

MODELING THE DYNAMICS OF INTERGROUP PROCESSES UNDER SOCIAL  
PRESSURES OF MAJORITY

by

Dolunay Uğur

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PRESSURES OF MAJORITY

APPROVED BY:

Prof. Yaman Barlas .....

(Thesis Supervisor)

Prof. M. Hamit Fişek .....

Assoc. Prof. Gönenç Yücel .....

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*To Mustafa  
who has always been there for me*

## ACKNOWLEDGEMENTS

This is not just an acknowledgment. It is some sort of narrative of my three years in academia which includes two master's degrees. This thesis was the last stand of an engineering student who wanted to study social science and thought that studying it with engineering tools could be a proper way. However, this thought completely and oppositely changed after finishing one-year master program in Sociology and Social Anthropology.

This M.S. thesis could not be written for a long time due to personal and country-based issues. During 2013 summer - the months in which I was expected to complete my thesis – more precisely during the Gezi Resistance, my last concern was my thesis. In that September, I started a one-year master program abroad in Sociology and Social Anthropology. Throughout the year upsetting news was coming from my “beloved” country, such a country that always has some frustrating news to inhibit master theses.

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## ABSTRACT

# MODELING THE DYNAMICS OF INTERGROUP PROCESSES UNDER SOCIAL PRESSURES OF MAJORITY

In this thesis, an integrated framework of individual and group based explanations of social influence is constructed. Having that integrated framework as its basis, a system dynamics model is built to depict major qualitative patterns of attitude, behavior, and group change under the social influences of majority and the minority group that split from the majority. By doing so, the thesis aims at finding out under what conditions such a minority group can survive as a new out-group and whether there are some stable equilibria where both groups sustain themselves under the reciprocal and simultaneous social influences. The simulation results show that (i) unless minority's strength parameter is significantly higher than the majority's, it is impossible for minority to survive as a group, (ii) effectiveness of utilized reward or punishment by the majority in constituting its social pressure has varying impacts on minority not only quantitatively but also qualitatively, depending also on the strength of minority, (iii) antagonism levels of both groups may be an important determinant in whether minority survives or not; it might foster as well as prevent minority's extinction, and (iv) in the case where minority and majority have the average strength value, a critical initial value of minority's size decides whether minority becomes extinct or not. The results demonstrate that in some narrow ranges, (i) minority's strength, (ii) majority's strength, and (iii) minority's initial size have nonlinear effects on minority's ability to sustain a non-zero equilibrium. In addition to these results, complex nonlinear dynamics, counterintuitive and potentially chaotic behaviors are obtained from simulation outputs in certain parameter ranges. Some of these outputs are reported for further inquiry of researchers particularly in the field of dynamical social psychology.

## ÖZET

# ÇOĞUNLUĞUN SOSYAL BASKILARI ALTINDA GRUPLAR ARASI SÜREÇLERİN DİNAMİKLERİNİN MODELLENMESİ

Bu tezde, birey ve grup temelli sosyal etki açıklamalarının bütünleşik bir çerçevesi oluşturmuştur. Bu birleşik çerçeveyi temel alarak, ortak bir gruptan doğmuş olan çoğunluk ve azınlık gruplarının sosyal etkileri altında düşünce, davranış, ve grup değiştirmenin başat nitel örüntülerini göstermek için bir sistem dinamikleri modeli kurulmuştur. Buradan hareketle, bu tez hangi koşullar altında böyle bir azınlık grubunun yeni bir grup olarak varlığını sürdürmeyi başarabileceğini ve iki grubun da birbirlerinin karşılıklı ve eşzamanlı sosyal etkilerinin altında bir denge halinde varlıklarını sürdürüp sürdüremeyeceklerini bulmayı amaçlamaktadır. Model sonuçları göstermektedir ki (i) azınlığın güç parametresinin çoğunluğa kıyasla ciddi miktarda yüksek olmadığı durumlarda, azınlığın ayrı bir grup olarak varlığını sürdürebilmesi mümkün değildir, (ii) çoğunluğun sosyal baskısını kurarken kullandığı ödül ya da cezanın etkisinin azınlığın gücüne de bağlı olarak, azınlık üzerinde sadece nicel olarak değil nitel olarak da değişen etkileri vardır, (iii) iki grubun da karşıtlık seviyeleri, azınlığın varlığını sürdürebilip sürdüremeyeceği konusunda önemlidir; azınlığın yok oluşunu destekleyebileceği gibi ona engel de olabilir, ve (iv) azınlık ve çoğunluğun eşit ve ortalama güç parametresine sahip olduğu durumlarda, azınlığın yok olup olmayacağını kritik bir azınlık başlangıç değeri belirler. Sonuçlara göre bazı küçük değer aralıklarında (i) azınlığın gücünün, (ii) çoğunluğun gücünün, ve (iii) azınlığın başlangıçtaki sayısının, azınlığın varlığını sürdürebilme yeteneğinin üzerinde doğrusal olmayan etkileri olmaktadır. Bu sonuçlara ek olarak, benzetim çıktılarında, karmaşık, kaotik özellikler taşıyan ve sezgilere aykırı davranışlar gözlemlenmiştir. Bunlardan bazıları, özellikle dinamik sosyal psikoloji alanında çalışan araştırmacılarının daha ileri sorgulamalarını mümkün kılmak adına tezde raporlanmıştır.



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## 1. INTRODUCTION

Social influence is a social psychological process which individuals exert and are exposed to with or without awareness. The presence of an 'other' person or group starts the influence process. Following social norms, behaving in a social group in an acceptable manner, wittingly or unwittingly considering others' thoughts while publicly answering a question, not criticizing a professor even if you do not agree with her opinion, involve different social influence types.

Social influence is more noticeable and identifiable when it comes from a social group. If the source of influence is a group which has the power of defining and maintaining social norms, or the privilege of using reward or punishment mechanisms, or only the numerical superiority - meaning the source is a majority group - individuals feel a huge social pressure to conform with. For example, if a member of a social group thinks dissimilarly about a specific subject in the sense that her opinion is different from the majority's consensus, what are the factors that affect her to or not to align her overt statement or public behavior according to her private opinion? What if there are some others who think like her? What if they form another social group due to this clash of opinion over the subject? Do the social pressures vanish?

This thesis is about the possible dynamics between such minority and majority groups, after a small number of people in the majority start to hold a different opinion, and form their own group. Under what conditions can those people survive as a new out-group? Or, under what conditions is conversion of more individuals from majority possible? Is equilibrium possible under the reciprocal and simultaneous social influence of both majority and minority, or will minority always vanish eventually? Such questions are typically in the domains of fields like social influence and intergroup processes. In this thesis, to seek answers to these kinds of questions, a system dynamics model will be constructed through the integration of individual and group based explanations of social influence. The thesis aims to depict qualitative major dynamic patterns of attitude, behavior, and group change under the social influences of majority and minority groups, to be qualitatively compared to the related literature from social psychology.



The thesis is structured as follows: In the following chapter, related literature of social influence and intergroup relations are reviewed and at the end of it, research objective of the thesis is proposed. Chapter three briefly describes the fundamental concepts of system dynamics method and gives the reasons of methodology choice for this thesis. Next chapter is about overview of the model in which theoretical frameworks that are crucial for the model are analyzed, and integrated through causal loop diagrams. Major feedback mechanisms are depicted and underlying logic is elucidated. Chapter five describes the stocks, flows, and major equations in the model. The rationales behind the equations are given through social psychology theories on which the model rely. In chapter six, structural and behavioral credibility, and the base behaviors of the model are analyzed. In the following chapters, sensitivity analysis and scenario analysis are conducted respectively. Finally, major findings of this thesis are briefly represented.

## 2. LITERATURE REVIEW AND RESEARCH OBJECTIVE

The social psychology theories that are utilized in building the system dynamics model will be explained throughout the thesis. Since it was impossible to find any system dynamics models about social influence in literature, this chapter of the thesis cannot provide a review of related modeling. However, to situate the research in the literature and to describe better how it integrates those theories, some significant research trends in the literature of social influence and intergroup behavior which have played significant roles in shaping the model, will be briefly explored in this chapter.

Muzafer Sherif is one of the pioneers in social influence research and famous with his experiments about auto kinetic effect in which subjects were asked to overtly estimate the distance of a moving light. Observing how subjects form group norms and how those norms influence their estimation, he concluded that group norms affect the visual perception of human beings [1]. However, those norms could have influenced “either their verbal reports or their eyesight” (p.70), as Crano [2] states. Twenty years later, Solomon Asch [3], another pioneer in social influence studies, conducted an experiment about public declaration of judgments about line lengths which were easily distinguishable. His experiments showed that 36.8 percent of minority subjects comply with majority’s obviously wrong answer because of group pressure (p.3,4).

In the same year, Morton Deutsch and Harold Gerard [4] made a distinction between *normative social influence* “to conform with the positive expectations of another” person or group (to be liked) and *informational social influence* “to accept information obtained from another [person or group] as evidence about reality” (to be right) (p.629). In 1958, Kelman [5] stated that three social influence processes can be defined and recognized: (i) *compliance*, i.e. “adopting the induced behavior not because he believes in its content but because he expects to gain specific rewards or approval and avoid specific punishments or disapproval by conforming”, (ii) *identification*, i.e. accepting influence to “establish or maintain a satisfying self-defining relationship to another person or a group”, and (iii) *internalization*, i.e. appropriating the induced behavior because the content of the new behavior is coherent with his existing opinions or values (p.53).

Indeed, the first social psychologist that paid attention to Kelman's distinction between internalization and compliance was Leon Festinger who labeled those as private acceptance and behavioral compliance. After his first theoretical article related to compliance behavior in 1953, he published his groundbreaking theory of cognitive dissonance in 1957, and then specifically focused on cognitive consequences of forced compliance [6]. Since his theories and concepts are indispensable for the theoretical framework of this thesis, they will be particularly described and analyzed in the following chapters.

In those years, social psychologists predominantly researched about how persons from minority behave under social pressure of majority, or under what conditions internalization follows induced, or forced behavior. The intensity of majority influence experiments begged some questions: Is minority influence possible? If yes, under what conditions, or to what extent? Serge Moscovici was the first researcher who claimed that a majority group and a minority group exert different kind of influences and yield different types of social behavior, namely *compliance behavior* and *conversion behavior* [7]. The difference again lies behind the relations between public statements and private opinions. As opposed to the social psychologists who focus on how compliance lead to private acceptance, i.e. internalization, like Kelman and Festinger, Moscovici [7] emphasized "what incites an individual to behave freely, to transgress the norms in which he no longer believes, to defy the prejudices of his society" (p.237), i.e. *externalization*.

Different from Moscovici, Bibb Latane's Social Impact Theory [8] argued that the only difference between majority and minority influence is purely quantitative (p.449). He claimed that majority and minority influence processes operates by the same principles and motives. Drawing an analogy between social forces and physical forces, Latane states that social impact on an individual is a multiplicative function of strength of source people, immediacy between them, and number of them (see Figure 2.1.). In Latane's framework [9,10], strength "represents stable characteristics of the individuals who are the sources of influence" (p.16) and is determined by "the source's status, age, socio-economic status" (p.344). Immediacy is defined for pairs of individuals, and means closeness, or "absence of intervening barriers or filters" (p.344). According to his theory, if the individual on whom social influence wanted to be calculated is a member of a social group then the impact

coming from an outside source is diffused among the people in this group according to their strength, immediacy, and number (see Figure 2.2).

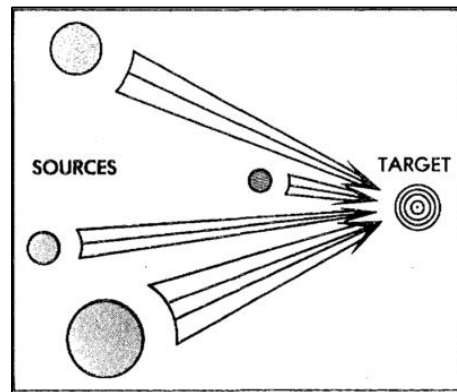


Figure 2.1. Multiplication of impact:  $I = f(SIN)$ .

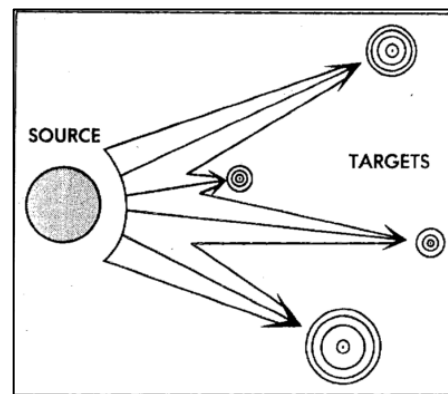


Figure 2.2. Division of impact:  $I = f(1/SIN)$ .

If source and target people are members of different groups, then the social impact on a target individual is a function of strength, immediacy, and number of source people and an inverse function of strength, immediacy, and number of target people [8]. Latane's Social Impact Theory regards majority and minority influence as reciprocal and simultaneous processes.

Almost ten years later from his original theory, in 1990 Latane [11] applied it to attitude change by a simulation model which was written in FORTRAN (p.368). By distributing individual characteristics (e.g. strength) heterogeneously, he conducted

dynamic simulation models of social influence; by doing so, he put his original theory into motion. There after Latane [9] named the theory as Dynamic Social Impact Theory, in which he regarded “the population as a self-organizing system or multiagent cellular automaton, where group-level regularities emerge from the interaction of individual elements.” (p.18)

As it can be inferred from the above literature review, many scholars have been regarded “social group as an essential element to understand social influence” (p.75), as Crano [2] states. However, the social groups in social psychology experiments regarding influence are newly established temporal groups based on subjects’ answers to specific questions as in the studies of Asch and Moscovici. In parallel with this, Latane’s meta theory, which testifies its validity by reproducing the results of those experiments, distinguishes social groups as majority and minority through initially assigning one of the two attitudes to individuals in the simulation runs [11] without adding any variable related to social groups which can affect social influence processes. One of those variables or concepts is out-group hostility or discrimination that will be reviewed in the studies of intergroup behavior in following paragraphs.

Some researchers in social psychology specifically focused on the effects of *social group membership* in influence processes. Despite the emphasis of interpersonal interactions in social influence studies for a long time, those scholars regarded influence in the continuum of interpersonal-intergroup behavior. Since these researchers were mostly specialized in intergroup relations, they were eager to analyze the effects of group membership on social influence. Henri Tajfel was one of the pioneers of this threat. His Social Identity Theory [12] regards social influence as the “experience of self as group member” (p.100). According to Tajfel [13], *social identity* is a “part of the individuals’ self-concept which derives from their knowledge of their membership of a social group (or groups) together with the value and emotional significance of that membership” (p.255). His successor John Turner proposed Self-Categorization Theory - as an extension of Social Identity Theory – where he mostly focused on social identifications or social interactions that are determined by group membership [12] instead of personal characteristics and inter-individual relationships. According to this tradition, categorization as a cognitive tool leads to in-group (we) – out-group (they) differentiation, accentuation of “intracategory

similarities and intercategory differences” (p.21) and in-group favoritism, as Tajfel [14] states. Those social categorization processes originated from group membership produce social influence [12].

Indeed, before Tajfel and his colleagues, in 1961 Muzafer Sherif focused intergroup relations in his famous Robbers Cave Experiment [15]. At a later time, the approach of Sherif and his associates in this study was named by Donald Campbell [16] as Realistic Group Conflict Theory claiming that “real conflict of group interests causes intergroup conflicts” (p.287). On the other hand, accepting the role of conflicting interests on out-group hostility, Tajfel [14] wondered “the minimal conditions that would create intergroup discrimination” (p.23). In his minimal group paradigm, trivial group membership was created among the strangers by eliminating all real life factors (historical, social, and the like) that can bring about antagonism. The results [14] showed that “intergroup discrimination can be caused by a "minimal" social categorization” (p.24).

It can be concluded that social influence literature is roughly divided by two traditions, one of which is more individualistic and the other approach is more group-based, analogous with American tradition and European tradition of social psychology [12]. However, those traditions can contribute each other, and new approaches combining concepts of both can be constituted (see Kalkhoff and Barnum, 2000). This thesis utilizes elements of both traditions to explore social influence as an intergroup process. Thus, it is in parallel with Tajfel’s suggestion [13], “The psychological study of these problems [increasing diversity and complexity of intergroup relations], which will manage to combine some of our traditional preoccupations with an *increased sensitivity to the nature of social realities*, is one of our most important tasks for the future” (p.32, emphasis mine).

Based on related social psychology theories, this thesis aims to build a system dynamics model that focuses on social influence processes in an intergroup context. Quantitative modeling is not a rare method in social psychology. However, those traditional models are static, have unidirectional cause and effect relations in which independent cause variables cannot be dependent on other variables in a circular fashion - even if they are in real life - and have mostly linear relations because of the mathematically unsolvable complexity of nonlinear formulations. To capture this inherently complex

feedback nature of social psychology, dynamical systems approach is introduced to the field by Robin Vallacher and Andrzej Nowak [17]. They emphasize “bidirectional causality”, “feedback mechanisms”, “system’s internal dynamics, [which] tend to produce a pattern that persists over time”, and “nonlinear relations” to go beyond traditional models in social psychology [17].

Indeed, Vallacher and Nowak [18] were the ones who recognize “emergent, or self-organizing, structures” (p.127) in nonlinear computational modeling together with Latane. As a matter of fact, Nowak worked with Latane in constructing computational simulation (multiagent cellular automaton) for Dynamic Social Impact Theory [11]. However, later Vallacher and Nowak also recognized that many higher level phenomena can simultaneously operate rather than mere interaction of individual elements in a group level fame [18]. They [17] elaborate on it by stating that:

“The qualitative behavior of large systems often does not depend a great deal on details involving the behavior of individual elements [...] To achieve qualitative understanding, it is often possible to build very simple models that capture only essential properties of the interactions in the system. Such simple models nevertheless allow for the proper description of aggregate behavior. A similar kind of universality holds in dynamical systems theory. Here, we speak about universality of types of behavior, types of changes of behavior, and so on” (p.286).

Following Vallacher and Nowak criticisms to traditional methodological approaches to social psychology [19], Holly Arrow and her associates study small groups dynamics as complex systems in both local and global level by using computational modeling. Accepting the difficulty of applying dynamical systems methodology to the empirical datasets in social psychology [20], as many scholars in this thread do, Arrow and her colleagues [19] clearly state that their aim is not predicting values of specific soft variables, but rather “identifying the qualitative patterns that are plausible for a system variable over time, given specified ranges of values for contextual parameters” (p.260). This aim enables them to make generalizations “across systems with regard to qualitative patterns, at the cost of precision in controlling variables” (p.266).

All in all, this thesis aims to integrate individual and group based explanations of social influence in a simulation (system dynamics) model so as to depict qualitative major patterns of attitude, behavior, and group change under the social influences of majority and minority groups. As stated in the introduction, the specific context of social groups the model represents involves a clash of opinions in a social group since the real life puzzle this thesis deals with is about possible dynamics between majority and minority groups, which were the same group once. As it can be seen in different types of social groups - student organizations, political parties, associations, small neighborhoods, and the like – in real life, a small number of people in a group can start to hold a different opinion, and form their own group due to this difference of opinion. This thesis is interested in intergroup dynamics between minority and majority after this separation, i.e. categorization of the others as an out-group minority.

The research objective of the thesis is thus to demonstrate intergroup dynamics in the situation of forming an out-group minority from an in-group (majority) due to a clash of opinions. More specifically, the aim is to investigate under what conditions such a minority group survives in the presence of majority's social pressure, and under what conditions conversion of some individuals from majority possible. The sub-objectives can be explained in three folds: First one is introducing system dynamics method to the thread of dynamical social psychology, and to demonstrate how systems dynamics can be utilized in studies of social influence in an intergroup context. Second one is offering a valid simulation model to the dynamical social psychology literature, as an experimental tool, in order to acquire new theoretical understandings about inter-group based social influence from possible counterintuitive patterns of behavior that model produces. Third objective is proposing an integrative framework for social influence processes in inter-group context by the help of causal loop diagrams, feedback mechanisms, and holistic approach of systems theory.



### 3. METHODOLOGY

In this study, system dynamics approach is utilized, which is superior over other methods to deal with the problems having dynamic, non-linear, and path-dependent aspects of complexity [21]. Furthermore, the problem and the research objectives of this study are compatible with using a system dynamics model.

First, studying the dynamics of intergroup processes requires one to consider the dynamic nature of the problem. In the social realm, let alone the intensities and degrees of variables, even the meanings are amenable to change over time. Adopting a static perspective would be a seriously flawed approach.

Second, the non-linearity present in social problems, particularly for our problem, is non-negligible. Although, arguably the most frequent practice in science due to its mathematical tractability, assuming that the world is linear would lead the researchers to erroneous oversimplifications, of which positivistic approach of social sciences suffers significantly.

Third, to be able to account for path-dependency, deploying feedback loops in a model is indispensable. The intergroup processes are very rich in terms of reciprocal relations or feedbacks, many of which are significant in terms of determining their dynamics.

Taking these points into consideration, system dynamics approach seems to be a perfect candidate to be deployed in this study. By means of using differential equations at the heart of modeling efforts, system dynamics is developed to study dynamic problems [21]. Second, system dynamics models are capable of dealing with nonlinearity, even at very complex levels, by means of simulation methodology. Finally, the distinctiveness of system dynamics modeling from simple differential equations modeling, is that it establishes a common language particularly suitable for social variables where fundamental feedback dynamics can be understood, explained, and discussed.

In system dynamics methodology, the main motivation is to study a problem by adopting a holistic approach. With a special emphasis on causal relations rather than mere correlations [21], system dynamics approach rely on the philosophy that “the whole is greater than the sum its parts”. In other words, the totality of the relationships, which is something different the sum of its elements, creates the dynamics of a system of interest.

Another key distinctiveness of system dynamics approach is its emphasis on endogeneity. As opposed to externalist perspectives, it is argued that it is the internal structure of a system which determines its behavior, rather than some external factors [21]. By means of employing circular feedback causality to account for the relationships among the elements of a system, the structure or the totality of the relations in a system becomes rich enough to determine the behavior.

In the light of the above description of system dynamics, by developing a credible model, that is representing the relations significant to the behavior of interest, providing an endogenous explanation and extensive experimentation becomes possible via simulation runs.

In system dynamics methodology, there are two central concepts used in modeling. First, *stocks* represent the accumulations in a system. They can be used to account for a broad range of phenomena, from physical to psychological notions. Some examples for stock variables can be population, knowledge level on a specific topic, anger level, etc. The stocks in a model usually represent the key variables which are also known as the state variables, denoting that the values of the stocks define the state of a system.

The other related significant concept is *flows*, which define how the stocks change. Put differently, the net of flows of a stock, define the rate of change of the stock. Births and deaths, reading and forgetting, and increase in anger or anger dissipation can be given as examples of flow variables related to the above stock variables [21].

Although, stocks and flows are sufficient to define to a system, a third variable type called converters or auxiliary variables are utilized to explicate intermediate parameters or variables. Note that these can be either constants or functions of stocks and/or flows.

The mathematical description of a system in system dynamics language is a set of first order differential (or difference if it is discrete-time model) equations where a stock with its flows is defined as a first order differential equation.

In model diagrams, on the other hand, which used both to understand and to communicate the model, stocks are represented as rectangular boxes, and flows as valves on arrows that point either into or out of the stock. If the arrowhead of the flow points into (out) the stock it is called an “inflow” (outflow). The logic behind this distinction is to differentiate between inflows which tend to increase the stock, and the ones that decrease it, that is outflows. There is one more symbol used in the stock-flow diagrams and they are clouds symbolizing either the sources or sinks for the flows in case they emanate from or discharge outside the boundary of the model. Note that they have no operational impact on the model. To illustrate better, an example of stock-flow diagram of for a psychological model, which is an adaption of the one in [22] is displayed in Figure 3.1.

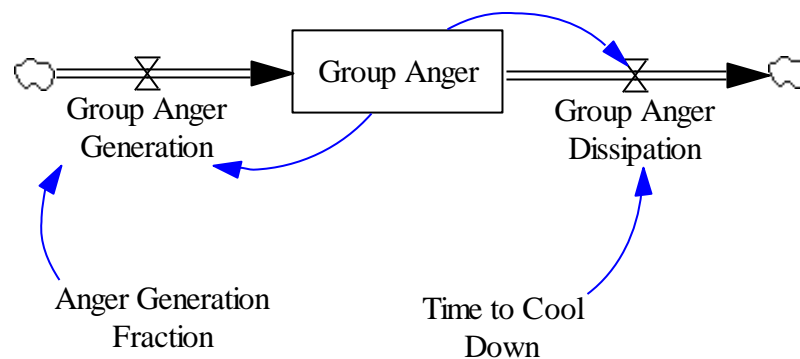


Figure 3.1. Stock-flow diagram of a simple group anger model.

Group Anger (t)

$$= \text{Group Anger (t - dt)} + (\text{Group Anger Generation} - \text{Group Anger Dissipation}) \times dt \quad (3.1)$$

$$\text{Group Anger Generation} = \text{Anger Generation Fraction} \times \text{Group Anger} \quad (3.2)$$

$$\text{Group Anger Dissipation} = \text{Group Anger} \times (1/\text{Time to Cool Down}) \quad (3.3)$$

In this extremely simple model, which is adapted to illustrate the use of system dynamics, the main stock variable is Group Anger. The inflow to the stock is Generation of Group Anger and the outflow Dissipation of Group Anger. Anger Generation Fraction and Time to Cool Down are converter variables. The arrows, which connect these variables, show the causal relationships between them. More precisely, the pointed variable is defined as a function of the variable, which resides on the tail of the arrow. Note that the incoming arrows can come from more than one source, denoting different causal relations. However, all the causal relations between two variables are symbolized by a single arrow.

As mentioned before, system dynamics approach provides an accessible language and another tool of it to do so is causal loop diagrams, which are used to capture the feedback structure of a model [23]. Figure 3.2 illustrates the causal loop diagram of the above model. Here, polarity of the arrow defines the nature of the relationship between the two variables. More precisely, a positive sign on an arrowhead denotes that an increase in the value of the source would yield an increase (decrease) in the destination variable's value above (below) what it otherwise would have been [23]. Conversely, a negative sign on an arrowhead denotes that an increase (decrease) in the value of the source would yield a decrease (increase) in the destination variable's value below (above) what it otherwise would have been [23]. Note that while assessing the polarity of a causal link, one needs to think between the relation between the cause and the effect *ceteris paribus*, meaning, keeping everything else constant.

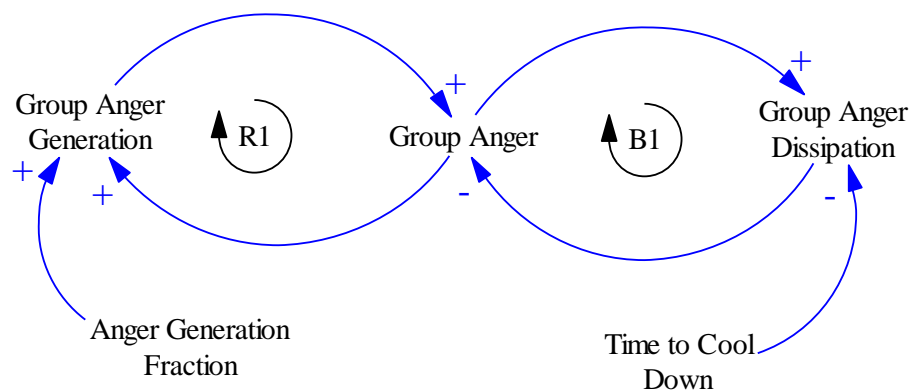


Figure 3.2. Causal loop diagram of the group anger model.

A loop is a circular path, leading one eventually to the point where she started, without passing the same path twice. In causal loop diagrams, there are two kinds of feedback loops: reinforcing or positive and balancing or negative. The polarity of a loop is found by the multiplication of the polarity of the arrows that it contains.

In Figure 3.2, there are two feedback loops: the first one is denoted as R1, where R symbolizes “reinforcing” or positive feedback loop and 1 states the identity of the loop. To interpret, the higher Group Anger is, the higher Group Anger Generation is, which in turn leads to even higher Group Anger. The second one is denoted as B1, where B stands for “balancing” and again, 1 is the identity of the loop. To interpret, the higher Group Anger is, the higher Group Anger Dissipation is, which in turn decreases Group Anger.

Identifying feedback loops is important because they are the engines of a system [21]. More specifically, reinforcing feedback loops forces the system either to grow increasingly or to collapse. On the other hand, a balancing feedback loop tries to maintain the system around a goal; if the concerned variable is above (below) the goal, then the negative feedback loop forces system to decrease (increase) its value to the goal. A thermostat, for example, has such a negative feedback loop in its system structure.

## 4. OVERVIEW OF THE MODEL

Before descriptions of causal relations and feedback mechanisms, it is important to reemphasize the history of majority and minority groups here. As stated before, members of the minority group in the model were members of a large group with majority; however, the minority formed their own group due to difference of opinions. Since a clash of opinions creates those two different groups, i.e. majority and minority, one's changing opinion or behavior also means changing her social group. For example, such a minority group can be formed by individuals who start giving importance to ethnic minorities in their political stand, as different from the majority's mainstream ideology in a communist party.

In this chapter, to capture the intergroup dynamics in the situation of forming an out-group minority from an in-group due to a clash of opinions, a simplified causal loop diagram will be constructed step by step through the integration of social influence and intergroup behavior literature. Related causal relations and crucial feedback loops will be explained with the help of social psychology theories that constitutes a theoretical framework for the model.

### 4.1. The Core of the Model: Latane's Social Impact Theory

Latane's Social Impact Theory is crucial for the underlying logic and formulations of the flows. The causal loop diagram (CLD) that demonstrates the principles of his theory is shown in Figure 4.1. This CLD also constitutes the model's backbone. Latane [24] suggests two types of social impact: persuasive impact coming from the opposing group, "the pressure to change to a different position", and supportive impact coming from one's own group, "the pressure to maintain one's present position" (p.239). According to Social Impact Theory, if source and target people are members of distinct groups, then the magnitude of social impact is a function of persuasive impact of opposing group divided by supportive impact of one's own group.

With the help of this framework, Latane challenges unilateral studies about majority and minority influence in which target of the social influence cannot be a source at the same time. Explaining with the same variables, Latane [8] regards “social influence as a unitary concept” (p.449). According to him, social impacts coming from majority and minority only quantitatively differ. With this understanding, his model enables us to analyze majority and minority influences simultaneously and reciprocally [2]. Latane’s Social Impact Theory establishes a framework for this research. However, this does not mean that the model adopts every argument in his theory. How and why the model is differentiated from his theory will be stated throughout this chapter.

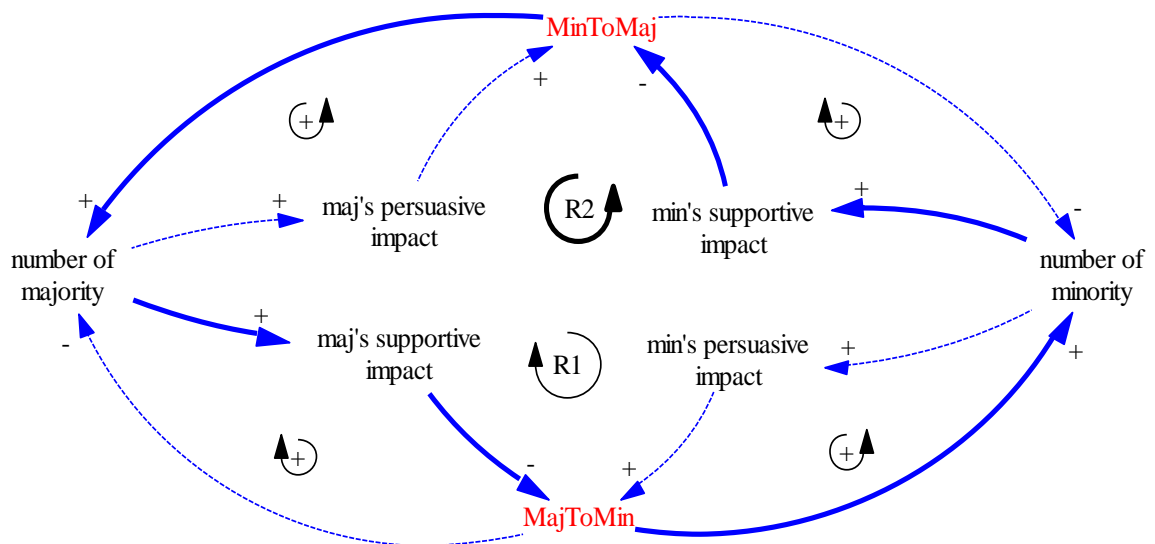


Figure 4.1. Simplified Causal Loop Diagram of Latane’s Social Impact Theory - the partial model.

Figure 4.1 shows the simplified causal loop diagram of Latane’s Social Impact Theory. Since strength and immediacy are exogenous constants in his static version of the model, the above CLD just includes number of source and target people. The feedback loops in Figure 4.1 are also essential in the model. The CLD consists of four reinforcing feedback loops for minority and another symmetric four feedback loops for majority. Only the ones related to number of minority are described here since it is easy to think symmetrical ones about number of majority.

The first two – indicated with “+” - can be easily seen in the right hand side of Figure 4.1. As the number of minority increases minority’s, persuasive impact goes up. This increase in persuasive impact makes more people in majority change their attitudes and adopt minority’s position, and this leads a rise in minority’s number. The other positive feedback loop in the right hand side of the figure depicts the positive relationship between the number of minority and minority’s supportive impact. As the number of minority increases, minority’s supportive impact goes up. This increase in supportive impact makes fewer people in minority change their attitudes and adopt majority’s position, and this leads a decline in the transition from minority to majority. Therefore, minority’s number becomes higher than what it otherwise would have been.

The other two reinforcing feedback loops related to number of minority are indicated as R1 and R2, both of which either decrease number of majority or slow down the increase in number of majority, and in turn, raise the increase in number of minority or slow down the decrease in number of minority. R1 – indicated with dashed lines - operates as follows: with an increase in the number of minority, minority’s persuasive impact rises. Therefore, more people in majority adopt minority’s position, and number of majority goes down. This brings about a fall in majority’s persuasive impact, and in turn, slows down the decrease in number of minority, i.e. decreases the transition from minority to majority. On the other hand, R2 – indicated with bold lines - operates as follows: an increase in the number of minority raises minority’s supportive impact thus slows down the increase in number of majority, i.e. decreases the transition from minority to majority. This brings about a fall in majority’s supportive impact, and in turn, more people in majority adopt minority’s position which leads to an increase in number of minority.

## 4.2. Antagonism

The above section, which depicts Latane’s theory, generates symmetrical causal loops for majority and minority influence. His theory regards minority and majority social groups according to their number. This approach enables him to distinguish majority and minority influences quantitatively. However, there are other dimensions that differentiate majority and minority groups. Distinct from number, most important dimension is power. William Crano [25] points out that majority, as a social group, “has the muscle to reward



or punish, [...] and it uses this power to get its way and to maintain its superior position.” (p.567)

The thesis identifies qualitative differences between majority and minority groups, and between their social impacts on each other as well as quantitative ones. Therefore, in the model, the privilege to use reward or punishment on minority is given to majority as the power dimension which differentiates those two social groups as a majority group and a minority group. In a nutshell, initial values for majority and minority represent the numerical advantages of majority compared to minority whereas the ability to use reward or punishment corresponds to the power advantages of majority. Different from social pressure created by social influence of majority on minority, utilized reward or punishment generates another social pressure on minority which forces people to hold majority's position. Therefore, utilized reward or punishment (RP) has a negative effect on number of minority, as it can be seen in Figure 4.2.

In addition to RP, the model includes antagonism variables for majority and minority. The motivation to add these variables comes from group-based explanations of social influence processes. As it is indicated in the literature review, there are two main schools of thought about intergroup hostility, or discrimination. First one tracks Muzafer Sherif's Realistic Group Conflict Theory. Second one is established based on Henri Tajfel's minimal group paradigm [14], which proposes that even when there is no explicit conflict between groups “intergroup discrimination can be caused by a "minimal" social categorization” (p.24). In other words, even identifying the belonging to a group creates a discrimination between us (in-group) versus them (out-group), and antagonism toward out-group.

The specific context of social groups in this model can be seen appropriate to both schools of thought. To be more precise, all people in the model were members of a large group once, and then clash of opinions creates two different groups: the majority, and the minority. The model argues validity after this point, i.e. after the identification of two distinct groups. As Tajfel [14] states: “There can be no intergroup behavior without categorization into groups, i.e. ‘social categorization’.” (p.31)

Returning to the subject of “antagonism”, one can argue that this specific contextualization, which consists of moving away from the mainstream opinion and forming a new group, results in explicit conflicts because of the groups’ history according to Realistic Group Conflict Theory. On the other hand, one can simply argue when social categorization exists - when they recognize the other group as “others” – out-group discrimination occurs according to social identity processes which even exist in “minimal” groups. As it is indicated above, the thesis will not specifically adopt one of the two. The important point is that both are justifiable, and this gives more than enough credibility to regard “antagonism toward out-group” as an important variable in such a context.

In a nutshell, different from Figure 4.1 that depicts feedback loops in Latane’s theory, the variables minority’s antagonism, majority’s antagonism, and RP are added to the model. The relations of these variables among themselves and with number of minority are demonstrated in Figure 4.2. Although minority’s number is common in both Figure 4.1 and Figure 4.2, there is no identical relation depicted in both.

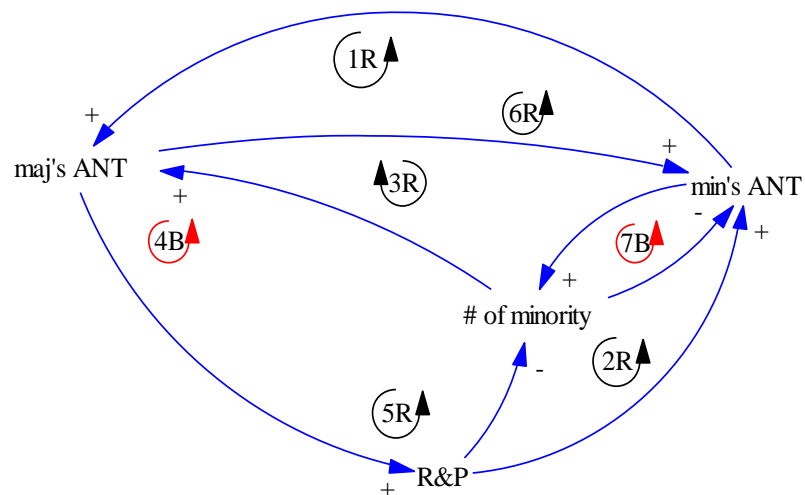


Figure 4.2. Causal Loop Diagram for Antagonism.

Before analyzing the feedback loops among minority’s antagonism, majority’s antagonism, RP, and number of minority, one important relation about ‘the reactance of minority’ should be explained here. As indicated in the literature review, many social psychologists investigate the influence of majority and its reward or punishment mechanisms on minority’s behavior. However, Nicole Mead [26] points out that reacting to

those social pressures, “having control over their actions and behavior is one of human beings’ most important and valued needs.” (p.725). Although Latane’s theory states that one changes her attitude or behavior if persuasive impact of out-group on her is greater than her in-group’s supportive impact, some people can behave differently. Even in this condition individuals can “react strongly to having options tak[en] away by external forces” (p.724), as Brehm [26] observed. Different kinds of social pressures (social influence, reward, or punishment) to limit or eliminate freedom of choice and action bring about an increase in minority’s antagonism. This increase leads to a decrease in transition from minority to majority, i.e. less people in minority change their opinion and adopt majority’s position. Therefore, minority’s antagonism has a positive influence on number of minority.

As it can be seen from Figure 4.2, majority’s antagonism is positively influenced by two factors, one of which is minority’s antagonism and the other is number of minority. Because of the specific context of social groups in this thesis, i.e. minority comes into existence as a distinct group through separation from majority, an increase in minority’s number means a decrease in majority’s number, and thus, enhances majority’s antagonism. On the other hand, minority’s antagonism toward majority is affected by three variables. Majority’s antagonism and RP have positive effects on minority’s antagonism whereas number of minority has a negative influence on it. Majority’s privilege of RP usage creates power differentials between groups. Minority’s antagonism toward majority is one of the consequences of “acknowledged realities of social differentials in power” (p.19), as Tajfel [14] states. The other influencing factor of minority’s antagonism is its own number. A decrease in number of minority means social pressures of majority is successful to convert people or force people to comply. This, for sure, increases antagonism of the rest in minority group.

In Figure 4.2, the feedback loop *1R* represents the reinforcing loop between antagonism levels of two groups. A social group’s hostility toward out-group enhances hostility of the opposing group.

The feedback loop *2R* operates as follows: while majority’s antagonism toward minority increases, the usage level of offer of reward or punishment on minority increases

above what it otherwise would have been. This increases minority's antagonism toward majority which in turn, yields more antagonism among people in majority toward minority.

The feedback loop *3R* operates as follows: in parallel with the increase in minority's antagonism, reactance to change occurs among people in minority group. This reduces transition from minority to majority, i.e. decreases the decline in number of minority. This in turn, raises majority's antagonism, and eventually minority's antagonism.

The feedback loop *4B* operates as follows: the increase in majority's antagonism raises the magnitude of reward or punishment they utilize. Utilized RP creates pressure on individuals in minority to change their attitudes. This decreases number of minority and in turn reduces majority's antagonism. In other words, by means of using offer of reward and threat of punishment, the majority group cools down.

The feedback loop *5R* operates as follows: in parallel with the increase in minority's antagonism, reactance to change occurs among people in minority group. This reduces transition from minority to majority, i.e. decreases the decline in number of minority. This in turn, raises majority's antagonism and their use of RP, which yields an increase in minority's antagonism.

The feedback loop *6R* operates as follows: an increase in majority's antagonism raises the magnitude of reward or punishment they utilize. Utilized RP creates pressure on individuals in minority to change their attitudes. Decreasing number of minority increases minority's antagonism and eventually majority's antagonism.

The feedback loop *7B* represents the reactance effect on minority's number: as number of minority decreases, antagonism of individuals who are left behind in minority goes up. The increase in minority's antagonism creates reactance to change among people in minority group. This reduces transition from minority to majority, i.e. decreases the decline in number of minority, which means number of minority becomes higher what it otherwise would have been.

### 4.3. Social Impact & Antagonism

The causal loop diagram in Figure 4.3 is constructed by integrating social impacts section and antagonism section written above. There are five new relations (dashed links in Figure 4.3) which are formed through the integration of those two sections. Four of them are the links between antagonism levels and immediacies. The other link is between number of majority and utilized reward or punishment.

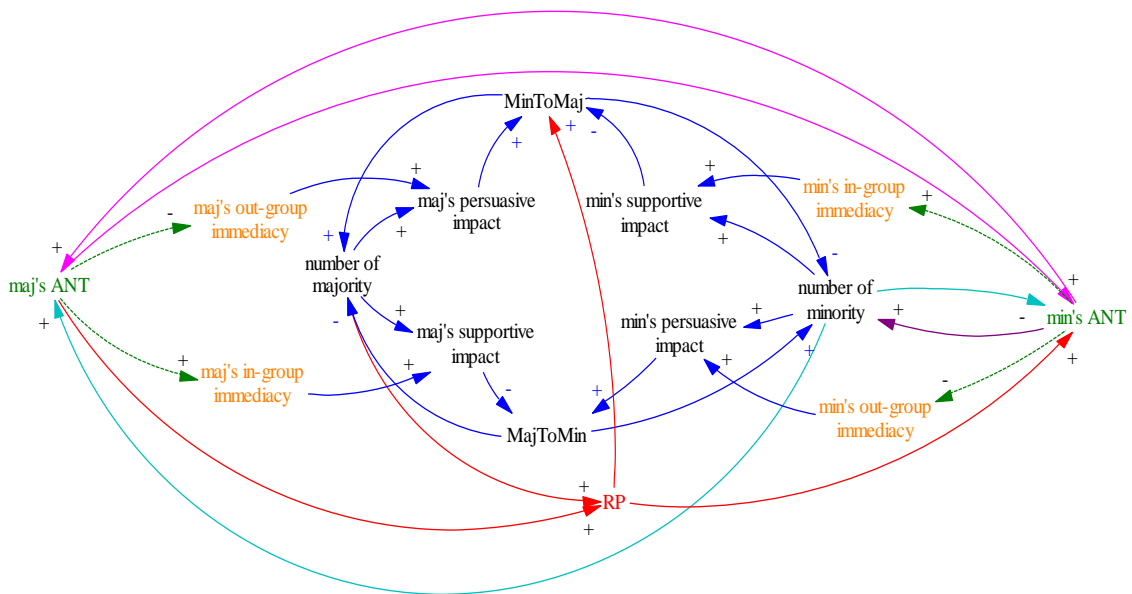


Figure 4.3. Simplified Causal Loop Diagram of the complete model.

Number of majority has a positive effect on RP. This is because; different numbers of majority create varied magnitudes of RP and social pressure on individuals in minority. Even though RP is majority's superiority about power and different from the numerical dominance, they are not completely independent in the model.

Between antagonism variables and social impacts, there are intermediate variables, namely in-group and out-group immediacies. Indeed, defining immediacy as closeness of the relationship between the target and source of influence, Latane [9] regards all pairs of actors as identical. In other words, he does not differentiate the immediacy between two persons from different groups from the immediacy between two individuals who belong to

same social group. However, from a group-based perspective in-group relations and out-group relations are inherently different because of the social categorization process [14].

Increasing antagonism levels toward the out-group by definition decreases the out-group immediacy. An increase in majority's antagonism (toward minority) means a decrease in out-group immediacy. In other words, increasing antagonism of majority reduces the openness of communication channels with minority. Symmetrically, an increase in minority's antagonism (toward majority) decreases its social closeness or immediacy with majority.

On the other hand, antagonism toward an out-group negatively affects the in-group immediacy. That out-group conflict creates in-group cohesion is commonsense; but also as Tajfel emphasizes [14], "there exists a long tradition" (p.15) about it in social psychology. From perspective of realistic group conflict theory, the explicit conflicts between groups "not only create antagonistic intergroup relations but also heighten identification with, and positive attachment to, the in-group" (p.33), as Tajfel and Turner [27] points out. On the one hand, one can argue that the privilege to use RP as a social differential in power, or the historical context of becoming an out-group, create explicit conflict, and in turn lead to in-group closeness or immediacy. On the other hand, following Tajfel [14], it can be argued that with the help of social categorization "implicit conflict between ingroup-favoring tendencies" (p.19) creates out-group hostility, and in turn, in-group immediacy.

In a nutshell, the model consists of two types of immediacy: out-group immediacy and in-group immediacy. As antagonism toward out-group goes up, the average out-group immediacy decreases whereas the average in-group immediacy increases. Another point that should be emphasized here is that immediacy becomes an endogenous variable rather than an exogenous constant, as in Latane's framework [11]. Differentiating immediacy variables between in-group and out-group and making them endogenous, this new framework enables us to depict more realistic relations between social influence and intergroup behavior. To be more precise, social impacts affect antagonism levels through changing number of people in groups whereas antagonism levels affect persuasive and supportive social impacts through, respectively, out-group and in-group immediacies.

## 5. DESCRIPTION OF THE MODEL

In Social Impact Theory, Latane does not pay attention to the distinction between attitude and behavior [8]. In other words, his theory does not detail the interaction between overt statement or public expression and private opinion or attitude. Moreover, Latane does not specify social influence processes that can lead to different results, such as conformity, compliance, internalization, persuasion, and the like [8].

In our model, the magnitude of social influence is calculated with Latane's formulation that will be described in the following sections. However, this research seeks to capture the qualitative differences between influences of majority and minority as well as quantitative ones. Hence, distinct from Latane's single layer conceptualization, changes originated from social influence are explored in two layers, namely attitude and behavior, and intermediate stocks in addition to majority and minority are added to the model. These stocks are compliant and confused, as it can be seen from simplified stock flow diagram<sup>1</sup> in Figure 5.1. By doing so, the distinction between private opinion and overt behavior, which is crucial in social influence literature, is emphasized and represented. This lasting school of thought, which highlights the interplay between private attitude and overt behavior, is reviewed through important studies in the literature review. Here, for the sake of simplicity, the qualitative difference between majority and minority influence and its effects on the distinction between attitude and behavior change is summarized through Crano's words [2]:

The majority persuades because it possesses coercive power, the capacity to monitor and to punish misbehavior. Overt compliance, but not conversion or private belief change, resolves source-target conflict in such cases. Conversely, by virtue of the unexpectedness of their position, minorities stimulate targets to try to understand why they hold a particular view. The outcome of a target's quest for understanding can result in minority- based social

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<sup>1</sup> Different simplified stock flow diagrams are used throughout the thesis taking into consideration the convenience of readers. The diagrams are numbered according to how simplified they are. For example, Simplified Stock Flow Diagram-2 in Figure 5.5 has more detail compared to Simplified Stock Flow Diagram-1 in Figure 5.1. The complete stock flow diagram can be found in Appendix B.

influence. However, owing to a hypothesized reluctance to be identified with the minority, [...] minority influence will be delayed. (p.74)

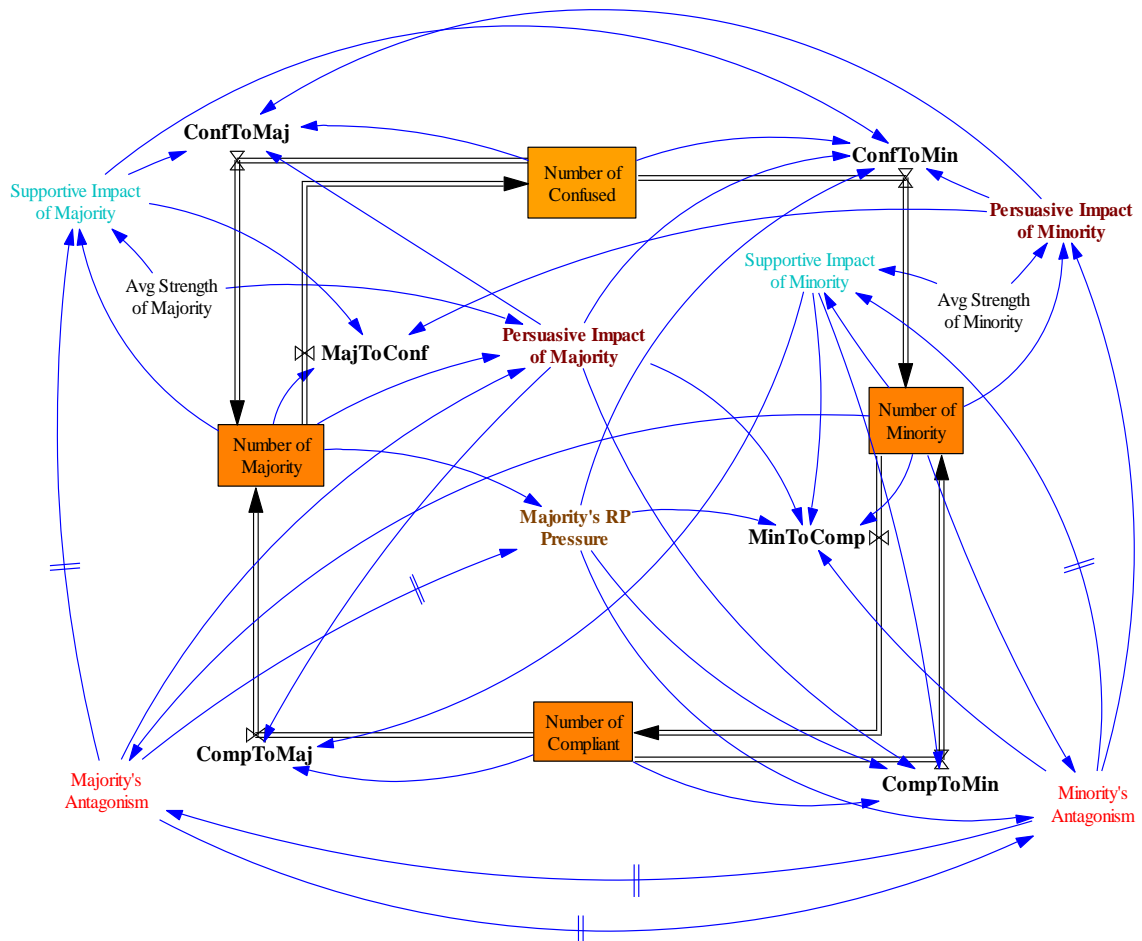


Figure 5.1. Simplest Stock Flow Diagram-1.

There are four stocks in the model that accumulate people. Majority and minority are the ones whose attitudes and behaviors are consistent with each other. On the other hand, because of the social pressures of majority, the people in compliant stock behave like majority even though they think like minority. Besides, the people in confused stock also behave like majority but their opinions or attitudes exactly align with neither majority nor minority. These are the ones who have become ‘privately confused’ by minority influence. In other words, the characteristic of their attitudes is not “a two-state flip-flop system whereby individuals could be either pro or con” (p.372), as in Latane’s simulation model [11]. As distinct from people in confused, two-state nature of attitudes are admissible for



the persons in other stocks. However, behavior has pro-con nature for all individuals in the model.

In terms of social impacts, the model can be divided in two different sections: First one is majority influence processes including majority, minority, and compliant stocks and flows among them. This section clearly shows that “in the face of a majority, the best way to lessen this [the] tension is to change one’s responses in the public realm” (p.216), i.e. to comply with majority, as Moscovici [7] states. Second section is minority influence processes including minority, majority, and confused stocks and flows among them. Here, opinion change in the private realms comes first “since it is very difficult to make direct concessions or to change behaviors or judgments in the public sphere” (p.216).

Even though the generic formula for the magnitude of social impacts and flow equations is described through Latane’s framework, the underlying logic of flow equations can also be viewed through the lenses of Leon Festinger. Festinger [28] regards social influence and creation / reduction of dissonance as interwoven processes (p.177).

In his Cognitive Dissonance Theory, the main argument is that people seek cognitive consistency, and if they feel dissonance, they try to reduce it. Festinger states that the desire to reduce cognitive dissonance is proportional to magnitude of dissonance. The more dissonance a person experience, the more she tries to decrease or eliminate it [28]. According to Festinger, two cognitive elements can be dissonant, consonant, or irrelevant with each other. Dissonance can arise from an inconsistency between behavior and attitude of a person (e.g. compliant and confused people in the model), or from a past experience which is contradicting her today’s opinion, or from new knowledge that challenges her behavior. There are two main dissonance reduction methods [28]: one is “decreasing the number of dissonant relations” and the other is “increasing the number of consonant relations” (p.94).

Indeed, Latane’s framework about opinion change [11], that is “whenever the impact on an individual from a group with a different opinion was greater than the impact of his or her own group, the attitude of that individual changed.” (p.367), is analogous with Festinger’s argument [28] “Whether or not opinions change when this is the case will, of

course, depend upon whether the dissonance created becomes sufficiently large to overcome the resistance to change of the opinion” (p.192). In other words, persuasive impact in Latane’s terminology is a source for dissonance (for the opposing group) whereas supportive impact creates consonance. That is because, persuasive impact by definition is dissonant with one’s opinion; on the other hand, supportive impact is consonant with it. Moreover, Festinger [28] regards social group as a mean for both dissonance creation and reduction, by saying “the social group at once a major source of cognitive dissonance for the individual and a major vehicle for eliminating and reducing the dissonance which may exist in him.” (p.177) Therefore, in the model, changing attitude or behavior, and thus social group, is a dissonance reduction method.

From the fundamental arguments of Cognitive Dissonance Theory, it can be easily inferred that all people in the model experience dissonance. People in minority and majority are exposed to social influence of each other (opposing social groups) that is dissonant with their opinion or attitude. If these attempted social influences become successful, and change their behavior (through majority influence processes), or opinion (through minority influence processes), then they respectively become compliant or confused. Compliant and confused people experience dissonance because their private attitude and public behavior are inconsistent with each other. However, Festinger’s theory is explicitly used in majority influence section of the model, since he focuses on “cognitive consequences of forced compliance” [6] and particularly defines the consonance and dissonance elements in the case of compliant. Even though according to his theory, it is clear that confused people in the model also feel dissonance, he does not specify the elements which are dissonant or consonant with their attitude, or behavior in minority influence processes.

An important point regarding the content of flows in the model, which should be clarified, is about the history of groups. As stated before, the members of the minority group in the model were members of a large group with majority; however, the minority formed their own group due to difference of opinions. Since a clash of opinions creates those two different groups, i.e. majority and minority, one’s changing opinion or behavior also means changing her social group. For example, some people in an orthodox Marxist group can decide to give importance to identity politics, or rights of people with different

sexual orientation, and form a new distinct minority group. Since the separation is because of a difference of specific thought, if minority's social influence is enough to change the opinion about identity politics of some people in majority through intergroup social influence processes, then this change in opinion means transformation of some people from majority to confused. If minority's social influence is enough to enable these people to state their thoughts publicly then this means conversion of some people from confused to minority.

## 5.1. Major Mathematical Equations

The model has many soft variables - variables that cannot physically measurable. Using antagonism, immediacy, or social pressure as variables in such a quantitative system dynamics model does not mean that the magnitude of those variables can be measured. However, they are quantifiable even though it is impossible to measure them [29]. Since the purpose of this thesis is not to predict the numerical magnitude of particular soft variables [29], incorporating the soft variables consistently to the "hard" model is enough to include those variables that have critical roles in real life dynamics. Following Barry Richmond, all soft variables are quantified by "assigning a number to" [29]; nevertheless, this assignment is not arbitrary. 0-100 scale is used as a consistent range for all soft variables [29]. For example, 0 represents the complete absence of antagonism and 100 represents the maximum possible antagonism for a group to have [29]. The important point is not the absolute number that is assigned to the variable but rather the comparison between different values, and "the impact that differences in the index number has on behavior" [29]. Social pressure, antagonism, strength, immediacy, and reward or punishment are the soft variables in the model and vary between [0, 100].

### 5.1.1. Social Impacts and Cognitive Dissonance

According to Latane's original formulation, social impact on a person is calculated by Equation 5.1.

$$\hat{I} = S \times I \times N^t \quad 0 < t < 1 \quad (5.1)$$

where  $S$  represents strength which is determined by individual characteristics like status and age.  $I$  denotes immediacy which refers closeness in relationship, or openness of a communication channel.  $N$  denotes the number of source people.  $t$  is a constant between 0 and 1, to be estimated (from the data if available). Analyzing different data sets, Latane [11] states “empirical studies have shown it [exponent  $t$ ] to vary around an average of approximately .5” (p.364).

This equation means that social impact is linearly proportional to strength of individuals and immediacy between them, whereas nonlinearly proportional to number of them, i.e. marginal impact of each individual decreases as the number of people goes up.

If the recipient is a member of a social group, then the magnitude of social impact exerted by the other social group is calculated by a multiplicative function of strength, immediacy, and number of people in the opposing group and an inverse function of strength, immediacy, and number of people in her own group [8] as it can be seen in Equation 5.2.

$$\hat{i} = f \left( \frac{S \times I \times N^t \text{ opposing group}}{S \times I \times N^t \text{ own group}} \right) \quad (5.2)$$

Here, since the target of influence is not alone, the impact is diffused or divided among her group members. But again, marginal division impact of each individual decreases as number of recipients goes up.

Festinger’s Cognitive Dissonance Theory has parallels with Latane’s Social Impact Theory in terms of the above formulations which calculate the magnitude of social impact on a person. This is analogous with the levels of cognitive dissonance in Festinger’s terminology. The positive relation between social influence and attitude change in Latane’s framework is similar with the positive relation between cognitive dissonance and wish of dissonance reduction. Since social groups are vehicles for dissonance reduction as well as creation, in the model, the rate of changing opinion, behavior, and also social group is higher in Festinger’s lenses when dissonance is greater, or in Latane’s eyes when social influence is higher.

The variables that affect the magnitude of social impact in Latane's theory are similar with those that influence the magnitude of dissonance in Festinger's theory. Festinger [28] mentions "the attractiveness of the person voicing the disagreement" (p.180) as a variable that affects magnitude of dissonance. Festinger [28] states "If the person voicing disagreement is seen as expert or very knowledgeable on such matters, the dissonance between knowledge of his contrary opinion and one's own opinion will be greater" (p.180), which corresponds the effect of strength on social impact in Latane's formulation. Moreover, about division of the influence among the recipients from the same group, Festinger [28] argues "The larger the number of people that one knows already agree with a given opinion which he holds, the less will be the magnitude of dissonance introduced by some other person's expression of disagreement." (p.179) It results in less need to reduce dissonance, and less change of opinion or behavior, and social group.

In a nutshell, in general, persuasive impact constitutes dissonance with one's opinion whereas supportive impact creates consonance with it. Even though the two frameworks of Latane and Festinger looks like substitutable, Latane's theory will be used in flow formulations since Festinger elaborates on compliance in the face of majority influence, and does not say much about minority influence process.

Integrating above formulations to system dynamics model needs some modifications. In the model, number of persons in the social group ( $N$ ) is normalized with total number of people, which is constant in this closed system. The normalization eases the model calibration.

$$\hat{I}_p = S \times I_o \times \left( N_o / \text{Total number of people} \right)^t \quad (5.3)$$

where  $\hat{I}_p$  denotes persuasive impact.  $N_o$  represents the number of sources of influence, i.e. individuals with the opposing opinion, or individuals from out-group.  $I_o$  denotes average immediacy between the recipient and all the sources in out-group.  $S$  is the average strength of the sources.

As it can be seen from Figure 5.2, in the model social impact is nonlinearly proportional to number of people, i.e. marginal impact of each individual decreases as the number of people goes up in parallel with what Latane proposes.

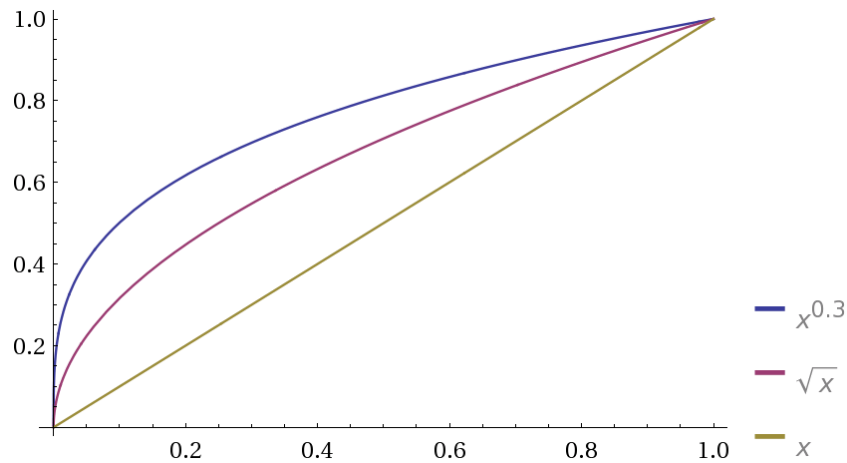


Figure 5.2. Nonlinear function of  $(N/\text{Total Number})^t$ .

$$\hat{I}_s = S \times I_i \times \left( \frac{N_i}{\text{Total number of people}} \right)^t \quad (5.4)$$

where  $\hat{I}_s$  represents supportive impact.  $N_i$  denotes the number of recipients of influence, i.e. individuals with the same view, or individuals from in-group.  $I_i$  refers average immediacy between all pair of targets, i.e. pair of individuals from in-group.  $S$  is the average strength of the recipients.

**5.1.1.1. Impacts of Majority and Minority:** In this sub-section, the exact formulations of majority's persuasive and supportive impacts and calculation of the variables in those equations are described. Since those equations are symmetric with minority's impacts, only majority's equations will be explained here.

**Persuasive Impact of Majority**

$$\begin{aligned} &= \text{Avg Strength of Majority} \\ &\times (100 - \text{Majority's Antagonism Toward Minority}) \\ &\times (\text{Number of Majority/Total Number of People})^t \end{aligned}$$

(5.5)

In the formulation of persuasive impact of majority, the only variable that needs to be clarified is out-group immediacy<sup>2</sup>, which is a decreasing function of majority's antagonism toward minority. By subtracting majority's antagonism toward minority from 100, the maximum number assigned to all soft variables including both antagonism and immediacy, a decreasing linear function is defined as the relation of antagonism and out-group immediacy. To obtain a clear model, substitutable concepts are represented once in the model; thus, there is no explicit variable as 'out-group immediacy', it is instead represented by the above subtraction.

#### Supportive Impact of Majority

$$\begin{aligned}
 &= \text{Avg Strength of Majority} \times \text{Average Immediacy in Majority} \\
 &\times (\text{Number of Majority}/\text{Total Number of People})^t
 \end{aligned}
 \tag{5.6}$$

In Equation 5.6, the new, endogenous, and dynamic approach to Latane's framework is obtained from calculation of average immediacy in majority, in-group immediacy.<sup>3</sup>

#### Average Immediacy in Majority

$$\begin{aligned}
 &= \text{Effect of Majority's Antagonism on Average Immediacy in Majority} \\
 &\times \text{Max Immediacy}
 \end{aligned}
 \tag{5.7}$$

#### Effect of Majority's Antagonism on Average Immediacy in Majority

$$= f(\text{Majority's Antagonism}/\text{Max Antagonism Level})
 \tag{5.8}$$

where  $f$  is defined as in Figure 5.3.

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<sup>2</sup> Theoretical explanations about the relationships of in-group, out-group immediacies between antagonism levels toward out-group can be seen in Section 4.3.

<sup>3</sup> *ibid.*

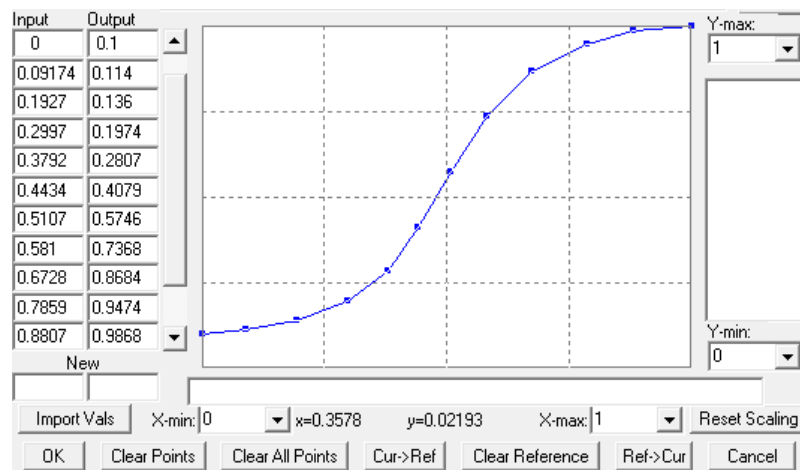


Figure 5.3. Effect function of majority's antagonism on average immediacy in majority.

As it can be seen from the Figure 5.3, in-group immediacy nonlinearly increases while out-group antagonism goes up. If majority's antagonism has its maximum value (100) majority's in-group immediacy reaches its maximum (100). However, even though antagonism is zero, effect function turns 0.1 as the minimum value. First, zero in-group immediacy means there is no social group at all. Second, drawing an effect function that has (0, 0) as a point connotes that in-group immediacy depends only on out-group antagonism, which would be a wrong general assumption.

### 5.1.2. General Flow Equation

According to Latane's social impact theory [11], "whenever the impact on an individual from a group with a different opinion was greater than the impact of his or her own group, the attitude of that individual changed." (p.367) Before this condition occurs, there is no attitude change. In other words, the nonlinearity of the relationship between social impact and attitude originates from Latane's assumption [11] that "when the ratio of persuasive to supportive impact is even slightly greater than 1, one's attitude shifts completely, so the resultant attitude is not proportional to the relative strength of persuasive and supportive forces." (p.372)

This essential nonlinearity is used in the model with two modifications. First, the ratio condition in Equation 5.9 is modified as in Equation 5.10, which is mathematically consistent with Latane's formulation.



$$\frac{\text{Persuasive Impact}}{\text{Supportive Impact}} > 1$$

(5.9)

$$\frac{\text{Persuasive Impact}}{(\text{Persuasive Impact} + \text{Supportive Impact})} > 0.5$$

(5.10)

The primary aim of this change is to obtain a ratio always in a fixed region, i.e. [0, 1] for Equation 5.10. The secondary reason is to make the ratio analogous with Festinger's formulation about obtaining compliant behavior. Festinger [6] regards "total magnitude of dissonance as being a function of 'D' divided by 'D' plus 'C' (p.204) where "sum of all the dissonances involving some particular cognition as 'D' and the sum of all the consonances as 'C'." (p.203)

$$\text{Total Dissonance} = f\left(\frac{D}{(D + C)}\right)$$

(5.11)

In Equation 5.11, 'D' is analogous with persuasive impact, and 'C' is similar with supportive impact in Equation 5.10. According to Festinger [28], dissonance relations about a particular issue should be greater than consonance relations to obtain compliant behavior (pp. 90, 91).

The second modification comes from the fact that Latane and Festinger specify the condition that 'a person' changes her attitude or behavior in the presence of social pressures and dissonance originating from them. On the other hand, in the system dynamics model, the condition regarding the change of attitude or behavior, and social group is defined for groups of people in the stocks. Therefore a corresponding nonlinear function, which has a steep slope at intermediate values, is defined as in Figure 5.4.

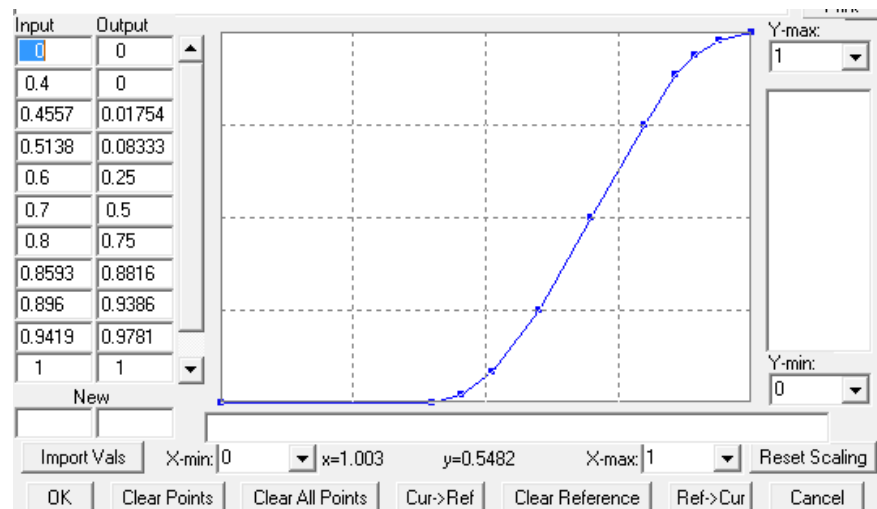


Figure 5.4. Generic effect function of perceived pressure balance on flow fraction.

With such a function, when the ratio in Equation 5.10 approaches 0.5, the related flow starts to work, rather than starting suddenly at 0.5 and being exactly 0 before it. All flows between stocks that accumulate people operate with the same effect function; however, their ratios are calculated of course by different pressures. As the ratio departs from 0.5, the flow quickly gets larger values. As the ratio approaches 1, the flow approaches its maximum possible value.

That is to say, the equations of six flows (MinToComp, CompToMin, CompToMaj, MajToConf, ConfToMaj, ConfToMin) related to the stocks for individuals (Majority, Minority, Compliant, Confused) have a generic form of which details will be given.

$$\text{Outflow} = \text{Stock} \times \text{Flow Fraction} \quad (5.12)$$

$$\begin{aligned} \text{Flow Fraction} &= \text{Effect of Perceived Pressure Balance on Flow Fraction} \\ &\quad \times \text{Max Flow Fraction} \end{aligned} \quad (5.13)$$

where *Max Flow Fraction* represents the maximum percentage of people that can change their opinion or behavior, and thus their social group per week. This fraction will be taken the same for each flow. The reason is to see whether flows properly operate according to literature. If attitude or behavior, and social group changes take place as expected with the same max flow fraction value, this means that the structure of the model endogenously

reproduces the flows through perceived pressure balance calculations, which enhances the behavioral validity of the model.

Effect of Perceived Pressure Balance on flow fraction

$$= f(\text{Perceived Pressure Balance}) \quad (5.14)$$

where  $f(\text{Perceived Pressure Balance})$  is defined as in Figure 5.4. Perceived pressure balance is the delayed version of pressure balance (Equation 5.15). To be able to affect the attitude or behavior change, and thus transmission between groups, first social pressures on persons should be perceived by them.

Perceived Pressure Balance(t)

$$\begin{aligned} &= \text{Perceived Pressure Balance}(0) \\ &+ \int_0^t ((\text{Pressure Balance} - \text{Perceived Pressure Balance}) \\ &\quad / \text{Perception Delay}) \times dt \end{aligned} \quad (5.15)$$

Equation 5.15 demonstrates the generic formula for the perception (information) delays that affect related flow coefficients. Therefore, perception delays are not written down in the following sections, while flow equations are described.

From the individuals' point of view in different stocks, perception delays are different. Table 5.1 demonstrates perception delay times for each flow, i.e. each attitude or behavior change, and thus group change. Perception delays for first three flows are smaller than others since they are related to the flows of opinion (attitude) change. The delay for MinToComp is lower than the others related to behavior change because the social group one will be attached is majority after the change. However, last two flows are inflows of minority, i.e. after the behavior change one will be attached to minority. The delay for CompToMin is lower than the one for ConfToMin since compliant individuals were publicly members of minority once, different from the confused ones who will be overtly attached to minority for the first time.

Table 5.1. Perception delay times for each flow.

Flow names	Related Stock	types of change	Observed social group after the change	Delay Time (week)
MajToConf	Maj	attitude	Maj	3
ConfToMaj	Conf	attitude	Maj	3
CompToMaj	Comp	attitude	Maj	3
MinToComp	Min	behavior	Maj	4
CompToMin	Comp	behavior	Min	5
ConfToMin	Conf	behavior	Min	7

If the direction of the related flow is from majority to minority (CompToMin, MajToConf, ConfToMin), pressure balance is calculated as in Equation 5.16. However, total majority's and minority's pressure are formed by different variables for each flow, as it can be seen in Table 5.2. If the direction of the related flow is from minority to majority (MinToComp, CompToMaj, ConfToMaj), pressure balance is calculated as in Equation 5.17. However, total majority's and minority's pressure are formed by different variables for each flow, as it can be seen in Table 5.2. The effective variables for each balance equation, i.e. for each flow can be seen in the simplified stock flow diagram in Figure 5.5.

Pressure Balance

$$\begin{aligned}
 &= \text{Total Majority's Pressure} \\
 &/(\text{Total Majority's Pressure} + \text{Total Minority's Pressure})
 \end{aligned}
 \tag{5.16}$$

Pressure Balance

$$\begin{aligned}
 &= \text{Total Minority's Pressure} \\
 &/(\text{Total Minority's Pressure} + \text{Total Majority's Pressure})
 \end{aligned}
 \tag{5.17}$$

It is important to observe in Table 5.2 that some of the flows represent simply behavior change while others represent attitude (opinion) change.

Table 5.2. The variables that constitute group pressures.

<b>Flows</b>	<b>Types of Change</b>	<b>Majority's Pressure</b>	<b>Minority's Pressure</b>	<b>Condition</b>
<b>MinToComp</b>	Behavior	Majority's Persuasive Pressure	Minority's Supportive Pressure	Majority's Pressure > Minority's Pressure
		Majority's RP Pressure		
<b>CompToMin</b>	Behavior	Majority's Persuasive Pressure	Minority's Supportive Pressure	Minority's Pressure > Majority's Pressure
		Majority's RP Pressure		
<b>CompToMaj</b>	Attitude	Majority's Persuasive Pressure	Minority's Supportive Pressure	Majority's Pressure > Minority's Pressure
<b>MajToConf</b>	Attitude	Majority's Supportive Pressure	Minority's Persuasive Pressure	Minority's Pressure > Majority's Pressure
<b>ConfToMaj</b>	Attitude	Majority's Persuasive Pressure	Minority's Persuasive Pressure	Majority's Pressure > Minority's Pressure
		Majority's Supportive Pressure		
<b>ConfToMin</b>	Behavior	Majority's Persuasive Pressure	Minority's Persuasive Pressure	Minority's Pressure > Majority's Pressure
		Majority's Supportive Pressure		
		Majority's RP Pressure		

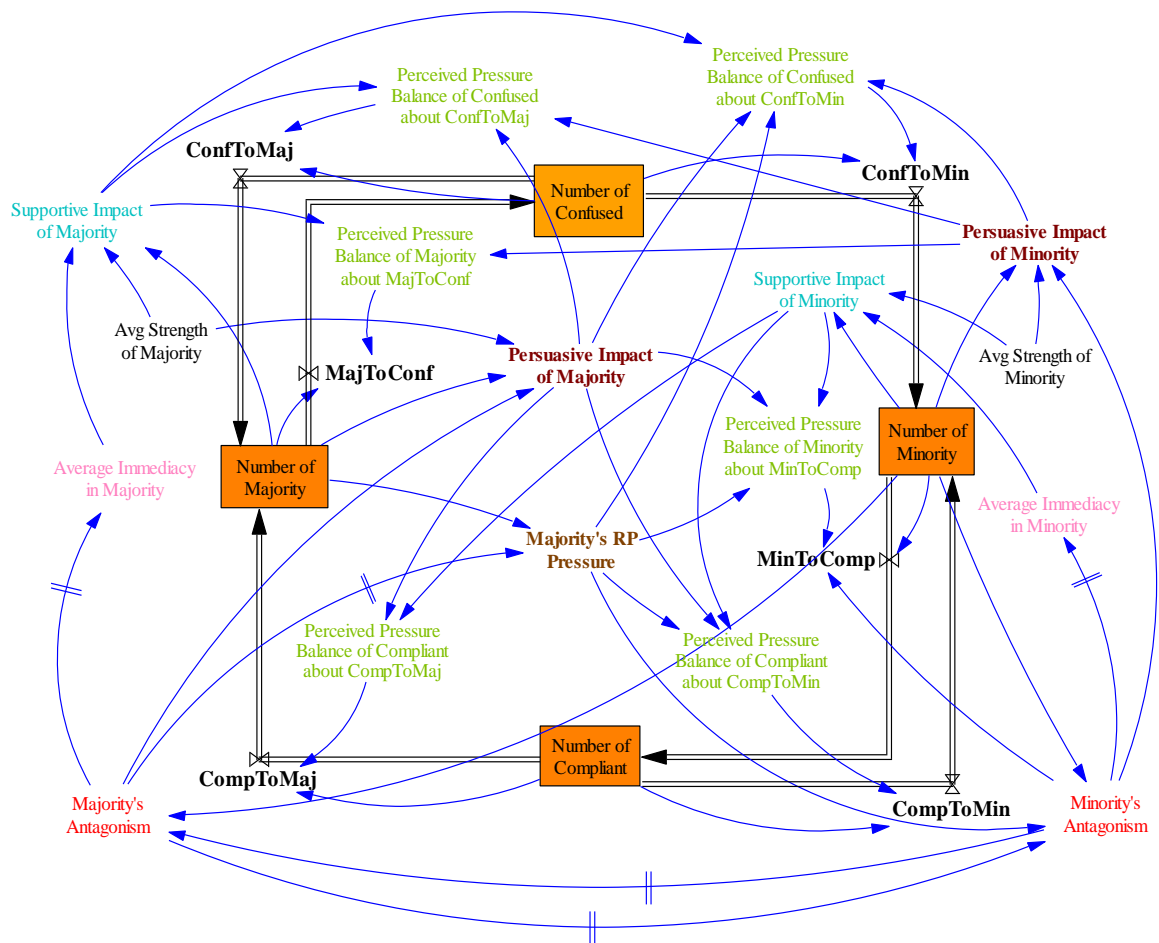


Figure 5.5. Simplified Stock Flow Diagram-2.

## 5.2. Majority Influence Processes

In this section, underlying logic and equations of three flows which are related to compliant stock will be explained. Those flows (MinToComp, CompToMaj, CompToMin) are grouped under majority influence processes since compliant behavior is the consequence of majority's pressure consisting of majority's persuasive impact and RP. In the explanations of these flows, the theories of Latane and Festinger will be interwoven.

### 5.2.1. From Minority to Compliant

Analyzing cognitive consequences of forced compliance, Festinger [28] specifies the situations in which public compliance without accompanying opinion change occurs through a threat of punishment for noncompliance or an offer of reward for complying. If

those conditions – reward or punishment – are sufficient to obtain compliant behavior, the person who is exposed to social influence or pressure publicly aligns her behavior with source people of influence. However, according to Festinger [28] her “private opinion will remain essentially unchanged for the moment” (p.85); thus, for that moment she stays in the compliant stock in the model.

$$\begin{aligned} \text{MinToComp} &= \text{Number of Minority} \times \text{MinToComp Fraction} \\ &\quad \times \text{Effect of Minority's Antagonism on MinToComp} \end{aligned} \tag{5.18}$$

This flow is the only one which does not exactly fit the general formulation in Equation 5.12. It is atypical because of the effect minority’s antagonism on the flow, i.e. reactance effect, which will be described after explaining the typical part of the equation.

$$\begin{aligned} \text{MinToComp Fraction} \\ &= \text{Effect of Perceived Pressure Balance of Minority on MinToComp Fraction} \\ &\quad \times \text{MAX MinToComp Fraction} \end{aligned} \tag{5.19}$$

$$\begin{aligned} \text{Effect of Perceived Pressure Balance of Minority on MinToComp Fraction} \\ &= f(\text{Perceived Pressure Balance of Minority about MinToComp}) \end{aligned} \tag{5.20}$$

where  $f$  (*Perceived Pressure Balance of Minority about MinToComp*) is defined as in Figure 5.4.

According to Festinger’s theory [28], the transition from minority to compliant can be possible only if the pressure to change one’s opinion is sufficient to overcome the resistance to change (pp. 90, 91). This nonlinearity between pressure and behavior change is analogous with the nonlinearity between social impact and attitude change in Latane’s framework. Festinger argues that when the forced compliance has not occurred yet, the sum of consonant relations is greater than the sum of dissonant relations [28]. In this situation, cognitive elements that are consonant with overt behavior correspond to the

social support of the social group which shares the same opinion with the person. For this flow in the model, that social group is minority. On the other hand, cognitive elements that are dissonant with overt behavior correspond to the social pressure of the social group which tries to induce the person to change her opinion and the knowledge that a reward will be obtained and or that a punishment will be avoided [28]. For this flow in the model, that social group is majority, and its persuasive impact and RP are the ones that utilized to force the person to change her behavior, as it can be seen in Equation 5.21.

Pressure Balance of Minority about MinToComp

$$\begin{aligned}
 &= \left( (2/3) \times \text{Majority's Persuasive Pressure} + (1/3) \right. \\
 &\quad \left. \times \text{Majority's RP Pressure} \right) \\
 &/ \left( \left( (2/3) \times \text{Majority's Persuasive Pressure} + (1/3) \right. \right. \\
 &\quad \left. \left. \times \text{Majority's RP Pressure} \right) + \text{Minority's Supportive Pressure} \right)
 \end{aligned}
 \tag{5.21}$$

Therefore, in the model, majority's social pressure on minority is equal to weighted sum of the majority's social influence (majority's persuasive impact) and utilized reward or punishment. Since those elements are dissonant with minority's overt behavior, their sum is also equal to the sum of dissonant relations, in Festinger's terminology. On the other hand, Latane calls supportive impact what Festinger [28] names "social support" (p.177). To be more precise, minority's social influence to maintain one's present opinion in group is also equal to the sum of consonant relations, in Festinger's theory.

The atypical part in Equation 5.18 is about minority's reactance<sup>4</sup> to majority's social pressure, its threat of punishment or offer of reward. Even the condition of behavior change, i.e. being compliant, occurs some individuals can react strongly to this forced or induced compliance. Different kinds of social pressures (social influence, reward, or punishment) to limit or eliminate freedom of choice and action bring about an increase in minority's antagonism. Rather than gathering those resistant individuals in a different stock, reactance as a socio-psychological process is approached in the model as a negative

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<sup>4</sup> More explanation can be seen in Section 4.2.



effect on MinToComp flow. To be more precise, reactance is demonstrated as a nonlinear negative effect of minority's antagonism on the flow.

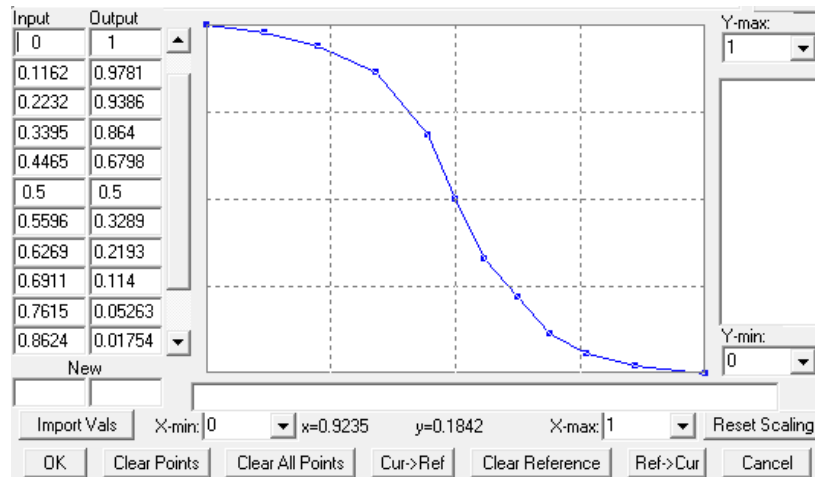


Figure 5.6. Graphical function for Effect of Minority's Antagonism on MinToComp.

Effect of Minority's Antagonism on MinToComp

$$= f(\text{Minority's Antagonism/Max Antagonism Level})$$

(5.22)

where  $f$  is defined as in Figure 5.6.

### 5.2.2. From Compliant to Majority

This flow is about opinion change after forced compliance, i.e. internalization. Festinger [6] states "If a person is induced to do or say something which is contrary to his private opinion, there will be a tendency for him to change his opinion so as to bring it into correspondence with what he has done or said." (p.209)

$$\text{CompToMaj} = \text{Number of Compliant} \times \text{CompToMaj Fraction} \quad (5.23)$$

CompToMaj Fraction

$$= \text{Effect of Perceived Pressure Balance of Compliant on CompToMaj Fraction} \\ \times \text{MAX CompToMaj Fraction}$$

(5.24)

$$\begin{aligned} &\text{Effect of Perceived Pressure Balance of Compliant on CompToMaj Fraction} \\ &= f(\text{Perceived Pressure Balance of Compliant about CompToMaj}) \end{aligned} \quad (5.25)$$

where  $f(\text{Perceived Pressure Balance of Compliant about CompToMaj})$  is defined as in Figure 5.4.

Since compliant people behave like majority, in the eyes of majority they are not the ones who should be punished or rewarded. This flow represents a private change that can be realized only by those individuals. Therefore, RP is not in the pressure balance calculation (see Equation 5.26).

$$\begin{aligned} &\text{Pressure Balance of Compliant about CompToMaj} \\ &= \text{Majority's Persuasive Pressure} \\ &\quad / (\text{Majority's Persuasive Pressure} + \text{Minority's Supportive Pressure}) \end{aligned} \quad (5.26)$$

### 5.2.3. From Compliant to Minority

Since people in compliant stock have attitude-discrepant behavior, they can reduce dissonance through either changing their attitude to align it with their behavior, or changing their behavior to make it consonant with their attitude. The flow from compliant to minority corresponds to the latter.

$$\text{CompToMin} = \text{Number of Compliant} \times \text{CompToMin Fraction} \quad (5.27)$$

$$\begin{aligned} &\text{CompToMin Fraction} \\ &= \text{MAX CompToMin Fraction} \\ &\quad \times \text{Effect of Perceived Pressure Balance of Compliant on CompToMin Fraction} \end{aligned} \quad (5.28)$$

$$\begin{aligned} &\text{Effect of Perceived Pressure Balance of Compliant on CompToMin Fraction} = \\ &f(\text{Perceived Pressure Balance of Compliant about CompToMin}) \end{aligned} \quad (5.29)$$

where  $f$  (*Perceived Pressure Balance of Compliant about CompToMin*) is defined as in Figure 5.4.

Since this flow is about overt behavior change, RP utilized by majority is taken into consideration in the pressure balance formulation (see Equation 5.30).

Pressure Balance of Compliant about CompToMin

$$\begin{aligned}
 &= \text{Minority's Supportive Pressure} \\
 &/ \left( \text{Minority's Supportive Pressure} \right. \\
 &+ \left. \left( (2/3) \times \text{Majority's Persuasive Pressure} + (1/3) \right. \right. \\
 &\left. \left. \times \text{Majority's RP Pressure} \right) \right)
 \end{aligned}$$

(5.30)

### 5.3. Minority Influence Processes

The crucial qualitative difference between majority and minority influence processes is that the former induces *compliance* “to publicly endorse the majority position” whereas latter creates *conversion* “to change what group members privately believe” (p.580), as stated in Encyclopedia of Social Psychology [26]. In this section, underlying logic and equations of three flows which are related to confused stock will be explained. These flows (MajToConf, ConfToMin, ConfToMaj) are grouped under minority influence processes since ‘becoming confused’ is the consequence of minority’s influence on majority, which aims opinion change.

#### 5.3.1. From Majority to Confused

The transition from majority to confused occurs only if minority’s persuasive impact is greater than majority’s supportive impact. The underlying mechanism of this flow is similar to the flow from minority to compliant. Both occur if out-group pressure is greater than in-group pressure, but out-group and in-group are opposites in these situations.

$$\text{MajToConf} = \text{Number of Majority} \times \text{MajToConf Fraction} \quad (5.31)$$

$$\begin{aligned}
& \text{MajToConf Fraction} \\
& = \text{Effect of Perceived Pressure Balance of Majority on MajToConf Fraction} \\
& \times \text{MAX MajToConf Fraction}
\end{aligned}
\tag{5.32}$$

$$\begin{aligned}
& \text{Effect of Perceived Pressure Balance of Majority on MajToConf Fraction} \\
& = f(\text{Perceived Pressure Balance of Majority about MajToConf Fraction})
\end{aligned}
\tag{5.33}$$

where  $f(\text{Perceived Pressure Balance of Majority about MajToConf Fraction})$  is defined as in Figure 5.4.

The significant difference between MinToComp and MajToConf is that the former is about overt behavior change while the latter is about private opinion change. Therefore, the individuals who change their behavior take utilized RP into consideration. On the other hand, since attitude is a subtle positioning, the individuals cannot be pressured via RP because of their private attitude or opinion. Therefore, they do not perceive utilized RP as pressure, and thus it is not in the pressure balance calculation for this flow (see Equation 5.34).

$$\begin{aligned}
& \text{Pressure Balance of Majority about MajToConf} \\
& = \text{Minority's Persuasive Pressure} \\
& \quad / (\text{Minority's Persuasive Pressure} + \text{Majority's Supportive Pressure})
\end{aligned}
\tag{5.34}$$

### 5.3.2. From Confused to Minority

This flow is about to what extent individuals who became confused through minority influence exhibit public behavior accordingly. Even though “minority members hope that the changed private belief will lead to a change in public behavior that coincides with the private belief” (p.580), publicly holding minority’s position is difficult since it requires moving from a comfortable majority’s zone to an un-normative, generally unacceptable minority’s spot, as stated in Encyclopedia of Social Psychology [26].

$$\text{ConfToMin} = \text{Number of Confused} \times \text{ConfToMin Fraction} \quad (5.35)$$

ConfToMin Fraction

= Effect of Perceived Pressure Balance of Confused on ConfToMin Fraction  
 × MAX ConfToMin Fraction

$$(5.36)$$

Effect of Perceived Pressure Balance of Confused on ConfToMin Fraction

=  $f$  (Perceived Pressure Balance of Confused about ConfToMin)

$$(5.37)$$

where  $f$  (*Perceived Pressure Balance of Confused about ConfToMin*) is defined as in Figure 5.4.

Pressure Balance of Confused about ConfToMin

= Minority's Persuasive Pressure

/ (Minority's Persuasive Pressure

+ (2/3)

× ((1/2) × Majority's Persuasive Pressure + (1/2)

× Majority's Supportive Pressure) + (1/3) × Majority's RP Pressure))

$$(5.38)$$

As it can be seen in Equation 5.38, majority's influence pressure consists of both majority's persuasive pressure and supportive pressure. This is peculiar to confused people since their attitudes are not dichotomous<sup>5</sup>. Even though all people in other stocks have two-state attitude structure, majority's or minority's opinion, confused people have continuous attitude structure. In other words, their opinions vary in a continuum between opinions of majority and minority rather than having one of the two categories.

---

<sup>5</sup> More explanation can be found in Section 5.

Indeed, the conceptually comparable stock for confused is compliant in the sense that they both have inconsistency between their behavior and attitude. However, there is not much in the literature about the stages in minority influence processes whereas there is a vast number of research publications in the literature for compliance due to the tradition of one-sided majority influence on minorities. As a result, attitude of compliant is regarded as like minority depending on literature; thus, minority's pressure on compliant is always calculated using minority's supportive impact. On the other hand, majority's pressure on confused is calculated by averaging majority's supportive and persuasive impact, since their opinion is identical to neither majority's nor minority's. In the following section, Equation 5.42 demonstrates the same peculiarity described here for the other outflow of confused.

### 5.3.3. From Confused to Majority

The persons in confused stock act like majority; but, their opinions correspond to neither pure majority nor pure minority. Since they have behavior-discrepant attitude, they can reduce dissonance through either changing their behavior to make it consonant with their attitude, or changing their attitude to align it with their behavior. The flow from confused to majority corresponds to the latter.

$$\text{ConfToMaj} = \text{Number of Confused} \times \text{ConfToMaj Fraction} \quad (5.39)$$

ConfToMaj Fraction

= Effect of Perceived Pressure Balance of Confused on ConfToMaj Fraction

× MAX ConfToMaj Fraction

(5.40)

Effect of Perceived Pressure Balance of Confused on ConfToMaj Fraction

=  $f$  (Perceived Pressure Balance of Confused about ConfToMaj)

(5.41)

where  $f$  (*Perceived Pressure Balance of Confused about ConfToMaj*) is defined as in Figure 5.4.

Pressure Balance of Confused about ConfToMaj

$$\begin{aligned}
 &= \left( (1/2) \times \text{Majority's Persuasive Pressure} + (1/2) \right. \\
 &\quad \left. \times \text{Majority's Supportive Pressure} \right) \\
 &/ \left( \left( (1/2) \times \text{Majority's Persuasive Pressure} + (1/2) \right. \right. \\
 &\quad \left. \left. \times \text{Majority's Supportive Pressure} \right) + \text{Minority's Persuasive Pressure} \right) \\
 & \hspace{15em} (5.42)
 \end{aligned}$$

The explanation about minority's pressure on confused given for Equation 5.38 is also valid for Equation 5.42. The only difference between them is that majority's RP pressure is taken into consideration for ConfToMin but not considered for ConfToMaj since the latter is about private opinion change.

#### 5.4. Antagonism

Antagonism levels toward out-group are modeled as information delays. The delay formulations are symmetrical for majority and minority; thus, here given only for minority in Equation 5.43. Perception delay of individuals is taken 2 weeks while antagonism increases, and 36 weeks while antagonism decreases. This significant difference between two values depends on commonsense reasoning that it is very difficult to calm down when out-group hostility is formed once. For the generic case of this thesis, i.e. constituting an out-group from an in-group, antagonism comes with categorizing the people who were in the same camp before, as a different group.

The inputs (goals) of antagonism levels are implied antagonisms which are determined by different variables for each social group. Those variables will be explained in the following sections.

Minority's Antagonism(t) = Minority's Antagonism(0) +

IF (Minority's Implied Antagonism > Minority's Antagonism)

$$\int_0^t ((\text{Minority's Implied Antagonism} - \text{Minority's Antagonism}) \\ / \text{Time to Adjust Perception of Minority when Antagonism increases}) \\ \times dt$$

ELSE

$$\int_0^t ((\text{Minority's Implied Antagonism} - \text{Minority's Antagonism}) \\ / \text{Time to Adjust Perception of Minority when Antagonism decreases}) \\ \times dt$$

(5.43)

where Minority's Antagonism (0) is determined according to different scenarios. In the base run, initial levels of minority's and majority's antagonism are 30, and 40 respectively.

#### 5.4.1. Majority's Antagonism

Majority's implied antagonism is determined by two variables<sup>6</sup>: minority's antagonism and minority's number. Both minority's antagonism and minority's number have positive effects on majority's implied antagonism.

Majority's Implied Antagonism

$$= \text{Max Antagonism Level} \\ \times ((1/3) \times \text{Minority's Antagonism} + (2/3) \\ \times \text{Effect of Minority's Number on Majority's Implied Antagonism})$$

(5.44)

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<sup>6</sup> More explanation can be found in Section 4.2.



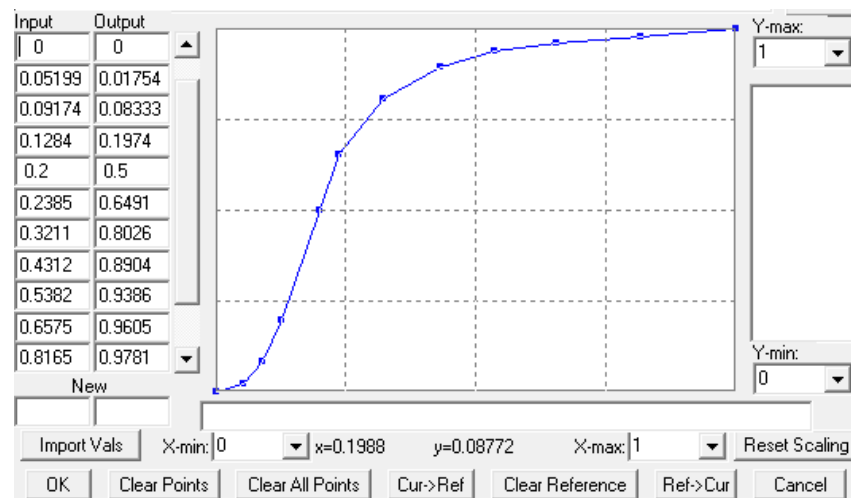


Figure 5.7. Graphical function for Effect of Minority's Number on Majority's Implied Antagonism.

Effect of Minority's Number on Majority's Implied Antagonism

$$= f\left(\frac{\text{Number of Minority} / \text{Total Number of People}}{\text{MAX ratio}}\right) \quad (5.45)$$

where  $f$  is defined as in Figure 5.7.

$MAX\ ratio=0.5$  It means that maximum possible number of people in minority group cannot be greater than half of the population in this closed model. If it happens the other way around, minority starts to numerically dominate majority; and in turn, the model structure loses its validity.

Majority's antagonism affect three variables: majority's RP pressure, average immediacy in majority (in-group immediacy), and majority's immediacy toward minority (out-group immediacy).

Majority's RP Pressure

$$= \text{Effect of Majority's Antagonism on Majority's RP Pressure} \\ \times \text{MAX Utilized RP} \times (\text{Number of Majority} / \text{Total Number of People})^t \quad (5.46)$$

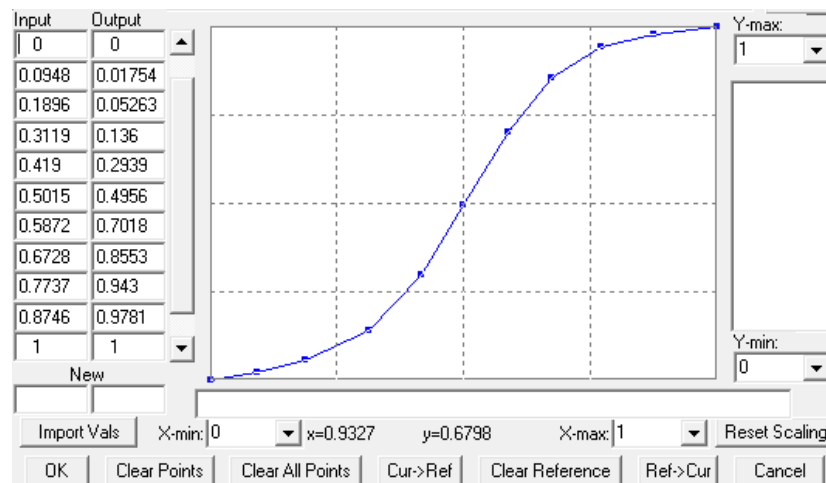


Figure 5.8. Graphical function for Effect of Majority's Antagonism on Majority's RP Pressure.

Effect of Majority's Antagonism on Majority's RP Pressure

$$= f\left(\frac{\text{Majority's Antagonism}}{\text{Max Antagonism Level}}\right)$$

(5.47)

where  $f$  is defined as in Figure 5.8.

Average immediacy in majority (in-group immediacy) and majority's immediacy toward minority (out-group immediacy) are also affected by majority's antagonism. Those relations are explained in the descriptions of majority's impacts formulations (see Section 5.1.1.1).

#### 5.4.2. Minority's Antagonism

Minority's implied antagonism is determined by three variables<sup>7</sup>: Majority's antagonism, RP, and minority's number. Majority's antagonism and RP have positive effects on minority's antagonism whereas number of minority has a negative influence on it.

<sup>7</sup> More explanation can be found in Section 4.2.

Minority's Implied Antagonism

$$\begin{aligned}
 &= \text{Max Antagonism Level} \\
 &\times ((0.15) \times \text{Majority's Antagonism} + (0.25) \\
 &\times \text{Effect of Majority's RP Pressure on Minority's Implied Antagonism} \\
 &+ (0.6) \\
 &\times \text{Effect of Minority's Number on Minority's Implied Antagonism})
 \end{aligned}
 \tag{5.48}$$

Effect of Majority's RP Pressure on Minority's Implied Antagonism

$$= f(\text{Majority's RP Pressure}/\text{MAX Utilized RP})
 \tag{5.49}$$

where  $f$  is defined as in Figure 5.9.

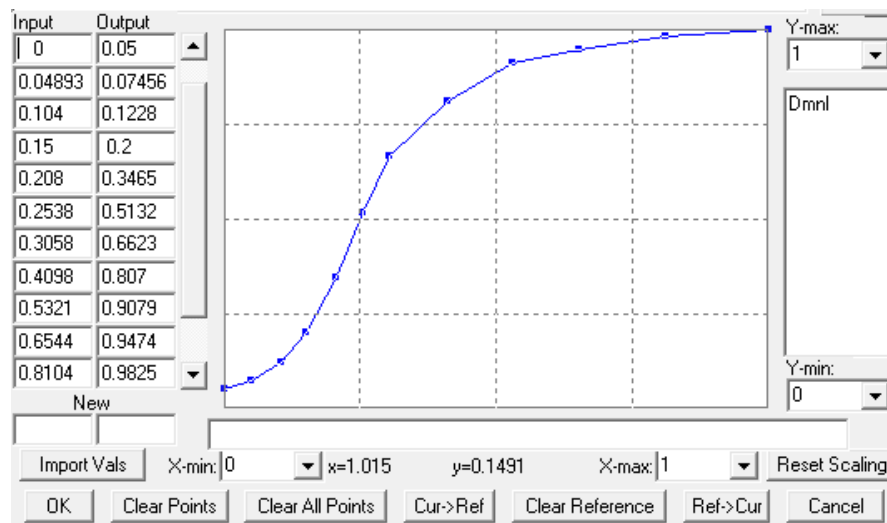


Figure 5.9. Graphical function for Effect of Majority's RP Pressure on Minority's Implied Antagonism.

Effect of Minority's Number on Minority's Implied Antagonism

$$= f((\text{Number of Minority}/\text{Total Number of People})/\text{MAX ratio})
 \tag{5.50}$$

where  $f$  is defined as in Figure 5.10.

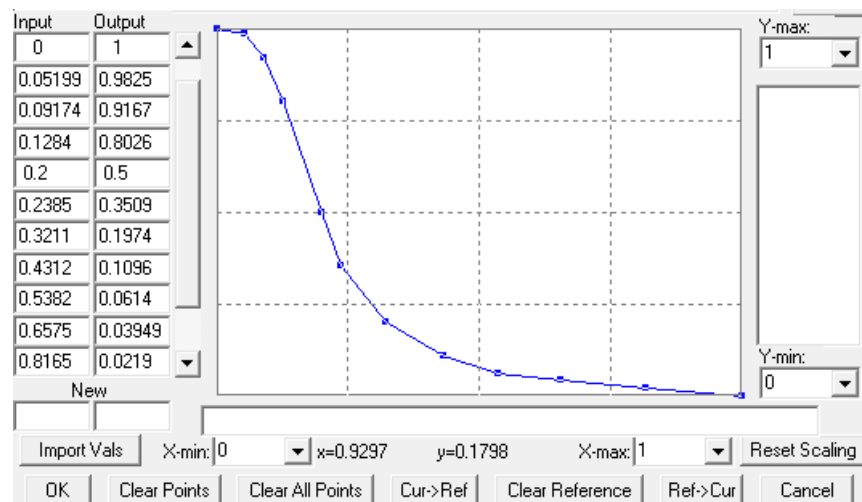


Figure 5.10. Graphical function for Effect of Minority's Number on Minority's Implied Antagonism.

Minority's antagonism affects three variables: average immediacy in minority (in-group immediacy), minority's immediacy toward majority (out-group immediacy), and minority's reactance. First two relations are similar to majority's which are explained in the descriptions of impacts formulations (see Section 5.1.1.1). The last one is described in the formulations of MinToComp flow (see Section 5.2.1).

The model consists of other minor variables and equations of more trivial nature that are not explicitly discussed in this chapter. See all model equations listed in Appendix A.

## **6. VALIDATION AND ANALYSIS OF THE MODEL**

### **6.1. Structural Credibility**

Structural validity of the model is the primary necessity for system dynamics models. It is about whether the model's internal structure is an adequate, acceptable description of the real system structure with respect to the research objective [30]. Since endogenous relations in the structure causes model behavior, structural credibility must be established before behavioral credibility [30]. Indeed, it is not a distinct process from model building. In this thesis, every relation in the model is constructed through intense qualitative logical tests of related literature. Equations correspond to real life processes, and every parameter has a real life counterpart. Finally, there is dimensional consistency in all equations, as it can be seen from model equations in Appendix A. Note that the variables of which units are not specified are dimensionless.

### **6.2. Structure Oriented Behavior Tests**

Structure oriented behavior tests are indirect structure tests about the robustness of the model. An important kind of these tests is known as extreme condition tests which involve simulations of the model under extreme conditions to see whether the model valid in the extreme. Those special simulations can be applied to the whole model. Many extreme condition tests are applied to the model and the model responded credibly in all cases. Here, two important tests will be demonstrated as illustrations.

First extreme condition test is about the model behavior under the extreme situation in which there is no majority. The expected result is that all people in the model gather in minority stock because all pressure values of majority are zero. The model produces the corresponding behavior in Figures 6.1 and 6.2.

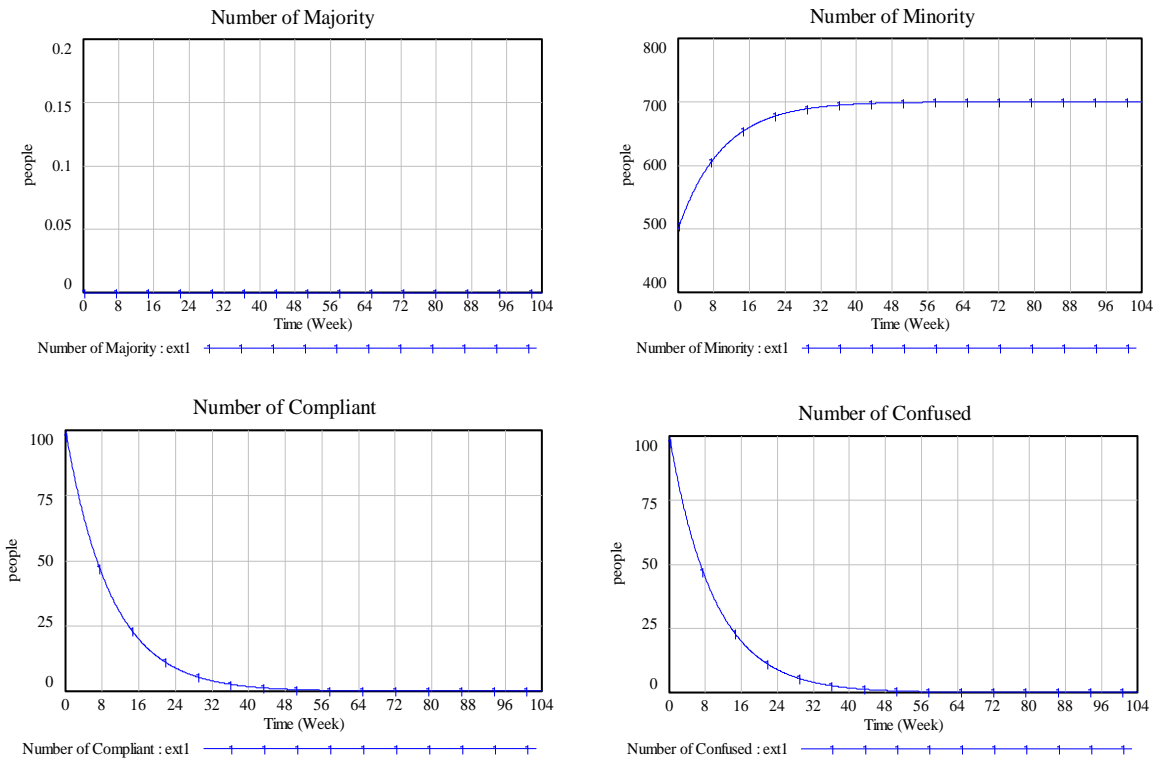


Figure 6.1. Major stocks in the first extreme condition.

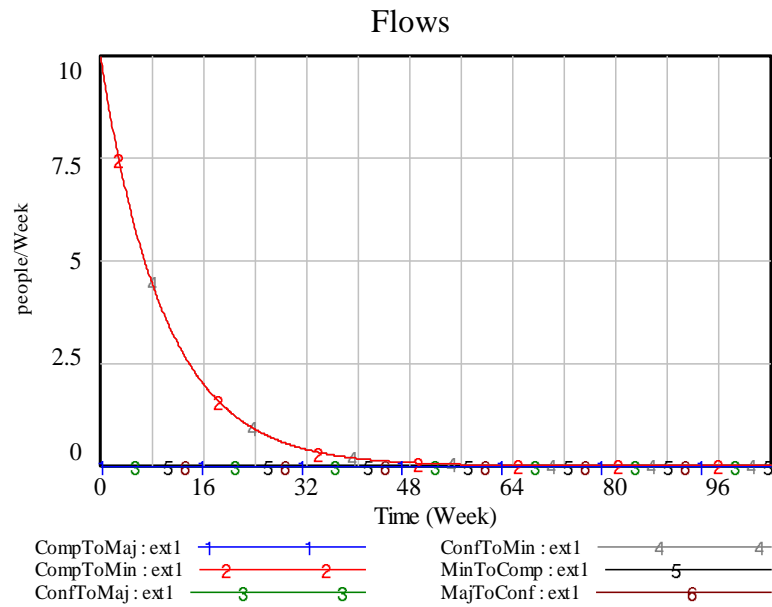


Figure 6.2. Flows between the major stocks in the first extreme condition.

Second extreme condition test is about the model behavior under the extreme situation in which there is no minority. The expected result is that all people in the model gather in majority stock because all pressure values of minority are zero. The model produces the corresponding behavior in Figures 6.3 and 6.4.

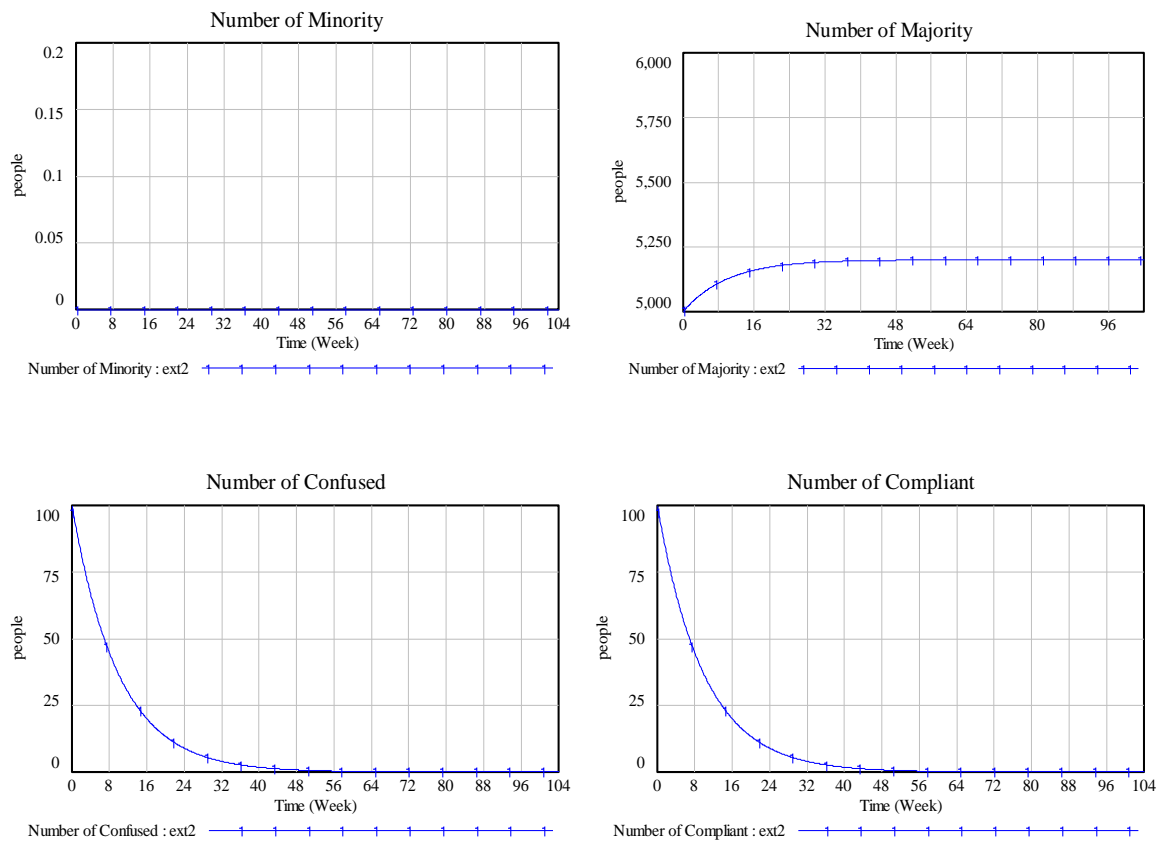


Figure 6.3. Major stocks in the second extreme condition.

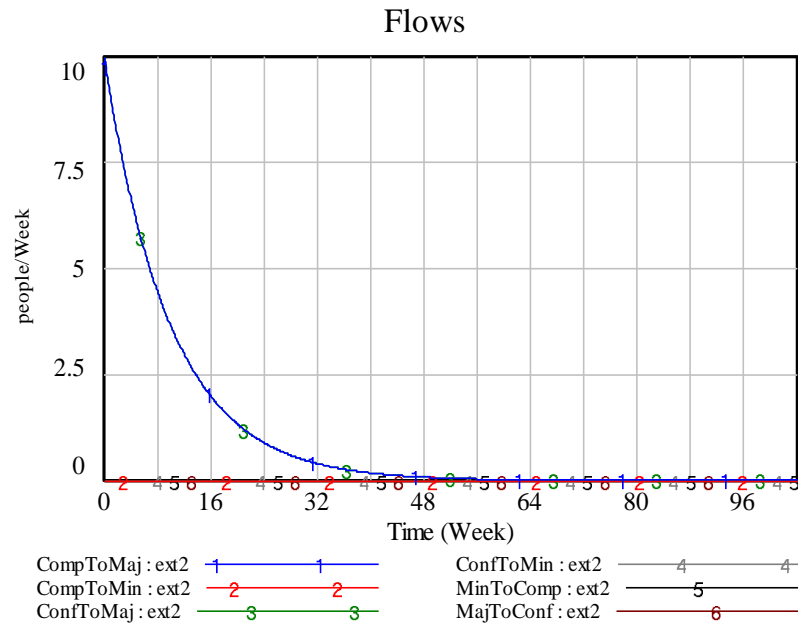


Figure 6.4. Flows between the major stocks in the second extreme condition.

### 6.3. Base Behaviors and Behavior Validation

As highlighted before, this simulation model aims to represent qualitative patterns of attitude, behavior, and social group change under the social influences of majority and minority groups. Andrzej Nowak [17], one of the pioneers of dynamical social psychology, states “reproduc[ing] and predict[ing] empirical data quantitatively [...] is too ambitious for social psychology; it is more reasonable to look for qualitative agreement and qualitative understanding.” (p.285) In parallel with this, accepting the difficulty of using empirical datasets in social psychology in dynamical systems methods, behavioral validation of the model is provided through the fundamental qualitative understandings in the literature of social influence and intergroup relations.

For the base run, the values of all parameters<sup>8</sup>, coefficients in equations, and initial values in the model are given in Table 6.1 and 6.2. Note that the variables of which units are not specified are dimensionless. Strength and antagonism values (soft variables) are between 0 and 100. The value of  $t$  is taken from the literature (see Equation 5.1). Max flow

<sup>8</sup> Perception delay times can be found in Table 5.1.



fraction is used as 0.1. The other coefficients in Table 6.2 are determined by logically thinking about the importance of each effect on the related variables.

Table 6.1. Parameters and their values in the base run.

<b>Parameters</b>	
Avg Strength of Majority	50
Avg Strength of Minority	50
Initial Number of Majority	5000 (people)
Initial Number of Minority	500 (people)
Initial Number of Compliant	100 (people)
Initial Number of Confused	100 (people)
Initial Antagonism of Majority	40
Initial Antagonism of Minority	30
max flow fraction	0.1 (1/week)
t exponent	0.5

Table 6.2. Coefficients in main equations and their values in the base run.

<b>Coefficients in Equations</b>		
coefficients in the equation of Majority's Antagonism	Minority's Number effect	0.66
	Minority's Antagonism effect	0.33
coefficients in the equation of Minority's Antagonism	Minority's Number effect	0.6
	Majority's Antagonism effect	0.15
	Majority's RP Pressure effect	0.25
coefficients in the equations of Majority's Pressure on behavioral change	Majority's RP Pressure effect	0.33
	Majority's Impact Pressure effect	0.66
coefficients in the equations of Majority's Pressure on Confused	Majority's Persuasive Supportive effect	0.5
	Majority's Persuasive Pressure effect	0.5

Base run depicts the situation where majority absorbs all people in the model. Even though minority group can slightly increase the number of confused people, minority's social pressure is not enough to convert some of them. This result is expected in such a base run that average strength of minority is equal to majority's. Since majority has both the numerical advantage and the power to reward or punish, it is not likely for minority to increase its number or preserve in a non-zero level without higher strength differences from majority.

This result is in parallel with what many scholars argue regarding minority influence. Emphasizing the asymmetry between majority and minority influence, Moscovici [7] states the difficulty to “change behaviors and judgments in the public sphere” (p.216) in the face of minority influence. Regarding the rareness of overtly holding minority's opinion, Saul Kassin and his associates [31] claim “It's no wonder that most people think twice before expressing unpopular positions.” (p.264) In the presence of majority's pressure - created by social influence or reward-or-punishment (RP) – on individuals who publicly behave like minority, aligning one's behavior with her unpopular attitude necessitates extra social support, or supportive impact.

It is important to emphasize that these behaviors are not obtained by constructing the model taking into account this specific knowledge about minority influence. To be more precise, any variable that makes ConfToMin rare is not added to the model. Instead, same max flow coefficient is used for all flows to see whether flows properly operate by itself according to literature. If attitude or behavior, and social group changes take place as expected with the same max flow fraction value, this means that the structure of the model endogenously reproduces the flow fractions through perceived pressure balance calculations, which enhances the behavioral validity of the model.

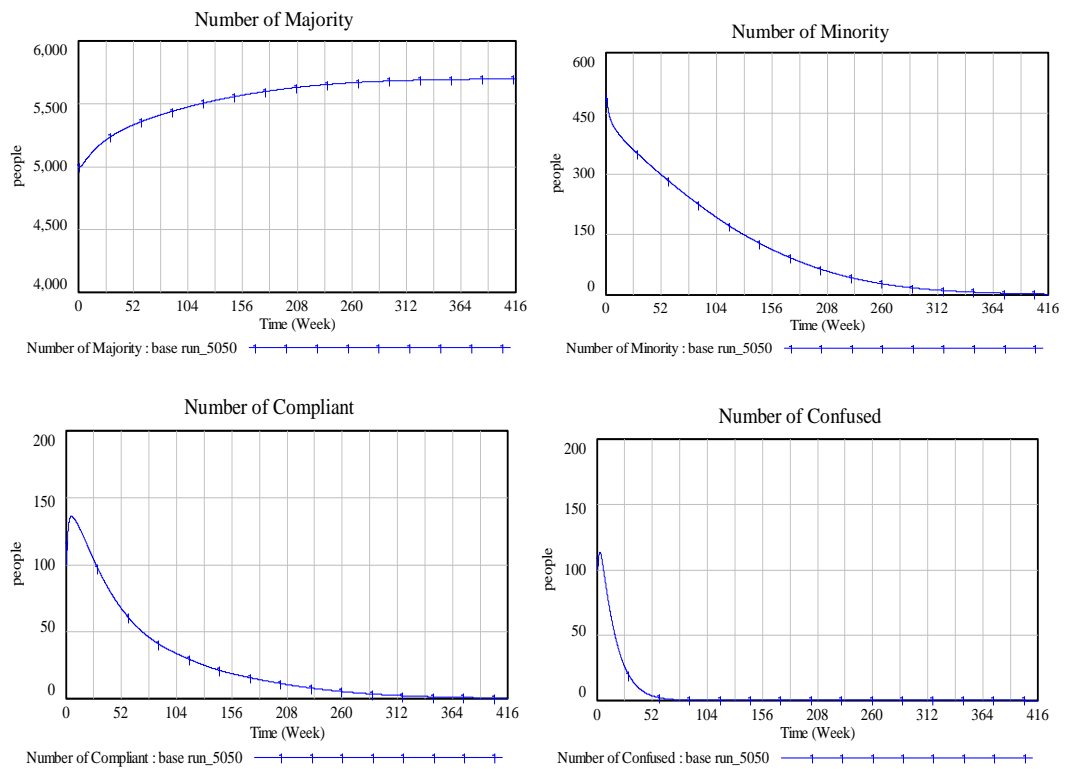


Figure 6.5. Model behavior of major stocks in the base run.

As it can be seen in Figure 6.6, the fractions of the flows in the direction of majority to minority are zero, except for the slight value of MajToConf fraction in the very beginning of the run. The fractions of flows related to publicly adopting minority's position, i.e. ConfToMin and CompToMin, are utterly zero, as expected. On the other hand, the fractions of flows in the direction of minority to majority are positive and converges max flow coefficient (0.1 in the base run) since the effect of minority's social pressures in the pressure balance calculation, and thus on the flow fractions, goes to zero as minority goes to extinct. There is no specific literature related to the easiness of these three flows. However, the output behavior created by the structure of the model is reasonable. The dynamic behavior of the MinToComp fraction is below than the other two since it involves behavior change. Both ConfToMaj and CompToMaj represent attitude change. Nevertheless, confused persons thought like majority for a period, even if they are confused by minority now. Therefore, it is plausible to observe ConfToMaj fraction above than the other two.

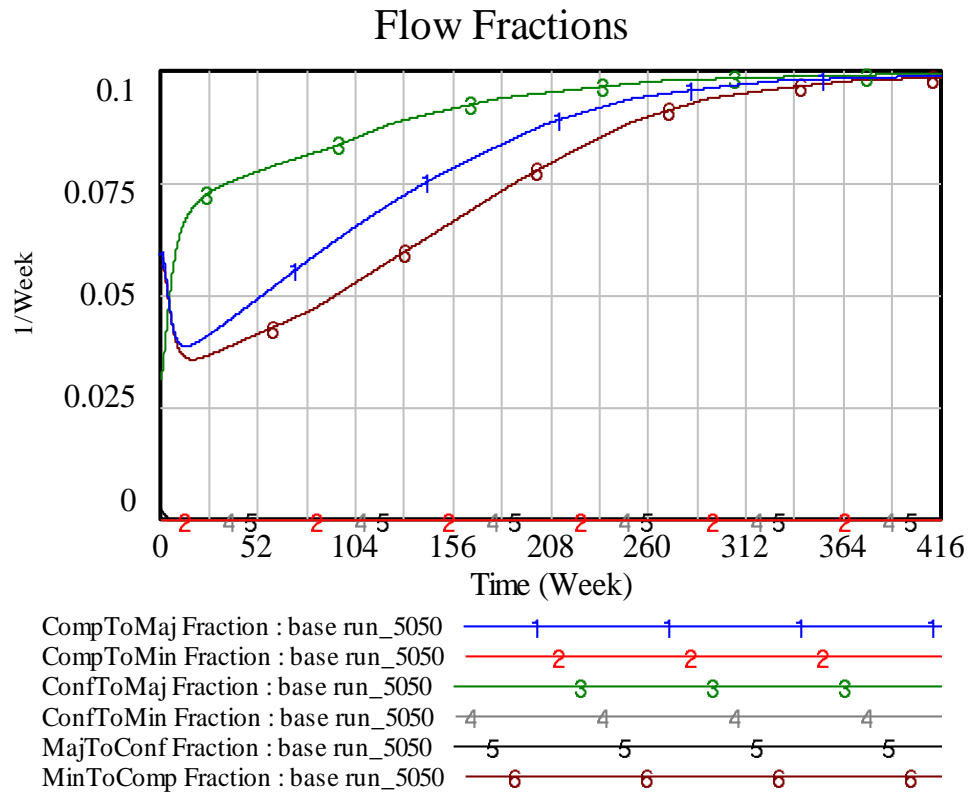


Figure 6.6. Dynamics of flow fractions in the base run.

In order to reinforce validity of the model and to have a benchmark for different strength values, the below runs are plotted. Keeping all other variables equal, strength values are changed. From now on, in the figures depicting output behaviors, numbers in the titles of runs (e.g. 5070) refer to two strength values. First two digits are for majority's strength (e.g. 50) whereas the rest refer to minority's (e.g. 70). As it can be seen in Figure 6.7, minority can increase its number and sustain it with higher strength differences from majority, as in the run 5095.

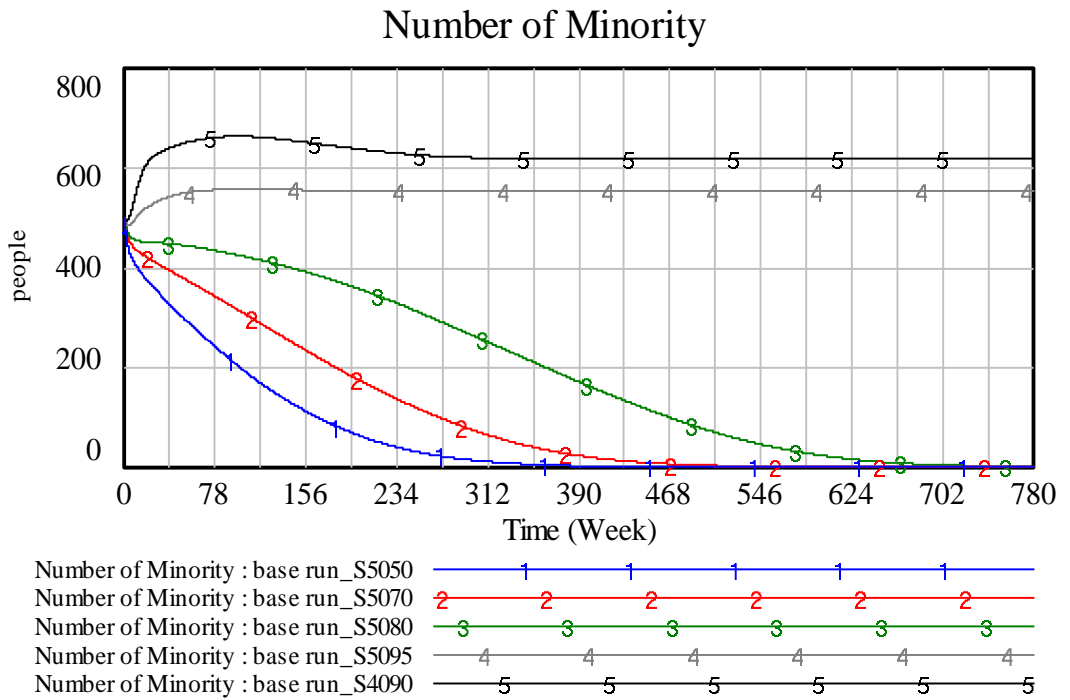


Figure 6.7. Minority's numbers with different strength values.

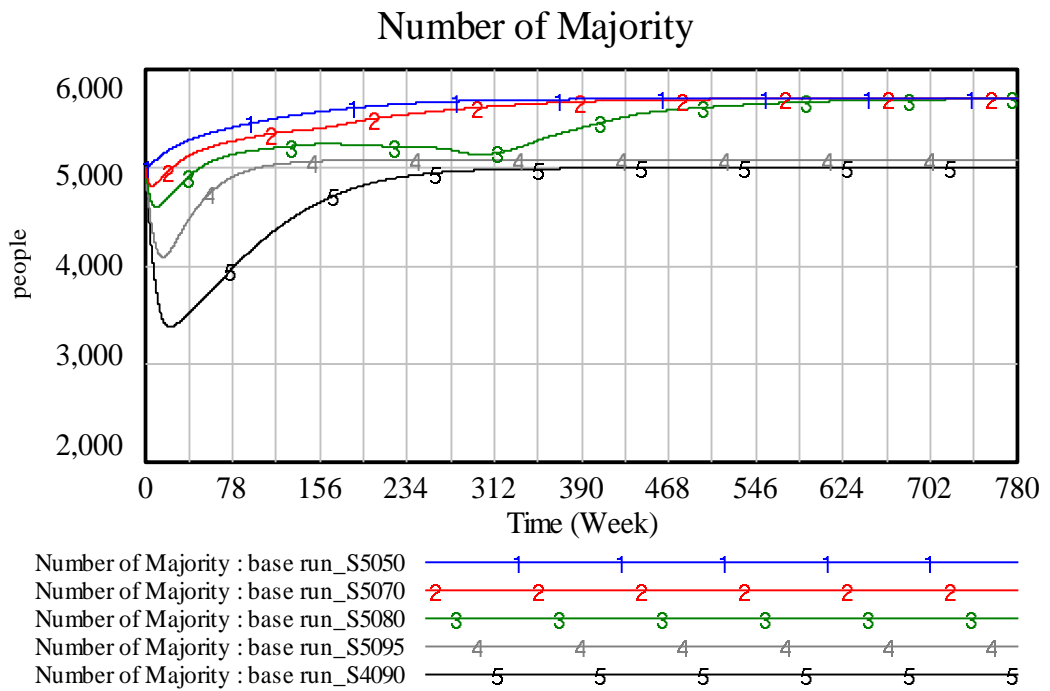


Figure 6.8. Majority's numbers with different strength values.

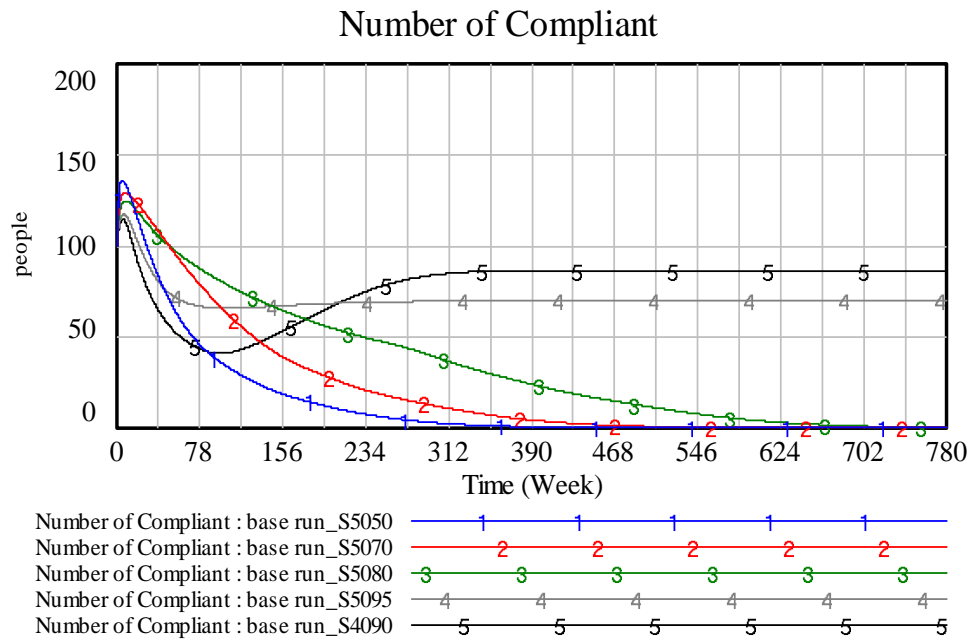


Figure 6.9. Compliant's numbers with different strength values.

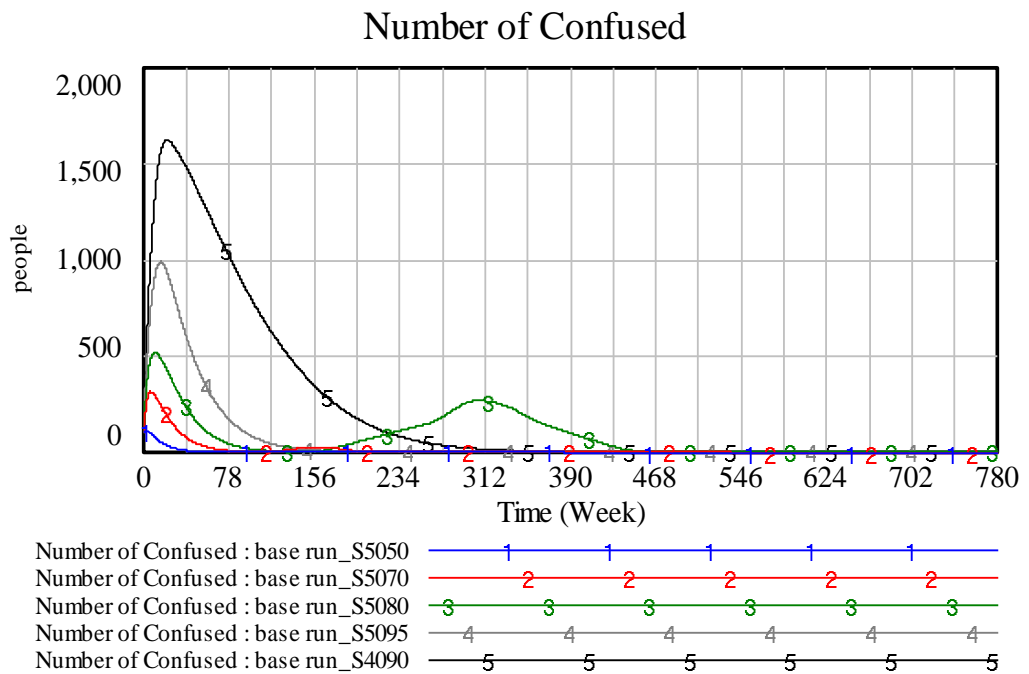


Figure 6.10. Confused's numbers with different strength values.

## 7. SENSITIVITY ANALYSIS

### 7.1. Weight of Different Impacts in Calculations of Majority's Pressure on Confused

As it can be seen from Table 6.2, confused people are equally affected by majority's persuasive and supportive pressures in the base run. In these sensitivity runs, Conf\_0.66 refers the situation which confused persons are influenced by majority's supportive and persuasive pressures by the weight of 0.66 and 0.33 respectively. Conf\_1 refers the situation which confused persons are only influenced by majority's supportive pressure. Figures 7.1, 7.2, 7.3, and 7.4 demonstrate that even if there are slight differences for high strength values of minority (95) – the runs marked by the numbers of 4, 5, and 6 – in general, the effect of changes in weights of majority's supportive and persuasive pressures on confused are low on the model behavior.

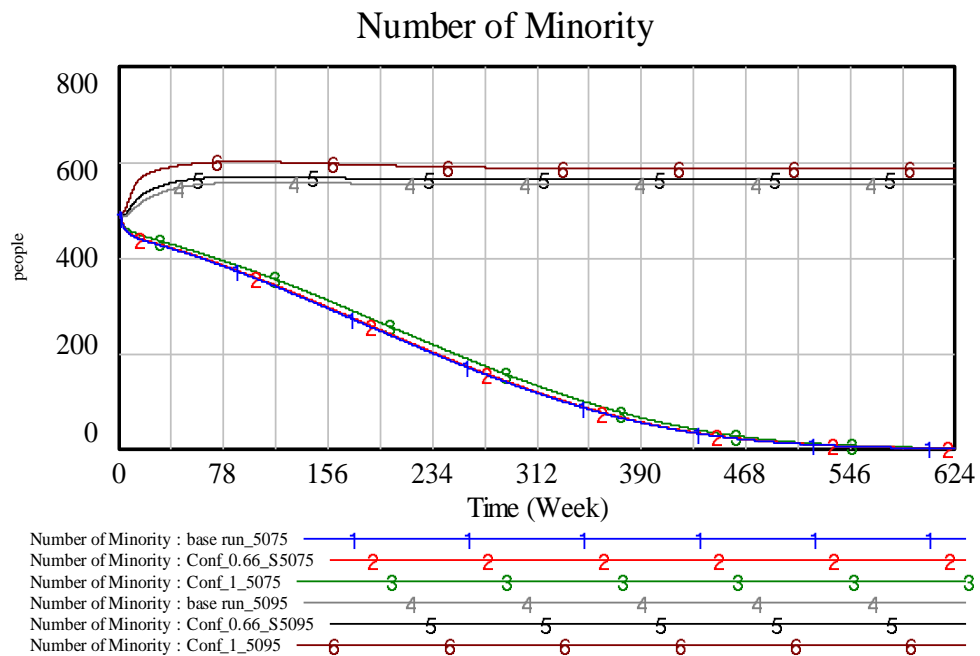


Figure 7.1. Minority's number with different strength values and related weights.

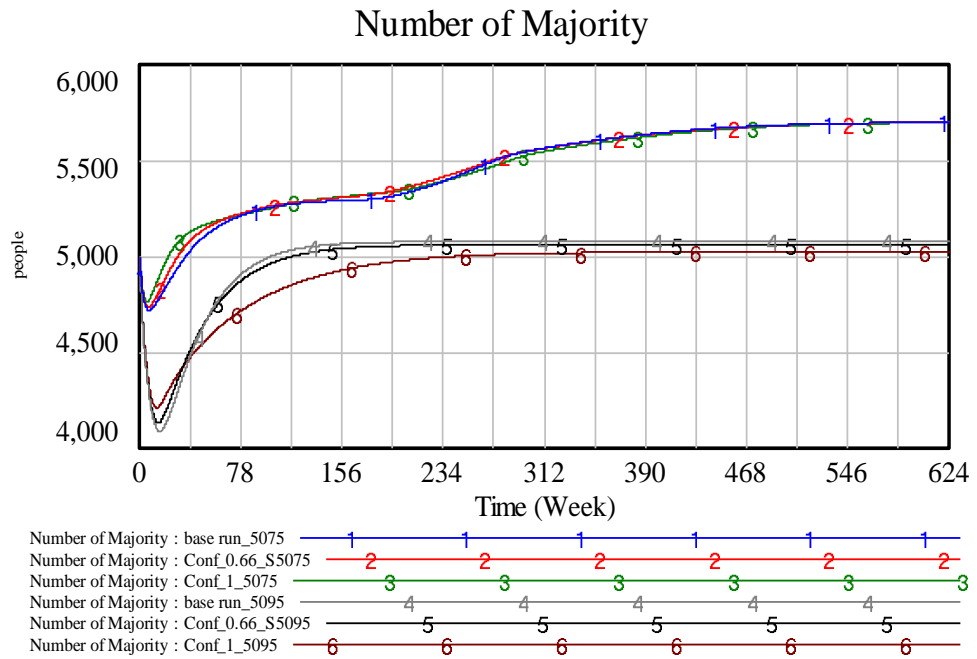


Figure 7.2. Majority's number with different strength values and related weights.

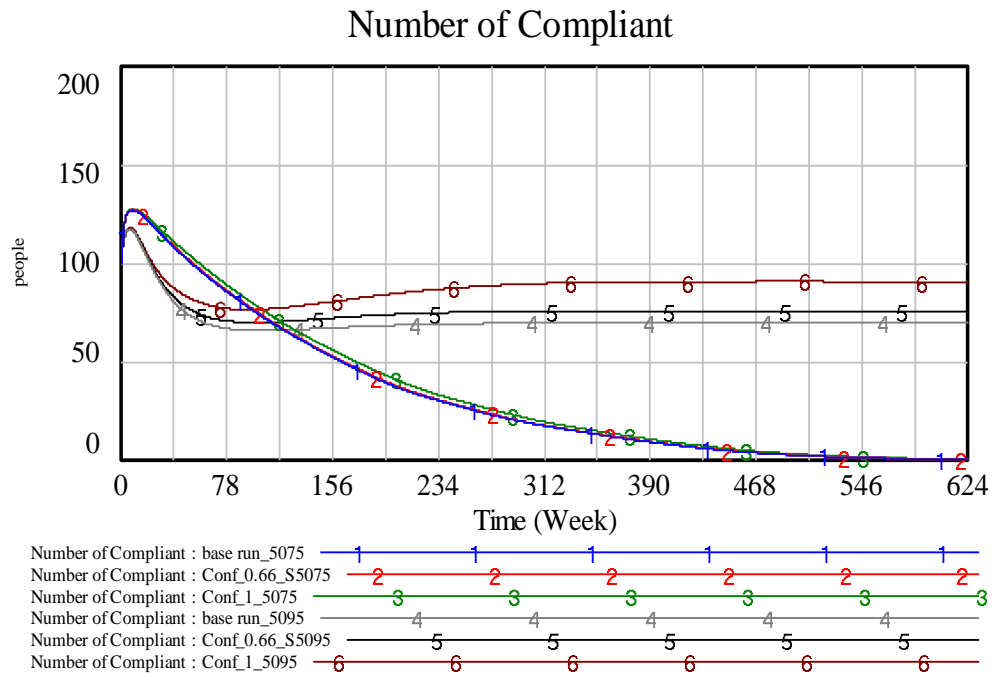


Figure 7.3. Compliant's number with different strength values and related weights.



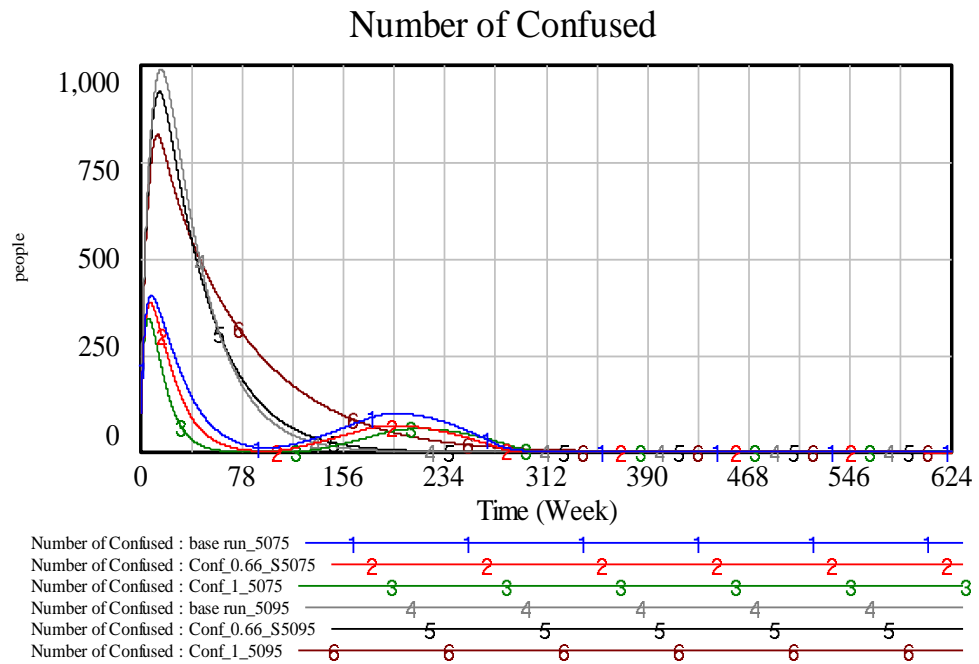


Figure 7.4. Confused’s number with different strength values and related weights.

### 7.2. Sensitivity Runs with the Exponent $t$

Even though Latane [11] states “empirical studies have shown it [exponent  $t$ ] to vary around an average of approximately .5” (p.364), sensitivity analysis is conducted for the exponent  $t$ . As it can be seen from Figure 7.5, when  $t$  takes 0.25, for some strength values the dynamics of minority’s number start to cycle. Even though the amplitude and period slightly change, a similar limit cycle for different strength values are obtained when  $t$  takes a value of 0.33 (see Figure 7.6). Indeed, this behavior that model creates is not unique to certain  $t$  values since almost all runs that are depicted have similar patterns, which can be squeezed between some values of parameters. As it can be seen in Figure 7.7, base run also has the same pattern of behavior with higher amplitudes and periods. These results, i.e. that equilibria are not produced “by any particular state but, rather, by the pattern of changes between states” (p.740), are parallel with what Vallacher and Nowak [32] propose in the field of dynamical social psychology: Social interactions can be characterized by *periodic* or *limit-cycle* attractors depending on initial conditions, or parameter values (see Beek & Hopkins, 1992; Gottman, 1979; Nezlek, 1993 cited in [32]).

To illustrate some of the different behavior types that model produce, Figure 7.8 (with  $t=0.1$ ) can be analyzed. Among different behaviors, two of them (5026 and 5027) are salient in the sense that they reach non-zero equilibriums. Flow and net flow dynamics of the model (Figure 7.9 and Figure 7.10) are given for the case of 5027.

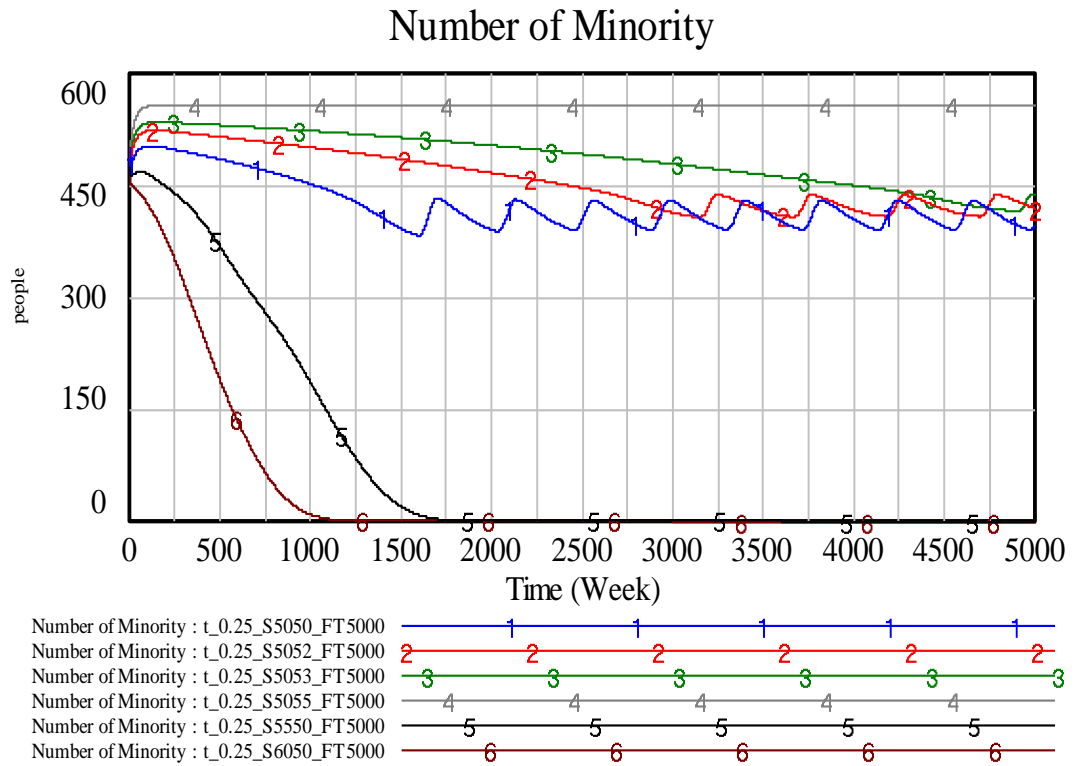


Figure 7.5. Minority's number with different strength values when  $t=0.25$ .

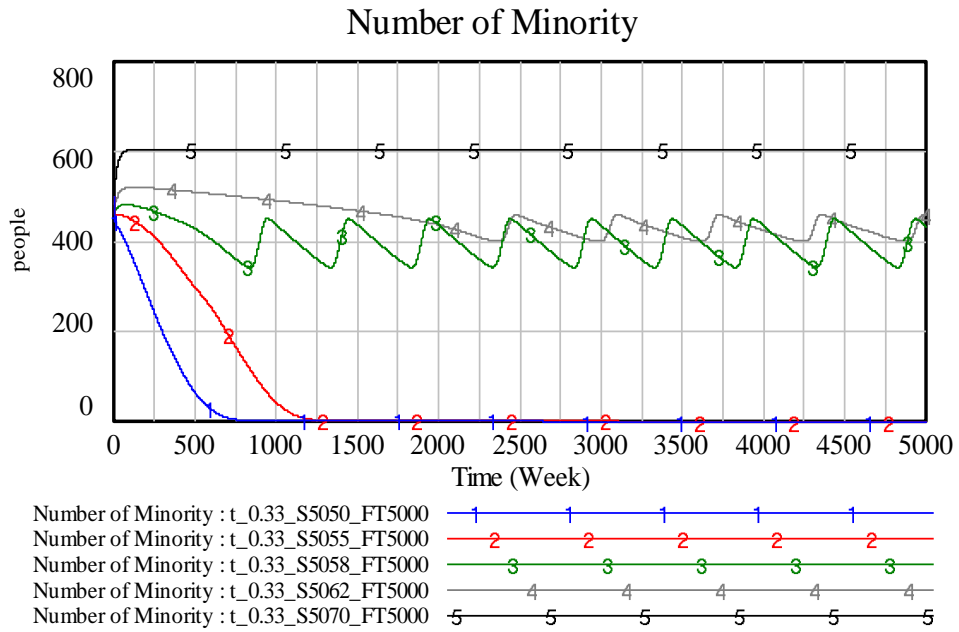


Figure 7.6. Minority's number with different strength values when  $t=0.33$ .

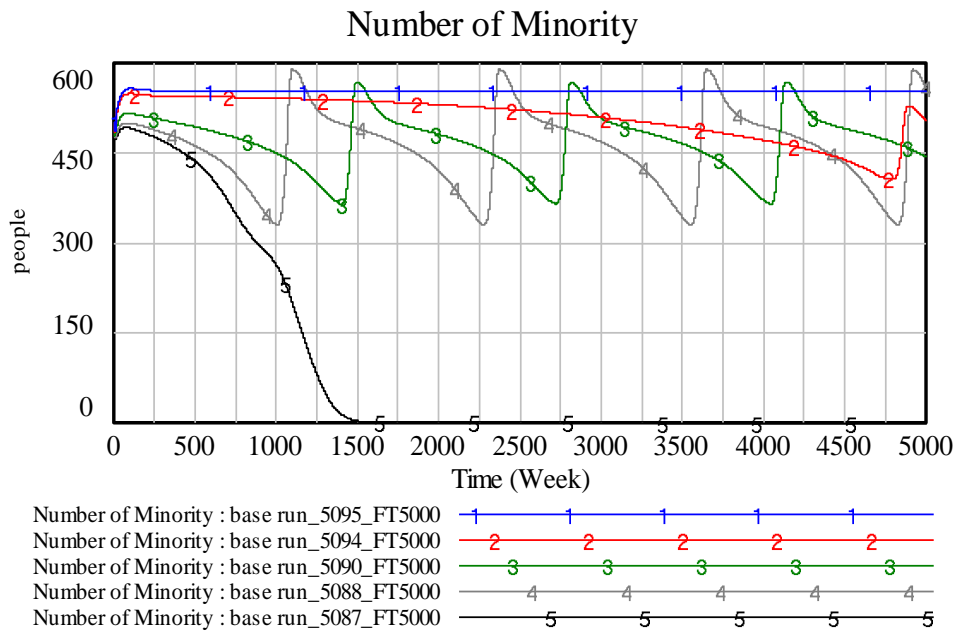


Figure 7.7. Minority's number with different strength values when  $t=0.5$  (base run).

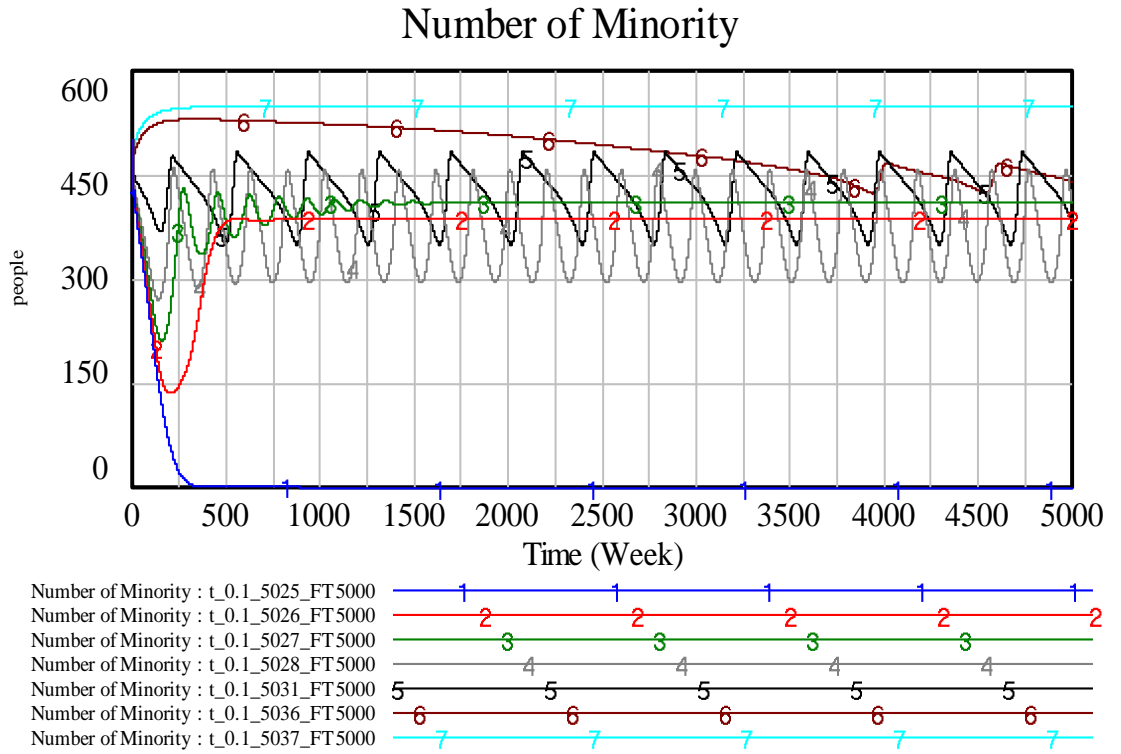


Figure 7.8. Minority's number with different strength values when t=0.1.

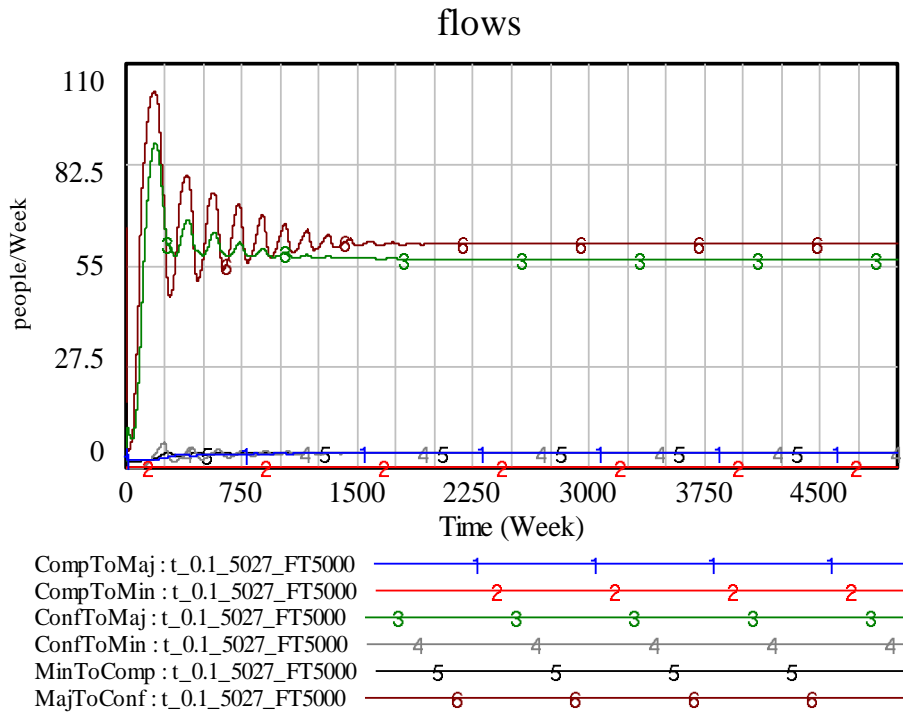


Figure 7.9. Dynamics of flows for the specific strength value of 27 when t=0.1.

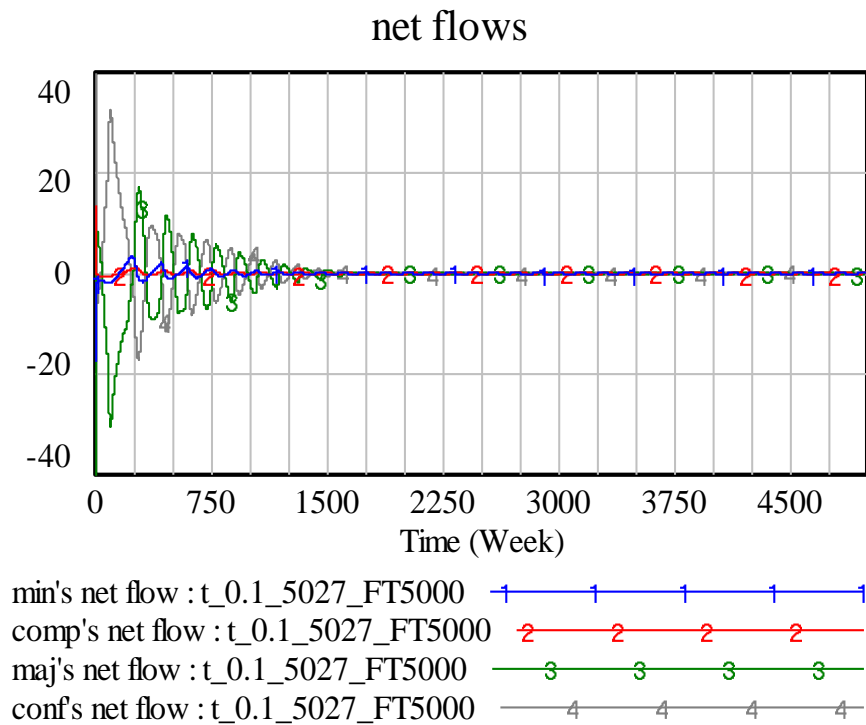


Figure 7.10. Net flows for the specific strength value of 27 when  $t=0.1$ .

### 7.3. Sensitivity Analysis with Max Flow Coefficient

From Figure 7.11 and Figure 7.12, comparisons of model outputs with different max flow coefficients can be conducted. In the base run, max flow coefficient is taken as 0.1 (1/week). For different strength values, Figure 7.11 compares base run and the sensitivity run when max flow coefficient is 0.05 whereas Figure 7.12 compares base run and the sensitivity run when max flow coefficient is 0.2. Analyzing these behaviors, one can simply argue that the amplitude of limit cycle and the starting point of it change when max flow coefficient takes different values.

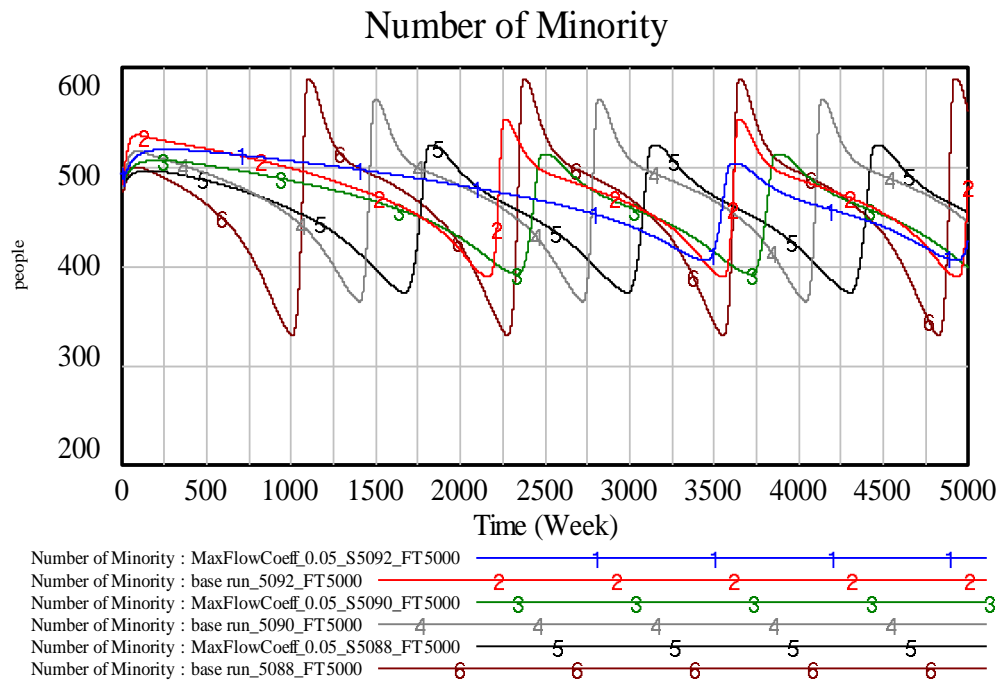


Figure 7.11. Number of minority with different strength values when max flow coefficient=0.05.

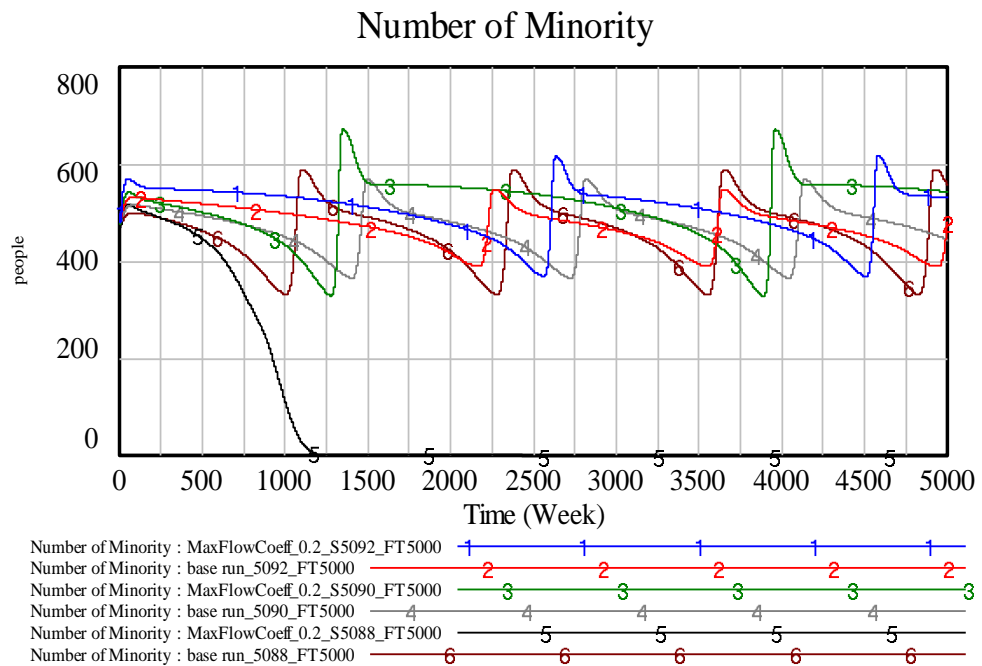


Figure 7.12. Number of minority with different strength values when max flow coefficient=0.2.

### 7.4. Antagonism Coefficients

An extensive set of sensitivity analysis runs are conducted on the weights of effects in antagonism variables. However, only two of them which give examples of different qualitative patterns for model behavior are demonstrated in below figures. The values of the weights in the base run and these sensitivity runs can be seen in Table 7.1. Starting from base run, minority's number effect is gradually decreased whereas majority's antagonism and RP pressure effect are gradually increased in run 6 and 28.

Table 7.1. Values of weights in antagonism equations for scenario analysis.

		Base	6	28
Majority's Antagonism	Minority's Number effect	0.66	0.66	0.66
	Minority's Antagonism effect	0.33	0.33	0.33
Minority's Antagonism	Minority's Number effect	0.6	0.5	0.33
	Majority's Antagonism effect	0.15	0.2	0.33
	Majority's RP Pressure effect	0.25	0.3	0.33

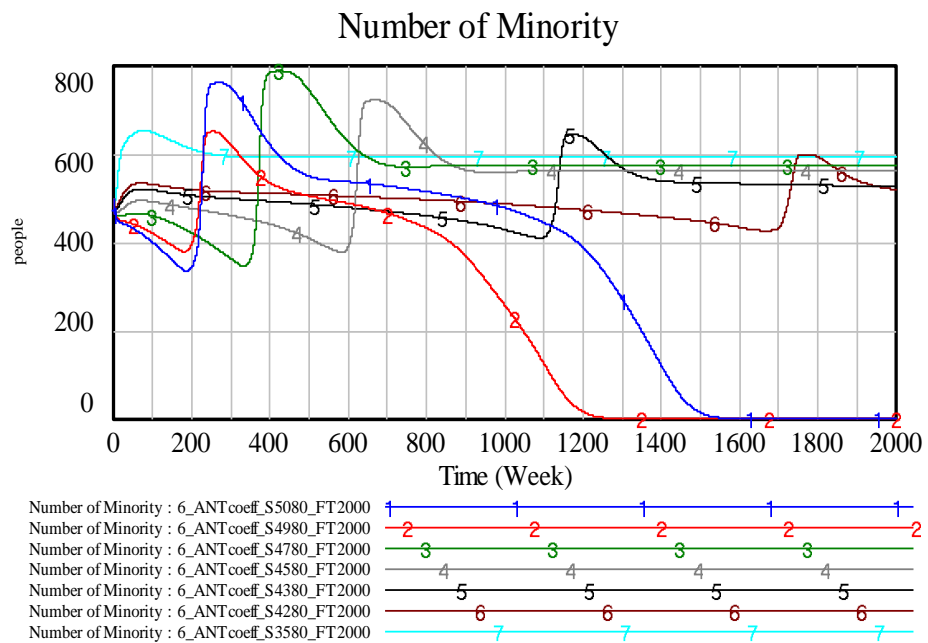


Figure 7.13. Minority's number with different strength values in run 6.

In sensitivity run 6, minority's strength is kept constant in the value of 80, and majority's strength is changed from 35 to 50. As it can be seen from Figure 7.13, minority cannot sustain its number and goes to extinct for the strength values of 50 and 49. Then minority reaches equilibrium for the lower values of majority's strength, which is intuitive. However, between the strength values of 47 and 42, minority sustains its number more easily for increasing strength values of majority, which is quite counterintuitive. These results, i.e. complex non-linear dynamics, correspond to "changing fixed-point attractors" (see Thom, 1975; Tesser & Achee, 1994; Latané & Nowak, 1994 cited in [32]). In these changes, Vallacher and Nowak [32] highlights the role of *splitting factor* of which low (high) values characterizes the system's behavior as linear (non-linear) by deciding whether the system influenced by single or two attractors (p.745). Nevertheless, these factors and attractors are not identified in this thesis since it is much harder to define them in this model than simple models in dynamical social psychology, and also it is not in the research objectives of this thesis.

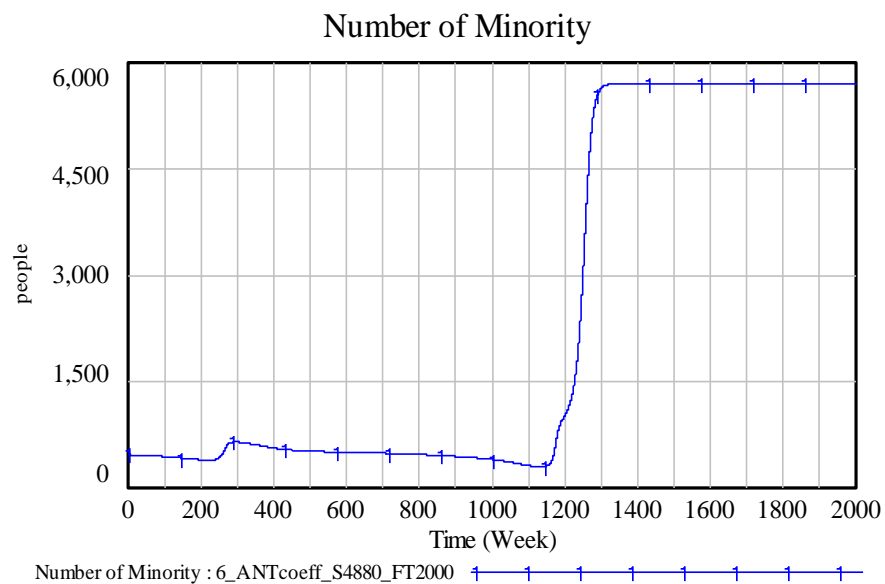


Figure 7.14. Minority's number with the strength values of 48 in run 6.

More interestingly, model produces the behavioral pattern in Figure 7.14 for the strength values of 48, which means the transition between the behaviors with strength values of 49 and 47 is also quite nonlinear and counterintuitive. To be more precise, changing the majority's strength values between 49 and 47, the model produces three



different patterns of behavior, namely minority goes to extinct, absorbs all population, and reaches a non-zero equilibrium around 600. It is important to note that output behavior in Figure 7.14 is not valid after minority gets a numerical superiority over majority. Since minority's absorbing more than half of population changes the relations between two groups, (minority becoming 'majority') this should necessitate some structural arrangement (e.g. about majority's privilege of RP usage), which makes the model invalid after this point.

In sensitivity run 28, majority's strength is kept constant in the value of 50, and minority's strength is changed from 50 to 95. Figure 7.15 depicts examples of counterintuitive behaviors in which increasing strength of minority creates a disadvantage for itself, and makes difficult for minority to reach equilibrium. Figure 7.16 demonstrates output behaviors in a longer time horizon to see their equilibriums (compare the runs with minority's strength values of 77 and 78, and 83 and 85). Figure 7.17 shows the unique strength values in which minority absorbs all population nonlinearly and counterintuitively.

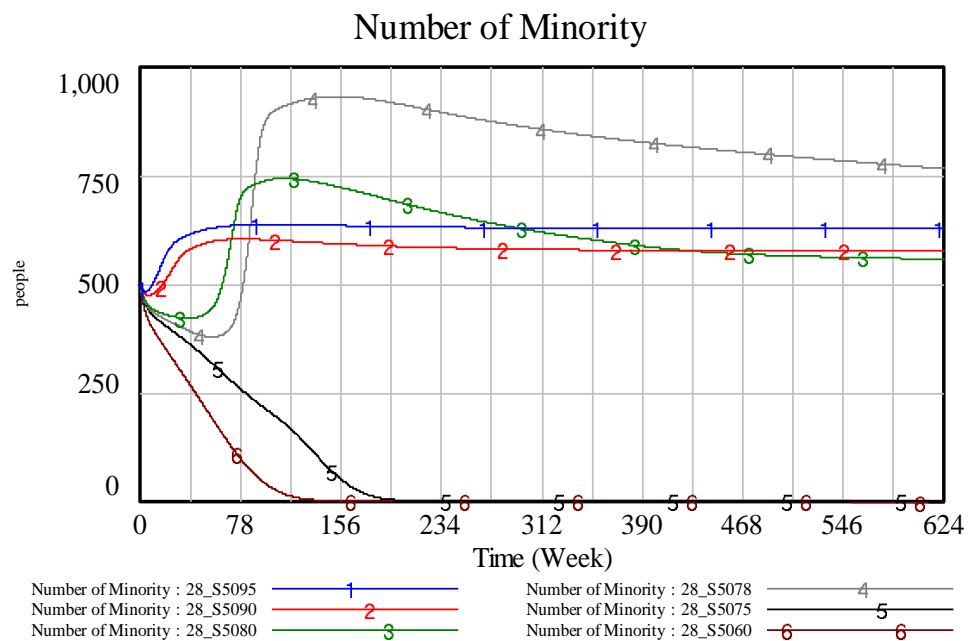


Figure 7.15. Minority's number with different strength values in run 28.

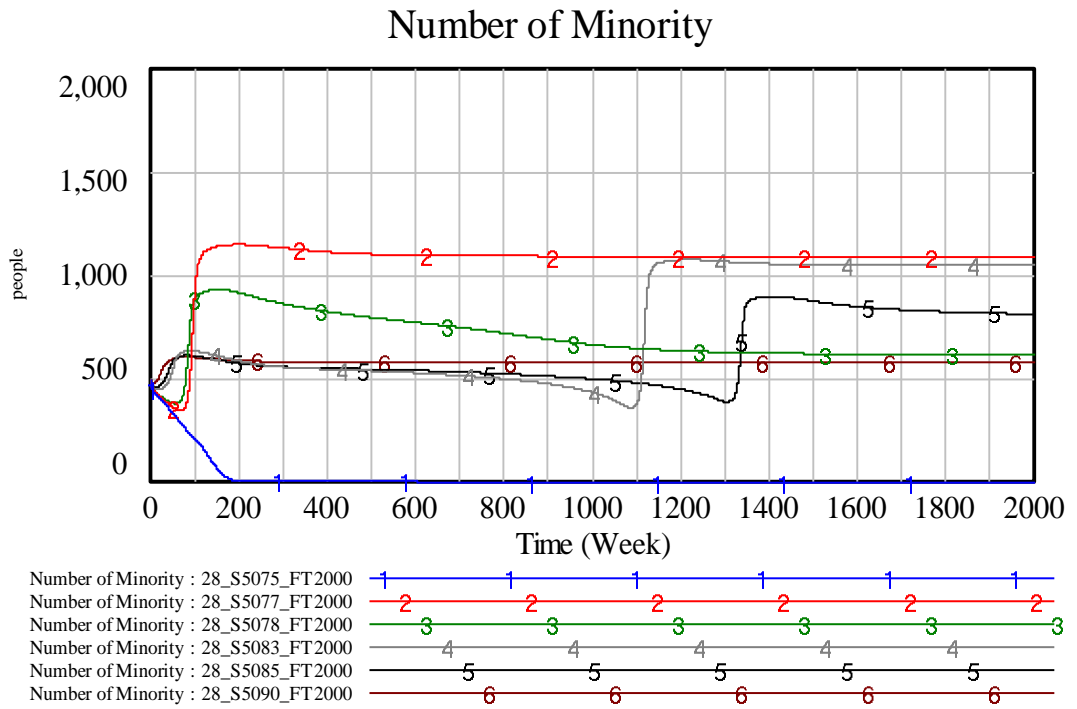


Figure 7.16. Minority's number with different strength values in run 28.

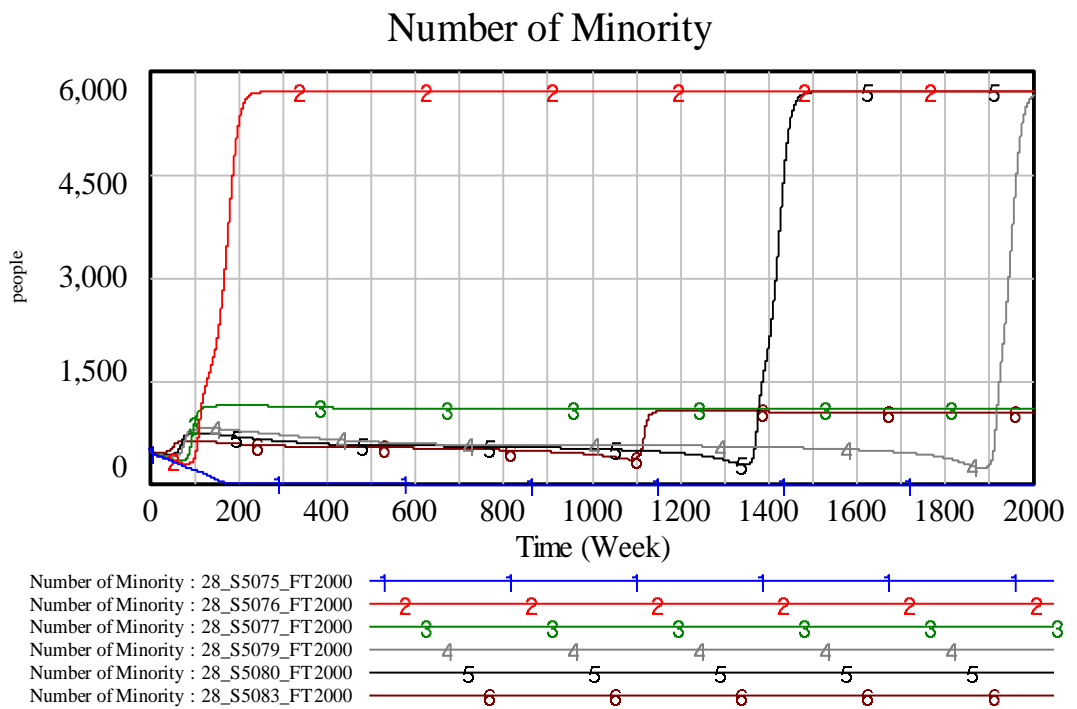


Figure 7.17. Minority's number with different strength values in run 28.

Indeed, the counterintuitive relation between strength and the ability to resist occurs in almost every run for different strength ranges, either in the behavior of reaching non-zero equilibrium as in Figure 7.13 and in Figure 7.16, or minority's absorbing all population as in Figure 7.17. For base run, this unexpected result is squeezed around minority's strength values of 35 when majority's strength is 70, as it can be seen in Figure 7.18.

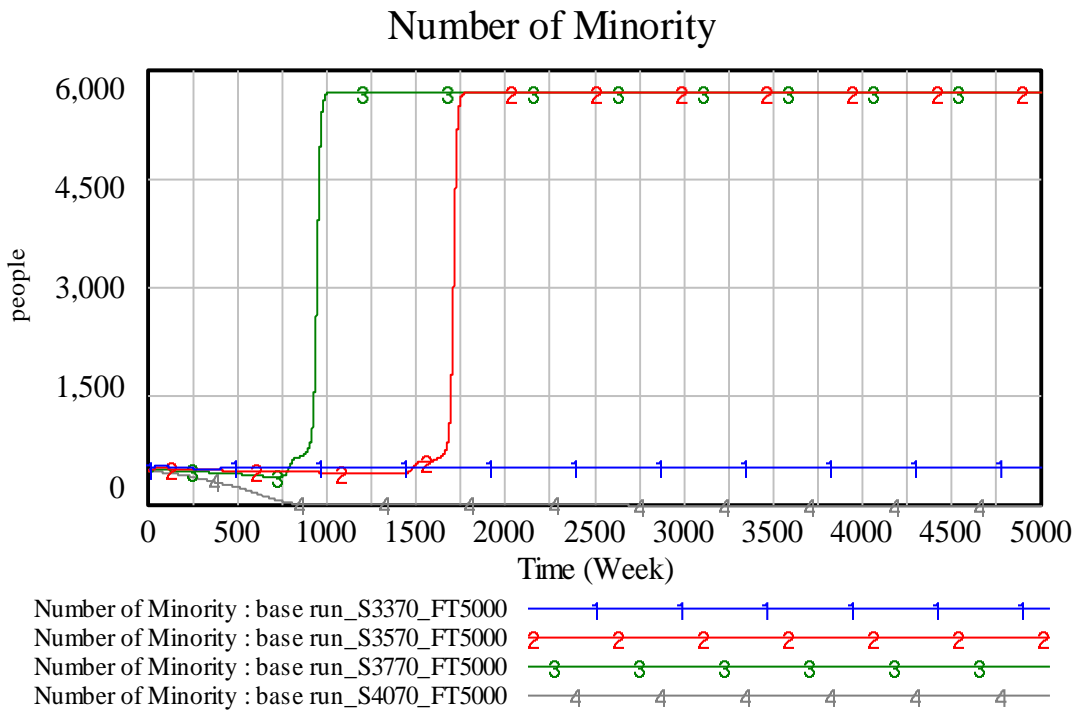


Figure 7.18. Minority's number with different strength values in the base run.

## 8. SCENARIO ANALYSIS

### 8.1. Weight of RP in Majority's Pressure Calculations

Since RP is an endogenous variable, it cannot be changed directly; but rather its effectiveness in the equations of majority's pressure on behavior change can be altered. In the base run, the weight of majority's RP pressure effect is 0.33, as it can be seen in Table 6.2. In these sensitivity runs, the weight of RP is changed as 0.5 and 0.66 respectively.

Figure 8.1 shows that in the cases of decreasing minority dynamics (with less strength differences from majority) an increase in weight of RP pressure in the pressure equations enables minority to resist on. This can be seen through comparing the three runs with strength values of 5060 in Figure 8.1. Starting from base run – which is marked with the number 6 - to the run with RP weight of 0.66 – which is marked with the number 4 - minority resists longer. This is because; decreasing minority's number means lower majority's antagonism level and lower RP usage. In this situation (the case of decrease in minority's number), higher effectiveness of RP on pressure balances, i.e. increasing the weight of RP, means to get a higher portion from decreasing (RP) pressure. Therefore, higher weights of RP operate as an advantage to minority, in the case of decreasing minority dynamics.

However, in the case of increasing minority (with higher strength differences from majority), an increase in weight of RP pressure in the pressure equations prevent minority to reach equilibrium in a higher level. This can be seen through comparing the three runs with strength values of 4090 in Figure 8.1. Starting from base run – which is marked with the number 3 - to the run with RP weight of 0.66 – which is marked with the number 1 - minority reaches equilibrium at lower levels. This is because; increasing minority's number means higher majority's antagonism and higher RP pressure. In this situation (the case of increase in minority's number), increasing weights of RP means to get a higher portion from higher (RP) pressure which in turn leads to an expected result from increasing weights of RP. In other words, increasing weights of RP pressure makes difficult for minority to sustain itself in non-zero equilibrium.

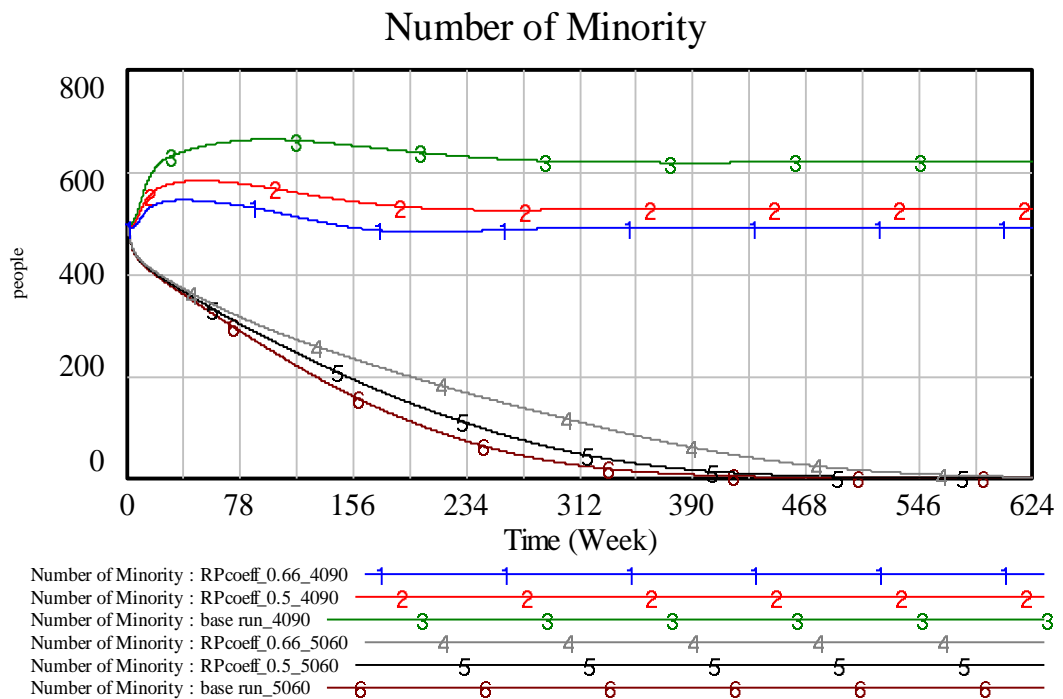


Figure 8.1. Minority's number with different strength values and RP weights.

## 8.2. Scenarios with Initial Antagonism Levels

Remembering the context of the majority and minority groups in the model, i.e. forming a minority out-group from an in-group due to clash of opinions, this scenario tries to answer: what if majority or minority has significantly higher levels of antagonism at the beginning of this separation. Figure 8.2 shows the situation in which majority starts the intergroup relationship with a higher level of hostility towards minority. In these runs, majority's initial antagonism is 70 whereas minority's is 30. Figure 8.3 illustrates the other way around.

Comparing to the base run, both Figure 8.2 and Figure 8.3 show that if the number of minority starts to increase, then high antagonism – regardless of where it comes from – makes it difficult to sustain minority population at non-zero equilibrium. On the other hand, for the reverse condition where the number of minority decreases, high antagonism – regardless of where it comes from – enables minority to resist longer.

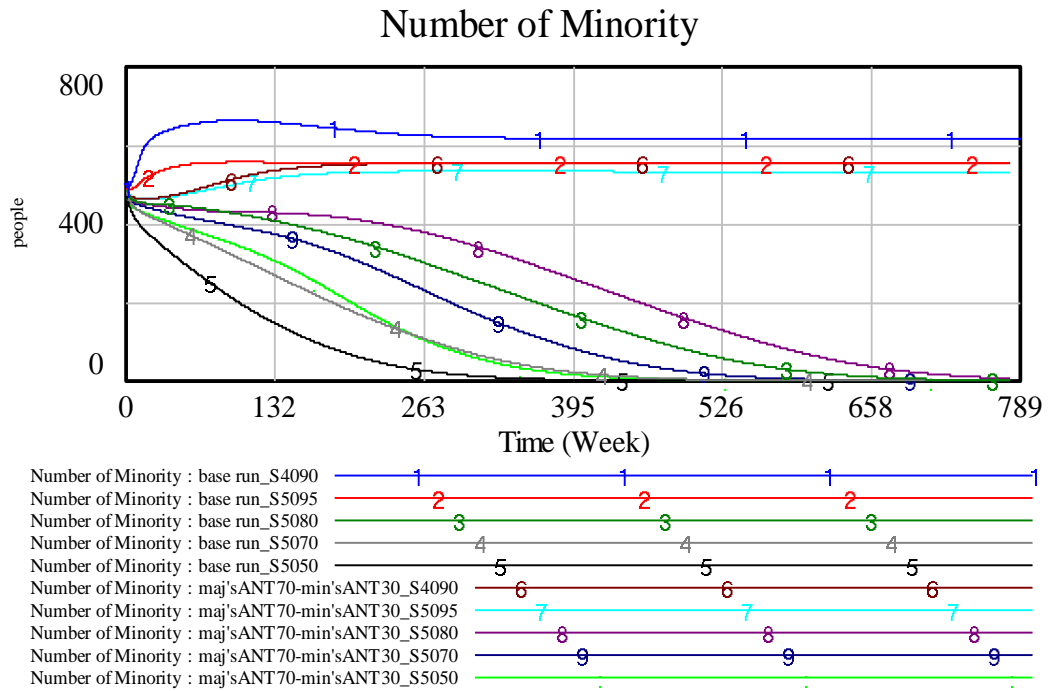


Figure 8.2. Minority's number with different strength values when majority's initial antagonism=70 and minority's initial antagonism=30.

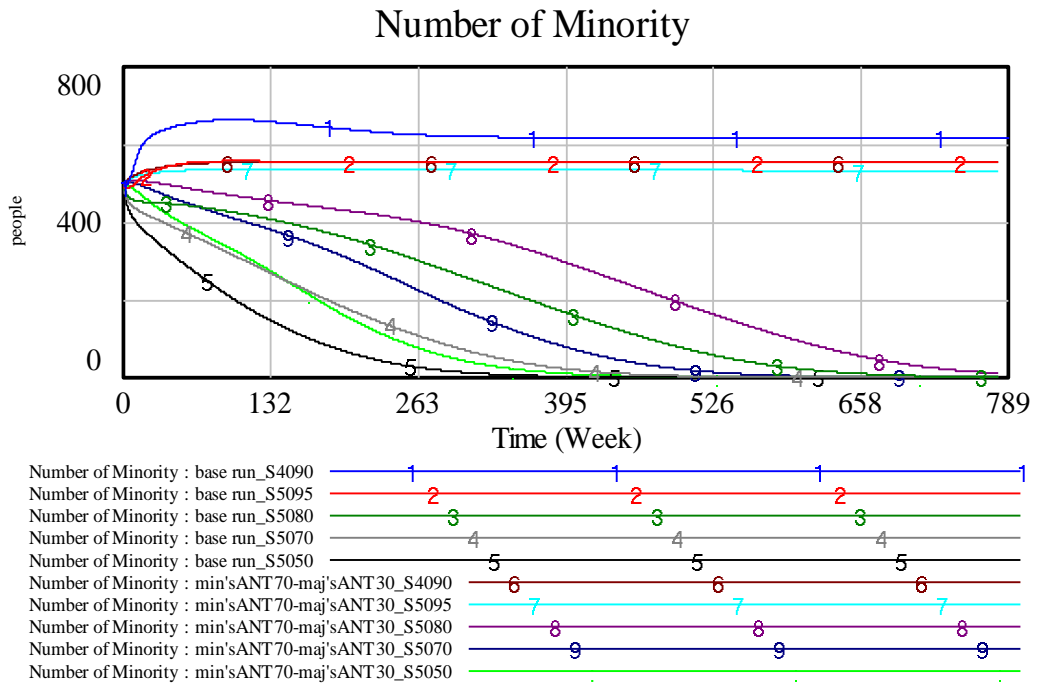


Figure 8.3. Minority's number with different strength values when minority's initial antagonism=70 and majority's initial antagonism=30.

### 8.3. Minority's Number to Sustain

This scenario seeks to find a threshold for minority's number: What is the minimum possible initial ratio of minority over majority that enables minority to reach non-zero equilibrium, (i) when majority has an average strength value (50), and minority has the maximum possible strength (100), and (ii) when both majority and minority have the average strength value (50)? In parallel with the aim (i), all the other initial numbers in stocks are kept constant, and initial number of minority is changed gradually from 250 to 500 (the value in the base run).

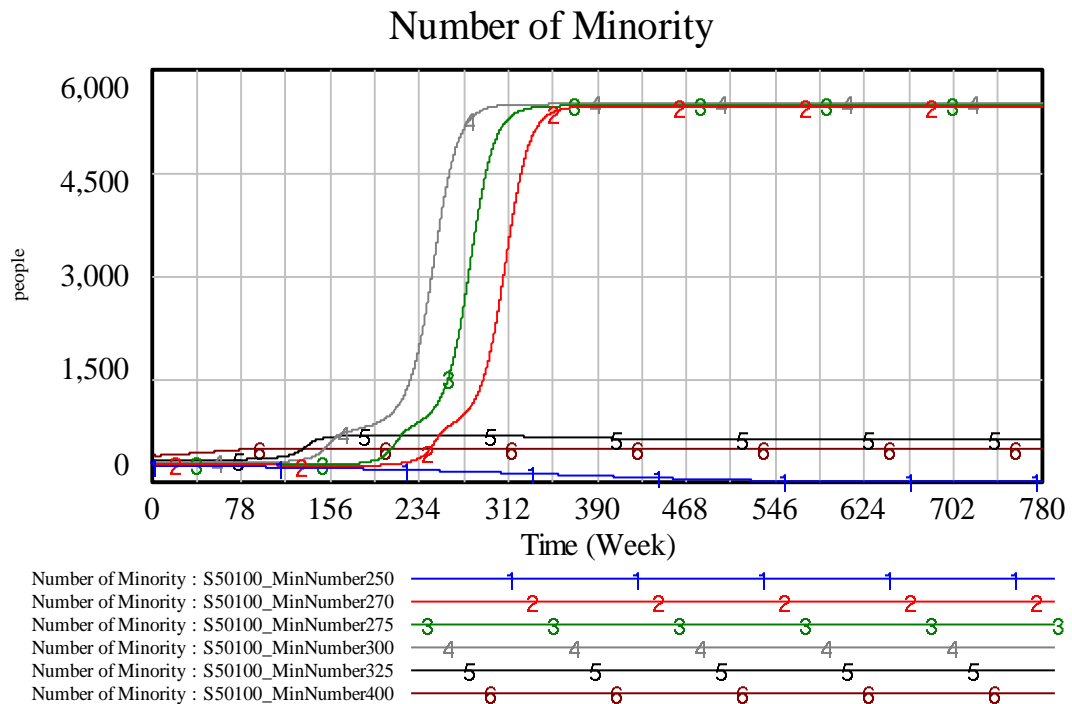


Figure 8.4. Minority's number with different initial values at its maximum strength.

Figure 8.4 shows that for the initial values of 270, 275, and 300 the minority absorbs all population; however for the initial value of 325 the minority reaches a non-zero equilibrium value which is close to its initial value. Figure 8.5 displays same output results without minority's absorbing all population to be able to analyze closely. This figure demonstrates that the relation between minority's number and its ability to sustain is counterintuitive between the initial numbers of 325 and 400. To be more precise, with its

maximum strength value minority reaches a higher equilibrium when its initial number is 325 than in the situation when its initial number 400.

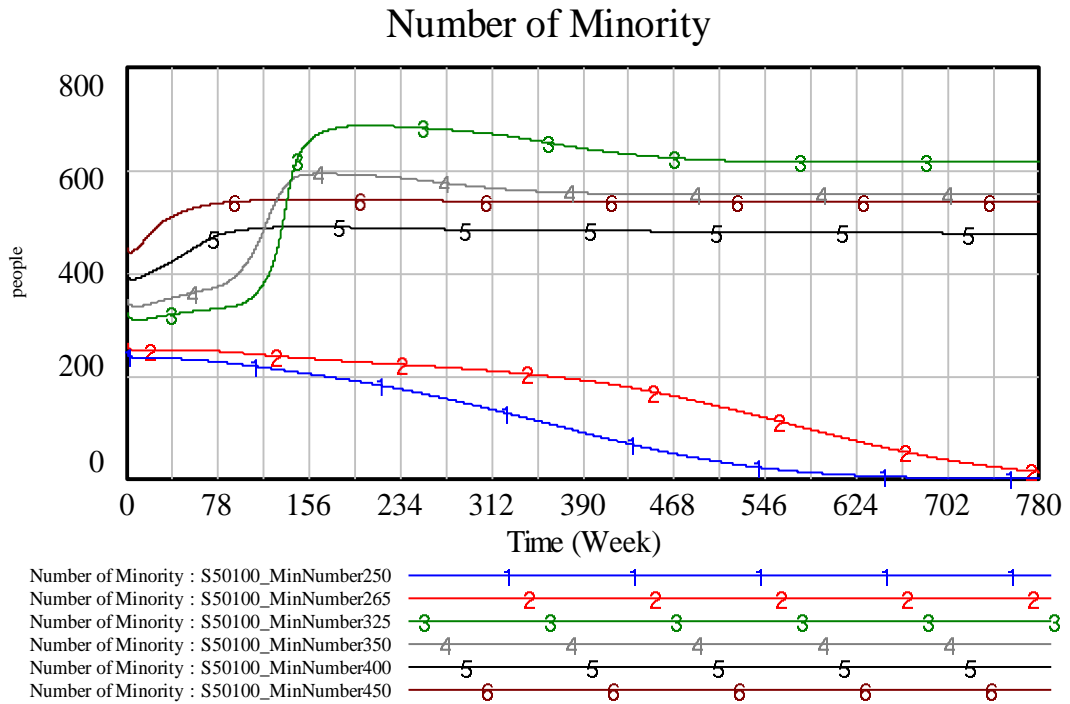


Figure 8.5. Minority’s number with different initial values at its maximum strength.

For aim (ii), all the other initial numbers in stocks are kept constant, and initial number of minority is changed gradually from 500 (the value in the base run) to 5000. As it can be seen from Figure 8.6, in all runs with the initial value under 3439 minority goes to extinct whereas minority absorbs all population in the runs with the initial value above 3440. In other words, these points are critical points that create bifurcation in the behavior pattern. As stated before, minority’s absorbing more than half of the population – the runs marked by the numbers of 4, 5, and 6 in Figure 8.6 - makes the model invalid after this point. For example, the run marked by the number 4 is started with 3440 as the initial number of minority; thus, as soon as minority’s number exceeds 4320<sup>9</sup> the rest of the behavior is invalid.

<sup>9</sup> Total number of people in the model for this run: 3440+5000+100+100 = 8640



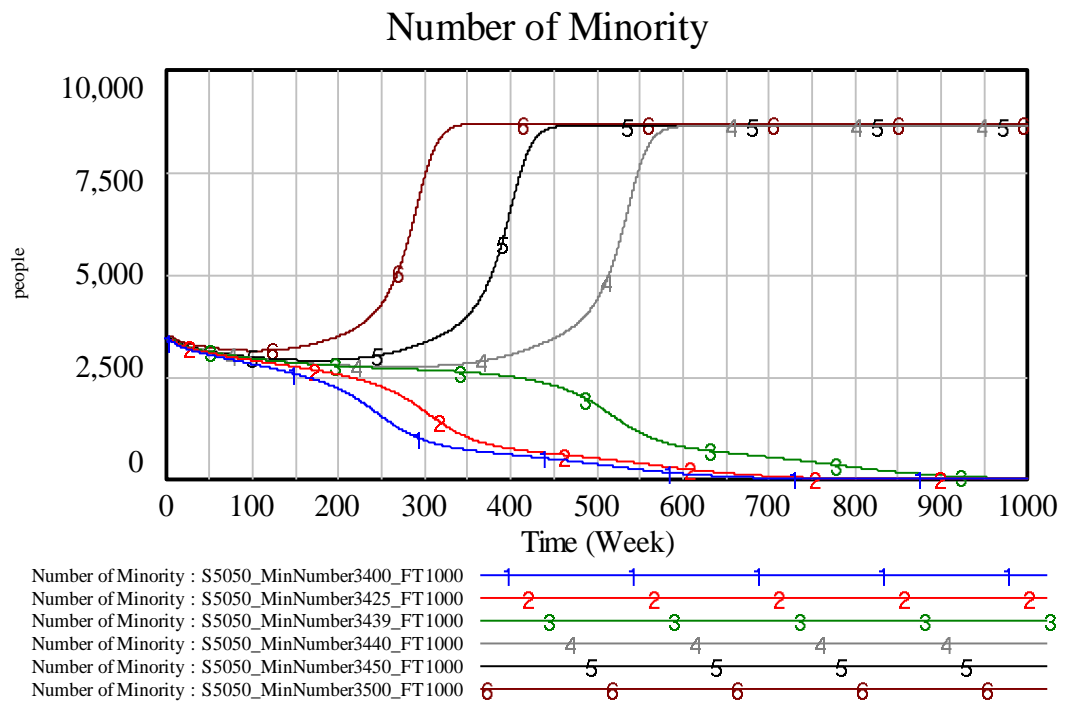


Figure 8.6. Minority's number with different initial values at the average strength (50).

## 9. CONCLUSION

Integrating individual and group based explanations of social influence, a system dynamics model is built to depict qualitative major patterns of attitude, behavior, and group change under the social influences of majority and minority groups that split from the majority. First, an integrative framework for social influence processes in inter-group context is proposed by the help of causal loop diagrams, feedback mechanisms, and holistic approach of systems theory. Second, this framework is transformed into a system dynamics model through the modifications and calibrations necessary to make the model with many soft variables internally consistent and robust. Through detailed description of the modeling process, how systems dynamics can be utilized in studies of social influence in an intergroup context is demonstrated, and system dynamics methodology is introduced to the thread of dynamical social psychology.

Base simulation run is considered as the situation where majority has intergroup differentials in number and power, i.e. the privilege to use reward or punishment mechanisms. The results show that unless minority's strength is significantly higher than the majority's, it is impossible for minority to survive as a group, as consistent with the literature. First simulation scenario demonstrates that effectiveness of reward or punishment (RP) in constituting majority's social pressure has different impacts on minority in different situations. In the cases where minority is powerful enough to survive or increase its size, higher RP effectiveness makes it difficult for minority to sustain itself in non-zero equilibrium. On the other hand, in cases where minority is unable to survive, higher RP effectiveness counterintuitively enables minority to persist for a longer time, even if they eventually become extinct. Second scenario results indicate that higher levels of antagonisms of either group has a negative impact on the size of minority group such that higher antagonisms make it difficult for minority population to sustain itself at non-zero equilibrium. But for minority groups which do not have the potential to survive, higher levels of antagonisms enable minority to resist longer. Final scenario shows that in the case where minority has maximum possible strength value, the threshold for the minimum initial ratio of minority over majority that enables minority to reach non-zero equilibrium cannot be identified, unless all values are tried because of the nonlinear

relation between initial number of minority and its ability to reach non-zero equilibrium. On the other hand, in the case where minority and majority have the average strength value, a bifurcation point that splits the behavior patterns into two is observed.

Some of the unexpected results of the model are limit cycles, unstable equilibria, bifurcations, and counterintuitive behaviors in very small ranges of parameters. The model demonstrates that in some narrow ranges, (i) minority's strength, (ii) majority's strength, and (iii) minority's initial value have nonlinear effects on minority's ability to sustain non-zero equilibrium. These unexpected behaviors persist in almost every case even though their location in the ranges of parameters, their amplitudes, periods, and specific behavior shapes may be different. These complex non-linear dynamics can be squeezed in small ranges of parameters, but it is impossible to completely eliminate them. They deserve further inquiry by researchers particularly in the field of dynamical social psychology. In this respect, a valid simulation model is offered to the dynamical social psychology literature as an experimental tool, in order to acquire new theoretical understandings about inter-group based social influence from the counterintuitive patterns of behavior that the model produces.

## APPENDIX A: MODEL EQUATIONS

Average Immediacy in Majority= Effect of Majority's Antagonism on Average Immediacy in Majority\*Max Immediacy

Average Immediacy in Minority= Effect of Minority's Antagonism on Average Immediacy in Minority\*Max Immediacy

Avg Strength of Majority= 50

Avg Strength of Minority= 50

Change in Compliant's Perception about CompToMaj= (Pressure Balance of Compliant about CompToMaj - Perceived Pressure Balance of Compliant about CompToMaj ) / Perception Delay of Compliant about CompToMaj

Change in Compliant's Perception about CompToMin= (Pressure Balance of Compliant about CompToMin-Perceived Pressure Balance of Compliant about CompToMin)/Perception Delay of Compliant about CompToMin

Change in Confused's Perception about ConfToMaj= (Pressure Balance of Confused about ConfToMaj - Perceived Pressure Balance of Confused about ConfToMaj ) / Perception Delay of Confused about ConfToMaj

Change in Confused's Perception about ConfToMin= (Pressure Balance of Confused about ConfToMin - Perceived Pressure Balance of Confused about ConfToMin ) / Perception Delay of Confused about ConfToMin

Change in Majority's Antagonism= IF THEN ELSE( Majority's Implied Antagonism > Majority's Antagonism , (Majority's Implied Antagonism-Majority's Antagonism)/Time to Adjust Perception of Majority when Antagonism increases , (Majority's Implied Antagonism-Majority's Antagonism)/Time to Adjust Perception of Majority when Antagonism decreases )

Change in Majority's Perception about MajToConf= (Pressure Balance of Majority about MajToConf- Perceived Pressure Balance of Majority about MajToConf ) / Perception Delay of Majority about MajToConf

Change in Minority's Antagonism= IF THEN ELSE( Minority's Implied Antagonism > Minority's Antagonism , (Minority's Implied Antagonism-Minority's Antagonism

) / Time to Adjust Perception of Minority when Antagonism increases , (Minority's Implied Antagonism - Minority's Antagonism) / Time to Adjust Perception of Minority when Antagonism decreases )

Change in Minority's Perception about MinToComp = (Pressure Balance of Minority about MinToComp - Perceived Pressure Balance of Minority about MinToComp) / Perception Delay of Minority about MinToComp

comp's net flow = MinToComp - CompToMaj - CompToMin [Units: people / week]

CompToMaj = Number of Compliant \* CompToMaj Fraction [Units: people / week]

CompToMaj Fraction = Effect of Perceived Pressure Balance of Compliant on CompToMaj Fraction \* MAX CompToMaj Fraction [Units: 1 / week]

CompToMin = Number of Compliant \* CompToMin Fraction [Units: people / week]

CompToMin Fraction = MAX CompToMin Fraction \* Effect of Perceived Pressure Balance of Compliant on CompToMin Fraction [Units: 1 / week]

conf's net flow = MajToConf - ConfToMaj - ConfToMin [Units: people / week]

ConfToMaj = Number of Confused \* ConfToMaj Fraction [Units: people / week]

ConfToMaj Fraction = Effect of Perceived Pressure Balance of Confused on ConfToMaj Fraction \* MAX ConfToMaj Fraction [Units: 1 / week]

ConfToMin = Number of Confused \* ConfToMin Fraction [Units: people / week]

ConfToMin Fraction = Effect of Perceived Pressure Balance of Confused on ConfToMin Fraction \* MAX ConfToMin Fraction [Units: 1 / week]

Effect of Majority's Antagonism on Average Immediacy in Majority = LOOKUP EXTRAPOLATE (Graph for Effect of Majority's Antagonism Toward Minority on Average Immediacy in Majority, SMOOTH3 (Majority's Antagonism , 2) / Max Antagonism Level)

Effect of Majority's Antagonism on Majority's RP Pressure=  
 LOOKUP EXTRAPOLATE (Graph for Effect of Majority's  
 Antagonism on Utilized RP, SMOOTH3( Majority's Antagonism,  
 2)/Max Antagonism Level)

Effect of Majority's Antagonism on Minority's Implied  
 Antagonism=  
 LOOKUP EXTRAPOLATE (Graph for Effect of  
 Majority's Antagonism on Minority's Implied Antagonism,  
 SMOOTH3( Majority's Antagonism, 2)/Max Antagonism Level)

Effect of Majority's RP Pressure on Minority's Implied  
 Antagonism=  
 LOOKUP EXTRAPOLATE (Graph for Effect of  
 RP on Minority's Implied Antagonism, Majority's RP  
 Pressure/MAX Utilized RP)

Effect of Minority's Antagonism on Average Immediacy in  
 Minority=  
 LOOKUP EXTRAPOLATE (Graph for Effect of Minority's  
 Antagonism Toward Majority on Average Immediacy in Minority,  
 SMOOTH3(Minority's Antagonism , 2 ) / Max Antagonism Level)

Effect of Minority's Antagonism on Majority's Implied  
 Antagonism=  
 LOOKUP EXTRAPOLATE (Graph for Effect of  
 Minority's Antagonism on Majority's Implied  
 Antagonism, SMOOTH3( Minority's Antagonism, 2)/Max Antagonism  
 Level)

Effect of Minority's Antagonism on MinToComp=  
 LOOKUP  
 EXTRAPOLATE (Graph for Effect of Antagonism on MinToComp,  
 Minority's Antagonism/Max Antagonism Level )

Effect of Minority's Number on Majority's Implied Antagonism=  
 LOOKUP EXTRAPOLATE (Graph for Effect of Minority's  
 Number on Majority's Implied Antagonism, (Number of Minority/  
 Total Number of People ) / MAX ratio )

Effect of Minority's Number on Minority's Implied Antagonism=  
 LOOKUP EXTRAPOLATE (Graph for Effect of Minority's  
 Number on Minority's Implied Antagonism, (Number of Minority/  
 Total Number of People ) / MAX ratio )

Effect of Perceived Pressure Balance of Compliant on  
 CompToMaj Fraction=  
 LOOKUP EXTRAPOLATE (Graph for Effect of  
 Perceived Pressure Balance of Compliant on CompToMaj  
 Fraction, Perceived Pressure Balance of Compliant about  
 CompToMaj)

Effect of Perceived Pressure Balance of Compliant on  
 CompToMin Fraction=  
 LOOKUP EXTRAPOLATE (Graph for Effect of  
 Perceived Pressure Balance of Compliant on CompToMin

Fraction, Perceived Pressure Balance of Compliant about CompToMin)

Effect of Perceived Pressure Balance of Confused on ConfToMaj Fraction= LOOKUP EXTRAPOLATE (Graph for Effect of Perceived Pressure Balance of Confused on ConfToMaj Fraction, Perceived Pressure Balance of Confused about ConfToMaj)

Effect of Perceived Pressure Balance of Confused on ConfToMin Fraction= LOOKUP EXTRAPOLATE (Graph for Effect of Perceived Pressure Balance of Confused on ConfToMin Fraction, Perceived Pressure Balance of Confused about ConfToMin)

Effect of Perceived Pressure Balance of Majority on MajToConf Fraction= LOOKUP EXTRAPOLATE (Graph for Effect of Perceived Pressure Balance of Majority on MajToConf Fraction, Perceived Pressure Balance of Majority about MajToConf)

Effect of Perceived Pressure Balance of Minority on MinToComp Fraction= LOOKUP EXTRAPOLATE (Graph for Effect of Perceived Pressure Balance of Minority on MinToComp Fraction, Perceived Pressure Balance of Minority about MinToComp)

exponent t= 0.5

FINAL TIME = 624 The final time for the simulation.

Graph for Effect of Antagonism on MinToComp( [(0,0)-(1,1)], (-1,1), (0,1), (0.116208,0.97807), (0.223242,0.938596), (0.33945,0.864035), (0.446483,0.679825), (0.5,0.5), (0.559633,0.328947), (0.626911,0.219298), (0.691131,0.114035), (0.761468,0.0526316), (0.862385,0.0175439), (1,0), (2,0))

Graph for Effect of Dissonant Elements Proportion of Majority on Disidentification Fraction([(0,0)-(1,1)], (0,0), (0.5,0), (1,1), (2,1))

Graph for Effect of Majority's Antagonism on Minority's Implied Antagonism( [(0,0)-(1,1)], (-1,0), (0,0), (1,1), (2,1))

Graph for Effect of Majority's Antagonism on Utilized RP( [(0,0)-(1,1)], (-1,0), (0,0), (0.0948012,0.0175439), (0.189602,0.0526316), (0.311927,0.135965), (0.41896,0.29386), (0.501529,0.495614), (0.587156,0.701754), (0.672783,0.855263), (0.7737,0.942982), (0.874618,0.97807), (1,1), (2,1))

Graph for Effect of Majority's Antagonism Toward Minority on Average Immediacy in Majority( [(0,0)-(1,1)], (-1,0.1), (0,0.1), (0.0917431,0.114035), (0.192661,0.135965), (0.299694,0.197368), (0.379205,0.280702), (0.443425,0.407895), (0.510703,0.574561), (0.58104,0.736842), (0.672783,0.868421), (0.785933,0.947368), (0.880734,0.986842), (1,1), (2,1))

Graph for Effect of Minority's Antagonism on Majority's Implied Antagonism( [(0,0)-(1,1)], (-1,0), (0,0), (1,1), (2,1))

Graph for Effect of Minority's Antagonism Toward Majority on Average Immediacy in Minority( [(0,0)-(1,1)], (-1,0.1), (0,0.1), (0.0611621,0.109649), (0.137615,0.135965), (0.201835,0.22807), (0.244648,0.372807), (0.302752,0.561404), (0.370031,0.75), (0.501529,0.885965), (0.663609,0.951754), (0.840979,0.97807), (1,1), (2,1))

Graph for Effect of Minority's Number on Majority's Implied Antagonism( [(0,0)-(1,1)], (-1,0), (0,0), (0.0519878,0.0175439), (0.0917431,0.0833333), (0.12844,0.197368), (0.2,0.5), (0.238532,0.649123), (0.321101,0.802632), (0.431193,0.890351), (0.538226,0.938596), (0.657492,0.960526), (0.816514,0.97807), (1,1), (2,1))

Graph for Effect of Minority's Number on Minority's Implied Antagonism( [(0,0)-(1,1)], (-1,1), (0,1), (0.0519878,0.98246), (0.0917431,0.91667), (0.12844,0.8026), (0.2,0.5), (0.238532,0.3509), (0.321101,0.1974), (0.431193,0.1096), (0.538226,0.0614), (0.657492,0.03949), (0.816514,0.0219), (1,0), (2,0))

Graph for Effect of Perceived Pressure Balance of Compliant on CompToMaj Fraction( [(0,0)-(1,1)], (0,0), (0.4,0), (0.455657,0.0175439), (0.513761,0.0833333), (0.6,0.25), (0.7,0.5), (0.8,0.75), (0.859327,0.881579), (0.896024,0.938596), (0.941896,0.97807), (1,1), (2,1))

Graph for Effect of Perceived Pressure Balance of Compliant on CompToMin Fraction( [(0,0)-(1,1)], (0,0), (0.4,0), (0.455657,0.0175439), (0.513761,0.0833333), (0.6,0.25), (0.7,0.5), (0.8,0.75), (0.859327,0.881579), (0.896024,0.938596), (0.941896,0.97807), (1,1), (2,1))

Graph for Effect of Perceived Pressure Balance of Confused on ConfToMaj Fraction( [(0,0)-(1,1)], (0,0), (0.4,0), (0.455657,0.0175439), (0.513761,0.0833333), (0.6,0.25), (0.7,0.5), (0.8,0.75), (0.859327,0.881579), (0.896024,0.938596), (0.941896,0.97807), (1,1), (2,1))



Graph for Effect of Perceived Pressure Balance of Confused on  
 ConfToMin Fraction( [(0,0)-  
 (1,1)], (0,0), (0.4,0), (0.455657,0.0175439), (0.513761,0.0833333  
 ), (0.6,0.25), (0.7,0.5), (0.8,0.75), (0.859327,0.881579), (0.8960  
 24,0.938596), (0.941896,0.97807), (1,1), (2,1))

Graph for Effect of Perceived Pressure Balance of Majority on  
 MajToConf Fraction( [(0,0)-  
 (1,1)], (0,0), (0.4,0), (0.455657,0.0175439), (0.513761,0.0833333  
 ), (0.6,0.25), (0.7,0.5), (0.8,0.75), (0.859327,0.881579), (0.8960  
 24,0.938596), (0.941896,0.97807), (1,1), (2,1))

Graph for Effect of Perceived Pressure Balance of Minority on  
 MinToComp Fraction( [(0,0)-  
 (1,1)], (0,0), (0.4,0), (0.455657,0.0175439), (0.513761,0.0833333  
 ), (0.6,0.25), (0.7,0.5), (0.8,0.75), (0.859327,0.881579), (0.8960  
 24,0.938596), (0.941896,0.97807), (1,1), (2,1))

Graph for Effect of RP on Minority's Implied Antagonism(  
 [(0,0)-(1,1)], (-  
 1,0.05), (0,0.05), (0.0489297,0.0745614), (0.103976,0.122807), (0  
 .15,0.2), (0.207951,0.346491), (0.253823,0.513158), (0.30581,0.6  
 62281), (0.409786,0.807018), (0.53211,0.907895), (0.654434,0.947  
 368), (0.810398,0.982456), (1,1), (2,1))

Initial Antagonism of Majority toward Minority= 40

Initial Antagonism of Minority toward Majority= 30

Initial Number of Compliant=100 [Units: people]

Initial Number of Confused= 100 [Units: people]

Initial Number of Majority= 5000 [Units: people]

Initial Number of Minority= 500 [Units: people]

INITIAL TIME = 0 The initial time for the simulation.

maj's net flow= CompToMaj+ConfToMaj-MajToConf [Units:  
 people/week]

Majority's Antagonism= INTEG ( Change in Majority's  
 Antagonism, Initial Antagonism of Majority toward  
 Minority)

Majority's Implied Antagonism= Max Antagonism Level  
 \* (1/3) \* Effect of Minority's Antagonism on Majority's

Implied Antagonism + (2/3) \* Effect of Minority's Number on Majority's Implied Antagonism )

Majority's Persuasive Pressure= Persuasive Impact of Majority\*Pressure per Impact for Majority

Majority's RP Pressure= Effect of Majority's Antagonism on Majority's RP Pressure\*MAX Utilized RP\*(Number of Majority/Total Number of People)^exponent t

Majority's Supportive Pressure= Supportive Impact of Majority\*Pressure per Impact for Majority

MajToConf= Number of Majority\*MajToConf Fraction [Units: people/week]

MajToConf Fraction= Effect of Perceived Pressure Balance of Majority on MajToConf Fraction\*MAX MajToConf Fraction [Units: 1/week]

Max Antagonism Level= 100

MAX CompToMaj Fraction= max flow fraction [Units: 1/week]

MAX CompToMin Fraction= max flow fraction [Units: 1/week]

MAX ConfToMaj Fraction= max flow fraction [Units: 1/week]

MAX ConfToMin Fraction= max flow fraction [Units: 1/week]

max flow fraction= 0.1 [Units: 1/week]

Max Immediacy= 100

MAX MajToConf Fraction= max flow fraction [Units: 1/week]

MAX MinToComp Fraction= max flow fraction [Units: 1/week]

MAX ratio of minority's number over total population= 0.5

MAX Utilized RP= 100

$\text{min's net flow} = \text{CompToMin} + \text{ConfToMin} - \text{MinToComp}$  [Units: people/week]

$\text{Minority's Antagonism} = \text{INTEG} ( \text{Change in Minority's Antagonism, Initial Antagonism of Minority toward Majority} )$

$\text{Minority's Implied Antagonism} = \text{Max Antagonism Level} * ( (0.15) * \text{Effect of Majority's Antagonism on Minority's Implied Antagonism} + (0.25) * \text{Effect of Majority's RP Pressure on Minority's Implied Antagonism} + (0.6) * \text{Effect of Minority's Number on Minority's Implied Antagonism} )$

$\text{Minority's Persuasive Pressure} = \text{Persuasive Impact of Minority} * \text{Pressure per Impact for Minority}$

$\text{Minority's Supportive Pressure} = \text{Supportive Impact of Minority} * \text{Pressure per Impact for Minority}$

$\text{MinToComp} = \text{Number of Minority} * \text{MinToComp Fraction} * \text{Effect of Minority's Antagonism on MinToComp}$  [Units: people/week]

$\text{MinToComp Fraction} = \text{Effect of Perceived Pressure Balance of Minority on MinToComp Fraction} * \text{MAX MinToComp Fraction}$  [Units: 1/week]

$\text{Number of Compliant} = \text{INTEG} ( \text{MinToComp} - \text{CompToMaj} - \text{CompToMin}, \text{Initial Number of Compiants} )$  [Units: people]

$\text{Number of Confused} = \text{INTEG} ( \text{MajToConf} - \text{ConfToMin} - \text{ConfToMaj}, \text{Initial Number of Confused} )$  [Units: people]

$\text{Number of Majority} = \text{INTEG} ( \text{CompToMaj} - \text{MajToConf} + \text{ConfToMaj}, \text{Initial Number of Majority} )$  [Units: people]

$\text{Number of Minority} = \text{INTEG} ( \text{ConfToMin} + \text{CompToMin} - \text{MinToComp}, \text{Initial Number of Minority} )$  [Units: people]

$\text{Number of Observed Majority} = \text{Number of Compliant} + \text{Number of Confused} + \text{Number of Majority}$  [Units: people]

$\text{Perceived Pressure Balance of Compliant about CompToMaj} = \text{INTEG} ( \text{Change in Compliant's Perception about CompToMaj}, \text{Pressure Balance of Compliant about CompToMaj} )$

Perceived Pressure Balance of Compliant about CompToMin= INTEG ( Change in Compliant's Perception about CompToMin, Pressure Balance of Compliant about CompToMin)

Perceived Pressure Balance of Confused about ConfToMaj= INTEG ( Change in Confused's Perception about ConfToMaj, Pressure Balance of Confused about ConfToMaj)

Perceived Pressure Balance of Confused about ConfToMin= INTEG ( Change in Confused's Perception about ConfToMin, Pressure Balance of Confused about ConfToMin)

Perceived Pressure Balance of Majority about MajToConf= INTEG ( Change in Majority's Perception about MajToConf, Pressure Balance of Majority about MajToConf)

Perceived Pressure Balance of Minority about MinToComp= INTEG ( Change in Minority's Perception about MinToComp, Pressure Balance of Minority about MinToComp)

Perception Delay of Compliant about CompToMaj= 3  
[Units: week]

Perception Delay of Compliant about CompToMin= 5 [Units: week]

Perception Delay of Confused about ConfToMaj= 3  
[Units: week]

Perception Delay of Confused about ConfToMin= 7  
[Units: week]

Perception Delay of Majority about MajToConf= 3  
[Units: week]

Perception Delay of Minority about MinToComp= 4  
[Units: week]

Persuasive Impact of Majority= Avg Strength of  
Majority\*(100-Majority's Antagonism)\* (Number of  
Majority/Total Number of People)^exponent t

Persuasive Impact of Minority= Avg Strength of  
Minority\*(100-Minority's Antagonism)\* (Number of  
Minority/Total Number of People)^exponent t

Pressure Balance of Compliant about CompToMaj= Majority's  
Persuasive Pressure/(Majority's Persuasive  
Pressure+Minority's Supportive Pressure)

Pressure Balance of Compliant about CompToMin= Minority's  
 Supportive Pressure/(Minority's Supportive  
 Pressure+((2/3)\*Majority's Persuasive  
 Pressure+(1/3)\*Majority's RP Pressure))

Pressure Balance of Confused about ConfToMaj= ((1/2) \*  
 Majority's Persuasive Pressure + (1/2) \* Majority's  
 Supportive Pressure) / (((1/2) \* Majority's Persuasive  
 Pressure + (1/2) \* Majority's Supportive Pressure) +  
 Minority's Persuasive Pressure)

Pressure Balance of Confused about ConfToMin= Minority's  
 Persuasive Pressure/(Minority's Persuasive Pressure+((2/3)\*  
 (1/2) \* Majority's Persuasive Pressure + (1/2) \* Majority's  
 Supportive Pressure) +(1/3)\*Majority's RP Pressure))

Pressure Balance of Majority about MajToConf= Minority's  
 Persuasive Pressure/(Minority's Persuasive  
 Pressure+Majority's Supportive Pressure)

Pressure Balance of Minority about MinToComp= ((2/3)\*  
 Majority's Persuasive Pressure +(1/3) \* Majority's RP  
 Pressure)/ ( ((2/3)\*Majority's Persuasive  
 Pressure+(1/3)\*Majority's RP Pressure)+Minority's Supportive  
 Pressure)

Pressure per Impact for Majority= 0.01

Pressure per Impact for Minority= 0.0125

SAVEPER = TIME STEP The frequency with which output is  
 stored.

Supportive Impact of Majority= Avg Strength of  
 Majority\*Average Immediacy in Majority\* (Number of  
 Majority/Total Number of People)^exponent t

Supportive Impact of Minority= Avg Strength of  
 Minority\*Average Immediacy in Minority\* (Number of  
 Minority/Total Number of People)^exponent t

TIME STEP = 0.125 The time step for the simulation.

Time to Adjust Perception of Majority when Antagonism  
 decreases= 36 [Units: week]

Time to Adjust Perception of Majority when Antagonism  
 increases= 2 [Units: week]

Time to Adjust Perception of Minority when Antagonism  
decreases= 36 [Units: week]

Time to Adjust Perception of Minority when Antagonism  
increases= 2 [Units: week]

Total Number of People= Initial Number of  
Majority+Initial Number of Minority+Initial Number of  
Confused+Initial Number of Compliant [Units: people]

## APPENDIX B: STOCK FLOW DIAGRAMS

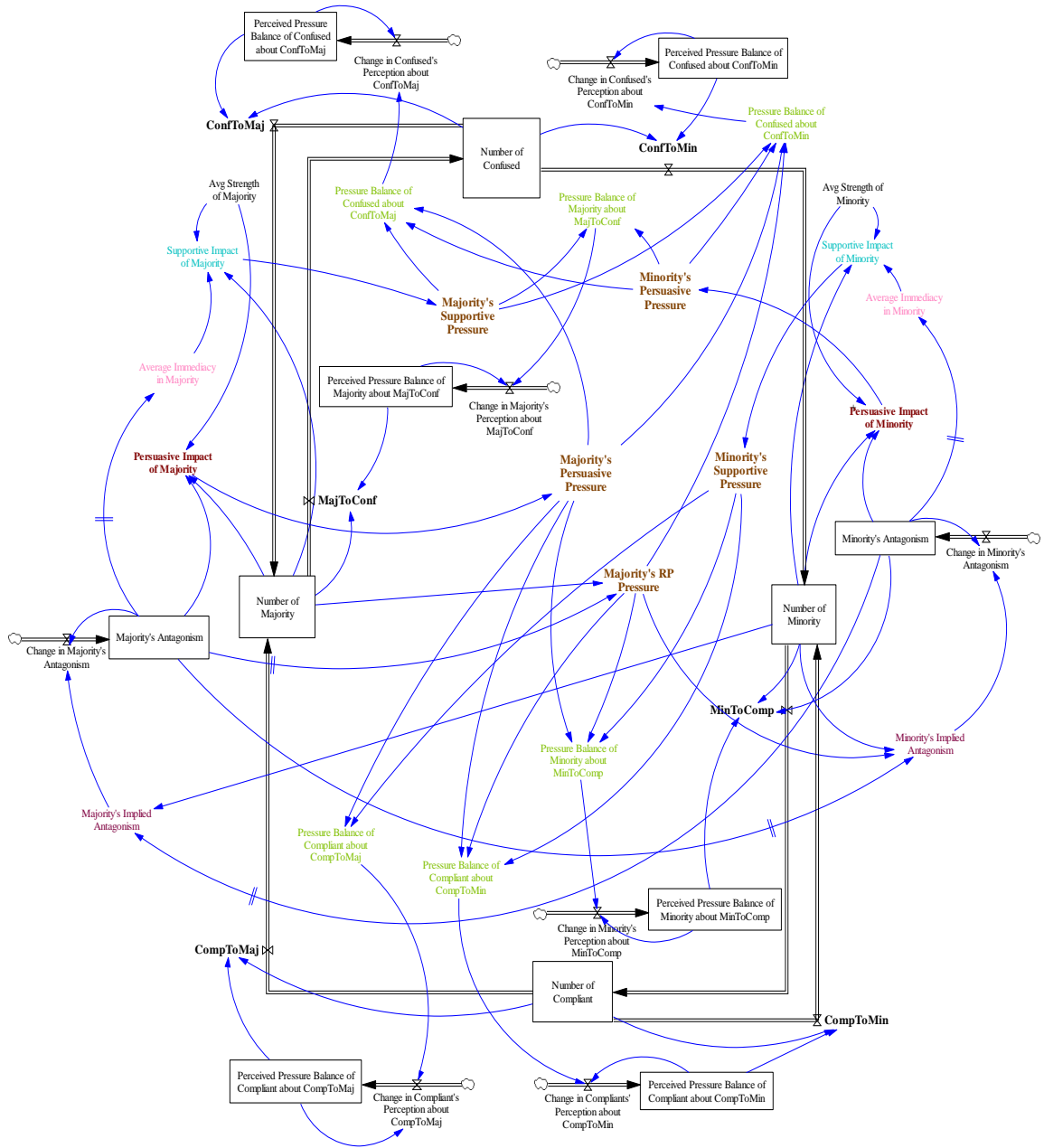


Figure B.1. Simplified Stock Flow Diagram-3

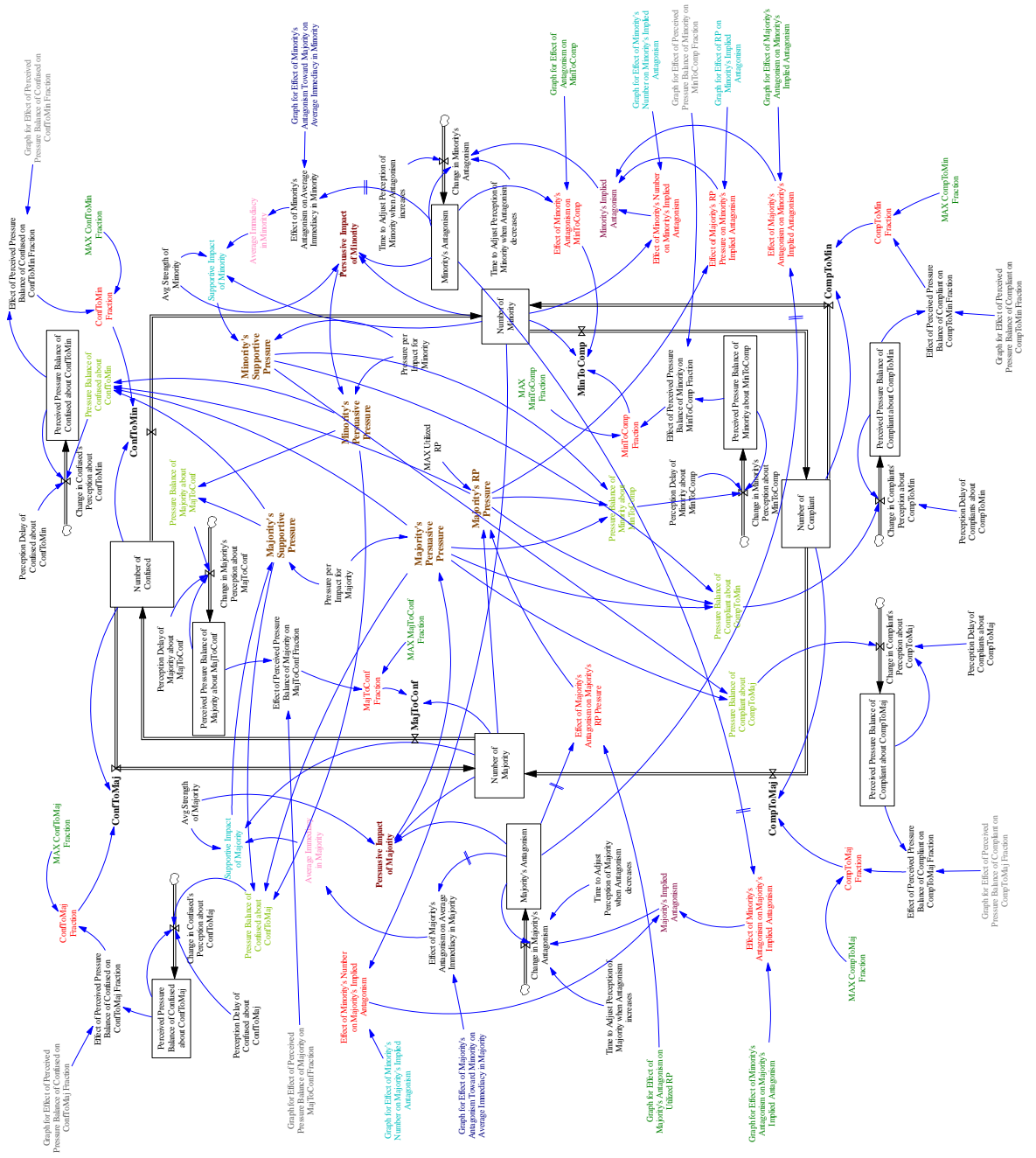


Figure B.2. Complete Stock Flow Diagram



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