Sustainable incentives for promoting compliant behaviors

Speaker: Xin Zhou

DL4LD 28th June 2021

Systems and Networking Laboratory
Prospect review

Planner: Planner_VMCA

Edit actions

```python
me.address = "myPublicKey"
me.private = "myPrivateKey"

sensor001.emergency == true:
    token1 = auditor1.signature(PARKING1_DATA, OMC, VMCA, TRAFFIC_DIVERSION)
    token2 = auditor2.signature(PARKING1_DATA, OMC, VMCA, TRAFFIC_DIVERSION)

token1 && token2:
    result = data1.send(bucket2, [token1, token2])

result:
    print("ok")

result:
    print(result.status)
```
Prospect review

- Supercomputing Conference 2020
- ICT Open 2021
Policy enforcement and incentives

- **Methods**
  - Practical
  - Theoretical

- **Levels**
  - Interdependent
  - Complementary

- **Effect on non-compliant behavior**
  - Unable
  - Unwilling

**Policy enforcement**
- Policy
  - Laws and Regulations
- Incentives
  - Operation
  - Modeling and Reasoning

**Incentive mechanism design**
Research question

● If the incentives can be implemented by the third-party in a sustainable way?
● How long it will take to drive all participants choose to cooperate?
● Also how does the incentives influence the accumulated wealth of the market?
● In this work, we try to explore the effect of incentives, considering its sustainability
## Model

- Market with participants
- Compliant $\Leftrightarrow$ cooperate (C)
- Non-compliant $\Leftrightarrow$ defect (D)

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>R</td>
<td>S</td>
</tr>
<tr>
<td>D</td>
<td>T</td>
<td>P</td>
</tr>
</tbody>
</table>

- Mutual cooperation payoff $R$
- Mutual defection payoff $P$
- Temptation payoff $T$
- Sucker’s payoff $S$
Model

- Incentive mechanism

### Table 1. Related parameters under different conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reward</th>
<th>Probability of reward</th>
<th>Fine</th>
<th>Probability of fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>[C, C]</td>
<td>( r_0 ) *</td>
<td>( P_0^r = R_{CC} )</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>[C, D] or [D, C]</td>
<td>( r_1 ) *</td>
<td>( P_1^r = R_{CD} )</td>
<td>(</td>
<td>f_1</td>
</tr>
<tr>
<td>[D, D]</td>
<td>-</td>
<td>-</td>
<td>(</td>
<td>f_0</td>
</tr>
</tbody>
</table>

- Change the expected payoff of participants

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>D</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>R</td>
<td>S</td>
<td>R + R_{CC}</td>
<td>S + R_{CD}</td>
</tr>
<tr>
<td>D</td>
<td>T</td>
<td>P</td>
<td>T - F_{CD}</td>
<td>P - F_{DD}</td>
</tr>
</tbody>
</table>
Model

- Incentive mechanism

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reward</th>
<th>Probability of reward</th>
<th>Fine</th>
<th>Probability of fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>[C, C]</td>
<td>$r_0$</td>
<td>$P_0^r = R_{CC}$</td>
<td>$-$</td>
<td>$-$</td>
</tr>
<tr>
<td>[C, D] or [D, C]</td>
<td>$r_1$</td>
<td>$P_1^r = R_{CD}$</td>
<td>$</td>
<td>f_1</td>
</tr>
<tr>
<td>[D, D]</td>
<td>$-$</td>
<td>$-$</td>
<td>$</td>
<td>f_0</td>
</tr>
</tbody>
</table>

- Population: cooperators ($x$), defectors ($y$)

- Cost[1-3]:

\[ E = x^2 \cdot M \cdot R_{CC} + xy \cdot M \cdot R_{CD} + \alpha \cdot M(xy \cdot F_{CD} + y^2 \cdot F_{DD}) \]

- Income[4,5]:

\[ I = c_0 \cdot M + xy \cdot M \cdot F_{CD} + (y)^2 \cdot M \cdot F_{DD} \]
Simulation experiments design for reward

- **Reward**

![Diagram showing equilibrium under rewarding policy]

**Fig. 1. Equilibrium under rewarding policy**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reward</th>
<th>Probability of reward</th>
<th>Fine</th>
<th>Probability of fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>$[C, C]$</td>
<td>$R_{CC}$</td>
<td>-</td>
<td>$F_{CC}$</td>
<td>-</td>
</tr>
<tr>
<td>$[C, D]$ or $[D, C]$</td>
<td>$R_{CD}$</td>
<td>-</td>
<td>$F_{CD}$</td>
<td>-</td>
</tr>
<tr>
<td>$[D, D]$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

$R_{CC} = 1, +0.25^{...}, 3$

$R_{CD} = 2, +0.25^{...}, 4$

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>D</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1(R)</td>
<td>-2(S)</td>
<td>2(R)</td>
<td>0(S)</td>
</tr>
<tr>
<td>D</td>
<td>2(T)</td>
<td>0(P)</td>
<td>2(T)</td>
<td>0(P)</td>
</tr>
</tbody>
</table>
Simulation result: $x^{100}$

- Reward incentive (beta = 4)
Simulation result: *dynamic wealth*

- **Reward incentive (beta = 4)**
Conclusions

- This work is our working paper
- Aim at efficiently and effectively motivate agents’ compliant behaviors
- An complementary to our former work