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Two Aspects of Quantitative Methodology: Uniform Areal Data Units and Analog Simulation

The number, quality, and sophistication of Latin American studies employing statistical and mathematical methodology rose remarkably during the 1960's, and will probably rise even more during the 1970's, The purpose of the present essay is to examine briefly some of the factors contributing to the rise of quantitative methodology, to discuss two specific aspects of quantitative methodology on which I have been working, and to suggest three guidelines for future work.

The principal cause of the rise of quantitative methods was the search for more objective analysis. Traditional subjective methodology had permitted description and analysis of a broad range of geographic relationships without rigid training, detailed research design, or sophisticated measuring and computational equipment. The criterion of excellence was literary. Geographers ranged widely, employed creative and imaginative ingenuity, and provided academia with a haven for scholars who did not want to be molded into the rigid role of many of the more popular disciplines. The principal shortcoming of the earlier work produced by geographers was the subjective nature of virtually all their studies. The 1950's witnessed increasing concern for an objective methodology which would free the geographer, to a greater degree, from his own prejudices. Recent work in quantitative methodology has gone far in doing just that. The criterion of excellence was scientific. The quantitative methodology was further developed in the 1960's and applied increasingly by regionalists, including Latin Americanists.

A secondary cause was the search for a more coherent body of theory that could be applied. Many exciting theories from Von Thünen to Bunge were developed. Unfortunately, these theories were relegated to a relatively unimportant role and were used primarily to introduce a topic, rather than to serve as the basis for studying it. Those who dealt primarily with theory or the application of theoretical constructs were not, as a rule, in the mainstream of geographic thought. The 1950s and the 1960s witnessed the shift of theory into a prominent mainstream, if not the mainstream, of geographic thought. Increasing emphasis was placed on similarities and generalization rather than differences and uniqueness. With that shift came the emphasis on quantitative methods that would permit both formalization of theories and utilization of them as the basis of study.

The advent of the digital computer was the occasion, not the cause of the movement towards a more rigid methodology, The movement was well under way when the first generation digital computers of the 1950's made feasible the computation that expedited tile search for objective methodology and coherent theory. The second and third generation digital computers of the 1960's extended the computational capability. They incorporated a more rigid element into the curriculum for training many, if not most geographers.

Two activities illustrate the introduction of more sophisticated quantitative methods. The first has to do with the basic data units employed for geographic analysis. The second has to do with the computational process, specifically analog simulation.

Uniform area data units

The more rigid methodology forced a number of changes in the way data should be collected. Traditional methodology permitted loose analysis of areas through the use of data collected on the basis of whatever units (normally political-administrative sub-divisions) for which data were available. The varying size of the units injected a variable scale in the geographic reality described by such data but traditional methodology was not greatly affected. The need for data collected on the basis of areal units of uniform size became more critical with increasing use of quantitative methodology.

Beginning in 1964, the author has built a data system for Central America employing areal units of uniform size, The job has been long and tedious and only preliminary results have been forthcoming thus far; the final results should be ready for publication in late 1971 and 1972. There are 18,250 areal units of approximately 12 1/2 square miles, each covering three minutes of latitude and three minutes of longitude (3' x 3') for population and settlement data; the data on other selected aspects of the cultural and physical environment are by 50 square mile units (6' x 6'). These were the smallest areas for which reasonably reliable data could be obtained. (Densidades de Población, 1966). The data will be used to make population density forecasts for each 3' x 3' area for the years

1980, 1990, and 2000. The population projections made by demographers for each of the Central American countries will be redistributed within each country according to measured relationships between population and environmental factors (physical and cultural) as well as theoretical constructs and differing sets of assumptions (Nunley, 1967).

The data system permits a more objective description and analysis of Central America than data based on traditional political-administrative subdivisions, especially insofar as a uniform scale of geographic generalization is maintained. The latitudinal and longitudinal coordinates employed are reasonably independent of the dominant cultural and physical processes of Central America; they also remain relatively constant through time. The data units can be aggregated to different levels of generalization to ascertain the level of aggregation (degree of generalization) at which a geographic association most closely holds.

The data system will serve as an overall context for more detailed studies. Unfortunately there is no easy way to disaggregate the data below the 3' x 3' level for more detailed studies. However, once the general context has been established it will be possible to study selected areas in more detail and use them, within the general context, to infer characteristics of all of Central America. Present plans call for working on three types of more detailed studies. The first is a random sample that will be used on urbanized areas. The second type is of problem areas where residuals from regressions indicate extreme departures from the norm. The third type is opportunistic -- studying those areas for which detailed aerial photography (more detailed than 1:20,000) is available. Feasibility studies are now under way, but the actual detailed studies will not be completed until the late 1970's. Hopefully, they and other such studies will be completed in time to help institute such data units for the 1980 census both here and in parts of Latin America. Additional data are being developed currently for urban areas but they are beyond the scope of the present essay.

A study of preliminary results from the data system led me to conclude that population density maps based on traditional data units should not be labeled “Population Densities by Political-Administrative Subdivisions" but "Political-Administrative Subdivisions by Population Densities." (Nunley, 1968).

Analog simulation

Analog Simulation is a quite different aspect of quantitative methodology. The work being conducted at the University of Kansas on analog simulation, concurrent with the Central American population study, has been directed towards developing both teaching and research models. The models are less expensive and easier to operate than the high-speed digital computer models. They also have a higher intuitive appeal to geographers, particularly those of a non-quantitative bent.

In simplest terms, the analog field plotters involve drawing a map of the study area on paper that is electrically conductive. For example, current is induced into the map at the location of cities in amounts proportional to the size of cities. Electric potential is plotted on the map with a simple probe. The electric potential is directly analogous to Warntz-type population potential maps. The field plotter also demonstrates the hexagonal forms of the Christaller type; produces other polygons depending on the size and spacing of towns; and solves problems of stream profiles, great circle routes, atmospheric pressure, water pressure in an aquifer, the impact of highways, and accessibility measures under different locational constraints. In general, the field plotter permits the solution to complex LaPlace and Poison equations that underlie most of the basic geographic concepts of spatial interaction. Recent breakthroughs in electronic instrumentation and modeling materials have made the field plotter suitable for operation by persons who have no background in either electronics or mathematics (Nunley, 1969) and at a cost of only $500.

A more complex analog simulation model is the resistance network. Such a network replaces the map with a series of nodes. The continuous distribution of the field plotter paper is given up for the increased control of the resistance network. The increased control results from having a potentiometer to control the flow of electrons between each pair of neighboring nodes. Roads and barriers may be erected with virtually complete control. The resistance network also permits many more inputs than the field plotter. Perhaps the major advantage is that the resistance network can be programmed to solve non-steady state problems; the field plotter can only approximate these by a sequence of models. A 64 x 64 matrix of such potentiometers has been built, but it is difficult to use in that the resistance network is slow (it takes about 50 hours to program a problem and 20 hours to read out the results), it requires a knowledge of electronics to operate, and is not available commercially. To build a system large enough to handle meaningful problems would cost at least $10,000 in materials and time. Such a system is more a research instrument than a teaching instrument.

But why all the interest in electronics? In the first place, the simpler models such as the analog field plotter make it possible for a geographer, or an average freshman student, to apply a rigid methodology and sophisticated theory without a knowledge of either mathematics or electronics. In other words, it can bridge the gap between the so-called traditional geographers and the quantifiers.

Another reason for concern. and one that relates to Latin America and other developing areas, is the need to teach geographic concepts to our counterparts and planners in Latin America. The materials on the field plotter are being translated into Spanish and we plan to use them to teach the basic concepts to Central American geographers and Central American planners. Research of Anglo Americans will not be used in Latin America as effectively as the research done by trained Latin Americans (Nunley, 1970). Thus the field plotter should be an effective teaching and research instrument both in this country and abroad. Resistance networks could be made available in a few research centers in Central America.

The final reason for interest in electronics is an important one. It is an inherently intriguing instrument with a high intuitive appeal for geographers. Working with it has much of the excitement of field work. It is not a substitute for field work; rather it drives one into the field with very specific objectives. It appears to have the capability of bringing experimental science into the geography laboratory.

Guidelines for the future

Several guidelines for the 1970's may he suggested based on the above discussion. First, geographers working on Latin America should have as complete a set of tools as possible. If the problem they are working on requires the use of aerial photographs, they should become photo interpreters. If remote sensing imagery is available and can do their job better, they should make themselves familiar with such imagery and its interpretation. Similarly, if a more objective methodology and more coherent theory can improve their studies, they should become more familiar with them.

Secondly, they should hold onto (yes, even improve) the capabilities and delights of the field observer employing traditional methodology. Language training is very important; a broad background in the cultural development of the area is indispensable; a "feel" for the area under study is more important than ever. The cliche in computer work, "Garbage in, garbage out," can be guarded against when employing quantitative methods only by the kind of understanding which traditional training in the regional geography of Latin America gives. If such regional training is lost, geography will become a narrow specialty and lose the kind of refreshment that the academic world needs and that attracted most of us to it.

Thirdly, combining the first two, geographers should bridge the gap between the quantitative and traditional groups. This means the geographer must become more of a generalist. Perhaps it means that more cooperative research will be necessary in order that the group will be able to attain the competence that one individual cannot. It probably means that the amount of learning required after one receives his doctorate will be greater in the 1970's than ever before; if so, it might not be a bad thing.

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