Common Owning, Transmission and Development of Knowledge

Susumu Egashira

Otaru University of Commerce,
3-5-21, Midori, Otaru, 047-8501, Japan
TEL/FAX: +81-134-27-5300

University of Cambridge
11, Glenoven Court, Searle Street
Cambridge, CB4 3DW, UK
TEL/FAX: +44 1223 302 603
egashira@res.otaru-uc.ac.jp

Takashi Hashimoto

Japan Advanced Institute of Science and Technology,
Tatsunokuchi, Ishikawa, 923-1292, Japan
Tel: +81-761-51-1756
Fax: +81-761-51-1149
hash@jaist.ac.jp

Abbreviated title: Common owning, transmission of knowledge

ABSTRACT

This paper studies the relationship between social institutions and individual behaviour through the development of the cognitive framework of individuals. Social sciences have had interests in social institutions or norms. Much of the studies treat the problem from the viewpoint of social costs and lack focusing on individual action and cognition. To consider the problem as a whole naturally means that the discussion have to be made according to subjectivism. Setting subjectivism forth as a premise, the problem of relativity of the cognition is studied through reconsideration of the conception of information and its transfer. By adopting a multi-agent model having the cognitive framework and the interaction among agents, the formation process and the feature of institutions are computationally investigated. From results of simulation, it is confirmed that the cognitive frameworks of agents are affected action mimicing others' superficial behaviour. Moreover, it is eventually shown that the assumption of isolated individuals is unsuited even in studying in less communicative communities.

Keyword: Formation of institutions, Institutional action, Cognitive framework, Multi-agent model

INTRODUCTION

This article deals with the relationship between social institutions and the behaviour of individuals in terms of the formation of a cognitive framework. It is a well-known fact that we form institutions as social rules and follow them. A lot of theoretical explanations about a role of institutions have been proposed in economics or sociology. The transaction cost theory of new institutionalism which asserts that actions following existing rules (institutions) can largely decrease the cost has influence on not only economics, but also law or sociology (Coase, 1937). In those fields, they define the conception of an institution as the situation in which incentives for every one are compatible (Aoki, 1988, 1997). However, we have to consider the institution from the viewpoint of the cognition of each agent, because the institution affects his or her choice. In daily action of making decisions, each person has to decide individually not only what are right options but also what choices, criteria or information are useful for making the *correct* decisions. However, little attention has been given to this problem in modern social science. In game theory, for example, which partly introduces subjectivism, the structure of the games and the information is predetermined. Even when rationality is bounded or information which can be obtained is regulated, such argument has the same structure, in which each player deals with the given information in a way which is decided initially and finds correct (or wrong) solutions (Simon, 1957). However, in real world in which the problem of subjectivity is unavoidable, the structure of the game is not given to each agent. Moreover, we have to decide subjectively what is necessary information or what is an appropriate or wrong solution.

In the next section, we explain the details of the basic idea which is suggested here. In the third section, we show an example of the relationship between the formation of the cognitive framework of each agent and the social norm by using a multi-agent model. In the fourth section, we show the noteworthy result of simulation and in the last section, the implication of the model and significance of this argument are considered.

SOCIAL NORMS IN TERMS OF SUBJECTIVISM

We should give a specific definition to each term, 'signal', 'information' and 'knowledge' so as to avoid confusion.

- signal: data which is still not interpreted by an agent.

- information: signal which is already interpreted by an agent.

- knowledge: accumulation of experience which is used for the formation of a cognitive framework for interpreting signals.

For example, saying the fact that "there are lots of information on the internet" in everyday language, we should say that "there are lots of signals on the internet" because most of them are not interpreted by most people. In this case, information is signals which an agent judged to be necessary and obtained from the internet. Knowledge is sometimes identified with cognitive framework, but the latter is formed as the result of accumulation of the former. Metaphorically speaking, knowledge plays the part of a 'genotype' and the framework of interpretation is its 'phenotype'.

It seems that, in our daily life, we do not face such a serious problem that we do not have a way to confirm whether other people correctly understand what we said. We are so successful in communicating with each other that we can say that we share language as a communication rule. This fact suggests that our successful communication depends more on the problem whether individual agents can internally give a consistent interpretation to signals received than on the correctness of information transfer. That is to say, the agent A can understand the sequence of signals that is sent by agent B according to the coherent framework of interpretation (Kaneko & Matsui, 1999)

In this case, such a possibility is unavoidable while agent B talks about the football, agent A understands this story as apples. However, in this paper, we consider that such a 'misunderstanding' also is part of the nature of communication. Thus, in that case, even if communication fails in objective term, we consider that it is successful as long as each agent does not have problem.

From strict subjectivism, it is clear that we have to reconsider the definition of information.

In modern economics, information is defined as such is needed to make an optimal decision in economic choices. For example, each consumer needs to know information about his or her own utility function which has transitivity (Arrow, 1952, 1968) This conception of information is uniquely defined in every case even when economists think about the problem of imperfect information. Economists always know information which is necessary-sufficient for reaching equilibrium. In this sense, we can call the conception in orthodox economics 'appropriately processed information'.

However, in the real world which is dominated by subjectivity, we have to judge by ourselves "what is information for us". We have to pick up part of the signals which is circulating in our society and convert them into information which are useful for us. That is, we necessarily face the problem of interpretation

when we try to obtain information.

Moreover, now, a more serious problem arises. In order to form the cognitive framework for consistently interpreting signals received, it can be presupposed that signals are coherent because if signals do not have any coherency, the effort of consistently understanding them is in vain. Thus, it is a necessary condition of communication that receivers of signals at least can *believe* that signals which they are receiving have some kind of coherency.

Each agent does not initially have method to judge whether they are worth interpreting. This is concerned with the problem of the reliability of information. If we try to confirm the reliability of signals received, we need additional information. Furthermore, this additional signal also has the same difficulty because the additional information for verification of reliability of first signal is also the result of interpreting additional signals. Then, the problem of checking the reliability of the additional signals arises. This chain cannot be cut logically. (Stochastic approach to this kind of problem is meaningless because it requires strong rationality to estimate the probability distribution of reliability.)

If reliability of signals cannot be internally confirmed, each agent has to solve the problem by replacing its own reliability with something else. Such behaviour is often observed in the real world. For example, when we choose such behaviour as habit, imitate others action or follow the authority or reliability of others, we have no apparent reason but adopt it as 'temporary' criteria of judgment.

Such imitative behaviour is an attempt at sharing knowledge of successful agent with other people. The merit of imitation is to make use of knowledge of successful person without having the same experience in reality. When some kind of criteria for action is lacked, there is high possibility that behaviour of each agent is completely erratic. However, to repeat the behaviour of successful person partly decreases number of possible choices and gives temporary criteria of action.

We, here, have to consider the essence of imitation. The only thing which each agent can observe is apparent action because according to strict subjectivism, no one can directly see the cognitive framework of others. Therefore, each agent infers the framework of others from his or her observation of superficial actions. Each agent in reality conjectures through trial and error. We cannot say that in this process, every agent always improves his or her cognitive framework. We should discuss rather what influence the imitation and inference make on the process of formation of cognitive framework than whether the imitation is 'rational' or not.

As a result of imitation of those actions, the cognitive framework obtained can have striking similarity with neighbours of each agent although he or she cannot directly observe their frameworks. Of course, the path which each agent follow and the quality or quantity of the knowledge which he or she can obtain in their process are different because of the difference in circumstances. However, it is an interesting point that each cognitive framework as a 'phenotype' of his or her knowledge has some similarity in terms of analyzing the relationship between knowledge of people and group actions, especially norms or social institutions.

Although it is one of the simplified group actions that we consider in this article, it suggests significance when we argue the problem of social institutions. A lot of studies about social institutions and norms have already been published (Aoki, 1988; Castelfranchi, Conte & Paolucci 1998; Doran 1998), but in most of their explanations, social institutions or norms are regarded as affecting and regulating only apparent actions and decreasing the transaction cost. However, it is also a feature of social institutions or norms that they affect the formation of individuals' mind or framework of cognition and internally decide the actions and a way of thinking such as language, culture, a conventions and so on.

As Ittelson and Cantril (1954) pointed out, our cognitions, actions and the external world are associated with each other. However, many social institutions are not maintained by a reasoned judgment, but rather accepted unquestioningly as habits or conventions. It is not 'rational' indeed to drive on the right against the traffic rule but the reason why we usually drive on the left is that such an action is already imprinted on our unconscious. (The argument of tacit knowledge (knowing) of Polanyi (1962, 1966) or Hayek (1945) closely related to the essential conception of knowledge in this article.)

In the next section, we discuss the problem of the relationship between the social institutions and the cognitive framework of individuals in terms of agent simulation. There, it makes clear that the assumption of 'isolated individuals', especially in modern economics, cannot be used even approximately in the society that depends on institutional actions. We suggest that this problem can be explained not only from the viewpoint of externality which is usually adopted but also from the viewpoint of the formation of the cognitive framework.

MULTI-AGENT MODEL

We introduce a multi-agent model which represents the situation mentioned above. The precise description of the model is in (Hashimoto and Egashira, To appear). The model consists of two kind of agents, information suppliers and receivers. The information suppliers observe original signals and interpret

them with their own cognitive frameworks. The information interpreted is sent to the information receivers. Each receiver adopts a supplier as a source of information and interprets the signal sent from the suppliers with his or her own cognitive framework. The information interpreted by each receiver is evaluated by comparing with the original signal. After the evaluation, a new original signal is given to all suppliers and the flow of information is repeated.

In the model, the cognitive framework and the original signal are expressed by a 10 bit string, respectively. The interpretation process of information by each agent is represented by XOR bit operation, which is defined as $\text{XOR}(x, y) = 0$ for $x = y$, $\text{XOR}(x, y) = 1$ for $x \neq y$, where x and y are binary variables. The suppliers and receivers constitute 20×20 cell planes with periodic boundaries, respectively. The information flow is illustrated in Fig. 1.

Insert Figure 1 About Here

The results of evaluation of a receiver is measured by the number of coincident bits in information interpreted with the original signal. The receivers change their behaviour according to the score. If a receiver has the lowest score in his or her neighbouring 8 receivers, a randomly selected bit in his or her cognitive framework is flipped. When a receiver continues to get the lowest score alone for longer than r times, he or she changes his or her supplier to one who is employed by the best receiver in his or her neighbourhood. The parameter r is called 'the interval of revision', since it reflects how often receivers observe their neighbors in order to change their action.

SIMULATION RESULTS

In this section, cluster formation and the dynamics in the model are reported. For the detailed analysis of the system, please refer to (Hashimoto and Egashira, To appear). There are clusters which consist of receivers who adopt the same suppliers. The cognitive frameworks of the receivers in one cluster become homogeneous, while they have diversity among clusters. Since they share the interpretation method, the clusters are regarded as social norms.

To consider what occurs in the process of development, we investigate the average score, denoted by $\langle P \rangle$, and the average number of clients, $\langle c \rangle$. The latter value is the average number of receivers who adopt

suppliers and estimates the size of clusters. In addition to these two values, the number of receivers who change their frameworks, n^f, and the accumulated number of receivers who change their supplier, n^s, is assessed in order to see how the mechanisms of revision work. Figure 2 depicts the dynamics of these four values in the course of time.

_____

Insert Figure 2 About Here

_____

Development of the system can be divided into four phases by the course of change of the average score. In the first phase ($t \cong 0 \sim 2000$), it increase monotonically. The rate of growth of the score decreases at the end of the first phase. In the second phase ($t \cong 2000 \sim 7500$), the score continues to go down. In the third phase ($t \cong 7500 \sim 20000$), the score ascends again with the lower rate than in the first one. Eventually it achieves a maximum score. Then, the system reaches a fixed state. It is the 4th phase ($t \gtrsim 20000$).

These four phases coincide with the dynamics of cluster formation and that of change of behaviour by receivers. At first, many receivers change their suppliers and, as a result, clusters expand. At the end of this phase, the average score come to 80% out of full marks. In the second phase, since many receivers have the same suppliers as their neighbours, they try to improve the performance by internal change of the cognitive frameworks. However, it is difficult to set remaining 20% in the frameworks appropriately by a random search. In the third phase, suppliers who are adopted by receivers with better performance spread. Thus, the clusters again develop.

We can summarize the dynamics of receivers as follows. At first receivers use both internal change of frameworks and switching suppliers. Then the change of frameworks and suppliers function alternately. Finally they attain the maximum performance by changing the frameworks. From the explanation above, receivers converge finally into some groups adopting the same suppliers. We can conclude that the clusters of receivers have two feature. One is that they adopt the same supplier and the other is they share the same cognitive framework.

We are interested in the dependency of the size of clusters on the interval of revision, since it represents how the strength of interaction among receivers affects the behaviour of system. The result is shown in Fig. 3. We confirm that the relationship between the interval of revision and the average size of clusters obeys a power law, $\langle c \rangle = br^{-a}$. This fact supports the cluster formation in our system. Moreover it reveals that

the receivers make clusters even when the interval of revision is extremely long. In other words, we can not neglect effect of formation of norms to consider behaviour of agents, even in weak interaction between agents.

———————————————

Insert Figure 3 About Here

———————————————

DISCUSSION

To imitate the actions by mimicking others' apparent actions means sharing knowledge between individuals. According to Peirce (1934), the cognition of humans is regulated by the knowledge which has been accumulated. To imitate the actions of others makes it possible to possess knowledge which is not dependent on his or her direct experience. In a sense, such an action saves time and avoids risk. However, little attention has been given to the problem of the interactive process between a cognitive framework and a group action. The result of computer simulation in this article leads us to suggest two propositions.

Proposition 1

If a person refers to the action of others in making his or her decision, it affects the process of the formation of his or her cognitive framework.

In this article, agents follow the rules to adopt the actions of others who temporarily obtain the best score among their neighbours. We can regard the group which is formed by this rule and consists of such members who adopt the same action which is choosing the same supplier of information as an institutionalized community. They adopt not only the same apparent action but also the internal cognitive framework which has a great deal in common. If we can consider the cognitive framework as something which determines the our judgment, it means that the knowledge of a particular person is with others.

Proposition2

The model which does not take interactions among people into account cannot be an approximation of the event which more or less has such an interaction.

As we saw in the previous section, even when the interval to observe others' action is very long, the agents make some groups very frequently and such behaviour affects the process of the formation of

cognitive frameworks. In the many models in economics, especially the models which do not introduce the problem of externality, each agent is assumed to be isolated. This is method to make the problem easier (especially mathematically). However, in modern society, there are few cases in which every one does not have interaction with each other, even if they are 'prisoners'. Thus, when we deal with social problems, the model which assumes 'isolated' individuals may mislead us. On the other hand, the argument in this article is useful to make clear the mechanism of sharing the same customs between isolated communities such as villages in the Amazon or Europe in the medieval period (Ginzburg, 1979). There is a possibility that influence of interaction between people is stronger than we usually thought.

Many social scientists tend to consider the existence of social institutions from the viewpoint of whether it is useful or not for our life. However, we should notice that the social institutions or norms emerge from the interaction of people spontaneously and they do not decide whether it is right or wrong, or good or bad. In such studies, we should think of the institutions or norms according only to the evolutionary viewpoint which considers whether they can survive even in the short term.

CONCLUSION

In this article, we regard the social institutions or norms as sharing knowledge in the community and observing the influence on the formation of the cognitive framework on which we depend when we decide our action. We assume that revision of the cognitive framework is made by direct changes internally and by imitations of the action of others. In this assumption, we can understand that heteronomous behaviour of people affect the formation of the cognitive framework even when the framework is not directly observable but only superficial action can be observed. We see that when we consider the problem of society an isolated individual cannot be assumed even if an approximation.

ACKNOWLEDGEMENT

REFERENCES

Aoki, M. (1988). *Information, incentives and bargaining in the Japanese economy.* Cambridge: Cambridge University Press.

Aoki, M. (1997). The evolution of organizational conventions and gains from diversity. *working papers of Stanford University, Department of Economics.*

Arrow, K. J. (1952/1984). The principle of rationality in collective decision. In *Collected papers, vol.1.* Mass: Harvard University Press.

Arrow, K. J. (1968/1984). General Equilibrium, In *Collected papers, vol.2*, Mass: Harvard University Press.

Castelfranchi, C., Conte, R, & Paulucci, M. (1998). Normative reputation and the costs of compliance, *Journal of Artificial Societies and Social Simulation, 1*,

http://www.soc.surrey.ac.uk/JASSS/1/3/3.html

Coase, R. (1937). The nature of firm, *Economica, 4*, 386-405.

Doran, J. (1998). Simulating collective misbelief, *Journal of Artificial Societies and Social Simulation, 1*

http://www.soc.surrey.ac.uk/JASSS/1/1/3.html

Ginzburg, C. (1979). *Benandanti: Stregoneria e culti agrari tra cinquecento e sei.* Piccola biblioteca Einaudi.

Hashimoto, T. & Egashira, S., (To appear). Formation of social norms in communicating agents with cognitive frameworks, *Journal of Systems Science and Complexity.*

Hayek, F. A. (1945). The use of knowledge in society, *American Economic Review, 35*, 519-29.

Ittelson, W. H. & Cantril, H. (1954). *Perception: A transactional approach.* USA:Doubleday.

Kaneko. M. & Matusi, A. (1999). Inductive game theory: Discrimination and prejudices, *Journal of Public Economic Theory, 1*, 101-137

Polanyi, M. (1962). *Personal knowledge: Toward a post-critical philosophy.* Chicago: Chicago University.

Polanyi, M. (1966). *Tacit dimension.* London: Routledge.

Peirce C. S. (1934). Pragmatism and pragmaticism, In *Collected papers of Charles Sanders Perice, vol.5.* MA: Harvard University Press.

Simon, H. A. (1957). *Models of man: Social and rational*, New York: Wiley.

FIGURE CAPTIONS

Fig.1

Information flow from objective situation to a receiver through a supplier.

Fig.2

The time series of the average score, $\langle P \rangle$, the average number of clients of suppliers, $\langle c \rangle$, the number of receivers who change their framework, n^f , and the accumulated number of receivers who change their supplier, n^s. The the interval of revision is $r = 1$. All values are appropriately scaled to make it easier to compare the relative dynamics.

Fig.3

Average size of clusters v.s. the the interval of revision. Both axes are scaled by logarithm. The straight line is a function . It is clearly shown by the graph that the relation between the average number of clients and the revising interval obeys a power law.

objective situation   1 0 0 1 0 1 1 1 0 1

supplier's
cognitive framework   1 1 0 1 0 0 1 1 0 0

XOR

information
from a supplier   0 1 0 0 0 1 0 0 0 1

receiver's
cognitive framework   0 1 0 1 0 0 1 0 1 1

XOR

action of a receiver   0 0 0 1 0 1 1 0 1 0   matching