ANAC SCML 2021 - STD/COLLUSION

MEDIOCRE AGENT

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1. MOTIVATION FOR AGENT STRATEGY

Two main characteristics of Mediocre Agent are decision feasibility and caring interests of both parties. We define here the feasibility as staying always in a lossless zone and ensuring decisions not to be infeasible. To achieve a good deal for both parties, Mediocre Agent makes bids considering the partner's benefit as well as its own benefit rather than looking for any exploitation that can gain from the partner. Therefore, it does not force edges of its own profitability and tries to survive together with others thanks to using a specialized bidding space for each negotiation. We believe that if any bankruptcy occurs in the production graph, it increases the risk of the market and it can lead poorly rational agents to bankruptcy as well. In the light of this motivation, Mediocre Agent prefers to eliminate risks by restricting delay of market flow as much as possible since risk increases as time passes due to the effect of decisions made by irrational agents and it seeks any way of ensuring the flow by attaining reasonable contracts. Therefore, our agent follows inherently a collusive strategy as well.

2. UTILITY FUNCTIONS

$$Sell\ Utility: u_s = q * min\{p^{1.1}, 1.5 * p\} \quad (1)$$

$$Buy\ Utility: u_b = q/(p - P_{min} + 1) \quad (2)$$

$$Breach\ Score: B = \gamma^{s'-r} * Breach\ Level * Breach\ Prob. \quad (3)$$

$$Sell\ Contract\ Utility: U_S = u_s * \sqrt{B} * \sqrt[10]{\omega} \quad (4)$$

$$Buy\ Contract\ Utility: U_B = u_b * \sqrt{B} / \sqrt[10]{\omega} \quad (5)$$

ω is the delaying time of contract, $\omega = t - s'$, t is the delivery time, s' is current step in the tournament, and r is the last financial reporting step.

γ is a multiplier for the breach score. We assume that breach score of any agent increases at each step once it breaches, so, we set γ to a value greater than 1 such as 1.1.

3. NEGOTIATION STRATEGY

a. Independent Negotiators

Mediocre Agent engages in negotiations with independent negotiators which have different bidding space for each partner. It follows two parameters to adapt its behavior in negotiations which are about its own state and partner state. One of them is 'Neediness' level which is about its own state and depends on available inventory and quantities of not concluded contracts.

$$Future\ Outputs = Current\ Inputs + Signed\ Future\ Inputs + Current\ Outputs \quad (6)$$

$$Neediness' = (Future\ Outputs - Signed\ Future\ Outputs)/ Future\ Outputs \quad (7)$$

$$Neediness = max\{-1, min\{1, Neediness'\}\} \quad (8)$$

For (7), $Neediness$ is set to zero if $Future\ Outputs$ is zero. Note that $Signed\ Future\ Outputs$ cannot be positive if $Future\ Outputs$ is zero according to the signing strategy of Mediocre Agent. We use (8) to obtain a value between -1 and 1 for neediness. If neediness is negative, Mediocre Agent needs buying and it needs selling if it has positive neediness.

The other indicator, which is about partner state, is 'Eagerness' level. Eagerness rates are utilized for both negotiations and resource allocation. It represents the level of willingness to trade with that partner. In each step, the eagerness score of each partner is calculated based on the following metrics, and all eagerness scores are scaled between 0 and 1.

$$Negotiation\ Score = Agreement\ Rate * \sqrt{Avg.Contract\ Utility * Last\ Contract\ Utility} \quad (9)$$

$$Market\ Score = Last\ Balance/ (1 + \sqrt{B}) \quad (10)$$

$$Eagerness: E = Negotiation\ Score * Market\ Score \quad (11)$$

Using the eagerness metric, Mediocre Agent provides more trade volume for partners which are good to deal with by its strategy for resource allocation to the independent negotiators and making bids that can increase the chance of mutually signed contracts.

b. Setting Issue Bounds

To set minimum and maximum prices, production cost, catalog prices, trading prices, and 'traded prices' are firstly considered. Traded prices are calculated based on all contracts and contracts in the previous step. Secondly, price bounds are adjusted based on an impoverishment indicator defined using traded input price, traded output price, and production cost. Lastly, trade experience with that partner is considered to adjust the bounds. If no contract is achieved after the first quarter of the tournament, prices are slightly changed in favor of the partner.

Mediocre Agent sells only available inventory which is not allocated for any contract. The remaining output quantity is given to all seller negotiators as the maximum quantity to sell. The more eager Mediocre negotiators are, the more they sell. For the allocation of buying quantity respect to suppliers, Mediocre agent aims to use its full production capacity, therefore, it manages its buying trade by setting a target quantity and this target quantity is allocated to negotiators with respect to their eagerness to trade with their corresponding partner supplier.

For delivery time, Mediocre Agents delays its sales at most 3 steps and buys at most 6 steps later in the negotiations it initialized. In the negotiations initialized by other agents, it prefers to sell and to buy early at the beginning of negotiation

and it starts to consider the preference of the opponent for delivery time after the first half of negotiation.

Bounds for unit price and quantity define 'the feasible bid space' to reach an agreement for the negotiator.

c. Acceptance and Proposing Strategy

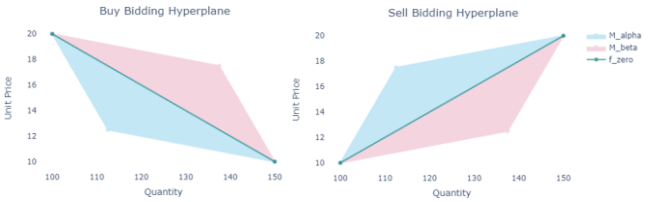

Figure 1. Buy and Sell Bidding Hyperplanes for given unit price and quantity bounds when α=-0.5 and β=0.5

We define hyperplanes for bidding spaces as in Figure 1 to consider interests of both parties in the negotiation. Mediocre Agents limits desirable bids for itself and limits its profit loss by using two piecewise functions, f_α and f_β where $-1 \leq \alpha \leq 0 \leq \beta \leq 1$, and one linear function f_0, which is the mean preference line depending on the bounds of the issues. Note that f_0 has always a strictly positive slope for sell bidding, and strictly negative for buy bidding. For the sell bidding hyperplane, breaking point of f_α is defined regarding the distance from f_0 to (Q_{min}, P_{max}) by the proportion of $-\alpha$. The area between f_α and f_0 defines M_α. f_β is defined similarly but respect to (Q_{max}, P_{min}) for the sell bidding. f_β and f_0 defines the area of M_β. M_α serves for straining to achieve better deals as much as possible depending on the state of the opponent in the market and its negotiation behavior. M_β represents the comfort zone to survive and serves for the pursuit of agreement (i.e., to survive together). Mediocre Agent generates bids only from these two bounded regions called 'Mediocrity Zone' ($M = M_\alpha + M_\beta$).

Seller Mediocre accepts bids below M_α and Buyer Mediocre accepts bids above M_α. If counter bid x of opponent a is in the feasible region and the eagerness for it is high i.e., $E_a \geq 0.5$, a 'responsive' bid y is selected from a bid set S where maximum utility is bounded by an upper utility value and opponent preferences for quantity and delivery time is considered after some negotiation time pasts. (12) and (13) set the upper utility bound for y.

$$U(y) \leq U(x) + \Delta \quad (12)$$

$$\Delta = (max\_utility - U(x)) * insistence * (1 + max(0, opponent\_concession)) \quad (13)$$

In (13), $max\_utility$ is the utility of best bid can be generated in that negotiation, $insistence$ is 1 until last quarter of negotiation and decreases to 0.7 at most based on neediness level, and $opponent\_concession$ is calculated over utilities of the last five bids of the opponent which is between -1 and 1. 'get_good_bid' function takes S and restricts it by considering neediness and remaining negotiation time, and then selects a bid y at random with a probability based on bid utilities. If counter bid x of opponent a is not in the feasible bid space or $E_a < 0.5$, a bid y is generated using only get_good_bid function. If utility difference between y and x is lower than a threshold based on the neediness level, x is accepted, otherwise y is proposed.

d. Setting α and β

It is worth noting that β should be high enough to enhance the possibility of agreement. Absolute degree of α represents the focus on self-interest while degree of β is the level of caring the interest of the opponent.

At the beginning of the tournament, α and β are set to mean rates, -0.5, and 0.5 respectively. Laterly, they are updated based on the following criteria throughout the tournament:

- If wealth of partner does not decrease too much, decrease α, i.e., increase M_α.
- For negotiations requested by partners, α is set to -1.
- β increases as the tournament progresses.
- If contract rate $*$ sign rate with a partner is low, increase β.
- If Mediocre is at first or last production level, increase β.

4. SIGNING STRATEGY

Supplier and consumer contract lists are sorted in decreasing order of contract utility, which were given as (4) and (5) in Section 2. Then, these lists are evaluated based on the feasibility criteria which is summarized as follows.

To limit buying, two main parameters are considered: The total amount that can be produced from the signing step to the last production step and ratio of total buying and selling. Mediocre Agent converts all inputs to outputs, but it stops the production after last 10% tournament steps (N). Therefore, it calculates its total production capacity in a tournament by excluding that number of last steps of the tournament, which is depicted via (14) and (15). Throughout the first half of the tournament, it limits its buying by that total production capacity, and then considers the flow ratio. If the flow ratio is lower than 0.5 after that time, it decreases the maximum possible buying amount by 50%.

$$To\ Be\ Produced = Signed\ Future\ Inputs + Current\ Inputs \quad (14)$$

$$Total\ Prod.Cap. = (Number\ of\ Steps - Current\ Step - N) * Prod.Cap. - To\ Be\ Produced \quad (15)$$

For the decision of signing sell contracts, all contracts are signed in the order if prospective output inventory on that delivery time is enough. Mediocre Agent takes into account the risk of bankruptcy of its suppliers in the calculation of stepwise future output inventory by considering their cash amount and their breach score.