The Influence of Coalition Formation on Idea Selection in Dispersed Teams: A Game Theoretic Approach

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Abstract. In an open innovation environment, organizational learning takes place by means of dispersed teams which expand their knowledge through collaborative idea generation. Research is often focused on finding ways to extend the set of ideas, while the main problem in our opinion is not the number of ideas that is generated, but a non-optimal set of ideas accepted during idea selection. When selecting ideas, coalitions form and their composition may influence the resulting set of accepted ideas. We expect that computing coalitional strength during idea selection will help in forming the right teams to have a grand coalition, or having a better allocation of accepted ideas, or neutralising factors that adversely influence the decision making process. Based on a literature survey, this paper proposes the application of the Shapley value and the nucleolus to compute coalitional strength in order to enhance the group decision making process during collaborative idea selection.

Key words: idea selection, game theory, coalition formation, dispersed team, open innovation

1 Introduction

With the increased use of Internet technology, companies are increasingly trying to reduce transactional costs. R&D costs may similarly be reduced by the adoption of Internet technology, as this fosters the communication in dispersed working teams and across collaborating companies. Indeed, with the adoption of these collaboration tools, we are well on the road to open innovation. The expertise relevant for the design of a new product is not always available within the boundaries of one team or firm. Hence the idea of open innovation suggests to create online distributed teams in which people from different companies and disciplines co-operate on the design of a new product. However, utilising a team's full innovation potential poses some serious problems. Most research thus far has focused on the extension of the set of ideas, and researchers have tried to neutralise potential pitfalls. There are however indicators that dispersed teams do come up with enough ideas, but just do not select the right ideas. Hence, we should take a closer look at enhancing idea selection, rather than looking at ways to extend the set of ideas during idea generation[1]. Focusing on the idea selection stage of the creative process and the corresponding coalition formation may help find ways to optimise the selection process. Besides, people are often more risk averse when having an idea accepted with a chance of having more ideas accepted and more risk-seeking when preventing to lose an idea that had already been accepted. This in turn may lead to the escalation of commitment by participants. Eventually ideas have to be accepted, and as a result of the escalation of commitment, we search for an optimal allocation of accepted ideas among all participants to satisfy each participant, also known as satisficing: this may lead to the adoption of minimally acceptable solutions. These non-optimal solutions may also be caused by coalition formation during both idea generation and idea selection. We will further explain this in this paper.

This paper presents a literature review on the problems dispersed teams currently face during the idea generation and selection process. Furthermore, it stresses the use of coalitional strength during the process of idea selection by presenting a game theoretic approach. In section 2, we will describe economic and psychological factors that influence collaboration, followed by a game theoretic approach meant to overcome problems in idea selection. We will draw our conclusions in section 3 based on the literature review in section 2. The theoretical framework sketched in this paper will be part of a PhD study conducted within the EU FP7 funded idSpace project. Future research to be conducted in this context will be described in section 4.

2 Theoretical background

When looking at the incentives for collaboration, we see that collaboration is a way for people to learn from each other, or to create new things with the combined knowledge that they have. In corporate environments, teams are created to generate innovative solutions or new products. While historically we see that research and development mainly took place inside the firm, we now see a tendency towards an increase of inter-firm alliances to support so-called open innovation[2]. The reasons for alliances between companies involve sharing risks, obtaining access to new markets and technologies[3], reducing product-to-market times, and pooling complementary skills[4, 5]. Research and development departments of these companies tend to use open innovation to introduce new products faster and at a lower cost. This however requires collaboration and the corresponding notions of trust, reciprocity and negotiation, as co-operation is likely to have competitive aspects as well[6].

When firms collaborate through open innovation, we see that they are hindered by a variety of problems. They may experience individual problems regarding decision making, such as emotional involvement, exogenous factors[7], bounded rationality[8] and escalation of commitment[9]. Besides, the collaboration may be subject to group deficiencies, such as social loafing, group think and group polarisation. The latter two influence the formation of coalitions in open innovation teams. Especially in idea generation and selection, we see that people need additional support for their ideas to have them accepted. Hence, they form coalitions to stand stronger against other people's coalitions and ideas. They are self-interested, however, as one may support other people's ideas in return for their support, also known as reciprocity. As a consequence, coalition formation in idea generation leads to a non-optimal set of accepted ideas. For instance, in a collaborative idea generation session, when person A is above person B in the organisation's hierarchy, person A may be more informed on the company's strategy and mission statement. Therefore, person B, who actually has a good idea, will be likely to accept person A's ideas, as he knows person A is more informed. Though, person A may rather be self-interested, and names one of his own moderate ideas that is not so close to the organisation's strategy. Thus, person A names an idea with a lower utility, but person B is willing to form a coalition under the presumably rational thought that person A is higher informed and acts accordingly. This example shows that good ideas are often generated in collaborative idea generation, but due to individual and group deficiencies, the selection of ideas is disturbed.

In order to overcome the problem of a non-optimal set of accepted ideas, we need to study the influence of coalition formation on the allocation of accepted ideas. To compute this, we need to know what the share of each participant is in the coalition. After doing so, we may propose a division of the coalition's payoff. A considerable amount of research has been conducted on the division of the coalition's payoff. In formal game theory, there exist mainly two types of approaches to compute the share of each participant in the coalition and thus the division of the coalition's payoff: the Shapley value[10] and the nucleolus[11]. Both these concepts are central to games in coalitional form, also known as many-person co-operative games. In such games, players may gain profit from their actions and this profit may be transferred to others as a result of forming coalitions. This transferrable utility is expressed in the form of side payments among players. Side payments are a from of sharing profit from mutually beneficial strategies. For instance, consider three companies that decide to co-operate and share their R&D departments. They find out that it is wiser to shut down one R&D department to reduce the costs. The revenue will then be accountable to the two other R&D departments, whereas the third company made the decision to shut down their R&D department to reduce costs, a decision from which all three companies benefit. Therefore, the company that shut down its R&D department will receive a share of the profit made by the other two company's R&D departments, the so-called side payment.

To compute the side payment, we need to compute the value of a coalition with respect to not forming a coalition. The characteristic function v of the game defines the values of the set of coalitions that may be formed by the players. To compute the values of the set of coalitions, we first need to define what eligible coalitions are. For instance, if we have three players, eight different coalitions may be formed. First, we have the empty coalition denoted by $\oslash$, an empty set with no players. Second we have the one-person coalitions $\{1\}$, $\{2\}$ and $\{3\}$. The two-person coalitions are{1,2}, {1,3} and {2,3}. The grand coalition in which every player participates is called N. The grand coalition is considered to be the coalition that has the highest payoff, thereby satisfying the common statement that the sum of the whole is more than the sum of any of its parts.

The *Shapley value* focuses on the way participants of an n-person co-operative game view the value of forming a coalition. The so-called players of the game weigh the value of co-operation against the value of not co-operating. The value of the game is computed by taking the value of the coalition and subtracting the value of the sub coalitions, divided by the number of participants in the coalition. For instance, if the coalition {1,2} has value 4, coalitions {1} has value 2 and coalitions {2} has value 1, then the value of coalition {1,2} is 4 2 1 = 1. We denote this as constant c{1,2} = v{1,2} v{1} v{2}. Let's assume that the following values are given: c{1} = 2 c{2} = 1 c{1,2} = 1 c{1,3} = 3 cN = -2

We can now compute the Shapley value for person 1, which is the sum of the constant values of each coalition person 1 participates in divided by the number of participants in the coalition. With the values given above, we compute player 1's Shapley value ϕ 1 = c{1} + c{1,2}/2 + c{1,3}/2 cN/3 = 2 + 1/2 + 3/2 2/3 = 3 + 1/3. If we do this for all three players, we have the Shapley value for the coalition N. The Shapley value may then be used to divide the coalition's payoff. In our example, player 1 receives a 3 + 1/3 share of the coalition's payoff of for instance 12.

Another way of dividing the coalition's payoff is the *nucleolus*. The nucleolus is an extension of the Shapley value, that is, we try to find the characteristic function v and the minimal amount of payoff the players would receive if they co-operate. The payoff vector containing the minimum payoffs is called the imputation, which has the form x = (x1, ..., xn). We then ask the participants how dissatisfied they are with the proposed imputation (that is, the worst division of payoffs) and try to minimise the maximum dissatisfaction. The payoff computed by use of the nucleolus may differ from the Shapley value, as we take into account what the players expect to have. For instance, if a bank goes bankrupt, people would like to claim their savings. Player A has 2000 euros in his savings account, player B has 4000 euros in his savings account and player C has 6000 euros in his savings account. However, the bank has only 7200 euros to divide among the players. Player C is sure of receiving 1200 euros, as players A and B receive a total of 6000 euros. Thus v(C) = 1.2. If we do the same for A and B, we find v(A) = 0 and v(B) = 0. Similarly, v(AB) = 1.2, v(AC) = 3.2, v(BC) = 5.2 and v(ABC) = 7.2. After a series of calculations, the nucleolus v is found to be (1,2.1,4.1), while the Shapley value is (1.2,2.2,3.8). The division of payoff would then be respectively (1200,2100,4100) versus (1200,2200,3800). The Shapley value and the nucleolus will thus lead to different payoff distributions. For player B this makes a difference of 300 euros extra money, while player C will receive 300 euros less. If we compare this to the pro rata distribution of (1200,2400,3600), we see that player C, will actually receive 500 euros extra when the nucleolus is used for payoff distribution.

If we translate the example given above to idea selection, it is not always the case that we have an equal distribution of the set of ideas among participants, based on their individual skills in idea generation. If we compare the outcomes for the coalitions and the individual payoff when not co-operating, we may see different distributions of the payoff. For instance, if we base our imputation on the number of ideas generated during individual idea generation, it may be that forming a coalition pays off. We expect that this is the reason why people choose to form coalitions during idea selection.

3 Conclusions

We think that studying coalition formation in open innovation is a sensible approach, which regrettably has been ignored thus far. We need to pay attention to the way coalitions are formed during collaborative idea selection and to what extent this influences the allocation of accepted ideas among the participants. Based on literature, we see that people often run into a number of problems while co-operating, such as escalation of commitment, bounded rationality, group think and group polarisation, which may lead to the formation of coalitions in such a way that a non-optimal set of ideas are accepted during idea selection. It is shown that the nucleolus and the Shapley value may lead to different distributions than the pro rata distribution of ideas. We expect that if we present the participants with the computations of the nucleolus and Shapley value, they may become better aware of the group's potential, thus forming coalitions that are better suited to optimise the set of accepted ideas. And if such coalitions are not formed, a moderator may try to put different people together during idea selection to have the right coalitions formed. However, forming coalitions may not always be beneficial for all participants, due to the problems we have sketched in this paper. We may thus choose to try to neutralise the factors that benefit some, but are detrimental to others. For instance, if a group is polarised, we may add people that bridge the gap between the groups that represent the poles to prevent a sub optimal idea from being accepted. If we do so, we may deviate from the original game theoretical notions of the Shapley value and the nucleolus, as we include external (social) factors.

4 Future Research

The above overview suggests many avenues for further research on coalition formation in open innovation. These avenues will be investigated in the context of the EU funded idSpace project, which focuses on tools for distributed, collaborative product innovation. The following steps are envisaged. Based on the literature, we will first define a model that describes the formation of coalitions in idea selection. This will be followed by a social simulation that will help us in analysing the resulting set of accepted ideas. After that, we will try to adapt the model in such a way that we will be able to predict the formation of coalitions. The desired result of our final model will be either the optimisation of the formation of 'optimal' coalitions, that the influencing factors of 'sub-optimal' coalitions will be neutralised, or that the right people will be chosen in advance of idea generation to eventually have a grand coalition during idea selection. These findings will be empirically tested and underpinned in suitable contexts in which open innovation takes place. We will also look into the possibility of extending our results to contexts in which collaboration takes place which is not necessarily focused on (open) innovation. A case in point would be so-called Learning Networks [12], which are online, social networks designed to foster non-formal learning and knowledge exchange.

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