DEVELOPING NATION: A System Dynamics Model

John M. Richardson Jr.
The American University - Washington, D.C.

ABSTRACT

This paper describes a model of a prototypical developing nation. The purpose of the model is to understand why violence and violent repression are so pervasive in the development process.. Further it is intended to show how violence affects and is affected by other aspects of development. The model, which is programmed in micro dynamo, has three sectors, POPULATION, ECONOMY, AND GOVERNMENT. Preliminary results show that fluctuations in economic growth can lead to outbreaks of violence and deteriorating economic performance.

## PROBLEM DEFINITION AND REFERENCE MODE

This paper describes DEVELOPING NATION, a system dynamics model of a prototypical developing nation. In its present form, the model is generic and theoretical. The present version has not been developed with a specific client in mind. I would describe the model, rather, as an exploratory contribution to the theory of development. Later versions will be adapted to the needs of development organizations with whom I work regularly. The model will also be used, possibly in the form of a game, for educational purposes.

DEVELOPING NATION's purpose is to represent the dynamics of violence in the development process. Further it is intended to show how violence affects and is affected by other aspects of development. Violence, instability and violent repression are endemic, costly and tragic realities for the people of of virtually all Third World nations. The forms of violence - guerilla warfare, mass demonstrations, revolutions and the repressive activities of governments intended to control these outbreaks - consume desperately needed resources and inflict widespread human suffering. If we better understand the causes of violence, perhaps we can begin to reduce or eliminate it.

During the past two years we have collected time series data on violent behavior in about twenty five nations. The data collection process continues. Figure 1 presents a typical reference mode, based on events data (Banks, 1974). During the period from 1925 through 1966, the nation described, Argentina, suffered from numerous outbreaks of violence directed against the government.

In the historical literature, these outbreaks of violence are mostly "explained" by specific circumstances and personalities (Forgette, 1981). But the same patterns of violence are characteristic of many, if not most, Third World nations. With slight modifications, the reference mode diagram

FIGURE 1. CIVIL VIOLENCE IN ARGENTINA, 1925-1966
(Data from Banks, 1974)
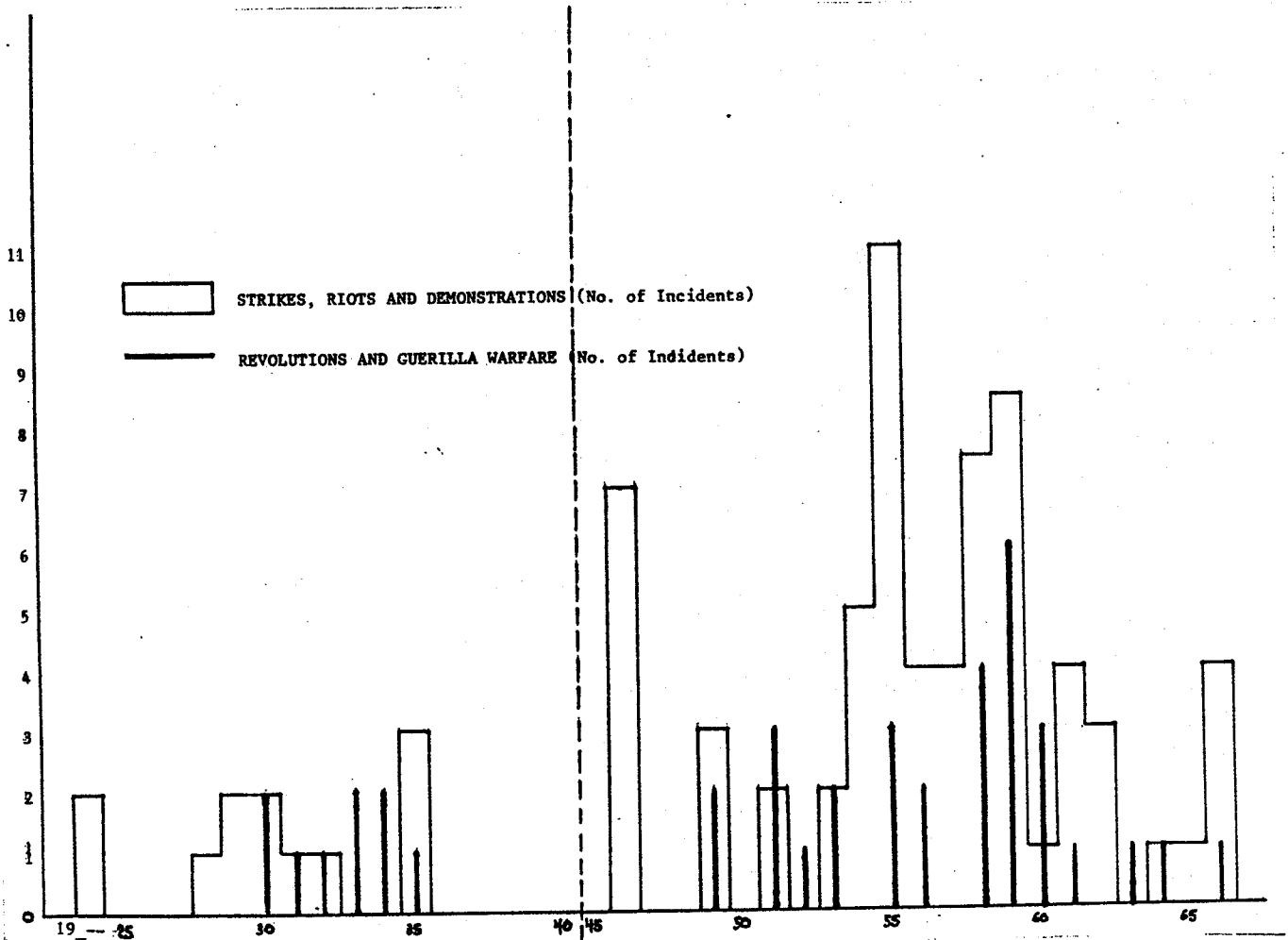
for Argentina would be applicable to Iran, to Egypt, to Nigeria, and to
scores of other Latin American, African and Asian nations. Thus the goal of
developing a generic model to represent the dynamics of violence does not
seem unreasonable.

Although the focus here is on violence and development, the research has a
broader long term goal. That goal It is to provide answers to the question:
"how can development, oriented toward ending hunger and meeting basic human
needs, occur without violence or violent repression?"   All too often well
meaning efforts to modernize third world nations and to promote political
stability have been, ineffective, counterproductive or, in some cases, even
tragic.   The study of system dynamics sensitizes us to the fact that in
order to solve a problem, one must first be able, through modeling, to
generate it. DEVELOPING NATION is a step in this direction.

STATE OF THE ART

A detailed review of the voluminous literature on violence and development
would not be appropriate.   But a brief overview may be helpful.   One
important source is the numerous of course numerous historical studies of

individual revolutions and of the process of revolution.   Brinton's classic (1938)   is probably the best known.

Quantitatively oriented political scientists have also been concerned with the issue of political violence.   The work of Ted Robert Gurr and various associates is particularly well known (1981,1970,1972).   Gurr's influential writings emphasize regression-based causal models of cross sectional data. He argues - as does this paper - that "conflict events have similar properties and causes across all contemporary nations" (1972, p. 7).

In a comprehensive survey article,   Gurr noted the curvelinear relationship between economic development and violence.   He argued that transitional societies are particularly susceptible to collective violence and that violent conflict intensifies in periods of rapid socioeconomic change (1972, pp. 36,7)   Mancur Olson (1964) reached similar conclusions.   Forgette (1981) found that in the area of basic human needs, "progress" in development could lead to instability under certain conditions.   This literature for the most part, uses case studies or static and attempts to infer longitudinal conclusions from statistical analysis of cross sectional data.

There is also an extensive literature that views collective violence from a psychological perspective.   The classic works of Dollard et. al. (1939) and Berkowitz (1962) and Dollard et. al. are well known have and provided the basis for numerous case studies as well as psychologically oriented cross sectional analyses (for example Feierabend and Feierabend, 1966; Fierabend, Fierabend and Nesvold, 1969).

Among system dynamicists,   Khalid Saeed has shown the greatest interest in the issues addressed here.   A model presented at the 1982 system dynamics conference focused on the relationship between economic growth and political instability (1982).   Related work has looked and broader issues in the field of development with particular emphasis on Pakistan (1980, 1982).

PRINCIPAL FEEDBACK LOOPS AND DYNAMIC HYPOTHESIS

Some of the principal feedback loops in DEVELOPING NATION are presented in Figures 2 and 3.

In figure 2, major growth loops are presented.   This representation of the development process is consistent with mainstream literature in the field of economic development (Kuznets, 1971, Rostow,   1981).   Emphasis is on growth in productivity, particularly in the capital sector. A strengthened productive sector, makes resources available throughout the society, not only for consumption but for education, human services and the development of infrastructure. In the 1960s and 70s, government was often assumed to be the key element in the development process. But recently increased emphasis has been given to the development of a viable private sector. (Bauer, 1972; Bauer and Yamey, 1978).

Figure 4 identifies major sources of violence and stagnation in the development process and presents the major dynamic hypothesis of the DEVELOPING NATION model. In this representation, rising output and the

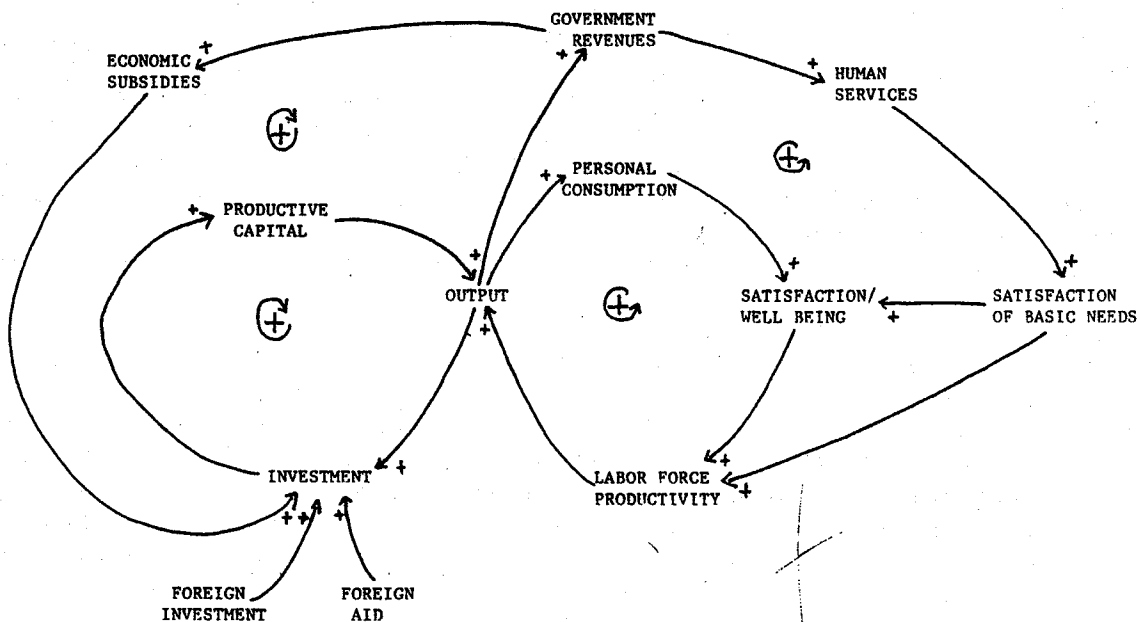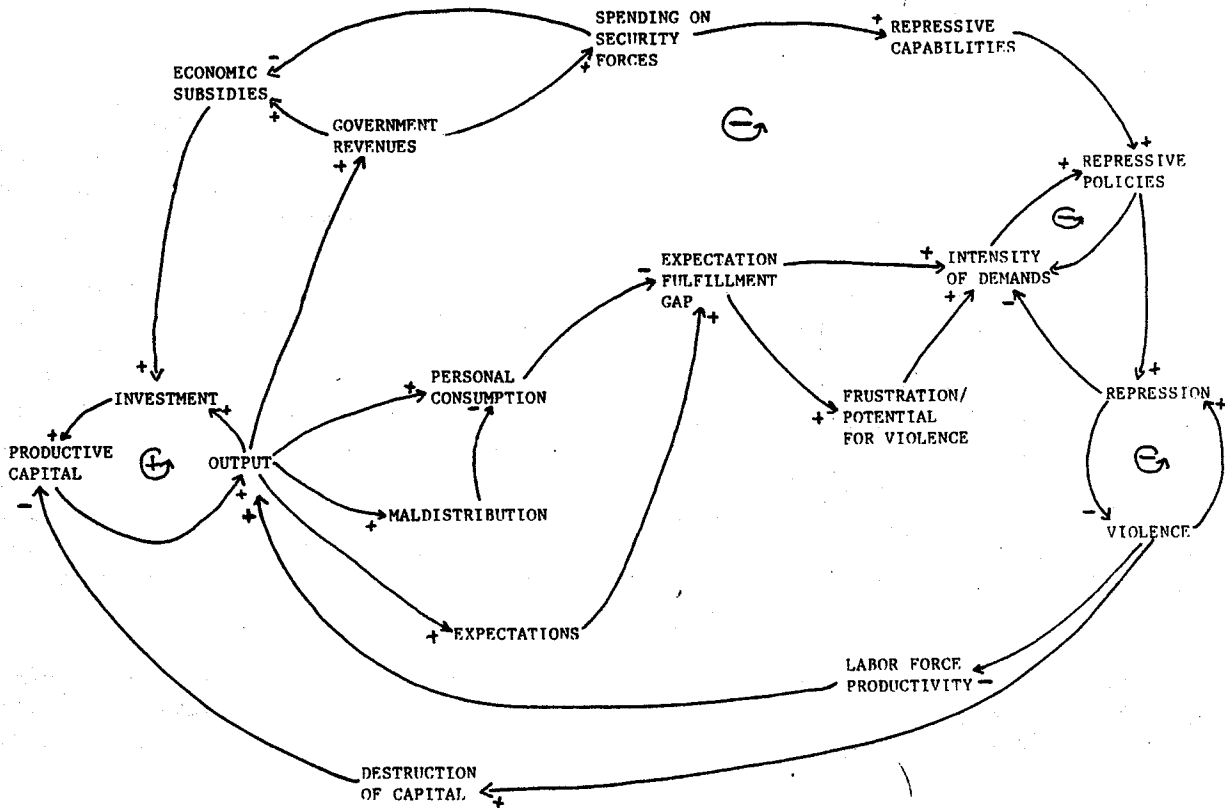FIGURE 2.   MAJOR GROWTH LOOPS IN THE DEVELOPMENT PROCESS

FIGURE 3.   SOURCES OF VIOLENCE IN THE DEVELOPMENT PROCESS

improved communications, and higher literacy associated with the development process produce not only increased consumption, but rising expectations. Given the fact that Third World nations are susceptible to world economic fluctuations, that rising inequality tends to be associated with rapid economic growth, and that economic development is, at best an uncertain process, expectations are often unmet. This leads to the intensification of demands and, not infrequently, to the violent expression of demands. These expressions are often viewed as threatening by the government. In most Third World nations, the concept of nationhood and the legitimacy of the government are not well established. (Soedjatmoko, 1980; Nyererre, 1961) In some, political leaders are committed to the maintenance of their own privileges and the privileges of an elite class of political supporters.

Governments respond to threats with repressive policies by diverting resources to the military and by an increased use of military forces for internal security. Foreign assistance may also be requested for these purposes and both major aid giving nations, the USA and the USSR have been happy to provide this kind of assistance to their allies. Resentment increases and the performance of the economy declines. When violence does break out, economic performance suffers further as needed resources are diverted and the attention of political leaders focuses on maintaining political stability.

In brief, the dynamic hypothesis of DEVELOPING NATION is that the potential for violence is inherent in the development process and that typical government responses to initial signs of violence tend to exacerbate frustrations and reduce the national capability for stable development in the long run. More specifically, it is argued that "normal" fluctuations in economic performance can create the potential for violence and for its mirror image, violent repression.


MODEL STRUCTURE

Figure 4 pictures the major sectors and principal interrelationships of the DEVELOPING NATION model. This section will describe the general functions of each sector. In the next section a more detailed description of two areas violence and satisfaction/dissatisfaction will be presented.

The POPULATION sector models basic population dynamics, demand for consumption goods, satisfaction and dissatisfaction. Levels of satisfaction and dissatisfaction determine the potential for violence and, when it occurs, the duration and intensity of violence. Violence is "triggered" by random events. The probability of such events occurring increases as the potential for violence increases. Consumption demands are met by allocations to personal consumption from the economic sector and other needs are met by human services allocations from the government sector. Increased levels of development, as measured by personal consumption per capita, reduce death (and later birth) rates and increase the productivity of the labor force.

The GOVERNMENT sector receives revenues from the economic sector and allocates them to to human services and to the maintenance and development of its security establishment. Decreased allocations to human services generate political pressures to increase the allocation. The national

FIGURE 4.   MAJOR SECTORS AND INTERRELATIONSHIPS
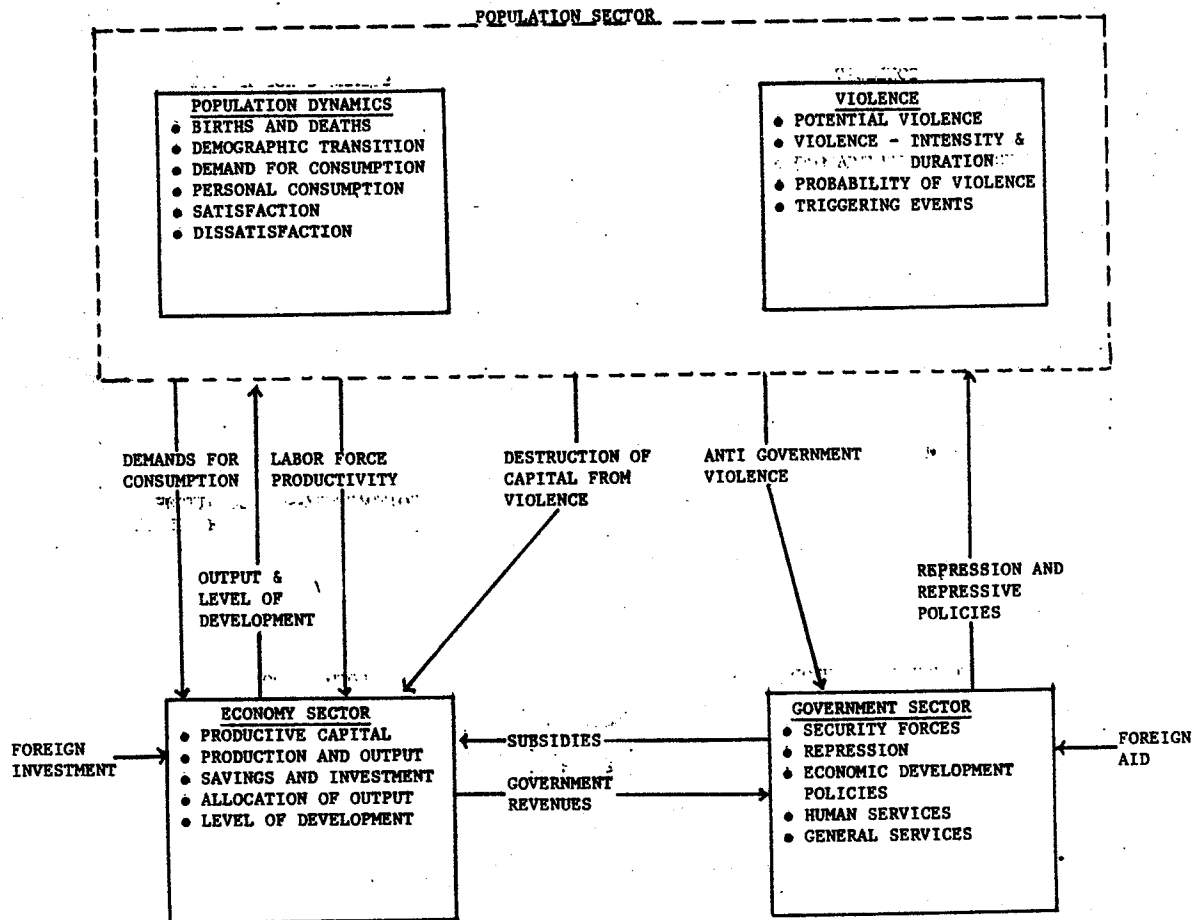
security establishment also generates political pressure to increase its share of the budget.   Its capability to do this increases as its size increases.   Also, it is more effective in exerting pressure in turbulent times than in placid ones.   The government's repressive policies limit the expression of demands and the outbreak of violence.   When violence does break out, the capability of the security forces is be a factor in determining its intensity and duration.   The government can be the recipient of foreign aid which can be allocated to consumption, investment, human services or national security, or, in the form of investment subsidies, it can be used to stimulate the economy.

A simple ECONOMY sector generates output and allocates it in response to demands for consumption, for allocations to government and for savings. The internal dynamics of the model affect the relative weight given to each of these priorities.   In addition, parameters can be set to reflect differing social choices about these matters.   When violence breaks out, productive capital can be destroyed, thus reducing output.   As noted above, the productivity of the labor force is also affected by its level of satisfaction and dissatisfaction as well as by the level of development.

There are nine major levels in three sectors of DEVELOPING NATION, approximately approximately 200 variables and constants and, excluding the definition of constants and initial values, about 90 equations. The model is written in micro dynamo and runs on an IBM PC-XT with 128K of memory. It is not, then, a large model, but it is too large to be fully documented here. What will be done is to present some of the more interesting features. (The model and full documentation can be obtained by sending two discs, plus return postage and $10.00 to the author.)

A DETAILED DESCRIPTION OF TWO FORMULATIONS

A. RATIO OF PERSONAL CONSUMPTION TO DESIRED PERSONAL CONSUMPTION

One of the more interesting formulations in the model is the calculation of the ratio of personal consumption to desired personal consumption (RPCDPC). A DYNAMO flow chart of this is presented in Figure 5.

FIGURE 5. PERSONAL CONSUMPTION AND DESIRED PERSONAL CONSUMPTION
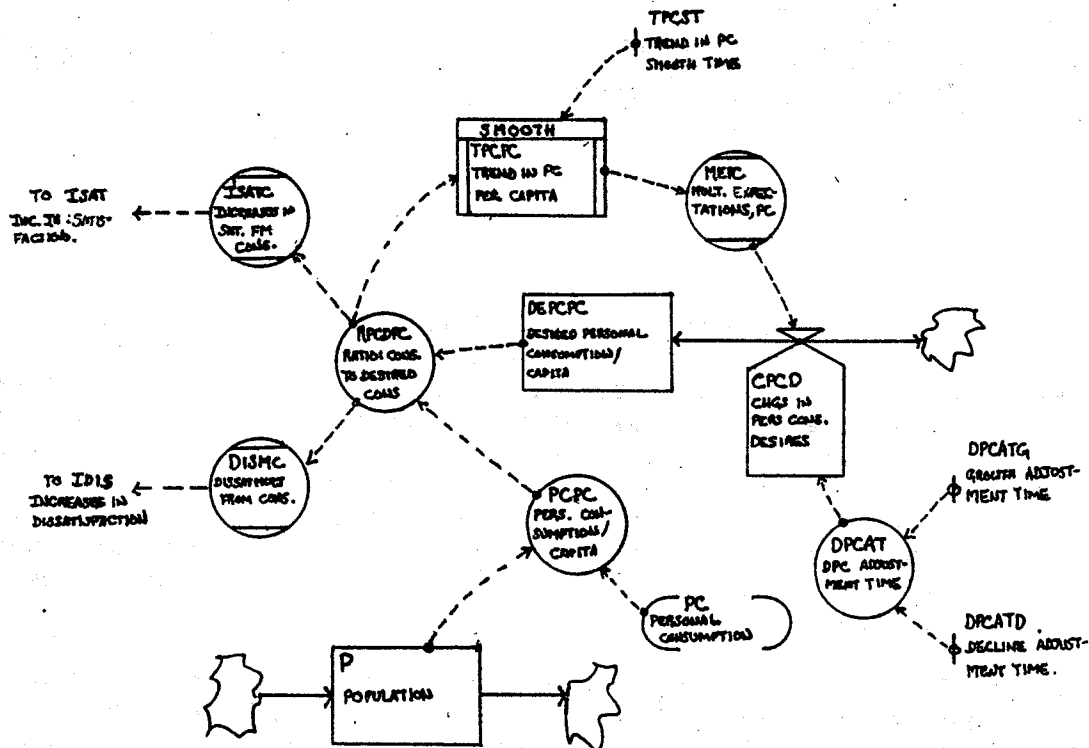
The ratio of desired personal consumption per capita to actual personal consumption per-capita (RPCDPC) is the principal determinant of changes in levels of satisfaction and dissatisfaction. Dissatisfaction levels are also affected by the level of violence (violence actually reduces dissatisfaction in a kind of cathartic process) and by perceived levels of repression (which increase dissatisfaction. RPCDPC is, then a highly sensitive variable in the model and is responsive to changes in performance and expectations.

Desired personal consumption per captia (DEPCPC) is adjusted to reflect the actual performance of the economy, personal consumption per capita (PCPC). However the adjustment is affected by psychological processes that might be categorized on the general heading, optimism. It is assumed that when things are getting better, people assume that they will continue to do so. And even when things are getting worse there is the expectation that they will get better, and dissatisfaction when they don't, at least for a while. Thus, changes in personal consumption desires (CPCD) are affected not only by recent experience but by the perception of recent trends (TPCPC).

In the model, expectations associated with trends (MEPC) exert a much more positive effect on desires when the economy is improving than when it is in decline. In addition, there are differing adjustment times for CPCD when the economy is in a growth mode (DPCATG) and when it is in decline (DPCATD). The former is defined as three years, the latter as six. It is assumed, then at it takes a good deal more time for people to adjust their desires downward in worsening conditions than it does for them to adjust desires upward when things are getting better.

This formulation of the potential gap between expectations and performance is of course, very general, but I believe that understanding and modeling this kind of relationship is one of the keys to understanding the causes of violence in the development process. Gaps between expectations and performance can arise when there is inequality in a society, when communications or advertising raise hopes that cannot be fulfilled, when one class or ethinc group is clearly in a superior or inferior position in the society. And the gaps are exacerbated, of course, by normal fluctuations in economic performance and by failures in policy. Homogenious countries with relatively modest, stable patterns of economic growth would seem to have the best prospects for stable development.

The modeling of satisfaction (SAT) and dissatisfaction (DIS) may also merit brief comment for two reasons. First, the two variables are separate levels affected in different ways by RPCDPC and other phenomena. Thus it is possible to have positive levels of dissatisfaction and satisfaction and the same time. The second comment is that I am not entirely happy with this formulation. Although there is ample precedent for discussing concepts like frustration and satisfaction as aggregate attributes of a society in the sociological and political science literature, I do not believe it is consistent with good system dynamics practice. In later versions of the model I intend to represent satisfied and dissatisfied individuals as well as numbers of people in opposition of the government and participating in violent incidents.

B. VIOLENCE

A dynamo flow chart for the formulation of outbreaks of violence is
presented in Figure 6.   There are two level variables, intensity of
potential violence (IPV) and intensity of violence (V).

FIGURE 6. POTENTIAL VIOLENCE AND THE OUTBREAK OF VIOLENCE
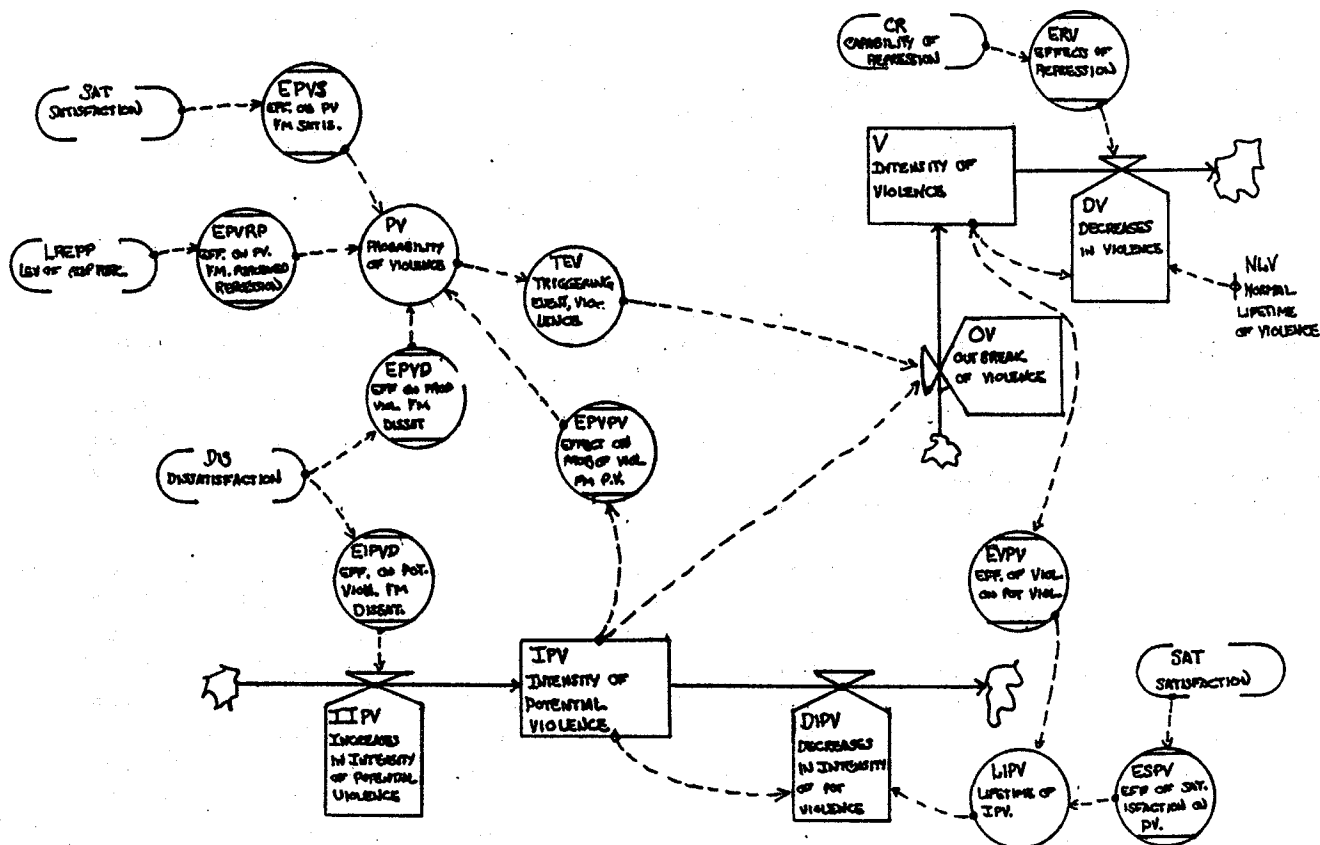
Increases in IPV are caused by dissatisfaction.   Decreases are caused by a
normal lifetime of intensity of violence, by high levels of satisfaction and
by outbreaks of violence.   When violent outbreaks occur, it is assumed that
the potential for future violence is reduced, at least temporarily.   This is
consistent with Brinton's view (19XX).   Gurr and Lichbach point out, on the
other hand,   that outbreaks of violence can breed additional violence(1981).
I   believe that both theories are accurate,   but on different time horizons.
The loop described by Gurr and Lichbach is not presently incorporated in the
formulation.

A violent outbreak occurs when there is a catalytic triggering event   (TEV)
that initiates it.   The equation for TEV incorporates a somewhat unusual use
of the NOISE function:

    TEV.K=FIFGE(0,1,NOISE()+.,PV.K),

where PV is the probability of violence. The equation for PV is:

$$PV.K=(1-(1/EPVD.K*1/EPVPV.K))*EPVS.K*EPVRP.K$$

where: EPVD is the effect of dissatisfaction (DIS)
       EPVPV is the effect of potential violence (IPV)
       EPVS is the effect of satisfaction (SAT)
       EPVRP is the effect of perceived repressiveness (LREPP)

Dissatisfaction and the intensity of potential violence are positively related to the probability of violence. Satisfaction and perceived repressiveness are negatively related, though for different reasons.

When an violent outbreak occurs, its intensity will be determined by the intensity of potential violence. If there is no repression, the half life of violence is assumed to be one year (NLV=2). Higher repressive capabilities, on the part of the government can reduce that. There is a relationship between the repressive capabilities of the government and the perceived level of repression, the latter being determined by repressive policies as well as capabilities. A government can be quite repressive, yet not have the capability to put down an insurrection when it occurs (an excellent example would be the Tsar's government at the time of the Russian Revolution.) The converse can also be true.


PRELIMINARY RESULTS

Two runs are presented here to illustrate the type of results obtainable from the model. The first, presented in Figure 7, is mode of behavior that might be termed, moderate, stable growth. Output grows at a rate of between 3.4% at the beginning of the run and 4.3% at the end of the run. Population growth is about 2.4%. Output per-capita and personal consumption per-capita approximately double during the run. There is a very moderate growth in the size of government and in the marginal propensity to save. Personal consumption, as a fraction of total output, declines from about 80 to about 78 per-cent.

In this run, satisfaction rises slightly above the normal value of ten. Because the government has imposed moderate repressive policies, there is also a modest amount of dissatisfaction. At the end of the run, the intensity of potential violence is about ten per-cent of its potential maximum. There have been three very modest expressions of dissent, in the form of violence, but they have had no serious consequences for the economy or the society.

The moderate growth mode provides an example of a stable society in which desires and performance have been kept in realistic balance. The mode is unrealistic for at least two reasons. First, fluctuations in economic performance are endemic in developing nations. Second, even without fluctuations, influences from the "outside world" or from inequities in the society would almost certainly create a wider expectations-performance gap than is represented here. The mode does, however, provide useful point of reference.

FIGURE 7. MODERATE GROWTH MODE
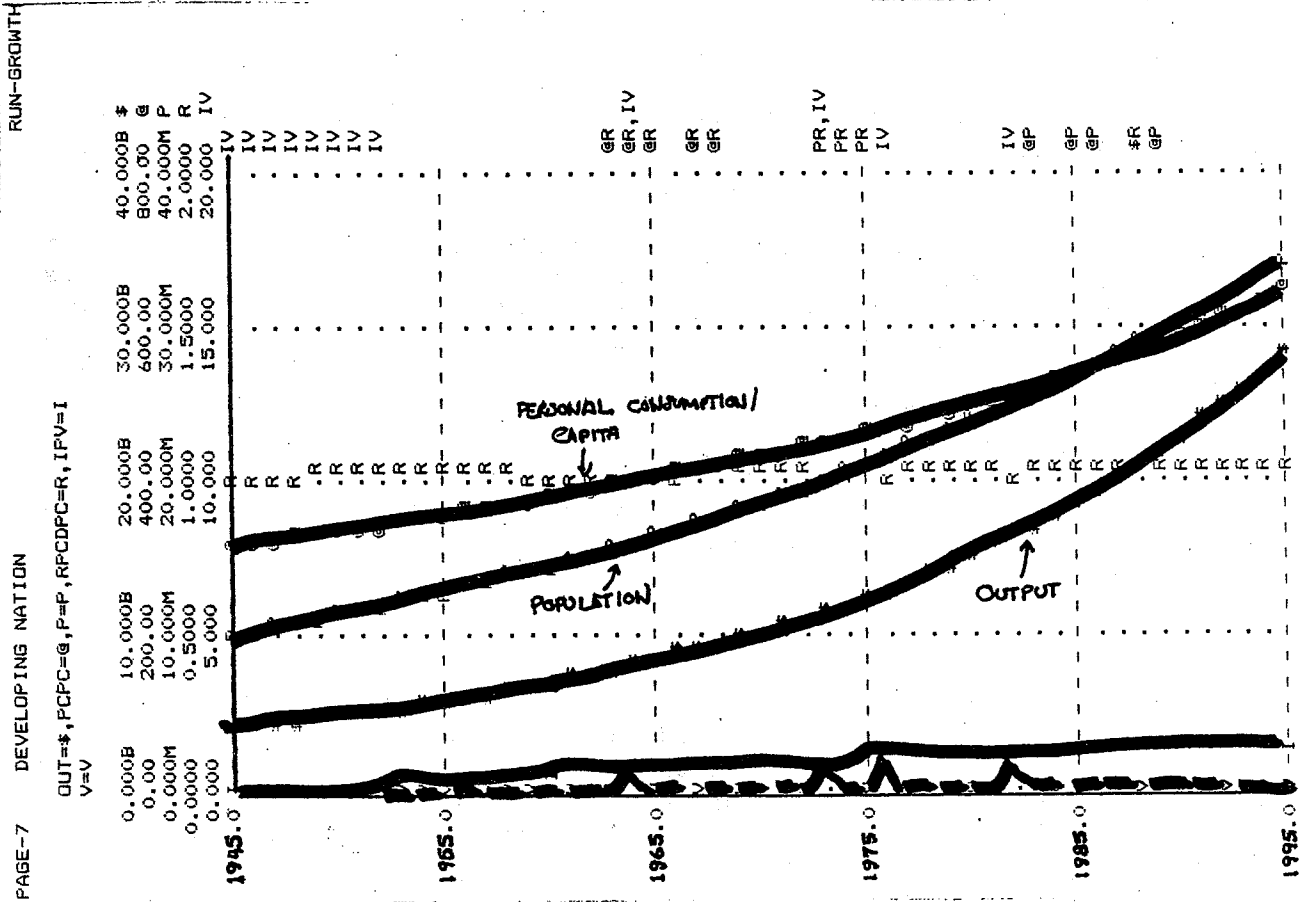
The run pictured in Figure 8 tests the hypothesis that fluctuations in economic performance are, in themselves, a major source of instability in developing nations. This run is similar to the moderate growth mode, up to 1955. But after this year, we assume that increasing modernity and closer links to the developed world lead to fluctuations in the economy. The hypothesis is tested by varying productivity, using a sine wave input, over a period of ten years with an amplitude of plus or minus 25 per-cent. Figure 8 is illustrative graphic output from this run. Fluctuations in output and output per capita lead to unmet expectations. The result is rising levels of potential violence and violent outbreaks that become stronger, more frequent and longer in duration. Savings are shifted to in personal consumption in response to political pressures .for increased consumption. This results in a diminished stock of capital and reduced output. Problems in the economy are increased by reduced productivity (due to the dissatisfaction of the labor force) and by the destruction of capital due to violence. By 1975, the behavior mode of the economy has shifted from growth to decline. The decline continues throughout the remainder of the

run. By the end of the run, in 1995, violence is endemic in the society. Both output and personal consumption are below 1945 levels.

FIGURE 8. FLUCTUATING ECONOMIC PERFORMANCE
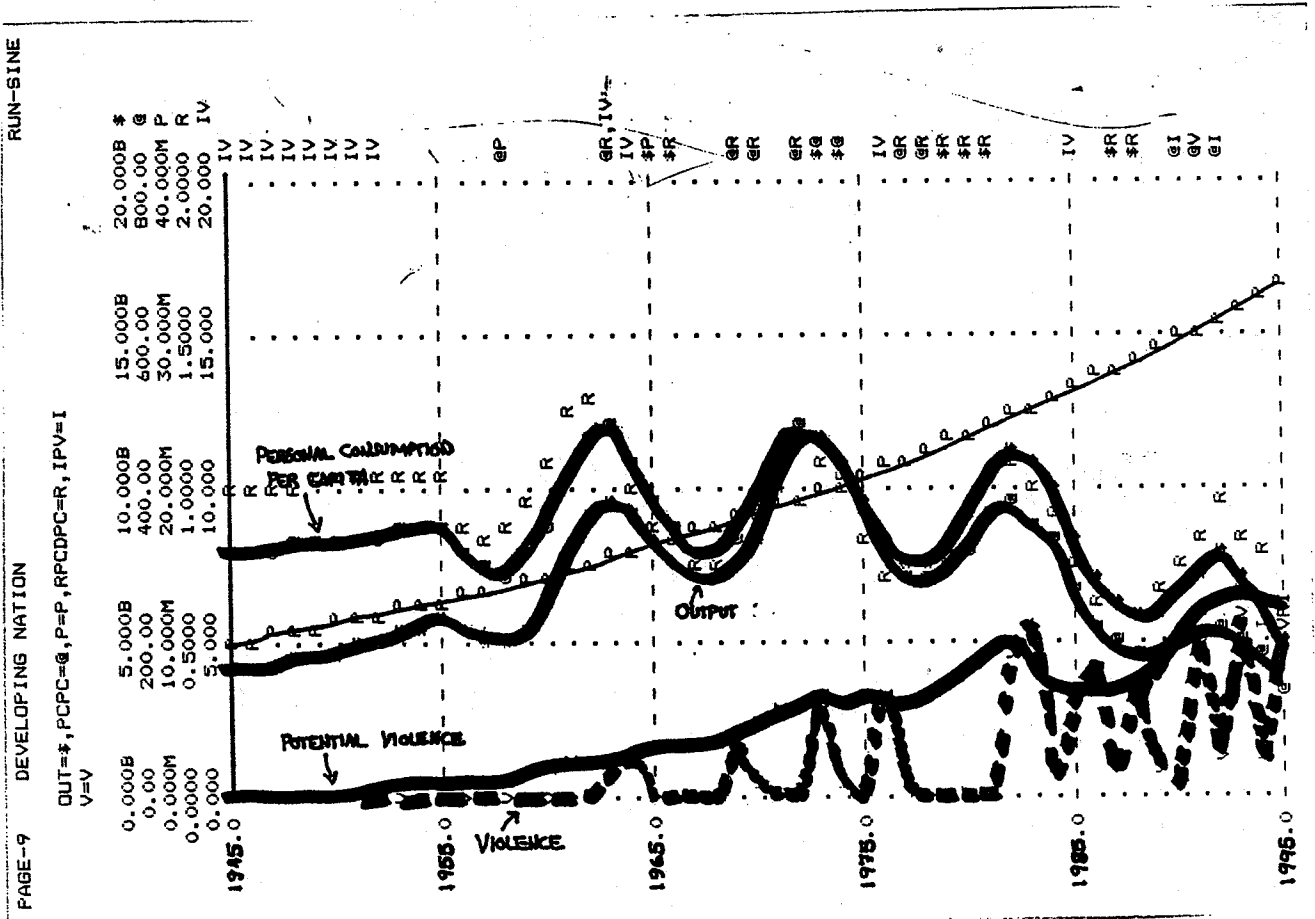
This run provides modest evidence, I believe, that the model is capturing some of the basic dynamics of violence in the development process. Like the first run described, it is not intended to be "realistic". It does provide useful insights and can serve as a basis for further experimentation with the model.

CONCLUSION

DEVELOPING NATION has now completed the first phase of its own development. The model is robust and produces reasonable, provocative results. It offers one theory about the reason that intermediate stages of the development process are so frequently characterized by violence. It suggests the importance of desires and expectations in development. It supports the conventional wisdom that inequitable developing nations are likely to be more unstable than equitable ones.

The opportunities for further work with the model seem promising. Although individual sectors have been subjected to exhaustive sensitivity analysis, I have just begin to explore the implications of the overall structure. This work will continue. Because of its accessability and relative simplicity, the model should be useful in its present form as an educational tool. It would be valuable to parameterize the model for specific developing nations. I believe that the formulation of potential violence and the outbreak of violence should be refined. Disaggregated versions of the model could address problems involving education, disparities between rural and urban sectors, the gaps between rich and poor and ethnic diversity.

The overall goal of this project, as noted above, is to provide answers to the question "how can development, oriented toward ending hunger and meeting basic human needs occur without violence or violent repression." DEVELOPING NATION has begun to identify issues that underlie this question more sharply.

REFERENCES

Banks, Arthur S., Domestic Conflict Behavior, Ann Arbor: Interuniversity Consortium for Political Research, International Relations Archive, 1974.

Bauer, Peter T., Dissent on Development. Cambridge: Harverd University Press, 1972.

_____, and Basil S. Yamey, "The Third World and the West: An Economic Perspective," in The Third World: Premises of U.S. Policy. San Francisco: Institute for Contemporary Studies, 1978.

Berkowitz, Leonard, Aggression: A Social Psychological Analysis. New York: McGraw Hill, 1962.

Brinton, Crane, The Anatomy of Revolution. New York: Norton, 1938.

Dollard, John et. al., Frustration and Aggression. New Haven: Yale University Press, 1939.

Feierabend, I.K. and R.L., "Aggressive Behaviors within Polities, 1948-1962: A Cross National Study." Journal of Conflict Resolution, 1966, Number 10, pp. 249-271.

Feierabend, I.K and R.L., and Betty Nesvold, "Social Change and Political Violence: Cross National Patterns." In H.D. Graham and Ted Gurr, eds., Violence in America: Historical and Comparative Perspectives. Washington, D.C.: National Commission on the Causes and Prevention of Violence, 1969.

Forgette, Eloise M., Civil Violence and the Satisfaction of Basic Human Needs. Unpublished Doctoral Dissertation, The American University, Washington, D.C., 1981.

Gurr, Ted R., "The Calculus of Civil Conflict." Journal of Social Issues,

Volume 28, Number 1, January, 1972, pp. 27-47.

_____,   Why Men Rebel.   Princeton: Princeton University Press, 1970.

_____   and Mark Lichbach, "The Conflict Process: A Formal Model." Journal of Conflict Resolution, Volume 25, Number 1, March, 1981, pp. 3-29.

Kuznets, Simon, Economic Growth of Nations. Cambridge: Harvard University Press, 1971.

Nyerere, Julius K., "One Party Government", Spearhead: The Pan African Review, Volume 1, Number 1.

Olson, Mancur, "Rapid Growth as a Destabilizing Force." Journal of Economic History, Volume 23, No. 4, 1963, pp. 529-551.

Rostow, W.W., The World Economy: History and Prospect. Austin & London: University of Texas Press, 1978.

Saeed, Khalid, Economic Growth and Political Instability. Unpublished model documentation, MIT, August 19, 1982.

_____, Rural Development and Income Distribution: The Case of Pakistan. Unpublished Ph.D. Thesis, MIT, 1980.

_____, "Worker Compensation and Income Distribution in Agrarian Economies: Patterns and the Underlying Organization." Dynamica, Volume 9, Part I, Summer, 1983, pp. 20-32.

Soedjatmoko, Development and Freedom, Ishizaka Lectures 2 Tokyo: Simul Press, 1980.