MMM

Kazuki Komori

Tokyo University of Agriculture and Technology
komori@katfuji.lab.tuat.ac.jp

1 Behavior on Standard Track

1.1 Negotiation Management

MMM inherit *IndependentNegotiationsManager*. Negotiation choices are the same way of the class. We set utility function U, target quantity q^{target} and acceptable unit price p_i^{accept}, where i is the given time step, as follows.

$$\begin{aligned}
\mathrm{U} &= \begin{cases} LinearUtilityFunction((1,5,5)) & \text{if selling} \\ LinearUtilityFunction((1,-5,-5)) & \text{if buying} \end{cases} \\
q^{target} &= \begin{cases} \frac{1}{2} \times n_{lines} & \text{if selling} \\ n_{lines} & \text{if buying} \end{cases} \\
p_i^{accept} &= \begin{cases} p_i^{sell} - 3 & \text{if selling} \\ p_i^{buy} + 3 & \text{if buying} \end{cases}
\end{aligned}$$

$$\begin{aligned}
p_0^{sell} &= p_{output}^{catalog} + 2 \\
p_i^{sell} &= \begin{cases} p_{i-1}^{sell} + 1 & \text{if } q_{i-1}^{output} > \left(1.3 + \left(\frac{i}{n_{steps}}\right)^2\right) \times n_{lines} \\ \max\left(p_{i-1}^{sell} - 1, p_0^{sell} + 1\right) & \text{if } i < 0.7 \times n_{steps} \\ p_{i-1}^{sell} - 1 & \text{otherwise} \end{cases} \\
p_0^{buy} &= p_{input}^{catalog} - 2 \\
p_i^{buy} &= \begin{cases} p_{i-1}^{buy} + 1 & \text{if } q_{i-1}^{input} > \left(2 - \frac{i}{n_{steps}}\right) \times n_{lines} \\ \min\left(p_{i-1}^{buy} - 1, p_0^{buy} - 1\right) & \text{otherwise} \end{cases}
\end{aligned}$$

n_{lines} : number of production lines in the factory
n_{steps} : number of simulation steps
$p_{output}^{catalog}$ / $p_{input}^{catalog}$: catalog price of the output/input
q_{i-1}^{output} / q_{i-1}^{input} : quantity of outputs/inputs contracted in the last time step

1.2 Risk Management

In order to manage risk, MMM decides whether or not to sign contracts according to the following rules.

Selling Contracts

MMM does not sign the selling contract if:

$$\sum_{i=0}^{t-1} q_i^{arrival} < \sum_{i=0}^{t} q_i^{shipment} + q,$$

where t, q is the delivery time step, quantity of the contract and $q_i^{arrival}/q_i^{shipment}$ is the arrival/shipment quantity in step i. Selling contracts are signed by the following sequence.

1: for $d = 0$ to 3:
2: for contract in all contracts:
3: if $p \geq p_t^{sell} - d$:
4: Sign the contract
5: if $d > 0$ and $\sum^{sign} q > \left(1.3 + \left(\frac{i}{n_{steps}}\right)^2\right) \times n_{lines}$:
6: Finish the signing

Buying Contracts

MMM does not sign the buying contract if:

$$t > 0.9 \times n_{steps} \quad \text{or} \quad q + I_t^{input} + \sum_{i=t+1}^{n_{steps}} q_i^{arrival} > (n_{steps} - t - 1) \times n_{lines},$$

where I_t^{input} is the estimated number of input products stored in the inventory in step t. Buying contracts are signed by the following sequence.

1: for $d = 0$ to 3:
2: for contract in all contracts:
3: if $t = t_{min}$ or $p \leq p_t^{buy} + d$:
4: Sign the contract
5: if $d > 0$ and $\sum^{sign} q > \left(2 - \frac{i}{n_{steps}}\right) \times n_{lines}$:
6: Finish the signing

where t_{min} is the minimum value of all t.

2 Behavior on Collusion Track

2.1 Allies Recognition

MMM makes a special negotiation request for all suppliers and consumers (e.g. quantity $q = 9999$). If the request is received, MMM recognizes the sender as an ally. MMM recognizes allies in all simulations. If the agent has no allies, it behaves as described in Section 1. We refer to these agents as standard agents.

2.2 Distributions of Property

Normally, MMM behaves as described in Section 2. However, they distribute the money to their allies in the last few steps. This is to maximize the median value. If the agent has allies in consumers, make the special request for one of them. This request is absolutely accepted and signed.

$$\text{quantity} : 1, \text{ unit price} : 1.25 \times b_0 - b_t, \text{ delivery time} : t + 1$$

Where t is the time step when it is made and b_i is the balance in step i. The partner loses a lot of money but can also get the money from allies in the partner's consumer. This request is repeated until the unit price $p \leq p_{output}^{catalog}$.

Edge Agents

If the agent has no allies in consumers but has allies in suppliers, the agent can only give the money. We refer to these agents as the edge agents. Only one victim is selected from edge agents and the victim gives the money to allies in suppliers until bankruptcy.
We refer to the agents who is not the victim but edge agent as gifted agents. They receive a lot of products from their allies in suppliers at the lowest unit price (unit price $p = 1$).
The flow of money and products is shown in Figure 1.

3 Evaluation

MMM was tested in simulations against *DecentralizingAgent* and *BuyCheapSellExpensiveAgent*. It outperforms other agents in many cases.
On the collusion track, the Q1 score is higher than -2000, the median score is lower than 2500 and the Q3 score is higher than 2500 in many cases. These results suggests that the number of victims is less than a quarter of the total number of MMM and the number of agents who got the money from allies are between a quarter and a half in many cases. Therefore, the median of all agents is higher than the median of all standard agents.

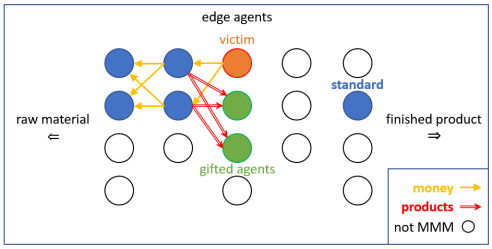

Figure 1: The flow of money and products