Demography as a Spatial Social Science

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Abstract

Many social scientists have taken note of the re-emerging interest in issues concerning social processes embedded within a spatial context. While some argue that this awakening is refreshing and new and, in fact, long overdue, I demonstrate that spatially focused demographic theories and research agendas clearly predate contemporary interest in these topics. I assert that recent methodological advancements have merely encouraged and brought refinement to the expanding body of spatially oriented population research – research strongly rooted in demographic tradition and practice. Indeed, I make the claim that, until roughly the mid-20th century, virtually all demography in the United States (and elsewhere, but not specifically examined here) was *spatial* demography. (I define spatial demography as the formal demographic study of areal aggregates, i.e., of demographic attributes aggregated to some level within a geographic hierarchy.) While some may find the claim overstated, and argue specific exceptions, I develop my theme, in part, through historical narrative. I posit that until around 1950 almost all demographic analysis involved data taken from areal units. Then, shortly after mid-century, a paradigm shift occurred, and the scientific study of population quickly came to be dominated by attention to the individual as the agent of demographic action. Traditional spatial (or macro-level) demography gave way to micro-demography, and, I argue, most demographers simply abandoned the data and approach of spatial demography. This assertion notwithstanding, I then proceed to show how the tradition of spatial demography actually did persist in small corners of our discipline during the latter half of the 20th century – despite the ascendancy of the micro-demography paradigm – through the contributions primarily of rural demographers and of others working in the new sub-field which appropriated the appellative "applied" demography. In closing the paper I include a brief but necessary discussion of the recent awakening that has come to spatial demographers from developments in other disciplines – principally from geography, regional science and spatial econometrics. Attributes of spatially referenced data generally violate at least one of the assumptions underlying the standard regression model, which necessitates both caution regarding these violations and attention to methods designed to correct for them. These emerging methods are the topics of a large and rapidly expanding literature. I also include mention of the important recent role played by methods of multilevel modeling (hierarchical linear modeling) in bridging the 50-year-old split between micro-level and macro-level demography by introducing techniques which simultaneously consider individual (family or household) variation in demographic attributes or behavior as well as the broader geographic contexts in which individual demographic action occurs.

Demography as a Spatial Social Science

Many social scientists have taken note of the re-emerging interest in issues concerning social processes embedded within a spatial context (see, for example, the papers in Goodchild and Janelle, 2004). This re-awakening to matters of space and place is no less true in the field of quantitative demography and, while some argue that this movement is refreshing and new (cite), I demonstrate that spatially focused demographic theories and research agendas clearly predate contemporary interest in these topics. I further assert that recent methodological advancements have merely refined the expanding body of spatially oriented population research that is clearly rooted in earlier traditions and practices. In this paper I broadly discuss the role of geographic space, location or place, in the discipline of quantitative demography.[1] I argue in the following section that, until roughly the mid-20th century, virtually all demography in the United States was spatial demography. Here, I define spatial demography as the formal demographic study of areal aggregates, i.e., of demographic attributes aggregated to some level within a geographic hierarchy. As such, spatial demography is viewed as analogous to the "statistical geography" of Duncan, Cuzzort and Duncan (1961). In the second section, I argue briefly that in the years since approximately 1950 the scientific study of population came to be dominated by attention to the individual as the agent of demographic action. That is, spatial demography gave way to micro-demography.[2] I offer two, mutually renforced, explanations for this shift. During this period, those demographers whose research and writings primarily addressed aggregate demographic trends or comparisons among areal units – what I here call macro-level or spatial demography – slipped into a disciplinary minority. In section three I discuss how the tradition of spatial demography persisted during the latter half of the 20th century, despite the dominance of micro-demography, through the contributions of rural demographers and of others working in the

sub-field of "applied" demography. Following this, I discuss the recent awakening that has come to spatial demographers from developments in other disciplines. This development is in regard to the specialized – some would say "spatialized" – set of statistical tools appropriate for the multivariate analysis of data aggregated to areal units. Attributes of spatially referenced data generally violate at least one of the assumptions underlying the standard regression model, which necessitates both caution regarding these violations and attention to methods designed to correct for them. This is followed by a section in which I briefly discuss the recent role played by the methods of multilevel modeling (hierarchical linear modeling) in bridging the 50-year-old split between micro-level and macro-level demography by introducing techniques which simultaneously consider individual (family or household) variation in demographic attributes or behavior as well as the broader geographic contexts in which individual demographic action occurs. Finally, I close with a concluding summary and a note of encouragement for those researchers analyzing geo-referenced data.

TRADITIONAL DEMOGRAPHY WAS (MOSTLY) SPATIAL DEMOGRAPHY

Prior to the advent of public use microdata files from the decennial census, and before the arrival of large public use analytical files from major surveys (e.g., Current Population Survey, General Social Survey, National Longitudinal Study of Youth, Panel Study of Income Dynamics), most demography in the U.S. consisted of the analysis of population trends or comparisons among geographic entities (e.g., counties), or aggregates of such entities (e.g., states, census regions/divisions, or metropolitan/nonmetropolitan aggregates, etc.). With only a bit of exaggeration, one can make a convincing case that traditional demography was *spatial* demography.

Exceptions to this generalization are few.[3] They mostly involve the pioneering work of statisticians, actuarial scientists and early mathematical demographers who established the groundwork in renewal theory, the stable population model and the examination of formal relationships among demographic phenomena (e.g., Dublin and Lotka, 1925; Feller, 1941; Lotka, 1918, 1938, 1939, 1942, 1948). For these early quantitative demographers, these methods of studying populations were established as guidelines under which the less formal "empirical" approach to population analysis would serve as a concrete illustration (Lotka, 1938). Yet, the assumption was that the two approaches would complement one another and proceed in tandem, with the empirical analyses generally drawn from aggregate population information for specific geographic areas such as countries (Dublin and Lotka, 1925, 1930; Lotka, 1938; Thompson, 1929; Willcox, 1896) or individual states in the U.S. (Dublin and Baker, 1920; Dublin and Lotka, 1936; Lotka, 1936; Whelpton, 1930). Thus, even conceding this exception to our assertion, it remains true that spatial comparisons were a significant part even of this early formal demographic literature.[4]

Demography, the official journal of the Population Association of America, commenced publication in 1964, and *Population Index* (which dates from 1937) was primarily a bibliographic resource. Consequently, one must look more broadly in the social science, statistical and medical literatures to track the topical emphases in demography from its formal beginnings in the U.S. Lorimer's (1959) comprehensive overview of the origins of demography makes clear the difficulty and artificiality of trying to establish the precise origins of the demographic discipline in the U.S. Many different roots extend deep into European soil. The "political arithmetic" of the late 17th and 18th centuries, for example, was well advanced before the formal investigation of demographic phenomena emerged in America in the early 20th

century. Certainly a strong and mature study of population dynamics had taken hold in the U.S. before the founding of the Population Association of America in 1931, but perhaps not much before that date.

The early years of empirical demography in the U.S. were dominated by analyses in which areal aggregates were the chief units of analysis. I mention some of these analyses in a later section of this paper. Many other studies which, for space limitations cannot be individually cited, appeared in the period roughly spanning 1940 to 1970 as state or regional Agricultural Experiment Station bulletins (Voss, 1993).

In subfields of sociology closely related to demography, the analysis of aggregated social data also flourished. The classical theoretical foundations of human ecology date from the 19th century, but the emergence of the Chicago School in the 1920s and 1930s brought many of the concepts of biology and general ecology (e.g., adaptation, competition, interaction, division of labor) to the study of human "organisms" (Theodorson, 1961). The theoretical language used to describe such ecological processes often focused on the organism, or individual, level. Yet, it is instructive to recall two aspects of early human ecology in the United States. First is that the Chicago School was highly influenced in its theoretical orientation by Galpin's (1915) study of agricultural *communities* in Wisconsin (see Mowrer, 1938:88; Park, 1929:60).[5] Second, that Hawley's (1950) highly influential book on the subject was subtitled "A Theory of *Community* Structure" (emphasis added), and much of the research over ensuing decades that flowed from this disciplinary paradigm examined structure and change of social aggregates. Dozens of studies followed Shevky and Bell's (1955) early "social area analysis," which attempted to relate measures of social heterogeneity to ecological patterns and processes at different levels in the urban hierarchy. Studies in "factorial ecology" (e.g., Hunter, 1971) extended this line of

research by applying such formal statistical routines as factorial analysis and principal components analysis to understand the latent structure underlying social systems. Around the same time, methodological sophistication was brought to the examination of residential segregation (Duncan and Duncan, 1955), a general line of social inquiry at the areal unit level that persists to this day. Despite the fact that general issues of spatial distribution and differentiation can be found in the sociological, human ecological and demographic literatures throughout the 20th century, I argue in the following section that sometime around mid-century a substantial share of demographers changed the lens on their research to focus not on spatial aggregates but on individuals, families and households.

THE SHIFT FROM MACRO-DEMOGRAPHY TO MICRO-DEMOGRAPHY

Two forces likely propelled the change of focus from macro- to micro-demography. One was the emergence of large scale microdata files which provided access to detailed individual/household-level data. The initial motivation for such data sets appears to have been a response to the low levels of fertility in the U.S. reached during the 1930s (Kiser and Whelpton, 1953). The continued analysis of "data of the census type," while providing some understanding of "the relation of fertility to such factors as region, rural-urban residence, colour, nativity, occupation, education and other measures of socio-economic status," simply could not yield information regarding the underlying "social and psychological factors affecting fertility" (Kiser and Whelpton, 1953:95). This recognition prompted the first ever large effort in the U.S. to study contraception practice and planned family motivations at the husband-wife level of analysis: the *Indianapolis Study of Social and Psychological Factors Affecting Fertility* was carried out in Indianapolis, in 1941 with 1,444 "relatively fecund" couples (Whelpton and Kiser, 1946, 1950). The success of this effort led to additional localized survey efforts such as the

Detroit Area Study (see Freedman and Sharp, 1954; Freedman, Goldberg and Sharp, 1954) and later to national surveys, including initially (1) the Growth of American Families (GAF) studies carried out in 1955 and 1960 (see Freedman, Whelpton and Campbell, 1959; Whelpton, Campbell and Patterson, 1966), (2) the longitudinal Family Growth in Metropolitan America Study (see Westoff and Mishler, 1961), and (3) the series of National Fertility Surveys and National Surveys of Family Growth. (For information and citations to publications based on these surveys, see http://opr.princeton.edu/archive/nsfg or http://www.cdc.gov/nchs/data/nsfg/c1and2bydate.pdf.) The value of microdata for analyzing individual knowledge, values, beliefs and behaviors was well established by the 1970s.[6]

Also by the 1970s, the U.S. Census Bureau had begun to release anonymized public use microdata sample (PUMS) files from the decennial census.[7] These complemented the microdata files from the long-running Current Population Survey, also conducted by the Census Bureau. A cursory examination of relevant journals suggests that by the 1980s more basic demographic research in the U.S. was being conducted using microdata files than from census files or reports presenting data for areal aggregates.

A second force behind the shift away from the analysis of spatial aggregates to micro analysis was the predicament presented by what came to be known in sociology as the "ecological fallacy." Gehlke and Biehl (1934), in a brief but pioneering study of scale effects in the analysis of census tract data, concluded that "a relatively high correlation might conceivably occur by census tracts when the traits so studied were completely dissociated in the individuals or families of those traits" (1934:170). It was Robinson (1950), however, who pressed this point forcefully in what became required reading for demography graduate students in the decades to follow. He demonstrated the pitfalls of using aggregated data to draw inferences about

individual characteristics and relationships. While it remains somewhat in the realm of speculation, it is not too far a reach to argue that Robinson's paper directly led to a conscious desire on the part of demographers to avoid the trap of what came to be called the "ecological fallacy" (or in other circles, "aggregation bias") – inappropriately drawing inferences about individuals from aggregated data.

But Robinson's paper also drew attention to a more damaging problem for those who espoused ecological analysis: different results are obtained when relationships among variables are calculated at different levels of aggregation (say, first for census tracts and then for counties). Well, this was not good at all. If one's findings are dependent upon whatever specific areas (census tracts, counties, etc.) happened to be available, and, additionally, acknowledging the often arbitrary boundaries of those units (whatever their spatial scale), what importance should be attached to those findings? At the time, quantitative geographers were also wrestling with this dilemma (although by a different name: the "modifiable areal unit problem" – or MAUP), and today some argue that the inability of geographers to respond satisfactorily to critics who pointed to the problems of scale and zoning in geographical analysis actually precipitated a decline of interest in quantitative geography in the 1980s (Fotheringham, Brunsdon and Charlton, 2000).

But dilemmas abound, even when taking precautions against the ecological fallacy. It frequently is mentioned by those who study ecological aggregation biases (e.g., Jones and Duncan, 1996), that those who strictly eschew the analysis of areal aggregates (thereby avoiding the ecological fallacy) ironically run the risk of falling prey to the "atomistic fallacy." Here, the individual is considered in isolation of his/her environment. Alker (1969) points out that choosing to work at the individual level misses the context in which individual behavior occurs, while choosing to work only with areal aggregates fails to recognize that it is individuals, not

aggregates, who act. I return to this issue in a later section in which I discuss the emergence of multilevel models. I simply note here that attention to the various analytical difficulties surrounding the matter of aggregation bias reinforced the inclination on the part of sociologists and demographers to take full advantage of the opportunities afforded by the increasing number of microdata files entering the public domain.

And so they did. The shift toward micro-level analyses established the preeminence of the individual, family or household as the demographic actor, and left but a small proportion of professional demographers continuing the serious scholarly inquiry of population change among demographic aggregates.

CONTINUED INTERSEST IN SPATIAL DEMOGRAPHY AMONG SOME DEMOGRAPHERS

Despite the shift in emphasis to micro-demography, there remained some demographers for whom ecological analyses continued to hold fascination. This was not done out of disregard to the ecological fallacy but rather in the belief that some interesting and important research questions can (and sometimes *only* can) be addressed at the aggregate level.[8] Much of this work can be placed into one of two categories: (1) migration and population distribution research, work carried forward predominantly by rural demographers, and (2) population estimation research, work which came to dominate the portfolio of many applied demographers.

Rural Demography

Despite many earlier publications reporting empirical research on migration patterns, renewed intellectual energy was brought to the topics of migration and population redistribution in the 1930s. There is little question but that this arose out of deep public concern for the extensive and painful social upheaval resulting from the Great Depression and the ensuing

disruption of the national economy, and of jobs and family life. Research into the determinants and consequences of human migration carried out by social scientists at the University of Pennsylvania and elsewhere (see, for example, Creamer, 1935; Goodrich, Bushrod and Thornthwaite, 1936; Thornthwaite, 1934), and by teams of research analysts assembled by the Division of Social Research of the Federal Works Progress Administration (see, for example, Lively and Taeuber, 1939; Webb, 1935; Webb and Brown, 1938), brought new interest in migration that sparked the intellectual imaginations of scholars for the next several decades.

Continued post-war research into the dynamics of internal migration was carried out largely in the context of massive metropolitanization in the U.S. during the 1950s and 1960s. It focused on the shifts of population into the western region of the country, on the interregional flows of blacks from rural communities in the south to the expanding industrial centers of the northeast and midwestern regions, and on the exodus of populations from farms and rural communities throughout the nation. Much of this research was descriptive in nature. Mucht of it was carried out by rural social scientists. Almost all of it was spatial.[9]

A similar line of research was developed following the release of the 1970 and 1980 censuses, when it was discovered that patterns of internal migration in the U.S. (and, it should be added, elsewhere) had shifted, and nonmetropolitan counties were growing at higher levels than their metropolitan counterparts (Beale, 1975; Fuguitt, 1985). By the 1980s natural population decrease, especially among nonmetropolitan counties, had also emerged a subject of increasing interest among rural demographers. This development was the consequence of agricultural adjustments in rural America, declining rates of fertility everywhere, and migration patterns that pulled many young people (potential parents) out of rural areas upon graduation from high school and the “aging in place” of older rural residents (Beale, 1969; Johnson, 1993).

Returning for a moment to mid-century, the 1940s and 1950s witnessed another critical thread of research that was to be very important to the development of spatial demography in the U.S. Around this period, migration research began to focus on the migration *event*, per se, such as how to conceptualize migration, how to compute migration rates, and how to manipulate other variables to derive estimates of net migration for an area. This work was strongly rooted in substantive migration studies of the 1930s and 1940s (for example Hamilton, 1934; Hamilton and Henderson, 1944; Hutchinson, 1938; Shryock, 1943; Shryock and Eldridge, 1947). But in the 1950s, and on into the 1960s, several important methodological studies brought conceptual clarity to these issues and set in motion the routine production of methodologically sound estimates of net migration.

This research was important to spatial demography because migration is not a reported or registered event in the U.S. Instead, net migration gain or loss among areas must be estimated from aggregated data. Eventually, component models for calculating population estimates and projections required that reasonable estimates of net migration and of net migration rates be made available, and these estimates increasingly were based on the analysis of population change among small geographic areas. Because the Census Bureau was not engaged in population estimation below the state level prior to the 1970s, and because it frequently fell to rural sociologists and agricultural economists at Land Grant colleges of agriculture (due to the mission of such institutions) to respond to the need for substate population estimates, many demographers in rural sociology departments around the country found themselves actively engaged in the production efforts of population estimates for relatively small areal units in the 1950s and 1960s (see Voss, 1993, for citations and a general overview of this literature). In the

1970s this work coalesced under a new rubric within the population sciences: applied demography.

Applied Demography

This brings us to an important second category of continuing work in spatial demography: population estimation research. In addition to advances in migration research, the 1950s was also a decade of major improvements in the development of population estimation models for application at the substate level (i.e., counties, cities, and even smaller geographic areas). There were three pivotal activities during this period, and each extended the focus on spatial units, thus continuing the role of space in the population sciences, even while many demographers had begun to shift their analytical efforts to the emerging microdata files.

First was the model development work that occurred primarily at the U.S. Census Bureau and in selected university settings. Indeed, it was the early 1950s that spawned small-area population estimation models that even today have been improved upon only modestly. Second was the production work (i.e., the production of small-area population estimates) that found its way into state and local agencies rather than the Census Bureau. Third were the few early tests of various estimation methods against the census counts of 1950 (see, for example, Schmitt 1952; Siegel, Shryock and Greenberg, 1954), and the significant advances in population estimation and forecasting during the 1960s.

In the 1970s, the emergence of state and local demography and, somewhat later, the field of business demography within the Population Association of America, brought a fresh perspective to the analysis of spatial units. This group of demographic practitioners appropriated for their work the term "*applied* demography," the distinguishing feature of which is that it involves almost exclusively the analysis of demographic data or the production of population

estimates and forecasts for spatial units (see Merrick, 1987; Murdock and Ellis, 1991; Rives and Serow, 1984). Thus, applied demographers joined hands with rural demographers and brought renewed vigor to the study of the demography of space. Their work was aided enormously by the summary tape files from the 1970 census – the first census to place into the hands of demographic researchers huge electronic files of census data for geographic areas as small as census blocks. The importance of these files to the development of business demography in the U.S. has been chronicled by Russell (1984) and by Merrick and Tordella (1988).

The decade of the 1980s witnessed yet another boost to the analysis of spatially-arrayed data. The coming together in the late 1980s and early 1990s of five remarkable products radically changed the world of demography, including parts of demographic study not traditionally concerned with spatial variation. These products were (1) the Census Bureau's TIGER files – digital, seamless, block-level geographic databases for the U.S. released as a 1990 Census product, (2) the summary tape files from the 1980 and 1990 censuses, (3) extensive natural resource, crime, and epidemiological databases – all of which were largely outside the scope of traditional demographic interest, (4) incredibly powerful geographic information system (GIS) software for mapping and, importantly, for *integrating* spatially-arrayed data from diverse and disparate georeferenced systems, and, finally, (5) the awesome, but affordable, computing hardware platforms on which to bring together these various elements. These elements, having converged so forcefully by the early 1990s, began to alter the way in which spatial demographic research was carried out. Together, these forces motivated the formation of new and broadly interdisciplinary collegial relationships on campuses and elsewhere, and began to foster the development of hypotheses and researchable questions in areas where only a few demographers and ecologists had previously ventured.[10]

RECENT RENEWED INTEREST IN SPATIAL DEMOGRAPHY

By the mid-1990s, demographers could be described as pursuing population science along two different lines.[11] The larger group consisted of those demographers whose research continued to mostly ignore the dimension of geographic space and focused the locus of demographic action on the individual, family or household. The smaller group, among them predominantly rural demographers and applied demographers, continued the much earlier tradition of spatial demography by focusing on areal aggregates as units of analysis. I argued in the preceding section that trends in technology during the 1980s and 1990s brought increasing sophistication to the work of demographers in the latter group. However, the 1980s witnessed the emergence of two additional developments that bring the examination of the split between macro- and micro-demography up to the present. The first is the awareness among the social sciences of developments that occurred in the 1980s in the disciplines of geography, regional science and spatial econometrics was, until quite recently, largely overlooked by spatial demographers. The second was the emergence of the theory and tools of multilevel modeling.

MULTILEVEL MODELING

In the first few sections of this chapter, I discussed how the maturing of demographic science in the U.S. witnessed a shift around 1950 from an interest in population change among geographic areas to an interest in individual-level demographic behavior. I also discussed the re-emergence in recent years of interest in areal data brought about by growing awareness of the tools and techniques for properly specifying and estimating statistical models based on geospatial data. I now close our chapter with a brief discussion of how these two perspectives, macro- and micro-demography, are presently being bridged by new interest in multilevel modeling techniques.

These methods deal with data organized hierarchically (such as individuals within neighborhoods, pupils within schools, or crimes within census tracts) and provide the opportunity to simultaneously study variation at different levels of the hierarchy. Such models acknowledge that individuals are embedded in social units (schools, tracts, neighborhoods, regions, etc.). As such, they blur the artificial boundaries between micro and macro analyses. Many examples of multilevel modeling are found in sociological and demographic research since the 1980s (e.g., Cotter, 2002; DiPrete and Grusky, 1990; Entwisle and Mason, 1985; Entwisle et al., 1984; Entwisle et al., 1986; Hirschman and Guest, 1990; Mason et al., 1983-84; Raudenbush and Bryk, 1986; Sampson, 1988, 1991; Sampson and Wooldredge, 1987). Comparable to the experience with spatial analysis, technological advances in software capabilities have greatly facilitated an already existing interest in hierarchical data analysis. The motivation for the development of these analytical tools also is strikingly similar to that underlying the expansion of spatial methods: "Almost all data collected in the social sciences have some form of inherent hierarchical structure, and this structure should be reflected in the statistical models that are used to analyze them" (Paterson and Goldstein, 1991, in Westert and Verhoeff, 1997:7). Broadly, the hierarchical structure might refer to individuals within non-spatial structures such as companies or organizations. Spatially, the hierarchical structure includes some geographic unit such as census tracts, counties and the like.

As with spatial regression modeling, however, multilevel strategies bring their own distinct set of methodological issues and cannot be analyzed by conventional statistical approaches. Hox and Kreft (1994) provide a useful summary of the problems that arise when applying single level models to multilevel data (see also Bryk and Raudenbush, 1992; Raudenbush and Bryk, 2002). Only one stochastic error component is allowed in a single level

model, and is assumed independent, normal, and homoskedastic. If the data are multilevel, the unmodeled group variation will produce a residual error term at the group or higher level that assumes a nonzero covariance between the residual error terms of individuals comprising the group. In doing so, it incorrectly assumes independence between the observations. Because the data contain observations nested within a shared spatial unit, the data are in effect dependent; households residing within the same neighborhood are likely to have more similar characteristics relative to households within another neighborhood. This dependency, and the accompanying error structure, is not accounted for in a single level model. Therefore, the assumption upon which standard errors and variances are determined is violated and the model produces inefficient estimates of standard errors and overall "explained" variance. Such single level model estimates are biased and unreliable for multilevel data structures.

Consequently, in recent years, software development has resulted in many statistical packages offering tools to specify and properly model hierarchical data. The most focused and well known is Hierarchical Linear and Non-Linear Modeling (HLM) (Raudenbush et al., 2000), but other packages including SAS (SAS Institute, 1999-2001) and S-Plus (Insightful Corporation, 1987-2001) also enable the analysis of multilevel data. Equipped with these tools, contemporary demographic research bridges the important gap between micro- and macro-level processes. These methods allow the analyst to simultaneously address the ecological and atomistic fallacies by appropriately modeling the social processes at both levels in addition to estimating the relationships between the two levels. In essence, the associations estimated for one level (e.g., child's school performance and SES) are interacted with the second level, thereby allowing for variation in the parameters, or the nature and magnitude of the association,

according to the second-level values (e.g., neighborhood SES). Such an approach takes full advantage both of individual (family or household data) and geospatial data.

SUMMARY

In this chapter, I have discussed the role of geographic space in quantitative demography. I have argued that until sometime around mid-20th century, nearly all of quantitative demography used geographic units as the unit of analysis. As more microdata files became available, beginning in the 1940s and 1950s, a majority of demographers shifted their attention to behavioral process in population studies. I argue that the motivation behind this shift was not simply the availability or novelty of microdata, but also the desire to avoid the analytical problems associated with areal data such as aggregation biases and the ecological fallacy. I also recognize and highlight a counter trend: the continued fascination with demographic processes linked to areal units, what I refer to as spatial demography, that characterized the research agendas of many rural demographers since the 1950s and of applied demographers, beginning in the 1970s. The latter sub-discipline, in fact, was largely defined by its attention to geographic units – particularly the smaller units near the bottom of the U.S. census geographic hierarchy. I then shifted our focus to the re-emerging interest in spatial demography that slowly is beginning to appear as an increasing number of demographers seek to adopt the formal tools of spatial econometrics to improve on traditional regression models of demographic processes operating in space.[12] I introduced the concept of spatial autocorrelation and ways to correctly specify multiple regression models in the presence of spatial autocorrelation. This lengthy section is made more concrete through an illustration of spatial modeling of county level growth during the 1990s in the U.S. Great Plains region. Finally I draw attention to ways of bridging the split between macro-demography and micro-demography by the further adoption of multilevel models.

We take particular delight in these latter two developments. It is our belief that as our own statistical models become more sophisticated, as spatial processes are brought into empirical demographic studies to correct for potential misspecification, and as our work begins to add in significant ways to the larger literature on spatial data analysis, I will have moved the science of spatial demography forward in very exciting ways. The growing interest in the field of spatial econometrics among several disciplines in the social sciences, of which the re-emergence of interest in spatial demography is a part, suggests an exciting future for quantitative demographers. Clearly the future will involve more interdisciplinary efforts – scholars from different disciplines brought together because of a common interest in scientific exploration of processes taking place in space. Spatial demographers will have many opportunities to lend their expertise to these efforts, including the understanding of the spatial data from, and the geographic hierarchy of, the decennial census (and hopefully from the emerging American Community Survey), and of the special demographic perspectives and insights that demographers will bring to such efforts.

ENDNOTES

[1] I focus my attention on demography as practiced in the United States, although I assert that the general argument holds as well for demography as practiced outside the U.S.

[2] My choice of words here may be confusing to some readers, as the term "micro-demography" has earlier been used by Bogue to mean, "the study of…local area" (Bogue, 1957:46). Bogue's definition would apply to my use of the term areal demography, macro-level demography, or, my preferred term, spatial demography. In this paper my use of the term "micro-demography" follows more recent convention by referring to the statistical analysis of individual-level (or family- or household-level) records from a microdata file, such as a census PUMS file.

[3] I do not allow as exception to my thesis the work of early population forecasters (e.g., Bonynge, 1852; Pritchett, 1891; Pearle and Reed, 1920) who used various univariate models to "fit" a set of census counts and then to extrapolate population change into the future. Dorn (1950) provides a helpful review and critique of these early forecasting efforts. While this work predates much of what today is considered the modern science of demography, I simply note in passing that, by definition, these efforts involved reference to populations attached to geographic space.

[4] Our review of this extensive literature is necessarily brief and deliberately parochial. Since the focus of this paper is on spatial demography in the U.S., I have omitted from this review important contributions by population scientists elsewhere (e.g., Gini, 1924; Henry, 1957; Rhodes, 1940; 1941).

[5] I extend my appreciation to Frank M. Howell for drawing my attention to the Chicago School's debt to the earlier community-level work of Charles Galpin (Howell, 2004).

[6] Major U.S. national surveys of importance and interest to demographers have not been mentioned here due to space limitations. Moreover, if our lens were widened in scope to examine important international demographic and health surveys, the list would number in the hundreds. In this latter regard, a helpful website is http://www.measuredhs.com/aboutdhs/history.cfm.

[7] The first such file was released in 1971 based on a large sample from the 1970 census. Shortly thereafter, in 1973, the Census Bureau released a public use microdata sample file from the 1960 census. Since these early releases, the Census Bureau has worked in conjunction with various sociologists and demographers to create PUMS files from most of the U.S. decennial censuses. Today, files spanning most decades between 1850 and 2000, in addition to international PUMS

data files, are available in machine-readable format free of charge through the Minnesota Population Center at http://www.ipums.org.

[8] This point was made by several sociologists in response to Robinson's (1950) article. See, for example, Menzel (1950) and Goodman (1953). I express my appreciation to Glenn Fuguitt for calling my attention to the Menzel response.

[9] For a recent interesting and encompassing review of the early history of migration research, the reader is directed to Greenwood and Hunt (2003).

[10] One example of such collaboration is the emergence of demographers working in the area which has become known as "environmental demography" (see, for example, Dietz and Rosa, 1994; Lutz, 2002; Lutz, Prieto, and Sanderson, 2000; O'Neil, MacKellar, and Lutz, 2001; Schnaiberg, 1980; Schnaiberg and Gould, 1994). Florax and Vlist (2003), among others, have drawn particular attention to the way in which recent increases and availability of spatially referenced data have partly driven the research agendas of several disciplines and have fostered new interdisciplinary collaborations.

[11] This obviously is an oversimplification. Both the demographic discipline (as a course of study) and the demographic profession (which defines the areas of pursuit and practice of various population scientists) are mature and multifaceted. That said, I maintain that the division here described applies readily to most demographic research and practice today, regardless of the specific substantive foci of the efforts, which are many.

[12] I take fascination in the fact that a recent article by Messner and Anselin (2004) makes precisely the same claim for empirical studies seeking to explain spatial heterogeneity of homicide rates. The authors assert that early interest in areal analyses shifted to studies that were "largely insensitive to spatial context." They go on to say, "The field has changed dramatically

in recent years, and criminologists are increasingly applying formal tools of spatial analysis to describe and explain variations in levels of homicide (and other crimes)" (2004:127).

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