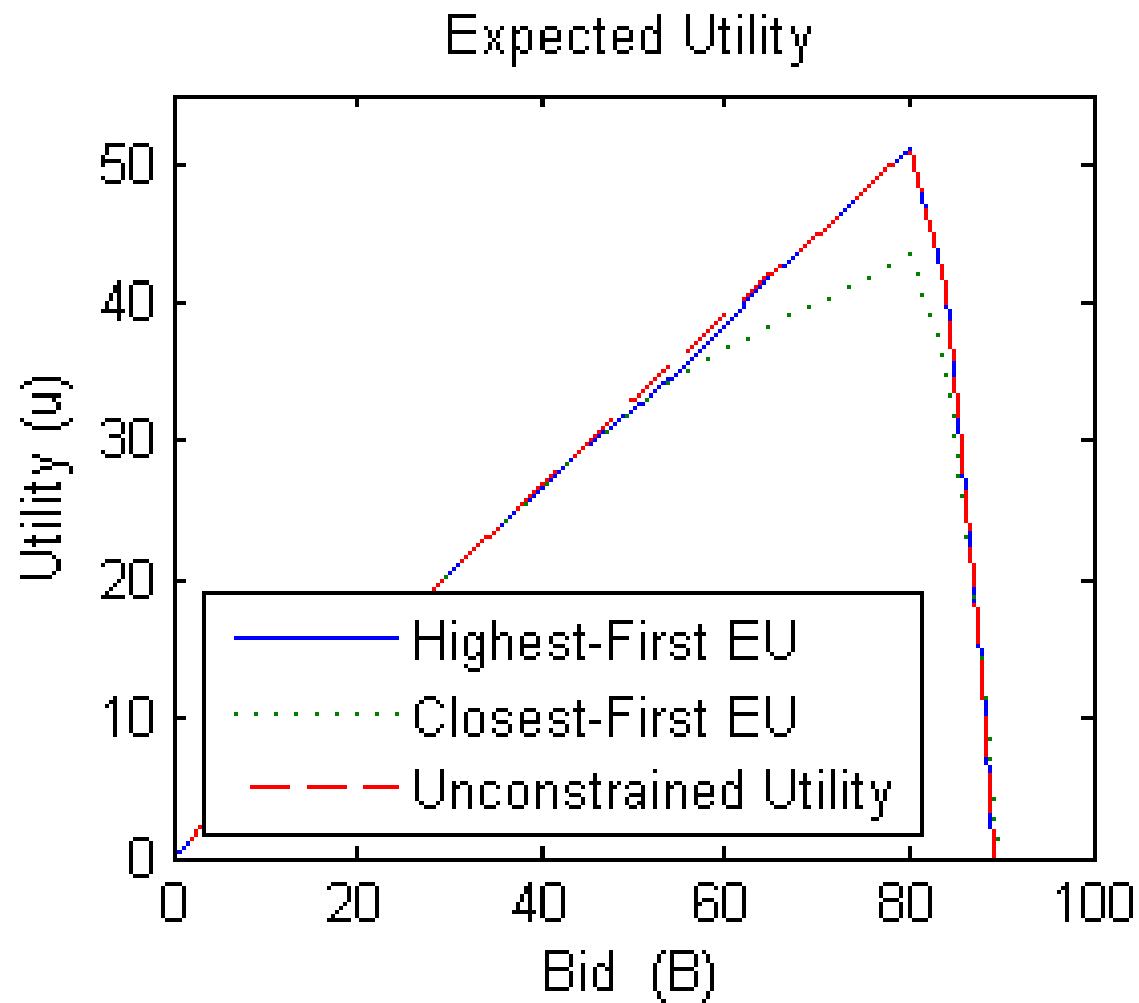
- Competitive







Search Cost is high



Unconstrained utility:

$$u_j^{(1)} = f_j(\Omega_j, R_j - B_j) + sg_j(B_j) + cb_j(B_j) - s_j(B_j).$$

Constrained utility:

$$u_j^{(2)} = f_j(\Omega_j, R_i - S_D + B_i) + sg_j(S_D - B_i) + cb_j(S_D - B_i) - s_j(B_j).$$

Expected utility:

$$\begin{aligned} E_{B_i}[u_j(\Omega_j, R_j, B_j)] &= \int_0^{S_D - B_j} u_j^{(1)} p(x) dx + \int_{S_D - B_j}^{S_D} u_j^{(2)} p(x) dx \\ &= \int_0^{S_D - B_j} [f_j(\Omega_j, R_j - B_j) + sg_j(B_j) + cb_j(B_j) - s_j(B_j)] p(x) dx \\ &\quad + \int_{S_D - B_j}^{S_D} [f_j(\Omega_j, R_i - (S_D - x)) + sg_j(S_D - x) + cb_j(S_D - x) - s_j(B_j)] p(x) dx \\ &= (f_j(\Omega_j, R_j - B_j) + sg_j(B_j) + cb_j(B_j) - s_j(B_j)) P(S_D - B_j) - s_j(B_j) \\ &\quad + \int_{S_D - B_j}^{S_D} [f_j(\Omega_j, R_i - (S_D - x)) + sg_j(S_D - x) + cb_j(S_D - x)] p(x) dx \end{aligned}$$