Dynamic Social Judgment Scheme (DSJS) with Information Lag: An Agent Based Model

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ABSTRACT

Davis's (1996) Social Judgment Scheme (SJS) is a conceptually well established and empirically well tested group decision model. This study uses an agent based model to simulate the dynamic interaction in Social Judgment Scheme (SJS) and expand it as Dynamic Social Judgment Scheme (DSJS) by including group members' real-time interaction. One of the main different of dynamic SJS and SJS is information time lag. Therefore, this study examined how information time lag would affect a group decision. The result shows that dynamic group decision process is highly sensitive to information time lag. The real-time simulation shows that a virtual sales group will make similar group decision as SJS model at the beginning, but information time lag cause by communication may significantly change the decision path soon after. However, the overall pattern of DSJS is still similar with SJS. The information time lag is important, but not determinant.

Keywords: Group decision, Group behavior, social judgment scheme, agent based model, information lag

INTRODUCTION

Social Judgment Scheme

J.H. Davis proposed Social Judgment Scheme (SJS) model in 1996 assuming that group members' influence on the group decision declines with the distance from other members' judgments. After many years of development, SJS becomes a conceptually well established and empirically well tested group decision model. (Ohtsubo et al, 2002; Hulbert et al,1999)

Briefly speaking, SJS model estimates the group judgment as a weighted average of the group members' preference. Each member's preference is weighted according to its relative closeness to the other members' preference: the weight given to a particular member declines exponentially as the distance between its judgment and other members' judgments becomes greater. (Ohtsubo et al, 2002)

In detail, group decision G is the weighted mean of every group members' preference X.

$$G = c_1 x_1 + c_2 x_2 + \ldots + c_r x_r$$

The weight, C, of each group member's preference is according to some function of the distance between his or her judgmental position and other members' judgmental positions.

$$c_i = \frac{\sum_{j=1}^{r} f\left(\left|x_i - x_j\right|\right)}{\sum^{r}\sum^{r} f\left(\left|x_i - x_j\right|\right)}, i \neq j$$

$$f\left(\left|x_i - x_j\right|\right) = e^{-\theta\left(\left|x_i - x_j\right|\right)}, i \neq j$$

Where, Θ is a positive constant. In practical applications of the model to date, Θ = 1.00 (Davis, 1996; Tindale et al, 2003).

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Information Sharing and Dynamic System

Although SJS is proved to be very useful in predicting group decision, it is a very basic model which ignores two important aspects: Information Sharing, Dynamic interaction. JSJ model only focus on group members' different preference. But where those different preferences come from? Preference is the outcome of information and judgment, where information will be exchanged; judgment will also have influence to other group member. The function of group preference is showed as following:

Preference= (shared information + unshared information)* individual judgment

Research showed that shared information dominates discussion and determines decisions. Stasser and Titus designed a paradigm for studying the effects of shared and unshared information on group decision making. Their finding shows shared information plays a key role in group discussion and decision making, which referred as common knowledge effect (Stasser & Titus,1987).

Knowledge (information) sharing process has been proved as an important factor for group performance. Hansen (2002) studied 120 new product development projects in 41 business units of a large multiunit electronics company. The results showed that project teams obtained more existing knowledge from other units and completed their projects faster to the extent that they had short inter unit network paths to units that possessed related knowledge. Further, some scholars have introduced some information sharing system from industry. Dyer and Nobeoka (1998) researched on the knowledge sharing network used by Toyota. Most of the literature has shown that knowledge (information) sharing can improve group performance. But no previous research has discussed the effect of time lag on sharing information.

Another factor ignored by SJS model is the dynamic nature of group decision process. Dynamic means every group member affects each others at real time. The group decision process is actually not a linear, antecedent-consequence type process, but an interactive dynamic process.

In a dynamic system, even there is only a short discussion or other interaction, each member speaks, listens, agrees, disagrees, etc. and each action can affect, and is affected by, each and every other action. In groups with longer durations these factors vary over time and are affected by characteristics of the specific members, the group, and the social/institutional context (Arrow, McGrath, & Berdahl, 2000).

Chaos theory is the most famous field of study on dynamic systems. A chaos system looks like random walk but actually a determinant system. Chaos theory is first found and researched by Edward Lorenz who accidentally found the chaos phenomenon in his weather simulation programming (Lorenz, 1961).

The main attribute of chaos system is its sensitivity of initial condition, also called “butterfly effect”. Back to 1995, Thietart and Forgues have mentioned the importance of Chaos theory in organization research. They argued that because of the coupling of counteracting forces, organizations are potentially chaotic. Also, when the organization is in the chaotic domain, small changes can have big consequences that cannot be predicted in the long term.

CONTRIBUTION OF STUDY

The present study integrates shared information and dynamic nature into SJS model to create Dynamic Social Judgment Scheme (DSJS) model, which is an extension of SJS in dynamic context. In DSJS, group members interact with each other directly and indirectly through information, as well as physical action.

It is easy to accept that human groups have dynamic nature. However, very limit literature has paid attention on building dynamic models for group decision making. One of the main obstacles is that dynamic system is very sensitive to small changes, and falls into chaos. Chaos refers to a kind of unpredictability. It looks like random, but actually is deterministic behavior which is very sensitive to its initial conditions. Obviously, unpredictability is not favorable by researchers, but it is the nature of human groups.

In previous research, information was categorized as shared and unshared, and was examined separately to see which category plays more important role in decision making. Information was treated as a steady factor. But in my Dynamic model, this study introduce the concept of information source, where new information is generated continuously. Group members have their unique information sources. They acquire new unshared information from their own information sources and then share that information through a certain information structure. In DSJS, information is flowing.

In this study, we specifically focus on a very important factor long ignored by the literature of group decision study: time lag of information. In the real world, group members do not receive all the information immediately. Usually, every group member gets their unique information first, and then shared with each other. This information sharing process is not an immediately process. The matter of time plays a key role in real dynamic world. Thus, even the sharing process is very fast, such as a ten minutes meeting or one minute conversation, it still may cause significant change of the group members' behavior. In following contents, we will use DSJS model to illustrate whether this kind of information lag effects exist.

DYNAMIC SOCIAL JUDGMENT SCHEME (DSJS) MODEL

Dynamic Social Judgment Scheme (DSJS) model is a kind of agent based model using computer programming to simulate interactions between group members in a group decision process. DSJS contains three dimensions: physical position dimension, information source dimension, and information structure dimension.

Physical position dimension represents the heterogeneous condition of different group members. It means even if people get same information and make same individual preference, their physical action is different. In figure 1, both A and B want to achieve position M. Due to their different initial position, A and B go through different paths. (See figure 1)

Information source dimension represent the information distribution on time sequence. In DSJS, every group member gets his/her unique information from a specific information source at a specific time. The information is a function of time, f(t), and could be either discrete or continuous. In our model, we do not study on how individuals think, which is beyond the capacity of agent based model. Here, we simply stipulate that the group member's unique information is his/her individual preference.

$$\text{Info.}\,(\text{a}) = \text{F}(\text{T})$$

Information structure dimension shows a certain information diffusion pattern. In DSJS, group members share information through different channel. Also, the sharing process takes a certain time. In figure 1, agent C report to agent B, agent B report to agent A. If the report process takes 1 minute, at certain time when A want to make decision, he/she will based on 2 minutes ago information from C, 1 minutes ago information from B, and real time information from himself/herself. (See Figure 2)

Two processes associate these three dimensions together: Judgment process, action process. Judgment process is how a group balances different preferences from every member to make a group judgment. In DSJS, we follow the exactly same methodology with SJS, which is introduced at the beginning of this paper. The only difference is: In my model, there is nobody called "group". Group decision is represented by a set of consensus individual judgments. However, if we don't know other members' preferences at real time, those consensus judgments may not be exactly the same, but almost the same. The present study defines group as a number of people interact with each other to achieve a common goal.

Action process shows how a group member implements his/her decision. In our model, we simplify this process as moving towards the judgment at a certain velocity, which is a vector quantity. In DSJS, group members' action affects each other at real time. They also have a vector towards each other. This kind of influence also follows certain structure. For example, if the influence structure is the same as information structure shows in graph3, A and B affect each other directly, but B and C does not directly affect each other. (See Figure 3)

The scenario of DSJS is very simple and clear. 1) At first, different information sources generate unique information for different group members followed time sequence. 2) Then, group members share information through information structure. 3) Members make group judgment based on other people's preference (information) using SJS approach. 4) Members take action to the judgment by moving towards the judgment from their physical position. 5) Members physically affect each other. They tend to move towards each other through influence structure.

In this model, we focus on information lag effect. Specifically, we suppose that if there is a small time lag for sharing the information, then the group judgment would be slightly different among the members. This tiny difference, then, would change the action of a group member a little bit. Since group members affect each other, one member's change in position will lead to other members' change directly or indirectly. Further, the change of other members will cause reversely affect. Therefore, our hypothesis is that in DSJS model, a very small time lag can significantly change the action of group members.

A SIMPLE EXAMPLE OF DSJS SIMULATION

In this study, we use programming language FORTRAN to simulation our DSJS model. All the data used in this simulation is just for providing a simple example. A three people group with member A, B, and C was examined in this case. They are a marketing team selling donuts at different sweetness and price.

Their initial physical positions are random set as A(1,2) B(20,30) C(3,50) because they don't know customers' tastes. A(1,2) means A is selling donuts with sweetness level 1 at price $2.

Their information sources are three linear function of time T (minute). In this example, information sources can be regarded as the surveys conducted by A, B, and C. At every time T, they receive a survey report of customers' preference. As time goes by, customers taste and affordability changes continually. (See Figure 4)

Their information and influence structure are same: A lead B and C. This structure means that both B and C share their survey report with A. But they don't share reports directly. In this case, we suppose that if the team sells similar donuts, they can lower the cost. So, both B and C try to follow A's selling strategy to save cost.

Their judgment process follows SJS:

Group Preference = C(A)*Preference A+ C(B)*Preference B+ C(C)*Preference C, Where C is the weight calculated by equation 2.

As mentioned, in DSJS, individual preference is the same with their unique information. So,

$$\text{Preference A} = \text{info. (a)}$$

The action process: The every group member has a velocity towards group preference with a quantity of 5. In this case, the velocity represent the speed of switch one's selling preference to others'. They also have the same velocity towards other group members follows influence structure. (i.e. A←→C, A←→B)

The information lag is set as small as one minute, which means A will get info. B (T-1) and info. C (T-1); B will get Info. A(T-1), info. C(T-2); C will get Info. A(T-1), info. B(T-2). In the case, this one minute could be the time they use to communicate through the phone.

The following figure 5 shows the physical position dimension of the group members at the first 200 units of time (t=6,200). The first 5 unit of time is reserved for group members sharing their information, so that every member knows other peoples preference.

As shown in figure 5, the group members start from different initial positions. They share information, make judgment and move towards their preference. Due to the interaction between group members, their physical path of moving towards group preference is not linear, but chaotic. (It looks like random walk, but is actually deterministic) figure 6 shows only the path of member A at first 50 minute. It is much clear to see the movement of A.

Then, in next case, it can assume that there is no time lag on information sharing. In other words, in this case, everyone has real time information from others. Thus, their judgment result would be exactly the same. The present study expect to use this simulation case to show how much the information lag affects the physical movement of group members. Graph Y show the comparison of the two simulation case.

In figure 7, it can be observed that the information lag only generate slightly different for member A at very beginning. However, after a few minutes, this very small change was exaggerated by time and significantly changes the pattern of A's movement. Both of the two lines follows similar path, but are substantially different. If traditional SJS model results are added into this graph, it can be found that the group reference calculated by SJS model is the guideline of member A's movement. (See Figure 8).

CONCLUSION AND FURTHER RESEARCH DIRECTION

The present study expands a well-established group decision model, Social Judgment Scheme (SJS), into dynamic context. In our new model, Dynamic Social Judgment Scheme

(DSJS), group members discuss and interact at real time to achieve their group preference. Also, chaos theory is introduced into this model. Due to the information lag, the group preference have tiny difference among members. My result shows that DSJS, like other chaos systems, is very sensitive to initial changes. The preference of individual group member changes similarly with random walk but actually determined. Thus, my hypothesis is supported by the simulation results that small information lag can significantly change the action of group members.

Since the judgment process of DSJS is the same with SJS, it shows that although group members' physical position derives from SJS group decision, their general patterns are not seriously different from each other.

DSJS integrates information structure and dynamic factor into SJS model. Therefore, theoretically, it should be a better simulation of the mechanism of group decision process in real world. Thus, in further study, it is expecting to use empirical data to test whether DSJS can exceed the overall fitness of SJS. For management practice, DSJS model could be a useful tool in the prediction of group decision result. Predicting competitors' or a company's own group decision will provide great advantage in business competition. It also can be applied in testing the reliability of a knowledge sharing network. DSJS model can help to tell whether organizational decision will be severely distort by information time lag. In other words, it helps manager to test how fast they should share information in order to prevent losses that cause by a decision based on imperfect information.

In this simulation case, it only showed an example of small selling group with simple information structure. It would be interesting if add more members in a group and make the information structure more complex in future research. Also, nonlinear or discrete information could also be examined in further research.

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APPENDIX: LIST OF FIGURES

Figure 1: Physical position dimension

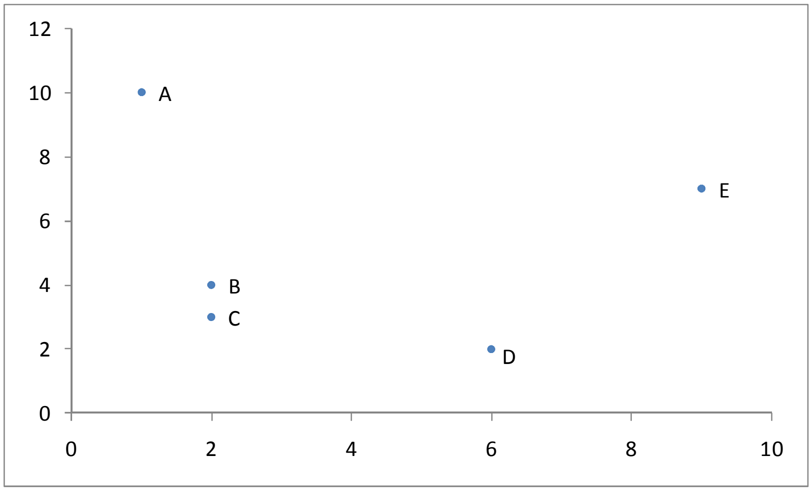

Figure 2: Information Structure

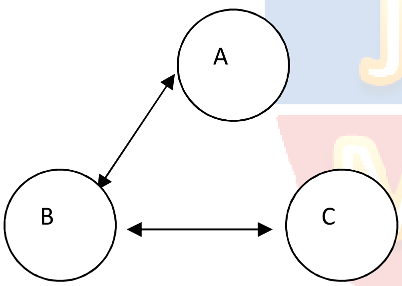

Figure 3: Group Preference

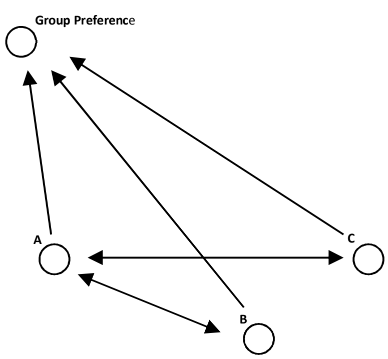

Figure 4: Linear Simulation Results

Info. A (a,b): a= 9+T, b=2*T
Info. B (a,b): a= 3*T, b=3+4T
Info.C (a,b): a= 10+2T, b=80+T

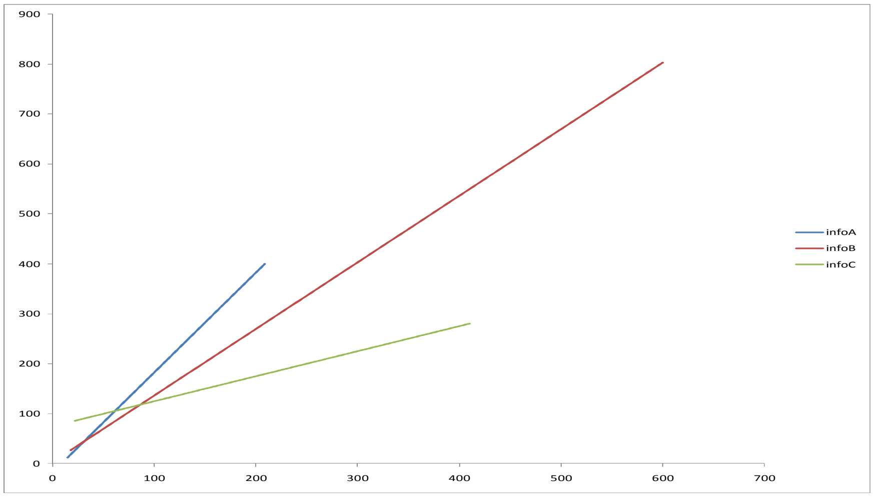

Figure 5: Physical position of all members from T=6 to 200

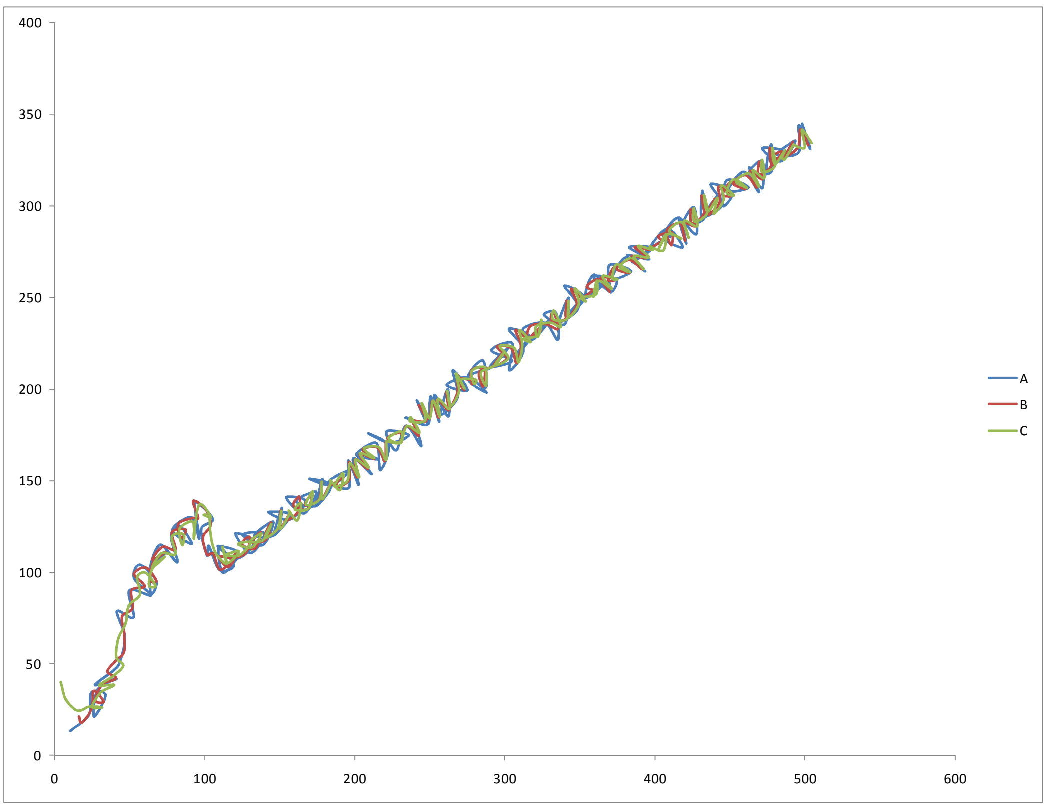

Figure 6: Physical position of member A from T=6 to 50

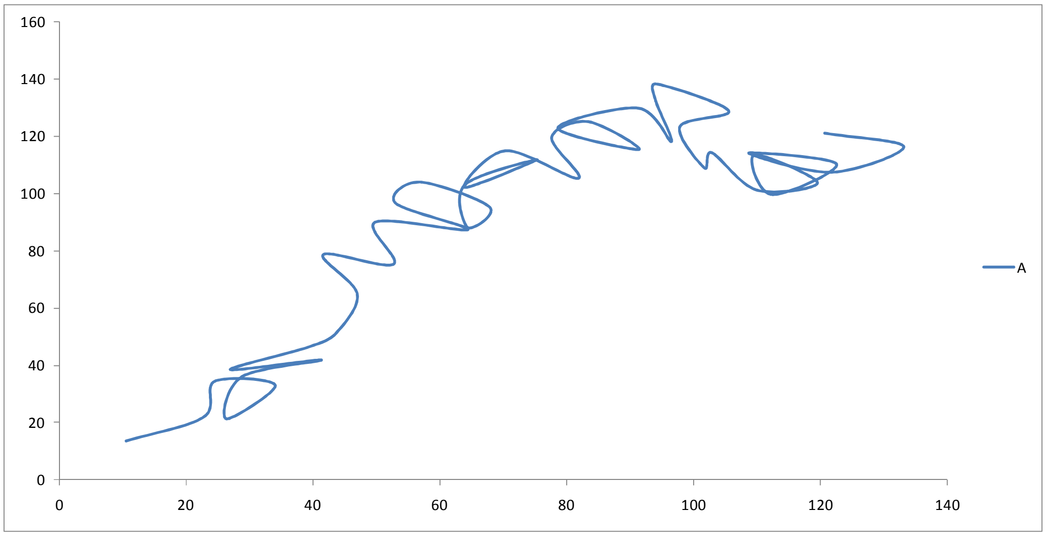

Figure 7: Comparison of A's movement in two cases.

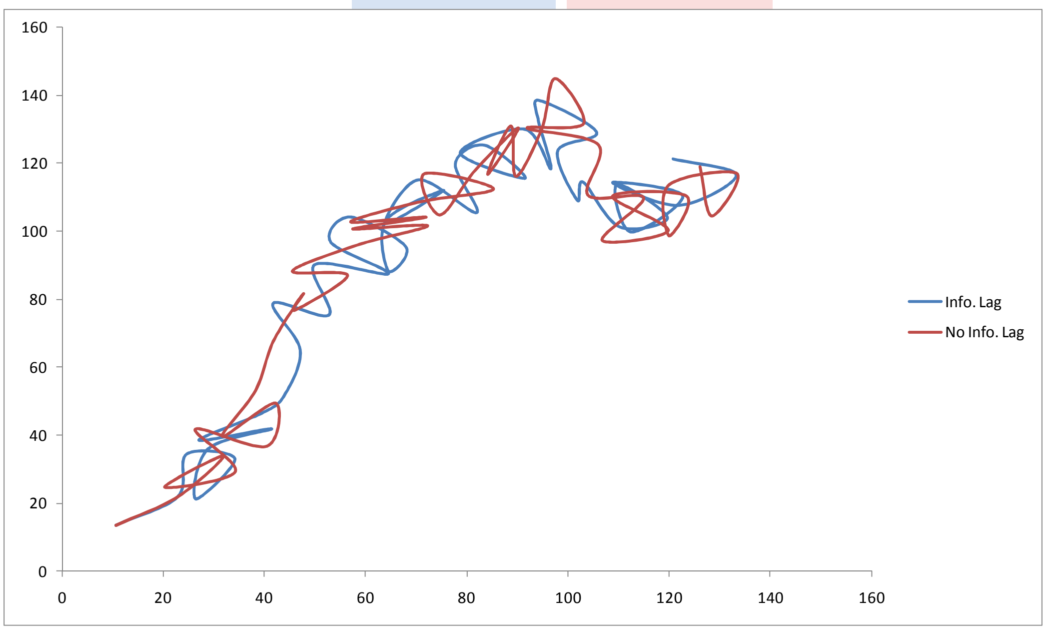

Figure 8: Comparison of DSJS (with info. lag and without info lag) and traditional SJS