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Modeling Opportunity: Employment Accessibility and the Economic Performance of Metropolitan Phoenix Neighborhoods

by C. Scott Smith

1. Introduction

The concept of accessibility, defined as the ease with which activities can be reached from a specific location, is widely applied by researchers to perform a variety of tasks (USDOT 1997). Commercial planners identify optimal locations for businesses based on the accessibility of target markets. Land-use planners propose locations for public facilities based on user accessibility. Similarly, equity planners utilize measures of accessibility to assess whether resources are fairly distributed throughout an urban area (Cervero, Rood, and Appleyard 1995). In these ways accessibility measures influence land-use decisions that have the potential to empower communities or create vast barriers of social inequity (Beatley 1994).

This research focuses on one particular aspect of accessibility—that is, the relationship between job accessibility and the economic performance of central city neighborhoods. Researchers from a range of disciplines have argued that the job accessibility of central city workers has declined over time due to a host of factors including exclusionary housing practices, limited mobility, and employment suburbanization (Ihlanfeldt 1992; Ihlanfeldt and Young 1999; Kain 1968; Kasarda 1990; Kasarda 1994; Knox 1990; Turner 1997). The ensuing *skills mismatch* is marked by concentrations of low-skill workers living within central cities where high-skill jobs prevail. This is coupled by a *spatial mismatch* of central city workers with inferior access to high-growth suburban areas where there are substantial low-skill job opportunities.

Using metropolitan Phoenix as a case study, this article suggests that job accessibility measures are powerful indicators of economic performance and should therefore be utilized by decision makers in the planning process. More specifically, it argues that indicators of job accessibility can greatly assist decision-makers by providing an assessment of how urban growth may influence the distribution of economic performance and variations in social and environmental equity.

Hypotheses

This paper simultaneously relates measures of job accessibility and economic performance for the purpose of addressing the following two hypotheses:

- Levels of job accessibility decline with respect to occupational skill level such that high-skill workers have greater accessibility to employment than low-skill workers.
- Job accessibility has significant adverse effects on the economic performance of central city workers.

The first hypothesis addresses the job-skills mismatch assumption, which argues that the demand for skills has increased in urban labor markets over time (Burns and Gober 1998; Kasarda 1990; McLafferty 1996; McKenna 1996; Kain 1968). Central city minority residents lag behind other population groups with respect to training and educational attainments and are therefore less likely to procure nearby job opportunities in upper labor market segments (i.e., job opportunities in Phoenix's central business district).

The second hypothesis relates to the spatial mismatch assumption, which argues that high unemployment is correlated with the spatial distribution of employment opportunities (Kain 1968). Previous research has suggested that the suburbanization of employment, exclusionary housing practices, and limited mobility have effectively concentrated low-skill minority workers in the central city with sparse access to job opportunities (Hughes 1990; Hughes 1991; Sheppard 1990; Summers 1993; Wacquant 1993). As a result, central city workers are more likely to live in neighborhoods plagued with high levels of joblessness (Arnott 1998; Bauder 1999; Boswell 1997; Darden, Bagaka, and Shun Jie 1997; McLafferty 1996).

2. Laying the Theoretical Groundwork: A Review of Spatial Mismatch and Job Accessibility Literature

The U.S. economy, by many measures, is a burgeoning system. With a per capita gross national income of $34,260 it is one of the wealthiest countries in the world (World Bank 2001). Low inflation and unprecedented economic growth has permeated the 1990s and is projected to continue, albeit at slightly slower rates from the rapid pace of the past several years. National employment growth consistently outpaces population growth and, at four percent, the annual unemployment rate is the lowest it has been since the Nixon era (Current Population Survey 2000).

Despite these impressive indicators, there is one particular subculture of the population that this prosperity eludes. Ironically, this group resides in some of the most job-rich areas in the country—central cities. Over the past 20 years, researchers have referred to this spatially concentrated, ethnically diverse group as the *urban underclass* (Kasarda 1990; Massey 1993), the *truly disadvantaged*

(Wilson 1987), the *underemployed* and the *new urban poor* (Wilson 1996; Knox 1990).

For this group, the American economy imparts a much harsher reality. Predominantly minorities, the central city poor are both economically and spatially excluded from the economic, social, and political mainstream of society. Extreme levels of poverty and joblessness often pervade their residential communities. Many households are headed by single women and a high percentage of the population either receives public assistance or has withdrawn from the labor force (Marcuse 1997). Different from the immigrant and ethnic enclaves that preceded it, this new *outcast ghetto* is socially destructive (Marcuse 1997). Opportunities for a viable education or cultural life are often eroded.

Spatial mismatch: A structural explanation for joblessness

Throughout the political continuum researchers heatedly debate the root causes and continued emergence of today's central city poor. In 1966, the controversial anthropologist Oscar Lewis emphasized that there were personal traits—such as immaturity and unreliability—associated with cultures of poverty (Lewis 1966). Conservatives adopted this hypothesis, claiming that efforts to eliminate poverty through social policy are unproductive. Charles Murray's *Losing Ground*—which became a conservative icon during the Reagan administration—suggests that social programs of the 1960s and 1970s fostered dependence and welfarism and thus did little to improve the condition of poorer populations (Murray 1984). This and related supply-side or individual-based explanations for minority joblessness continued to find support in the 1990s and culminated in the Personal Responsibility Act passed by the 104th Congress and signed by President Clinton in 1996.

In contrast, liberal research has primarily focused on demand-side explanations for central city joblessness, including racial discrimination and spatial mismatch. A Chicago-based study by Ellwood found racial composition to be the dominant explanatory variable for employment rates (1986). Later studies have also evidenced that unemployment is highly correlated with the employment status of working minorities (Bendick, Jackson, and Reinoso 1994; Cervero, Rood, and Appleyard 1995; Neckerman and Kirshenman 1991; Turner 1997).

However, most theorists place greater emphasis on the skills and residential locations of workers than on discriminatory practices and attitudes of employers (Meiklejohn 2000). Spatial mismatch, for instance, is the dominant demand-side explanation for the prevalent joblessness found in many central city neighborhoods. According to this hypothesis, central city residents, with lower educational attainments and skill sets, typically do not have the professional requirements to procure jobs in the upper labor markets that tend to dominate most central business districts. Furthermore, housing segregation coupled with the limited mobility of minority residents—marked by low vehicle ownership and inadequate public transit systems—inhibits their ability to procure low- to moderate-skill jobs that have progressively migrated outside the central city.

Kain first posited the hypothesis that central city unemployment is correlated with job accessibility (Kain 1968). Using Detroit and Chicago as case studies, Kain found that the negative effect of housing segregation on African American employment was magnified by the decentralization of jobs. The hypothesis gained momentum in the mid to late-1980s and was assigned the moniker *spatial mismatch*.

Since its inception over 30 years ago, there have been more than 50 published spatial mismatch studies. The methodogies used in these studies reflect the popular epistemologies and analysis tools of the time. A thorough examination and classification of these methods was undertaken by Ihlanfeldt (1992) and Stoll (1999). Together, these studies have yielded inconclusive results. However, Ihlanfeldt argues that much of the research made inappropriate assumptions and suffered from flawed methodologies (1992). If the flawed studies are dismissed, Ihlanfeldt claims that the empirical evidence lends credibility to the spatial mismatch hypothesis.

Advances in measuring job accessibility

Job accessibility is defined as the ease with which employment opportunities can be reached. It is regularly identified as an important element of smart growth and sustainable development principles. Roseland, for example, suggests that cities should work to increase job accessibility in order to improve air quality and worker productivity by relieving traffic congestion and reducing commute times (1998). Transit-oriented development, mixed-use zoning, and alternative-mode provisions are strategies that planners are promoting to better integrate land use and transportation, thereby enhancing worker access to employment opportunities.

While the benefits of advancing job accessibility are generally understood, researchers are less likely to reach consensus on the appropriate methods to measure it.[1] Instead, researchers implement a wide variety of approaches that vary with respect to geographic and demographic complexity. A large share of these approaches can be separated into two basic classes: direct and indirect measures. Direct accessibility calculations—the kind applied in this study—report variations of employment availability and demand on an interval-scale by *neighborhood*. Neighborhoods are commonly represented as census tracts or traffic analysis zones (TAZs). Because direct measures are interval-scale and are reported at relatively detailed levels of geography, they allow planners to visually assess a continuous variation of job accessibility throughout an urban environment.

In contrast, indirect measures of accessibility generalize space by grouping residential locations of workers into broad categories such as “central city” or “suburbs.” This approach does not account for the physical transportation system or the actual costs of commuting to specific employment opportunities. Indirect measures also fail to consider the level of competition between similarly skilled

[1] For a thorough review of these approaches refer to Ihlanfeldt (1992).

workers and thus potentially underestimate job demand. Direct measures, therefore, are more likely to reflect the urban environment in that neighborhoods are modeled with respect to their geographic and demographic context in the metropolitan area.

To better understand the versatility and limitations of direct job accessibility measures, however, it is important to consider their characteristic flaws. Direct measures have been criticized in previous research for the three following reasons. First, these measures typically do not account for the endogeneity of residential location in the employment process. This so-called simultaneity effect suggests that people may opt to reside in communities with inferior job accessibility in order to consume more affordable housing and other reasons, which consequently muddles the effects of job access on economic performance. If this factor is ignored, effects of job access on economic performance can be underestimated (Ihlanfeldt 1992; Stoll 1999).

A second criticism of direct measures of accessibility concerns the assumption that the demand for employment opportunities is uniformly distributed and that job opportunities have no capacity limitation (Shen 1998). Workers, however, are not evenly distributed throughout the urban environment nor do they have similar skill sets. For example, it is probable that low-skill central city workers have poor job accessibility even though they live in job-rich areas (e.g., most central business districts). Additionally, no single job opportunity can support more than one employee. Therefore, neighborhoods, because of their unique locations within the region, will exhibit disparate levels of job demand.

The third criticism relates to the typically auto-centric calculation of direct accessibility. That is, commute times are often confined to automobile commutes and thus fail to consider the greater frictional factors associated with alternative transportation modes such as public transit, walking, or bicycling. An automobile owner, for example, typically has greater access to employment opportunities than his/her neighbor who commutes by bicycle or public transportation.

This study, given its scope and data limitations, does not address all of the known issues outlined above. Given that the simultaneity effect is only expected to enhance the predictive ability of job access, ignoring this factor does not discredit this study’s results. Also, unlike previous studies, this research accounts for employment demand, variable skill levels, and multiple modes of transportation using refined GIS and statistical procedures.

3. Setting the Stage: Housing, Transportation, and Employment Trends in Metropolitan Phoenix

Metropolitan Phoenix[2] is an appropriate case for studying employment accessibility primarily because it has developed differently than most eastern and midwestern cities that are disproportionately represented in spatial mismatch research. Unlike these cities, metropolitan Phoenix did not become a large urban center until after World War II, when Arizona became the nation's fastest growing state. With well over 500,000 new jobs created during the 1990s, metropolitan Phoenix ranks among the nation's leaders in population and economic growth.

Also, public transit, save for a period between 1890 and 1940, has led a meager existence in the region. The great majority of transportation improvements over the past 30 years have been dedicated to developing the expansive, yet late-blooming, freeway network. The disparity between freeway and public transit spending explains the exceptionally small per capita transit miles in the area. At seven miles, the per capita rate is exceeded by comparable-sized metropolitan areas such as San Diego (11 miles per capita), Seattle (23 miles per capita), and Denver (20 miles per capita) (Morrison Institute for Public Policy 2000).

Metropolitan Phoenix also differs from other regions highlighted in spatial mismatch literature in that the dominant minority population is Hispanic (or Latino) (over 16 percent). The percentage of population that is African American (approximately three percent)—the ethnic group most often identified with the new urban poor—is well below the 1990 national average of 13 percent (U.S. Census Bureau 1990).[3]

Additionally, Phoenix never had strong low-skill industrial and manufacturing sectors (e.g. steel and automobile) as did other cities commonly researched in spatial mismatch literature. Its isolated location in the Southwest has historically been more conducive to air transportation, which is more efficient for small, high value, and often highly technological goods (Gammage 1999).

Nonetheless, metropolitan Phoenix also shares many characteristics with its eastern and midwestern counterparts. For example, the area has a history of institutional racism, which fostered residential ethnic segregation that is conspicuously present in the Valley today (Luckingham 1994). Metropolitan Phoenix has also experienced, although not as profoundly, the impact of post-Fordist economic restructuring from mainly low-skill agricultural and manufacturing occupations to service occupations.

Phoenix's central city also resembles the nationwide urban patterns of decay, redevelopment, and gentrification. The central city experienced a significant de-

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[2] Metropolitan Phoenix refers to Maricopa County, Arizona, which comprises the city of Phoenix and 23 other incorporated communities.

[3] Hispanic is a cultural category and is used here to refer to any Spanish-speaking race. It is also used interchangeably with the term Latino, as in U.S. Census Bureau reports. Census 2000 figures indicate that the percentages of Hispanic and African American populations in Maricopa County increased to 24.8 and 3.7 respectively.

cline after World War II such that by the late 1960s it had no department stores. Retail jobs and shopping centers had gradually migrated to suburban regional malls. It was not until the late 1980s that the city made a concerted effort to redevelop its urban core. With the help of a strong mayor and citizen support the city has redefined itself as the area's sports, entertainment, and government center (Gammage 1999). Moreover, federal dollars have retrogressively shaped the social and economic landscape of metropolitan Phoenix via federal highway administration grants, public housing, and other federal grants as is the case in other cities (Norquist 1998).

Housing segregation: Central city ghettoes and suburban citadels

One need only to observe distributional maps of ethnicity and income to conclude that there are cogent forms of segregation at work in metropolitan Phoenix. Minority and lower-income residents are concentrated in the urban core while higher-income households reside outside the central city (Figures 1 and 2). In some cases these patterns may be economic and voluntary such as the development of immigrant enclaves due to chain migration and the rational consumption of affordable housing (Marcuse 1997). Alternative explanations for this polarized ethnic and economic landscape include institutional racism, misguided federal housing and transportation policy, and economically exclusive housing practices (Kunstler 1993a; Kunstler 1993b; Schill and Wachter 1995; Norquist 1998).

Luckingham wrote of the evolving residential patterns of Phoenix minorities (Luckingham 1994). In Phoenix’s early history, Latino, African, and Chinese Americans were involuntarily forced by the white majority to reside in segregated quarters. The legacy of these quarters, along with the lack of affordable housing and the historic and continued discrimination against minorities by lending institutions (Cuomo 1999), has restricted the residential and economic opportunities of minorities.

For example, educational advancements of central city residents are often restricted because of inadequate schools. A recent report by the Morrison Institute for Public Policy identifies a dramatic achievement gap—evidenced by poor performance on standardized test scores—between white and non-white school districts (2000). The predominantly minority populated areas of central and southwestern metropolitan Phoenix averaged 34 and 35, respectively, on the Stanford 9 Achievement tests. This contrasts the principally white northeast and southeast districts that scored 72 and 59.[4] The report warns:

> The region has to worry about the education of children in central Phoenix and the southwest portion of the region. Individual economic success correlates particularly with educational attainment. The weak schools of the center present

[4] Scores reflect an average of reading and math. A rank of 34 means that on average, students taking the test scored lower than 64 percent of students nationwide.

a powerful impetus for [further] decentralization. (Morrison Institute for Public Policy 2000)

Public transit: Difficulty escaping the urban core

Public transit has had a turbulent history in metropolitan Phoenix. Falling in and out of public ownership and support, the region continues to struggle to find a common ground between providing transit services and freeing traffic for those who drive automobiles (Abbitt 1990). Much of the problem is rooted in the historically less dense pattern of development that is pervasive in the Valley and not conducive to public transportation. In 1985, Maricopa County voters passed legislation to construct 233 miles of freeways. Since then, most state and county money has focused on highway building and neglected transit.

Not only are there fewer transit services in general, but the specific services provided for low-income residents who are less likely to make the capital investment for an automobile are inferior when compared to the services provided for their wealthier counterparts. For instance, several low- to moderate-skill employment opportunities are available outside the central city. However, the region's express buses (30 percent of all bus routes) are targeted toward providing high-skill, higher-income suburban residents an efficient means to commute downtown. These buses do not provide similar services to downtown residents who make suburban commutes. As a result, central city residents have limited access to suburban job opportunities. Transit riders who live in central city and work in the suburbs must often partake in circuitous, multiple bus journeys to their workplaces.

Labor market trends: Considerable growth, considerable distance

The positive national employment trends outlined earlier in this paper are amplified for the state of Arizona. Since the end of the last recession in 1991, the state has experienced a record setting span of continuous economic growth (Center for Business Research 2000). Per capita personal income rose 4.7 percent in the state between 1997 and 1998, which is significantly higher than the 3.6 percent national average. 1999 marked the seventh year of strong expansion indicated by an employment-to-population ratio exceeding 56 percent, a record. Maricopa County's average unemployment rate of 2.9 percent in 1999 compares favorably with the national average of 4.2 percent. Undoubtedly these are impressive numbers. However, the manner in which these trends play out across the urban landscape is a cause for concern.

While many large urban areas are evolving from a monocentric (i.e., one employment core) to a polycentric structure (i.e., multiple cores), Phoenix continues to have a relatively centralized urban form with respect to employment. This may, in part, be due to the fact that the region only recently began constructing freeways. According to a recent study, one third of the region's employment opportunities are located in two central areas of the urban core. The majority of these jobs, however, are in upper labor market segments that require substantial education. Thus:

> There is a potential separation in the region between appropriate job opportunities and the location of less-skilled workers. In metropolitan Phoenix, these less-skilled workers often reside predominantly in or near the downtown Phoenix employment areas. However, the jobs accessible to them are heavily weighted toward professional positions. That raises the possibility of their spatial isolation from needed entry-level work opportunities. (Morrison Institute for Public Policy 2000)

Employment opportunities outside the central city are primarily construction, service, and retail jobs. Although educational attainment for jobs in these sectors are less demanding, the considerable distance of these opportunities from the central city prohibits many downtown residents from procuring them.

4. Recalibrating Employment Accessibility

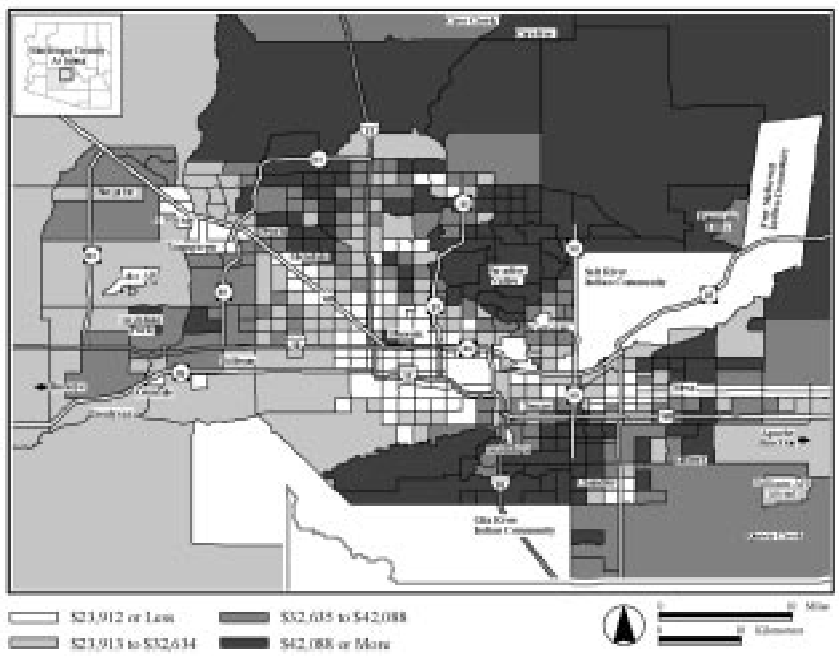
This paper utilizes direct measures of accessibility that were calculated using two equations. The equations are adapted from Shen's model, which overcomes many of the limitations of direct accessibility measures expressed earlier in the paper (Shen 1998). Unlike Shen's model, however, the following equations consider three levels of mobility, four occupation skill levels, and impedance values that were calculated using rule-based geographic information system (GIS) automobile and transportation networks. Particular details of the models and their divergence from other measures are provided below.

Equation 1 calculates the job accessibility of origin neighborhood *i* ($A_i^{\mathrm{mod}et}$) with respect to the percentage of workers with skill set *k* (W_k) that commute to work using transportation mode *t* ($a_k^{\mathrm{mod}et}$). The numerator computes the sum of relevant employment opportunities (E_j) or job availability within the metropolitan area from an origin neighborhood while accounting for impedance costs ($C_{ij}^{\mathrm{mod}et}$) to procure the opportunities.

$$A_i^{\mathrm{mod}\,et} = \sum\nolimits_j E_j\, f(C_{ij}^{\mathrm{mod}\,et}) \,/ \sum\nolimits_k (\alpha_k^{\mathrm{mod}\,et} W_k\, f(C_{kj}^{\mathrm{mod}\,et}) + (\alpha_k^{\mathrm{mod}\,en} W_k\, f(C_{kj}^{\mathrm{mod}\,en})) \quad (1)$$

In contrast, the denominator represents the worker demand for relevant employment opportunities accounting for the sum of impedance costs of workers commuting by transportation mode *t* and all other analyzed modes of transportation ($C_{kj}^{\mathrm{mod}et}$). Equation one was repeated for each transportation mode and subset of workers. Given that this study identifies four categories of occupational skill and three categories of transportation mode, the equation yielded 12 sets of accessibility values.

Figure 1



Impedance costs (C) were calculated using an exponential decay function having the form $e^{-\beta d_{ij}}$. Where e is the natural log, β is the exponent for distance decay, and d_{ij} represents the distance between locations *i* and *j*. The distance decay exponent changes with transportation mode so that accessibility decreases at a greater rate for low mobility transportation modes, such as bicycling and walking, and at a slower rate for high mobility transportation modes such as the automobile (Figure 1).

Equation 2 calculates the general employment accessibility (A_1^G) of workers with a specific skill set living in neighborhood *i* while accounting for all transportation modes. It is a composite index that weights results of (1) by the ratio of workers utilizing specific modes of transportation for their work commutes. Therefore, (2) will yield four sets of accessibility values—one for each occupation skill set.

$$A_i^G = (\alpha_i^{\text{mod}\,et} W_i / W_i) A_i^{\text{mod}\,et} + (\alpha_i^{\text{mod}\,en} W_i / W_i) A_i^{\text{mod}\,en} \qquad (2)$$

Three important characteristics of the general accessibility equation 2 are:

1. Values equal the ratio of the total number of opportunities to the total number of opportunity seekers. Therefore, if the number of jobs equals the number of workers, general accessibility equals one.

2. Values equal the potential for an opportunity seeker with specific skill sets to procure a job in a particular location. That is, they stratify the labor force population into like occupational groups and match the skill levels of residents to relevant employment opportunities.
3. Values are compared between varying modes of transportation, commute distances, and occupational categories.

Data sources and the role of GIS in the modeling process

The equations above require several data sets, including multi-modal impedance values or travel costs between residential and employment locations, employment of workers by both place of residence and place of work, and worker occupational skill sets. Most base demographic and spatial data required by the models were made available by national sources. A description of these data, their sources and applied function are provided below. ESRI's Arc/Info Geographic Information System (GIS) was used extensively for the spatial data analysis.

- TIGER/Line 1992 Maricopa County Street Network
  Road quality and spatial information provided with this transportation data set was used in a GIS to generate impedance costs. Speed limits, for example, were assigned to network segments based on road quality or function, which are identified by TIGER census feature class codes (CFCCs). This speed limit information was then used together with network segment lengths to calculate shortest network paths for traversing between residential and employment locations. A similar GIS network modeling technique was used by Wang to model commuting patterns in Chicago (2000).
- TIGER/Line 1992 Maricopa County Census Tracts and 1990 Census Summary Tape File 3A (STF3A)
  The areal units of analysis for this study were neighborhoods defined as individual census tracts. All demographic and employment data were allocated to and mapped by this geographic unit. The TIGER/Line files provide spatial boundary information and the summary tape file provided occupational and commuting characteristics of workers by place of residence. The means or transportation modes that workers used for work commutes were categorized into three levels of mobility. Workers who drove alone, carpooled, or used a motorcycle as their primary transportation to work were identified as having high mobility (MODE1). Those using public transportation were classified as moderately mobile (MODE2). And workers who either bicycled or walked to work were said to have low mobility (MODE3).
- 1990 Census Transportation Planning Package (CTPP)
  The Urban CTPP, released on CD-ROM in 1996 by the Bureau of Transportation Statistics, provides occupational and transportation characteristics of workers by place of employment. Part 2 of the CTPP Urban Element provides data by traffic analysis zone (TAZ)—a relatively small unit of geography—that

Table 1: Occupational Categories for Job Accessibility Calculations

Category	Occupation
High skill (OCC1)	Executive, administrative, and managerial Professional specialty
Moderate to high skill (OCC2)	Administrative support including clerical Technicians and related support Protective services Sales
Low to moderate skill (OCC3)	Precision production, craft, and repair Transportation and material moving Service occupations, except protective and household Machine operators, assemblers, and inspectors Handlers, equipment cleaners, helpers, and laborers
Low skill (OCC4)	Farming, forestry, and fishing Private household services

were later aggregated into census tracts using a TAZ to Census Tract equivalency file.

- Bureau of Labor Statistics occupation by educational attainment
  In order to reduce redundancy and unnecessary complexity in the accessibility measures, it was necessary to group occupations into four main occupational categories based on skill level. Table 1 presents the four categories identified using the BLS occupation by educational attainment data set. Figure 2 charts the percentage of workers by occupational category and educational attainment.
- 1990 City of Phoenix Bus Book, Summer Edition
  The Metro Phoenix Bus Book, which includes origin and destination times of express and local bus routes was used to calculate average velocities of public transit in metropolitan Phoenix. This measure was later used to calculate β in the exponential distance decay function discussed earlier in the paper.

Employment accessibility model results

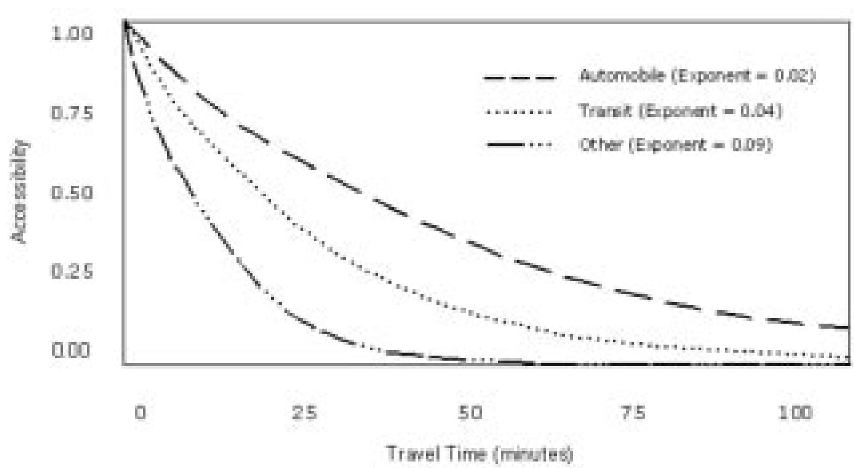
The minimal public transit system is evidenced in the distribution of workers who commute by transit (Table 2). At three percent, the county's average is two points below the relatively stable national rate of people reaching work by transit (Bureau of Transportation Statistics 1999). Those who do utilize public transportation, however, reside predominantly in the central city (Figures 3 and 4). Further, captive public transit riders are more likely to be low to moderately skilled compared to the superior mobility status of high-skill workers (Figures 5 and 6).

Table 2: Mobility Categories and Average Modal Velocities for Job Accessibility Calculation

Category	Means of Transportation to Work	Number of Workers[1] (%)	Average Speed[2]
High mobility (MODE1)	Drove alone Carpooled Motorcycle	898,286 (93.9)	35.3 mph
Moderate mobility (MODE2)	Bus or other public transportation	28,567 (3.0)	19.2 mph
Low mobility (MODE 3)	Bicycled or walked	40,333 (4.2)	7.8 mph

Data Sources: [1] US Bureau of the Census, STF3A, 1990; [2] Mode 1 velocity is based on speed limits and street network distances provided by Dynamap and 1992 TIGER/Line files; Mode 2 average velocity is based on bus routes identified in the Metro Phoenix Bus Book Summer Edition, 1990; Mode 3 average velocity is based on trip distance and length provided in National Transportation Statistics, 1996.

Figure 3



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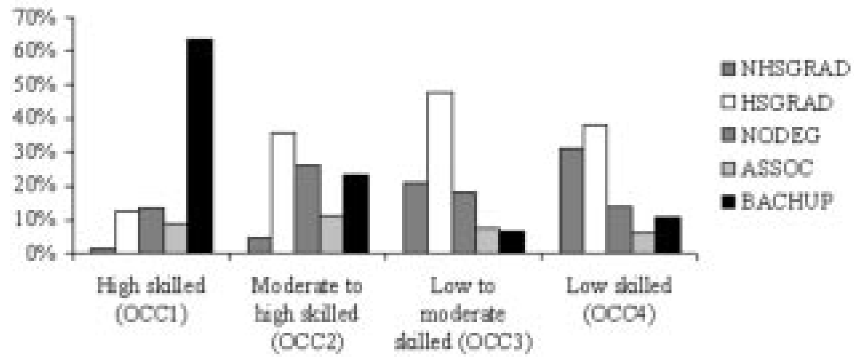

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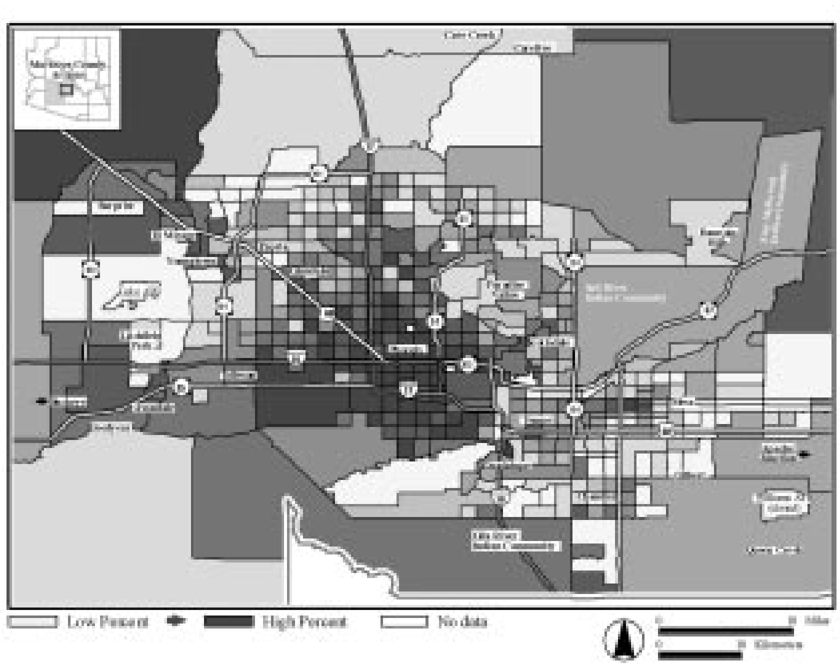

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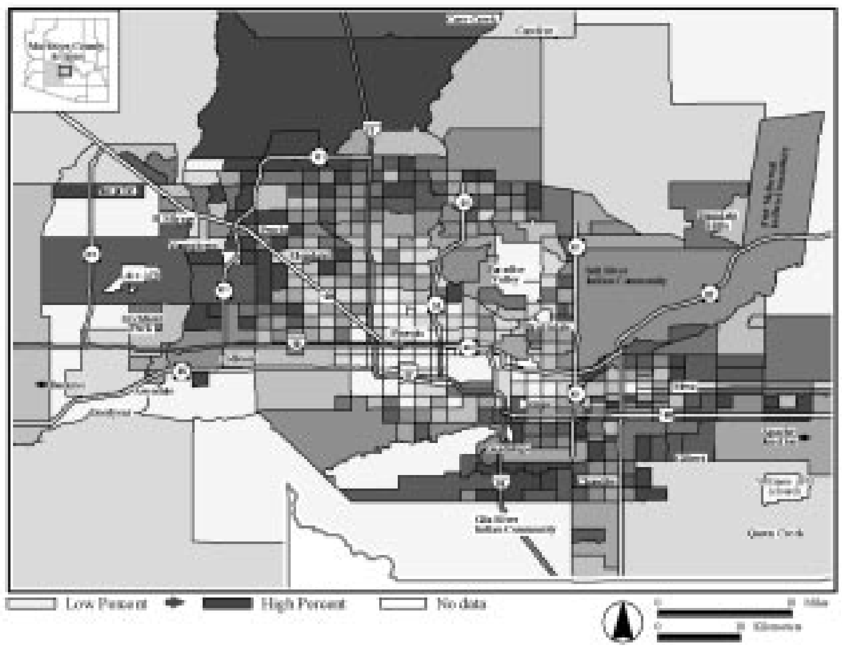


The combination of low skills and low mobility can exacerbate the economic hardships of central city workers. For example, the number of relevant job opportunities that can be accessed by workers with high mobility far surpasses the number of jobs that can be accessed by workers with lower mobility but similar skill sets. Figures 7 and 8 spatially present the distribution of job accessibility of low- to moderate-skill workers with different mobility potentials.

The relatively weak ratio of low-skill job availability to job demand is apparent in the central city (Figure 9). This pattern is in part due to the residential concentration of workers with low-skill sets, which amplifies the demand for low-skill jobs. This spatial distribution contrasts with the pattern of demand for high-skill jobs (Figure 10).

The ratio of high-skill job availability to job demand appears to be negatively correlated with neighborhoods occupied by high-skill workers. One anomaly is that of the city of Chandler where Intel and other high-technology manufacturers are located in close proximity to their workers, resulting in a concentration of high-skill workers with similar employment demands.

The distribution of high-skill jobs is more concentrated in the study region than low- to moderate-skill employment opportunities. The Phoenix central business district, where employment-to-population ratios are highest, comprises the greatest concentration of high-skill jobs (Figure 11). However, low- to moderate-skill jobs

Figure 7

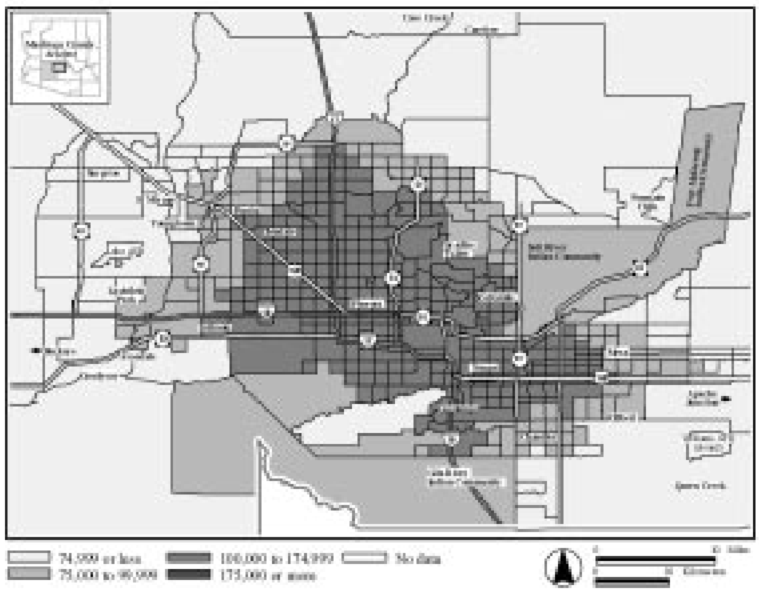


Figure 8

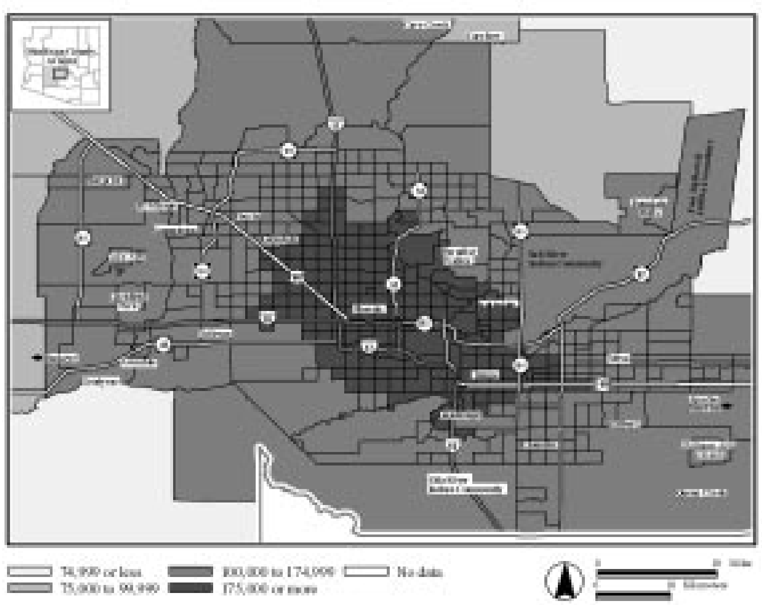


Figure 9

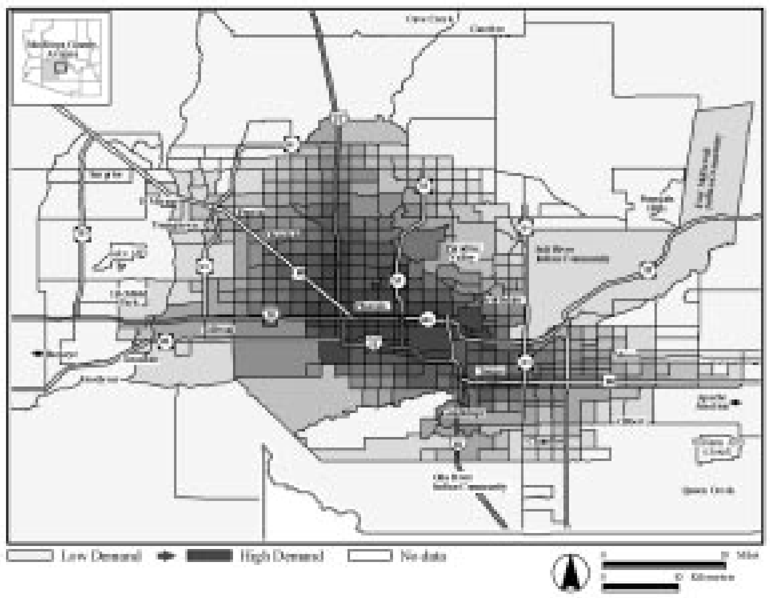


Figure 10

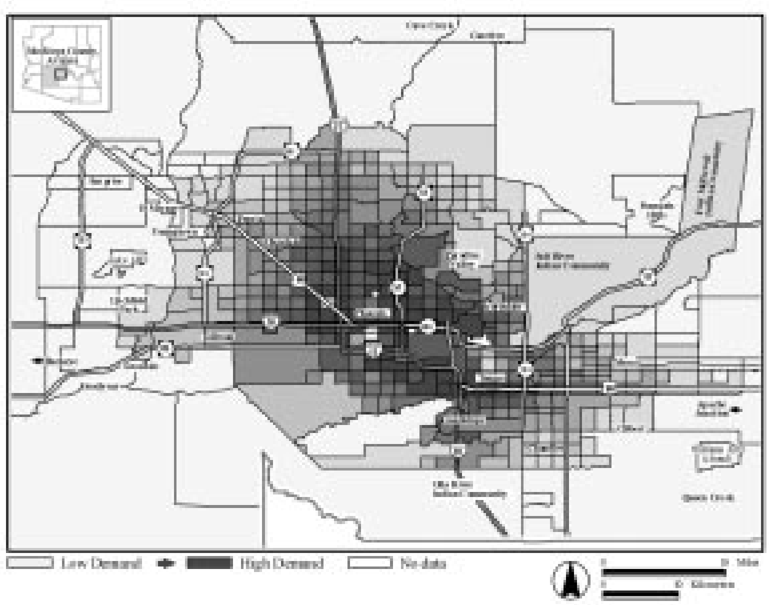
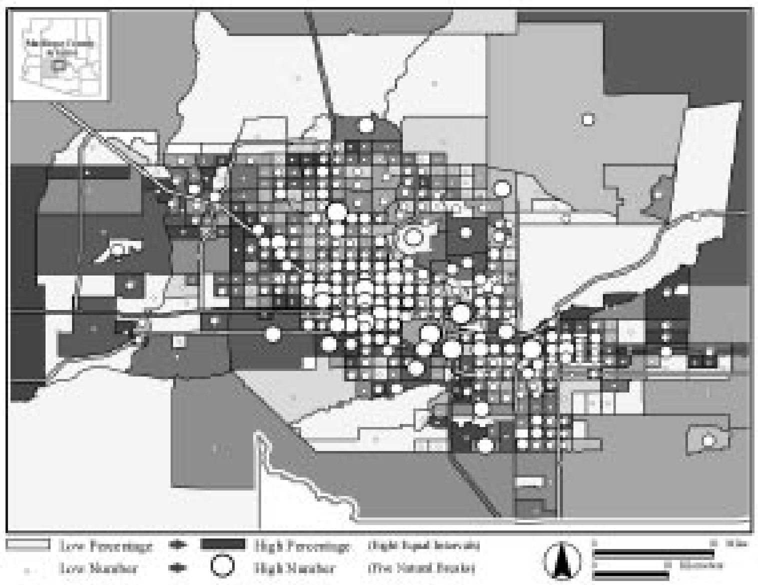


Figure 11



are evenly distributed throughout the landscape including areas with high residential growth (Figure 12). Note that the low- to moderate-skill employment demand in these areas are weak relative to the job opportunities.

Figures 13 and 14 show the spatial pattern of general accessibility (2) for low- to moderate-skill workers and high-skill workers respectively while accounting for all transportation modes. The visual pattern supports the spatial mismatch hypothesis in that employment accessibility for low- to moderate-skill workers and high-skill workers are low near where these populations reside.

In summary, the spatial distribution of job accessibility agrees with what was posited in the research—that a spatial mismatch exists between central city worker's residences and their relevant employment opportunities. Table 3 also supports the first hypothesis in that average job accessibility decreases with skill level. The next step is to determine whether these values are significantly and independently related to the economic performance of neighborhoods.

5. Fitting the Statistical Model

The present analysis followed a two-step procedure based in part on an approach recommended by Anderson and Gerbing (1988). In the first step, confirmatory factor analysis is used to develop two latent constructs—job accessibility and

Figure 12

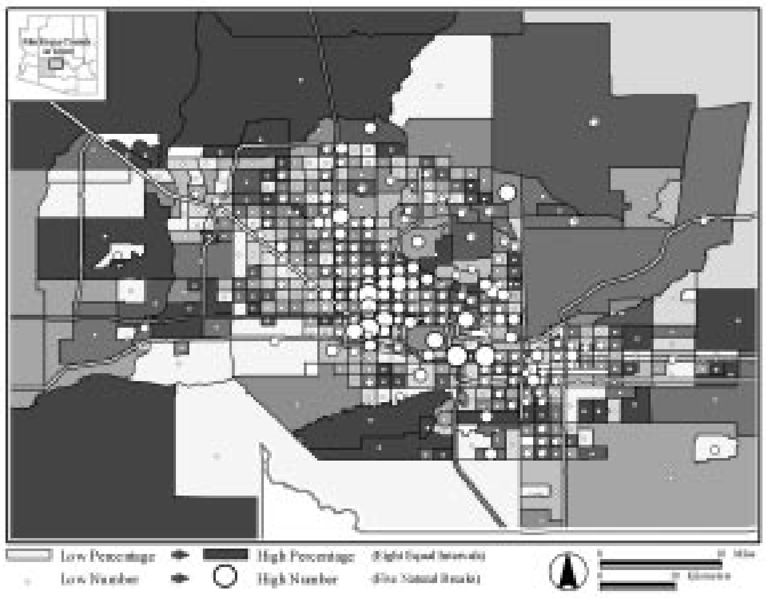


Table 3: Summary of Estimated General Accessibility Values by Occupation

	General Accessibility*			
Occupation Category	Mean	Minimum	Maximum	SD
High skill (GAOCC1)	0.934	0.669	1.029	0.048
Moderate to high skill (GAOCC2)	0.923	0.614	1.008	0.047
Low to moderate skill (GAOCC3)	0.903	0.578	0.996	0.047
Low skill (GAOCC4)	0.845	0.494	0.955	0.050
All Skill Levels (GALL)	0.923	0.240	1.016	0.065

Note: Measures consider all transportation modes.

Figure 13

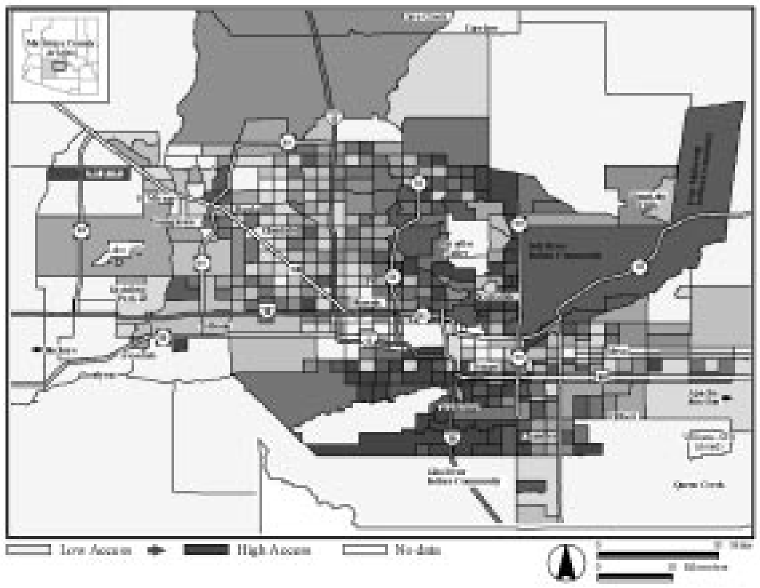


Figure 14

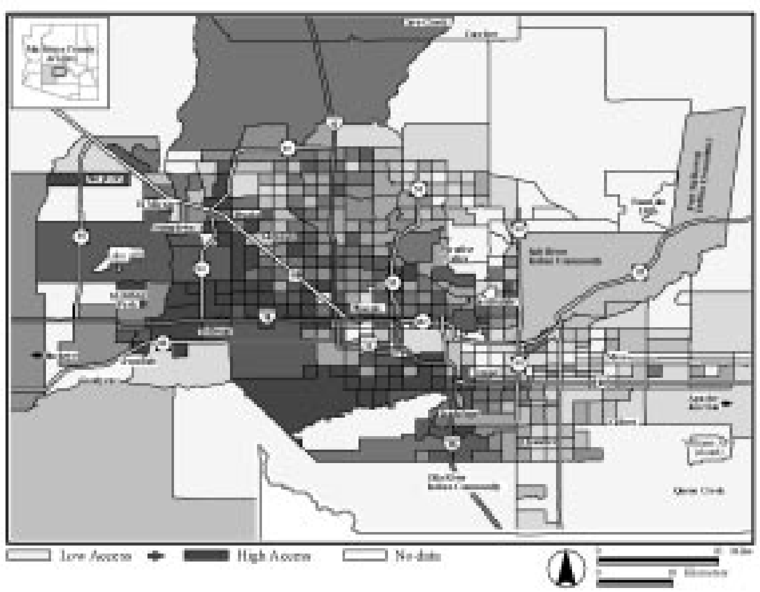


Table 4: Bivariate Correlations of Indicator Variables

	NOINCOME	NOWORK	NOTINLF	CHPOVTY	NOVEHS	GAOCC3	BUS15LSS	WKR23VEH
NOINCOME	1							
NOWORK	0.892	1						
NOTINLF	0.846	0.885	1					
CHPOVTY	0.288	0.290	0.322	1				
NOVEHS	0.472	0.432	0.458	0.648	1			
GAOCC3	-0.301	-0.310	-0.296	-0.223	-0.289	1		
BUS15LSS	0.358	0.369	0.352	0.474	0.611	-0.209	1	
WKR23VEH	-0.282	-0.231	-0.213	-0.335	-0.503	0.151	-0.450	1

N = 441. All Correlations are significant at the 0.01 level (2-tailed).

economic performance. Four indicators of each latent construct were identified from a pool of theoretically related variables. All latent and indicator variables were allowed to covary in a measurement model to determine whether the variables were indeed significantly and independently related. In step two, the measurement model was modified so that it came to represent the theoretical model in which job performance is "predicted" by the single latent variable job accessibility. The remainder of this section describes the process outlined above.

Latent constructs: Job accessibility and economic performance

The variables job accessibility and economic performance are each difficult to capture using a single observed variable. This is evident by the numerous forms the variables have assumed in previous studies. Job accessibility, for example, has been measured as mean travel time, area ratio of jobs to workers, number of jobs within a 30-minute transit commute, and network and/or straight-line distance from residence to place of work (Ihlanfeldt 1992). Similarly, economic performance has been expressed as employment rate, employment probability estimates, labor force participation, and earnings.

Rather than allow a single measure to wholly represent one of these variables, this research utilized job accessibility and economic performance as latent constructs or factors to be inferred by observable or indicator variables. The factors, when integrated in a structural equation model, can support greater complexity by allowing second order factor relationships and information about indirect and direct variable effects. Such analyses cannot be performed in standard multivariate regression models.

Data in the study were analyzed using AMOS 4.0 structural modeling software and the models tested were covariance structure models. Standard deviations and bivariate correlations for the study's eight indicator variables are provided in Table 4.

Figure 15

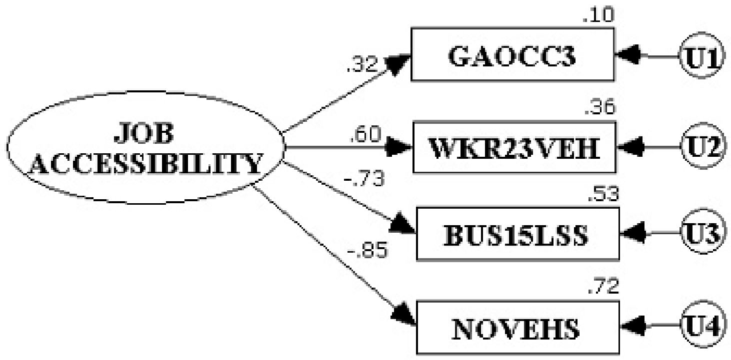


Figure 16

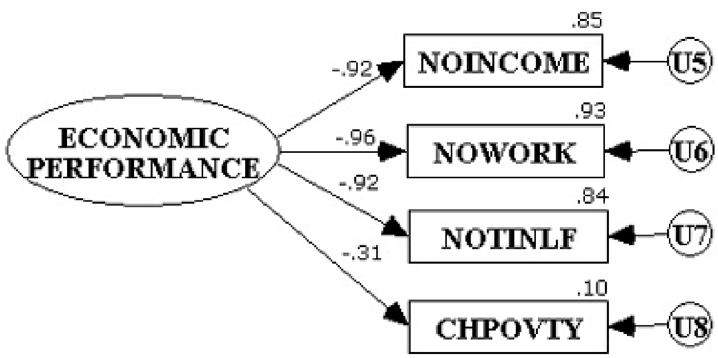


Table 5: Job Accessibility Single Factor Results

Latent Construct	Observed Indicator	Standardized Estimates	Squared Multiple Correlations	Error Variance
Job Accessibility	GAOCC3	0.316	0.100	0.900
	WKR23VEH	0.599	0.358	0.642
	BUS15LSS	-0.725	0.526	0.474
	NOVEHS	-0.847	0.717	0.283
	Composite Reliability	0.729	Variance Extracted Estimate	0.425
	X^2 (df)	2.712 (2)	Probability level	0.258

N = 441

Figures 15 and 16 present single-factor models for the latent constructs job accessibility and economic performance. Observed variables are represented as rectangles, latent constructs as ovals and measurement errors—the amount of error not explained by the latent construct—for the observed variables are represented as circles.

The observed, continuous variables were selected from a pool of theoretically related variables based on their ability to fulfill the assumption of multivariate normality.[5] The list of variables was further truncated based on their ability to uniquely load on their associated theoretical latent constructs—job accessibility or economic performance. Each variable's contribution to the model was initially tested using exploratory factor analysis then reaffirmed using confirmatory factor analysis.

The figures also present the standardized regression weights for each observed variable. All weights (i.e., factor loadings) have the predicted signs and all indicator variables either moderately or greatly load on their associated constructs. Job accessibility accounted for 71.7 percent of the variance of households with no vehicles (NOVEHS), followed by workers that commute by bus (BUS15LSS, 52.6%), two-worker households with three vehicles (WKR23VEH, 35.8%), and general accessibility of low- to moderately-skilled workers (GAOCC3, 10%) (Table 5). Economic performance accounted for 93.0 percent of the variance of the rate of population that did not work in 1989 (NOWORK), followed by neighborhood rates of no 1989 income (NOINCOME, 85.3%), labor force participation (NOTINLF, 84.3%) and child poverty (CHPOVTY, 9.9%) (Table 6).

[5] The Kolmogorov-Smirnov goodness-of-fit test was used to test whether the empirical distribution of the observations was consistent with a random sample drawn from a normal distribution.

Table 6: Economic Performance Single Factor Results

Latent Construct	Observed Indicator	Standardized Estimates	Squared Multiple Correlations	Error Variance
Economic Performance	NOINCOME	-0.924	0.853	0.147
	NOWORK	-0.964	0.930	0.070
	NOTINLF	-0.918	0.843	0.157
	CHPOVTY	-0.315	0.099	0.901
	Composite Reliability	0.884	Variance Extracted Estimate	0.578
	X^2 (df)	4.736 (2)	Probability level	0.094

N = 441

Both constructs exceed the minimal acceptable composite reliability of 0.600 and have nonsignificant chi-squares marked by corresponding *p* values above 0.5.[6] The relatively low variance extracted estimate for job accessibility (0.425) indicates that variance due to measurement error exceeds variance captured by the factor. However, this parameter is conservative and, given the other satisfactory indices, may not be wholly indicative of factor reliability.

Initial measurement model

An initial measurement model (M_i) was constructed using the latent factors and indicators outlined above (Figure 17). The covariance between the latent factors—represented by a curved arrow—was estimated using the maximum likelihood method (ML) and the chi-square value for the model was statistically significant x^2 (19, N = 441) = 249.13 (Table 7). In addition to the unsatisfactory chi-square, a number of other results indicated that the model was not appropriately fit. The squared multiple correlation of CHPOVTY suggests that economic performance accounts for only 10 percent of the variance in child poverty rates. The model, therefore, does not explain the remaining 90 percent of the variation of this indicator.

Revised measurement models

Goodness of fit indices for the initial and respecified models are presented in Table 7. Their associated measurement model diagrams are shown in Figure 18. Dropping both CHPOVTY and NOVEHS from the analysis considerably improved

[6] When the proper assumptions are met (large sample, multivariate normal distribution), the chi-square test provides a statistical test of the null hypothesis that the model fits the data. Therefore, a good model is one with a relatively small or nonsignificant chi-square value.

Figure 17

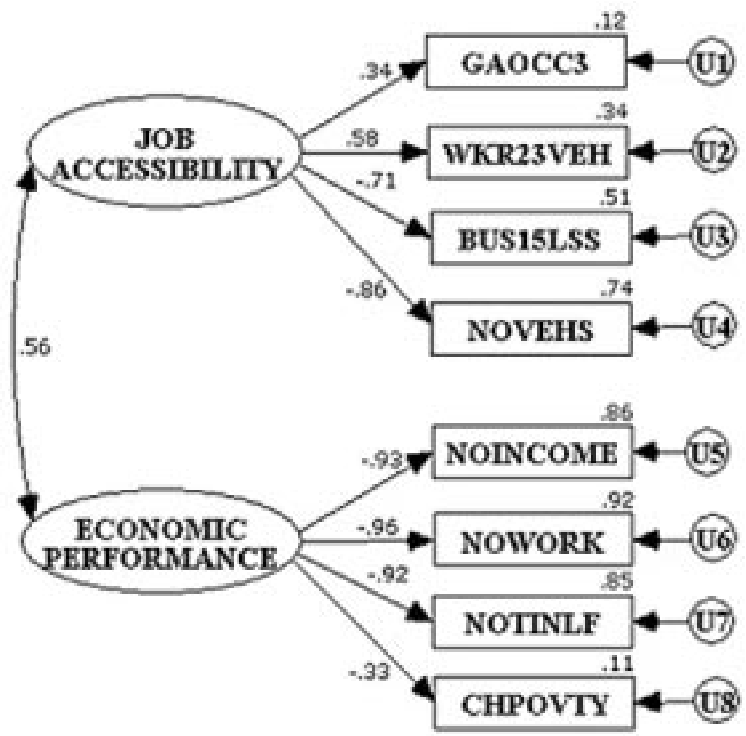
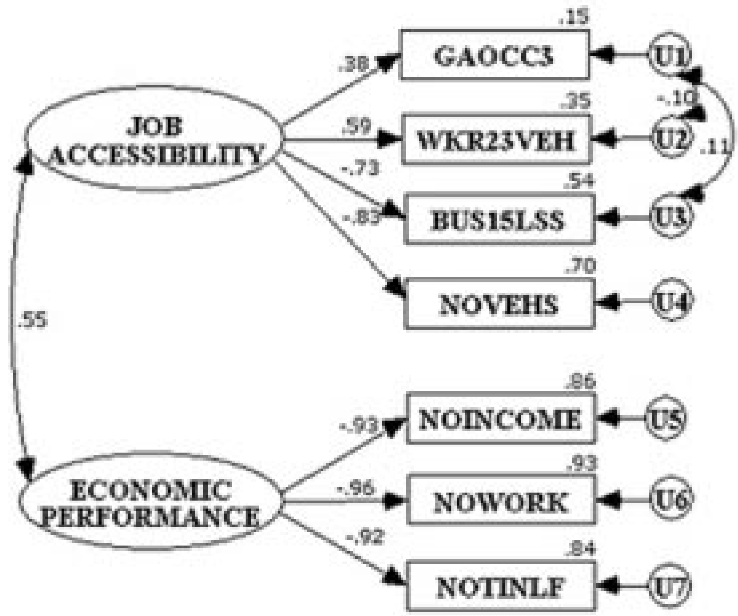


Table 7: Measurement Models Goodness of Fit Indices

	Measurement Model		
Index	M_i	M_1	M_2
Chi-Square	249.133	30.610	11.242
df	19	8	6
X^2 Probability	0.000	0.000	0.081
NFI	0.887	0.981	0.993
CFI	0.895	0.986	0.997
PR	0.679	0.533	0.400

N = 441; NFI = normed fit index; CFI = comparative fit index; PR = parsimony ratio.

Figure 18



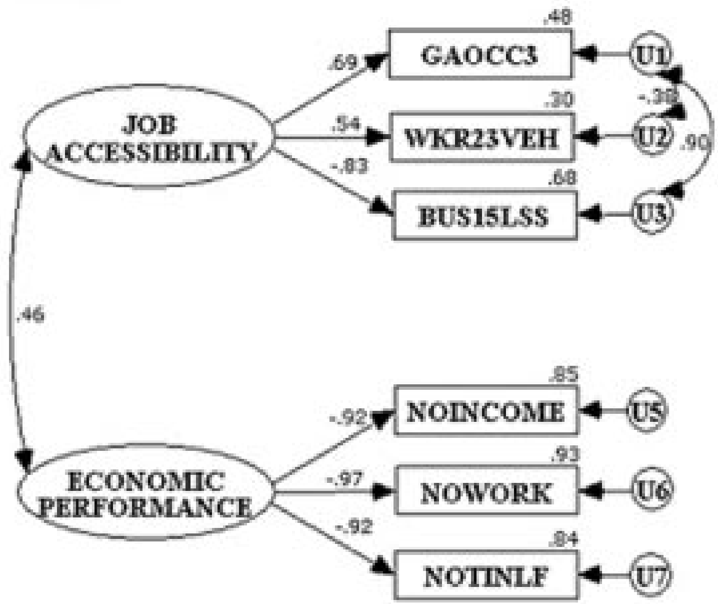
the first revised model (M_1) marked by a lower chi-square value and greater model fit.

Two goodness of fit indices were used in this analysis: the normed fit index, or NFI, and the comparative fit index, or CFI. Both values may range from 0 to 1, where 0 represents the goodness of fit associated with a model with all uncorrelated variables, and 1 represents the goodness of fit associated with a model that perfectly reproduces the original covariance matrix (Bentler 1980; Bentler 1989).

The parsimony or relative simplicity of the model was also tested using the parsimony ratio or PR (James 1982). The ratio equals the degrees of freedom for the model divided by the degrees of freedom of the null model (the null model predicts no relationships between any of the study's variables) and ranges from 0 to 1. Therefore, an upper value of 1 indicates the most parsimonious model possible because it makes the fewest assumptions between the variables.

Adding error covariances between GAOCC3 and WKR23VEH, and GAOCC3 and BUS15LSS, in the second revised model (M_2) allowed the chi-square to be rejected at the 95 percent level. Although the parsimony ratio is low, indicating the complexity of the model is high compared to the explanatory power, the other satisfactory indices were encouraging enough to accept this second revised model as the final measurement model.

Figure 19



The final measurement model was then modified to show the causal path associated with the hypothesis that job accessibility is related to economic performance. This is represented in Figure 20 as a single headed arrow drawn between the latent constructs. Because it is a simple structural model with a single independent and dependent latent variable, the model fit indices are identical to the final measurement model.

The direct, indirect, and total effects of the variables are presented in Table 8. The final model indicates that over 46 percent of the variance of economic performance is accounted for by job accessibility. Therefore, greater access to jobs has a significant effect on a community's economic situation. BUS15LSS, GAOCC3, and WKR23VEH account for over 48 percent of the factor variance of job accessibility. NOTINLF, NOWORK, and NOINCOME account for almost 88 percent of the factor variance of economic performance

6. Conclusions and Recommendations

This research has explored (a) forces that influence spatial mismatch, (b) refined measures of job accessibility, and (c) a statistical model that relates these measures to the economic performance of central city neighborhoods in metropolitan

Figure 20

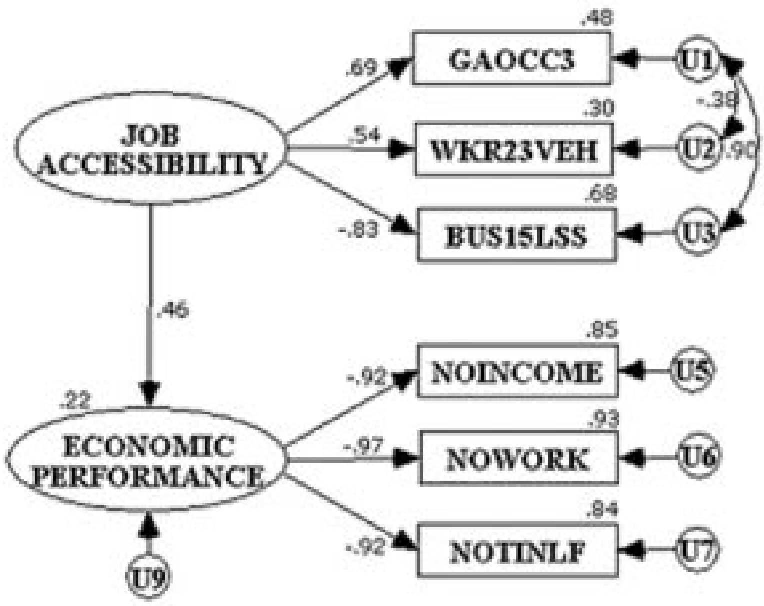


Table 8: Structural Equation Model Results

Latent Construct	Observed Indicator	Standardized Estimates	Squared Multiple Correlations	Error Variance
Economic Performance	NOINCOME	-0.924	0.854	0.146
	NOWORK	-0.965	0.931	0.069
	NOTINLF	-0.917	0.841	0.159
	Composite Reliability	0.955	Variance Extracted Estimate	0.875
Job Accessibility	GAOCC3	0.694	0.482	0.518
	BUS15LSS	-0.826	0.682	0.318
	WKR23VEH	0.545	0.297	0.703

N = 441

Phoenix. Thus it is fitting to end this paper with a brief discussion of why planners should operationalize job accessibility measures in planning practice and, more specifically, how these measures can be used to improve social equity in transportation systems and enhance the link between land use, environmental, and transportation planning.

Recent policy changes, existing environmental justice mandates, and smart growth and sustainable development principles exemplify reasons why planners should operationalize measures of accessibility. The U.S. Department of Transportation's Transportation Equity Act (TEA-21) program, for example, has a significant job accessibility component. Activated in 1999, the component is commonly referred to as the Job Access and Reverse Commute or Welfare to Work program and assists states and municipalities in developing new or expanded transportation services for connecting low-income persons to jobs and other employment related services. Toward this end, job accessibility values can be applied to identify communities in need of transportation services. Once identified, a collaborative effort could be made by metropolitan planning organizations, transportation providers, affected communities, and their stakeholders to develop a project that serves the community. In 2000, Congress appropriated $75 million for such programs.

Planners could also operationalize accessibility to promote environmental justice in transportation. In addition to TEA-21, there are laws, regulations, and policies that require the consideration of minority and low-income populations. For instance, Title VI of the Civil Rights Act of 1964 mandates that "no person in the United States shall be denied the benefits of any program or activity receiving Federal financial assistance." Further, a 1994 Presidential Executive Order directed every federal agency to consider the effects of all programs, policies, and activities on disadvantaged communities. In order to comply with Title VI and the executive order, metropolitan planning organizations need to enhance their analytical capabilities to ensure that long-range transportation plans and investments are fairly distributed. Hence, job accessibility measures could be incorporated in urban modeling and alternative plan analysis to determine whether prospective initiatives work toward accomplishing these goals. UrbanSIM, an urban modeling application developed by Paul Waddell and the University of Washington, is an example of an effective model that addresses the interactions between housing and labor markets using job accessibility values (Waddell 1998; 2001).

Finally, planners would benefit by using job accessibility measures to help forward some of the most basic principles outlined in smart growth, New Urbanism, sustainable development, and related anti-sprawl initiatives. America's transportation infrastructure since the 1950s has prioritized highway building, fostering an auto-dependent society. The initiatives mentioned above attempt to remedy the deep structural imbalances caused by such a society and the sprawling urban form that supports it. Job accessibility measures could be used as performance indicators of progress toward smart growth.

The Netherlands, for example, has made considerable headway in applying job accessibility measures. They have classified various locations within cities by accessibility levels that help planners and local area citizens support prospective businesses that match the accessibility profiles of their neighborhoods (Cervero, Rood, and Appleyard 1995).

In conclusion, job accessibility values, when measured appropriately, can be implemented in ways that advance citizen participation, equitable transportation, and overall efficiency in urban design.

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