TOPOLOGY AND SOCIAL BEHAVIOUR OF AGENTS

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1 Abstract

We call in a social group its members as agents. On a capital market the social group is formed from those who are buying and selling shares. In general the social group we characterise in accordance with T. Plummer / The Psychology of Technical Analysis, rev.ed., Probus Pub.Com., Chicago, 1993/. We assume that individual behaviour of agents is influenced to some degree by the need to associate with other agents and to obtain the approval of other agents in the group. The group is characterised by a very large nonrational and emotional element to decisions of agents. It is due to the fact that making decisions an individual equates own needs with those of the other agents from the group. Any two agents from the group may interact. The interaction consists of the exchange of information and it costs some energy. The information is well defined, and we assume that agents interact in such a way that they give reference to the origin of the information if asked by other agents. Thus the agent may verify obtained information. It is natural then that there exits a subgroup of interacting agents the interaction of which has the following property: it is nonreducible in the sense that in this subgroup there exists the interaction of a given agent with another one, this another one agent again interacts with another agent, and because it has no sense to exchange the information with the first one to verify the information, this last mentioned agent is different from the first one. This third agent can thus always verify the information from two sources either interacting with the first one, either he/she is interacting with the fourth agent. In the first case we have a minimal subgroup of interacting agents, which form a closed subgroup in which every agent verifies information from two sources - agents. In the second case the fourth agent either interacts with the first one and verifies exchanged information, either with the second one and verifies information. He of course can interact with the third one agent, however to verify information he needs again to interact with different agent from that interacting with which he obtained the new information. This is the reason why he interacts either with the first one agent, either with the second one. In the first case we have a closed subgroup of four agents in which every agent interacts with two agents. In the second case the closed subgroup reduces to the group of three interacting agents /last three agents/, verify information interacting with the fifth agent. Then by the same procedure as in previous case we may obtain nonreducible subgroups of three, of four and of five agents, or the fifth agent interacts with the sixth one. And so on. Thus we obtain closed subgroups of interacting agents in which every agent interacts with two other agents, and in which the process of verification of information leads to closed linear structure. If any of agents from such an subgroup exchange and thus verifies information with any third one agent from the subgroup, the structure of the subgroup changes, the subgroup becomes reducible to two new nonreducible subgroups. This is the process of differentiation of the first nonreducible subgroup to two new ones. This is an example of an elementary transformation between two configurations of nonreducible subgroups. An vice versa: if the interaction between two agents which interact with three agents in the configuration of two nonreducible subgroups vanishes, a new one nonreducible subgroup creates and information is still verifiable. When the configuration in which an agent was interacting with three agents which were not interacting between themselves transform to a configuration in which two of the mentioned three agents interact, then we may observe
the process of mitosis: a new nonreducible group appears. Thus the transformation between this two configurations is reversible. A cell is such a configuration of a given number of nonreducible subgroups in which every two interacting agents belongs to two nonreducible subgroups/subgroups are connected in this sense and which is closed. Such a cell may disappear and may be created, may change number of nonreducible subgroups in a reversible way. Because the structure, configuration of interactions between agents in the group, forms a macroscopic structure, we say that it is a microreversible process any process within a nonreducible subgroup and within a cell. Statistical equilibrium of the whole group is characterized by a set of different subgroups of the type mentioned above, and by a probability that such a subgroup occurs. Thus we have probability distribution which characterizes the group. Moreover there exists an equation of state which enables to compare different macroscopic states of the group. The statistical equilibrium due to microreversibility is characterized by the maximum of entropy and by the minimum of energy/costs of information exchange/. There exist constrains, such as a fixed number V of agents in the group, a number E of interactions within the group, a number F of subgroups which are nonreducible, and a number C of cells. Thus we have a structure which is equivalent to random cellular networks. Such networks and their evolution were described by N. Rivier/Physica 23D (1986) p. 129/. He applied methods of statistical mechanics to study these structures. We will use methods described by Rivier to study social behaviour of agents, mainly the presence of topological structure of interactions between agents and its changes, which is the most important property of the group of agents. The area of a nonreducible group which belongs to those nonreducible groups which form the cell may be formed again for example by a sum of areas of agents characteristic areas. Note that area of the nonreducible group may be also some other characteristics of the group of agents depending on studied social relations between agents. Thus we are able to study topology properties of interactions of agents. Their social behaviour is discussed. It can be shown that the equilibrium number of agents with which a given agent interacts is three for a group without cells/the group forms a single cell/.
2 Introduction

We call in a social group its members as agents. In general the social group is characterised in accordance with T. Plummer [1]. We assume that individual behaviour of agents is influenced to some degree by the need to associate with other agents and to obtain the approval of other agents in the group. The group is characterised by a very large nonrational and emotional element to decisions of agents. It is due to the fact that making decisions an individual equates own needs with those of the other agents from the group. Any two agents from the group may interact. The interaction consists of the exchange of information and it costs some energy. The information is well defined, and we assume that agents interact in such a way that they give reference to the origin of the information if asked by other agents. Thus the agent may verify obtained information. It is natural then that there exits a subgroup of interacting agents the interaction of which has the following property: it is nonreducible in the sense that in this subgroup there exists the interaction of a given agent with another one, this another one agent again interacts with another agent, and because it has no sense to exchange the information with the first one to verify the information, this last mentioned agent is different from the first one. This third agent can thus always verify the information from two sources either interacting with the first one, either he/she is interacting with the fourth agent. In the first case we have a minimal subgroup of interacting agents, which form a closed subgroup in which every agent verifies information from two sources - agents. In the second case the fourth agent either interacts with the first one and verifies exchanged information, either with the second one and verifies information. He of course can interact with the third one agent, however to verify information he needs again to interact with different agent from that interacting with which he obtained the new information. This is the reason why he interacts either with the first one agent, either with the second one. In the first case we have a closed subgroup of four agents in which every agent interacts with two agents. In the second case the closed subgroup reduces to the group of three interacting agents /last three agents/. This process can continue further, because the fourth agent may also verify information interacting with the fifth agent. Then by the same procedure as in previous case we may obtain nonreducible subgroups of three, of four and of five agents, or the fifth agent interacts with the sixth one. And so on. Thus we obtain closed subgroups of interacting agents in which every agent interacts with two other agents, and in which the process of verification of information leads to closed linear structure. If any of agents from such an subgroup exchange and thus verifies information with any third one agent from the subgroup, the structure of the subgroup changes, the subgroup becomes reducible to two new nonreducible subgroups. This is the process of differentiation of the first nonreducible subgroup to two new ones. This is an example of an elementary transformation between two configurations of nonreducible subgroups. An vice versa: if the interaction between two agents which interact with three agents in the configuration of two nonreducible subgroups vanishes, a new one nonreducible subgroup creates and information is still verifiable. When the configuration in which an agent was interacting with three agents which were not interacting between themselves transform to a configuration in which two of the mentioned three agents interact, then we may observe the process of mitosis: a new nonreducible group appears. Thus the transformation between this two
configurations is reversible. A cell is such a configuration of a given number of nonreducible subgroups in which every two interacting agents belongs to two nonreducible subgroups and which is closed. Such a cell may disappear and may be created, may change number of nonreducible subgroups in a reversible way. Because the structure, configuration of interactions between agents in the group, forms a macroscopic structure, we say that it is a microreversible process any process within a nonreducible subgroup and within a cell. Statistical equilibrium of the whole group is characterized by a set of different subgroups of the type mentioned above, and by a probability that such a subgroup occurs. Thus we have probability distribution which characterizes the group. Moreover there exists an equation of state which enables to compare different macroscopic states of the group. The statistical equilibrium due to microreversibility is characterized by the maximum of entropy and by the minimum of energy. The group forms a single cell.

3 Human groupings have hierarchical structure.

Human groupings have hierarchical structure. The civilisation consists of societies, societies consist of groups, and groups consist of individuals. A social group has power to organise individuals and to group together for its own purposes. An agent we call a member of a social group, we assume that his/her special properties are defined.

Agent - its behaviour is influenced to some degree by the need to associate with other agents and to obtain the approval of other agents in the group. A group is characterized by a very large nonrational and emotional elements in decisions of agents, and agent equates his/her needs with those of the other agents from the group. The equilibrium number of agents with which a given agent interacts is three for a group without cells /the group forms a single cell/.
energy and consists of the exchange of information about his/her needs, the information is well defined. Specification of agents here: agents interact in such a way that they give reference to the origin of the information if asked by the other agent. Thus an agent may verify obtained information.

Nonreducible subgroup of the group of agents is a group which defined in the following way. There exists interaction of a given agent with another one. This another one agent interacts with another one. It has no sense for him/her to exchange information with the first one to verify information/to obtain approval of at least another one agent/: thus the agent interacts with and agent different from the first one. This the third agent can verify the information from two sources: either interacting with the first one, either interacting with the fourth one. The first case leads to formation of a nonreducible subgroup of three agents in which every agent verifies information from two different sources/we asuem that information is verified if an agent verifies information from at least two different sources/. The second case: the fourth agent interacts either with the first one, and we ontain a nonreducible subgroup of four agents, either this agent interacts with the second agent, and we obtain a nonreducible subgroup of three agents, this process may continue further: the fourth agent may verify information interacting with the first ones, the process just describes now may lead to a nonreducible subgroup with three, four or five agents, etc. Thus in the group of interacting agents there exist nonreducible subgroups of agents which are closed as concerning exchange of an information and in which every agent interacts with two and only two other agents, thus the structure of interaction of agents is "linear-circular".

4 Nonreducible subgroups of the group of agents may transform.

Reduction of a nonreducible subgroup to two nonreducible subgroups: if any agent from a given nonreducible subgroup interacts as concerning exchange of an information with a third one agent from the nonreducible subgroup. And vice versa: if the interaction as concerning exchange of an information between two agents in the configuration of two nonreducible subgroups vanishes, a new one nonreducible subgroup appears. Mitosis is a process in which an agent which was interacting with three agents which were not interacting between themselves transforms to a configuration in which two of the mentioned three agents interact, then a new nonreducible subgroup appears, this process is reversible.

Cell is a configuration of a given number of nonreducible subgroups in which everz two interacting agents belong to two nonreducible subgroups of a closed subgroup formed from nonreducible subgroups. Cella of the group of agents may reversible transform, they may disappear, may be created, may change a number of nonreducible subgroups.

5 The structure of the group is macroscopic

The group has a given number of agents, of nonreducible subgroups and of cells as concerning exchange of information. Statistical equilibrium of the group
is characterized by different macroscopic structure as concerning exchange of an information and by a probability that a nonreducible group appears, this probability characterizes the group. Equation of state comparison of different macroscopic states of the group. Statistical equilibrium exist in the group due to reversibility, it is characterized by the maximum of entropy and by the minimum of energy /costs of information exchange/. Constraints are given by a fixed number $V$ of agents in the group, a number $E$ of interactions, a number $F$ of subgroups which are nonreducible, a number $C$ of cells, note that conservation law holds \[4]:

$$-C + F - E + V = 1$$

(1)

Note that structural stability exists \[4]: only agents with interaction with four agents are structurally stable in 3d, and only agents with interaction with three agents are structurally stable in 2d. This structure is equivalent to random cellular networks, such networks and their evolution were described by N. RIVIER \[3], \[4] by methods statistical mechanics.

We will use these methods to study social behaviour of agents, and changes of this behaviour, mainly the presence of the topological structure of interactions between agents and its changes, the most important property of the group of agents which corresponds to maximum of informational entropy.

One can define an area of nonreducible subgroup and volume of the cell. We assume that there is homogeneity, and no costs of information.

### 6 Personal area and social behaviour of agents of the group

The average area $A(n)$ of an $n$-sided cell is \[3], \[4] / if $A$ is the total area in which group is localised/:

$$A(n) = \frac{A}{F} \lambda (n - (6 - \frac{1}{\lambda}))$$

(2)

Assume that this area corresponds to a personal area of agents forming an $n$-sided nonreducible subgroup, due to homogeneity and equilibrium every agent contributes $\frac{1}{6}$ personal area $A(n)$, thus $\lambda = \frac{1}{6}$ and

$$A(n) = \frac{An}{6F}$$

(3)

One agent contributes $\frac{1}{6}$ of his personal area to the area $A(n)$, if we denote $r$ the radius of the agent’s personal area then:

$$\frac{\pi r^2}{3} = \frac{A}{6F}$$

(4)

As we see personal radius increases as a square root with increased total area $A$ per a nonreducible group. As we see personal radius decreases as an inverse square root with increasing number of nonreducible groups, in towns personal area is observed to be smaller than in villages \[2], this corresponds to smaller $\frac{A}{F}$ ratio in towns than in villages according to our equation above, the ratio $\frac{A}{F}$ is more-less constant in area $A$ in these cases, however it
is increasing with the density of agents in the group (town, village) and thus number of nonreducibile groups is increasing in our equation for personal area qualitatively, personal radius is increasing with decreasing risk which a person expects [2]: intimous - smaller radius is 0.15 m and less for intimous contacts /love, security, ... /, intimous - larger radius is 0.15 m to 0.45 m for less intimous contacts /relatives/, personal - smaller radius is 0.45 m to 0.90 m for personal contacts with close friends and relatives, personal - larger radius is 0.90 m to 1.20 m for personal contacts with friend, business people, neighbours. Thus we see from our equation that F may be associated with risk: for constant area A the larger F the smaller r and smaller acceptable risk (*). Personal radius is large for inhabitants [2] of New Zealand, Australia and white North-Americans, it is middle for inhabitants of Great Britain, Switzerland, Sverige, Germany, Austria and it is small for inhabitants of Arab countries, Japan, South-Americans, inhabitants of countries around Meditterrenien sea /Italy, France, Greece, ... / and black North-Americans: one can say qualitatively that (probably due to temperament) the first group is characterised by low risk activities and by their preference, the second group is characterised by middle risk activities, and the last group is characterised by high risk activities. Thus first group has F lower than the second group, and second group lower than the third group: this is consistent with the statement (*).

7 Conclusion

We conclude that the three mentioned empirically observed dependencies of personal radius dependence on some factors enabled us to characterize the quantity F as the quantity which characterizes verification of information, the smaller personal radius the larger process of verification of verbal and non-verbal information about the other person in order to accept the risk that this person will be closer to us as a person. We expect that this conclusion is a general conclusion.

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