Agent-Based Evolutionary Labor Market Model with Strategic Coalition

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Abstract. A real-world labor market has complex worksite interactions between a worker and an employer. This paper investigates the behavior patterns of workers and employers with a job capacity and a job concentration empirically considering a strategic coalition in an agent-based computational labor market. Here, the strategic coalition can be formed autonomously among workers and/or among employers. For each experimental treatment, the behavior patterns of agents are varied with a job capacity and a job concentration depending on whether a coalition is allowed. Experimental results show that a strategic coalition makes workers and employers aggressive in worksite interactions against their partners.

1 Introduction

A labor market is said simply to consist of workers and employers with complex worksite behaviors [1]. In a real-world labor market, the behavioral characteristics expressed by workers and employers, such as trustworthiness and diligence, depend on who is working for whom [2], [3]. Therefore, the behavioral patterns of the worksite interactions may affect heavily the flexibility of the labor market. Accordingly, there have been a great deal of studies on the analysis of the behavioral patterns of the agents and unemployment in the future labor market using agent-based computational models. However, they have focused principally on the analysis of the limited worksite interactions such as one to one mapping between a worker and an employer without considering the union of the agents.

Before the worksite interaction with a certain employer, a worker may want to form a strategic coalition with other workers to get more benefits from his/her worksite partner (i.e., employer) while so does an employer. Here, the strategic coalitions between workers and/or between employers may be spontaneously occurred without supervision. It is similar with the labor unions of workers and the federation of employers in a real-world labor market. In this paper, we model an agent-based evolutionary labor market with a strategic coalition using the prisoner's dilemma game. Furthermore, we investigate how the strategic coalition influences the behavioral patterns of the agents in an evolutionary labor market. For meaningful investigation, we adopt the asymmetric test environments reflecting real-world labor markets de-

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rived from the ratio of the number of workers and employers such as a job concentration and a job capacity.

This paper organizes as follows: Section 2 explains the related works such as the prisoner's dilemma game, and a labor market framework. Section 3 describes the definition of the strategic coalition between the agents and how they form a strategic coalition. In Section 4, we describe the experimental results of the strategic coalition in each test environment. Finally, we conclude this paper in Section 5 with a few remarks.

2 Backgrounds

2.1 Iterated Prisoner's Dilemma Game

In a real labor market, a worker and an employer compete to get more benefits from their worksite partner. Therefore, their actions appear in the form of cooperation and defection as if two prisoners do so. In the classical prisoner's dilemma game [4], [5], [6], two prisoners may cooperate with or defect from each other. If the game is played for one round only, the optimal action is definitely defection. However, if the game is played for many rounds, mutual defection may not be the optimal strategy. Instead, mutual cooperation will guarantee more payoffs for both of the prisoners [7]. In the same manner, mutual cooperation between a worker and an employer is helpful for the improvement of wage earning and the productivity in the real economy. Because it is non-zero sum game one player's gain may not be the same with the other player's loss. There is no communication between the two players.

2.2 Evolutionary Labor Market Framework

The labor market framework comprises *NW* workers who make work offers and *NE* employers who receive work offers, where *NW* and *NE* can be any positive integers. Each worker can have work offers outstanding to no more than *wq* employers at any given time, and each employer can accept work offers from no more than *eq* workers at any given time, where the work offer quota *wq* and the employer acceptance quota *eq* can be any positive integers [2], [3].

Each agent depicted in an evolutionary labor market framework has the internal social norms and behaviors with the same attributes represented in bit-string with a strategy table and a history table. They update their worksite strategies on the basis of the past own and opponent's actions. They also evolve with genetic operations such as selection, crossover, and mutation [5].

The interaction between a worker and an employer can be described as work offering and accepting. For example, a worker offers his work to a potential worksite partner who is randomly selected from the population of employers. Then the offered employer determines whether he/she will accept the worker's offer according to his/her past worksite interaction history. If the employer accepts the worker's offer they work together. On the other hand, if the employer refuses the worker's offer the worker receives the refusal payoff (*F*) which is regarded as a job searching cost in a negative form. At the time, the employer does not receive any penalty on the refusal. Instead, the employer receives the inactivity payoff (*I*). Being afraid of receiving the refusal payoff, a worker may do not submit work offer. In that case, the worker also receives the inactivity payoff.

If an employer accepts work offer from a worker, they are said to be matched as worksite partners and participate in the worksite interactions modeled as the prisoner's dilemma game. Then the worker can cooperate with or defect from the employer according to his/her worksite strategy while the employer does either one. For example, the worker may work hard in the worksite (Cooperation) or work lazily to exploit the employer's favor (Defection). The employer may make good working conditions for his/her worker (Cooperation) or decrease the worker's payment (Defection). Such worksite behaviors are determined by the last action of each worksite partner encoded in a history table.

In the worksite interaction between a worker and an employer, a cooperator whose worksite partner defects receives the sucker's payoff (*S*); a defector whose worksite partner also defects receives the mutual defection payoff (*P*); a cooperator whose worksite partner also cooperates receives the mutual cooperation payoff (*R*); and a defector whose worksite partner cooperates receives the temptation payoff (*T*). In this paper, we follow Tesfation's payoff values for labor market modeling described in [2] and the values also satisfy Axelrod's payoff function $(T+S) < 2R$ of the prisoner's dilemma game. The relation of each payoff value is as follows.

$$\boldsymbol{S < P < F < I(0) < R < T}$$

Job Concentration. To model an evolutionary computational labor market, we initialize the population with the real number of workers (*NW*) and employers (*NE*). According to the ratio of the number of workers and employers, the behavioral patterns of workers and employers can be varied. To investigate the impact by the ratio of the number of workers and employers, three setting are tested such as a high job concentration (NW/NE=2/1), a balanced job concentration (NW/NE=1), and a low job concentration (NW/NE=1/2). Workers are more than employers when a job concentration is high, and the numbers of workers and employers are the same in a balanced job concentration, and workers are less than employers in a low job concentration.

Job Capacity. In worksite interactions, each worker has the same work offer quota *wq*, where *wq* is the maximum number of potential work offers that each worker can make. In the same manner, each employer has the same acceptance quota *eq*, where *eq* is the maximum number of job openings that each employer can provide. According to the ratio of the number of workers and employers with the quota, a job capacity can be divided into a tight job capacity ($(NE*eq)/(NW*wq)$=1/2), a balanced job capacity ($(NE*eq)/(NW*wq)$=1), and a excess job capacity ($(NE*eq)/(NW*wq)$=2/1). Particularly, jobs are less than demand in a tight job capacity, jobs are equal to demand when a job capacity is balanced, and jobs are in excess supply when a job capacity is excess.

Classification of Agents. There are many different types of behavioral patterns in a multi-agent environment. In an agent-based computational labor market, we analyze the behavioral patterns of the agents described as workers and employers with three classes: nice, aggressive, and inactive. A nice agent selects persistently cooperation in worksite interactions against his worksite partner in despite of defection. An aggressive agent selects at least one defection against his worksite partner that has not previously defected from him. An inactive agent plays like an observer so as not to lose the refusal payoff (F) against his potential opponent. The inactive worker becomes persistently unemployment and the inactive employer is persistently vacant.

3 Strategic Coalition in an Agent-Based Computational Labor Market

In this section, we suggest a strategic coalition which can model a labor market more dynamically. At first, we describe the definitions of a strategic coalition. Then we formulate the procedure of a coalition formation.

3.1 Strategic Coalition

To get more benefits in worksite interactions, workers and employers may consider a strategic coalition separately in each population. It is because the strategic coalition among autonomous agents may be mutually beneficial even if the agents are selfish and try to maximize their expected payoffs [8], [9], [10]. The coalition between two workers in a population is formed autonomously without any supervision. That is, if the conditions of coalition formation are satisfied they will form a coalition [11], [12].

For the definitions of a strategic coalition, let $W=\{w_1, w_2,\ldots, w_n\}$, $E=\{e_1, e_2,\ldots,e_n\}$ be the collection of workers and employers in each population, respectively. Let $C_w=\{w_i, w_j,\ldots, w_k\}$, $|C_w|\geq 2$ and $C_e=\{e_i, e_j,\ldots, e_k\}$, $|C_e|\geq 2$ be the strategic coalition that can be formed among workers and employers. The coalitions, C_w and C_e, are the elements of the individual group, W: $C_w \subseteq W$, $|C_w|\leq|W|$ and E: $C_e \subseteq E$, $|C_e|\leq|E|$. Every worker has his own payoff, p_w^i, and every employer has his own payoff, p_e^i, that earns from the prisoner's dilemma game against his opponent. Then the coalition has the vector, $C_w = \langle C_w^p, N_w^c, f_w^p, D_w \rangle$ for workers' coalition, $C_e = \langle C_e^p, N_e^c, f_e^p, D_e \rangle$ for employers' coalition. Here, C^p, N^c, f^p, and D of C_w and C_e, mean the average payoff of a strategic coalition, the number of agents in the coalition, payoff function, and a decision of the coalition, respectively. Now we can define the strategic coalition as follows.

Definition 1. Coalition Payoff: Let w_w^i and w_e^i be the weight vectors for a worker and an employer corresponding to each payoff. The coalition payoffs, C_w^p for workers' coalition and C_e^p for employers' coalition, are the average payoff by the corresponding weight of the agents that participate in each coalition.

$$C_w^p = \frac{\sum_{i=1}^{|C_w|} p_w^i w_w^i}{|C_w|}, \quad C_e^p = \frac{\sum_{i=1}^{|C_e|} p_e^i w_e^i}{|C_e|} \tag{1}$$

where $w_w^i = \dfrac{p_w^i}{\sum_{i=1}^{|C_w|} p_w^i}$ and $w_e^i = \dfrac{p_e^i}{\sum_{i=1}^{|C_e|} p_e^i}$

Definition 2. Payoff Function: Workers and employers belonging to each coalition get payoffs with a given function after worksite interactions. In this paper, we follow Tesfatsion's payoff values for each experiment [2].

Definition 3. Coalition Identification: Each coalition has its own identification number. This number is generated when the coalition is formed by given conditions, and it may be removed when the coalition exists no more. This procedure is made autonomously according to evolutionary process.

Definition 4. Decision Making of Coalition: A strategic coalition must have one decision (i.e., cooperation or defection) that combines the behaviors of all participants belonging to the coalition. We use the weighted voting method for decision making of the coalition in this experiment. Decision making of the coalition, D_w for workers' coalition and D_e for employers' coalition, are determined by the function including the coalition payoff and its weight.

$$D_w = \begin{cases} 0 = \text{Cooperation}, & \text{if} \quad 1 < \dfrac{\sum_{i=1}^{|C_w|} p_i^C \cdot w_w^i}{\sum_{i=1}^{|C_w|} p_i^D \cdot w_w^i} \\ 1 = \text{Defection}, & \text{if} \quad 0 < \dfrac{\sum_{i=1}^{|C_w|} p_i^C \cdot w_w^i}{\sum_{i=1}^{|C_w|} p_i^D \cdot w_w^i} \le 1 \end{cases}, \quad D_e = \begin{cases} 0 = \text{Cooperation}, & \text{if} \quad 1 < \dfrac{\sum_{i=1}^{|C_e|} p_i^C \cdot w_e^i}{\sum_{i=1}^{|C_e|} p_i^D \cdot w_e^i} \\ 1 = \text{Defection}, & \text{if} \quad 0 < \dfrac{\sum_{i=1}^{|C_e|} p_i^C \cdot w_e^i}{\sum_{i=1}^{|C_e|} p_i^D \cdot w_e^i} \le 1 \end{cases} \quad (2)$$

where p_i^C : an agent that selects cooperation for the next action

p_i^D : an agent that selects defection for the next action

3.2 Coalition Formation

To investigate other worker's intention for a coalition formation, the prisoner's dilemma game is played between two workers. A worker is selected at random in workers' population, and the other worker is orderly selected in the same population. Thus, the worker selected randomly in the population plays against all the other workers (single worker or coalition) in the population. After each game, each of the two agents considers making (or joining) a coalition to get more payoffs from his worksite partner. Table 1 shows three conditions in order to form a strategic coalition used in this paper. If all conditions are satisfied, they form a strategic coalition. Employers also follow the same procedure with workers.

Table 1. Three conditions for a coalition formation

Condition	Characteristics
condition 1	Each agent's payoff before the game between two agents must be higher than the average payoff of the population
condition 2	Each agent's payoff after the game between two agents must be less than the average payoff of the population.
condition 3	Each agent's payoff after a coalition must be higher than the average payoff of the population

As the game is played over and over again, there may be many coalitions in the population. Therefore a worker can play the game against a coalition. A coalition can also play the game against another coalition. In the case that a worker joins an existing coalition, the workers within the coalition (including a new one) play another prisoner's dilemma game in a round-robin way to update all participants' rank. For example, when there are k workers in a coalition, $k(k-1)/2$ games will be played totally. If the total number of workers (i.e., k) is greater than a pre-defined maximum coalition size, the weakest worker (in terms of the total payoff obtained in all round-robin games) will be removed from the coalition. All workers within the coalition are ranked (sorted) according to each payoff. Then each of the workers has weight corresponding to his rank in the coalition. The weight plays an important role in determining the worker's impact on the coalition's next move.

If workers form a strategic coalition they act as a single agent from the time. Therefore, there must be a decision making method to combine the behaviors of all participants in the coalition for the next action (refer to equation (2)). In this paper, we use the weighted voting method which determines the weight value according to each participant's payoff belonging to the coalition. In other words, a superior agent gets a higher weight value for decision making of the next action. Employers also follow the same procedure because a worker and an employer have the identical attributes and internal state.

4 Experimental Results

The experimental design focuses on the independent variation of three factors: job concentration as measured by JCON=(NW/NE); and job capacity as measured by JCAP=(($NE*eq$)/($NW*wq$)); and coalition. Figure 1 describes the experimental design with three factors. For each experiment, the number of workers and employers are set as 24, respectively, when a job concentration is balanced (JCON=1). All remaining parameters are maintained at fixed values throughout all the experiments as shown in Table 2.

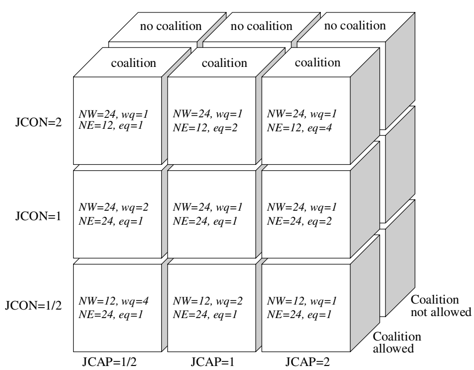


Fig. 1. Experimental design with three factors

Table 2. Experimental parameters

Parameter	Value
population size	24
crossover rate	0.6
mutation rate	0.005
number of generations	50
number of iterations	100
initial payoff	1.4
refusal payoff	-0.5
inactivity payoff	0.0
sucker's payoff	-1.6
temptation payoff	3.4
mutual cooperation	1.4
mutual defection	-0.6
history size	2

4.1 High Job Concentration

In a high job concentration (JCON=2), employers are beneficial when finding workers because the number of workers is more than that of employers. Such phenomena occur occasionally in a real-world labor market. Table 3 shows the experimental results of behavioral patterns of the agents in the high job concentration with each job capacity on average of 10 runs. In the table, when a coalition is not allowed and a job capacity is tight (JCAP=1/2), employers act more aggressively (employer 77%) and workers act principally inactively (worker 43%). The reason is that the tight job capacity causes the employers to exploit the workers who have weakness in job finding. The figure of percentage in the table describes the rate for each behavioral class of the agents in the final generation, and the sum of each class does not mean to equal 100% because some agents do not belong to the three classes or can be duplicated.

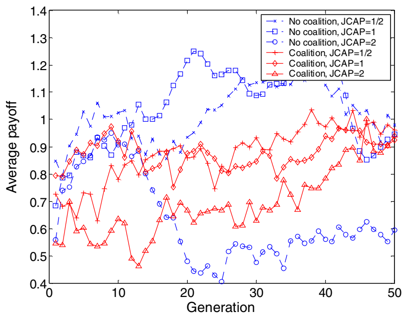
Table 3. The experimental results of a high job concentration considering a coalition

	Tight job capacity (JCAP=1/2)			Balanced job capacity (JCAP=1)			Excess job capacity (JCAP=2)		
		e	w		e	w		e	w
Coalition not allowed	Inact.	12 %	56%	Inact.	6%	9%	Inact.	14%	5%
	Aggr.	77%	43%	Aggr.	37%	50%	Aggr.	52%	55%
	Nice	10%	13%	Nice	46%	36%	Nice	20%	16%
	Utility	0.98	0.04	Utility	0.95	0.81	Utility	0.60	1.14
		e	w		e	w		e	w
Coalition allowed	Inact.	9%	54%	Inact.	6%	14%	Inact.	23%	15%
	Aggr.	62%	16%	Aggr.	46%	37%	Aggr.	61%	44%
	Nice	1%	3%	Nice	10%	0%	Nice	1%	6%
	Utility	0.96	0.16	Utility	0.92	0.53	Utility	0.94	0.48

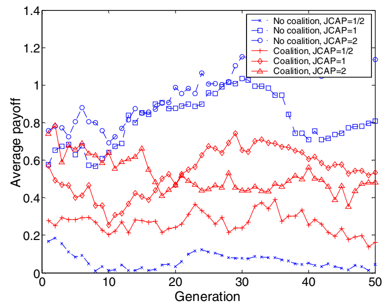
Employers and workers act principally as a nice agent when a job capacity is balanced (employer 46%, worker 36%) when a coalition is not allowed. It means that employers and workers do not compete severely for job match because the labor market structure is stable in demand and supply. When a job capacity is excess, however, inactive employers appear more in worksite interaction (employer 14%), which means that the labor market structure is unfavorable to employers.

If a strategic coalition is allowed the experimental results are varied according to a job capacity. Employers and workers become non-cooperative when a coalition is not allowed in every job capacity. It explains that the coalition selects mainly defection from its worksite partners and then it makes the population more competitive. In other words, a coalition causes nice agents to decrease, which means the agents in the coalition select more defection as the next action. It is also shown in the rate of aggressive agents in each job capacity.

In terms of utility (i.e., payoff) as shown in Figure 2, the payoffs of employers and workers become less if a coalition is allowed because non-cooperative agents increase in a competitive labor market environment. In Figure 2(a), the payoff of employers in an excess job capacity is less than that in tight and balanced job capacity while that of workers in tight job capacity is less than that in an excess and a balanced job capacity in Figure 2(b). It means that an excess job capacity is unfavorable to employers while a tight job capacity is unfavorable to workers with the ratio of employers and workers.



(a) Employer



(b) Worker

Fig. 2. Variation of average payoffs in a high job concentration. Employers get more payoffs than workers regardless of a coalition (Compare the average payoffs of two figures). It means that employers have more favorable position in finding worksite partners in a labor market as well as a real world

4.2 Balanced Job Concentration

Table 4 depicts the experimental results of a balanced job concentration with each job capacity. As shown in the table, although a job concentration is balanced the behavioral patterns of agents can be varied because work offer quota (*wq*) and work acceptance quota (*eq*) are different. When a job capacity is tight and a coalition is not allowed, workers act inactively in order not to lose the refusal payoff against employers (worker 38%). However, in a balanced job capacity, many employers and workers play nice strategy to cooperate with each worksite partner (employer 55%, worker 35%). That is, the behavior patterns of agents follow the labor market structure represented as a job capacity when a coalition is not allowed.

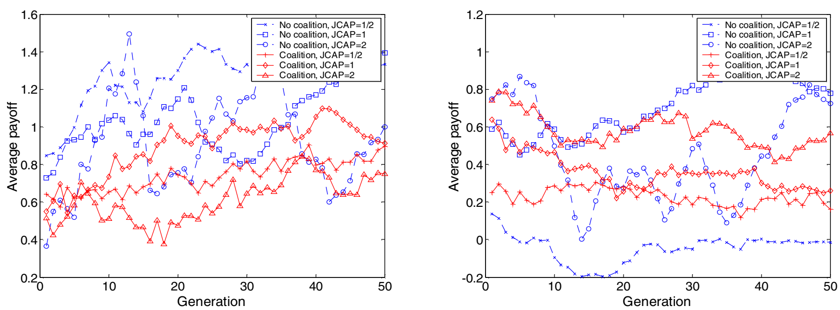
If coalition is allowed in a balanced job concentration, cooperative agents decrease in every job capacity. It is similar with the case of a high job concentration when a coalition allowed. Especially, 55% of nice employers and 35% of nice workers before a coalition decreases dramatically to 4% and 5%, respectively, after a coalition is allowed. It means that a coalition makes the population of employers and workers competitive extremely. Additionally, a coalition makes the increment of inactive agents from nice agents (employer 22%, worker 22%), which means that observers increase due to an unstable labor market structure.

The utility of agents are also varied on whether a coalition is allowed or not. Both of employer and worker get fewer payoffs when a coalition is allowed because the whole population becomes non-cooperative and each agent selects frequently defection in worksite interactions.

Table 4. The experimental results of a balanced job concentration considering a coalition

		Tight job capacity (JCAP=1/2)		Balanced job capacity (JCAP=1)		Excess job capacity (JCAP=2)	
		e	w	e	w	e	w
Coalition not allowed	Inact.	10%	38%	13%	13%	31%	3%
	Aggr.	65%	19%	34%	44%	57%	62%
	Nice	18%	18%	55%	35%	19%	19%
	Utility	1.33	-0.02	1.39	0.78	1.00	0.73
		e	w	e	w	e	w
Coalition allowed	Inact.	8%	37%	22%	22%	40%	11%
	Aggr.	46%	19%	67%	20%	61%	31%
	Nice	2%	2%	4%	5%	1%	8%
	Utility	0.90	0.16	0.91	0.26	0.75	0.57

Figure 3 shows the payoff variation when a job concentration is balanced. Employers get more payoffs when a coalition is not allowed, which means that cooperative employers dominate the population and then the population converges to mutual cooperation. In the case of workers, they get the least payoff when a job capacity is tight and a coalition is not allowed, which means the labor market structure is disadvantageous to workers.



(a) Employer (b) Worker

Fig. 3. Variation of average payoffs in a balanced job concentration. Notice Y axis value between two figures. Employers get more payoffs relatively when a coalition is not allowed (dashed lines in Fig. 3(a)). It is similar to the case of workers, but the difference is rather small

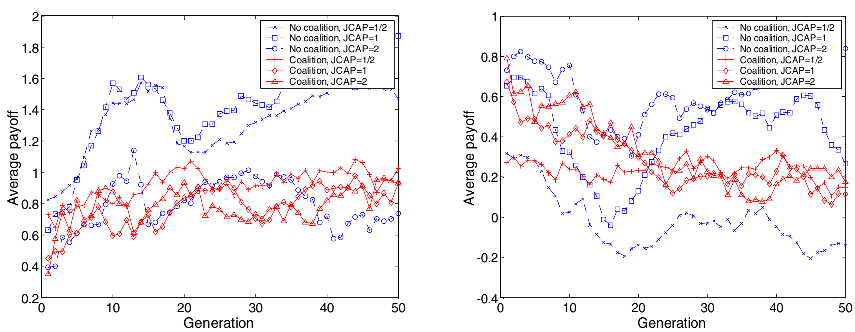
4.3 Low Job Concentration

In this section, we analyze the behavioral patterns of the agents when a job concentration is low (JCON=1/2) which means the number of employers is two times more than the number of workers (*NW*/*NE*=1/2). In this environment, workers have an advantage in finding his worksite partner. Table 5 shows the experimental results of a low job concentration with each job capacity. The rate of inactive agents is remarkably high in comparison with a high and a balanced job concentration regardless of a coalition. It describes that a low job concentration causes employers and workers to be a spectator by the low possibility of occupation. However, nice agents decrease when a coalition is allowed in the same manner of a high and a balanced job concentration (employer 6%, worker 5%). It results in the utility of employers and workers decreased when a coalition is allowed.

Table 5. The experimental results of a low job concentration considering a coalition

	Tight job capacity (JCAP=1/2)			Balanced job capacity (JCAP=1)			Excess job capacity (JCAP=2)		
		e	w		e	w		e	w
Coalition not allowed	Inact.	36%	47%	Inact.	31%	24%	Inact.	52%	5%
	Aggr.	63%	24%	Aggr.	58%	25%	Aggr.	48%	41%
	Nice	10%	18%	Nice	41%	52%	Nice	30%	21%
	Utility	1.47	-0.14	Utility	1.87	0.27	Utility	0.74	0.84
		e	w		e	w		e	w
Coalition allowed	Inact.	16%	29%	Inact.	28%	18%	Inact.	58%	16%
	Aggr.	52%	24%	Aggr.	44%	38%	Aggr.	41%	37%
	Nice	8%	1%	Nice	6%	5%	Nice	2%	7%
	Utility	1.02	0.15	Utility	0.93	0.11	Utility	0.93	0.18

Figure 4 depicts the variation of average payoffs in a low job concentration along generations. Employers get near the mutual cooperation payoff (payoff value 1.4) when a job concentration is balanced and coalition is not allowed. It means that the labor market is stable and most of agents (i.e., employers and workers) are cooperative in worksite interactions. Workers get fewer payoffs relatively than employers in every job capacity, which describes that they are exploited by aggressive employers due to an unfavorable market structure. Needless to say, if a coalition is allowed the payoffs become less due to non-cooperative behaviors of the coalition as well as other job concentrations.



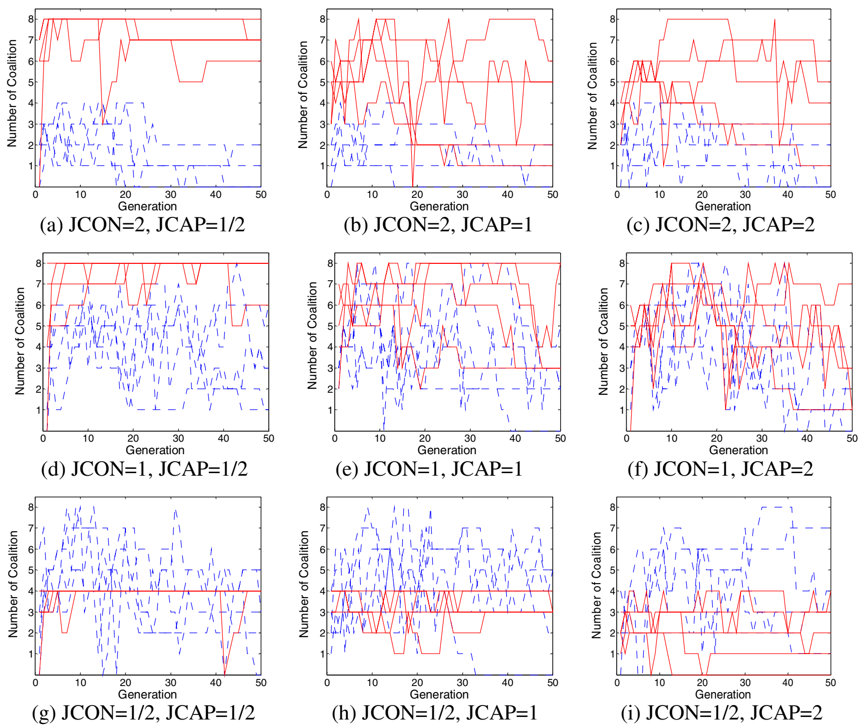
(a) Employer (b) Worker

Fig. 4. Variation of average payoffs in a low job concentration. Employers earn more payoffs rather than workers in every job capacity. Notice the values of Y axis in the figures. Most of payoff lines are lower when a coalition is allowed regardless of employers and workers

4.4 Number of Coalitions

Figure 2 shows how many coalitions are formed or dismissed along generations in each job concentration and a job capacity of 5 runs. Particularly, Figure 2(a), (b), (c) describe the variation of the number of coalitions when a job concentration is high (Notice that the maximum number of coalitions is one third of a population). Here, the number of workers' coalition is more than that of employers' coalition. It is caused by that the total number of workers is more than that of employers in each generation.

Figure 2(d), (e), (f) describe the number of coalitions when a job concentration is balanced. In the figure, the number of coalitions is varied almost equivalently between an employer and a worker. The reason is that the balance of the number of employers and workers permits the equivalent possibility of coalition formation. Figure 2(g), (h), (i) depict the number of coalitions when a job concentration is low. Each of the figures shows that the number of employers' coalition is more than that of workers' coalition, which means the possibility of coalition formation for employers is higher than the workers.



(a) JCON=2, JCAP=1/2 (b) JCON=2, JCAP=1 (c) JCON=2, JCAP=2

(d) JCON=1, JCAP=1/2 (e) JCON=1, JCAP=1 (f) JCON=1, JCAP=2

(g) JCON=1/2, JCAP=1/2 (h) JCON=1/2, JCAP=1 (i) JCON=1/2, JCAP=2

Fig. 5. The number of coalitions in each job concentration and a job capacity when a strategic coalition is allowed. Solid lines are for workers and dashed lines are for employers

5 Conclusions

A real-world labor market has complex worksite interactions among its constituents like workers and employers. Therefore, modeling the labor market and predicting the future market structure are an important study to help proper policies established and the policies adaptive to a changing environment. In this paper, we propose a strategic coalition to model complex interactions in an agent-based computational labor market. We also investigate how a strategic coalition affects the labor market structure and the behavior of workers and employers. Experimental results describe that a strategic coalition makes workers and employers more aggressive to their worksite partners. Specifically, employers and workers act cooperatively when a job capacity is balanced and a coalition is not allowed. However, they become non-cooperative players when a coalition is allowed. The number of coalitions varies according to a labor market structure which consists of the ratio of employers and workers. That is, employers form a coalition more actively when a job concentration is high. Conversely, workers form more coalitions when a job concentration is low. The utility level of employers and workers becomes less when a coalition is allowed. It means that labor market including a coalition between workers and/or between employers is changed to a competitive structure. This appears remarkably high when a labor market structure is in a tight and an excess job capacity.

Acknowledgements

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References

1. Tesfatsion, L.: Agent-based Computational Economics: Growing Economics from the Bottom Up, Artificial Life, Vol. 8 (2002) 55-82
2. Tesfatsion, L.: Structure, Behavior, and Market Power in an Evolutionary Labor Market with Adaptive Search, Journal of Economic Dynamics and Control, Vol. 25 (2001) 419-457
3. Tesfatsion, L.: Hysteresis in an Evolutionary Labor Market with Adaptive Search, S.-H. Chen (eds), Evolutionary Computation in Economics and Finance, Physics, Springer-Verlag, Heidelberg Germany (2002) 189-210
4. Axelrod, R.: The Evolution of Strategies in the Iterated Prisoner's Dilemma, Genetic Algorithms and Simulated Annealing, San Mateo, CA: Morgan Kaufmann, Ch. 3 (1987) 32-41
5. Colman, A. M.: Game Theory and Experimental Games, Pergamon Press, Oxford England (1982)
6. Darwen, P. J., Yao, X.: On Evolving Robust Strategies for Iterated Prisoner's Dilemma, Progress in Evolutionary Computation, Lecture Notes in Artificial Intelligence, Vol. 956. Springer-Verlag, Heidelberg Germany (1995) 276-292
7. Francisco, A.: A Computational Evolutionary Approach to Evolving Game Strategy and Cooperation, IEEE Transactions on Systems, Man and Cybernetics, Part B, Vol. 32, No. 5 (2002) 498-502
8. Shehory, O., Kraus, S.: Coalition Formation among Autonomous Agents: Strategies and Complexity, Fifth European Workshop on Modeling Autonomous Agents in a Multi-Agent World, Springer-Verlag, Heidelberg Germany (1993) 56-72

9. Shehory, O., Sycara, K., Jha, S.: Multi-agent Coordination through Coalition Formation, Proceedings of Agent Theories, Architectures, and Languages, Springer-Verlag, Heidelberg Germany (1997) 143-154
10. Garland, A., Alterman, R.: Autonomous Agents that Learn to Better Coordinate, Autonomous Agents and Multi-Agent Systems, Vol. 8, No. 3 (2004) 267-301
11. Tate, A., Bradshaw, M., Pechoucek, M.: Knowledge Systems for Coalition Operations, IEEE Intelligent Systems, Vol. 17 (2002) 14-16
12. Sandholm, T. W., Lesser, V. R.: Coalitions among Computationally Bounded Agents, Artificial Intelligence, Vol. 94 (1997) 99-137