

A SYSTEM DYNAMICS APPROACH TO
GROUP FORMATION AND PRODUCTIVITY

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ABSTRACT

Based on previous work on Group formation, in particular on the classic "The Human Group" by Homans (Homans 1950), we develop a System Dynamics model to portray the growth of two social subgroups within a larger work group. The work-group is the people working in the bank wiring room of the Western Electric facilities in Hawthorne, Illinois as described in Homans work (op.cit). Working with concepts taken from Cognitive Dissonance (Festinger 1957) we describe the dynamic interaction pattern of a synthetic group consisting of five individuals. Depending on hypothetical time constants describing the participants willingness to change, we get a distinct subgroup formation process before the development of a common set of beliefs for the entire group or just development of a "group culture" without the prior formation of the subgroups. Further research is suggested, notably the inclusion of antagonism in the model. It is also suggested that such SD models can be used to integrate knowledge of personalities to simulate the impact of a person on the performance and behavior of a work-group.

INTRODUCTION

Organization is a generic term for a purposeful entity of people involving more than one person. An organization usually includes several subgroups. Also characteristic for an organization is the existence of a goal shared in some way among its members. A sub-unit of an organization, where the members know of each other, perceive themselves as a distinct entity and also is perceived by outsiders as a distinct entity is called a group. (In an organization, very often the individuals are unknown to each other.) There are basically two competing types of groups within an organization. The one is the work group, which is formally defined. The other is the social group, most often spontaneously defined and not necessarily serving the goals of the organization. Characteristic for the latter is the shared interests and the Closeness in social value systems among the individuals belonging to the group.

The question of how work and social groups are formed has led to a considerable amount of research in the last fifty years. Common to a major part of these studies is the acknowledgement of the group formation process as a dynamic one. Even so, most work has consisted in explaining the necessary conditions for group formation, and very few have looked into the dynamics of the formation process. Simon (1952) is an exception, but that work is so formal that mainstream organizational research has not continued along the mathematical path he describes.

The Psychoanalytic/-dynamic group tradition with its emphasis on the projection of individual needs onto the group and the importance of different instances of personality (Coleman & Bexton 1975), does not explicitly deal with the group formation process. Another class of studies takes the group as given and is mainly concerned with the impact of existing technology, norms and individual values on production and other aspects of group output (Kolodny & Kiggundu 1980, Goodman 1986). Yet another class is

concerned with the boundary of the groups (Alderfer, 1976) and interaction between groups and subgroups.

The need for further investigation into the group formation process has been outlined by various scholars. Homans (1950) points out that lack of adequate mathematical tools makes difficult quantitative analysis of the group formation dynamics. His work is however "verbally quantitative" in the sense that it repeatedly mentions the constructs of mutual and circular causality. These features excited Simon (1952) to formulate a model of Homans postulates, but unfortunately Simon only investigates features that are traditionally focussed in control systems research (notably stability). The formation dynamics are only hinted at in his work.

In System Dynamics (Forrester 1961 and Richmond 1985) one has made available a set of tools and a paradigm for analyzing dynamic systems. The paradigm stresses that the underlying structure is a key factor in understanding behavior patterns and in proposing structural improvements. Combined with improved software, including graphical formulation of system structure (High Performance Systems 1985) one can hope for an increased interest among social scientists in exploring the dynamics of social processes. This work is an attempt to do so. In addition to show the potential of System Dynamics in traditional social science, this study has a more concrete goal: To prepare for future studies where individuals are structurally identical but parametrically different to explore different work group combinations in order to improve productivity through use of probable social group synergies.

Our empirical base is Homans (1950) description of AT & T's Western Electric plant in Hawthorne, Illinois and its bank wiring room. Whereas the original text deals with group sociology and considers the group as the unit of analysis, we take a social psychology viewpoint where we focus on the processes the single person is subject to. The group is then a consequence of the perceptions we find at the level of each worker. The unit of analysis are the 20 cooperating individuals in the work environment. We first look into the institutional setting before we quantify the dynamic behavior pattern. The simulation model is explained in two steps; We look into the overall structure leading to the behavior mode and then we describe the formulations. At last we run partial model tests. Later we show complete simulation runs before we conclude with suggestions for improvements and further research needed.

INSTITUTIONAL AND ORGANIZATIONAL SETTING

The mentioned Hawthorne facilities were some of the largest telephone facilities in the world when the Harvard-initiated studies took place in the 1930's. Thousands of blue-collar workers provided an ideal background for organizational research. The initial purpose of the studies was to investigate to what extent productivity depended on different task arrangements, in particular physical conditions (light, temperature), reward structures and benefit schemes. Various tasks were taken out of the ordinary assembly lines and parallel, investigatory, production lines formed. The famous "Hawthorne effect" is named after the fact that no matter how the physical environment, the groups taken out of the normal production lines outperformed the ones remaining. This finding led to a steep decline in the "Scientific Management" organizational paradigm prevailing at that time and the rise of a new paradigm focussing on human motivation and interaction; "Human Relations".

The bank wiring room consisted of twenty male workers divided into two interdependent work teams. A couple of quality controllers spent most of their time within the group, although they formally belonged to another department. The tasks performed required little

brainwork but a certain skill was needed to wire copper threads on a spool, or to do various various assembling and inventory tasks. Both teams performed both kinds of work. There was a dependency of the group upon outside resources, particularly of unfinished goods for processing by the teams. Also, the output of the activities in the wiring room was used elsewhere in the production process. As the production process was tightly scheduled, there were severe constraints on the production process due to shortages of resources.

The homogeneity of the work group is evidenced by the fact that the individuals were all male second and third generation americans and only one had a college degree. They ranged in age from twenty to fifty. The social communication among the younger focussed around matters like girls and booze, whereas the family fathers seemed to talk about more homely matters. Sports was a common interest to all of them. Both the work they performed, the language they spoke as well as most other sociological clues makes the description "working class" very accurate for all the individuals working in the room.

The participants had volunteered for the experiments, and as such the group was formed almost from scratch. When Homans entered the group, the social groups were already starting to cement, so his account of the formation process is not very substantive. But we must assume his accounts are based upon the social dynamics that partly finished the cementation and partly was the normal fluctuations around equilibrium levels of communications.

REFERENCE MODE¹

The reference mode describes important system variables over time. First, the flow of communication between individuals with similar interests and values grow over time to reach an equilibrium level. Also, the values they have tend to align more and more. The characteristics of a social group are then a high level of communication between individuals as well as shared values among its members, whereas non-members of a group have less communication with the insiders. The two different subgroups would be referred to as clusters in sociometric terminology. Some individuals in the work group does not belong to any group. They communicate little, and can be described as outsiders as evidenced by a marginal position on a sociometric diagram.

Individuals bring different value systems into the groups. Together with organizational norms and goals these interact to form a subgroup productivity norm. The subgroup norms are based on the Perceived Norms at the individual level and deal with both Social and Professional Values. Two distinct subgroups are formed. They are distinguished by the content of the social communication but also by the values exposed within the communication. Both the content and the quantity of communication has an impact on the Perceived Social Norm at the individual level. This perception in turn colors the Values held by each member of a social group. In an interactive way, this Value is in turned used by other individuals in forming their Perceived Social Norm and subsequent individual Value.

The young and unmarried individuals start communication because of an initial similarity of values and also because of a common language. Homans talks about the self-reinforcing cycle of communication between two friends. If two persons have something in common,

¹ The reference mode is the characteristic historical behavior of the main variables of the system. This mode serves as a reference to which the model-based simulation results of the system structure is compared.

they will emit signals of liking and therefore they will spend time together. The time spent together will lead to additional points of commonality being discovered. He mentions fishing trips in particular, where physical conditions might induce further closeness. In a work environment a similar sequence of activities promoting friendship and social group formation is assumed to take place.

Homans work (op.cit.) provides no explicit mention of how long the social grouping requires to take place. Implicit, there are however some clues. The process is not considered a long one, and we have therefore assumed that the main dynamics take place within the first year. The following three years are assumed to contain only minor adjustments compared to the initial ones. The variables are chosen because of their pertinence to the investigated system. They do not correspond directly to the concepts used by Homans, but as we shall see - are able to make the connection to social psychology and sociology theories developed later than his classic work. The main variables are portrayed in figure 1, and they are:

- a) The amount of Social Communication (measured in hours/day). This variable grows over time as people after an initial search period find out with whom they share interests, and thereafter develop relationships with those individuals.
- b) The Social Values held at the individual level (measured along a one-dimensional axis of liberal-conservative where ultra-liberal holds the value -5 and ultra-conservative holds the value 5). Homans refers to different age groups spending more time together than do people across such age groups. There is also a reference to lunch discussion topics showing that people tend to gather around areas of common interest and that common values in those interests is a predictive factor for determining belonging to a social group. There is an indication of polarization so that people will hold either one Social Value or another depending on their initial position along the liberal - conservative dimension. The shared Social Values constitute the subgroup norms that are active in the work group. In the model we deal with Social Values (and -Norms) along two dimensions: Degree of conservatism regarding leisure activities (Social Value_1) and regarding family activities (Social Value_2).
- c) The Social Norms that are perceived at the individual level. This construct is the processing variable leading to the Social Values mentioned above and is measured in the same way. A Norm is the subjective evaluation by each individual of the Social Values that exist in the environment. Internalizing Social Values is not done by a rational weighing of what is right and what is wrong, but more by a subconscious assimilation of the Norms that are perceived.
- d) The Value System held by each individual. It is also measured along a liberal - conservative dimension. This construct is similar to the ethnic and family background concepts evoked by Homans. Hence the Value System is concerned with many dimensions not directly relevant to the social group formation process we are describing. The construct is heavily anchored in childhood and social learning experiences and filters a lot of the perceptions of the environment. On the other hand, the experiences that the individuals get from the environment also influences the Value System variable, but the link is quite weak.
- e) The Professional Norm perceived at the individual level. This variable is measured in terms of deviance from the Production Norm set by the organization.

Figure 1 shows the behavior mode, i.e. how the Norms and Values develop over a time horizon of 2 1/2 years. We are portraying the behavior of person X who becomes a member of subgroup B. Note that his values change more than does the average of the

group. His Value System is only marginally adjusted towards conservatism. Communication increases gradually before it settles to an equilibrium value. Subgroup A is totally unaffected by individual X.

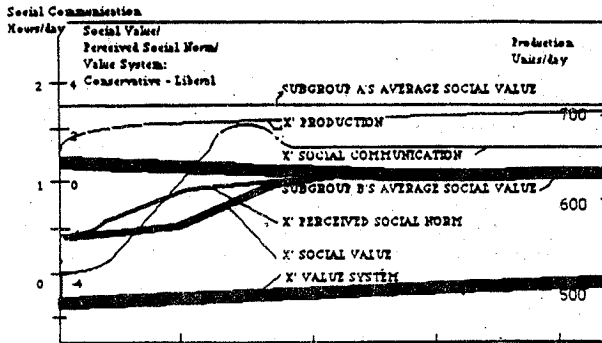


Figure 1: The Dynamics of the key variables during the first and settling 2 1/2 years of social subgroup B. Individual X becomes a member of this subgroup.

BEHAVIOR STRUCTURE DIAGRAMS

The notion of behavior structure diagram is a concept closely related to Morecroft's (1982) policy structure diagram. The difference being that policy diagrams deal with the management of physical systems whereas we are concerned with mostly unconscious processes where the related physical structure is regarded as exogenous to the system. But as Morecroft, we define the metastructure in terms of the major stock networks. In the behavior structure diagram we deal with the Social Norms 1 and 2, the Professional Norm and the Value System.

There is a mutual interaction between the Value System and the perception of the two Social Norms. The two Social Values are not interacting in the same way, they are simply first order smooths of the Perceived Norms they are connected to. In turn, the Social Values determine the Professional Norms in a unidirectional way. We remember that the subscripts 1 and 2 refers to the topics onto which the Norms and Values apply; 1 meaning family matters and 2 referring to leisure.

The process determining the subgroup formation is identical for each of the five modelled individuals. Only parametric differences distinguishes the men we are dealing with. Figure 2 portrays the meta-structure of that process.

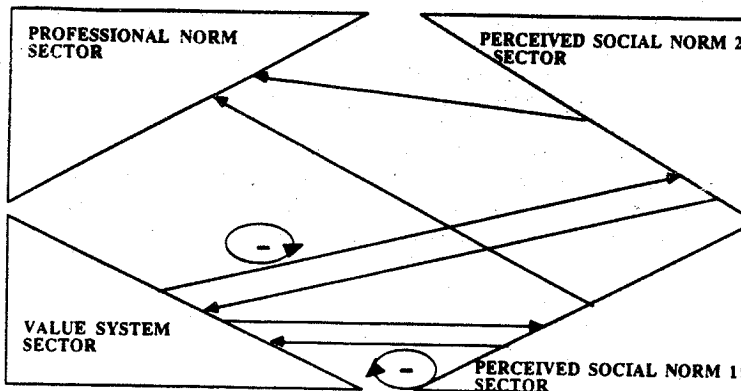


Figure 2: The behavior structure diagram of the main sectors of the system.

The second behavior structure diagram deals with interaction between individuals. Figure 3 portrays the metastructure behind the fact that when people communicate, they tend to reveal their social values. These values have an impact on the receiver of the message. Not shown is the fact that with a substantial timelag this Social Value is processed through a Social Norm to become internalized as the other persons Social Value and as such it is fed back to the initial transmitter of the communication. As will be shown later the model is highly simplified in the sense that impact is solely determined by arithmetic differences in Social Value. It is however easily conceivable that the Values of certain individuals carry more weight and impact than that of others so that our principle of total reciprocity does not necessarily hold.

Figure 3 shows the interaction process dealing with three individuals. The full model has an identical structure but deals with five individuals. Contrary to figure 2, not all the variables portrayed in figure 3 are stock networks, the impact circles represents graph functions.

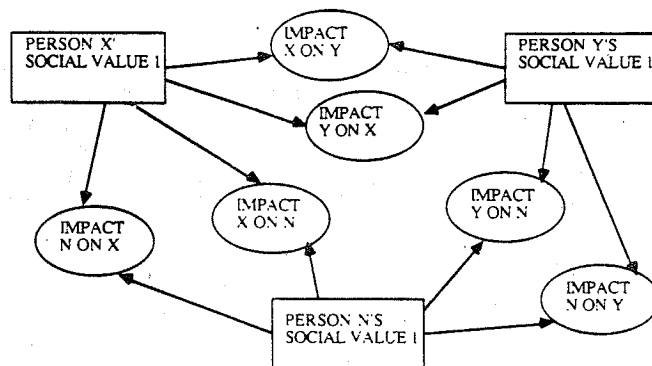


Figure 3: Behavior structure diagram of interaction between individuals.

Figure 4 illustrates the dynamic formulation of the perception of Social Norms. The initial Social Norm serves as an anchor, and the deeply rooted Value system is a filtering mechanism in an "Anchoring and Adjustment" process. The process ensures that the perceived Norms eventually will equal the Values that exists in the social environment. The auxiliaries "Impact Y on X" and "Impact N on X" are taken from figure 3. The adjustment method is related to the exponential smoothing described by Forrester (1961). Moreover, the process implies that individuals evaluate new information (consciously or inconsciously) in the light of both previously processed information and the multidimensional Value System.

This filtering corresponds to the fact that people only slowly change their views on social questions, and the further the new ideas are from their basic beliefs, the more internal resistance there will be in adopting the ideas that exist in the environment. Festinger (1957)

describes this theory in cognitive terms, calling it Cognitive Dissonance. He explains that people interpret their environment according to existing beliefs, and if there is a discrepancy (a dissonance) they have to reformulate either the perception of the environment or their previously existing beliefs. Our formulation represents a process whereby both the environment and existing beliefs are adapting to new evidence.

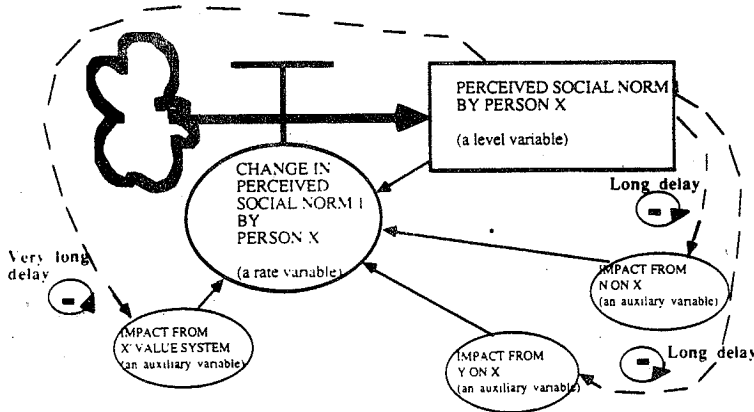


Figure 4: Formulation of Perception of Social Norms.

THE MODEL

The model describes five individuals. The reduction of the 20 workers down to 5 must be judged in light of our model's general purpose. We do not want to replicate the entire behavior in the original book. Instead we want to portray the key dynamics with as few variables as possible, though retaining similarity with the original case. We are still following Forrester (1961) stating that "one must focus upon modelling a problem, not a system". Since we want to establish two social groups and one outsider, we need at least five portrayed individuals.

In addition to differences in initial values in the stock variables, the individuals are unequal as regards both their Resistance To Change (in Value System) and the Impact their communication have on the surroundings. These two factors are portrayed by parametric means, by non-linear graph functions. As the individual personality and communication structures are equal across individuals, we will describe the formulation of only one such structure. The same argument allows us to narrow the description of the two individual Social Values to one of them.

Our choice of units is degree of conservatism. Contrary to most Industrial and System Dynamics work this model is free from countable physical units. Therefore, the unit choice is non-trivial, and our choice is guided by the original work. There we find descriptions of individual differences along a multitude of dimensions, it seems however as the scale of conservatism can be taken as an overlying construct covering all of them. The degree of conservatism ranges from -5 (ultra liberal) to 5 (ultra conservative) and is the measurement unit for Value System, Social Value 1, Social Value 2 as well as Perceived Social Norm 1 and 2. Social Communication is an impact construct. It is hence measured by a closely related unit: Hours/day spent on social communication. The scale ranges from 0 to 2 hours per day. The Perceived Professional Norms conceptualized as the deviance from the norm that the organization places upon the workers, it therefore measures relative deviance from the production norm and is dimensionless. Figure 5 represents the stock -and flow

structure of the Value and Norm sectors. It portrays only the formation of Norm and Values concerning leisure time activities. Family matters' Norm and Values would have been identical.

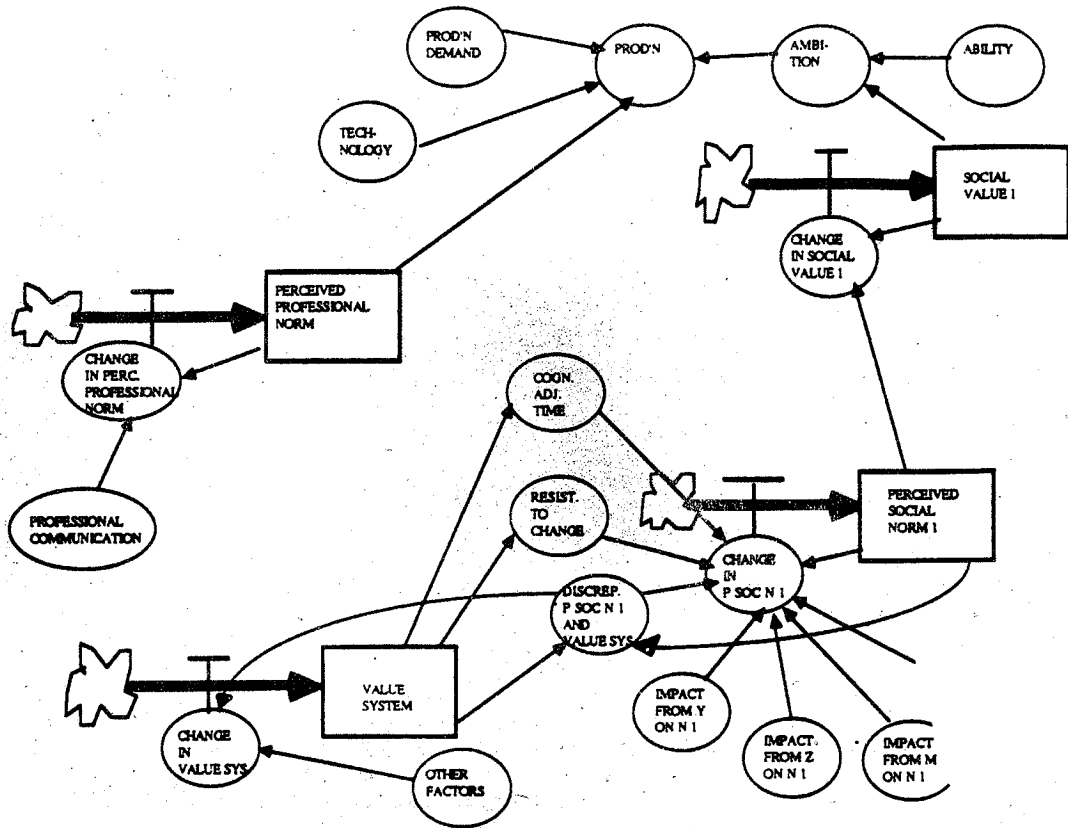


Figure 5: Stock and flow diagram of one individual. Norm 2 and Social Value 2 not portrayed.

VALUE SYSTEM SECTOR

The Value System

The Value System is a level variable and accumulates changes that are brought upon it from the outside world as well as from the internalized perception of surrounding Social Norms in the group. The reason behind it being conceived of as a level and not a constant, (we will see that the time constant governing its behavior ranges from 5 to 10 years) resides in the

fact that despite its slow change relative to the interesting dynamics, it is conceptually inconsistent to portray it as a constant.

The Change in Value System

The Change in Value System is measured in terms of influence from conservatism per time unit. The discrepancies at any time between actual Value System and Perceived Social Norm are closed within the horizon of the Cognitive Adjustment Time. Other Factors (the outside world) also influence the Value System. Through the Value System these factors eventually influences the Perception of Social Norm of a given individual. Through the interaction with other group members the Other Factors eventually spread their influence upon the whole interacting group.

Other Factors

Other factors are condensed into a single exogenous variable. It too has the measurement unit of degree of conservatism.

Discrepancy between the Value System and the Perceived Social Norm

This is the basic Cognitive dissonance term as explained by Festinger (1957) and it influences both the Perception of Social Norms as well as the Value System. Its measurement unit is difference in degree of conservatism.

Cognitive Adjustment time

This variable is measured in terms of weeks. It portrays the fact that the more conservative people are, the less able they are to change. (That is the definition of conservatism.) The variable ranges from 520 to 1040 weeks as degree of conservatism goes from -5 to +5. The graph function (non-linearity) is shown in figure 6.

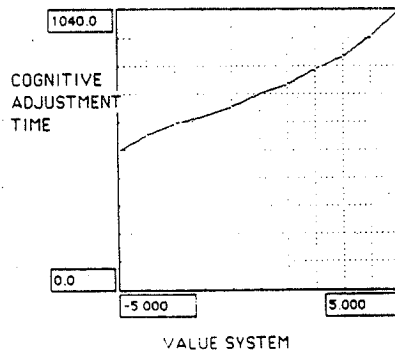


Figure 6: The Cognitive Adjustment Time as a graph function of degree of conservatism and measured in weeks.

THE PERCEIVED SOCIAL NORM SECTOR.

Perceived Social Norm

The Norm perception is previously defined. Suffice it here to underline that the change rate formulation governing its behavior is the core of the model.

The Change in Perceived Social Norm

$$\text{ChPSoNo}_t = \text{Dis}_{t-1} / \text{CogAT} + (\text{SoCo}_{2,t-1} / 4 + \text{SoCo}_{3,t-1} / 4 + \text{SoCo}_{4,t-1} / 4 + \text{SoCo}_{5,t-1} / 4 - \text{PSoNo}_{t-1}) / \text{ResToCh}$$

The measurement is in terms of conservatism per time unit. The first term is describing the impact of the Value System on the Change. The second is averaging the impact of the social communication from the 4 actors. This average is the goal that the level is searching for. Any discrepancies between the goal and current state of affairs are smoothed out with the Resistance to change parameter.

IN THE COMPUTER MODEL, THE SUBSCRIPTS ARE COMPREHENSIVE. THE SOCIAL VALUES ARE SEPARATED, SO THAT THEY HAVE THE EXPRESSION SO_VA1 AND SO_VA2 RESPECTIVELY. THERE ALSO IS A RECORD OF WHERE INFORMATION IS COMING FROM AND WHERE IT IS DIRECTED TO. SO LEISURE TIME SOCIAL COMMUNICATION FROM PERSON # 1 TO PERSON # 2 HAS THE SUBSCRIPTS: SOCo1_12

Social Communication (impact) variables

These are described in the next section.

Resistance to Change

This construct is conceptually a time constant. It regulates the time it takes for individuals to adjust to new information. It is a graph function of the Value System. The more conservative, the more stubbornly one is holding onto ones old perceptions. Figure 7 shows that the parameter goes from 26 to 52 weeks depending on the Value System of an individual.

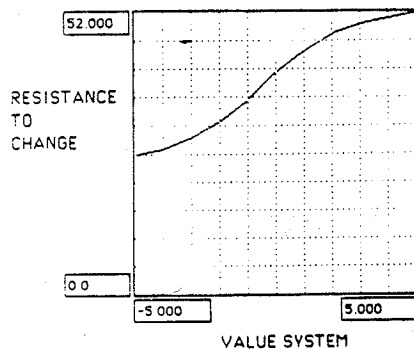


Figure 7: The graph of Resistance to Change as a function of the Value System of an individual

Social Value

Social Value is measured in terms of degree of conservatism. This construct is a simple first-order smooth of the Perceived Professional Norm.

Change in Social Value

This rate measures the speed of change in the Social Value. According to the original case description, we have chosen a time constant of one year - assuring that after 52 weeks 70 per cent of any initial discrepancy is smoothed out.

THE PROFESSIONAL NORM SECTOR

The Professional Norm is a construct similar to the Social Norm. But whereas the Social Norm is an active component (in the sense as it determines other variables as much as it is determined by them), the Professional Norm is not determined in such a circular way. This simplification of real-life complexity (obviously the Professional Norm also determines system behavior, but we are purposely omitting these systemic properties.) is to be explained by Homans' description of the subgroup formation. The process is a function of social interaction and the social values are the clues to this interaction. There is no mention of the professional norms playing any role in the subgroup formation. On the contrary, there is much evidence in Homans work that the informal subgroups to a large extent precede the professional norms.

The Professional Norm includes a dynamic interaction between individuals on professional matters. The professional Communication, here portrayed as time-independent, is also formulated omitting its systemic properties described under its social counterpart. The goal of the model being to describe the dynamics of the formation process and its impact on productivity makes it possible to deviate from certain real-life facts.

The Perceived Professional Norm.

This variable is dimensionless and normalized to 0. It then describes any down- or upward pressure to attain the goals that are put onto the work group from the organization outside. With a static communication, the variable serves the purpose of smoothing out eventual discrepancies between the Communication and the Norm.

The Change in Perceived Professional Norm.

Measured in yearly change of the discrepancy, this variable measures the speed of the smoothing process.

The Professional Communication.

This dimensionless parameter purports to maintain the link with a non-portrayed dynamic professional communication environment.

The Production

The dimension of the Production is units per week. This parameter enables the modelling of different individuals disposing different Technologies and Ambitions.

Technology

As the Technology varies, so does production. Hence a Technology constant is included at the individual level.

Production Demand

The Production Demand is the standard production norm used in the work group. Homans mentions it is 700 units per day. In a systemic sense, it would have been possible to model this variable as a sliding goal, slipping towards actual average production depending on the organizational culture and the time constants inherent in that culture.

The Ambition

The Ambition is dimensionless and converts the Social Values into attitudes towards work. It is assumed that individuals espousing conservative goals are more ambitious on achieving the goals than are the more liberal individuals. The ambition for an ultra liberal is then to produce 630 units per day (90 % of Demand), whereas the ultra conservative aims for a daily production of 770 (110 % of Demand). This rather arbitrary range is based on the verbal description in the case, where the quiet and older workers produce more than the noisy young ones. In addition to Social Values, the skill level or Ambition also influences Ambition.

The Ability

Skills and intelligence is also determines production. Although not specifically mentioned in the case, we still know these factors matters. The whole theory behind learning curves is based upon the fact that skills matter and that they can be improved. Likewise the rationale behind IQ tests is that IQ matters for performance.

THE INTERACTION SECTOR

The interaction sector describes the process taking place when individuals are exposed to each others' conversation. When there is social interaction, there is a seemingly strong correlation between closeness in social value content and the time spent and subsequent impact of that communication. The more people share values, the more time they spend together and the more impact differences in opinion have on each individuals' Perceived Social Norm. This hypothesis is confirmed in a lot of recent social psychology literature, where communication is set to be a result by either shared interests or forced physical closeness. But on the other hand, "opposites attract". So there must be a discontinuity in the function of time spent together as a function of shared interests. We propose a formulation where time spent together increases monotonically when difference in Social Values decreases from 10 to 2. There is however a decrease in time spent together when the Social Value difference drops below 0. This graph function is shown in figure 8.

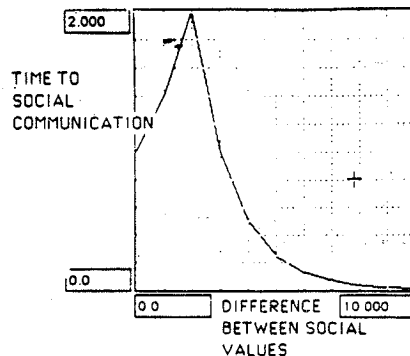


Figure 8: Time spent together as a function of arithmetic difference between individuals' Social Values.

Time to Social Communication

This variable is shown above, and its measurement unit is dimensionless.

The Difference in Social Values

This variable is measured in terms of conservatism, and it calculates the absolute difference between the Social Values between between 2 individuals.

The Impact of Social Communication.

The Impact of Social Communication is determined by the degree of conservatism revealed by a Social-Communication boosted by the impact of this communication. Both variables are described above. Below is shown a graphical representation of the impact formation in the model.

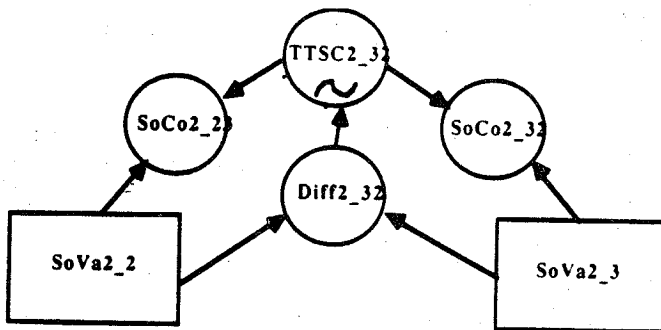


Figure 9: The impact formulation describing the Social Communication as a function of degree of conservatism as well as effected by time spent on communication.

PARTIAL MODEL TESTING

The model is a description of a social control theory phenomenon, also often referred to as homeostasis in biology. In that sense, any disturbances in the system will be smoothed out

over time. Since there are no growth processes, we are assured no disequilibrium caused by positive feedback loops. To test the formulations we first looked into what will happen if an individual has an initial discrepancy between his Value System and his Social Values. Given a situation where the Value System and Perceived Social Norms are set to 5 (and these variables are not dynamically connected to the system) and the Social Values for some reason start at -5, the behavior resulting from this discrepancy is shown in figure 10. After 210 weeks (4 years) practically all the initial discrepancy between the Social Value and the perceived Social Social Norms has disappeared.

Figure 11 shows another graph of same run where Ambition grows as the person adopts more conservative Values. Production follows the same pattern.

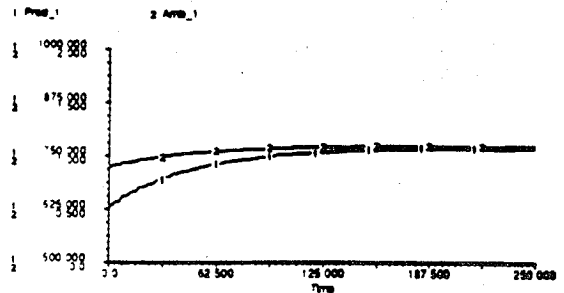
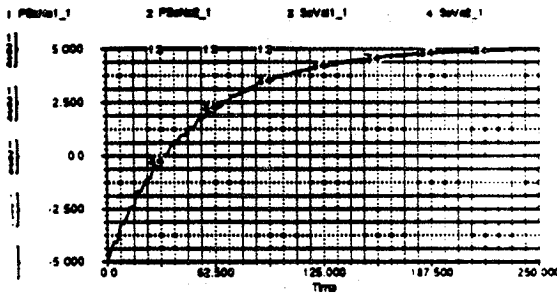


Figure 10: The Value System adjusts to the Perceived Professional Norm.

Figure 11: The Production increases as the individual adopts more conservative Values.

The interface with the interaction module was then included in the model by letting a neutral person interact with a conservative one. The neutral person slowly adapts the conservative. The reason this happens is to be found in the lack of feedback from the initially neutral individual back to the interaction process. Figure 12 shows this process, where the Social Value is a smooth of the Perception of Social Norm.

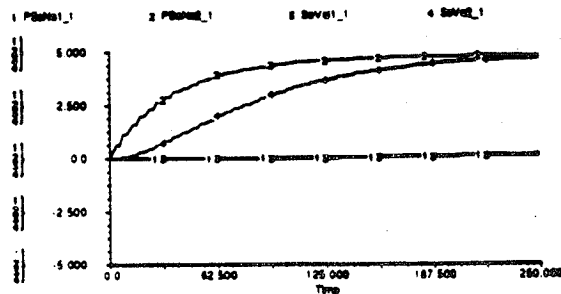


Figure 12: The impact of communication with a person that is conservative on family matters and neutral on leisure matters.

MODEL RUNS

The whole model includes, as we have seen, the five individuals, each with two separate Social Values and one Value System as well as a Professional Norm. To each individual is also assigned a five-person interaction sector. The initial setting allows for all Values and norms to be consistent for each individual. If the Value System is 4, then the initial value of Norms and Values are also set to 4. In the first run, figure 13, persons 1, 2, 3, 4 and 5 are characterized by initial levels of 5, 4, 0, -4 and -5 respectively. The figure shows that two subgroups are formed, but also that they converge into one by the fourth year. Interestingly, the "loner" becomes part of the final group.

Compared with the reference mode in figure 1, we see that the model run allows a group norm to be established. The difference can be explained in two ways. Either that the empirical base did not enable us to see long term (5 years) behavior, so that the description in Homans book was inaccurate. A more plausible explanation, however is to be found in the lack of bifurcationary elements in the model structure. Such elements would be able to assure the development of antagonism, and hence also of "negative communication" between the separate sub-cultures.

Figure 13 should be interpreted as the development of a Corporate Culture. The concepts of shared norm and culture are very related. But whereas our definition of a norm deals with one dimension of interest (Leisure or Family Activities), the culture deals with a multitude of dimensions. The culture construct then becomes more ill-defined than the norm, but its impact on productivity is probably more important than the Norms mentioned in our model. A more refined model would have to take the culture construct into consideration in a structural way. Another construct of interest, which is omitted is the intergroup conflicts and its impact on productivity.

Due to the negative feedback structures, and personal symmetries, the equilibrium degree of conservatism would be equal to the arithmetic mean of the Values held at the individual levels. However, since conservative individuals are more stubborn and have longer adjustment times than liberals, the final Values are more conservative than that.

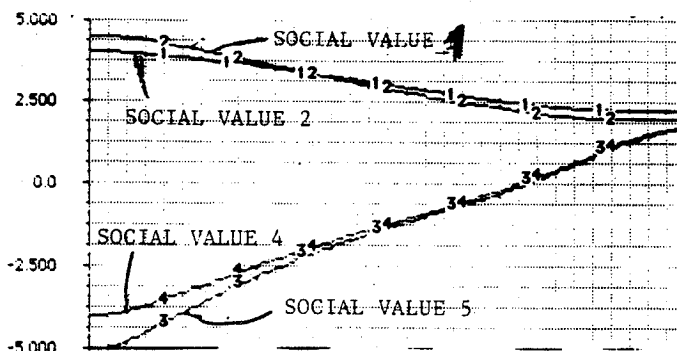


Figure 13: The development of Social Values over time. Individual 3 (initial Value 0) not shown.

Figure 14 portrays a situation where people are pleclustered in only 2 subgroups. Interestingly, the fact that person 3's individual Values are changed from 0 to 4.5, makes

no perceptible difference on the group formation pattern. The culture development pattern remains.

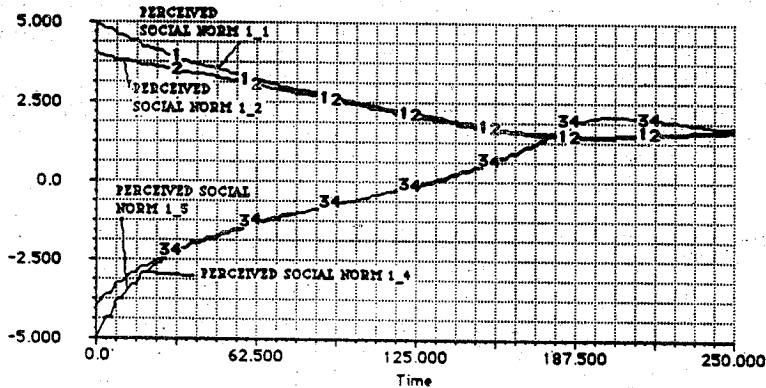


Figure 14: The development of Perceived Social Norms over time, individual 3 not shown.

Figure 15 shows the slow change of the Value System with the latter initial levels. Not shown is individual 5, starting with initial Value of -4. It should be noted that the Other Factors are equal to the levels initial degree of conservatism. So there are two opposing forces influencing the Value System. Other Factors push the Value System towards its initial Value, whereas the Social Values push the Values towards the perception of the environment.

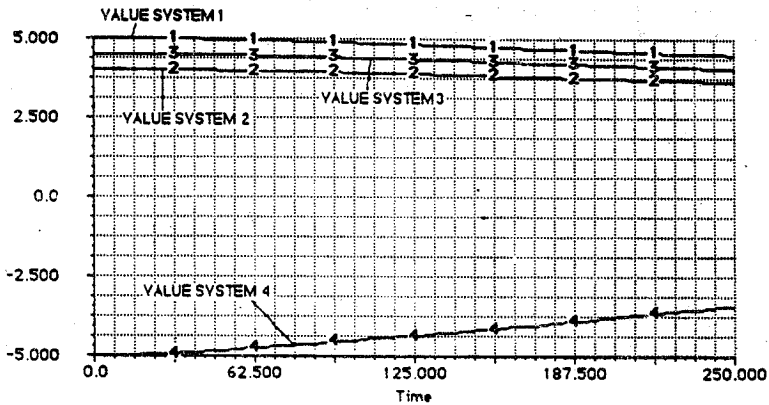


Figure 15: The evolution of Value Systems over time, individual 5 not shown.

One approach to improve the fit between figure 1 -the reference mode- and figure 13 would be to strengthen the influence of the initial Value System level. This would assure a slower development of the corporate culture, but at the same time unfortunately also prohibit the subgroups to form. In figure 16, the Cognitive adjustment time changing the Value System is lengthened to 20 years and it is made uninfluenced by degree of conservatism. The Cognitive adjustment time influencing Perceived Social Norms is reduced to 2 years on the

other hand. In figure 17 we have rerun 16 with an adjustment time regulating Perceived Social Norms reduced to 1/2 year. Especially figure 16 shows a closer fit to the reference behavior. Note that the initial Values are set to 5, 4, 4.5, -4 and 5 respectively and that individual 3 is not shown.

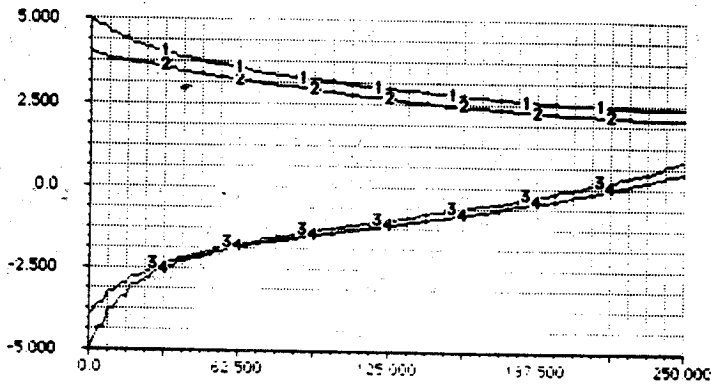


Figure 16: Norm Perception with stronger influence from the Value System.

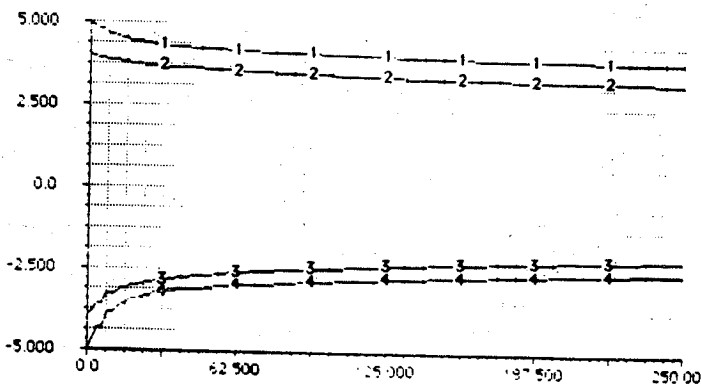


Figure 17: Norm Perception with extreme influence from Value System.

IMPLICATIONS AND FURTHER WORK NEEDED

Group formation is a complex issue. We have explained and formulated one case of group formation with a System Dynamics model. In doing so, we have intergrated cognitive concepts and a specific description. It seems, however, that our findings have general validity also outside our specific case. The group formation is the core of human socializing and society emergence, and if we substitute individuals for groups or organizations, we would be able to explain higher order social aggregations as well. With added antagonism, our model should also be able to explain coalition formation.

The lack of covergence between Warsaw-pact and NATO countries might also be explained with an improved model. In such a model the antagonism formulation could build upon the notion of "diabolic enemy images" (White 1984).

Further work should, in addition to a polarization/bifurcation structure, also include a more specific understanding of the relationships between specific values and productivity. Also lacking in our paper is a good statement of communication patterns between individuals with different Values; Who is submissive and who is dominant. We nevertheless hope that our work can be helpful in that future research as well as we hope that our model can be used in practical settings to make policy analysis of how individuals should be put together in groups to ensure high productivity.

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