

UC Berkeley

Earlier Faculty Research

Title

Job Accessibility as a Performance Indicator: An Analysis of Trends and Their Social Policy Implications in the San Francisco Bay Area

Permalink

<https://escholarship.org/uc/item/6mp941d9>

Authors

Cervero, Robert
Rood, Timothy
Appleyard, Bruce

Publication Date

1995-04-01

**Job Accessibility as a Performance Indicator:
An Analysis of Trends and Their Social Policy
Implications in the San Francisco Bay Area**

Robert Cervero
Timothy Rood
Bruce Appleyard

Institute of Urban and Regional Development
Department of City and Regional Planning
University of California
Berkeley, CA 94720-1850

*Working Paper
April 1995*

UCTC No. 366

The University of California Transportation Center
University of California at Berkeley

The University of California Transportation Center

The University of California Transportation Center (UCTC) is one of ten regional units mandated by Congress and established in Fall 1988 to support research, education, and training in surface transportation. The UC Center serves federal Region IX and is supported by matching grants from the U.S. Department of Transportation, the California Department of Transportation (Caltrans), and the University.

Based on the Berkeley Campus, UCTC draws upon existing capabilities and resources of the Institutes of Transportation Studies at Berkeley, Davis, Irvine, and Los Angeles; the Institute of Urban and Regional Development at Berkeley; and several academic departments at the Berkeley, Davis, Irvine, and Los Angeles campuses. Faculty and students on other University of California campuses may participate in

Center activities. Researchers at other universities within the region also have opportunities to collaborate with UC faculty on selected studies.

UCTC's educational and research programs are focused on strategic planning for improving metropolitan accessibility, with emphasis on the special conditions in Region IX. Particular attention is directed to strategies for using transportation as an instrument of economic development, while also accommodating to the region's persistent expansion and while maintaining and enhancing the quality of life there.

The Center distributes reports on its research in working papers, monographs, and in reprints of published articles. It also publishes *Access*, a magazine presenting summaries of selected studies. For a list of publications in print, write to the address below.



**University of California
Transportation Center**

108 Naval Architecture Building
Berkeley, California 94720
Tel: 510/643-7378
FAX: 510/643-5456

The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the U.S. Department of Transportation. This report does not constitute a standard, specification, or regulation.

Job Accessibility as a Performance Indicator: An Analysis of Trends and Their Social Policy Implications in the San Francisco Bay Area

Abstract

Shifts in job accessibility reflect, in part, the degree to which land use and transportation decisions are helping to economize on commuting and promote social equality objectives. This paper argues for the aggressive use of accessibility indicators as part of the long-range transportation planning process. As a case example, changes in job accessibility indices are traced for the San Francisco Bay Area from 1980 to 1990, computed for 100 residential areas and the region's 22 largest employment centers. The indices were refined based on occupational match indicators that weighed the consistency between residents' employment roles and labor force occupational characteristics at workplaces. The analysis revealed that peripheral areas tended to be the least job accessible. Moreover, employment centers that are home to highly skilled professional workers were generally the most accessible when occupational matching is accounted for. This was interpreted to reflect the existence of a more robust and responsive housing market in and around higher end employment centers. Our analyses also revealed that residents of low income, inner-city neighborhoods generally faced the greatest occupational mismatches. Through a path analysis, racial discrimination was found to be a more serious obstacle to employment than job accessibility, however. We conclude that the very purpose of tracking change in accessibility is to provide feedback on the degree to which resource allocation decisions in the urban transportation field are helping to redress serious inequities in accessibility to jobs, medical facilities, and other important destinations.

1. Introduction

Accessibility, as an indicator of *opportunities* to efficiently reach places, has gained increasing attention as a complement to transportation planning's more traditional mobility-based measures of performance, like "average delays" and "levels of service". Evaluating transportation performance in terms of accessibility allows a more balanced approach to transportation analysis and problem-solving. Notably, it gives attention to alternative strategies for reducing traffic congestion and coping with environmental problems, such as promoting efficient patterns of land

development and transportation demand management (TDM). Bringing urban activities closer together, through more compact development and inter-mixing of land uses, as well as by promoting tele-travel, can substitute for physical movements. While not a replacement for mobility-based planning, accessibility measures help gauge progress toward meeting other regional objectives like sustainability and social equality.

Although accessibility, as a normative principle, has been embraced by increasing numbers of commentators, there is little evidence that it is being operationalized in practice as part of long-range regional transportation planning. A fair amount has been done of late to incorporate accessibility measures into transit service planning (e.g., Rood, 1997). Many short-term transit plans, for instance, monitor what share of transit routes lie within a quarter mile walking distance of households within a service district. However, as input to long-range transportation plans, few, if any, rigorous analyses are undertaken to track progress in putting households closer to jobs, retail centers, medical facilities, and other major destinations. This has both efficiency and equity implications. One, without explicit attention to accessibility trends, it becomes unclear whether resource allocation decisions -- e.g., where to expand road capacity, where to site major new activity centers, etc. -- are cumulatively, over time, helping to economize on travel. Two, the distributional equity implications of past investment decisions -- e.g., who is better versus worse off in terms of relative access to job opportunities -- also get ignored. Inattention to the social equity implications of prior transportation decisions is particularly troubling. A number of analysts have argued that a chief explanation for inner-city poverty, especially among African Americans, is the increasing spatial separation from employment opportunities in the suburbs, what has been called "spatial mismatch" (Ihlandfeldt and Sjoquist, 1991; Kain, 1993). It is partly in response to such concerns that several federally supported pilot projects, called "Bridges to Work", have been introduced in Baltimore, Milwaukee, and other U.S. cities in recent years. These initiatives aim to link inner-city residents with suburban jobs by expanding door-to-door reverse-commute van services.

This paper uses census transportation planning data to study trends in job accessibility between 1980 and 1990, with the San Francisco Bay Area serving as a case context. The objectives of the analysis are multiple. One, the work seeks to advance the use of accessibility indicators as inputs to long-range transportation planning and monitoring. We argue that longitudinal measures of accessibility are important social indicators, illuminating the distributional equity implications of past investment and

regional planning decisions. We focus on tracking differences in job accessibility over time among spatially defined neighborhoods and employment centers in the San Francisco Bay Area. Second, our work aims to enrich how job accessibility is measured by introducing an “occupational match” refinement. This approach accounts for the consistency between employed residents’ skills and employment roles within specific neighborhoods and labor force occupational characteristics in employment zones. It thus adds an important qualitative dimension to studying job accessibility. Third, we use refined empirical measures of job accessibility to address the spatial mismatch question in the San Francisco Bay Area. Through path analysis, we examine the relative contribution of accessibility versus other factors, such as educational levels and race, in explaining unemployment rates in the region. This is complemented by an investigation into whether job accessibility advantages among the Bay Area’s largest employment centers are reflected in real estate market performance. We conclude with a call for more formally institutionalizing and expanding the use of accessibility indicators for evaluating and monitoring long-term transportation system performance as well as progress toward achieving broader social welfare objectives.

2. Methodological Approach

We opted to focus our work on measuring longitudinal shifts in job accessibility because all necessary data inputs are readily available from the Census Transportation Planning Package (CTPP). Any metropolitan area over 50,000 population is in a position to carry out a similar analysis using decennial census records.

Two approaches are commonly used to measure accessibility: (1) gravity-like measures (based on the denominator, or balancing factor, of a singly-constrained trip distribution model); and (2) isochronic measures (indicating the number of opportunities reachable within a given travel time or distance). Gravity-like measures, as originally formulated by Hansen (1959), are generally preferred since, unlike isochronic measures, they consider all trip end possibilities and thus avoid introducing a subjective and sometimes arbitrary spatial boundary. See Koenig (1980) for a comprehensive overview on the measurement and use of accessibility indicators in the urban transportation field.

Our work examines accessibility trends from the perspectives of both employed residents (i.e., at the residential end of work trips) and workers (i.e., at the employment end of work trips). Part I of the CTPP provides data on the number of

employed residents, stratified by occupational class, for census disaggregations (either census tracts or traffic analysis zones (TAZs). Part II of the CTPP does likewise at the employment end, specifying number of workers, by occupational class. To generate job accessibility indices, one only needs to supplement these data with zone-to-zone matrices of travel times (or distances), which are generally available from the network models maintained by metropolitan planning organizations (MPOs).

The locations of 100 randomly sampled residential census tracts and 22 largest employment centers in the 9-county San Francisco Bay Area that formed the cases for our analyses are shown in Figure 1. The 22 employment centers constituted some 47 percent of total regional jobs in 1990. See Cervero and Wu (1997) and Wu (1994) for discussions on the employment and density characteristics of these 22 centers.

2.1 Calculating Job Accessibility Among Residential Tracts

For the 100 census tracts in the San Francisco Bay Area (out of a 1990 regional total of 1382 tracts) whose predominant land use is residential housing, a “basic” gravity-like measure of job accessibility was measured as follows:

$$AI_i = \sum_j E_j d_{ij}^{-\gamma} \quad \forall i = 1, 2, \dots, 100 \quad (1)$$

where:

- AI_i = Accessibility Index for residential zone i , standardized as the number
- E_j = Employment -- number of workers in zone j ; $j = 1$ to 1382.
- d_{ij} = Distance (in miles) -- highway network distances between zonal centroids, for all i - j interzonal pairs < 45 miles.¹
- γ = Empirically derived impedance coefficient, set at -0.35 for commute trips in the San Francisco Bay Area.

Accessibility values were standardized to remove the effects of measurement units and sample size. Network highway distances (between the centroids of all interzonal combinations) were used to express spatial impedance.² The analysis was bounded to incorporate only interzonal pairs for which network distances were under 45 miles. This was partly a concession to the Bay Area’s unique urban geography. With a vast central bay, the region’s labor markets tend to be distinctively defined geographically. Few people working in the south bay (Santa Clara County) live in the north bay (Marin, Sonoma, Napa, and Solano counties), and vice-versa, because commute distances are simply too great. Thus, the south bay is not generally perceived as an employment possibility among north bay residents (in 1990, only

2,033 of the north bay's 513,120 employed residents worked in Santa Clara County). Also, the expression of the distance variable in inverse form and the setting of the impedance exponent at -0.35 was based on the best-fitting results from a gravity model estimated to explain 1990 work-trip interchanges in the region.

For purposes of introducing the element of "occupational matching" into our analysis, the job accessibility measure for residential neighborhoods was refined as follows:

$$AI_i = \sum_j \sum_k [p_{ik} E_{jk}] d_{ij}^{-\gamma} \quad \forall i = 1, 2, \dots, 100 \quad (2)$$

where variables are equivalent to those in equation 1, with the following additions:

- p_{ik} = Proportion of employed residents in zone i working in occupational class k, where k = 1 (executive, professional, managerial), 2 (sales, administration, clerical), 3 (services), 4 (technical), and 5 (all others, excluding all non-civilian positions).
- E_{jk} = Number of workers in zone j (j = 1 to 1382) working in occupational class k (k=1 to 5, as above).

Called an "occupational match" accessibility index, equation 2 adds an important qualitative dimension into the analysis. For any residential zone i, proximity to jobs in zone j will contribute positively to the accessibility index only if the occupational roles of employed residents (reflecting their skills and qualifications) in zone i match the occupational opportunities in zone j. Thus, if a large share of employed residents from a neighborhood in, say, Concord work in technical positions and a large number of available jobs in nearby Walnut Creek are in technical fields, then equation 2 shows that this combination will produce a high positive numeric value. On the other hand, where there is discordance between the skills and occupational roles of employed residents and the available job slots in close by areas, equation 2 shows little will be contributed to the accessibility index value, even if d_{ij} is very small. Building upon the work of Wachs and Kumagai (1973), the addition of this refinement allows conditions like occupational mismatches to be explicitly accounted for in the job accessibility index. Subtracting the standardized "base" accessibility index (equation 1) from the standardized "occupational match" index (equation 2) provides what we call a "match effect" -- an indication of the relative importance of occupational matching as an input into the calculation of job accessibility (wherein large positive values indicate that residents are generally well qualified for nearby jobs and a large negative value indicates the existence of a serious job mismatch).

2.2 Calculating Job Accessibility Among Employment Centers

A similar set of analyses were conducted with reference to the region's 22 largest employment centers. The "base" job accessibility index for workers at large employment centers took a similar form as equation 1:

$$AI_j = \sum_i R_i d_{ij}^{-\gamma} \quad \forall j = 1, 2, \dots, 22 \quad (3)$$

where expressions are equivalent as before, with the addition of:

- AI_j = Accessibility Index for employment center j (combinations of contiguous census tracts), standardized as the number of standard deviations from the mean score.
- R_i = Employed residents in zone i ; $i = 1$ to 1382.

Adding the "occupational match" dimension yielded the following refined measure of job accessibility among the region's large employment centers.

$$AI_j = \sum_i \sum_k [p_{jk} R_{ik}] d_{ij}^{-\gamma} \quad \forall j = 1, 2, \dots, 22 \quad (4)$$

where variables are equivalent to those in equation 1, with the following additions:

- p_{jk} = Proportion of workers in employment center j working in occupational class k , where $k = 1$ (executive, professional, managerial), 2 (sales, administration, clerical), 3 (services), 4 (technical), and 5 (all others, excluding all non-civilian positions).
- R_{ik} = Number of employed residents in residential zone i ($i = 1$ to 1382) working in occupational class k ($k=1$ to 5, as above).

2.3 Data Reconciliation

In computing accessibility indices for both 1980 and 1990 using equations 1 through 4, difficulties were encountered trying to reconcile differences in variable measurements and definitions of census tracts and traffic analysis zones (TAZs) between the two census years. We adopted 1990 census definitions of tracts, and in the roughly 15 percent of cases where tract boundaries differed over the two census years, we used Geographic Information Systems (GIS) techniques to reapportion 1980 data to fit 1990 boundaries. Conversion tables, obtained from the Metropolitan Transportation Commission (MTC), were used to express population and employment data for the region's 1099 TAZs according to census tracts. Where problems of incompatible variable definitions were encountered over the two census

years, variable categories were generally collapsed to express data at the most disaggregate level of compatibility.

3. Residential-Based Analysis

3.1 Trends in Job Accessibility Across Residential Neighborhoods

Basic Job Accessibility Trends

Figure 2 shows the calculated 1980 and 1990 job accessibility indices for the 100 residential Bay Area tracts, without any adjustment for occupational matching (e.g., from equation 1). It is noted that standardized accessibility values are presented, allowing scores for any one neighborhood to be compared against the regional mean. Several spatial patterns are evident from this output. One, the most job inaccessible tracts, ignoring occupational match, tend to occupy the periphery of the region -- e.g., the outer north and south bays. This partly reflects the constitution of these tracts as predominantly bedroom communities (Cervero, 1989; Wu, 1994; Cervero, 1996). It is also an artifact of the spatial constraints imposed on our analysis. Since the CTPP only provides tract-level employment for the 9-county region, job accessibility for more peripheral areas is understated since employment opportunities outside the region are ignored. This problem could be partly overcome by combining employment data from Part II of the CTPPs of surrounding metropolitan statistical areas (MSAs), however notwithstanding the additional resource demands that this would impose, problems would be encountered in consolidating network travel distance matrices from different MPOs and converting TAZs to census tracts across MPOs. No adjustments in employment totals were made for these reasons, although we acknowledge the biases against peripheral tracts inherent in conducting job accessibility studies within the confines of a single metropolitan area. Finding ways of overcoming these biases is a promising area for future research.

Figure 2 reveals that the more centrally located tracts ringing the San Francisco Bay averaged the highest job accessibility in both 1980 and 1990, again ignoring questions of occupational match. Neighborhoods in the region's two most urbanized cities, San Francisco and Oakland, were the most job accessible in terms of proximity to aggregate numbers of jobs. And with the exception of the north bay, Figure 2 suggests that "basic" job accessibility improved for most residents during the 1980s, a period of rapid employment decentralization (Cervero and Wu, 1997). In the absence of pro-active regional land-use planning, market-driven patterns of development seemed to put more residents closer to job opportunities, expressed in the aggregate, throughout the 1980s.

Occupational Matching

From the calculations carried out using equation 2, Figure 3 presents the refined 1980 and 1990 job accessibility indices, incorporating the element of occupational matching. The overall pattern follows that of Figure 2, with peripheral tracts averaging the lowest accessibility indices in both years and centrally located ones the highest. Occupational-matched accessibility scores tended to increase the most for the most job-accessible residential areas and fall off the most in the least job-accessible ones (Figure 4). That is, disparities generally widened over the course of the 1980s.

The job accessibility advantages of residential areas in San Francisco and the inner south bay (e.g., the Silicon Valley) were much more pronounced when occupational matching was accounted for. This is best revealed by Figure 5, which summarizes the "occupational match effects" for both 1980 and 1990: the difference from subtracting the calculated basic, or "non-matched", values from the "occupational matched" values. As noted, a high positive value signifies a strong match between residents' occupations and nearby job opportunities; a negative value suggests discordance -- the job roles of residents do not closely match nearby employment opportunities. The highest match effect tended to be in well-to-do residential neighborhoods -- north San Francisco (numbered dots 51 and 53 on the map), Berkeley-northeast Oakland (25 and 26), south Marin County (20 and 21), and Palo Alto-Mountain View (84 and 88) in the south bay. Median household incomes in these neighborhoods are well above the regional average. In 1990, the 10 neighborhoods with the highest "match effect" averaged an unemployment rate among adult working-age civilians of less than 3 percent, compared to a regional average of 7 percent. In none of these areas did African Americans make up more than 4 percent of total population. In contrast, the greatest job opportunity mismatches (e.g., high negative "match effect" scores) tended to be found in some of the region's poorest neighborhoods -- San Francisco's Tenderloin and Mission neighborhoods (numbered dots 53, 56, 63, and 64 on the map), south Oakland (28 and 29), and East Palo Alto/East Menlo Park in San Mateo county (82 and 83). All averaged household incomes and employment rates well below the regional average in 1990. Most also are dominated by African-American or Latino households. Additionally, while occupational matching generally improved among affluent neighborhoods during the 1980s, the opposite trend generally occurred among the poorest ones. That is, disparities in occupational matching widened substantially during the 1980s period of rapid employment decentralization.

These “match effect” findings likely reflect several dynamics. One, there was probably more fluidity in housing markets and greater residential mobility among well-educated, higher salary workers over the 1980s, enabling them to more easily sort themselves into locations reasonably close to job opportunities. This is consistent with recent research showing the existence of a strong, well-functioning housing market suited to the earnings and taste preferences among the Bay Area’s professional workers and upper-income strata (Cervero and Wu, 1997). Neighborhoods like Russian Hill in San Francisco, which recorded the highest “match effect” in 1990 as well as the highest “match effect” increase during the 1980s, attracted executives and highly paid young professionals seeking a mix of urbanity and close proximity to front-office jobs. Additionally, leading Bay Area firms also tended to locate with reference to potential pools of professional and executive employees during the 1980s (Saxenian, 1994). At the other end of the income spectrum, however, poor households anchored in often declining inner-city neighborhoods appear to have found themselves less and less accessible to jobs which they qualify for over the course of the 1980s. Zax (1990), for instance, found that segregation and housing discrimination in the United States prevented black households from moving to neighborhoods near suburban employment centers. These trends would appear to support the spatial mismatch explanation of chronic inner-city joblessness and social problems.

3.2 Job Accessibility and Unemployment: Space Versus Race

The Spatial Mismatch Hypothesis

To explore the relationship between job accessibility and unemployment in the Bay Area, and thus address the spatial mismatch question, we merged our accessibility scores with census data and proceeded to conduct a path analysis. As noted, the spatial mismatch hypothesis, first advanced by Kain (1968), holds that a root cause of chronic joblessness and persistent poverty has been the increasing physical isolation, or inaccessibility, of inner-city residents, especially young African-American adults, from suburban employment opportunities. The hypothesis has been shrouded in controversy owing to inconsistent and sometimes conflicting empirical evidence (Jencks and Mayer, 1990). Some (Holzer, 1991) argue that accessibility matters. Ihlanfeldt and Sjoquist (1989) found that accessibility to jobs explained between 30 and 50 percent of the difference in employment rates among black and white teenagers. Others (Leonard, 1987) counter that it is really lingering problems of overt racial

discrimination that explain inner-city unemployment. To them, spatial mismatch is a smokescreen to more deeply rooted racial divisions in our society. In an influential study of black households in Chicago, Ellwood found comparably high unemployment rates among blacks with similar education levels regardless whether they resided on the southside, away from job opportunities, or west of the city near the booming Interstate 88 employment corridor. From this he rather pithily concluded that the chief reason for chronic unemployment among blacks is “race, not space”. See Kain (1993) for a comprehensive review of the spatial mismatch literature.

For the 100 randomly sampled residential tracts, 1990 unemployment rates were predicted as functions of: occupationally matched job accessibility, racial composition, educational levels, and automobile ownership rates. Incompatible census definitions and treatments of variables related to unemployment and racial composition precluded us from conducting a 1980-1990 analysis of *changes* in unemployment as a function of *changes* in these predictors. The considerably smaller variations in data, when expressed in terms of changes, would have also constrained statistical analyses. For these reasons, a 1990 cross-sectional path analysis was opted for. By expressing accessibility to account for occupational matching, our indices provide a methodologically rich basis for separating the spatial dimensions of unemployment patterns among residential neighborhoods from other possible explainers like race.

Path Model Design

To probe the “space versus race” debate, we constructed two sets of path models. Model 1 explains unemployment in terms of “space”, or job accessibility, controlling for other possible explainers, like education and automobile ownership. It assumes race has no direct bearing on unemployment; rather the influences of race operate indirectly through such intermediate factors as education and vehicle ownership levels. Specifically, Model 1 posits that while African-Americans might be more likely than others to live in neighborhoods that are inaccessible to suitable jobs, to have less than a ninth-grade education, and to have no car available, they are not directly discriminated against in employment. Model 2, on the other hand, represents the “racial discrimination” model. It says that in addition to the indirect relationships in Model 1, there is a direct causal link between percent African-American and percent unemployed. If discrimination is not present, Model 1 should explain the observed correlation between percentage African-American and unemployment rates at least as well as Model 2.

Path Model Results

The standardized path coefficients, or beta weights, estimated for the links of the two path models are shown in Figure 6. The path coefficients from BLACK to the other explanatory variables represent simple Pearson Product-Moment correlations, while all other path coefficients were derived from regressing predictor variables on UNEMPLOYED, using ordinary least squares estimation. Figure 6 reveals that even when controlling for factors like job accessibility, education levels, and vehicle ownership, African American neighborhoods still have significantly higher unemployment rates than predominantly non-black neighborhoods. In fact, race has a stronger influence on unemployment rates in Model 2 than any explanatory variable. The superiority of Model 2 as an explainer of unemployment is further revealed by decomposing the correlation between BLACK and UNEMPLOYED into direct and indirect effects (see Asher, 1981). Table 1 shows that Model 2 almost perfectly accounts for the observed correlation (0.757) between percent African-American and unemployment.³ By comparison, Model 1, absent a direct link between BLACK and UNEMPLOYED, is clearly underspecified. While “space”, or job accessibility, certainly matters in explaining unemployment in the San Francisco Bay Area, race and educational attainment matter a whole lot more. Our findings clearly give more credence to “race” than to “space” in explaining persistent joblessness in the region.

4. Employment Center Analysis

During the 1980s, like many areas of the country, the Bay Area experienced considerable employment decentralization (Cervero, 1989; Wu, 1994; Cervero and Wu, 1997). In light of this trend, we were able to explore trends in job accessibility across the region’s largest employment centers (ECs).⁴ As a complement to the residential-based analysis, we examined these trends across classes of employment centers. Moreover, we probed the relationship between job accessibility and office real estate market performance among the ECs. Changes in job accessibility among different occupational classes of workers were also examined. The results of these analyses are summarized in this section.

Table 1. Decomposition Analysis of Correlation Between Percent African American and Unemployment Rate

Pearson Product-Moment Correlation of BLACK and UNEMPLOYED = 0.757

Model 1: Spatial Model

<u>Direct effects</u>	<u>Indirect effects</u>		<u>Total Effects</u>
0	ACCESS:	(-0.206) (-0.173) = 0.036	0.475
	NOHISCHOOL:	(0.578) (0.681) = 0.394	
	NOCAR:	(0.292) (0.157) = 0.046	

Model 2: Racial Model

<u>Direct effects</u>	<u>Indirect effects</u>		<u>Total Effects</u>
0.436	ACCESS:	(-0.206) (-0.152) = 0.031	0.752
	NOHISCHOOL:	(0.578) (0.422) = 0.244	
	NOCAR:	(0.292) (0.138) = 0.040	

4.1 Trends in Job Accessibility Among Employment Centers

Figures 7 and 8 show the 1980 and 1990 accessibility indices calculated for the Bay Area's 22 largest employment centers (ECs), "without" and "with" occupational match adjustments, respectively. Both figures reveal similar spatial patterns with respect to job accessibility among EC workers in both cases. In general, centrally located ECs -- CBDs in San Francisco and the inner east bay (Oakland, San Leandro, and Hayward) -- averaged the highest levels of job accessibility, both with and without occupational matching. For example, Figure 7 shows that the occupationally matched accessibility index for San Francisco was 1.21 standard deviations above the mean for all 22 ECs. In contrast, peripheral job sites fared the poorest, both in 1980 and 1990.⁵ Two exceptions were the region's two fastest growing ECs, San Ramon and Pleasanton, both located on the periphery of the east bay. Both San Ramon and Pleasanton, homes of the region's two largest master-planned business parks, were major recipients of back office relocations from downtown San Francisco and Oakland during the 1980s. Among the many factors attracting firms to these peripheral locations were their available pools of college-educated residents and in particular, back-office clerical and secretarial labor (especially middle-class married women, many of whom at the time were just beginning to enter the labor force) (Nelson, 1984; Cervero, 1989). Such factors could explain, in part, the relatively high occupationally matched job accessibility indices among workers in San Ramon and Pleasanton.

Pleasanton, moreover, experienced the largest 1980-1990 increase in occupationally matched accessibility among all ECs.

Subtracting the accessibility index “without” from the index “with” occupational match yielded estimates of “match effect” for the 22 ECs, for both 1980 and 1990 (Figure 9). Consistent with the residential-based findings, the strongest match effects appeared at ECs, like Palo Alto, Walnut Creek, and San Ramon, with high shares of professional, white-collar employees. Over 40 percent of employees in the Palo Alto, Walnut Creek, and San Ramon ECs work in executive, professional, or managerial positions, compared to an average of 34 percent among all 22 ECs. In contrast, the weakest match effect tended to be among ECs, like San Leandro, Hayward, and San Francisco Airport, with high shares of blue collar and manufacturing jobs. This is consistent with recent research findings showing shortages of affordable housing production within reasonable proximity to many areas with large shares of nonprofessional workers (Wu, 1994; Cervero and Wu, 1997).

4.2 Job Accessibility and Office Rents

Employment centers with relatively high levels of job accessibility could be expected to have relatively healthy office real estate markets. After all, locations that are fairly close to labor pools of a particular occupational make-up should command higher office rents. The demand for these locations should in turn drive down office vacancy rates.

To test these propositions, commercial leasing data on 1990 rents and vacancy rates were obtained for samples of office properties within each of the 22 ECs.⁶ Attempts to estimate hedonic price models that predicted average asking rents of ECs as functions of occupationally matched accessibility indices as well as control variables, like average building age, freeway proximity, and straightline distance to downtown San Francisco, proved unsuccessful. Nor were vacancy rates significantly explained by occupationally matched job accessibility indices in a multiple regression framework. While analyses of variances (ANOVAs) of mean asking rents and vacancy rates across classes of ECs (defined in terms of their common job accessibility values) provided statistically significant results, this was mainly due to the primacy of downtown San Francisco (representing the EC class with the highest occupationally matched job accessibility).⁷ For example, median 1990 office rents in downtown San Francisco were \$19.63 per square foot in 1990, compared to just \$1.72 per square foot in the next priciest office market cluster, ECs in the Peninsula (San Mateo County). While San Francisco had a higher 1990 occupationally matched accessibility index than

did ECs in the Peninsula, office rent differentials cannot be attributed to these differences, at least not entirely. In a region with fairly ubiquitous access like the Bay Area, it could be that office rents outside of downtown San Francisco are more a function of site factors (e.g., proximity to an amenity, like a major university) as well as dynamics of the local real estate markets. This is consistent with recent findings showing the supply of Bay Area office space to be generally elastic enough to outweigh any rent premiums due to locational advantages, at least in the long term (Landis and Loutzenheimer, 1995).

4.3 Job Accessibility Among Occupational Classes

As a final analysis, we transformed equation 2 to the following to allow us to examine 1980 to 1990 changes in job accessibility among the five occupational classes used in this study:

$$AI_k = \sum_i \sum_j [p_{ik} E_{jk}] d_{ij}^{-\gamma} \quad \forall k = 1, 2, 3, 4, 5 \quad (5)$$

where:

- AI_k = Accessibility Index for occupational class k, where k = 1 (executive, professional, managerial), 2 (sales, administration, clerical), 3 (services), 4 (technical), and 5 (all others, excluding all non-civilian positions); standardized as the number standard deviations from the mean score.
- p_{ik} = Proportion of employed residents in zone i (i = 1 to 1382) working in occupational class k.
- E_{jk} = Number of workers in employment center j (j = 1 to 22) working in occupational class k.
- d_{ij} = Distance (in miles) -- highway network distances between zonal centroids, for all i-j interzonal pairs < 45 miles.
- γ = Impedance coefficient, set at -0.35.

Table 2 shows the results. Consistent with earlier findings, those in the highest-salaried positions -- executives, professionals, and managers -- enjoyed the highest overall levels of job accessibility in both 1980 and 1990. Moreover, their level of job accessibility increased the most during the 1980s. Those in the "other" occupational class, representing mainly blue collar and manufacturing workers, saw their level of job accessibility slip the most during the 1980s.

Table 2. Job Accessibility Indices Among Occupational Classes, 1980 and 1990

<u>Occupational Class:</u>	<u>Accessibility Index</u>		<u>Absolute Change</u>
	<u>1980</u>	<u>1990</u>	
Executive, Professional, Managerial	0.858	1.383	0.525
Technical & Related	-1.194	-1.040	0.154
Service	-0.964	-0.822	0.142
Sales, Administration, Clerical	0.825	0.567	-0.258
Other	0.475	-0.087	-0.563

5. Conclusions

An important step in operationalizing “accessibility” as a performance measure will be a clearer articulation of objectives, framed not only in terms of movement efficiencies but with regards to such concerns as sustainability and social equity. Trying to make cities and regions more accessible inescapably leads to different approaches to long-range transportation planning, in particular giving greater prominence to integrated transportation and land-use planning. For long-term investment planning, it is important that longitudinal accessibility indices be developed that allow the efficiency and equity implications of past capital investment and land-use decisions to be carefully evaluated.

So far, the Netherlands has made the most headway in reforming regional transport planning to give equal emphasis to accessibility and mobility. There, local planners draw *mobility profiles* for new businesses which define the amount and type of traffic likely to be generated. They also classify various locations within a city according to their *accessibility levels*. For example, “A-locations” that are well-served by public transport, have nice pathway connections, and feature mixes of retail shops receive high accessibility marks, and thus are targeted for land uses that generate a steady stream of traffic, like college campuses, shopping plazas, and public offices. Thus, to make sure the right business get the right location, planners make sure the mobility profile of a new business matches with the accessibility profile of a neighborhood.

Alternatives to standard gravity-based measures of accessibility are needed. Particularly important is to stratify accessibility indicators along socio-economic and other qualitative dimensions. While residents of a neighborhood might be close to a lot of job opportunities by a crow’s flight, if they do not have the skills or education to qualify for those jobs, then they are hardly accessible to employment. Accessibility indicators need to reflect this.

Our research showed that the Bay Area's largely market-driven patterns of regional employment growth have failed to improve job accessibility among residents of the region's poorest, inner-city neighborhoods. Minority neighborhoods in the inner east bay and parts of San Francisco averaged the worst occupational mismatches in terms of proximity to available jobs throughout the 1980s. Controlling for occupationally matched accessibility, educational levels, and vehicle availability, Bay Area neighborhoods with high shares of African-Americans still had disproportionately high unemployment rates in 1990. We conclude that the very purpose of tracking changes in accessibility should be to provide feedback on the degree to which resource allocation decisions in the urban transportation sector are helping to redress serious problems related to unequal access opportunities, whether to jobs, medical facilities, or other important destinations.

At the 1996 World Habitat II "City Summit" Conference in Istanbul, the accent on *accessibility* was evident in the *Global Plan for Action*, wherein all signatory governments agreed to:

Improve access to work, goods, services, and amenities *inter alia*, by promoting effective and environmentally sound, accessible, quieter and more energy efficient transport systems and by promoting spatial development patterns and communications policies that reduce transport demand.

Whether such pleas take root will depend in large part on whether the transportation planning profession embraces and operationalizes accessibility as a legitimate performance measure. Pirie (1980) suggests that accessibility concerns have historically failed to attract political attention in large part because those who are least accessible tend to wield the least political clout. Making clearer connections between accessibility and serious social problems like chronic inner-city poverty would likely go a long ways toward elevating political interest in accessibility as both a transportation performance measure and a broader social welfare indicator.

Acknowledgment

This research was supported by a grant from the University of California Transportation Center. The views and opinions expressed in this paper are ours, and do not necessarily reflect those of the sponsor. We gratefully acknowledge the assistance of Kenya Wheeler in compiling some of the census data used in conducting the path analysis presented in this paper.

References

- Asher, H. *Causal Modeling*. Beverly Hills, California: Sage University Papers, Quantitative Applications in the Social Sciences, University Paper 3, 1981.
- Cervero, R. 1989. *America's Suburban Centers: The Land Use - Transportation Link*. Boston: Unwin Hyman.
- Cervero, R. 1996. Jobs-Housing Balance Revisited: Trends and Impacts in the San Francisco Bay Area. *Journal of the American Planning Association* 62, 4: 492-511.
- Cervero, R. and Wu, K.L. 1997. Polycentrism, Commuting, and Residential Location in the San Francisco Bay Area. *Environment and Planning A* 29, 865-886.
- Ellwood, D. 1986. The Spatial Mismatch Hypothesis: Are There Teenage Jobs Missing in the Ghetto? *Black Youth Employment Crisis*, R. Freeman and H. Holzer, eds. Chicago: University of Chicago Press, pp. 147-190.
- Hansen, W. 1959. How Accessibility Shapes Land Use. *Journal of the American Institute of Planners* 25: 73-76.
- Holtzer, J. 1991. The Spatial Mismatch Hypothesis: What Has the Evidence Shown? *Urban Studies* 28, 105-122.
- Ihlanfeldt, K. and Sjoquist, D. 1989. The Impact of Job Decentralization on the Economic Welfare of Central City Blacks. *Journal of Urban Economics* 26: 110-130.
- Ihlanfeldt, K. and Sjoquist, D. 1991. The Role of Space in Determining the Occupation of Black and White Workers. *Regional Science and Urban Economics* 21: 295-299.
- Jencks, C. and Meyer, S. 1990. Residential Segregation, Job Proximity, and Black Job Opportunities. *Inner-city Poverty in the United States*, L. Lynn, Jr. and M. McGeary, eds. Washington, D.C.: National Academy Press, 1990.
- Kain, J. 1968. Housing Segregation, Negro Employment, and Metropolitan Decentralization. *Quarterly Journal of Economics* 82: 175-197.
- Kain, J. 1993. The Spatial Mismatch Hypothesis: Three Decades Later. *Housing Policy Debate* 3, 371-460.
- Koenig, J. 1980. Indicators of Urban Accessibility: Theory and Applications. *Transportation* 9: 145-172.
- Landis, J. and Loutzenheiser, D. 1995. *BART @ 20: BART Access and Office Building Performance*. Berkeley: Institute of Urban and Regional Development, Working Paper 648.

Leonard, J. 1987. The Interaction of Residential Segregation and Employment Discrimination. *Journal of Urban Economics* 21: 323-346.

Nelson, K. 1984. *Back Offices and Female Labor Markets: Office Suburbanization in the San Francisco Bay Area*. Berkeley: Department of Geography, University of California, Ph.D. dissertation.

Pirie, G. 1981. The Possibility and Potential of Public Policy on Accessibility. *Transportation Research* 9A, 145-172.

Rood, T. 1997. The Local Index of Transit Availability (LITA) and Other Tools for Coordinating Land Use and Transportation Planning at the Local Level. Washington, D.C.: Institute of Transportation Engineers, Resource Paper for the 1997 International Conference on "Transportation and Sustainable Communities".

Saxenian, A. 1994. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, Massachusetts: Harvard University Press.

Wachs, M. and T. Kumagai. 1973. Physical Accessibility as a Social Indicator. *Socio-Economic Planning Science* 6: 357-379.

Wu, K.L. 1994. A Study of the Spatial Relationship Between Jobs and Housing in the San Francisco Bay Area in 1990: Improving the Jobs-Housing Balance to Improve Regional Mobility. Berkeley: Department of City and Regional Planning, University of California, master's thesis.

Zax, J. 1990. Race and Commutes. *Journal of Urban Economics* 28, 336-348.

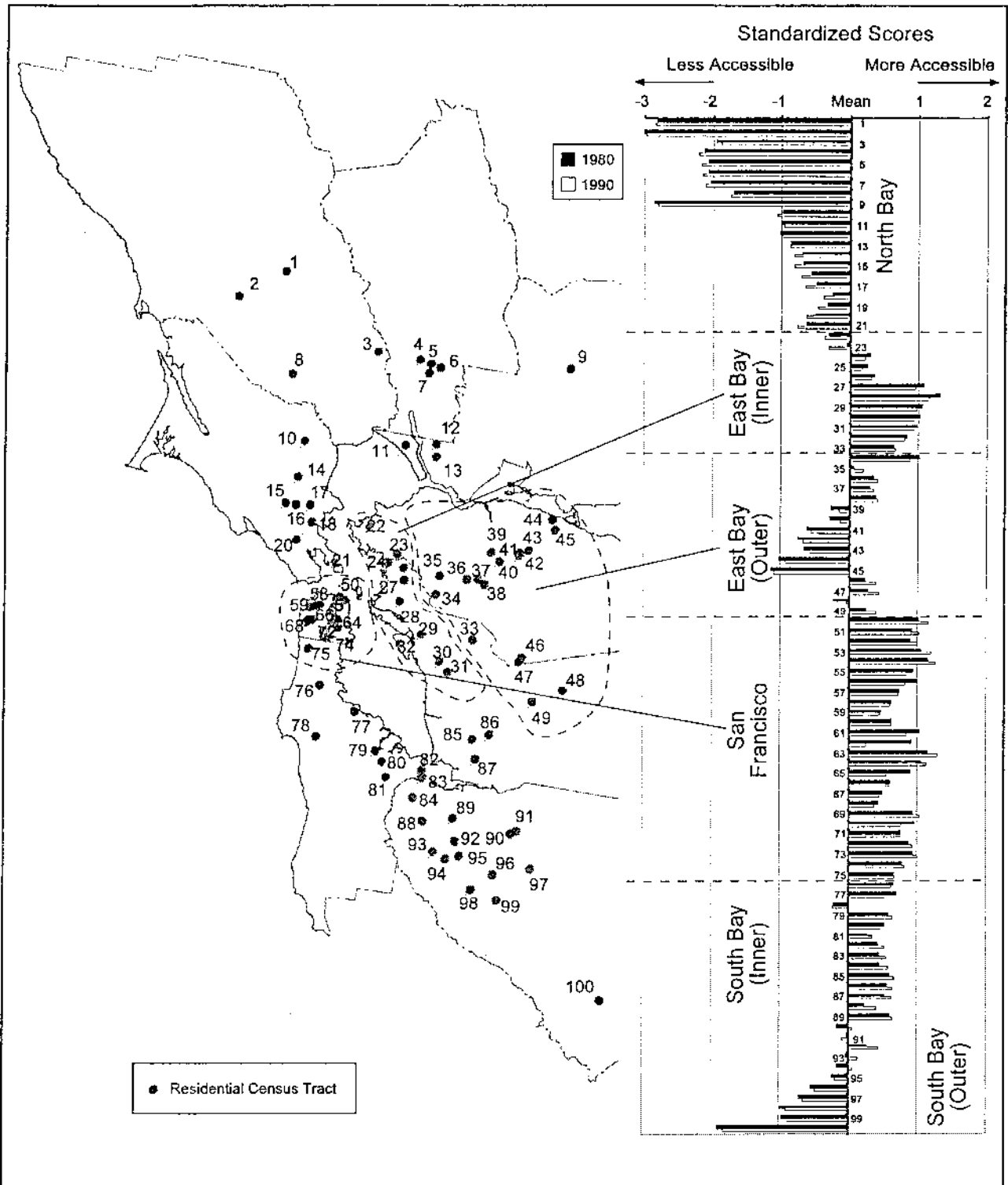


Figure 2. Job Accessibility Indices of Bay Area Residential Areas, *Without* Occupational Matching, 1980 to 1990

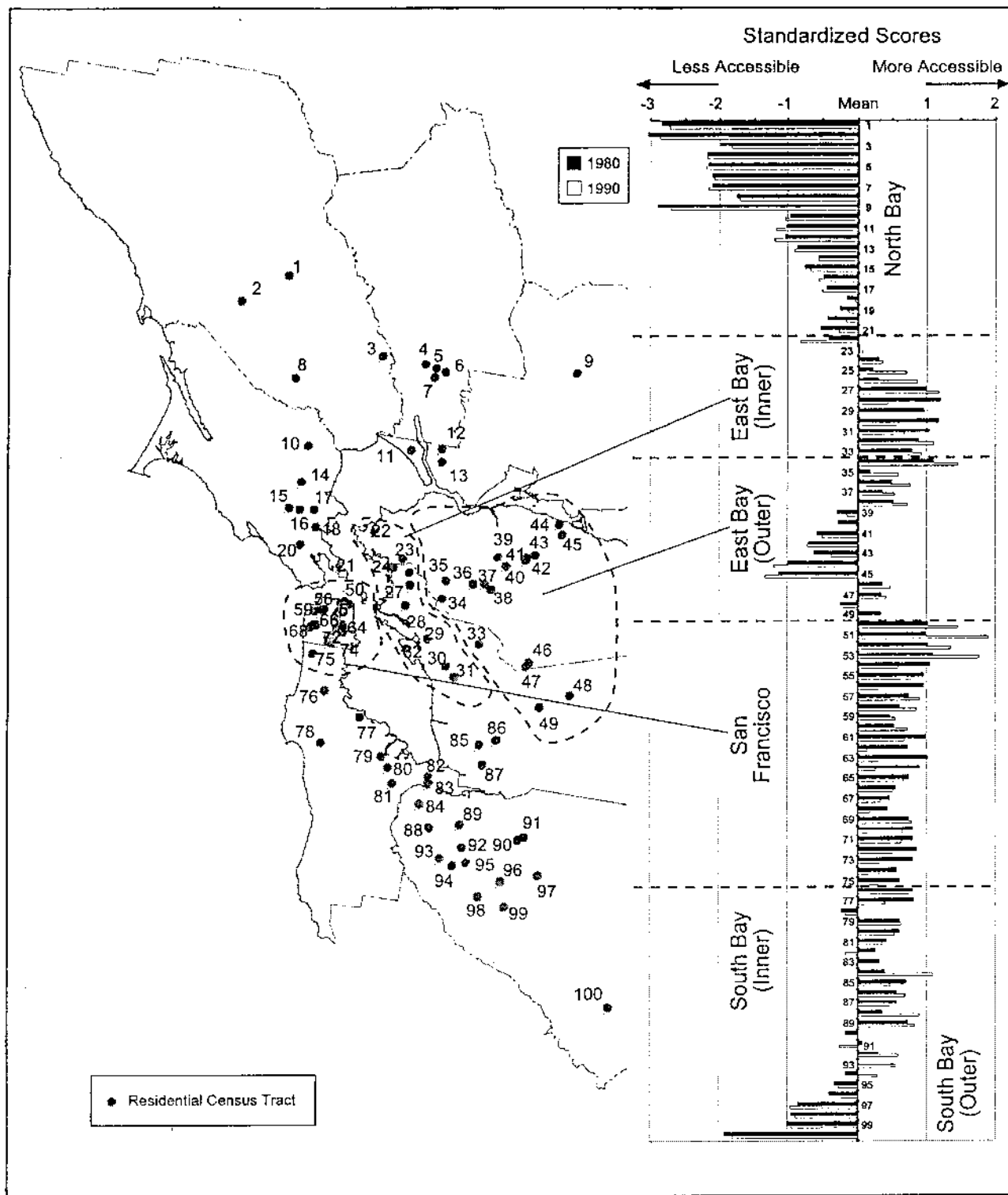


Figure 3. Job Accessibility Indices of Bay Area Residential Areas, *With Occupational Matching*, 1980 and 1990

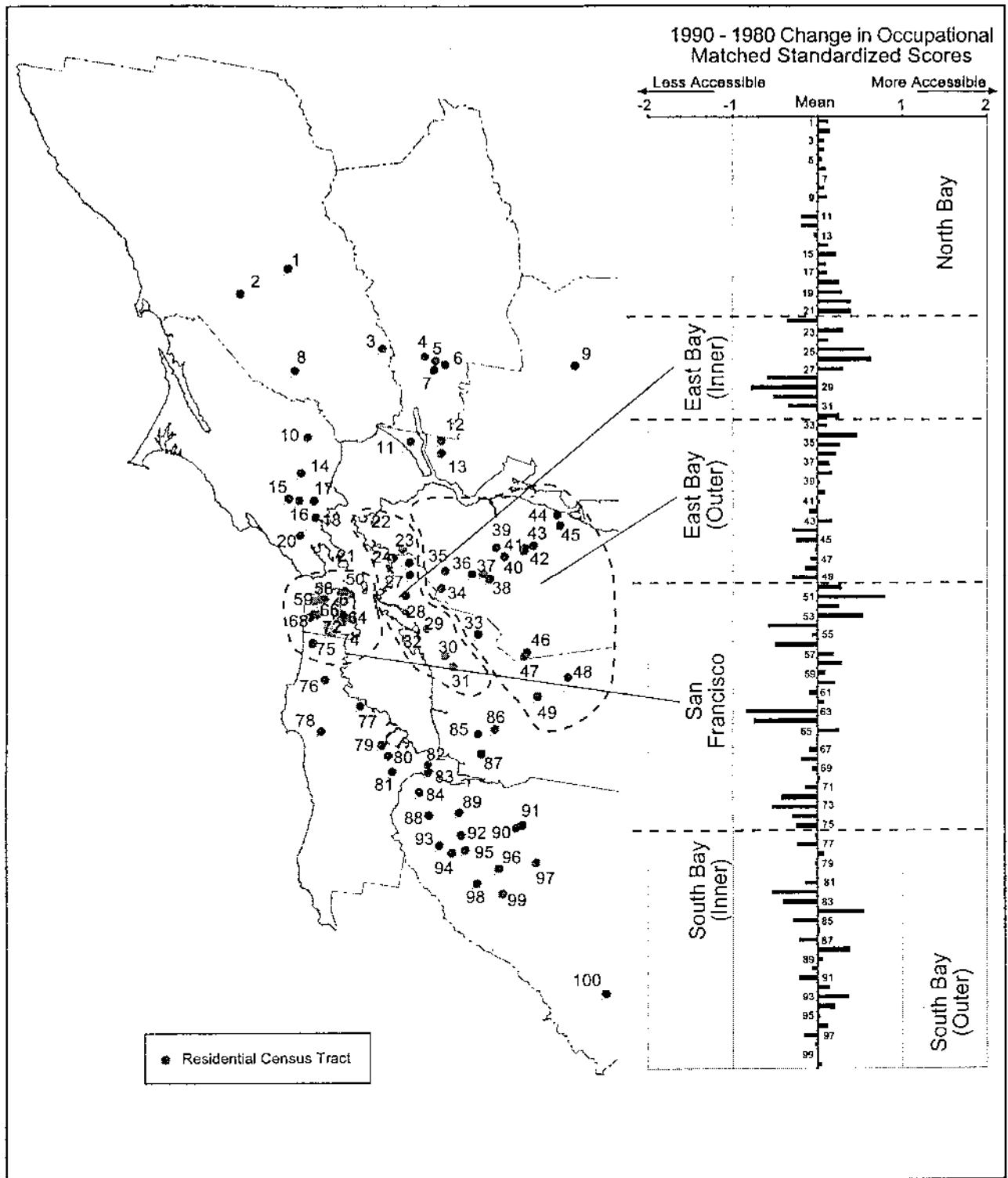


Figure 4. 1990-1980 Changes in Job Accessibility Indices of Bay Area Residential Areas, *With Occupational Matching*

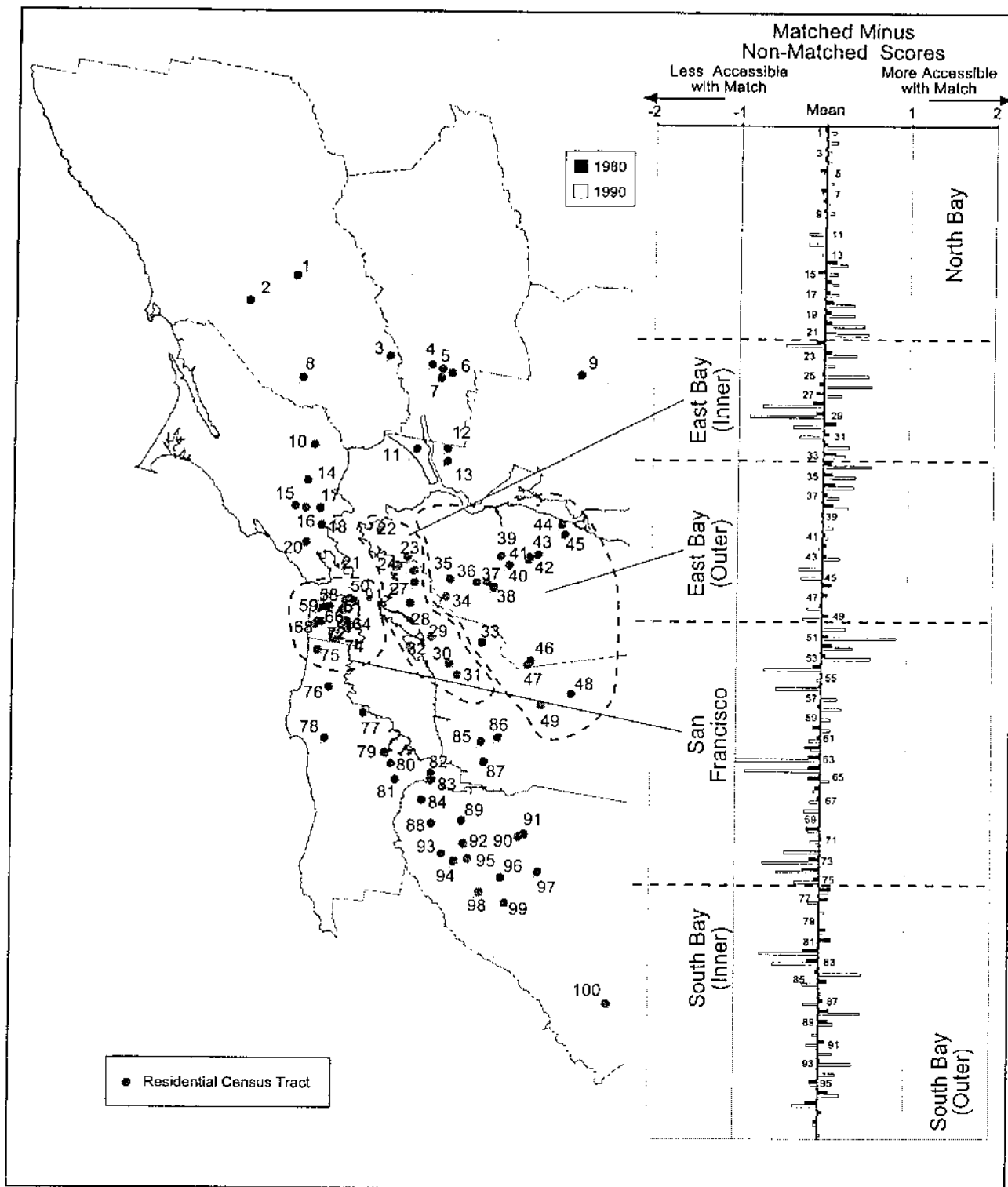
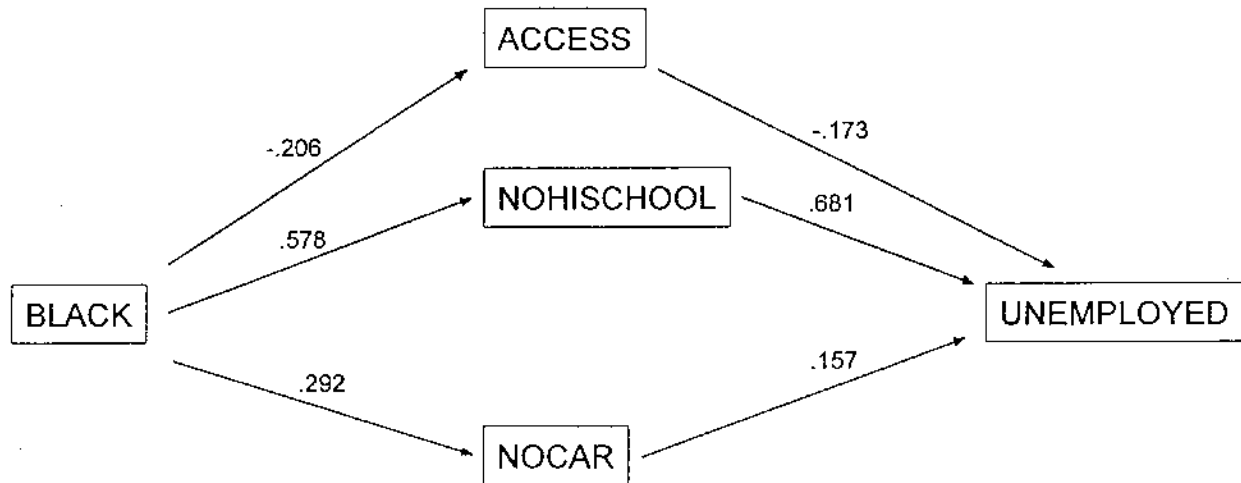
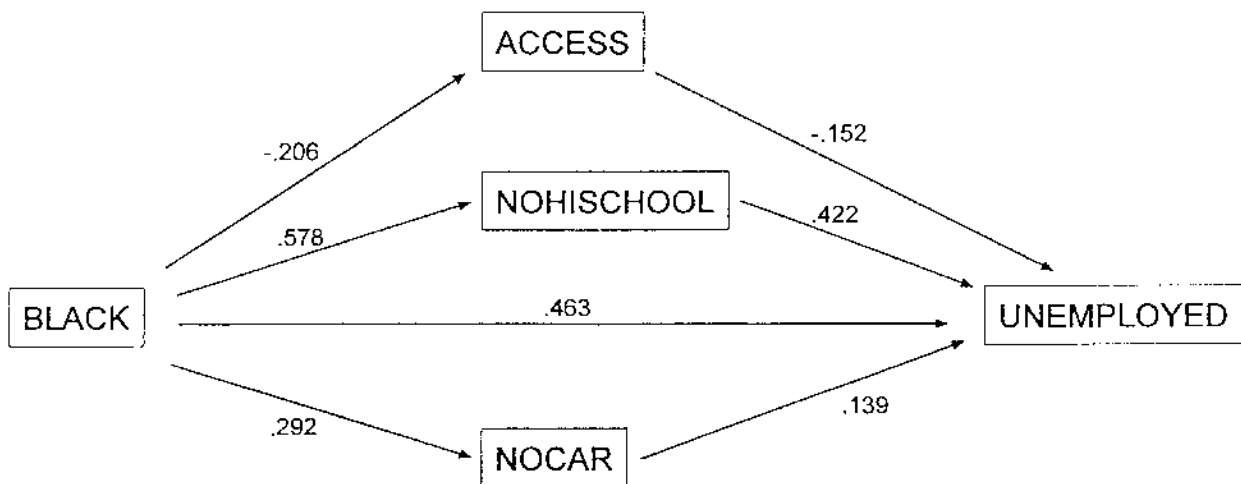


Figure 5. Occupational Match Effect for Bay Area Residential Areas, 1980 and 1990

Model 1: Spatial Model ($R^2 = .615$)



Model 2: Racial Model ($R^2 = .757$)



Variables:

- UNEMP = Percent of residents age 16 to 65 who were unemployed in 1990, excluding non-civilian employment
- ACCESS = Job accessibility index, with occupational match
- BLACK = Percent of residents (age 16 to 65) who are African-Americans
- NOHISCHOOL = Percent of residents (age 16 to 65) with educational level of less than ninth grade
- NOCAR = Percent of residents (age 16 to 65) with no access to an automobile

Figure 6. Summary Results for the Two Path Models of Race and Unemployment

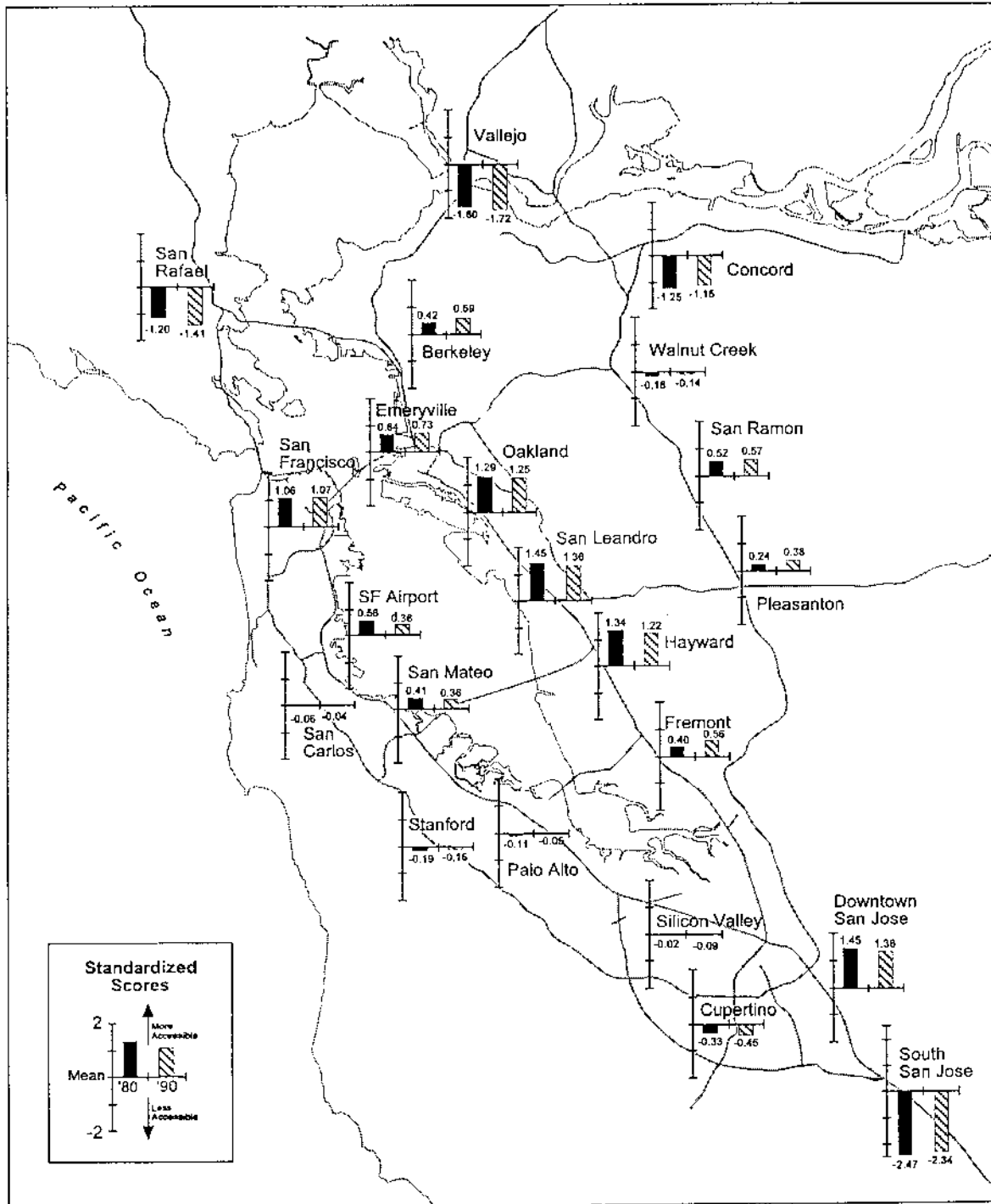


Figure 7. Job Accessibility Indices for Bay Area Employment Centers, *Without* Occupational Matching, 1980 and 1990

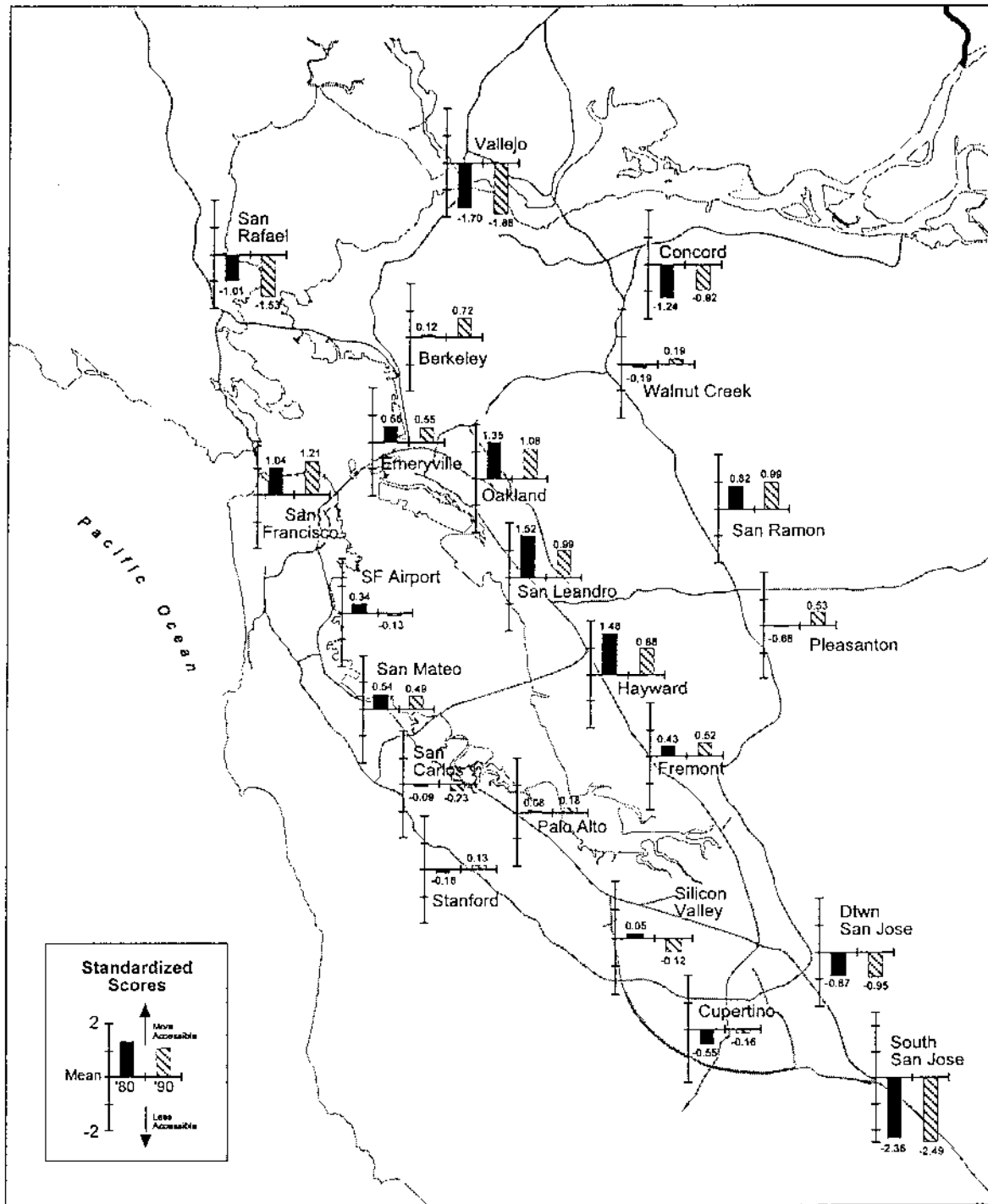


Figure 8. Job Accessibility Indices for Bay Area Employment Centers, With Occupational Matching, 1980 and 1990

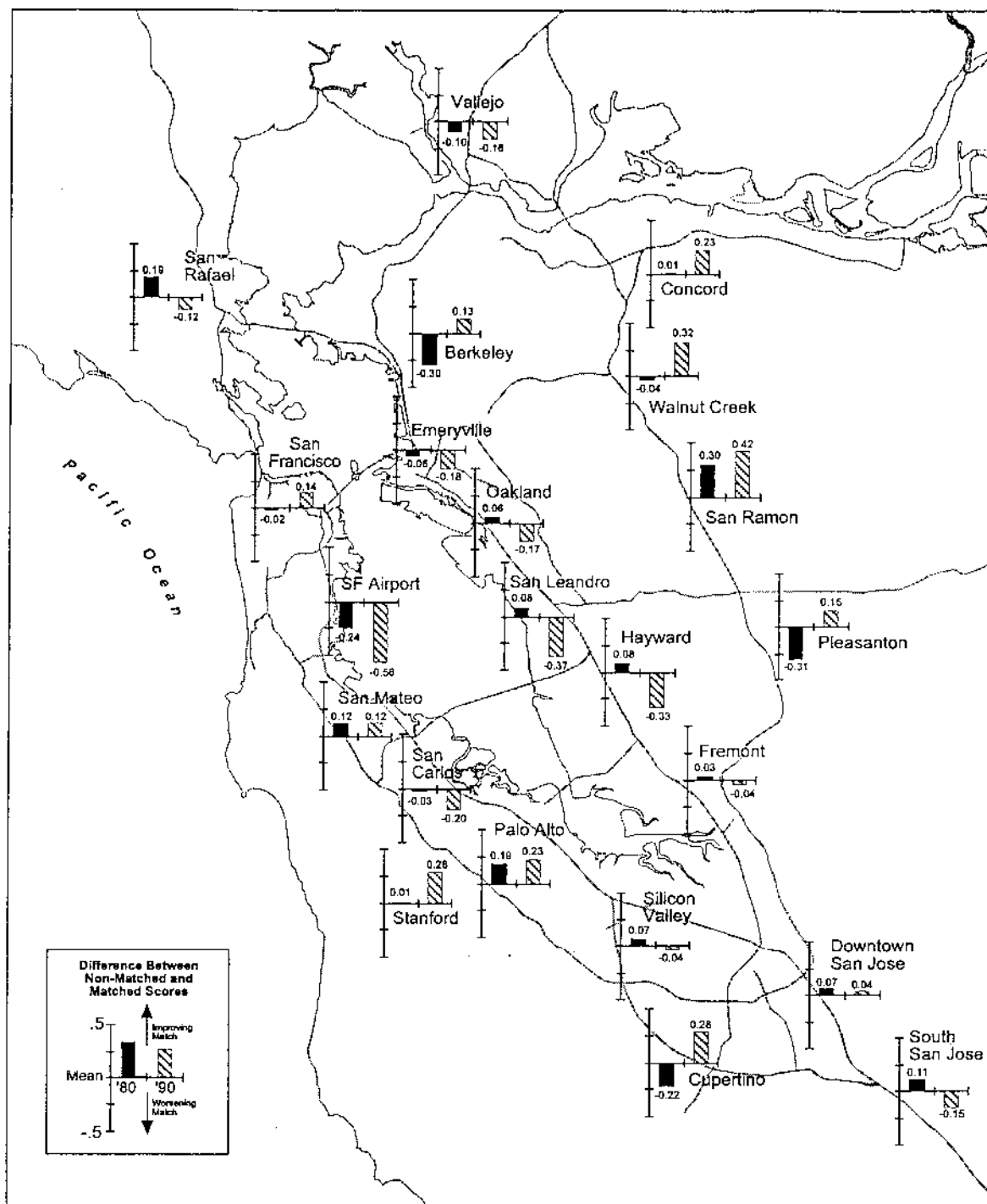


Figure 9. Occupational Match Effect for Bay Area Employment Centers, 1980 and 1990

¹ Distance as opposed to travel time was used to gauge impedance since the best-fitting gravity model for explaining work-trip interchanges was a function of distance instead of duration. Also, network distances were considered to be more reliable since, in the census long form, travel times are self-reported.

² As such, the analysis focuses on job accessibility via highways. No attempt was made to incorporate distances via mass transit into the analysis since, given the region's predominantly bus-based transit system, most regional transit trips are made over the same highway network. Because accessibility measures opportunities rather than actual trips between origin-destination pairs, there was no basis for stratifying the analysis by highway versus transit travel.

³ This is revealed by the sum of direct and indirect effects, or total effects, which equals 0.752, very closely approximating the Pearson Product-Moment correlation between BLACK and UNEMPLOYED of 0.757.

⁴ Each of these centers comprises a contiguous group of census tracts which, in 1990, total over 10,000 workers and support an employment density higher than the regional average.

⁵ As in the case of the residential-based analysis, these results are partly due to data constraints imposed on the analysis from using data for the 9-county metropolitan area. Since the methodology prevents peripheral employment centers from drawing on residents of surrounding metropolitan areas as potential labor in the calculation of job accessibility, the accessibility indices for these peripheral work sites are biased toward low or negative values.

⁶ Data were compiled from the commercially available *Black's Office Guide, 1989-1991*. For properties where data were not available for 1990, rent figures were adjusted to the summer quarter of 1990 using a consumer price index for all consumer goods in the Bay Area. Average asking rent was estimated for each EC by weighting the asking rent per square foot for each sampled building by its available square footage. Similarly, the office vacancy rate for each EC was estimated as the available square footage divided by total square footage for all sampled buildings.

⁷ ECs were grouped in the following clusters, which generally were rank-ordered in terms of their job accessibility levels from highest to lowest as follows: Primary Center (San Francisco CBD); Mature Centers (inner east bay: Oakland, Berkeley, Emeryville, Fremont, San Leandro, and Hayward); High-Tech Centers (Peninsula and Silicon Valley: San Francisco Airport, San Carlos, San Mateo, Stanford, Palo Alto, and Silicon Valley); Rapidly Growing Suburban Centers (outer eastbay: Pleasanton, San Ramon, and Walnut Creek); Peripheral Centers (south bay: downtown San Jose, Cupertino, and south San Jose); and Peripheral Centers (north bay: San Rafael, Vallejo, and Concord).