OPTIMAL TRADING STRATEGIES OF AGENTS IN A POPULATION OF FIRMS: SOCCER TRANSFER MARKETS

KEHINDE SALAU

1. Model Description

This is the model description of the model described in Salau (2008). The model description follows the ODD protocol for describing individual- and agent-based models (Grimm et al. 2006) and consists of seven elements. The first three elements provide an overview, the fourth element explains general concepts underlying the models design, and the remaining three elements provide details. Details of the software implementation will also be presented.

2. Purpose

The purpose of the model presented by Salau is to study the 'player profit vs. club benefit' dilemma present in professional soccer organizations, in truth, it is present in most of the sports industry. This social dilemma is present on two intertwined levels, the managerial front and the base level of players. This model also seeks to locate any factor(s) that may lead to the long run stability or instability of team structure and change in frequency of transfer bids.

3. State Variables and scales

Though the general model can have arbitrary population sizes for the number of clubs and players, The simulations were done with an initial distribution of 20 clubs, each club having 22 players. During its reevaluation period, a club manager may choose to bid for a player from another club. The success of the trade depends on the 'expected' impact the new player can have on the team, and also on the salary profit the player stands to gain from the trade.

4. Process overview and scheduling

1.) Each club plays two games with every other club (home and away games), from that, club record, capital, and player salary is calculated.
2.) The earliest reevaluator is awoken,
   a) A specific club manager is awoken when its mean reevaluation time is minimal. Managers with larger clubs take longer to make decisions.
      - The manager of club m reevaluates when, $\Delta t = -\ln(\text{random number }(0,1)) * n_m/\alpha$

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is minimal when compared to the mean time of the other managers.
n_m is the number of players at club m.
$\frac{1}{\alpha}$ is the revaluation rate.
- Multiple club managers may reevaluate at the same time

b) The club manager then picks a random player from another team and, with some probability/threshold, will put in a trade bid for that player if it has enough capital.
c) The player then assesses if any acceptable profit can be made from the trade. If so, the player will move

5. **Design Concepts**

Emergence - To boost profit, less skilled players move to clubs with greater pedigree. To boost record, clubs with greater pedigree buy up most of the available players
Adaptation - Great players learn to stay with less-populated teams as they have more to gain as far as being the 'star' and earning a large salary.
Fitness - The fitness of a club is measured by its win record, strength, and average skill of its current squad. The fitness of a player is measured by its skill and salary.
Prediction - A player can estimate how much salary profit it will gain with another team next season in order to decide whether to stay or leave its current club. A club can estimate the impact a prospective player will make next season in order to decide whether or not to place a trade bid for it.
Sensing - Global information includes the reevaluation rate of club managers, the likelihood of trade bid placement, the minimum fraction of profit accepted by players during negotiation, and the number of prospects a club is allowed to negotiate with.
Interaction - Club managers are able to interact with one or more prospect players per evaluation period in order to determine whether a trade can materialize.
Stochasticity - A given club will win a game with a certain probability determined by the strength of its squad versus the strength of the opposing squad. A club manager will put in a bid for a player with some probability determined by the average skill of its current squad and the skill of the prospect.
Collectives - Each club is made up of a certain number of players. However, due to the fluidity of this model, that number is always capable of changing
Observation - For model testing, the configuration of clubs (number of clubs, club size, average skill and strength at clubs, etc) was observed for different initial skill and club pedigree distribution. And for model analysis, data such as average number of transfers, average tenure length etc., is collected.

6. **Initialization**

Default settings: Initially, there are 20 clubs each containing 22 players. The skill of players are distributed evenly between all teams, no team has an obvious advantage.

Skewed settings: Initially, we have 20 clubs with each club containing 22 players. The pedigree of teams are skewed, we have some great teams (15 percent), some bad teams (25 percent), and many mediocre teams (55 percent); this setting was inspired by the English Premiere League (EPL Settings). Other experiments were done with 33.3 percent great teams, mediocre teams, and poor teams (Uniform Settings). Also with 55 percent poor teams, 25 percent mediocre teams, and 15 percent great teams (MLS Settings).

7. **Input**

Expression	Definition	Simulation Value
α	reevaluation rate for each club/manager	1
β	controls the frequency with which a club will consider a player of lesser skill than the average at the club	1
ρ	the amount of salary profit the player is expecting before deciding to make a switch	1
Prospects	Maximal number of players a club is allowed to negotiation with	check results

TABLE 1. Sensed Parameters

8. **Submodels**

Each club plays two games with every other club and, from that, club record, capital, and player salary are calculated. A win is probabilistic and depends on the strength and depth of the clubs involved in the match-up. The model assumes 'home club advantage' which means, the home club gets to choose the random number that decides whether they win or lose. Say, club m plays host for a match against club n, the home club will win if they pick a random number, denoted γ, such that,

$$\gamma < \frac{S_m}{S_m + S_n} \tag{1}$$

where, $0 < \gamma < 1$, S_m is the sum of the skill of players on club m (can also be referred to as club *strength*), and S_n is the sum of the skill of players on club n. So, (1) is actually the probability that club m wins the game with the added advantage that it gets to choose the random number that may grant it the victory.

The budget of a given club is calculated as a function of the club's record, basically, it is the number of games won by the club. So, the budget of club m, B_m, is given as,

$$B_m = R_m \tag{2}$$

where R_m is the number of wins recorded by club m in the current season. The club budget is then split in half, one part is distributed among the players (deservedly, each player's salary is proportional to their skill level) and the other part is left with the club to use as transfer costs for bringing in new players. And so the salary of player i, denoted b_i, on club m is written as,

$$b_i = \frac{\frac{1}{2} B_m \frac{t_i}{6}}{l_m} \tag{3}$$

where t_i is the skill type of player i, and l_m is the number of players on club m with the same skill type as player i, including the player itself. And the benefits for club m, denoted U_m, which is used solely for player transfer costs is given as,

$$U_m = \frac{1}{2} B_m \tag{4}$$

Clubs and players use their respective 'benefits' functions to guide them in their decision to accept or decline transfer bids. Clubs also use the knowledge of their team pedigree, which is the average skill of players at the club, to guide them during the negotiation period. The initial success or failure of negotiations depend on whether or not club expectations are met. And so club m will only consider a transfer bid for randomly chosen player i if,

$$\eta < \left(\frac{s_i}{P_m}\right)^{\beta} \tag{5}$$

where, P_m is the pedigree of club m, and $\beta \geq 1$. β controls the frequency with which a club will consider a player of lesser skill than the average at the club, that frequency decreases as β grows. Before the transfer bid is placed, clubs also make sure they have enough benefits from the current season to pay the transfer costs of the prospective player. A Club will only place a transfer bid for a player if a portion of its benefits are enough to pay the players current salary, and so this serves as the player's transfer cost. And so, club m will place a bid for player i only if,

$$\frac{U_m}{\text{no. of prospects}} > b_i \tag{6}$$

The prospective player makes the final decision. Prospect i of club m compares its current salary to the salary it could have earned as a player on the 'asking' club n. If the the salary profit is significant enough, meaning if,

$$\frac{\frac{1}{2} B_n \frac{t_i}{6}}{l_n + 1} > \rho b_i \tag{7}$$

then the player accepts the transfer bid and will switch teams before the start of the new season. ρ affects the amount of salary profit the player is expecting before deciding to make a switch; of course, $\rho \geq 1$.

9. Model implementation

The model was completed on November 17, 2008 and replicated using *NetLogo* 4.0.3. Figure 1 is the result of 50 simulations, each lasting 3000 seasons, where the number of prospects is varied. The results were as expected; increasing the number of prospects also increases the average number of trades per season and, consequently, average tenure of players is lowered. Furthermore, trade negotiations are heightened when there is an increased imbalance in club pedigree distribution; more trades occur, on average, in the EPL and MLS as opposed to the Default and Uniform Leagues. Figure 2 is also the result of 50 simulations, each lasting 3000 seasons, it features the average pedigree distributions of clubs for each of the different settings; the EPL and MLS have the most skewed pedigree distributions, this supports the claim that more heterogeneity in initial pedigree distribution leads to more successful transfer negotiations. If you find any errors in my implementation, keep it to yourself...or let me know (ksalau@asu.edu).

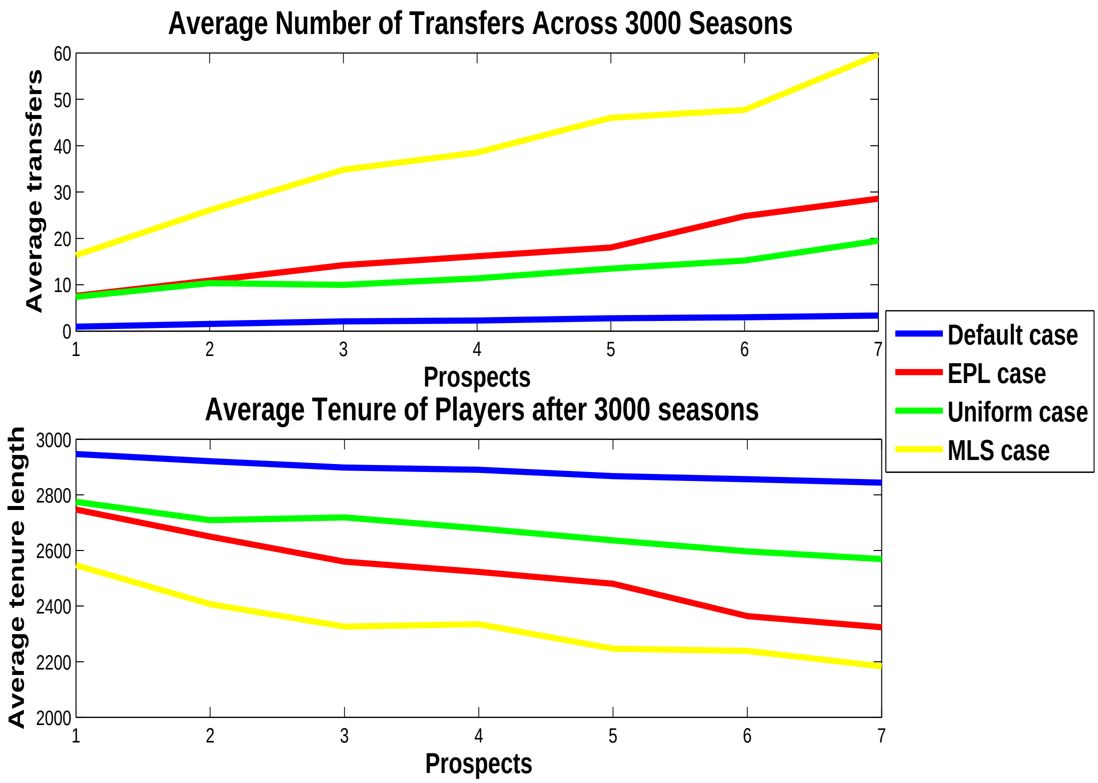

FIGURE 1. Averages were taken over 50 runs. This figure showcases the average number of transfers and average tenure lengths of players after 3000 seasons when the number of allowed prospects is varied for each of the four different league cases. As expected, the more prospects allowed a club, the more successful trade negotiations occur which causes a decrease in the average tenure lengths of players. The top diagram suggests that successful transfer negotiations occur at a higher rate when there is more heterogeneity in club pedigree across the whole league. Average tenure lengths of players mirror the information we gain from the average transfer rate of players in the four different leagues. Tenure length decreases when league heterogeneity is present, so players are more apt to move when there is greater disparity in club pedigree.

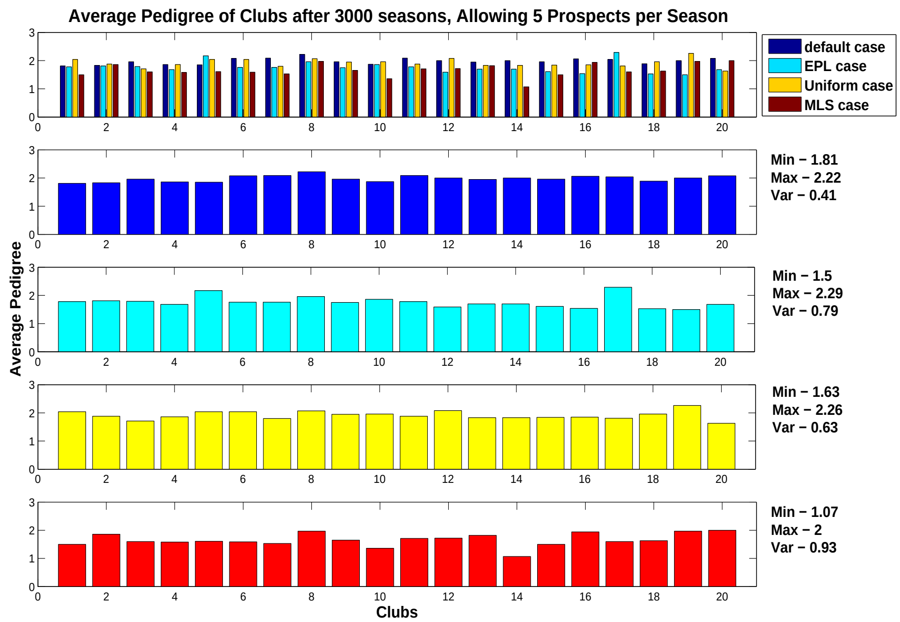

FIGURE 2. Averages were taken over 50 runs. This figure showcases the average club pedigree for each of the four different league cases across 3000 seasons when each club is allowed 5 prospects during the transfer period. To the right of each plot of pedigree distribution is the maximum average pedigree, minimum average pedigree, and variance of pedigree in that league. As displayed, there is higher variance of pedigree when the initial distribution of club pedigree is heterogeneous.

10. **References**

Salau, K. (2008) Optimal Trading Strategies of Agents in a Population of Firms: An Agent-Based Approach to Soccer Transfer Markets in the Evolution of Organizations

Grimm, V., U. Berger, F. Bastiansen, S. Eliassen, V. Ginot, J. Giske, J. Goss-Custard, T. Grand, S. Heinz, G. Huse, A. Huth, J.U. Jepsen, C. Jrgensen, W.M. Mooij, B. Mller, G. Peer, C. Piou, S.F. Railsback, A.M. Robbins, M.M. Robbins, E. Rossmanith, N. Rger, E. Strand, S. Souissi, R.A. Stillman, R. Vab, U. Visser, D.L. DeAngelis (2006) A standard protocol for describing individual -based and agent-based models. *Ecological Modelling* 198: 115-126