

Geography, Space, and Science: Perspectives from Studies of Migration and Geographical Sorting

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For the past four decades a significant subset of geographers have had a strong interest in using scientific methods and tools to answer questions about society and societal change. The scientific endeavor, learning and verifying new knowledge, has been at the heart of this project. Even though the discipline as a whole seems currently less interested in the classic science project, that project continues within geography and is a part of the wider social science community's attempt to provide verifiable and useful knowledge to a wide range of stakeholders. The findings from studies of migration and the life course, and segregation and geographical sorting reemphasize the very real contribution of spatial science to understanding societal change. Recent work on the geography of neighborhoods and mobility with the context of legal contestation goes beyond academic research per se to show the continuing relevance of an informed scientific approach and the contributions of geography beyond narrow disciplinary boundaries.

Introduction

The scientific approach in geography was more evolutionary than revolutionary and has been told and retold in numerous essays and compendiums. There is a long history in geography of trying to provide numerical measurements of a wide variety of geographical phenomena. While physical geographers were always concerned with measurement, the process of statistical formulation and analysis was slower to develop in human geography. As we know, it was the work of Garrison and his students at Washington (Garrison 1956; Garrison et al. 1959) presented at the Lund Symposium in 1960 and synthesized and extended by Haggett (1965) that set out a research agenda that was influential for several cohorts of graduate students.¹ The diffusion of new graduates from Washington and research on spatial structures

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(Dacey 1964; Berry 1967), geographic scale (Tobler 1963), and urbanization and economic development (Berry 1961) set the context of much of the early work that used statistical methods and the “scientific approach.” While some of that early work can in hindsight be seen as overly ritualistic in its approach, it provided a way of thinking, a way of organizing data, and a way of presenting results, which still stands us well today. To the extent that we arrange our approaches and organize our material in a repeatable manner, we are engaging in the most elemental approach to creating new knowledge. I am centered within the group of academics who argue that things are knowable even while acknowledging that objectivity is a difficult path, and of course knowledge is constructed within a social context. Still, I believe that careful measurement, thoughtful modeling, and testing and evaluation are at the core of understanding and measuring change in society. Moreover, it is only through these processes that we can inform policy makers on how we can proceed in dealing with the problems thrown up by an evolving and changing society.

John Dewey wrote more than a century ago that “the future of our civilization depends on the widening spread, and deepening hold, of the scientific habit of mind; and that the problem of education is therefore to discover how to mature and make effective this scientific habit” (Alberts 2004). A culture of science is critical beyond knowledge for its own sake. It is not that science alone will create a more prosperous and rational world but without science we are susceptible to media pundits who outline simplistic solutions to complex problems (Alberts 2005) and many of these complex problems are at their heart geographic problems. From issues of sustainability to social problems of concentrated poverty, it is only science that will provide us a structure for analyzing, evaluating, and providing solutions. Appeals to social inequality without definition, to the White power structure, or to White racism will likely not increase our understanding of social problems although they may resonate with some constituencies.

Science has two roles: increasing our understanding and providing a basis for understanding those findings. Science is “an unending frontier in the long struggle of human beings to understand the world that surrounds us” (Alberts 2005). Science builds upon old knowledge to create new ways of understanding and manipulating our world to produce benefits for humanity. Within this framework we social scientists tackle some of the most difficult problems. Social science is not rocket science, it is more difficult!² It is a truth that is increasingly apparent in the world of science as physical scientists turn their attention to social problems, problems that are outside the realm of the natural world. Those of us who have struggled with these problems for the past three or four decades realize that we have only begun to make inroads on the social problems that face our postindustrial societies.

After restating some generalizations about science and social science and particularly the difficult role of making generalizations about behavior in a spatial context, I examine some of the policy extensions of analytical research. A recurrent theme in the discussion that follows is the way in which the spatial sciences,

geography, and environmental studies are necessarily involved in the larger policy issues of “what to do” in planning for the future arrangement of our society. Where should people live, what arrangements do we need for getting people to work and to school, what sort of communities do we want to live in, and what sort of environment will be the umbrella within which we live? These are critical questions and require basic research on the components that will allow informed judgments about how to proceed in the future.

Earlier I suggested that science and policy are inextricably linked and I suggested that science can be translated into informed decision making. Thus, policy is linked to outcomes from basic research. “It is irrational for a government anywhere to make decisions without sound scientific advice” (Alberts 2005), although in fact decisions are made without scientific advice and sometimes even contrary to the advice. Still, at least the basic information is on the table. None of this is to suggest that science can tell government what to do about a particular problem. However, it can say, if you decide to allow x percent of some known carcinogenic in the water supply, it is likely to have this effect in one, two, or three decades from the present. The ability to evaluate a program, to test a particular input, this predictive ability is what gives science its power in the greater process of decision making in the wider attempt to structure society for the greatest good.

Testing and rejecting, and predictive power, have been central in the natural science community but it has been more difficult to place them at the center of the social science disciplines. Still, predictive ability is what makes science critical for policy makers. Knowing what is likely to happen is a critical element of making decisions in the future. Within the social science community the issue of prediction has been less central, but it is something that the social science community is still wrestling with in the concern to be relevant in a complex world (Alberts 2004).

Science is at one and the same time an international endeavor and a local concern. Solving a problem for a neighborhood is only one element in the scale of trying to solve problems globally. These are the issues that will be a part of the substantive contribution of this presentation.

The science of space and the science of behavior in space

The last four decades have moved geo-demographic research from cross-sectional analysis to an emphasis on dynamic systems and a concern with movement in space. Dynamic spatial modeling grew up to improve our understanding of the evolution of phenomena through time under various degrees of spatial constraint (Griffith and MacKinnon 1981). A substantial part of the research focused on partitioning space into regions or neighborhoods and studying the processes of movement through those spaces and explanations for the time space patterns that emerged. In essence, the focus on migration and sorting are still derivative from those conceptualizations. While the initial work was often theoretical rather than

empirical, it laid the foundation for the empirical studies and modeling of migration and sorting.

The research on spatial modeling attempted too to integrate the behavior of households and individuals. How do households make choices of where to shop, where to live, and how to make the journey to work? These spatial behaviors became central to the development of theories of the growing field of spatial behavior (Gollledge and Rushton 1976). Borrowing ideas and techniques from psychology, psychometrics, and transportation economics, geographers provided new theories to help understand the choice-making process and how spatial behaviors and outcomes can be tied to the geographic context in which they arise. That research was an important element of the growing work in geography on migration (Brown and Sanders 1981), mobility (Moore 1972), and neighborhood choice (Moore and Clark 1990).³

Not only is it difficult to model behavior in space, but for much of the past three decades the other social science disciplines proceeded without much attention to spatial structures or to the work by geographers. Economists concerned with microeconomic processes focused on individual responses to pricing, sociologists looked at group behavior, and political scientists considered party affiliation and voting outcomes. Only slowly, and essentially driven by the increasing availability of spatial data, have these disciplines begun to acknowledge the contributions of geographers and how research findings change when economic, social, and political processes are examined with specific attention to space and behavior in space.

Economists now acknowledge the role and power of space in their recent work. Krugman (1991) in particular has espoused a return to geographical economics to a new economic geography. Still, for many geographers, the theorizing about economics in space has still to focus on real places (Martin 1999). The preoccupation with abstract models, with points and lines, echoes the early work in abstract geometries by geographers and the often-barren abstract analysis of point patterns and concentric circles. Economic geography has come a long way since those abstract conceptualizations and is more concerned with topics like "flexible specialization" and its impact on the organization of economic activities in space. There is a more complete discussion of the differences between economic geography and the new geographical economics in Martin's (1999) recent critical survey.

Political scientists, or at least some subsections of the discipline, have long been concerned with the spatial structure of voting and districting and even more so with the evolution of powerful GIS methods for creating and changing voting districts. Different electoral districts create very different outcomes for legislatures and representation in general. How voters are grouped into districts also affects the balance of power between political parties (Forest 2005). It is little wonder that districting and redistricting has become a major focus of political scientists and others interested in voting outcomes. The technical ability to organize voting districts has increased especially since 1990 when GIS technology became a central part of the redistricting process and space per se became more important. As Forest

notes, GIS technology is now the major way in which districts are created and recreated. GIS can display and manipulate the basic data, demographic, and voting, which is the basis of creating a voting district—a geographic district (Forest 2005). Clearly, geography is at the heart of this process but beyond districting and redistricting political behavior is not much investigated. The recent work that examines whether neighborhood interactions influence voting outcomes is still at the margin of much in the political science literature.

Sociologists and health scientists are now interested in space from the perspective of neighborhood effects. There is a growing literature that claims significant personal effects from the neighborhood of residence. Nowhere have there been more concerted efforts to measure neighborhood effects than in health outcomes. As Diez-Roux (2001, p. 1783) notes, we “have witnessed an explosion of interest in neighborhood or area effects on health.” Much of the interest in area or neighborhood effects comes from the increased interest in social determinants of health and the idea that social influences may operate through the types of areas or neighborhoods in which people live. The health research draws on the notion that neighborhood contexts may be related to health outcomes independently of individual-level attributes, but it is just this issue that is at the heart of the research by Durlauf (2004), among others, which suggests that we view with caution neighborhood effects. Much of the work appears to be in the “correlative vein,” the way in which individual outcomes vary across areas. As we noted earlier, this does not establish area causation. Neighborhood differences in outcomes beg the question of the causal processes underlying the outcomes.

Much of the attention to geographical processes has been stimulated and extended by the growth in spatially referenced data. As data with general or specific geographic coordinates have increased, there has been a growing interest in mapping and analyzing those data. But while geographers have long worried about the definition of spatial units that are used in any spatial analysis and the difficulty of making inferences from spatially aggregated data, that worry is only now being recognized beyond the geographic community. The modifiable areal unit problem (MAUP), the impact of varying sizes of a spatial unit on a particular outcome, has been of concern in geography for two decades (Openshaw and Taylor 1981). In general, most geographers argue that linear and logistic regressions are quite sensitive to the size and structure of the areal units (Fotheringham and Wong 1991), and we must proceed with caution in using any areal data. The question that is central is whether different-sized units affect the results of models of socio-spatial phenomena. To counter the MAUP difficulty and with the increasing availability of individual geo-referenced data, geographers have moved to spatial smoothing and the specific inclusion of weighting matrices to account for distance decay effects over space (Anselin 1988).

The socio-spatial linkage will only increase in relevance. It may be, as has been argued recently, that this linkage is the “key to the advancement of science.” That may be going too far, but with the increase in geo-coding, tracking, and linkage to

larger spatial units, it is clear that spatial location will be more, not less, relevant in description, analysis, and policy. I will return to this issue in the policy discussion later in this article.

Space, place, and the contribution of geography to science and policy

Migration and the life course

Research on migration and residential mobility has provided a set of well-accepted findings on the process and outcomes of residential change.⁴ We know a great deal about the correlates of migration, we have models of the choice process, and we have provided a rich set of findings on the gender basis of migration and mobility. Much of this research has been set within the structure of the human capital model, and the research has documented the process whereby households evaluate current and potential locations that can fulfill their housing, job, and neighborhood needs. We know that household moves are triggered by changes in household composition, especially the addition of children and marital dissolution, that they are responsive to job changes as households try and control their commuting distances, and that changes in the composition of neighborhoods can stimulate residential change.

Geographic research on residential mobility and migration was initially set within the notions of the life cycle, the notion that passing through various stages in the life cycle led to short- and long-distance residential change. Much of that research focused on the aging process and linked various ages to mobility and migration behavior. However, increasingly it became clear that even though age is clearly intertwined with mobility and migration, it is not necessarily a good predictor of mobility and migration and it was even more difficult to create distinctive stages in the life cycle which had predictive outcomes for mobility and migration. As household and family composition changed, as the age at marriage increased, and as alternate family compositions (single-parent families, two-earner households without children) emerged, it became clear that stage in the life cycle was no longer an adequate formulation for the link between family composition, age, and mobility outcomes.

An alternate formulation to the stage in life cycle, a formulation that is more responsive to change, the life course, provides a structure in which multiple processes—family formation, job changes, and housing change—can be linked together (Clark and Dieleman 1996). The life course asks about the linkage between these processes and disengages mobility and migration from changing age per se. As families change, at different times (ages) for different families, these “events” can be modeled with event history models. Event history analysis uses statistical methods to examine events, their timing, and the intervals between them. Of course, event history analysis requires panel data, but as these data sets have become available (the Panel Study of Income Dynamics in the United States, the British Household Panel Study, the European Panel and the Dutch Housing Panel), it has been possible to introduce timing specifically into the mobility process. Thus,

while the life cycle emphasizes a set of predetermined categories through which a household passes, the life course emphasizes, not the categories but the trajectory from young adulthood through death. These life course models of migration have focused on labor force access in the context of the increasing labor force participation of women. This research has been designed both to broaden the human capital formulation (from the individual to the family) as an explanation for migration and to incorporate the changing nature of the family into the research on migration and mobility.

As more women pursue not just employment, but professional careers, balancing family formation and family support (jobs) becomes more difficult and leads to difficult trade-offs (Clark and Davies Withers 2002). It is now well established that the traditional family where the husband worked and the wife stayed home is less and less common. It will soon, if it is not already, be the exception. The outcome for mobility and migration research is that the decision making has become more complex and the spatial outcomes more diverse. The change in family composition has also led to research that has placed the gendering of migration at the heart of explanations for moving, and entry and exit from the labor force (Cooke and Bailey 1996; Boyle et al. 2001). The research has added an additional complexity to the research on migration by emphasizing the impact of family relations on the probabilities of entering or leaving the labor market. Still, the issue of labor force participation, and by implication the geography of labor force participation, is at the heart of studies of mobility and migration—who gains and who loses and how much are still questions that are fundamental in studies of migration. A focus on the way in which migration disruptions and disruptions in the labor market are interconnected and in turn translated into family changes has enriched our understanding of the migration process. It is clearly more complicated than past studies of male earners moving in response to job opportunities.

By and large, most economists have not been especially concerned with the impact of place on the migration process. For the most part, the focus on place has been limited to incorporating measures of unemployment or of city size as explanatory variables in the likelihood of a woman reentering the labor force. Place is in fact central in recent work that challenges two enduring beliefs about migration—that migration leads to economic gains and that family migration is detrimental to wives. Both issues have been central tenants of work in economics for the past two decades (Smits 2001). In the Smits (2001) paper, the belief is so strong that he challenged the empirical findings when the data did not confirm the view that men make gains from migration. In this presentation I do not have time to explore the logic that has led to these two beliefs, but I want to summarize recent work by geographers that challenges and reinterprets both statements. One of these involves a specific consideration of space and place, the other a focus on gender migration and the role of the family writ large.

In general, the human capital theory has always argued that households move for economic gains as measured in the labor market. Earlier research tends to sup-

port his overall view of the migration process. But what of the situation when migration does not provide an economic gain? How can we interpret those results? In new research, we argue that “since virtually all studies of the economic returns of migration for wives and their families use nominal earnings, the geography of these moves has been completely ignored” (Davies Withers and Clark 2006). By including the geographic variation in the cost of living, we are able to estimate whether migration is a net benefit or leads to a net loss in the migration process. Because the cost of living, and especially the housing proportion of the cost of living, varies markedly between places (the units of analysis in this research are counties), we can adjust the nominal incomes at the origin and destination by the cost of living to compute a “return to migration.”

It is not possible to repeat the extensive research results in Davies Withers and Clark (2006), but two empirical findings are important. First, the “returns to migration” vary considerably on the basis of whether the migration is to a more or less affordable “place”; second, the outcomes for women are also geographically dependent. Wives exit the labor market when the move is to a more affordable place, and wives enter the labor market when the household moves to a more expensive housing market (Davies Withers and Clark 2006). The research shows that it is essential to set migration within the geographic context, and to the extent that economic analysis alone does not do this, it fails to explore the nuances of family migration and its outcomes. The new research accomplishes what has long been a goal of quantitative research, to link migration and the local housing market and show the nature of the links between the two (Clark and Huang 2006). Again the research emphasizes just how space and place matter in the outcomes of choice and decision making.

These same issues of the role of place are central in the debates about international migration. It is not news to report that there has been a dramatic rise in both the number of documented and undocumented immigrants arriving in the United States in the last decade or decade and a half. Now there are about 35 million foreign-born residents in the United States. This includes about 10 million legal permanent residents, nearly 12 million naturalized citizens, and about 11.5 million unauthorized migrants. The fact that about seven and a half million of the 11 million unauthorized migrants arrived in the last 10 years is what makes this change so different from the flows of immigrants in the past 30 years. The increase in immigration, and in particular in unauthorized immigration, has led to calls for both amnesty programs and greater enforcement on the U.S.–Mexican border.

Much of the debate about international immigration has been about the economics of the new flows. Do the recent immigrants impact the wages of the native born or the previously arrived immigrants? Do immigrants cost more than they contribute to the economy? These questions have been at the heart of the debates about the flows in the past two decades and the debate continues. However, there is growing attention to a new, and more obviously geographical issue. What are the

impacts of new immigrants on communities and neighborhoods? Is poverty increasing in inner-city neighborhoods where immigrants concentrate? What are the schooling outcomes for immigrants concentrated in inner-city neighborhoods? These questions reiterate how important the quantitative geographical approach is to understanding the outcomes of this changed context of international flows.

Sorting, segregation, preferences, and policy

Three decades ago, Thomas Schelling (1971) published his important paper on how sorting occurs in the residential fabric. That paper provided a theoretical basis for why groups cluster together, whether in the lecture hall, the dormitory, or the residential neighborhood. The core of his argument is that quite small differences in the preference of an individual to be with someone similar (e.g., in ethnicity) can lead to markedly distinct patterns of separation in the residential fabric. The core of the Schelling argument draws on the individual preferences tradition in economics to show microlevel voluntary choices, and economic competition can create or maintain macrolevel patterns of residential segregation along ethnic and socioeconomic dimensions. Schelling (1971, 1978) also provided an extended discussion of the nature of tolerance and how tolerance relates to the creation of preferences.

The attempt to provide an empirical test of the Schelling conceptualization used survey data on the expressed preferences of samples in a variety of U.S. cities. Those studies provided extensive data on the combinations of races and ethnicities that were “preferred” by urban residents (Clark 1991, 1992). The conclusions of, now, more than a dozen studies demonstrate that there are differences across racial and ethnic groups in the preferred combination of other race groups. Initially the research focused on the differences between Blacks and Whites, where Whites preferred mostly White neighborhoods and Blacks preferred 50/50 neighborhoods of Blacks and Whites. That research was later extended to other races and groups and shows that own-race preferences are strong across all groups.

Those empirical studies led to an extensive debate about the relative contribution of preferences to the explanation of residential separation. In essence, is a reliance on preferences alone, enough to explain the continuing separation in the residential fabric? A vigorous debate (Clark 1986, 1989; Galster 1988) examined the relative roles of multiple variables as explanations for ethnic and racial separation. Among the explanations, several papers sought to provide an empirical basis for preference-based explanations for separation. Those papers (Clark 1991, 1992) showed that there was an empirical basis for Schelling’s theoretical model, and extended the empirical analysis from Black–White preference relationship to multiethnic explanations for residential separation patterns. Research on actual mobility related expressed preferences to actual behavior and showed that behavioral selections were even more likely to generate separation than expressed preferences. The recent paper by Krysan and Farley (2002) acknowledges that residential preference held by Whites and Blacks are not compatible with integration even

though they, like many other critics of preference studies, revert to a discussion of White hostility to explain these preferences.

An underlying motivation, at least from my own perspective, of the debates was to redress what I saw as an unsupportable one-dimensional explanation for the patterns of residential separation. I also found that court decisions were being founded on what I believed were incomplete explanations of households' behavior and neighborhood change. From my research, it was clear that discrimination alone was insufficient to account for the extent and continuing nature of residential separation. A review of survey evidence on reasons for moving, an analysis of affordability and the potential differences created by differences in preferences created a more multifaceted explanation for continuing separation. While discrimination undoubtedly played a role in the patterns of separation, it was far from the only factor and perhaps not even the most important factor in explaining separation. That research stimulated a reassessment of the reliance solely on discrimination as the explanation and a recognition that the explanation for continuing segregation is multidimensional.

However, as Fossett (2006) so presciently notes, these studies did not show "how" preferences created the patterns of separation, and no model provided an explanation of how preferences and the urban structure intersected to create patterns of residential segregation. Thus, the thrust of his research is to use simulation methodology to explore the theoretical question—"is it reasonable to entertain the hypothesis that social distance and preference dynamics could generate and sustain significant levels of segregation in the absence of discrimination?" As we will see later in this discussion, the answer is yes.

Agent-based modeling and neighborhood sorting

The new research on segregation uses simulation and agent-based modeling to explore segregation dynamics. The core of the research approach is to create a way of testing how alternate specifications of preferences can generate different residential patterns. What is agent-based modeling and how is it relevant in geographical investigations of segregation and separation? Agent-based modeling conceives of agents (households or individuals in the context of the Schelling formulation) who decide to move (and make choices of where to move) in response to local racial composition. We can think of this in a game-theoretic context with feedback loops. An agent may want a neighborhood with half Black and White residents but a resident of the neighborhood does not want to live in such a neighborhood and moves away, thus reacting to the initial move. By doing so, the neighborhood composition changes. The agent-based model simulates these decisions over as many intervals as the researcher feels are relevant for the system. Clearly, while the system is dynamic it is also stylized and closed. We do not have new housing and neighborhoods being constructed, housing is not demolished and so on. These may be incorporated eventually, but for the time being most agent-based models do not

operate in a dynamic housing market, although the best of them include housing market costs as a central element of the decision-making process.

What have we learned from agent-based modeling, what new insights does the work provide? Several iterations of a specifically designed agent-based model have enriched our understanding of the Schelling model and of the operation of segregation in the residential mosaic. The SimSeg model (Fossett 1998) was specifically designed for the purpose of conducting simulation experiments of segregation dynamics (Fossett 1998, 2006). In the formulation, agents are “virtual households with the ability to search in a virtual housing market and make residential choices. Households have preferences for co-ethnic contact specified in terms of the percentage of co-ethnic households found in the neighborhood in which the household lives or to which it is considering moving” (Fossett and Warren 2005, p. 1895). In various versions of the SimSeg model, housing values are incorporated to create a “more real-world” housing market.

The results of the SimSeg model are compelling (Clark and Fossett 2008), although there are still discussions of the technical points of the modeling process (Bruch and Mare 2004). The results of the simulation can be summarized in three major findings. First, ethnic preferences have the theoretical capability within the constraints of the model, of course, to produce substantial levels of ethnic segregation *without* discrimination. Second, ethnic preferences and social distance dynamics not only generate high levels of majority–minority segregation, but high levels of minority–minority segregation. Third, hypersegregation can arise in the context of the simulation model and is an outcome of the interaction of housing quality, neighborhood quality, and ethnic preferences. He summarizes the totality of his findings with the notion that ethnic segregation may be sustained by multiple sufficient causes, including preferences and discrimination. I would add in addition, as the model specifically takes housing quality into account, that the sufficient causes are, as I have argued elsewhere, economics (affordability), preferences, and discrimination. That the outcome supports arguments that I have made elsewhere (Clark 2002) is of course pleasing, but beyond that validation the model provides us with a tool to examine other formulations and to further test these first outcomes.⁵

Despite a claim by Zhang (2004a) that he was the first to provide a rigorous model of the Schelling formulation (several presentations by Fossett [1998] predate his work), he does provide a mathematical interpretation of the agent-based simulation model. That interpretation shows that segregation, or as I prefer the neutral terminology of separation, is a stochastically stable state “that tends to emerge and persist in the long run regardless of the initial state” (Zhang 2004a). It is the finding in Zhang’s study that patterns of separation by race emerge, whatever the initial state, that confirms other studies that have investigated the mechanism of separation and its dynamic.

The finding that separation can exist in the residential fabric even if most people prefer integrated neighborhoods is important because it explains the continuing patterns of separation even in a world that is increasingly tolerant and where

society has made major attempts to eliminate discrimination in the housing market. Of course discrimination still occurs but we do not need to invoke discrimination to observe separate residential areas in our cities. “Without any discriminatory behavior in the housing market a slight preference for like-color neighbors . . . can give rise to a high level of residential segregation and cause it to persist” (Zhang 2004b, p. 164). Asymmetrical preferences are an important element of understanding continuing separation.

While the work by Zhang has provided an initial mathematical explanation for the sorting patterns that we see, it is the simulation work of Fossett (2006) that provides the context and a richer link to an urban housing market with prices and actual mobility behavior and vacancies.⁶ The SimSeg model provides substantial evidence that his decade-long approach to the problem has taken us a major step forward in the process of understanding the way in which segregation comes about and provides a compelling spatial presentation of those processes.

Changing places and policy intervention

Place and mobility are increasingly the focus of policy concern. In particular, there is a concerted effort to understand the spatial concentration of poverty and by extension how we might redress the inner-city concentrations of poverty that are common in many central cities in the United States. The questions are natural extensions of the discussion in the previous section—questions about the separation of poverty populations and the role of neighborhoods in creating particular outcomes and whether mobility opportunities are a viable method for solving these problems.

Neighborhoods and communities have been reified as places of importance in a variety of socioeconomic outcomes. The question about neighborhood effects has generated a substantial and growing literature, which examines the additive marginal effects of neighborhoods on residential outcomes for inner-city poverty populations (Galster 2003). Additive, that is, in terms of explanatory power after controls for socioeconomic and demographic characteristics of the household. The literature has struggled with questions of just how much is attributable to the neighborhood and how much is related to family composition (Dietz 2002). There is an increasingly divided approach whereby some suggest that where you live does matter—certainly an outcome that is consistent with much geographic literature on the role of place, but an equally strong position is that nearly all the outcomes are attributable to household composition.

Diez-Roux (2001) does a good job of identifying the problems of doing research that includes neighborhood measures. She notes the issues of neighborhood definition, the lack of distinctions between neighborhood and community, specifying the relevant neighborhood characteristics and the difficulty of distinguishing individual and neighborhood effects on any particular outcome. Significantly, for this paper she identifies geographic scale as a key issue in measuring environmental

characteristics (Diez-Roux 2003). Not only is it reasonable to assume that different scales may be relevant for the study of different processes, or to put it differently some processes may operate at very local scales while others operate more broadly across larger environments. Clearly, blocks or groups of blocks are important for social interaction but service areas for health or even shopping may be relevant for other outcomes. She reiterates that to date there has not been much attention to the effect of scale.

People move to and through neighborhoods. Local and international flows change communities, especially their demographic composition. These changes in turn interact with school composition and issues of racial balance in schools. Interventions designed to produce particular outcomes may or may not succeed because of local urban dynamics. The research on mobility within the parameters of legal intervention provides a contested evaluation of the role of social science in predicting outcomes. Can we provide a solution to poverty by moving households from high-poverty to low-poverty areas? Will households who are enabled to move from inner-city poverty neighborhoods to suburban low-poverty communities have better outcomes in employment, health, and education levels for the children of these families? At first thought the answer seemingly must be positive, of course a family moving from a high-poverty to a low-poverty area would be advantaged. But is it this simple?

Within the context of the metropolitan change it becomes more difficult to be so sure about the outcomes of policy intervention. The moving to opportunity program of the Department of Housing and Urban Development (HUD) was designed as an experimental program to evaluate whether a special mobility program would increase the likelihood of inner-city households moving to suburban and low-poverty neighborhoods (Clark 2005). However, well intentioned, such programs must be set within the content of changing metropolitan areas and the restless nature of American households. Cities change and people within cities make changes to bring their residential aspirations into adjustment with the available housing composition. Even when households are provided with incentives to locate in particular low-poverty neighborhoods, changes in their household and external opportunities can change their location choices over time. Indeed, we find that many households that moved initially to low-poverty neighborhoods later relocate again and the outcome was to reduce the policy aim of having these households live in low-poverty neighborhoods. Why did this occur?

As in all such situations, the intervention is in a dynamic system, and despite the good intentions of the policy intervention, the combination of changing household composition, changing urban structures, and the pull of familiar neighborhoods can combine to undo the best policy plans. Policy is often formulated without a specific recognition of the dynamics of the urban structure, and the dynamics, unless modeled in the policy decision, may well undo the best plans. In addition, the plans are often formulated without a specific recognition of the spatial structure and its complexity. The combination of migration and a changing spatial

structure is a context that makes intervention extremely difficult. As difficult as it is to accept, sometimes we simply cannot intervene with any sure knowledge of the outcome. In this survey of geography's quantitative contributions to policy, it is not possible to explore in any depth the policy ramifications of intervention, suffice it to say that it is much more difficult than suggested by policies such as the Community Block Grant program or the Moving to Opportunity Program.

Observations and the future of spatial science

Clearly, geographers are at the center of analytic questions about how society is organized and how it functions. In some sense it is ironic that this has occurred at a time that large sections of the discipline have moved away from analytic concerns to critical thinking and cultural studies. This essay suggests that the powerful contributions of spatial analysis are central to geography, and to the extent that we do not continue to engage in analytical statistical analysis, we will abandon these approaches to other disciplines anxious to bring space into their analytic traditions.

At the same time we should not "fret" about the paths that emerge within our disciplinary structures. The emergence of a discourse, which focused on measurement and prediction, placed the discipline firmly within the discourse of science. Even though there may have been a proportional decline in the number of papers with "quantitative themes," the research by Jackson et al. (2006) shows clearly that there continues to be a strong focus on geographical science. It is likely too that the cross-disciplinary embrace of GIS will continue to strengthen science in geography and geography outside the discipline.

Glscience will almost certainly play an important role in the evolution of spatial statistical analysis and is already important in incorporating spatial structure in models of spatial outcomes. Neighborhoods and communities are central to the organization of our cities and to our lives within them. We are often defined by where we live and our cities are divided by socioeconomic status and that division has a spatial pattern. It is that pattern which is summarized in neighborhoods, and among the questions now engaging investigators is whether the spatial unit matters over and above the composition of the households within the spatial unit. These are questions about neighborhood effects. What are the effects of living in particular neighborhoods after due controls for household composition, and how large are these neighborhood effects? These are questions that place scale and spatial structure at the heart of any statistical analysis and the identification of spatial outcomes in these models is intertwined with issues of statistical specification. It is here that the developing work in Glscience on spatial association is central (Getis 1999; Anselin 2003).

Spatial science should be at the center of continuing geographic analysis and is still our last best hope of being taken seriously in the wider scientific endeavor. The research on migration and sorting is an illustration of the powerful contributions that can be created within a rubric of geographical analysis. A continuing tradition

of careful statistical modeling, recognizing the complexity of our social and physical world, will “grow” geography and our recognition in the social science community.

Notes

- 1 The selective references here are only exemplars of the huge and creative body of statistical analysis that grew rapidly at Washington, but also at Iowa and Northwestern and then with the diffusion of the new graduates, at Chicago and Ohio State.
- 2 This is a modification of a statement about race in a recent Rand Publication on Diversity.
- 3 These very selective citations are only three of hundreds of papers on migration, mobility, and neighborhood choice that attempted to provide a behavioral context for choice in the landscape.
- 4 The literature on residential mobility and migration is now substantial. This discussion is not designed to summarize that literature, rather the aim is to show the modeling process that has been a central part of creating the body of knowledge about migration and mobility and extensions to debates about migration in the policy arena. We must recognize too an increasing interest in the mirror image of mobility, the immobility of populations (Hanson 2005).
- 5 The code for a simple formulation (useful for classroom teaching) and a more complicated formulation of SimSeg is available on the Web.
- 6 Zhang’s model requires instantaneous swapping of agents, rather than the more realistic searching for vacancies.

References

- Alberts, B. (2004) “A World that Banks on Science.” A Speech to the National Academy, April 19, 2004, Washington, DC.
- Alberts, B. (2005) “Summing Up: Creating a Scientific Temper for the World.” A Speech to the National Academy, May 2, 2005, Washington, DC.
- Anselin, L. (1988). *Spatial Econometrics: Methods and Models*. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Anselin, L. (2003). *GeoDa 0.9 Use Guide*. Champaign Urbana, IL: Spatial Analysis Laboratory, University of Illinois.
- Berry, B. J. L. (1961). “City Size Distributions and Economic Development.” *Economic Development and Cultural Change* 9, 573–88.
- Berry, B. J. L. (1967). *Geography of market Centers and Retail Distribution*. Englewood Cliffs, NJ: Prentice Hall.
- Boyle, P., T. J. Cooke, K. Halfacree, and D. Smith. (2001). “A Cross-National Comparison of the Impact of Family Migration on Women’s Employment Status.” *Demography* 38, 201–13.
- Brown, L., and R. Sanders. (1981). “Toward a Development Paradigm of Migration with Particular Reference to Third World Settings.” In *Migration Decision Making: Multidisciplinary Approaches to Micro-Level Studies in Developed and Developing Countries*, 149–85, edited by G. DeJong and R. Gardener. New York: Pergamon Press.
- Bruch, E., and R. Mare. (2004). “Neighborhood choice and neighborhood change.” On-Line Working Papers CCPR-00704, Center for Population Research, UCLA, Los Angeles.

- Clark, W. A. V. (1986). "Residential Segregation in American Cities: A Review and Interpretation." *Population Research and Policy Review* 5, 95–127.
- Clark, W. A. V. (1989). "Residential Segregation in American Cities: Common Ground and Differences in Interpretation." *Population Research and Policy Review* 8, 193–97.
- Clark, W. A. V. (1991). "Residential Preferences and Neighborhood Racial Segregation: A Test of the Schelling Model." *Demography* 28, 1–19.
- Clark, W. A. V. (1992). "Residential Preferences and Residential Choices in a Multi-Ethnic Context." *Demography* 30, 451–66.
- Clark, W. A. V. (2002). "Ethnic Preferences and Ethnic Perceptions in Multi-Ethnic Settings." *Urban Geography* 23, 237–56.
- Clark, W. A. V. (2005). "Intervening in the Residential Mobility Process: Neighborhood Outcomes for Low-Income Populations." *Proceedings of the National Academy of Sciences USA* 102, 15307–12.
- Clark, W. A. V., and S. Davies Withers. (2002). "Disentangling the Interaction of Migration, Mobility and Labor Force Participation." *Environment and Planning A* 34, 923–45.
- Clark, W. A. V., and F. Dieleman. (1996). *Households and Housing: Choice and Outcomes in the Housing Market*. New Brunswick, NJ: Rutgers, The State University of New Jersey, Center for Urban Policy Research.
- Clark, W. A. V., and M. Fossett. (2008). "Understanding the Social Context of the Schelling Segregation Model." *Proceedings of the National Academy of Sciences* 105, 4109–114.
- Clark, W. A. V., and Y. Huang. (2006). "Balancing Move and Work: Women's Labor Market Exits and Entries after Family Migration." *Population Space and Place* 12, 31–34.
- Cooke, T. J., and A. J. Bailey. (1996). "Family Migration and the Employment of Married Women and Men." *Economic Geography* 72, 38–48.
- Dacey, M. (1964). "Modified Poisson Probability Law for Point Pattern More Regular than Random." *Annals of the Association of American Geographers* 54, 559–65.
- Davies Withers, S., and W. A. V. Clark. (2006). "Expectations and Outcomes: The Geography of Family Migration." *Population, Space and Place* 12, 273–89.
- Dietz, R. (2002). "The Estimation of Neighborhood Effects in the Social Sciences: An Interdisciplinary Approach." *Social Science Research* 31, 539–75.
- Diez-Roux, A. (2001). "Investigating Neighborhood and Area Effects on Health." *American Journal of Public Health* 91, 1783–89.
- Diez-Roux, A. (2003). "Residential Environments and Cardiovascular Risk." *Journal of Urban Health: Bulletin of the New York Academy of Medicine* 80, 569–89.
- Durlauf, S. (2004). "Neighborhood Effects." In *Handbook of Regional and Urban Economics*, Vol. 4, 2173–242, edited by J. V. Henderson and J. F. Thisse. Amsterdam: Elsevier.
- Forest, B. (2005). "The Changing Demographic, Legal and Technological Contexts of Political Representation." *Proceedings of the National Academy of Sciences USA* 102, 15331–36.
- Fossett, M. (1998). "SimSeg: A Computer Program to Simulate the Dynamics of Residential Segregation by Social and Ethnic Status." Race and Ethnic Studies Institute Technical Report, Texas A and M University.

- Fossett, M. (2006). "Ethnic Preferences, Social Distance Dynamics and Residential Segregation: Theoretical Explorations Using Simulation Analysis." *Journal of Mathematical Sociology* 30, 185–273.
- Fossett, M., and W. Warren. (2005). "Overlooked Implications of Ethnic Preferences for Residential Segregation in Agent Based Models." *Urban Studies* 42, 1893–917.
- Fotheringham, A., and D. Wong. (1991). "The Modifiable Areal Unit Problem in Multivariate Statistical Analysis." *Environment and Planning A* 23, 1025–44.
- Galster, G. (1988). "Residential Segregation in American Cities: A Contrary Review." *Population Research and Policy Review* 7, 113–21.
- Galster, G. (2003). "Investigating Behavioral Impacts of Poor Neighborhoods: Towards New Data and Analytic Strategies." *Housing Studies* 18, 893–914.
- Garrison, W. L. (1956). "Applicability of Statistical Inference to Geographical Research." *Geographical Review* 46, 427–29.
- Garrison, W. L., B. J. L. Berry, D. Marble, J. D. Nystuen, and R. Morrill. (1959). *Studies of Highway Development and Geographic Change*. Seattle, WA: University of Washington Press.
- Getis, A. (1999). "Spatial Statistics. Chapter 16." In *GIS: Principles, Techniques, Management, and Applications*, 239–51, edited by P. Longley, M. Goodchild, D. Maguire, and D. Rhind. New York: Wiley.
- Golledge, R. G., and G. Rushton. (1976). *Spatial Choice and Spatial Behavior*. Columbus, OH: Ohio State University Press.
- Griffith, D., and R. MacKinnon. (1981). *Dynamic Spatial Models*. Alphen aan de Rijn, The Netherlands: Sijthoff and Noordhoff.
- Haggett, P. (1965). *Locational Analysis in Human Geography*. London: St. Martins Press.
- Hanson, S. (2005). "Perspectives on the Geographic Stability and Mobility of People in Cities." *Proceedings of the National Academy of Sciences USA* 102, 15301–06.
- Jackson, A., R. Harris, L. Hepple, A. Hoare, R. J. Johnston, K. Jones, and P. Plummer. (2006). "Geography's Changing Lexicon: Measuring Disciplinary Change in Anglophone Human Geography Through Journal Context Analysis." *Geoforum* 37, 447–54.
- Krugman, P. (1991). *Geography and Trade*. Cambridge, MA: MIT Press.
- Krysan, M., and R. Farley. (2002). "The Residential Preferences of Blacks: Do They Explain Persistent Segregation?" *Social Forces* 80, 937–80.
- Martin, R. (1999). "The New Geographical Turn in Economics: Some Critical Reflections." *Cambridge Journal of Economics* 23, 65–91.
- Moore, E. G. (1972) "Residential Mobility in the City." Resource Paper No. 13, Commission on College Geography, Washington, DC.
- Moore, E. G., and W. A. V. Clark. (1990). "Housing and Households in American Cities: Structure and Change in Population Mobility 1974–1982." In *Housing Demography*, 203–31, edited by D. Myers. Madison, WI: University of Wisconsin Press.
- Openshaw, S., and P. Taylor. (1981). "The modifiable unit problem." In *Quantitative Geography*, 127–44, edited by N. Wrigley. London: Pion.
- Schelling, T. (1971). "Dynamic Models of Segregation." *Journal of Mathematical Sociology* 1, 143–86.
- Schelling, T. (1978). *Micromotives and Macrobehavior*. New York: Norton.
- Smits, J. (2001). "Career Migration Self-Selection and the Earnings of Married Men and Women in the Netherlands, 1981–1993." *Urban Studies* 38, 541–62.

- Tobler, W. R. (1963). "Geographic Area and Map Projections." *Geographical Review* 53, 59–78.
- Zhang, J. (2004a). "Residential Segregation in an All-Integrationist World." *Journal of Economic Behavior and Organization* 54, 533–50.
- Zhang, J. (2004b). "A Dynamic Model of Residential Segregation." *Journal of Mathematical Sociology* 28, 147–70.