Small-Area and Business Demography

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INTRODUCTION

A chain of supermarkets decides to launch a new line of ethnic foods. Where should it concentrate its marketing efforts? A school district is plagued by increasingly crowded elementary schools. Is this a temporary phenomenon or a continuing long-run trend? A hospital considers adding an obstetrics unit. Will anticipated service demand cover the additional costs? A metropolitan transportation agency plans to expand its rapid transit system. Where should new routes and transit stops be added? A manufacturer needs to build a new plant. Where can it find enough skilled workers to staff that plant? Answering questions like these lies at the heart of small-area and business demography.

Small-area and business demography are distinct but closely related fields of applied demography. Both focus mainly on practical applications of demographic methods and materials, designed to help managers, administrators, and government officials analyze and solve the problems faced by their organizations (Siegel, 2002). Each draws on many of the same concepts, data sources, and techniques, but not all small-area analyses pertain to the world of business, and business demography is not confined just to small areas. In this chapter, we review the objectives and distinctive features of small-area demography, the evolution and practice of business demography, and the primary tools used in both fields. We present several illustrations from these two decision-oriented fields and offer our observations about recent developments and future prospects. Although our primary focus is the United States, many of the issues we discuss have their counterparts in other nations as well.

SMALL-AREA DEMOGRAPHY

Small-area demography refers to demographic applications and analyses at local or regional scales. The term *small area*, however, has no exact or universally recognized definition. It may refer to any subnational area for which area-specific samples from national surveys are too small to provide estimates with acceptable levels of precision (e.g., Rao, 1999). More frequently, small areas refer to counties and subcounty areas such as cities, ZIP code areas, traffic analysis zones, census tracts, and individual blocks (e.g., Murdock and Ellis, 1991). We use the latter definition here. Small areas vary in size from less than an acre to thousands of square miles, and from a mere handful of residents (or none at all) to many millions.

Objectives of Small-Area Analysis

Most small-area analyses have one of three basic objectives: to advance knowledge, to inform public policy, or to support business decision making. We consider all three, but focus primarily on the latter two.

Advance Knowledge. Some small-area studies are undertaken to advance the understanding of social, economic, demographic, environmental, epidemiological, and other conditions and trends. States, provinces, cities, and other small areas are used as units of analysis to investigate the causes and consequences of these conditions and trends. Examples include investigations of whether differences in government tax and expenditure policies affected interprovincial migration in Canada (Day, 1992); how poverty, urbanization, and geographic location affected the incidence of cholera among regions in Mexico (Borroto and Martinez-Piedra, 2000); whether residents of zones surrounding the site of an industrial accident in Italy experienced higher-than-normal cancer rates (Bertazzi, Consonni, Bachetti, Rubagotti, Baccarelli, Zocchetti, and Pesatori, 2001); and whether differences in geographic, industrial, educational, and demographic characteristics affected county population growth rates in the United States between 1840 and 1990 (Beeson, DeJong, and Troesken, 2001). Although they may have policy or business implications, these and similar studies are undertaken primarily for the scientific purpose of advancing knowledge.

***Inform Public Policy*.** Small-area analyses are also undertaken to inform public policy. Small-area data can be used to allocate government funds, determine eligibility for entitlement programs, delineate political and electoral boundaries, monitor the effectiveness of public policies, select sites for public facilities, and develop program budgets. Examples include using population estimates by traffic analysis zone for political redistricting (Serow, Terrie, Weller, and Wichmann, 1997); using block-level population and household projections for choosing sites for fire stations (Tayman, Parrott, and Carnevale, 1997); constructing school enrollment projections by grade for a public school district (McKibben, 1996); and calculating teenage birth rates by ZIP code to identify areas in need of adolescent pregnancy prevention programs (Gould, Herrchen, Pham, Bera, and Brindis, 1998). These studies may advance scientific understanding, but their primary purpose is to improve governmental decision making.

Support Business Decision Making. Small-area analyses also support business decision making, primarily in the areas of site selection, marketing, sales forecasting, strategic planning, litigation support, and human resources. Examples include evaluating an array of small-area demographic and socioeconomic data in order to select locations for a large supermarket chain (Morrison and Abrahamse, 1996); projecting the number of births in a hospital's service area to predict the future demand for obstetrical services (Thomas, 1997); constructing life tables for employees of a large corporation to determine potential healthcare costs (Kintner and Swanson, 1997); and developing small-area estimates and projections as part of a company's bank loan application (Murdock and Hamm, 1997). Many topics of business demography parallel those of public policy, but focus on private rather than public sector decision making.

Distinctive Problems of Small-Area Analysis

Several problems distinguish small-area analyses from those with a larger geographic scale. First is shifting geographic boundaries. For nations, states, and most counties, boundaries remain constant over time. For subcounty areas, however, boundaries change frequently: Cities annex adjoining areas, census tracts are subdivided, ZIP code areas are reconfigured, service areas are redefined, and new statistical areas are formed. When small-area data are used for time series analyses, the consistency of historical data series must be evaluated and adjustments made as needed. Achieving consistency is often time-consuming and sometimes impossible.

Second is data availability. Many types of data are not tabulated for areas below a certain level of geography. For example, vital statistics in the United States are generally tabulated for states and counties but not for subcounty areas. Consequently, analyses that are feasible at higher levels of geography often cannot be done at lower levels, or must rely on proxy variables. Data availability is even more problematic in many less developed countries (Cleland, 1996).

Third is data reliability. Even the best data sources are flawed. Errors affect data quality more severely for small areas than large areas, where they are often mutually offsetting. In addition, survey data are frequently less reliable for small areas than large areas because sample sizes are smaller and survey responses more variable.

Finally, individual events—such as the opening or closing of a military base, the construction of a large housing development, the addition or loss of a major employer, and changes in zoning requirements—are more likely to have an impact on population growth in small areas than in large areas, where their effects tend to be offset by the effects of other events. Also, physical characteristics such as flood plains and the availability of vacant land are more likely to affect growth trends in small areas than in large areas because fewer alternative locations are available. Furthermore, seasonal populations such as “snowbirds” and migrant farm workers potentially comprise a larger proportion of the total population in small areas than in large areas; these populations typically follow different growth trends and have different socioeconomic and demographic characteristics than the rest of the population. These and other location-specific factors can complicate analyses at any geographic scale, but small areas are by far the most vulnerable to their influence.

BUSINESS DEMOGRAPHY

Business demography involves the application of demographic concepts, data, and techniques to the practical concerns of business decision makers. It is an eclectic, loosely organized field, driven by tangible problems rather than by the quest to advance knowledge or to improve measurement. Specific applications have evolved in response to new data sources, computer technology, and analytical methods, as well as to changes in the business environment itself. Since many applications focus on small areas, a substantial overlap exists between business demography and small-area demography.

Evolution of the Field

Businesses have based decision making on demographic data and techniques for more than a century (Pol and Thomas, 1997). The emergence of business demography as a distinct field, however, is quite recent. The release of 1970 census data in machine-readable form gave rise to an electronic data industry, which began with a mere handful of companies in the early 1970s and grew to more than 70 companies by the mid-1980s (Russell, 1984). The number of data vendors subsequently declined as demographic data became more widely available, but these firms were replaced by other demographically-oriented firms specializing in survey research, trend analysis, marketing, mapping, and software development, as well as the provision of census data and the production of population estimates and projections. Today, many businesses routinely base decisions on the advice of consultants and employees skilled in collecting, analyzing, and interpreting demographic data.

Responding to these developments, the Population Association of America formed a Committee on Business Demography in 1982. In 1985, this committee joined with the Committee on State and Local Demography to begin publishing the *Applied Demography* newsletter; by 2001, its subscriber base exceeded 400. During this period, two commercially-oriented magazines (*American Demographics* and *Business Geographics*) were launched, reporting on developments in demographic trends and business applications. Business demography thus has coalesced into a visible and well-established field, although it remains somewhat loosely defined and organized.

The Practitioners

Professionally, business demographers fall into three distinct groups. First are analysts employed by private companies, whose work focuses primarily on the business activities of their employers (e.g., human resources, market analyses, customer profiles, site selection). Second are analysts with firms that contract out to clients needing demographic data and analysis (e.g., to develop estimates and projections of the population residing within five miles of a specific location). These firms serve a variety of government agencies and business enterprises. Third are individual consultants who work on specific projects for particular clients. Private consulting is a full-time activity for some, but a part-time pursuit for most.

Not all practitioners have formal training in demography. Many have backgrounds in economics, geography, marketing, statistics, survey research, real estate, or other disciplines. Even those with formal demographic training often acquire many of their job skills primarily through work experience rather than academic training. Few academic demography programs deal with business issues, and few business schools offer training in demographic applications.

The skills needed by business demographers extend beyond the scope of what academic training programs normally provide. In addition to applying general demographic knowledge and skills, business demographers must be able to:

- Explain and interpret demographic realities to audiences with little knowledge of demographic perspectives and techniques.
- Identify important effects and potential issues that demographic changes may pose for a specific firm or industry.
- Construct demographic assumptions about the future that serve the needs of business decision makers.
- Be conversant with a range of disciplinary frameworks and theories (e.g., economics, finance, marketing, psychology, sociology, and geography) that inform decision making within a specific business context.

In their day-to-day work, most business executives focus on concerns in areas such as marketing, product development, human resources, and strategic planning. Rarely do they have the time or expertise needed to analyze the underlying demographic forces that affect these concerns. Demographers can contribute to business decision making by offering new perspectives on business problems (for example, distinguishing among age, period, and cohort effects that shape and reshape a market). They can inform, advise, and even serve as catalysts for organizational change. By exposing executives to new concepts and perspectives, demographers can elevate management thinking from an operational to a strategic level (e.g., Kintner and Swanson, 1997; Pol and Thomas, 1997; Rives, 1997; Siegel, 2002).

TOOLS

The tools of small-area and business demography are the same as those demographers use generally: basic demographic concepts, measures, and techniques; computer hardware and software; and data from a variety of sources. What sets them apart is that—in small-area and business demography—they are used primarily for decision-making purposes. In many applications, the development and interpretation of population estimates and projections plays a particularly important role.

Demographic Concepts, Measures, and Techniques

The demographic concepts, measures, and techniques used most frequently in small-area and business demography focus on population characteristics (e.g., age, sex, race, education, income), consumer units (e.g., individuals, households, families), demographic events (e.g., births, deaths, marriages, divorces, migration), and the distribution of demographic events and characteristics across geographic areas (e.g., counties, census tracts, ZIP code areas). In addition, small-area and business demographers often extend common demographic concepts and measures to fit the needs of specific projects. For example, they may conduct cohort analyses of magazine subscribers, construct life tables for automobiles, or develop age-standardized rates of beer consumption (Siegel, 2002). They also combine demographic and consumer data to yield new products such as *lifestyle clusters* based on the classification of neighborhoods by demographic characteristics and consumer preferences (e.g., Mitchell, 1995; Weiss, 1988).

Since most of these concepts, measures, and techniques are covered elsewhere in this volume, we do not review them here. However, given the importance of population estimates and projections for so many purposes, we briefly describe and evaluate several commonly used estimation and projection methods. Later in this chapter, we provide a number of illustrations showing how demographic concepts, measures, and techniques can be applied to specific topics in small-area and business demography.

Computer Hardware and Software

Exponential increases in computing power and data storage capacity in recent years have greatly expanded the possibilities for organizing, integrating, and analyzing data. Powerful software packages have largely automated statistical analysis and reporting. Computer networks enable analysts to share information and transfer data globally through the Internet. Advances in reporting and displaying spatial information through geographic information systems have been especially influential because many analyses call for data grouped into customer service areas, traffic analysis zones, school districts, and other uniquely defined regions. Discussions of the role of computer technology in small-area and business demography can be found in Bryan and George (2003), Gobalet and Thomas (1996), and Smith, Tayman, and Swanson (2001).

Data Sources

The data used in small-area and business demography come primarily from three sources: censuses, administrative records, and sample surveys.

Censuses. Most industrialized countries enumerate their entire populations once every five or 10 years. Censuses are not as frequent or as reliable in most less developed countries, but they have become increasingly widespread and comprehensive over the last 50 years (Cleland, 1996). Censuses provide the most reliable source of demographic data throughout the world.

The United States has conducted a census every 10 years since 1790. Under current practices, the starting point for each decennial census is a list of housing units from the preceding census, which has been updated using delivery data from the U.S. Postal Service, information from local government agencies, and a variety of administrative records. Most housing units are mailed census forms that the occupants are asked to fill out and return by mail; in some rural areas, the forms are delivered by census enumerators. Follow-up visits are made to housing units from which no form was returned, and a variety of procedures are used to develop complete and accurate information. About five of six households receive short-form questionnaires collecting a limited amount of population and housing data; about one of six receives a long-form questionnaire collecting information on a broader set of variables (see Table 1).

(Table 1 about here)

Each housing unit is assigned a specific geographic location based on its latitude and longitude. Natural and man-made features such as rivers, streets, and city boundaries are also assigned locations. Population and housing data are then grouped into specific geographic areas using the Topologically Integrated Geographic Encoding and Referencing (TIGER) system developed by the U.S. Census Bureau. Census results are tabulated for a variety of geographic areas, including states, counties, cities, ZIP code areas, census tracts, block groups, and blocks. Discussions of issues and procedures related to the decennial census can be found in Anderson (1988), Anderson and Fienberg (1999), Edmonston and Schultze (1995), and Skerry (2000).

Administrative Records. Censuses provide accurate and comprehensive data, but only infrequently. What data sources can be used for the years after or between the censuses? One possibility is administrative records kept by federal, state, and local government agencies for purposes of registration, licensing, and program administration. Data on births, deaths, marriages, and divorces are called *vital statistics*. Most industrialized countries maintain accurate records of these events, but records are far from complete in many less developed countries (Cleland, 1996). Other administrative records include school enrollments, building permits, drivers' licenses, Medicare enrollees, voter registration lists, and property tax records. These records provide information on a variety of demographic events and population characteristics. Since they are available on an annual or even a monthly basis in many countries, they can be used to construct population estimates and to conduct a variety of demographic analyses.

A population register is a system of data collection in which population characteristics are continuously recorded (Wilson, 1985). A universal register attempts to include the entire population, whereas a partial register is limited to specific groups such as school children, registered voters, or social security recipients. Universal registers are maintained in only a few countries, but partial registers can be found in many countries throughout the world. Since migration plays a major role in small-area population growth, registers that capture moves from one place to another are particularly important. Although some European countries maintain migration registers (Rees and Kupiszewski, 1999), most countries do not.

The full benefits of population registers (or administrative records in general) can be realized only if data are accurate and up-to-date; if individuals can be linked from one register to another through a personal identification number; and if the political climate permits such linkages to be made. These conditions are met in only a few countries. Denmark and Finland have produced census statistics based solely on administrative records, and Norway and Sweden are moving rapidly in this direction (Longva, Thomsen, and Severeide, 1998). Problems with one or more conditions have prevented the use of administrative records to supplement or replace regular censuses in the United States, Great Britain, and many other countries (Redfern, 1989; Scheuren, 1999).

An additional drawback of administrative records is that they are not available for many small areas. Some are available only for states and counties. Others are available for some subcounty areas (e.g., cities) but not for others (e.g., census tracts, traffic analysis zones, school districts). If individual records are geocoded by latitude and longitude, of course, administrative records can be tabulated to fit any level of geography.

Sample Surveys. Administrative records cover only some of the variables that are of interest to demographers, economists, sociologists, geographers, epidemiologists, planners, and other analysts dealing with small-area data. Sample surveys are often employed to collect data on variables not covered by administrative records.

In the United States, the Current Population Survey (CPS) is a monthly survey of about 50,000 households conducted by the U.S. Census Bureau. It collects information on marital status, fertility, migration, income, education, employment, occupation, and other characteristics, in addition to basic demographic variables such as age, sex, and race. Data from the CPS are currently tabulated for regions, states, and large metropolitan areas, but not for smaller geographic areas. Even for these larger areas, small sample sizes sometimes result in unreliable data and misleading trends.

This is a common problem when survey data are used for small-area estimates and analyses. Although it can be alleviated to some extent by using techniques that “borrow strength” from other areas or data sources (e.g., Ghosh and Rao, 1994; Rao, 1999), small sample sizes often limit the reliability of survey estimates for small areas.

The American Community Survey (ACS) may overcome this problem (U.S. Census Bureau, 2002a). Begun on an exploratory basis in 1996, this survey collects the same types of data as the long-form questionnaire of the decennial census. If carried out as planned, the ACS will be fully implemented by 2003 with some three million households surveyed each year. Starting in 2004, it is expected to provide annual estimates of demographic, social, economic, and housing characteristics for every state and for all cities and counties with 65,000 or more residents. For smaller places, it will take two to five years to accumulate a large enough sample to produce reliable estimates. Under current plans, estimates will be made down to the block-group level for the entire nation by 2008 and the ACS will replace the long-form questionnaire in the 2010 census. These plans, of course, are subject to change.

Estimates and Projections

Censuses, administrative records, and sample surveys provide the primary data used in demographic analyses. For many purposes, however, these data must be transformed into population estimates or projections. Population estimates refer to past time periods for which census data are not available (e.g., years after or between censuses); they are typically based on methods that combine data from censuses, administrative records, and/or sample surveys. Population projections refer to the future and are based on historical trends and assumptions regarding future trends.

Estimates. Estimates refer to the size and/or characteristics of the population of a specific geographic area at a specific point in time. Businesses use population estimates to develop consumer profiles, to choose sites for new stores or branch offices, and to identify under-served markets. Federal, state, and local governments use them to establish electoral boundaries, to plan service delivery, and to determine the need for various types of public facilities. Researchers use them to study social trends, environmental conditions, and geographic movements. They are used as population size controls for sample surveys, as denominators for many types of rates, and as a basis for distributing public funds. Clearly, the development of accurate, timely population estimates is critical for many purposes.

Intercensal estimates refer to estimates computed for dates between two previous censuses; *postcensal* estimates refer to those developed for dates after the most recent census. Intercensal estimates can be based on mathematical interpolations between the two end points or can be tied to data series that reflect intercensal population changes. Postcensal estimates can be based on the extrapolation of historical trends or can be tied to data that reflect postcensal population changes. Most applications call for postcensal estimates, which reflect the most recent information available to data users; accordingly, in this chapter we focus on this type of estimate. Detailed descriptions of population estimation methods can be found in Bryan (2003); Murdock and Ellis (1991); Rives, Serow, Lee, Goldsmith, and Voss (1995); and Siegel (2002).

Postcensal estimates of total population are usually based on methods that incorporate symptomatic indicators of population change. (A symptomatic indicator is a variable that changes in conjunction with changes in population.) Population estimates are most frequently based on housing unit, component, and regression methods.

The *Housing Unit* method is the most commonly used method for making small-area population estimates in the United States (U.S. Bureau of the Census, 1990) and has been widely used in other countries as well (e.g., Simpson, Diamond, Tonkin, and Tye, 1996). In this method, the population of an area is calculated as the number of occupied housing units (i.e., households) times the average number of persons per household, plus the number of persons living in group quarters facilities (e.g., college dormitories, prisons, nursing homes) or without traditional housing (e.g., the homeless), according to the following formula:

$$POP_t = (HH_t \times PPH_t) + GQ_t$$

where *POP* is the total population, *HH* is the number of households, *PPH* is the average number of persons per household, *GQ* is the population residing in group quarters facilities or non-traditional housing, and *t* is the estimation date (Smith, 1986). The number of households can be estimated from data on building permits, electricity customers, property taxes, and other records that reflect changes in the housing stock. PPH can be estimated from previous values and variables associated with changing household size. The residual population can be estimated from public records or data provided by the administrators of group quarters facilities.

Component methods are based on the demographic balancing equation in which the population in year t is expressed as the population counted in the most recent census (POP_0), plus the number of births (B) and in-migrants (IM) and minus the number of deaths (D) and out-migrants (OM) since that census:

$$POP_t = POP_0 + B - D + IM - OM$$

Two of the best-known component methods are the *Component II* and *Tax Returns* methods developed by the U.S. Census Bureau (e.g., Murdock, Hwang, and Hamm, 1995; Starsinic, Lee, Goldsmith, and Sparr, 1995). These methods are similar in that both are used solely for estimating the population less than age 65 (estimates of the population aged 65 and older are based on changes in Medicare data); both use vital statistics data to measure the natural increase of the population (B – D); and both use foreign immigration data from the U.S.

Immigration and Naturalization Service. Where they differ is in the data and techniques used to estimate the domestic portion of net migration (IM – OM).

The Component II method bases estimates of domestic net migration on changes in school enrollments for grades 1-8; these estimates are converted into migration rates for all persons less than age 65 using migration data from the most recent decennial census. The Tax Returns method (formerly called the *Administrative Records* method) bases estimates of domestic net migration on address changes listed on federal income tax returns. Addresses are matched for different years and the number of persons represented by each return is determined by the number of exemptions claimed (excluding exemptions for age 65+ and blindness). For both methods, estimates of the group quarters population are developed separately.

A number of methods use regression techniques in which population estimates are based on symptomatic indicators of population change (e.g., O'Hare, 1976; Feeney, Hibbs, and Gillaspy, 1995). Commonly used symptomatic indicators include school enrollments, electricity customers, building permits, registered voters, drivers' licenses, tax returns, births, and deaths. The most widely used regression method is *Ratio-Correlation*, in which all variables are expressed as changes in proportions over time. Using county estimates as an illustration, the dependent variable in the regression equation is the percentage change in the county's share of state population between the two most recent censuses (e.g., 1990 and 2000). The independent variables are the percentage changes between those two censuses in the county's share of state totals for the symptomatic indicators. The regression coefficients are applied to percentage changes in county shares for the symptomatic indicators between the most recent census and the estimation date (e.g., April 1, 2000 and July 1, 2003); this provides an estimate of the percentage change in the county's share of the state population. A county's population can then be estimated by applying its newly estimated population share to an independent estimate of the state's population.

These methods can be used alone or in combination with each other. For many years, the U.S. Census Bureau used the Tax Returns method for city estimates and the Component II, Ratio-Correlation, and Tax Returns methods for county estimates. Since 1996, it has used the Housing Unit method for city estimates and the Tax Returns method for county estimates. Currently, the U.S. Census Bureau controls county estimates to a national total, but calculates state estimates as the sum of each state's county estimates (U.S. Census Bureau, 2002b).

All these estimation methods have been widely used and extensively studied. Each has an established track record for producing reasonably accurate estimates (e.g., Bryan, 2003; Shahidullah and Flotow, 2001; Smith, 1986; Smith and Mandell, 1984). In theory, all except the ratio methods can be used at any level of geography (since ratio methods express smaller areas as proportions of larger areas, they typically are used only for subnational estimates). In practice, however, the component and regression methods are used primarily for state and county estimates because the data needed to apply them for subcounty areas are seldom available. In contrast, the Housing Unit method can be used at virtually any level of geography, from states down to counties, cities, census tracts, and even individual blocks.

In general, population estimates tend to be more accurate for more populous places than less populous places, and for places registering moderate growth rates than for places that are either growing or declining rapidly. Evaluations of 1980 and 1990 estimates produced by the U.S. Census Bureau showed mean absolute percentage errors of about 2% for states and 4% for counties (Long, 1993). Errors for 2000 county estimates were slightly smaller than those reported for 1980 and 1990 (Davis, 2001). For subcounty estimates, mean absolute percentage errors were found to be 15.2% for 1980 and 12.4% for 2000 (the U.S. Census Bureau did not release an evaluation of 1990 subcounty estimates). Errors varied tremendously by size: In both years, places with fewer than 100 residents had mean absolute percentage errors of about 35%, whereas places with more than 100,000 residents had mean absolute percentage errors of about 4% (Galdi, 1985; Harper, Devine, and Coleman, 2001).

Estimates of demographic characteristics such as age, sex, and race are typically based on the cohort-component method, in which birth, death, and migration rates are applied separately to each age/sex/race group in the population (e.g., Siegel, 2002). Estimates for particular population subgroups are sometimes based on data from administrative records, such as when Medicare data are used to estimate the population aged 65+ (e.g., Bryan, 2003). Since estimates of demographic characteristics are more variable than estimates of total population, they are typically controlled to independent estimates of total population.

At the national and state levels, estimates of socioeconomic characteristics such as income, employment, and education can be based on sample surveys. For local areas, however, place-specific survey data are seldom available; when they are, they often provide unreliable estimates because sample sizes are too small or sample strata cross geographic boundaries (Siegel, 2002). For these places, estimates can be based on synthetic techniques in which proportions derived from other data sources or larger areas are applied to population estimates for smaller areas. For example, a city’s labor force could be estimated by applying labor force participation rates by age, sex, and race from a state or national survey to population estimates by age, sex, and race for that city. In contrast to estimates of total population, little research has considered the accuracy of estimates of demographic and socioeconomic characteristics for small areas.

***Projections*.** Population projections also serve many purposes. They can measure the relative contributions of mortality, fertility, and migration to population growth. They can illustrate the likely range of future demographic scenarios and the sensitivity of population growth to changes in particular assumptions. Most important, they can provide an objective basis for anticipating and accommodating future population change. Population projections have been used to forecast Medicare costs (Miller, 2001), welfare obligations (Opitz and Nelson, 1996), healthcare expenditures (Kintner and Swanson, 1997), water consumption (Texas Water Development Board, 1997), housing demand (Mason, 1996), and many other phenomena of interest to decision makers.

Many different approaches to projecting future populations have been devised, ranging from the conceptually simple and straightforward to the highly complex and data-intensive. Some are objective and replicable; others are subjective, intuitive, or vaguely defined. Some provide projections of demographic characteristics and components of growth; others provide projections only of total population. Discussions of national, regional, and global projections can be found in Bongaarts and Bulatao (2000) and O'Neill, Balk, Brickman, and Ezra (2001). Discussions of state and local projections can be found in Davis (1995), Pittenger (1976), and Smith, Tayman, and Swanson (2001).

Most objective methods can be grouped into three basic categories: trend extrapolation, structural, and cohort-component. *Trend extrapolation* methods express the future as a continuation of historical trends. Some methods are very simple, such as those in which past growth rates are projected to remain constant. Others are much more complex, such as those based on time series models. Trend extrapolation methods are often applied to the population as a whole, but can also be applied to particular population subgroups (e.g., a racial or ethnic group), individual components of growth (e.g., births or birth rates), or data expressed as ratios (e.g., county shares of state population). The defining characteristic of trend extrapolation methods is that a variable's projected values are based solely on its historical values.

Structural models provide population projections based on variables that are expected to have an impact on population change (e.g., wage rates, job opportunities, educational levels). Some structural models are relatively simple, involving only a single equation and a few explanatory variables; others are much more complex, containing many equations, variables, and parameters. Some focus on total population change; others differentiate among components of growth. The defining characteristic of structural models is that the projected values of a variable are based not only on its own historical values, but also on projected values of other variables. Whereas trend extrapolation models tell us virtually nothing about the causes of population change, structural models provide explanations as well as projections.

The *cohort-component* method accounts separately for births, deaths, and migration, the three components of population growth. Most applications subdivide the population into age/sex groups; some further subdivide by race, ethnicity, or other demographic characteristics. Projections of each component can be based on the extrapolation of past trends, projected trends in other areas, structural models, or some other technique. The cohort-component method is used more frequently than any other projection method because it can incorporate many different data sources, assumptions, and application techniques and because it provides projections of demographic characteristics as well as projections of the total population.

The choice of a projection method depends on the availability of resources and the purposes for which the projections will be used. Simple extrapolation methods require few resources and can be applied quickly at virtually any level of geography, but provide only limited demographic detail and have little usefulness as analytical tools. More complex extrapolation methods require more data and modeling expertise, but share most of the other attributes of simple extrapolation methods. Cohort-component models are more data-intensive, time-consuming, and costly than trend extrapolation methods, but provide a much higher level of demographic detail and are more useful as analytical tools. Structural models are often the most data-intensive, time-consuming, and costly, but provide a variety of interrelated projections and offer the greatest analytical usefulness. Choosing a projection method for any particular project requires balancing the need for geographic, demographic, and socioeconomic detail against time, money, and data constraints.

No single method or category of methods has been found to produce projections of total population that are consistently more accurate than those produced by any other method or category of methods (e.g., Long, 1995; Smith and Sincich, 1992; White, 1954). In general, mean absolute percentage errors tend to increase as population size declines; as growth rates deviate in either direction from moderate but positive levels; and as the projection horizon extends further into the future. For economic variables, many studies have found that combining projections based on a variety of methods, data sets, or assumptions leads to greater forecast accuracy than can be achieved using a single projection by itself (Armstrong, 2001). Although there have been few studies to date, we believe the same may be true for projections of demographic variables.

For 10-year horizons, typical mean absolute percentage errors for population projections have been found to be about 6% for states, 12% for counties, and 18% for census tracts; for 20-year horizons, errors are roughly twice as large (Smith, Tayman, and Swanson, 2001). Clearly, there is much greater uncertainty in projecting future populations than in estimating current or past populations. Given this uncertainty, population projections prepared by the U.S. Census Bureau and many other demographic agencies generally contain several alternative series based on different methods, different combinations of assumptions, or the development of formal confidence limits. Delineating alternative future scenarios strengthens decision making by underscoring the uncertainties inherent in population projections.

ILLUSTRATIONS

Demographers address a varied and ever-expanding range of practical concerns in the public policy and business arenas. Accurate forecasts of residential energy needs, school enrollments, medical expenditures, and homeownership trends depend partly on foreseeing changes in population size, distribution, and composition. Human resource planning requires data on the characteristics of the available labor force and the employer's specific personnel needs. Site analyses call for comparative information on the demographic composition of populations clustered in and around competing locations. Sound financial planning relies on information regarding the effects of demographic changes on wealth accumulation, consumption, and investment. Technical issues arising in adversarial contexts require the testimony of experts with an understanding of demographic data and methods and a familiarity with any legal requirements that may apply. The following examples illustrate the diverse nature of the topics addressed by small-area and business demographers.

Catering to Homebuyers

The home-building industry is highly decentralized. A typical builder constructs just a few dozen homes a year in one or two communities. Business volume depends on short-term factors such as interest rates, consumer confidence, and local housing-market conditions. Accordingly, builders tend to be inattentive to longer-term demographic trends and are notoriously weak in their marketing strategies. When homes sell in a region, builders are likely to build more of the same type until like-minded builders collectively saturate the local market. Typically, a builder’s major concern is simply to sell newly built homes quickly and profitably.

A demographic perspective can provide builders with valuable marketing insights, particularly in volatile times. For example, demographers can highlight the degree of diversity found within the baby-boom generation. Prospective home buyers may include individuals, childless married couples, single adults paired up with co-investors, and other domestic units that hardly resemble the traditional family of American nostalgia. Compared with families with children, such home buyers have distinctive needs and preferences (e.g., houses that are maintenance-free and contain such adult-oriented features as home offices, hobby rooms, and flexible internal space that can be adapted to fluid living arrangements). Demographic insights can help builders cater to the highly varied needs of prospective home buyers and target distinct segments within the overall market.

Newspaper Readership

Newspaper publishers and editors recognize that they must adapt to powerful societal and demographic changes that are transforming advertising markets, reading habits, and readers’ interests. Increasingly, large cities tend to be populated by ethnic pluralities. To gain circulation (and advertising dollars), publishers need to focus more news stories on specific groups who collectively account for substantial proportions of the residents of a city (e.g., Latinos and particular Asian nationalities). Furthermore, many readers live alone, are divorced or remarried, or are cohabiting. Among married couples, fewer have children at home but more anticipate future eldercare obligations. Accompanying these diverse lifestyles are new interests and activities.

Demographers can identify the changing demographics of newspaper circulation and readership, helping publishers cater to the collections of small audiences with shared interests who comprise an increasingly segmented readership (e.g., Morrison, 1995). They also can devise and calibrate specialized tools for segmenting a customer base. For example, the surnames of a newspaper's subscribers can be used to distinguish those who are likely to be Latino, Korean, or Chinese (e.g., Abrahamse, Morrison, and Bolton, 1994; Lauderdale and Kestenbaum, 2000).

Site Evaluation and Selection

For many businesses, geographic proximity to consumer markets is imperative because most retail transactions are made at specific locations. Geographic location can be equally critical to the provision of public services. In both the private and public sectors, then, small-area demography plays a central role in site evaluation and selection: Pediatricians seek office locations near families with young children; school boards try to predict where the next wave of families with young children will move; banks seek branch locations in high-income suburban areas; hotels search for areas with large numbers of tourists or business travelers; and supermarkets, hardware stores, and health clinics look for sites in the midst of densely populated areas. Demographic analysis can inform decision making by evaluating a proposed site or weighing the comparative merits of several competing sites (e.g., Johnson, 1997; Murdock and Hamm, 1997; Voss, 1997).

Tayman, Parrott, and Carnevale (1997) illustrate an application of site evaluation and selection in the public sector. These analysts chose locations for new fire stations in a growing metropolitan area. They used a model combining methods from demography, geography, and urban planning, and compared potential sites by evaluating small-area data on projected population and household growth, road networks, travel times, land use plans, and access to "critical sites" such as hospitals, schools, and nursing homes. This case study—involving a problem both broad in scope and requiring more than demographic expertise alone—typifies the kind of situations encountered by many public-sector demographers.

Morrison and Abrahamse (1996) illustrate a business application of site evaluation and selection. These analysts screened several thousand square miles within metropolitan Southern California to identify the 10 best locations for a large supermarket chain catering to one-stop shoppers. Using a variety of demographic factors that were expected to enhance sales, the analysts selected locations based on potential sales volume. To pinpoint the density of geographic concentrations of food expenditures, they devised a model positing that the fraction of customers drawn to any given store from an area *x* miles away is determined by the number of people living in the area, its distance from the store, and the personal characteristics of supermarket shoppers. To identify consumers likely to be attracted to the convenience of one-stop shopping, they used census tract data on the proportion of families with two employed adults (whose work schedules would necessitate convenience). Other factors judged to be important were the proportions of large households (conducive to family-centered meals at home) and long-time homeowners (who would have lower mortgage payments and hence higher disposable incomes). These factors were shown to enhance the conventional distance-decay models that are typically used for choosing optimal sites.

Forecasting School Enrollment: Myth vs. Reality

Not all changes in school enrollment trends are demographically induced. Seemingly minor policy changes often have a major impact on the size and direction of enrollment changes, particularly where the effects of policy changes happen to coincide with spurious demographic events. McKibben (1996) chronicled an instance where an obscure change in state educational policy led to the mistaken public perception that a local school district was on the cusp of a long-term growth cycle. By lowering the minimum age for a child to enroll in kindergarten, the state board of education—through a simple change in policy—had introduced a one-time inflation of kindergarten cohort size. Community residents, reading media reports on a national "baby boomlet," discovered its apparent manifestations locally at the kindergarten level and strenuously opposed the local school board's plan to close several rural elementary schools.

In fact, there was no "baby boomlet" in their district. McKibben's team of analysts uncovered both the policy and its effect, and produced an enrollment forecast that was not confounded by the artificial appearance of growth. Using local data and the cohort-component method, they developed population and school enrollment projections that better informed the public debate and strengthened the planning process, helping avert unwarranted and costly plans to keep unneeded schools open.

Spatial Analysis and Public Health

Small-area demographic analysis supported by geographic information systems (GIS) opens up a host of potential contributions to the field of public health. Gobalet and Thomas (1996) described several case studies in which demographic techniques and perspectives strengthened the planning of health education campaigns and services. In one, a county public health department sought to identify areas in which public health interventions might reduce unnecessary hospitalizations among elderly residents with an above-average risk of developing acute but preventable conditions. The point of departure was an index of indicators believed to describe factors placing a senior citizen at risk of—among other things—reduced independence, increased morbidity, and premature death. The indicators (based on decennial census data) included high rates of linguistic isolation, living alone, and poverty. Together, these indicators identified census tracts with high index values (designated *Senior Risk Zones*, or SRZs).

The question these analysts wished to answer was whether seniors residing in SRZs were in fact more prone to early disability, untreated health problems, and unnecessary hospitalization than other seniors, as hypothesized in the model. To answer this question, they obtained hospital discharge data on diagnoses and patient addresses. The data, however, were available only by ZIP code, not by census tract. Using GIS, the analysts converted ZIP code data into census tract estimates and compared diagnoses with risk-index values for areas both inside and outside the SRZs. The analysis demonstrated that SRZs were, indeed, areas where preventable hospitalizations among seniors were disproportionately concentrated, making them potentially useful tools for targeting public health intervention.

Political Redistricting

Officials in states, counties, cities, school districts, and other jurisdictions that elect representatives are required by law to redraw election district lines using new data from each successive decennial census. Redistricting is a politically sensitive process that is subject to exacting legal standards. Demographers can play a central role in this process by providing the data and analysis needed to ensure that political jurisdictions comply with legal mandates. Because redistricting typically bestows an advantage on one group at the expense of another, constructing new boundaries often foments controversy and sometimes leads to acrimonious legal proceedings (Morrison, 1997).

Legal challenges brought under Section 2 of the Federal Voting Rights Act generally arise when minority groups claim that their voting strength is diluted by the way particular boundaries are drawn. The concept of *dilution* focuses attention on counting those members of the population who are entitled to vote and distributing this population geographically into voting districts. Typically, the resources that demographers use for such purposes are census data for small geographic units (e.g., census tracts and block groups), in which age and citizenship are shown separately for each minority group.

Since categories are not always neatly delineated, measurement can be difficult. For example, *Black* and *Hispanic* are not mutually exclusive categories, and the term *Asian* obscures separate nationalities that may exhibit genuine political differences (e.g., Chinese and Vietnamese). The opportunity to designate more than one racial category in the 2000 census further complicated the issue, making it more difficult to evaluate changes in racial composition over time. Since demographers have been trained to respect definitional subtleties and to recognize data limitations, they can deal with successfully with many of the nuances that arise in redistricting.

Conforming to Legally Mandated Standards

Demographic data, concepts, and techniques can also be used to evaluate affirmative action goals for equalizing employment opportunities. Courts of law addressing employment discrimination disputes need an accurate picture of each minority group's proportion in a pool of prospective employees. The demographic and socioeconomic factors conditioning those proportions vary from place to place. Here, demographers may be called upon to delineate the racial and ethnic composition of a pool of workers eligible to be hired or promoted, and to defend their measures and conclusions in adversarial settings.

Suppose that City X has a population that is 30% Hispanic, but only 15% of the city's employees are Hispanic. Does that disparity mean that employment opportunities have been less available to Hispanic than to non-Hispanic job seekers? Turning the question around, if employment opportunities were equally available to Hispanics, what would be their expected proportion among qualified job seekers in a city that is 30% Hispanic? It would be naive to imagine that a group's proportion of qualified job seekers would be precisely equal to its proportion of the overall population because age/sex structures, labor force participation rates, and other characteristics differ considerably from one racial/ethnic group to another.

Changes in any of these characteristics increase the complexity of the analysis. For example, suppose that Hispanics made up 15% of City X's population a decade ago, and that the very same individuals who worked for the city then are still its employees. Under such conditions, today's 30% Hispanic share would be incorrect as a benchmark for analyzing people hired 10 or more years ago. However, would 15% be the correct benchmark?

As this hypothetical example suggests, a group's presence in the current population may not represent its actual availability in either the current or the previous pool of qualified job seekers. The legal, technical, and philosophical issues related to legally mandated standards are highly complex. Their resolution requires not only knowledge of the law and the ability to apply demographic data and techniques, but experience and wisdom as well. (For related literature on the interplay of demography and the law, see Morrison, 1993, 1998, and 1999a and Smith, 1993.)

Costs of Health Benefits

Applications of business demography to the structure and dynamics of large corporate workforces have strategic implications for managing the cost of health benefits. Most Americans receive health benefits through employers, making groups of employees (and their families) the basis for healthcare financing. How do changes in workforce size affect the cost of health benefits? Does reducing the workforce by a certain percentage reduce healthcare costs by the same percentage? Do employers have complete control over the number of persons receiving company-sponsored health benefits?

To answer these questions, Kintner and Swanson (1996) analyzed three possible sources of change in the health benefits group associated with salaried employees at General Motors (GM): (1) flows into and out of GM related to employment processes; (2) flows into and out of the health benefits group related to demographic processes; and (3) transfers from active employment to retirement or layoff.

The GM health benefits group includes employees and their dependents. Employees become eligible for benefits through hiring; they lose benefits through quits, discharges, and deaths. Employees also leave this group through layoff or retirement (but may still be eligible for health benefits). Figure 1 summarizes the flows into and out of the health benefits group. Additions include new hires and their families, plus births and marriages to employees already belonging to the group. The group loses members through quits, deaths, divorces, and lost eligibility. Transfers occur through retirement and layoffs.

(Figure 1 about here)

Kintner and Swanson estimated these flows using record-matching techniques and identified the relative contributions of employment and demographic processes to changing group size. Their analysis revealed the limits that GM faces in controlling the size of its health benefits group. GM's use of window retirement packages for downsizing gives it some control, as does its control over hiring and firing. Nevertheless, demographic processes unrelated to turnover or transfers tend to have a substantial impact on changes over time in the size and composition of GM's health benefits group.

Labor Force Characteristics

A company may operate several production facilities which were started at different stages in its history. One byproduct of such sequential expansion may be a workforce whose age structure varies across facilities, with attendant human resource implications. As part of a consulting project, one of the authors of this chapter (Morrison) studied a company that operated several production facilities across the nation. Some opened as early as the 1940s; others, as late as the 1980s. Each plant depended heavily on a small cadre of experienced engineering and maintenance employees to repair mechanical breakdowns, which impose costly reductions in output.

This company had compiled age data for its overall workforce, but had never examined them separately by facility. Doing so revealed that the workforce at some plants exhibited distinctive age structures. Figure 2 shows the age structures for two of the company's plants. Plant A has an age structure similar to that of the entire company. Plant B, by contrast, began operations 40 years ago and has a disproportionately older work force. The majority of Plant B's employees are nearing retirement age, foreshadowing the impending loss of many highly experienced employees—precisely those employees whose skills would be most difficult to replace.

(Figure 2 about here)

These elementary demographic insights carry several important messages about how the company might prepare for the future. To cushion against the expected future losses of worker skills through retirement, a prudent manager might view existing skills as assets whose value will sharply appreciate in the years ahead. A forward-looking company might try to conserve those assets, perhaps by establishing an "un-retirement bank" of retirees who would be willing to work part-time when the need arose. Plant B is an obvious pilot site in which to test such an innovation, perhaps as a first step toward instituting it across the company.

Spotting Hidden Market Opportunities

Demographers are sometimes called upon to highlight the long-term significance of impending population shifts for consumer markets. Characterizing market evolution with reference to changing age structure, household makeup, and spatial distribution introduces new perspectives on potential opportunities. The following example illustrates how a demographic perspective might inform business thinking on the potential market for a relatively new product, the low-speed electric neighborhood vehicle (Morrison, 1999b).

Neighborhood vehicles (NVs) encompass a wide range of lightweight contraptions for transporting people within settings that are sheltered from conventional automobile traffic. Unlike golf carts (ubiquitous in retirement communities), NVs travel faster and afford passenger-cargo configurations that can be adapted to fit the varied needs of households at different stages in the life cycle. For example, the same NV platform might suit the needs of four passengers (e.g., grandparents with visiting children or grandchildren) or two passengers (e.g., a childless couple with six bags of groceries).

The most likely locations for NVs are master-planned residential communities, either gated or otherwise separated from regular automotive traffic. Such communities represent several distinct markets that might form distinctive niches for NVs—for example, retirement communities populated by older adults; golf and leisure communities populated by empty-nesters; and new towns (e.g., Columbia, Maryland and Celebration, Florida) populated by a broad spectrum of locally-oriented suburbanites. Other potential markets would include sprawling health or industrial parks, college campuses, and controlled-access national parks.

Although the market for NVs was not highly developed at the end of the twentieth century, three ongoing developments are likely to spark consumer interest. First is the proliferation of compact communities, both residential and commercial, within which new types of personal transportation are required. The common denominator in such communities is the need to shuttle around conveniently in settings that are unsuitable for automobiles or public transportation. Second is the growing proportion of one- and two-person "empty-nest" households, which aligns well with the capacity limits of the NV. These households might desire NVs as an alternative to a second car or as a discretionary indulgence analogous to a snowmobile or powerboat. Third is the rapidly expanding elderly population, which will initially promote the spread of leisure communities for relatively young, active retirees, but will eventually lead to large numbers of people with health and mobility limitations.

Presently, the customer base for NVs is spatially and demographically concentrated, but it is likely to grow rapidly in future years. Distinct market niches will likely materialize that can be targeted with different variants of an NV built on a common platform. Demographic insights can spark new ideas and nurture a strategic business vision for this nascent industry.

CONCLUSIONS

Small-area and business demography are closely intertwined because they use many of the same demographic concepts, data sources, and statistical techniques, and they address many of the same practical questions faced by decision makers. Several recent developments have driven—and will continue to drive—the advancement of both fields.

First, small-area data have become increasingly prevalent in many countries. These data are generally based on administrative records, but sample surveys also have played a role (e.g., the American Community Survey). Often, they are spatially referenced, allowing for the aggregation of individual-level data into a variety of customized geographic areas (e.g., consumer market areas, school districts, traffic analysis zones). New or enhanced data sources permit analyses that were impossible only a few years ago.

Proprietary databases derived from customer records have also become more common. Many businesses have developed automated data registries for individual customers. Examples include airline frequent-flier programs that track individual travel behavior; supermarket bar code scanners that track each shopper's purchases; and purchase histories recorded by credit card companies. These data afford unprecedented opportunities for targeting consumers based on personal characteristics and purchase histories. "You are where you live"—the marketer's dictum from the 1980s—has been replaced by "You are what you just bought." Data from both public and private sources will become increasingly available in the coming years, at ever smaller geographic scales.

Second, computer power has increased exponentially. Applications that once required expensive mainframe computers and highly developed programming skills are now feasible using inexpensive personal computers and standard software. The technology for storing, retrieving, and matching data has advanced rapidly, permitting many new applications. The Internet has facilitated the collection of data from widely divergent sources, promoted the sharing of information across vast distances, and provided businesses and government agencies with a powerful marketing tool. The end of these advances is not in sight.

Third, the development of geographic information systems (GIS) has greatly facilitated the collection, organization, manipulation, and analysis of spatially referenced data. This may be the single most important recent development affecting small-area and business demography. GIS can be used to select sites, develop population or customer profiles, track changes in health status, target areas to participate in government programs, screen potential markets, launch new products, and improve the visual presentation of information (e.g., Borroto and Martinez-Piedra, 2000; Gobalet and Thomas, 1996; Gould et al., 1998). Advances in satellite imagery and global positioning systems have made it possible to use GIS to track population, housing, and other trends over time and space (e.g., Harvey, 2000; Lo, 1995; Webster, 1996). These advances are particularly useful for places lacking reliable administrative records. The growth of GIS databases may also facilitate the development of new methods for projecting future growth, such as spatial diffusion models that base changes in one geographic area on what happened earlier in nearby areas (e.g., Morrill, Gaile, and Thrall, 1988).

These three developments have greatly enhanced the value of small-area and business demography for decision making. Several potential barriers, however, could limit future advances. The most formidable arises from concerns about privacy and the confidentiality of data. The collection of personal information is widely viewed as an invasion of privacy. Other concerns include the loss of confidentiality that may occur when data are shared among government agencies and private businesses or used for purposes other than those for which they were collected. These concerns have tended to limit the collection and use of administrative records data in the United States, Germany, the United Kingdom, and several other countries (e.g., Doyle, Lane, Theeuwes, and Zayatz, 2001; Redfern, 1989; Scheuren, 1999). Since the linkage of personal records from several data sets is essential for many purposes, concerns about privacy and confidentiality could prevent the most effective use of data for both public and private sector decision making. As illustrated by recent discussions regarding the use of linked data for national security purposes, this promises to be a topic of vigorous debate during the coming years.

Not all applications of business demography pertain to small areas. As markets have globalized, business interests have focused increasingly on the emergence of massive groups of consumers in countries like India and China. Given their large populations and rapid economic growth, these countries provide huge but largely untapped consumer markets. Anticipating the future growth of these markets poses distinctive problems amenable to demographic analysis (e.g., Morrison, Levin, and Seever, 1996). Although many applications of business demography have focused on ever smaller geographic areas and demographic subgroups, we believe future applications will address these broader horizons as well.

Table 1. Data Collected in 2000 Census, United States

All Households (Short-Form Questionnaire)

Population: Name, relationship to householder, sex, age, date of birth, race, and Hispanic origin.

Housing: Number of people in household, telephone number, and tenure (ownership status).

Sample of Households (Long-Form Questionnaire)

Population: Same as short form, plus marital status, school enrollment, educational attainment, ethnic origin (ancestry), language spoken at home, place of birth, citizenship, year of entry into the U.S., place of residence five years ago, disability status, living with grandchildren, military service, employment status, employment history, place of work, transportation to work, occupation, industry, and income.

Housing: Same as short form, plus type of housing unit, year built, length of residence in current unit, number of rooms, number of bedrooms, plumbing facilities, kitchen facilities, telephone in unit, type of heating fuel, number of motor vehicles, size of lot, presence of home business, annual cost of utilities, monthly rent or mortgage payment, second mortgage, real estate taxes, property insurance, and value of property.

Source: Smith, Tayman, and Swanson, 2001, p. 37.

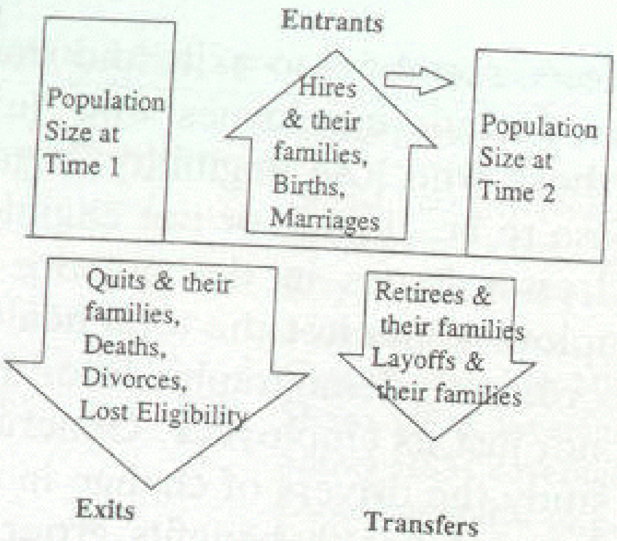

Figure 1. Flows into and out of health benefits group.

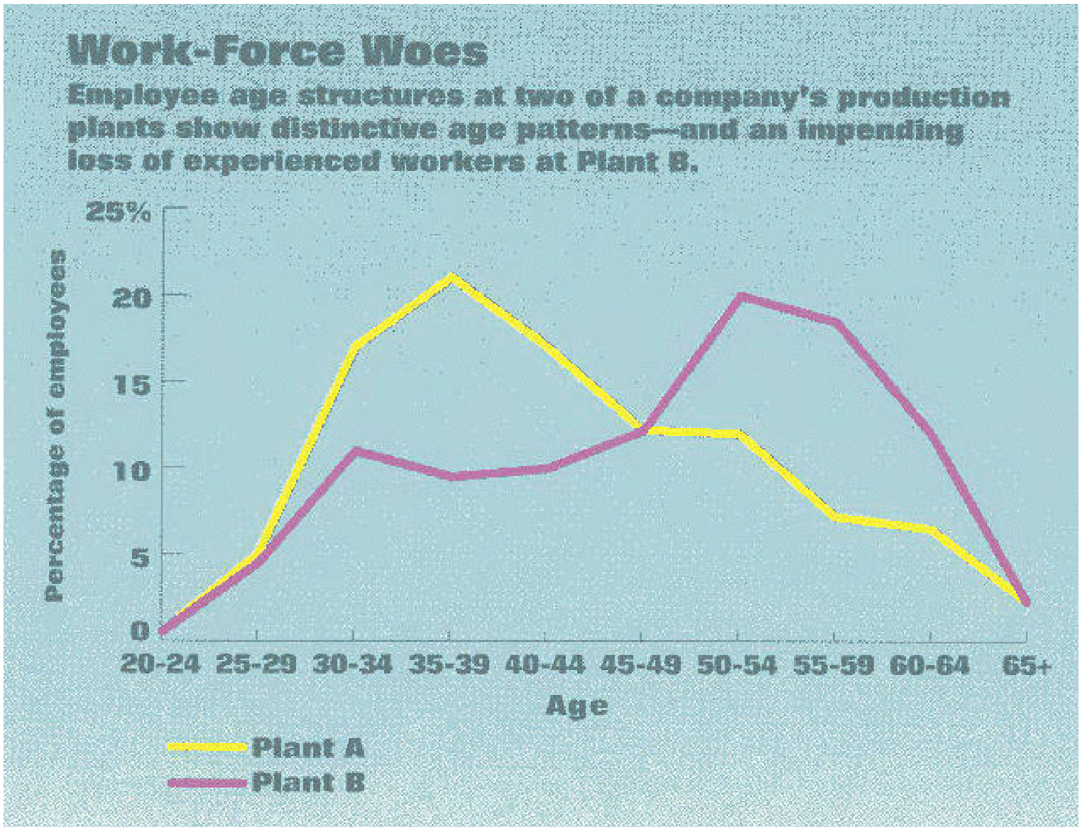
Work-Force Woes
Employee age structures at two of a company's production plants show distinctive age patterns—and an impending loss of experienced workers at Plant B.
25%
20
15
10
5
0
Percentage of employees
20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65+
Age
Plant A
Plant B

Figure 2.

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