CHANGE IN RESIDENTIAL PRICES:
A Cross-Sectional Time-Series Analysis for the Boston Metropolitan Area

by

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Submitted to the Department of Urban Studies and Planning in Partial Fulfillment of the Requirements of the Degree of
Master in City Planning
and
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ABSTRACT

In this thesis a pooled time-series cross-sectional analysis of rates of appreciation in single family home prices was conducted at the intra-regional level. The window of analysis included 103 individual or combined cities and towns within the five counties comprising the Boston Metropolitan Area: Essex, Plymouth, Middlesex, Norfolk and Suffolk.

The raw database used embodied all real estate transactions, commercial as well as residential, which occurred within the study area between 1983 and 1989, the time-frame for this analysis. From this database appreciation rates in single family home prices were estimated employing a weighted repeat sales regression model. This model was run subsequent to a series of measures taken to improve data integrity, including: address correction; elimination of all transactions on other than single family homes; removal of outlying observations; and inflation adjustment.

After calculating rates of appreciation in single family home prices by community, by year, a number of fiscal, demographic and location specific variables were introduced to explain differential rates of appreciation across time and space. Finally, spatial analysis of the data and regression results was performed using thematic mapping tools to aid interpretation of the model.

The regression results demonstrate that during periods of economic vitality, as was evident in the study area during the mid 1980s, communities generally viewed as less desirable exhibited higher rates of appreciation in home values than other localities, due to the effects of market speculation. In contrast, during periods of stable growth or decline, home buyers tend to be more risk averse, thus more attractive communities with favorable packages of public goods and amenities fared better.

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CHANGE IN RESIDENTIAL PRICES: A CROSS-SECTIONAL TIME-SERIES ANALYSIS FOR THE BOSTON METROPOLITAN AREA

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CHAPTER 1

INTRODUCTION: PROBLEM STATEMENT

During the 1980s housing prices in Boston and many other metropolitan areas across the country experienced a period of unprecedented appreciation, followed by an abrupt decline. In the Boston area, appreciation, caused largely by market speculation, sharply influenced the affordability of homes, prohibiting individuals and families from attaining the 'Great American Dream' of homeownership. As property values continued on their upward course, developers, recognizing an opportunity for profit joined on the bandwagon, and residential development of both single-family homes and condominium units increased dramatically.

By the end of the decade, a surplus in the housing stock was apparent, and numerous property foreclosures resulted in the insolvency of many financial institutions. As a result of this sharp turn in the real estate market Boston became characterized as 'the Houston of the 1990s' during the last decade of the twentieth century. Most of the studies conducted during the late 1980s and early 1990s focused on both the cause of this market bubble, and its inevitable burst. Few, however, have endeavored to ascertain the impact of traditional housing price determinants such as accessibility, density, property tax rates and income, too name just a handful, during periods of nontraditional market expansion and contraction. This final issue will be the focus of this thesis.

Historically, studies have attempted to identify the determinants of changes in housing demand and/or its price component (D = P * Q). Most of these studies have been limited to analysis either across location or time. Locational studies examine differences across regions of the country, or among communities within a region or metropolitan area. Time-series studies focus on changes induced by national or regional economic cycles, long-term trends, seasonal and irregular fluctuations. Studies endeavoring to describe and explain variations in housing prices across the dimensions of both time and space have been sparse.

For this thesis I conducted a pooled time-series cross-sectional analysis of appreciation in single-family home prices at the municipal level. The window of analysis included cities and towns located within the Boston Metropolitan area, and the time frame was the period from 1983 through 1989. My focus here was on how intra-jurisdictional differences in public goods and amenities affected rates of single family housing price appreciation during this period. As mentioned above, the boom period of the 1980s was of particular interest because it provided an arena for testing whether the traditionally assumed effects of financial and fiscal variables and amenities remain stable during periods of robust economic expansion.

The results of this analysis do not support the theory of tax capitalization during periods of exceptional market activity. In contrast, the findings of this study imply that in periods of flourishing real estate market conditions, those properties located in communities traditionally viewed as less desirable, may be considered undervalued. Thus rates of appreciation in the value of properties in less attractive municipalities tend to outpace appreciation rates on properties in communities commonly viewed as attractive.

I utilize community level measures of public goods and amenities as determinants community quality. For the purposes of this study, I classify these public goods and amenities into four major groups: structural characteristics, financial and fiscal determinants, locational considerations, and population characteristics. Structural characteristics of a property include factors such as building and lot size, number of bedrooms and baths, age of the structure, etc. Financial and fiscal determinants encompass variables such as mortgage interest rates, income and property tax rates, educational expenditures, expenditures on police and other municipal services, and debt service. Locational considerations embrace categories of zoning and land use, as well as density and accessibility. Population characteristics embody elements such as income, population, employment, racial composition, poverty population, and crime rates.

In Chapter Two I evaluate the existing literature, addressing the significance of various determinants of housing price disparities. The premier work on financial and fiscal factors was Charles Tiebout's (1956) theory which stated that locally produced public goods and property taxes will affect housing prices. I begin with the Tiebout presumption, and consider modifications of his theory introduced by other academics and scholars. In addition to evaluating variables of possible interest for inclusion in this model, I review alternative techniques for measuring the dependent variable (variations in rates of housing price appreciation across localities) expounding on the benefits and faults of these techniques.

In Chapter Three I discuss variations in the national, New England, and Massachusetts economy during the 1980s. Following a mild recession early in the decade, the New England region and Boston Metropolitan Area experienced a period of unprecedented expansion. The regional growth greatly exceeded the growth occurring nationally. As the decade drew to a close, however, regional growth stagnated and began to decline while national expansion continued, although at a modest pace. The unique context of the Boston Metropolitan area during the 1980s make it an ideal case for analysis of changes in housing prices.

In Chapter Four I select the most appropriate method for analyzing rates of appreciation in housing prices, and model differential rates across locations, utilizing fiscal, demographic, and locational variables. Descriptions of the variables included in the final model, and the methodology for compiling annualized measures of these variables by locality, are included in Chapter Four.

The model results are presented and discussed in Chapter Five. In this analysis I ran a series of models in order to ascertain both the spatial and time period effects on rates of housing price appreciation. These sub-models focused on the differential impacts of the various determinants of appreciation in urban, suburban, and exurban areas, during periods of economic expansion and decline. I employ the thematic mapping capabilities of Geographic Information Systems (GIS) technology in this chapter as a tool for analysis. These thematic maps more clearly depict locational and time-series variations, thus simplifying this complex analytical task.

In Chapter Six I present my conclusions. In addition, I address potential improvements to the model specified, and pose questions that would be of interest in future research. Given the abundance of data compiled for this study, a wealth of alternative analytical questions could be considered, and more valuable insight into the peculiarities of the Boston real estate market during the 1980s, commercial as well as residential, revealed.

CHAPTER 2

REVIEW OF RELEVANT LITERATURE

In this chapter I review the relevant literature which examines the effects of local disparities in the availability of public goods and amenities on housing prices. In the first section of the chapter, I focus my attention on the variables most frequently cited in interpretive studies of housing prices. I follow this discussion with a review of alternative methodologies for gauging changes in housing prices. Past housing studies have been conducted at various levels of aggregation: national, inter-regional (comparisons across Metropolitan Statistical Areas (MSA)), and intra-regional (comparisons among cities and towns within a state or MSA). Methodologies chosen have also varied from modeling techniques (OLS, Two-Stage LS, GLS, etc.) to surveys attempting to discern which factors most significantly influence a home buyer's decision to purchase a particular property. This review encompasses both inter- and intra-regional studies, and examines models utilizing a variety of these techniques.

THE DETERMINANTS OF HOUSING PRICES

Four categories of variables have most frequently been identified as explanatory variables in housing price regression models. Measurements of structural and property characteristics, most often utilized in hedonic price models (total square footage of a home, number of rooms, lot size); financial and fiscal determinants, at the national level (mortgage interest rates and federal income taxes), and at the local level (property tax rates, educational expenditures, and other municipal expenditures); locational factors (density, measures of distance or access to a major employment node, housing starts, crime rates); and population characteristics (population, median family or household income or wealth measures, (un)employment, age, educational levels, race, poverty population). These four categories of explanatory variables are described in more detail in the following sections.

Structural and Property Characteristics

Structural characteristics greatly influence the price of a home. Other things being equal, a 2000 square foot home will command a higher price than a 1000 square foot home. Similarly, a home with a large lot or swimming pool will command a higher price than a home on a smaller lot or without a pool, ceteris paribus. Hedonic price models have traditionally been used to control for variation in structural characteristics. A detailed discussion of hedonic models will be presented in the second section of this chapter.

<u>Financial and Fiscal Determinants</u>

National Level

Mortgage Interest Rates

National level variables have greatly influenced the demand for housing by altering the price component of the demand equation. Mortgage interest rates have historically had a negative impact on housing demand, and thus price (Kau and Sirmans 1984, Case 1986, Case and Shiller 1990). During the 1980s, the introduction and increased utilization of variable rate mortgages altered the certainty of housing expenditures and changed the effect of mortgage interest rates on the housing market. With fixed rate mortgages, an individual would purchase a home, acquire financing, and be guaranteed that a fixed payment would be required to pay off the mortgage. Variable rate mortgages caused fluctuations in mortgage payments, but allowed households to choose between risk, as variable rate mortgages run the risk of higher future mortgage payments due to changing interest rates, and return, as the base interest rate on fixed rate mortgages exceeds that of variable rate mortgages.

Personal Income Tax Rates

Personal income tax rates have also had a substantial effect on housing prices as changes in the deductibility of homeowner related expenses (mortgage interest, insurance, etc.) have resulted in changes in the true value or cost of property ownership and, consequently, an individual's wealth (Case and Shiller 1990). Grebler and Mittelbach (1979) conducted a survey of home buyers motivations for purchasing homes in 1975 and

1977 in Contra Costa and Orange County California, and found that approximately two-thirds of those investing considered income tax benefits of home ownership important in their decision. Furthermore, this tax benefit or subsidy increases with income, as marginal income tax rates have different effects on different income levels.

Local Level

Property Tax Rates

The pioneering work in the theory of the value of local expenditures and amenities to consumers of housing services was introduced in 1956 by Charles M. Tiebout. Tiebout utilized an assortment of local municipal finance variables - including property tax rates, educational expenditures, police and fire protection, and amenities (e.g., a public beach or golf course) - and determined that such variables strongly influence intra-metropolitan movements of the population. The Tiebout model had households choosing between urban and suburban localities based on the distribution of fiscal expenditures within a locality and not simply on variations in the income elasticity of demand for land. Tiebout stated "The consumer-voter may be viewed as picking the community which best satisfies his preference patterns for public goods (Tiebout 1956, 418)."

Tiebout's theory was based on a number of assumptions, some of which he and/or others recognized as weak. These assumptions were:

1. Consumers are fully mobile and base their locational choice on the fiscal characteristics of a community, choosing that locality which best fulfills their preferences.
2. Consumers are assumed to be fully aware of variations in fiscal expenditures across communities.
3. The pool of communities available from which the consumers may choose is large.
4. Employment opportunities are assumed to be identical among localities.
5. Public services supplied exhibit no economies or dis-economies of scale.
6. The optimal size of a community can be determined because a community has fixed resources, and is defined as the size at which average cost of the bundle of fiscal services provided is minimized.
7. Localities which fall below this optimum will seek to attract new residents while those above the minimum will attempt to deter them.

Since the publication of Tiebout's theory, numerous articles have been written critiquing his assumptions. In many of these articles, additional variables have been introduced to explain locational choice and/or resulting changes in housing values across locations. None of these studies have rejected the importance of property tax rates in determining location. However, Oates (1973) concluded that shopping among communities was more evident in suburban locations relative to the city. In his intra-regional analysis of 53 northern New Jersey commuting suburbs of Manhattan, Oates found that people were willing to pay relatively more for higher quality services or would choose locations with lower taxes where services of identical quality were offered. Wilson (1979) reiterated these findings. In his inter-regional analysis, Wilson concluded that higher quality residential packages relative to low tax rates were found in the suburbs, when compared with cities.

Hamilton (1975) expanded on Oates' conclusion and determined there exists a differential effect of property taxes in cities and suburbs; in the cities property taxes are viewed as an excise tax on housing while in the suburbs property taxes are regarded as a payment for services. Ihlanfeldt (1984) concurred with Hamilton in his estimation of housing demand equations for 30 SMSA's. Ihlanfeldt found that, if anything, higher tax payment is associated with a greater purchase of housing services in the suburbs, while in the city these payments do indeed act as an excise tax. Mills and Oates concluded that, "most central cities are almost certainly too large and too diverse to be able to provide public service bundles tailored to the needs of particular segments of their populations, and constitutional considerations greatly limit their ability to do so (Mills and Oates 1975, 9)."

All of the studies reviewed concluded that property tax rates bear a negative relationship to housing prices, thus supporting the theory of tax capitalization. This theory states that increased tax rates will result in lower property values, ceteris paribus. Studies of tax rate measures have been conducted in numerous ways. Levin (1982) postulated, given that market forces work, home prices in areas with higher effective tax burdens will grow more slowly than in areas where the effective tax burden is lower, other things equal.

Oates (1969), Levin (1982), Ihlanfeldt (1984) and Michaels and Smith (1990) advocated use of the effective or full value property tax rate to correct for differential assessment ratios among communities. For example, assume the characteristics and expenditures of Town A and Town B are identical. The property tax rate in Town A is 20 mils ($20 per $1000). Town B has a property tax rate of 15 mils. Thus, the rational consumer of housing services would choose to locate in Town B in order to minimize his or her property taxes. However, if this discrepancy in property tax rates is due to an assessment rate of 75% in Town A (.75 * 20 = 15) versus 100% in Town B (1 * 15 = 15) the consumer will be indifferent to the two locations, as the actual tax levy will be identical.

Educational Expenditures

In studies that have evaluated property tax rates and municipal expenditures, the primary category of expenditures included has been education. Oates (1969) advocated use of per pupil educational expenditures because this variable is the largest single cost item in most municipal budgets. He used the natural logarithm of educational expenditures per pupil as a proxy for educational quality in his analysis of New Jersey communities. Hamilton, Mills and Puryear (1975) concurred with Oates, and utilized educational expenditures as a surrogate for public services because it accounted for more than half of local government expenditures and had an income elasticity of demand substantially greater than zero.

Other studies where per pupil educational expenditures were utilized as a proxy for educational quality, and where a positive relationship was postulated between this variable and housing prices, include Tiebout (1956) and Hamilton (1975). Izraeli (1987) conducted a similar analysis at the inter-regional level, examining determinants of housing value and monthly rents in over two-hundred SMSA's in the U.S. He found per pupil educational expenditures to be a statistically significant predictor of housing values at the .05% level.

Alternative measures of educational quality have been recommended by others. Rosen and Fullerton (1977) re-estimated the Oates model at the inter-regional level. Using a four year panel study which followed movers, they replaced Oates's per pupil educational expenditure variable with grade-level performance of fourth graders on standardized tests of reading and math and found a positive and significant relationship between test scores and housing values. Michaels and Smith (1990) examined pupil-teacher ratios in suburban Boston school districts and found a negative relationship between this variable and property values; this translates into a positive relationship between school expenditures and property values as more teachers translate into higher costs.

Other Fiscal Variables

In addition to educational quality measures, many studies have evaluated the relationship of housing values to other municipal expenditures including police, fire, debt service, and other variables. In response to criticism by Pollakowski (1973), Oates (1973) redefined his earlier model by including a variable for all non-school related municipal expenditures in his intra-regional analysis of New Jersey communities, and found a positive relationship with property values, as would be expected under the Tiebout hypothesis. Although Oates acknowledged the significant predictive value of these non-educational municipal expenditures, he maintained that if tax capitalization does occur, it appears to be more strongly associated with educational expenditures than these other public services. Izraeli (1987) also discerned a positive relationship between housing values and non-educational expenditures across SMSA's.

Kohlepp and Ingene (1979) conducted an intra-regional analysis of thirty-nine suburban Columbus, Ohio communities. In this analysis they separated local public services into five categories, one of which was per pupil expenditures, and found that only this category exhibited a positive significant relationship with property values. In general, police and fire expenditures have exhibited a positive relationship with housing prices while debt service has maintained a negative relationship. Educational expenditures, however, have consistently asserted a far greater impact on home prices than these other municipal expenditure categories.

Locational Determinants

Zoning

In addition to Hamilton's criticism of the differential effects of property taxes on urban versus suburban locations, he further criticized Tiebout, stating that, "(the) Tiebout hypothesis seems to be a formula for 'musical suburbs' with the poor following the rich in a never-ending quest for a tax base (Hamilton 1975, 15)." Hamilton argued that exclusionary zoning, in the form of minimum lot size requirements, acts as a pricing mechanism: "...in an urban area with a large number of independent jurisdictions, judicious use of zoning can convert the residential property tax into an efficient price for local public services (Hamilton 1975, 13)." Tiebout (1956) would not dispute this criticism, and in his article on the theory of local expenditures he acknowledged that communities may utilize restrictive zoning laws to maintain or attain optimum size. However, he contradicted this statement with his first and third assumptions of full mobility and a large number of communities from which to choose. By imposing zoning restrictions, individuals are limited in their available choice of locations unless they possess the financial means to overcome these limitations. Mills and Oates (1975) also concluded that communities rely on land use regulations by which residents can regulate, to a certain extent, entry into the community.

Land Use

Non-residential property uses have generally had a negative impact on residential property values. As White (1975, 37) states, "...without some inducement communities would prefer to exclude business and factories from their borders." This effect is much more pronounced when the non-residential use is primarily industrial as opposed to commercial. Noise (Mieszkowski and Saper 1978) and pollution (Anderson and Crocker 1971, Izraeli 1987) have been determined to negatively impact property values and these disamenities are more prevalent among industrial properties.

Density

Michaels and Smith (1990) examined average lot size as a substitute measure of zoning in their survey of housing prices in suburban Boston communities, and determined a positive and significant (at 1%) relationship existed between average lot size and housing prices. Population per area or density is another proxy measure for zoning. However, density may also exhibit a strong negative relationship with accessibility to major employment nodes. Exclusionary zoning in a community will result in larger lots and correspondingly lower density as more land is required per housing unit.

Lower density and open space have been shown to exhibit positive impacts on housing prices as open space is a highly valued amenity, particularly in densely populated regions of the country. Correl, Lillydahl and Singell (1978) studied the effects of greenbelts on residential property values in the city of Boulder, Colorado. This city was chosen as the subject of analysis because in 1967 residents of Boulder approved a proposal to establish a fund for purchasing and managing greenbelts. This fund was to be financed by a 0.4 percent city sales tax. As of 1978 the Boulder Open Space Program had purchased some 8000 acres. Correl, et al. determined that distance from a greenbelt had a statistically significant negative impact on the price of residential property. Thus the greenbelts acted as a quasi-public good, disproportionately benefitting resident living in close proximity to this open space.

Accessibility

It is well established that residential choice of location is influenced by proximity to workplace. Therefore, accessibility should significantly affect housing prices. In a number of intra-regional studies, access measures have been confined to distance to the Central Business District (CBD), and the relationship to housing prices has consistently been negative.

Oates (1969) used linear distance to examine accessibility to Manhattan in his cross-sectional analysis of New Jersey commuting suburbs. He assumed, "within a metropolitan area the accessibility of the community to the central city should be of importance. Therefore, ceteris paribus, we would expect property values to vary inversely with distance to the central city (Oates 1969, 959)." Wingo's (1961) theory also assumed all employment was fixed in the CBD. In Wingo's model, a household was assumed to choose a location which minimized the sum of transportation costs to the

CBD and land use costs associated with the amount of land being consumed. Alonso (1964) likewise had households choosing location and land consumption as a tradeoff between cheaper rents and longer trips to work in the CBD. Jud (1985) included a variable measuring accessibility to downtown San Francisco and Los Angeles in his examination of the effects on home values in communities in these areas, and found the relationship to be negative and significant.

The main criticism of housing price models including only access to the CBD is that most urban areas have multiple employment nodes. In addition, technological advances in the area of computers and fiber-optic networks during the 1980s resulted in expansion of the market for back offices, thus increasing demand for office space outside the CBD. In the early 1990s these trends continued to support the development of multiple employment centers as leasing costs in suburban locations were more economical than in the CBD.

Strazheim (1975) criticized the models which assumed one central workplace as an apparent attempt to minimize analytical complexity. Successive models have attempted to prototype multiple employment nodes. Michaels and Smith (1990) used a weighted distance measure to various employment centers in the Boston MSA and discerned a significant (at 1%) negative relationship between distance and home prices. Johnson (1982) delved more deeply into the accessibility variable by including in his hedonic price model the natural logarithm of the sum of distances to employment centers, where distance was weighted by the proportion of total employment in that center.

Owner Occupancy

Dwelling types vary significantly across location and have been determined to affect housing values. Oates (1969) used median household income as a proxy for desirability of a neighborhood but recognized a problem in using this variable because he was actually interested in modeling only homeowners' income. In communities with a large number of renters, using median income to approximate the income of owner occupied dwellings tends to underestimate its true value, as proportionally more of the lower income residents of a community tend to be renters.

Other studies have included a measure of owner-occupancy to help explain housing values. In their suburban Chicago study, Anas and Eum (1984, 1986) examined the proportion of single family dwellings in the area, and found a positive (at 5%) relationship between this variable and home prices.

Population Characteristics

Income

Aside from property taxes, income is the determinant most frequently included in housing price models. Reid (1962) evaluated this relationship at the intra-regional level. Based on a group of households within a metropolitan area, stratified by census tract and housing quality, Reid found income elasticity of housing to be as high as two for homeowners.

A number of measures of income have been used in previous work including disposable income, per capita income and average family income. deLeeuw (1963) utilized disposable personal income in his analysis, and found this variable to be a significant positive determinant of home-buying units. Strazheim (1975) modeled intra-metropolitan variation among housing submarkets and determined average income to be a positive significant predictor of housing demand. Anas and Eum (1984) evaluated the effects of average family income on housing prices in suburban Chicago and also detected a positive significant (at 5%) relationship.

Other analysts perceived this positive relationship by employing measures of median income, arguing that average income values in a community or metropolitan area may be skewed upward by the presence of a few wealthy inhabitants. As mentioned previously, Oates (1969) included median family income as a proxy for intangible characteristics (e.g., beauty, neighborhood attractiveness) of New Jersey suburban communities, and ascertained that this variable exhibited a positive and significant (at 1%) relationship with home values. Jud (1985) employed median household income in his analysis of home prices in San Francisco and Los Angeles communities. This measure is more appropriate than family income measures because a single household may consist of multiple families. The most appropriate measure in the analysis of home purchase prices, as indicated by Oates (1969), is median homeowners' income. Izraeli

(1987) utilized median income of homeowners as a measure across SMSA's and found a positive significant (5%) relationship.

Employment

Case (1986) found the price elasticity of homes with respect to employment to be .82. In his model of a sample of Boston municipalities, Case estimated the log of total housing starts in double log form and solved simultaneously for price in order to evaluate the price-employment relationship. Case and Shiller (1988) surveyed housing consumers' opinions of the local economy, of which employment is a major factor, and found 29.5 percent of those surveyed in Boston, and 18.4 percent of those surveyed in Milwaukee, related the downturn in their respective local real estate markets to local economic conditions. In contrast, in the Anaheim, California, boom market, 25.4 percent of those surveyed attributed the upturn to improvements in the local economy.

Racial Composition

Racial composition of a community has also been determined to relate to differential rates of appreciation in home prices. Kain and Quigley (1975) examined the St. Louis housing market and determined that race was positively related to housing price levels. Because of discrimination, blacks faced limited housing choices and as the black population increased during the 1950s and 1960s, prices in communities of color were actually driven higher than prices for identical homes in primarily white communities. In contrast, Anas and Eum (1984, 1986) concluded that a significant (at 5%) negative relationship existed between property values and the proportion of blacks in Chicago suburban communities. Ihlanfeldt and Vazquez (1986) used data from the Annual Housing Survey of the Atlanta SMSA for the period April 1978 to March of 1979 and found race to exhibit a negative and significant relationship with home values at the .01 level. In this study a negative relationship was also expected as the market effects observed by Kain and Quigley were not as prevalent in the 1980s as they had been a quarter century earlier.

Poverty Rate

Rates of poverty vary across location, and higher rates of poverty have been demonstrated to relate to declining property values (Izraeli 1987, Oates 1963). Communities with a substantial poor population tend to be characterized by a large proportion of renters, as these impoverished residents are less likely to have the financial means to become homeowners. Furthermore, housing conditions in poorer neighborhoods are inclined to be worse than in more affluent areas. This may be caused by a combination of the inability of residents to finance improvements, poor maintenance of rental property by absentee landlords, and the presence of tax delinquent and vacant property.

Crime Rate

Housing consumers also highly value security, particularly those with children (Wilson 1979). Areas where crime is prevalent are considered undesirable places to live and raise a family. Often, poorer neighborhoods, and wealthier neighborhoods in close proximity to these less affluent areas, tend to be victimized by higher crime rates than other communities. These factors and other negative demographic impacts associated with less affluent communities have historically had a negative impact on growth in housing values.

Population

Measures of change in the population have also been utilized in an attempt to explain rising home prices. Generally, an increase in population will cause an increase in consumer demand for housing services, ceteris paribus. If consumer demand can be satisfied by additions to the supply of housing then prices will not tend to rise. Zoning laws, however, may restrict additions to supply, and housing prices may thus be bid up.

Izraeli (1987) examined population growth rates across SMSA's and did not find a significant relationship to changes in housing prices. Case (1986) found similar results in his study of five suburban Boston communities, as the population growth between 1976 and 1985 in Massachusetts (1%) lagged behind the nation (10%+) while growth in housing prices in the state exceeded national rates of appreciation. Others have argued that population growth is not an appropriate measure, especially during the 1970s and 1980s when this nation endured vast changes in traditional demographic trends. Russell (1982) notes that postponement of marriage and other demographic trends peculiar to the baby boom generation led to a rise in household formation. Thus a more appropriate measure would be growth in households rather than population growth. Mankiw and Weil (1989) determine that there was a negative correlation (-.57) between growth in the total population and housing demand. They then chose to limit population growth to those over the age of twenty-one and detected a much higher correlation with housing demand (.86). This data supports the household growth theory as most households are formed by adults over twenty-one years of age.

Age Composition

A number of studies, conducted primarily during the 1970s and 1980s have examined variations in the age structure of the population and its effects on the housing market. Wilson (1979, 5) divides the family life-cycle into seven stages, each distinguished by specific needs and either changing or constant family size. These seven stages are:

1. Marriage or household formation
2. Pre-child (constant size)
3. Child bearing (increasing size)
4. Child rearing (constant size)
5. Child launching (decreasing size)
6. Post child (constant size)
7. Widowhood, or family dissolution.

Wilson characterized the demands of households at each of these stages. In the first two stages access is of primary importance, both to consumer goods and place of work. The middle three stages are delineated by increased demand for homeownership of detached dwelling units. In addition, particularly during stages three and four, privacy, open space and the package of available residential services discussed above gain importance, (ie, school quality, open space, safe streets, accessibility to services).

The aging baby boom changed conventional patterns of the duration of each of these stages, and the age at which family heads entered each of these stages. Various definitions of the baby boom have been offered, but here I refer to the baby boom as the period between 1946 and 1964, with the peak in 1957, utilizing the definition offered by Mankiw and Weil (1989).

Traditionally, individuals who fall into the 18-25 year-old group, have remained at home with parents until marriage. Changing trends of the 1970s and 1980s resulted in an increase in heads of household living alone or with non-relatives, predominately in the 18-34 year-old age cohort. This group is referred to by the Census Bureau as "primary individuals". The rise in this group was a driving force behind the change in household incidence. In 1950, only 4 percent of the population between the ages of 25 and 34 were considered primary individuals, by 1980 this group comprised over 20 percent of all households (Russell 1982). Two additional trends caused an increase in non-family households: a delay in the age at which young adults married (Table 2.1); and a growth in the divorce rate (Table 2.2), particularly in the 30-45 year-old age cohort where the divorce rate is highest (Gruen, Gruen, and Smith 1982).

Table 2.1
Median Age at First Marriage
1960 - 1985

Year	Male	Female
1960	22.8	20.3
1965	22.8	20.6
1970	23.2	20.8
1975	23.5	21.1
1980	24.7	22.0
1985	25.5	23.3

Table 2.2
Percentage of the Population Divorced
by Sex, 1960 - 1985

Year	Male	Female
1960	2.0	2.9
1965	2.5	3.3
1970	2.5	3.9
1975	3.7	5.3
1980	5.2	7.1
1985	6.5	8.7

Source: U.S. Census Bureau, CPR: Population Characteristics, P - 20.

Other trends peculiar to the baby-boom have been determined to effect the housing market. Along with delaying marriage, as mentioned above, baby boomers postponed child bearing once married, and families were smaller than previously. In addition, an increasing proportion of women entered the labor force, and locational considerations may have been altered in families where both heads of household worked.

Due to the changes evident during the 1970's and 1980's, particularly the increase in non-family households, a more appropriate representation of demographic trends would separate the first stage of Wilson's model of family life cycle into two groups, thus creating an eight stage cycle with stage one as household formation and stage two as marriage. Furthermore, I would argue that a more fitting characterization would be household life cycle rather than family life cycle.

Most researchers who have considered the baby boom generation and changes in household and family formation have recognized that these demographic variables have had a substantial impact on the housing market. There was disagreement, however, as to which effects have been most prevalent among which age groups, and what the effects will be during the 1990's. Russell (1982) argued that expansion of the 35-44 year-old age group, along with their unique demographic trends toward household formation mentioned above, led to an increase in housing demand. Rosen and Smith (1986) also found that the population in the 35-44 year-old age cohort had a positive and significant influence both on the demand for resale housing and its price.

In their study of the effects of demographic changes on the housing market Gruen, Gruen and Smith (1982) determined that the 25-34 year-old age group, who embody the bulk of first time home buyers, would be forced to purchase starter homes or condominiums in the 1980's, if they could afford any home at all. They also argued that the 35-44 and 45-54 year-old age cohorts comprised the trade up market in that decade, and these households would use equity built-up to purchase traditional suburban single-family detached homes. In retrospect, these forecasts have proved valid.

Mankiw and Weil (1989) considered those between 20 and 30 years of age as those forming households, and predicted negative real growth to occur in housing prices between 1990 and 2010. Case and Shiller (1987), examined the consumption of housing units among 25-44 year-olds and found changes in this age group to be positive and significantly related to changes in home prices. Ihlanfeldt (1986) scrutinized housing consumption patterns among age groups 26-40, 41-55 and 56+ in his study of 30 SMSA's, and found the coefficients to be collectively significant when evaluated with other explanatory variables but not individually significant. Ihlanfeldt (1986) also found that in his white suburban resident equation, the coefficient of the 26-40 year-old age group was the highest, while the 41-55 age group had the lowest coefficient.

MEASURES OF HOUSING PRICE CHANGE

The variables mentioned above have frequently been utilized to explain variations in housing prices. In the following section of this chapter I evaluate alternative methodologies that have been utilized to quantify rates of appreciation in housing prices. In this section I discuss housing studies, most of which have endeavored to gauge housing demand, or its price component. Demand, however, is not an appropriate measure, as the quantity of housing demanded by consumers of housing services varies, and price is strongly influenced by this quantity. Models measuring the willingness to pay for housing services, or the price of these services are preferable, as long as they control for the level or quantity of housing services demanded by a home buying unit.

Median Sales Price

The National Association of Realtors (NAR) publishes monthly reports of home sales and provides quarterly reports of the median sales price of single-family homes in 54 metropolitan areas. The timeliness and availability of this data is advantageous, and thus many housing studies have relied on median sales price of existing single family homes and/or new construction as their dependent variable (Oates 1969, Hyman and Pasour 1973, Izraeli 1987). The problem inherent in using median sales price to explain housing values across time and location is variations in the quality of homes. If homes were homogeneous, median sales price would be an appropriate measure of value. However, because homes differ both within a community and among communities, at a fixed point in time, and the quality of properties sold varies over time, utilization of median sales price may result in a biased price index over time and space.

Hendershott and Thibodeau (1990) examined the relationship between median and constant quality house prices. They concluded that during the 1976 to 1986 period the NAR median house price figure overstated the increase in constant quality house prices by about 2 percent per year. The NAR acknowledges the potential bias in their data and offers these words of warning and advice in their Home Sales publication: "Movements in sales prices should not be interpreted as measuring changes in the cost of a standard home. Prices are influenced by changes in cost and changes in the characteristics and size of homes actually sold."

Hedonic Price Indices

Hedonic price models are constructed using structural and locational characteristics of a property in order to alleviate the problems inherent in looking at median sales prices of homes. Namely, the failure to account for variations in the quality or mix of homes that sell. For example, as the average size or amenities (ie. square footage, number of baths, etc.) of a lot or home increase within a community or between communities, one would expect non-inflation driven price increases.

Hedonic indices are based on the notion that homes are a collection of these commodities (square footage, number of baths or rooms, presence or absence of a garage or fireplace, age of the structure lot size, etc.), each of which has an intrinsic value to potential purchasers. Thus the market price of a home is calculated as the sum of the values of each of these characteristics (Chinloy 1977, Goodman 1978, Griliches 1974, Palmquist 1980). Through the use of multiple linear regression, the price of differentiated goods can be regressed on quantities of components or characteristics associated with each good. The resulting coefficients are termed hedonic prices, and can be interpreted as the implicit value placed on housing attributes or characteristics by consumers. Thus the weighted sum of the individual values is the market price of the dwelling.

Hedonic models can be used to estimate appreciation rates over time in two ways. If the sample of sales covers a number of time periods, time dummies can be used to capture shifts in value over time controlling for characteristics. Conversely, separate regressions can be run with the observations from each year, thus allowing the attribute prices to vary over time. Using this approach a "standard" house is thus "priced" using the time variant attribute prices.

Extensive literature on hedonic price models exists. Dubin and Sung (1990) provide a detailed review and analysis of this literature in their examination of twenty-one hedonic models which include structural variables, as well as variables from at least one of the following categories: socio-economic status, municipal services, and racial composition.

Repeat Sales Method

A repeat sales regression model for computing appreciation in home prices was introduced by Bailey, Nourse and Muth (BMN) (1963) in their intra-regional analysis of suburban Saint Louis. The authors argued that their method of constructing a repeat sales housing price index was an improvement upon previous repeat sales methods such as the multiplicative chain index, or chain method (Wenzlick 1952, Wyngarden 1927). The BMN method utilized regression techniques to overcome the weaknesses of the chain method, namely, including information about indexes for earlier periods contained in price relatives with final sales in later periods, and simplifying the computation of standard errors for the estimated index numbers.

A variation of the BMN method was developed by Case (1986) in an intra-regional analysis, using a sample of sales transactions in five heterogeneous cities in the Boston area. Case and Shiller (1987) expanded upon the earlier method and termed it the Weighted Repeat Sales Method (WRS). Their study was conducted at the inter-regional level, using a sample of sales transactions in four large metropolitan areas (Atlanta, Chicago, Dallas, and San Francisco).

The WRS methodology for computing appreciation in home prices measures actual rates of appreciation, using only those properties which have sold more than once, by regressing the change in the log price for each observation (paired sale) on a set of simple dummy variables. In the Case (1986) analysis, these dummy variables were set to one for all periods between and including the periods at which the two sales transactions occurred. The Case and Shiller (1987) modification included setting the dummy variables to minus one for the first transaction period and plus one for the second period of sale. All intermediate period dummy variables were given a value of zero. Utilizing this model, changes in the value of particular homes between two points in time may be analyzed. This implicitly controls for changes in home (dis)amenities and quality, and allows for period to period analysis of differential changes in prices across location.

Conclusions

There is significant evidence in the literature that house prices are affected by a large number of structural, financial and fiscal, locational and demographic characteristics. In Chapter Three I evaluate changes in the national, regional and local economy that transpired during the 1980's. These factors make Boston an especially interesting case for analysis. Those changes that occurred in the area's real estate market are of particular interest. In Chapter Four I present the data and construct various models for measuring these effects.

CHAPTER 3

THE CONTEXT: ECONOMIC CONDITIONS OF THE 1980s

In the preceding chapter I reviewed existing literature describing studies where analysts have evaluated and/or modeled attributes affecting variations in housing prices at the inter or intra-regional level. In this chapter, utilizing historical information available from the Federal Reserve Bank of Boston's New England Economic Indicators database, I familiarize the reader with the unique demographic and economic changes which occurred during the 1980s nationally, regionally and locally. Factors peculiar to New England, primarily in real estate related industries, but also in the general economy, make this region a textbook case for analysis. The "Massachusetts Miracle" of the 1980s turned into a disaster by the close of the decade. The Boston Metropolitan Area market is of particular interest; not only is it the largest region in New England, but trends that occur in Boston tend to be characteristic of the region as a whole, and often foreshadow regional trends.

THE NATIONAL AND REGIONAL PICTURE

Following a mild recession which "bottomed out" in early 1983, New England entered a period of robust economic expansion. Nationally the rate of growth was more modest. By 1988, however, regional growth had stagnated, while national growth slowed some, but continued. The extreme vacillations in the region were partially induced by, and partially the cause of, the rapid appreciation and subsequent decline in real estate values that transpired during the decade.

Income

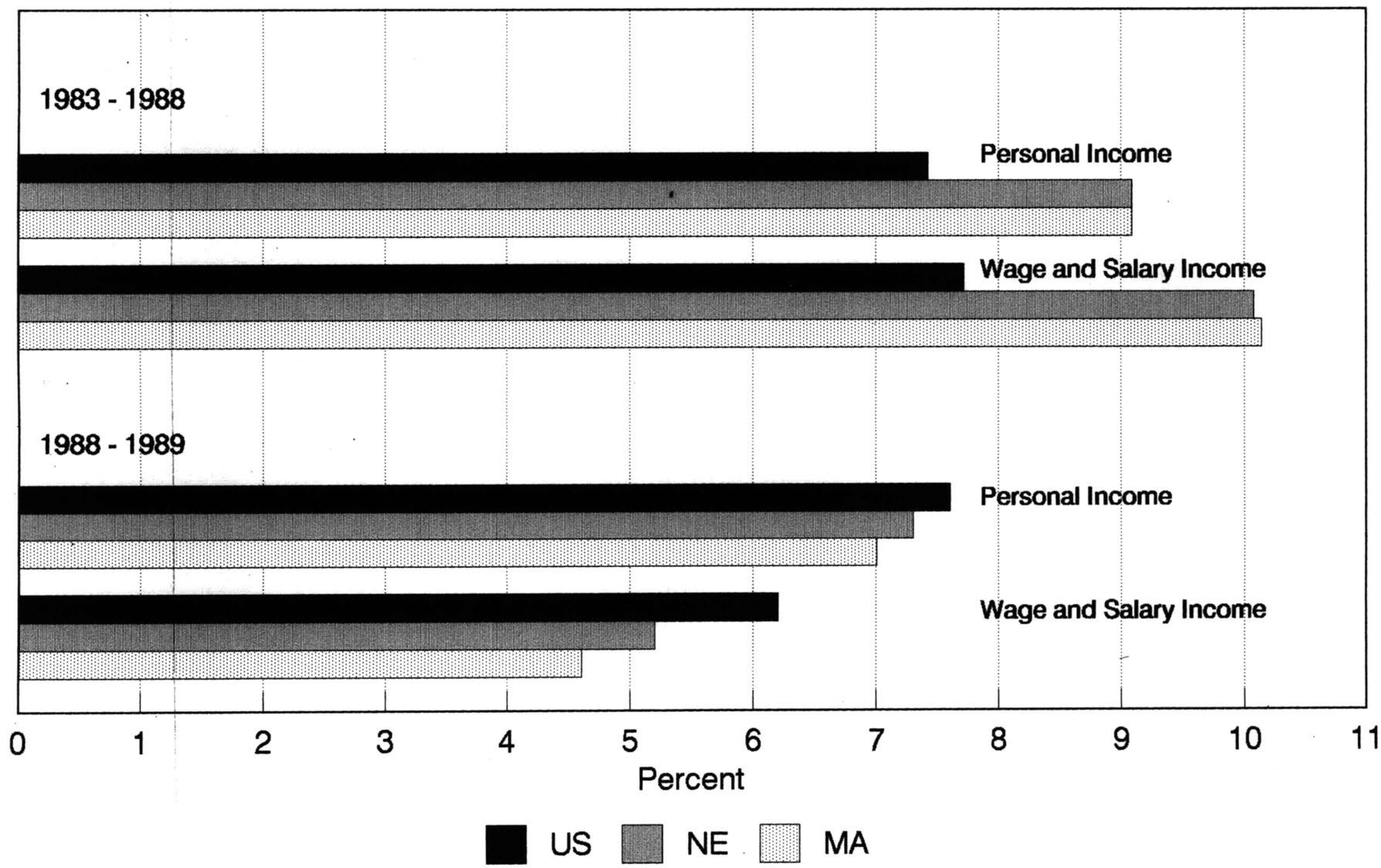
Personal income growth may be the optimal measure of success in a region, and during the 1983-1988 period, the 9.1 percent annual rate of growth in Massachusetts and New England confirmed the regional boom. Nationally, the average annual growth rate in personal income was lower at 7.4 percent. However, as personal income growth accelerated nationally in the 1988-1989 period, Massachusetts and New England lagged behind, with growth rates in personal income declining to 7.0 percent and 7.3 percent, respectively.

The root cause for the differential rates of expansion and contraction in personal income within the region and the nation was wages and salaries. As Figure 3.1 clearly depicts, in Massachusetts and the region wage and salary income flourished from 1983 to 1988, expanding at an average annual rate of 10.1 percent, versus a national rate of growth of 7.7 percent. However, this figure also illustrates that when the tide turned in 1988, Massachusetts felt the pinch more strongly, with wage and salary income growth of 4.6 percent failing to keep pace with inflation. Regional growth in 1988 contracted to a rate of 5.2 percent while the national rate fell to 6.2 percent.

FIGURE 3.1

INCOME GROWTH

Average Annual Percent



Employment

National wage and salary growth was partially explained by employment growth in the manufacturing sector. As Figure 3.2a illustrates, nationally manufacturing employment increased at an average annual rate of 1.0 percent between 1983 and 1988, while in Massachusetts and New England manufacturing employment fared far worse. Between 1983 and 1988 the state's manufacturing employment declined at an average annual clip of 1.4 percent and regional decline was not far behind, averaging 1.0 percent per year. Figure 3.2b elucidates the widening discrepancy between the nation and the region in the 1988-1989 period. While national manufacturing employment continued to expand, at a rate of 1.1 percent, regional industries, highly dependent on defense contracts, suffered greatly from cuts in defense spending. This was a major factor causing manufacturing employment to plummet 3.6 percent and 3.4 percent during that period in Massachusetts and New England, respectively.

During the 1983-1988 period wage and salary growth in New England was primarily caused by excess demand for labor. While nonmanufacturing employment growth thrived, only modest increases in population occurred, thus unemployment declined and wages increased. As Figure 3.2a illustrates, nonmanufacturing employment growth between 1983 and 1988 was highest in New England, growing at an average annual rate of 4.7 percent. Growth in Massachusetts was 4.3 percent, and nationally the rate of growth in nonmanufacturing employment was 3.7 percent.

FIGURE 3.2

EMPLOYMENT - AVERAGE ANNUAL GROWTH

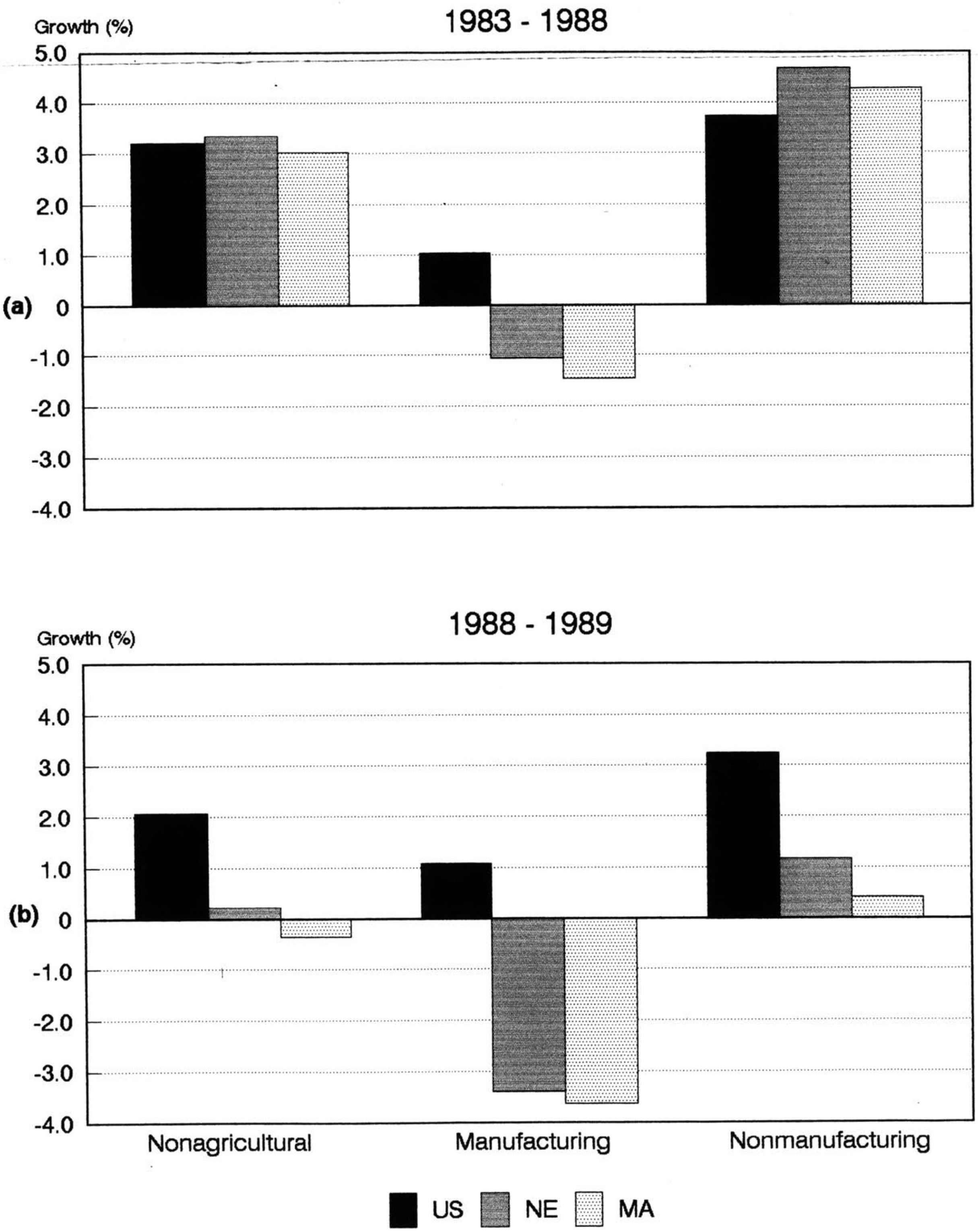


Figure 3.3a depicts cross-industry variations in the rate of nonmanufacturing employment growth during the 1983-1989 period. This figure portrays a fairly balanced national growth, although expansion in the services, construction, and finance, insurance and real estate (FIRE) industries, offset lower rates of employment growth in transportation and public utilities (TPU), trade, and government. The state and regional picture, however, was different. The boost in nonmanufacturing employment in Massachusetts and New England was precipitated by extraordinary employment gains in the construction industry. State and regional growth in this industry, as well as the FIRE industry, substantially outpaced the nation.

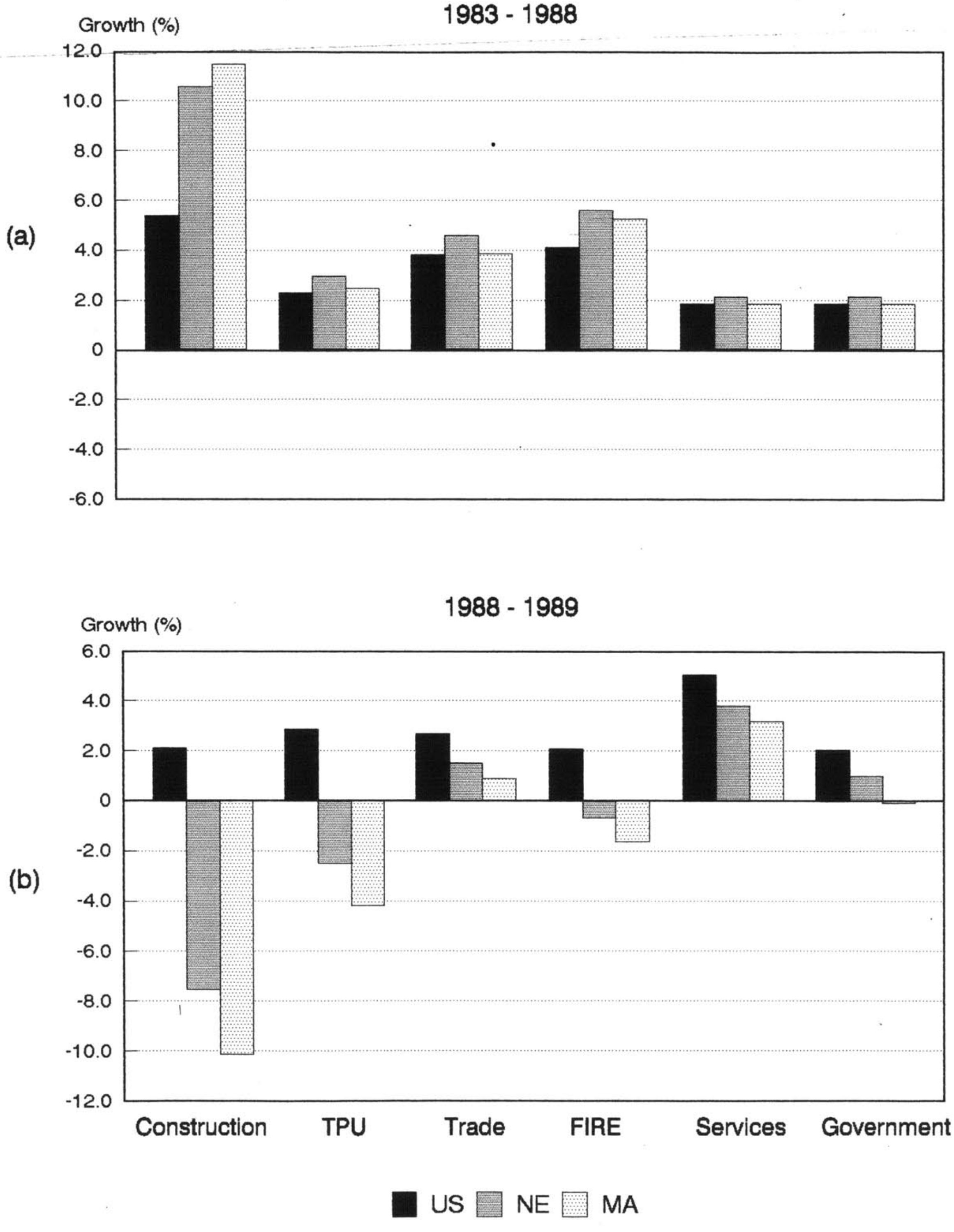
Although the construction and FIRE industries account for a relatively small portion of total nonagricultural employment, with construction averaging between 4 percent and 6 percent of total nonagricultural employment, and FIRE accounting for 7 percent to 9 percent of the total, their annual growth rates of 11.6 percent and 10.6 percent in construction, and growth in FIRE of 5.9 percent and 5.6 percent in Massachusetts and New England, respectively, had a marked impact on the region.

As Figure 3.3b illustrates, when the construction, FIRE and TPU industries took a turn for the worse during 1988, the effect on total nonmanufacturing employment in the region was significant. During that year the nation continued to see modest employment gains of 2.1 percent in both construction and FIRE, while construction employment plummeted by 10.1 percent in Massachusetts and 7.5 percent in New England. The

FIGURE 3.3

NONMANUFACTURING EMPLOYMENT

Average Annual Growth



contraction in construction employment was accompanied by a sharp drop in TPU and triggered losses in the FIRE industry, which had invested substantially in real estate. During the early 1990s the losses in FIRE would be amplified by non-performing real estate loans.

Unemployment

As would be expected, rates of unemployment followed suit. As Figure 3.4 illustrates, national unemployment rates continued to decline throughout the period, although remaining substantially above the state and regional unemployment rates. By 1988, the unemployment rate in Massachusetts began creeping upward, and by 1989 unemployment rates in both the state and region had risen substantially. These rising rates of unemployment induced outmigration, and thus amplified the weakening of the housing market.

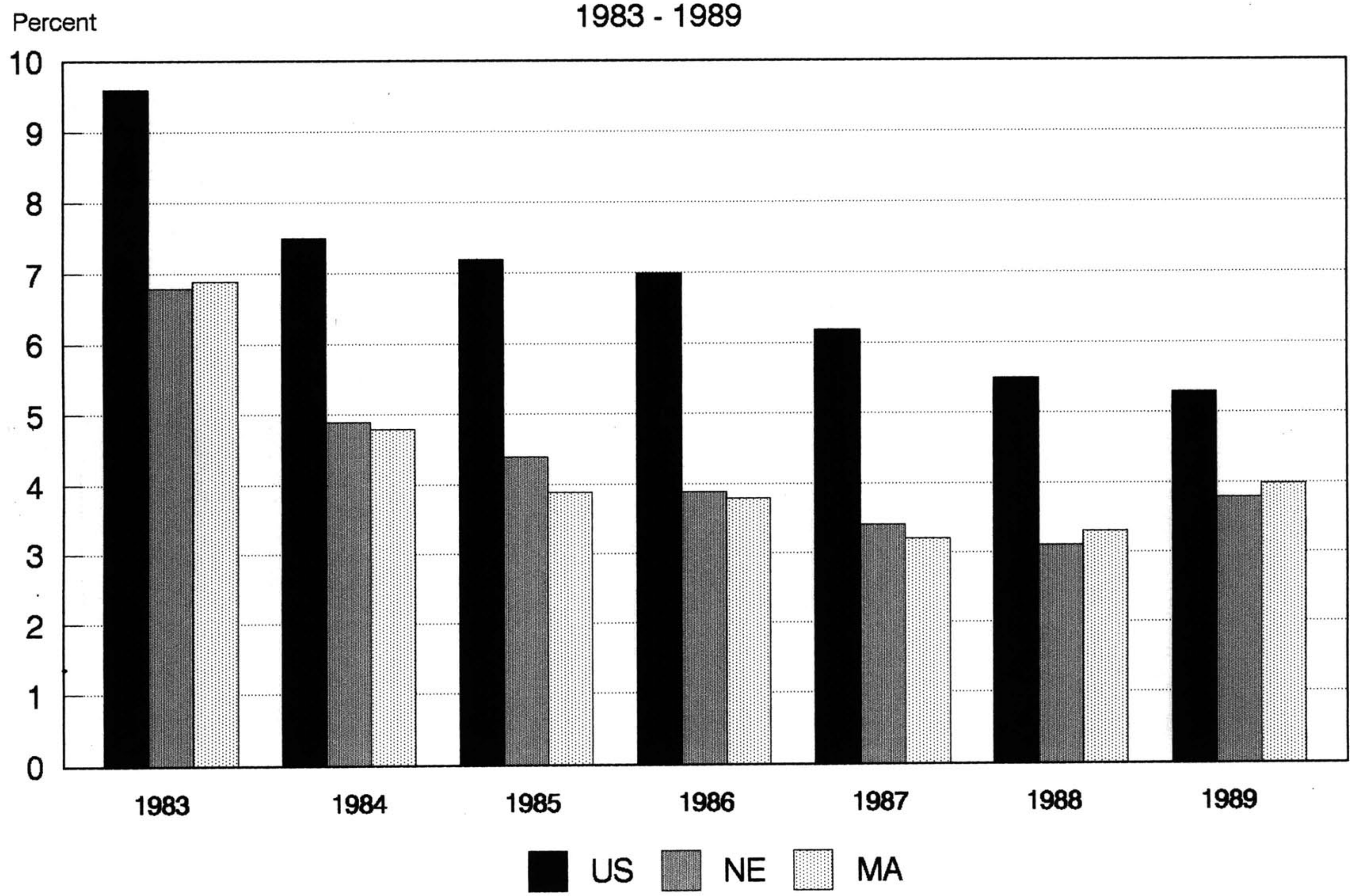
Construction and Mortgage Lending

During the 1983 through 1988 period, state and regional prosperity helped bolster the balance sheet of banking institutions, while nationally banks fared less well. Much of the regional banking strength was due to the booming real estate market. Mortgage lending by commercial banks in both the region and nation in 1984 accounted for 37 percent of selected assets, which include mortgage, consumer, and commercial and industrial loans. By 1988, mortgages accounted for the majority of selected assets in New England, at 52 percent, while nationally the rate increased to 45 percent. Mortgage

FIGURE 3.4

UNEMPLOYMENT RATE

1983 - 1989



lending on one to four family residential homes grew at an average annual rate of 27.2 percent in New England, nearly three times the national growth rate of 9.7 percent.

Construction lending advanced even more rapidly, both regionally and nationally, although regional lending advances, at an average annual rate of 44.3 percent, far outpaced national gains of 17.0 percent. Figure 3.5 depicts the magnitude of the discrepancy in mortgage and construction lending between the region and the nation as a whole from 1984 through the end of 1987. By 1988 the weakening real estate market in New England was apparent, and growth in mortgage lending subsided to a level more in line with the nation. Both regionally and nationally this level was 15.6 percent. Construction fared worse during the 1988 to 1989 period. In New England, construction lending growth plummeted to an average annual rate of 2.7 percent, nationally a lesser decline to 6.9 percent occurred.

The discussion above alludes to regional and state changes in the real estate market being a primary factor in economic changes during the decade. In 1983, as the region and the nation began to recover from a recession, interest rates began declining. In Massachusetts and New England these declining interest rates, accompanied by growth in earnings, caused housing demand to increase. However, supply was slow to respond to demand and home price increases accelerated. When supply finally did respond, the response was much too strong, given the relatively constant population and weakening economy.

FIGURE 3.5 SELECTED ASSETS OF COMMERCIAL BANKS

Average Annual Growth

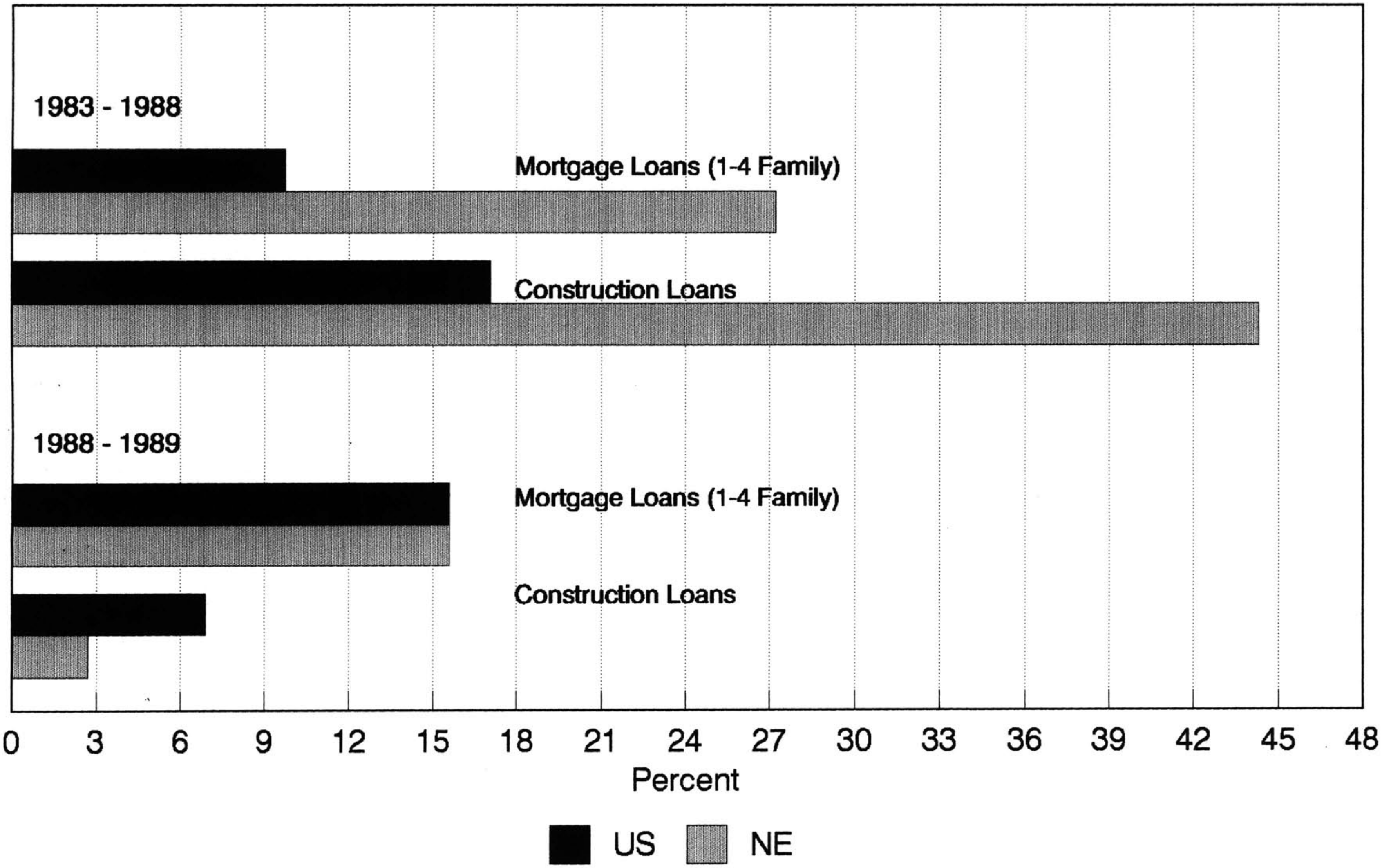


Figure 3.6 elucidates the response in construction in Massachusetts and New England, utilizing housing permits authorized, indexed to 1983. In 1986, in both the state and the region, nearly twice as many permits were issued as there had been three years earlier. Nationally, housing permit issues were growing at a more controlled pace. Assuming a one year lag until completion of construction, supply response was peaking in 1987, when the regional economy was beginning to falter, inducing further weakening in housing prices. Figure 3.7 utilizes the NAR median home price data, which fails to control for variations in housing quality, to illustrate the weakening real estate market in Boston. Although price appreciation continued after 1987, the rate of growth fell well below the national rate.

STUDY AREA

As confirmed by the statistics of real estate and general economic conditions described above, Boston is an interesting case for analysis. However, discrepancies in growth not only existed between the nation and the Boston area, but also within the area itself. For the purposes of this study, the Boston Metropolitan Area is defined to include localities in the following five counties: Essex, Middlesex, Norfolk, Plymouth and Suffolk, these five counties all fall within the ring defined by Interstate 495. The location of these counties is exhibited in Figure 3.8, while Figures 3.9a through 3.9e display the cities and towns located in each county.

FIGURE 3.6

HOUSING PERMITS AUTHORIZED

Single Units - Indexed

1983 - 1989

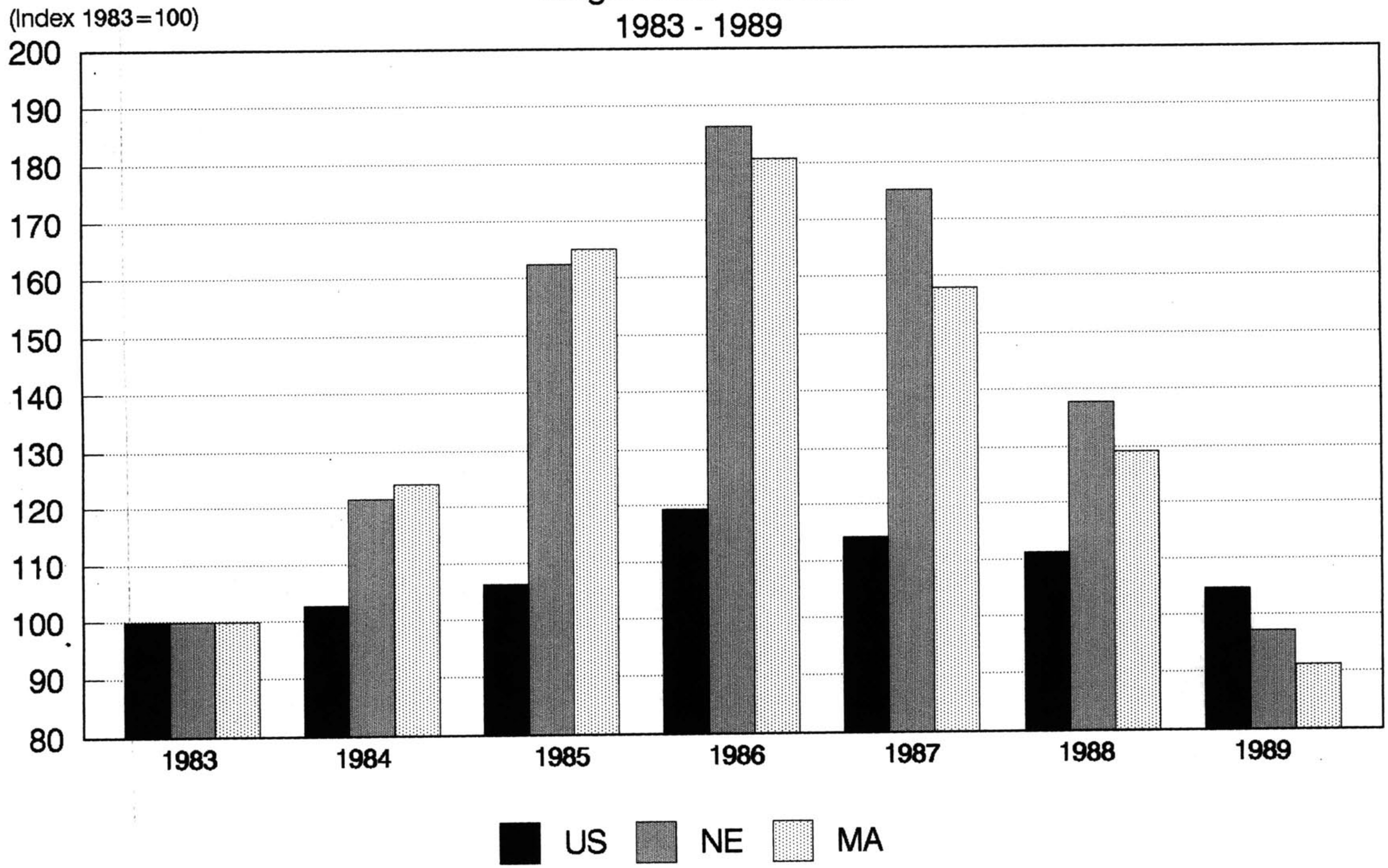
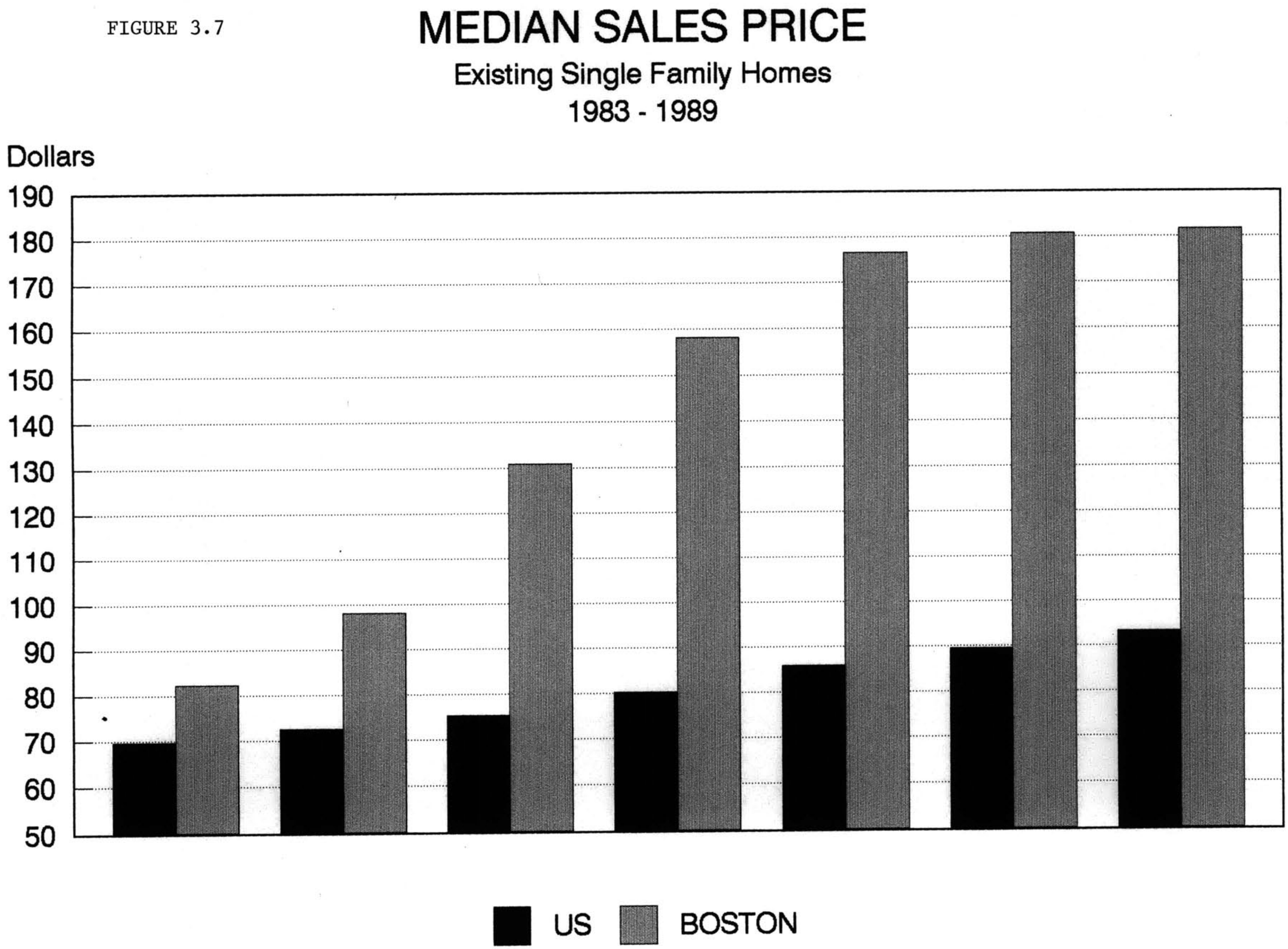


FIGURE 3.7


MEDIAN SALES PRICE
Existing Single Family Homes
1983 - 1989
Dollars
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
US
BOSTON

Each county has distinctively different characteristics. Accessibility to the Central business district (CBD) via both public and private transportation is best from Suffolk county and Norfolk and Middlesex counties which lie west of Boston. Essex and Plymouth counties have the added amenity of seacoast frontage, although accessibility is compromised. Suffolk county, which includes the city of Boston is by far the most urban. Although, as figure 3.8 depicts, its land area is substantially less than any of the other counties, its population is on par with Essex and Norfolk county, and greatly exceeds that of Plymouth county. Only Middlesex County, which comprises the largest area of land, is more populous. Table 3.1 displays the number of towns within each county, as well as 1990 county population estimates and the percentage of the study area total population falling within each county and the city of Boston.

Table 3.1

TOTAL POPULATION AND TOWN COUNTS PER COUNTY

COUNTY	# of TOWNS	POPULATION	% OF TOTAL POPULATION
Essex	34	670,080	17.7
Middlesex	54	1,398,468	37.0
Norfolk	28	616,087	16.3
Plymouth	27	435,276	11.5
Suffolk	4	663,905	17.5
Boston City		574,283	15.2

Source: Massachusetts Department of Revenue Municipal Data Bank.

FIGURE 3.8

Counties in the Boston Metropolitan Area

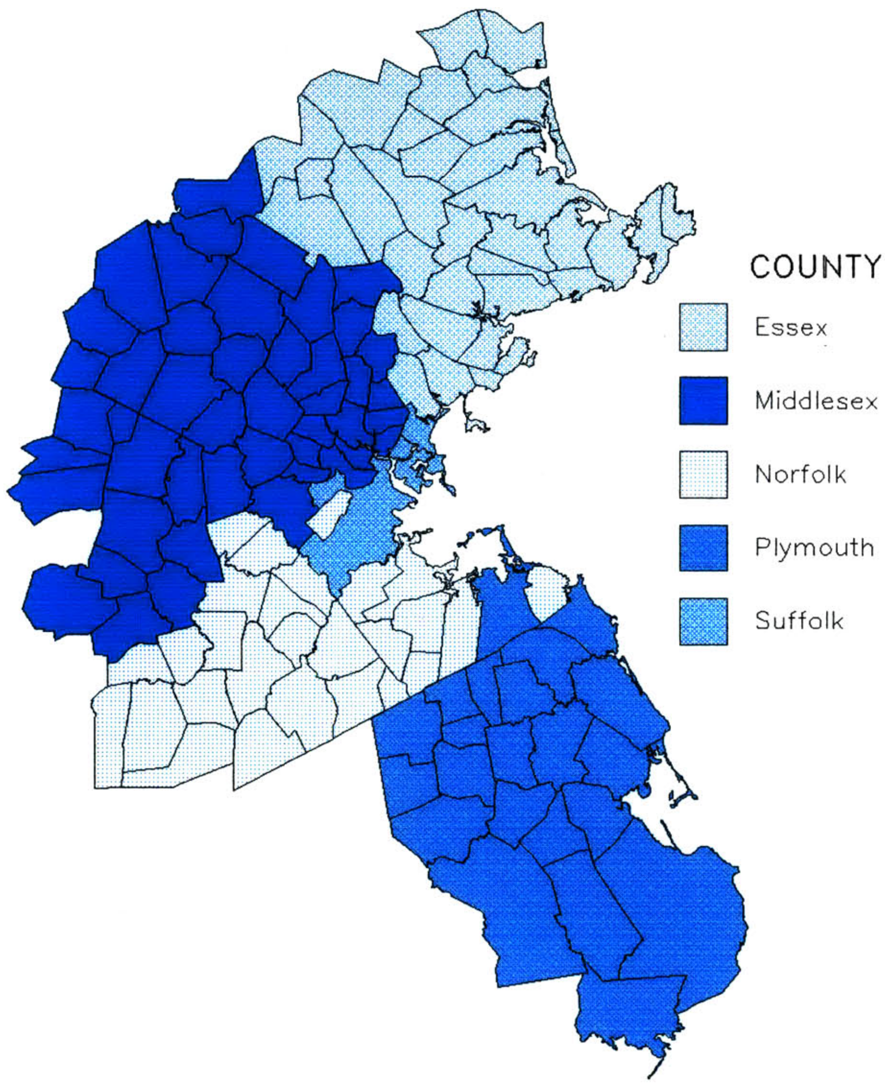


FIGURE 3.9 a

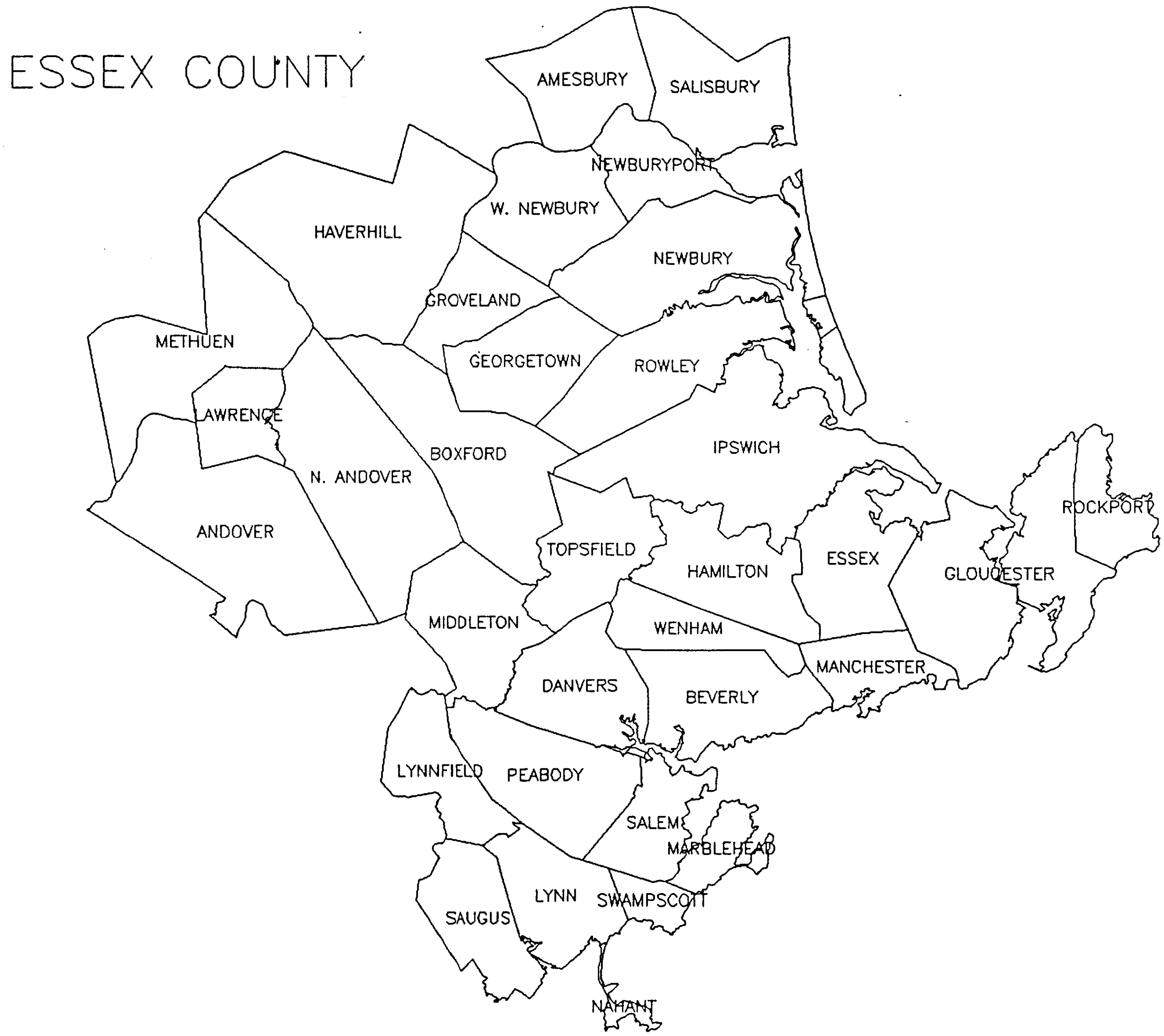

ESSEX COUNTY
AMESBURY
SALISBURY
NEWBURYPORT
W. NEWBURY
HAVERHILL
NEWBURY
GROVELAND
METHUEN
GEORGETOWN
ROWLEY
LAWRENCE
IPSWICH
BOXFORD
N. ANDOVER
ROCKPORT
ANDOVER
TOPSFIELD
HAMILTON
ESSEX
GLOUCESTER
MIDDLETON
WENHAM
MANCHESTER
DANVERS
BEVERLY
LYNNFIELD
PEABODY
SALEM
MARBLEHEAD
LYNN
SWAMPSCOTT
SAUGUS
NAHANT

FIGURE 3.9 b

MIDDLESEX COUNTY

FIGURE 3.9 c

NORFOLK COUNTY

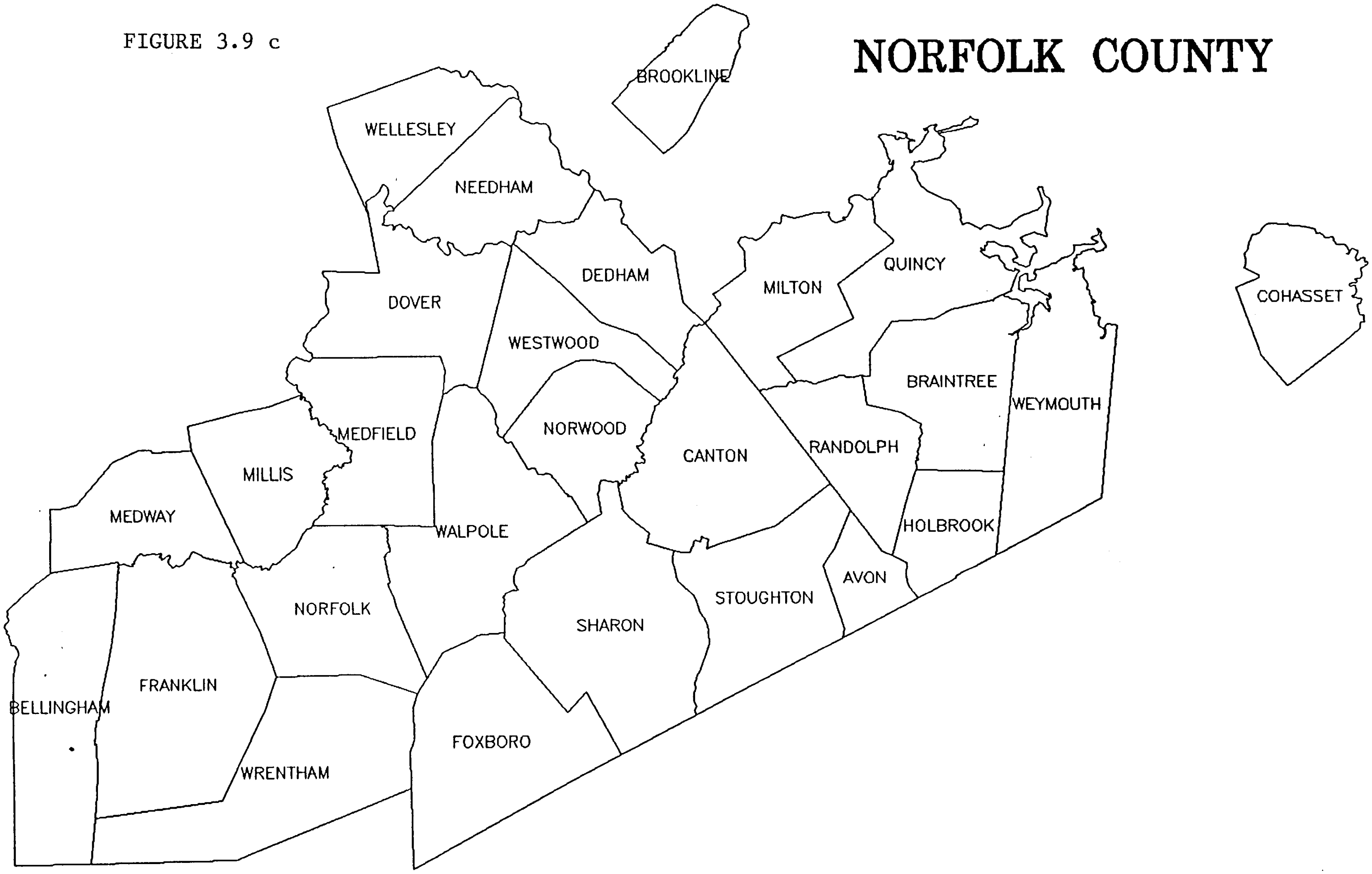


FIGURE 3.9 d

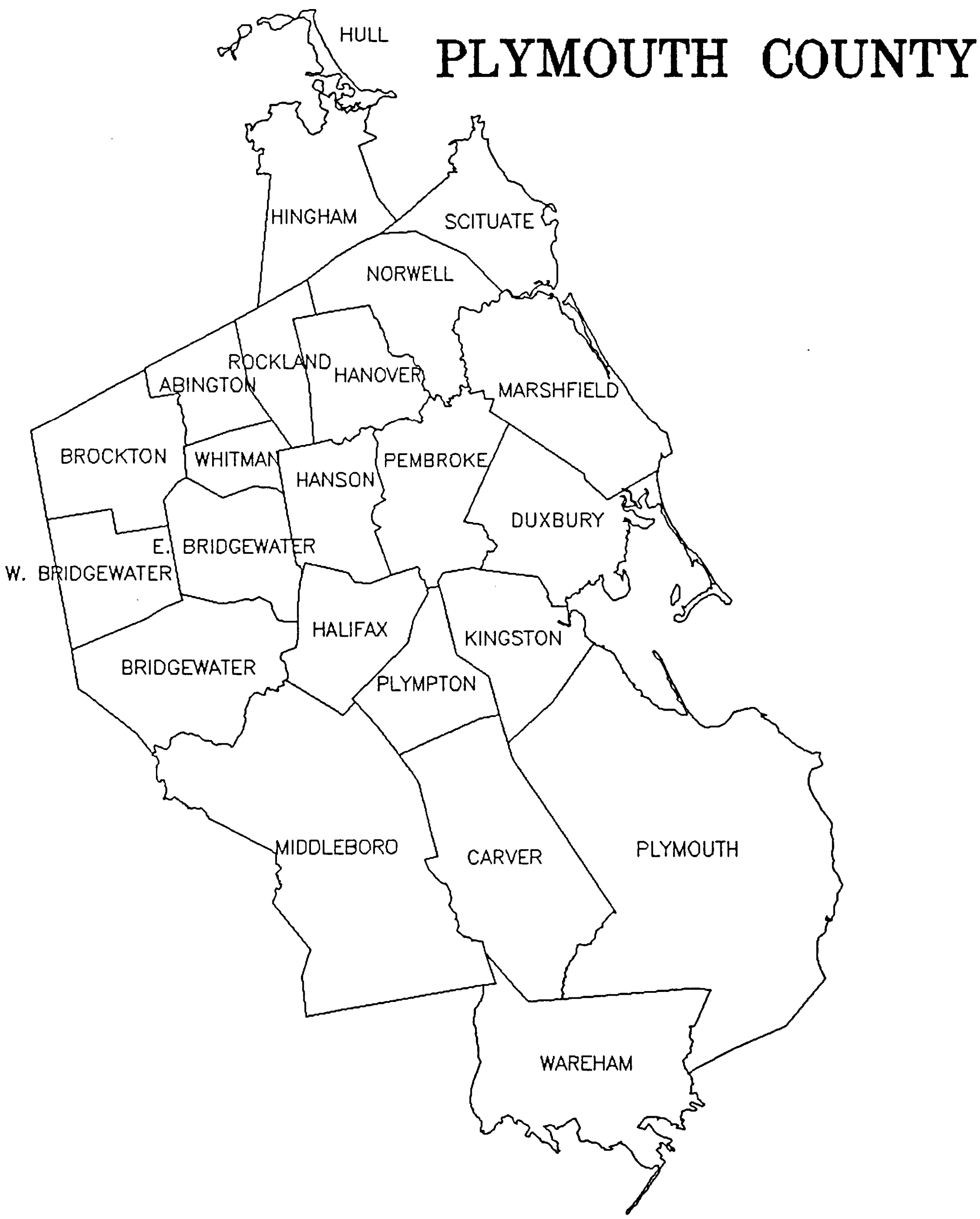
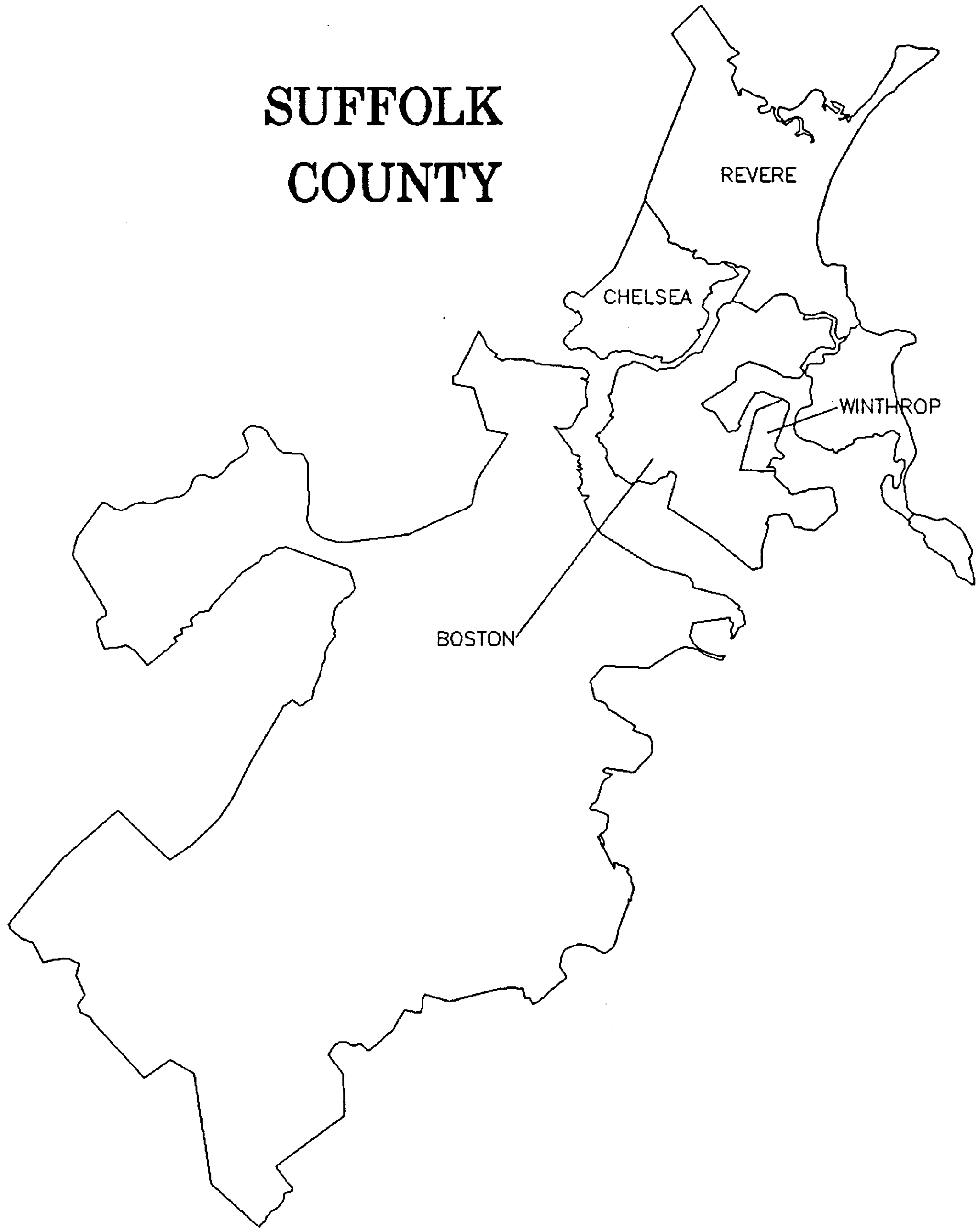

PLYMOUTH COUNTY
HULL
HINGHAM
SCITUATE
NORWELL
ROCKLAND
ABINGTON
HANOVER
MARSHFIELD
BROCKTON
WHITMAN
HANSON
PEMBROKE
DUXBURY
E. BRIDGEWATER
W. BRIDGEWATER
HALIFAX
KINGSTON
BRIDGEWATER
PLYMPTON
MIDDLEBORO
CARVER
PLYMOUTH
WAREHAM

FIGURE 3.9 e

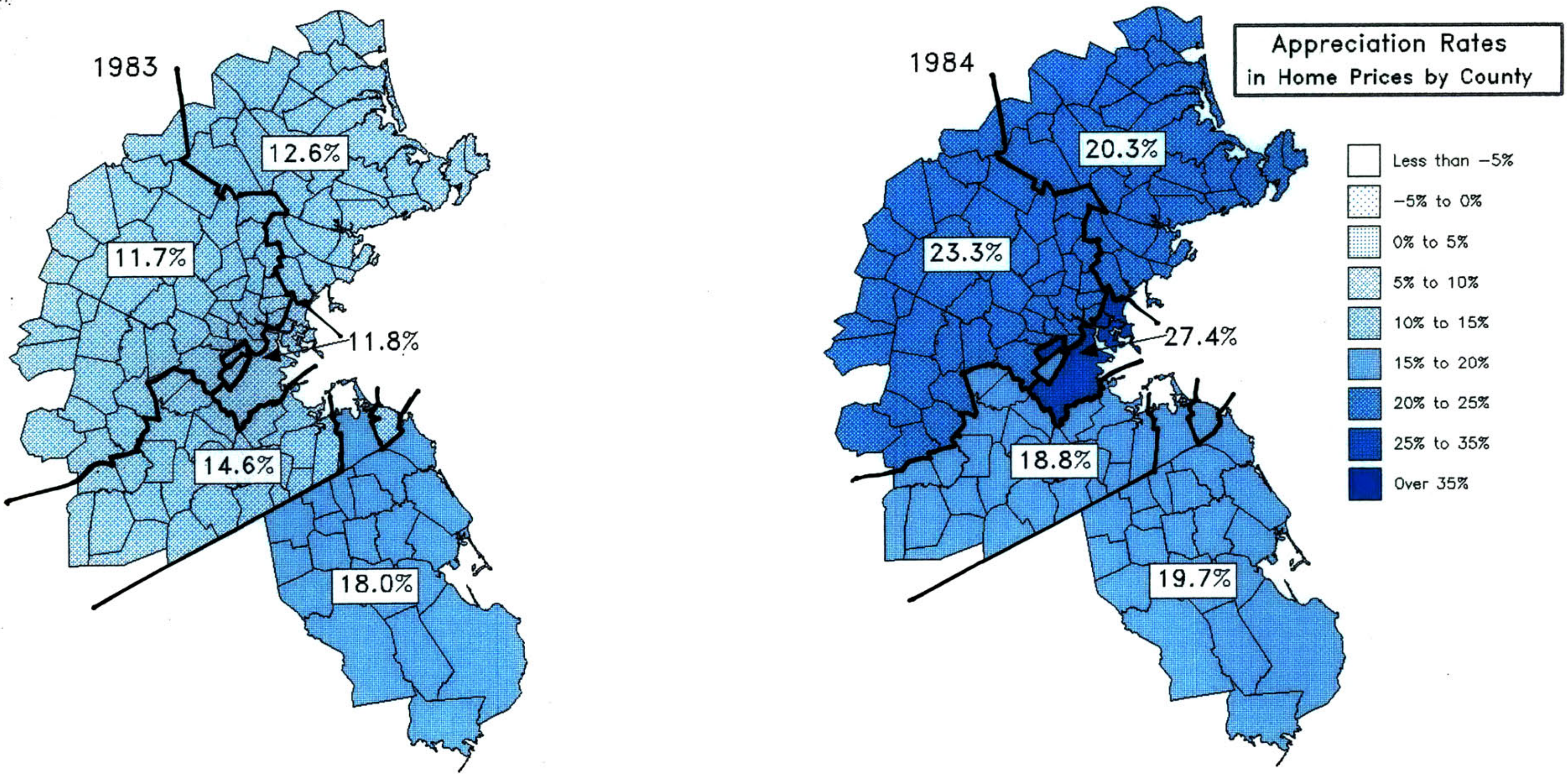


As can be discerned from this table, given its size, the city of Boston embodies a disproportionate share of total population. The city's population exceeds that of all of Plymouth County, and approaches the population level in Norfolk County. Furthermore, Boston accounts for approximately 85.5 percent of the population in Suffolk County. For this reason and reasons discussed later in this chapter,the city of Boston has been eliminated from this study.

Figures 3.10a-c present patterns of housing price change across the study area during the 1980s. These figures are based in the indices described in detail in Chapter Four. The duration and rates of housing price appreciation varied widely across the five counties during the study period. In Plymouth county, growth did not fluctuate as widely as in the other counties. In 1983 appreciation in Plymouth county exceeded any other county, and throughout the 1983 to 1988 period changes in both appreciation and depreciation in home prices appeared less striking than in other counties. In 1989, however, the rate of depreciation accelerated, outpacing any other county in the Boston Metropolitan Area.

Norfolk county growth was similar to that in Plymouth county, although the peak in appreciation rates exceeded that of Plymouth county, and the weakening of the Norfolk county market was more abrupt than in the neighboring market to the southeast. Middlesex county experienced its most vibrant market expansion earlier than other counties in the region, with the peak occurring in 1984. In 1985 appreciation rates

FIGURE 3.10 a



1983
12.6%
11.7%
11.8%
14.6%
18.0%
1984
20.3%
23.3%
27.4%
18.8%
19.7%
Appreciation Rates
in Home Prices by County
Less than −5%
−5% to 0%
0% to 5%
5% to 10%
10% to 15%
15% to 20%
20% to 25%
25% to 35%
Over 35%

FIGURE 3.10 b

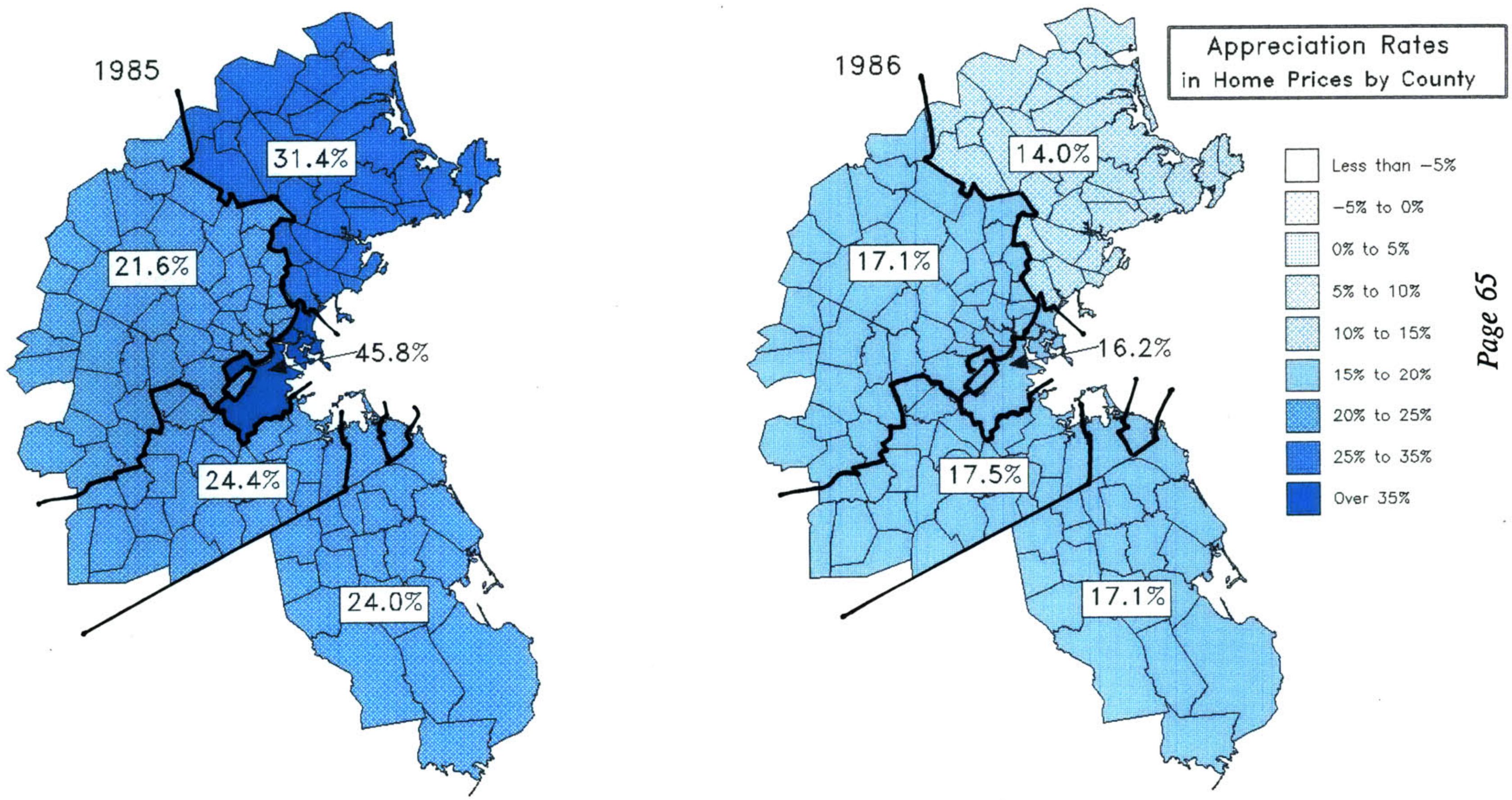
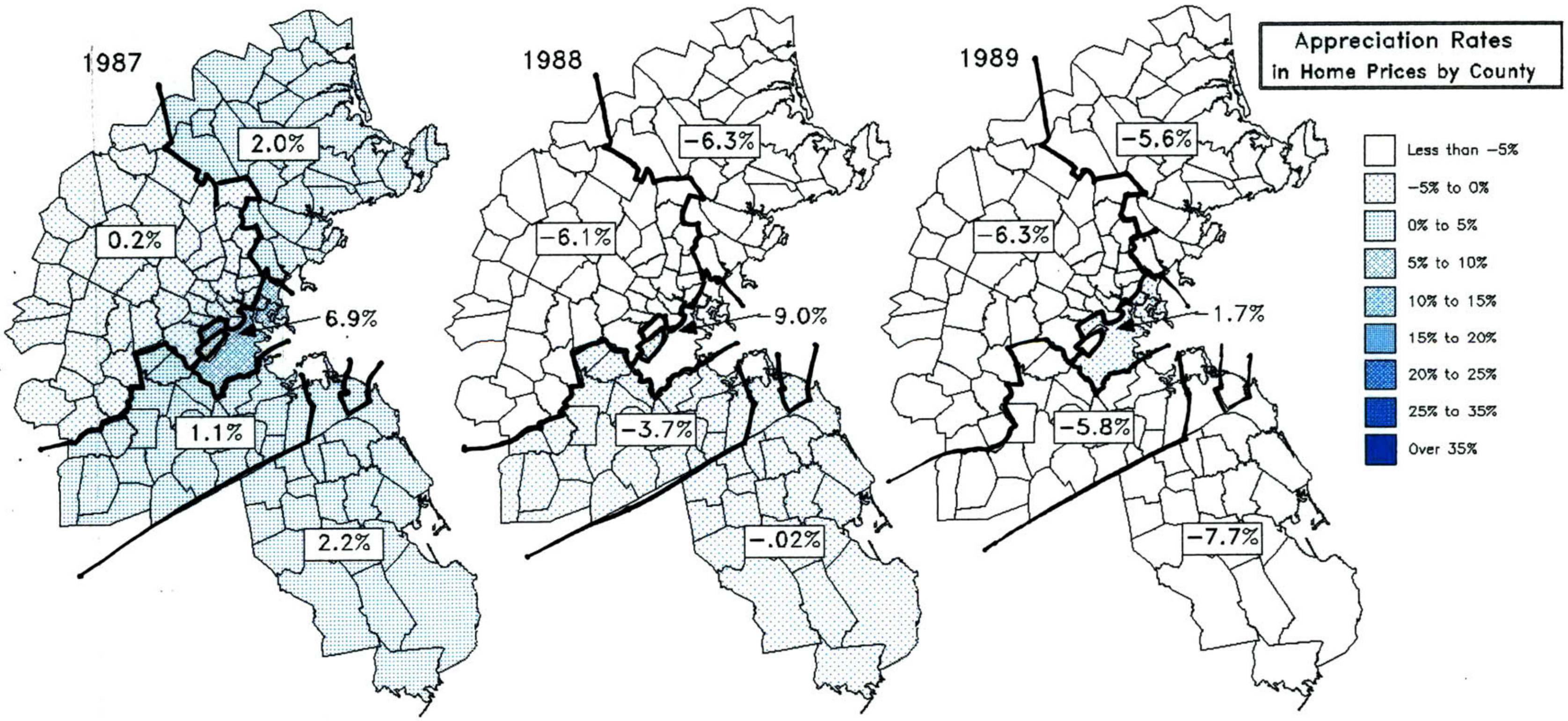

1985
31.4%
21.6%
45.8%
24.4%
24.0%
1986
14.0%
17.1%
16.2%
17.5%
17.1%
Appreciation Rates
in Home Prices by County
Less than -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 15%
15% to 20%
20% to 25%
25% to 35%
Over 35%

FIGURE 3.10 c


1987
2.0%
0.2%
6.9%
1.1%
2.2%
1988
-6.3%
-6.1%
9.0%
-3.7%
-.02%
1989
-5.6%
-6.3%
1.7%
-5.8%
-7.7%
Appreciation Rates
in Home Prices by County
Less than -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 15%
15% to 20%
20% to 25%
25% to 35%
Over 35%

abated, while during 1986 the decline in appreciation rates accelerated slightly, falling in line with both Norfolk and Plymouth counties. During 1987 prices in the Middlesex market remained fairly stable, neither increasing or declining substantially. However, in 1988 and 1989 the market weakened, causing prices to decline by more than six percent.

In Essex county prices were more volatile than in the three other counties which constitute suburban Boston; Plymouth, Norfolk and Middlesex. Modest growth in prices ensued during 1983 and 1984, but during 1985 growth rose sharply, causing the average sales price of homes to increase by nearly one-third. By 1986 prices sharply dwindled, falling below all other counties in the area. This weakening continued, and in 1988 and 1989 depreciation in housing values was similar to neighboring Middlesex county.

Prices of single family homes in more urban Suffolk county vacillated more widely than in any other county during the 1983 through 1989 period. In 1983 appreciation in housing prices in Suffolk county was weaker than all other counties except for Middlesex county. By 1984 price appreciation exceeded 25 percent and during 1985 appreciation skyrocketed, attaining an unprecedented rate of 45.8 percent. However, rates of appreciation turned abruptly in 1986, falling to 16.2 percent, nearly one-third the 1985 peak level. During 1987 the rate of appreciation diminished less sharply than in neighboring suburban counties. During 1988, however, the county experienced a rigorous decline, with average prices falling off by 9.0 percent. This was followed by a much more modest degree of decline during 1989.

This discussion of economic and employment changes in the New England region, and real estate trends occurring within the Boston area, verify the Metropolitan area's uniqueness during this period. In Chapter Four, I more clearly define the localities within the Boston area to be included in the model. In addition, I explain the formulation of the model and the variables selected, as well as the methodology utilized to construct both the dependent and explanatory variables.

CHAPTER 4

METHODOLOGY

In Chapter Three I examined national, regional and local trends in the general economy and real estate industry, and substantiated the case for analysis of housing price appreciation within the Boston Metropolitan Area. In this chapter I identify the localities to be included in the model, and explain my methodology for model formulation. I begin with a description of the formulation of my dependent variable, real growth in housing prices within communities in the Boston Metropolitan Area. I follow this section with a discussion of the explanatory variables. This discussion is parsed into three of the four categories of determinants set forth in Chapter Two; financial and fiscal determinants, locational factors, and population characteristics.

Many of the previous empirical studies of housing prices were designed to explain differences in the level of prices across sets of jurisdictions at a point in time. The focus of this study is, rather, to study differences in rates of price appreciation over time across communities. Chapter Three demonstrated clearly that the decade of the 1980s was a unique and interesting period in which home prices were significantly more volatile than in previous periods. The question that remains to be answered is what explains the pattern of price changes across communities? That is, as the market boomed, which towns experienced the most rapid rise, and as the market slowed, which towns seemed to suffer the sharpest reductions in appreciation rates.

It is important to keep this distinction in mind when interpreting the model. For most of the variables included, one would expect the effects to be similar in a "levels" equation and in an "appreciation" equation. For example, those towns with an attractive combination of public goods and taxes would be expected to have higher home prices, ceteris paribus, than towns with less favorable combinations at a point in time. Similarly, those towns would be expected to be more attractive at the margin during boom times. That is, one would expect to see houses in towns with favorable fiscal packages appreciate more rapidly than others as well. But clearly, interpretations must be made cautiously.

DEPENDENT VARIABLE: THE WEIGHTED REPEAT SALES MODEL

Various methodologies for quantifying appreciation rates in home prices in existing literature were discussed in Chapter Two. In particular, I demonstrated the inappropriateness of median sales price as a measure of housing price appreciation because of the failure of this variable to control for variations in housing amenities across both time and location. Although hedonic price indexes are superior to simple analysis of median sales prices of homes, there are also faults to this methodology. The primary drawback with the hedonic model is the substantial data requirements necessary to account for all attributes expected to exhibit either a positive or negative influence on home prices (Palmquist 1980). In addition to this problem, hedonic indexes typically model price levels at one point in time for each location, or attempt to control for locational variation and focus on differences occurring over time. Simultaneous analysis across space and time dimensions is difficult.

In this model I utilize the Weighted Repeat Sales (WRS) model described in Chapter Two. This methodology controls for variations in housing quality by analyzing changes in the sales price of houses that have sold more than once. The model form is exhibited in Appendix A. Criticisms of repeat sales models by Mark and Goldberg (1984) indicate that such models waste data and that homes that sell repeatedly may not accurately represent the total stock of housing.

Table 4.1

SINGLE-FAMILY HOME TRANSACTIONS 1982 - 1989

COUNTY	TOTAL SALES	REPEAT SALES	% REPEAT
Essex	51,423	6,253	12.16
Middlesex	89,890	9,207	10.24
Norfolk	46,716	5,085	10.88
Plymouth	41,841	4,318	10.32
Suffolk	27,552	2,706	9.82
Total	257,422	27,569	10.71

Table 4.1 lends some support to the validity of the Mark and Goldberg data criticism: In the five counties of the Boston Metropolitan Area examined, 27,569 paired sales were detected out of a base of 257,422 single family transactions. This represents

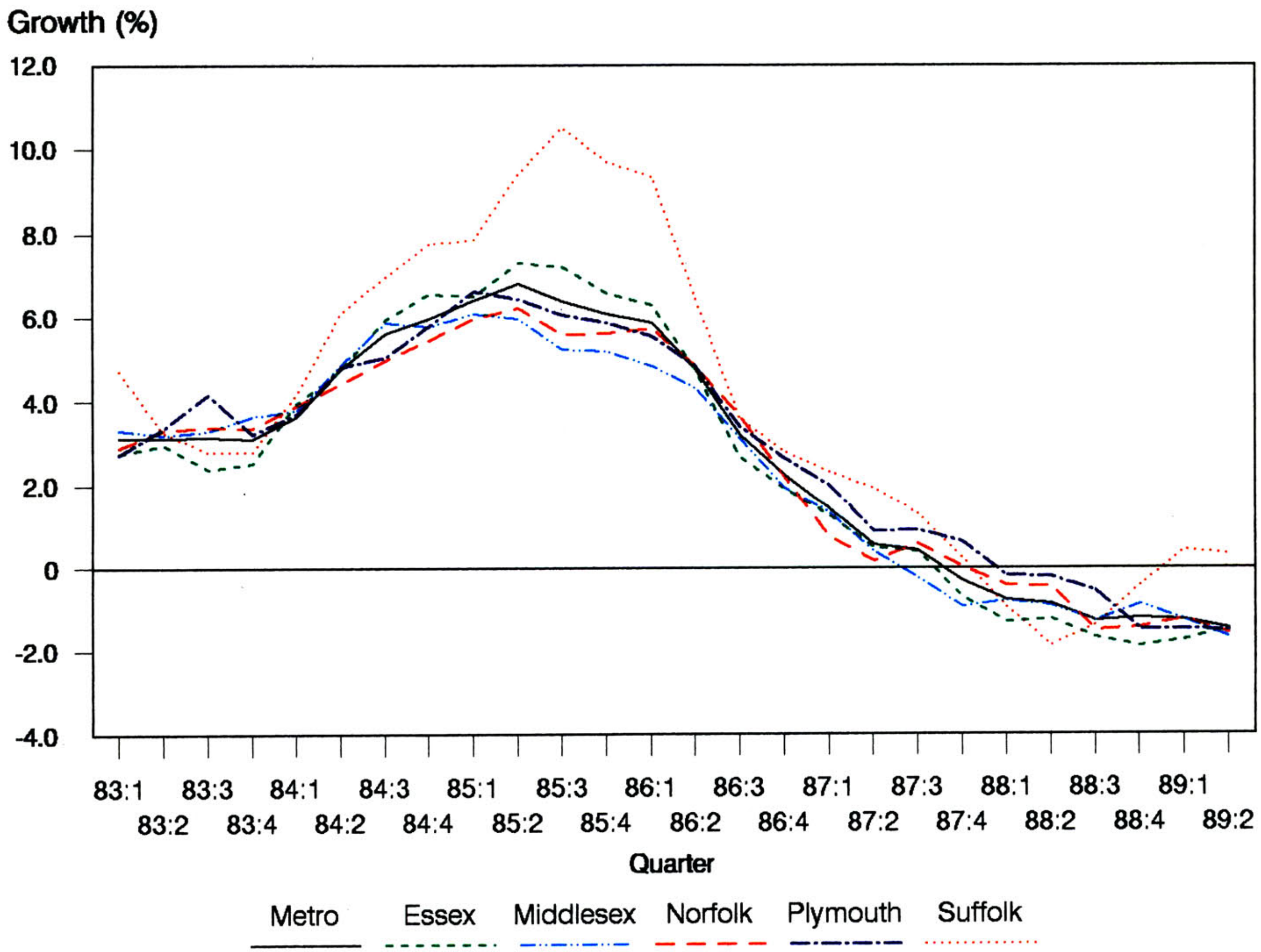
approximately 11 percent of all transactions, as each record contains two sales and approximately 3 percent of properties sold more than twice. Furthermore, no sales data were available pre-1982, thus indexes could not be calculated for 1982 as the volume of repeat transactions occurring was inadequate. This study overcomes the second criticism of Mark and Goldberg on representativeness because the majority of repeat sales were on homes which sold only twice during the period, and no properties had more than three transactions occurring. Furthermore, the volume of duplicate transactions that occurred was significant, as could be expected during the past decade given the unparalled divergence in the region's real estate market cycle from previous market cycles.

Near the end of Chapter Three I illuminated on interesting distinctions in the variations occurring over time between counties. Suffolk County, in particular, demonstrated unique fluctuations in rates of appreciation. Figure 4.1 confirms the uniqueness of the Suffolk County market, illustrating quarterly rates of change in home prices in each of the five counties and in the Boston Metropolitan area as a whole. As this figure clearly portrays, except for a brief convergence in the third quarter of 1986, real growth in housing prices in Suffolk County exceeded growth in any other county between the first quarter of 1984 and the third quarter of 1987. During 1985 and early 1986 Suffolk's county's divergence was most substantial. Given the annual growth rate of 45.8 percent that occurred in the county during 1985, this divergence would be expected. This

FIGURE 4.1

Appreciation in Housing Prices

Four Period Moving Averages



figure, however, does not necessarily translate into real appreciation in home values, as it fails to account for improvements to properties. Due to this failure rates of appreciation are likely overstated. A more detailed discussion of this potential bias is presented later in this thesis.

Data Set Preparation: Selection and Aggregation of Municipalities

In Chapter Three I explained that the city of Boston would not be included in this model because of its disproportionate share of total population, accounting for 86.5% percent of the total population in Suffolk county in 1990. Due to this disproportionate representation, accompanied by wide fluctuations in appreciation rates in the city, substantial differences in socio-economic characteristics between neighborhoods, and the lack of neighborhood level data, the city of Boston has been eliminated from this analysis. Outlying cities in the remaining four counties have been included because of their smaller size and a greater degree of homogeneity within their boundaries.

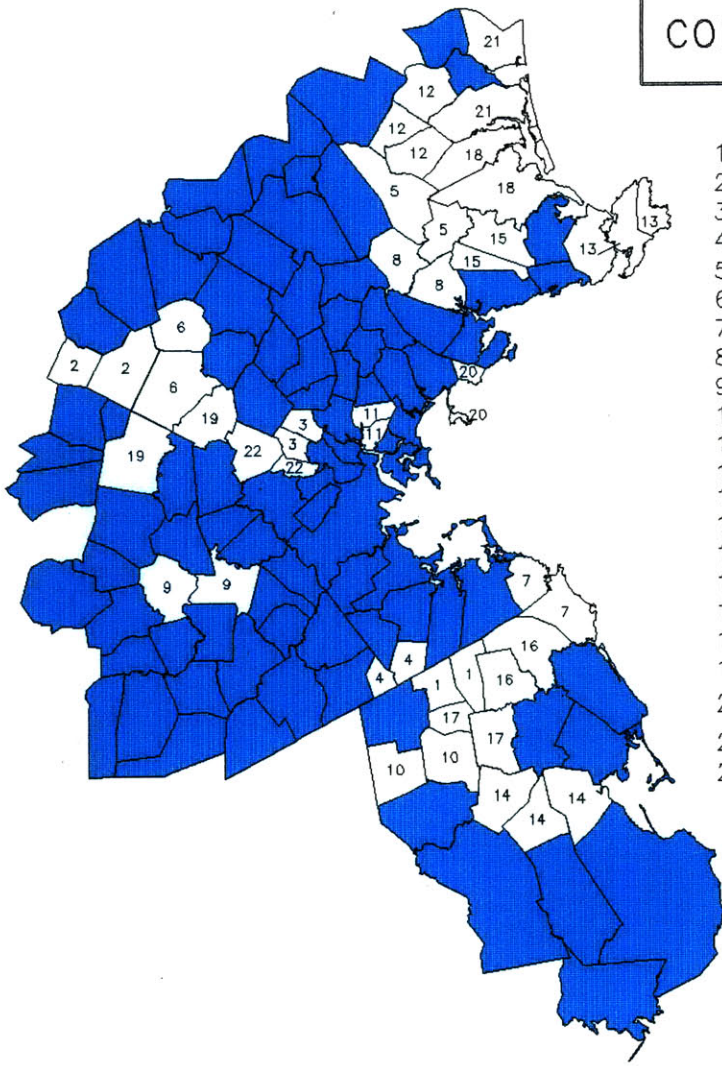
In other localities I encountered the opposite problem encountered in Boston. In many individual towns the volume of repeat sales was not adequate. Period to period growth rates in towns with fewer than 100 repeat sales transactions fluctuated considerably. Therefore, towns with fewer than 100 repeat sales transactions were either eliminated from the model or, preferably, combined with other cities and towns exhibiting similar fiscal, locational and population characteristics.

Most of the combined towns shared a school system and a common border. In addition to requiring close proximity and comparable schools as conditions for combining locations, median household income for combined locations in 1988 could not differ by more than 15 percent and unemployment rates by more than 0.5 percent between the towns. In most cases an appropriate "partner" town could be determined. However, a number of localities displayed unique characteristics given their location, and no suitable "partner" could be identified. Thus, in addition to Boston, some of these towns were eliminated from the analysis. Figure 4.2 displays towns combined, and Figure 4.3 depicts towns eliminated, due to inadequate data availability.

Quantifying Real Housing Price Appreciation

In order to create the WRS index a number of steps were required. The first step was cleaning up the original database to reduce the full database of all real estate transactions down to include only single-family home transactions. Once this step was completed, outlying observations were eliminated and sales prices were deflated. The final data base used in this study consisted of a near census of single-family housing sales within the Boston Metropolitan Area for the cities and towns included in the model, between January 1982 and year-end 1989 (Banker and Tradesman). A more detailed description of the steps taken to transform the data into a more usable form are presented below.

FIGURE 4.2



COMBINED LOCALITIES

1. Abington	Rockland	
2. Acton	Boxboro	
3. Arlington	Belmont	
4. Avon	Holbrook	
5. Boxford	Topsfield	
6. Carlisle	Concord	
7. Cohasset	Scituate	
8. Danvers	Middleton	
9. Dover	Sherborn	
10. E. Bridgewater	W. Bridgewater	
11. Everett	Malden	
12. Georgetown	Groveland	W. Newbury
13. Gloucester	Rockport	
14. Halifax	Kingston	Plympton
15. Hamilton	Wenham	
16. Hanover	Norwell	
17. Hanson	Whitman	
18. Ipswich	Rowley	
19. Lincoln	Sudbury	
20. Nahant	Swampscott	
21. Newbury	Salisbury	
22. Waltham	Watertown	

figure 4.2

FIGURE 4.3

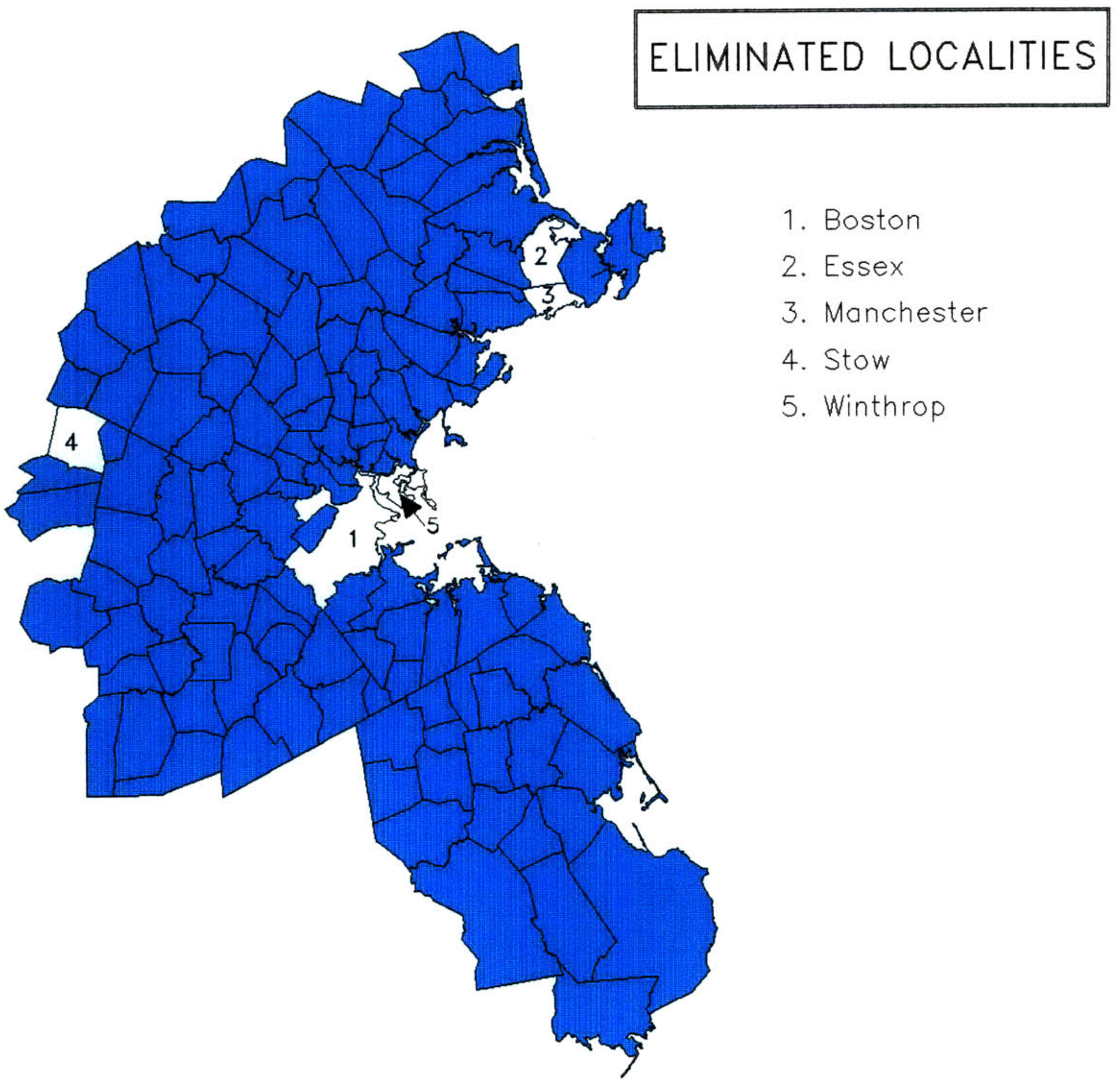


figure 4.3

Data Clean - Up

The original database contained records of all property transactions in the area, residential as well as commercial, and included details on transaction dates, address of the property, buyer and seller, purchase price, mortgage amount, and lending institution. In order to extract repeat sales of single family homes, a number of manipulations to the database were required. This included removing duplicate records, standardizing addresses, correcting erroneous addresses, identifying and eliminating non-residential transactions, and distinguishing and removing transactions for buildable lots, and condominium and multi-family residential properties. Appendix B includes a detailed list of the number of observations lost through each step of data cleanup.

Elimination of Erroneous and Extreme Cases

Once this preliminary clean-up was completed, all observations with a mortgage amount exceeding the sales price were assumed to be either non-residential transactions, building lots, or homes in severe disrepair requiring extensive renovation prior to occupancy. These cases were therefore eliminated. Transactions with a sales price below $10,000 were also suspect. Thus, properties were assumed to be either lots, debilitated homes, or non-armslength transactions. These cases were also removed from the database. Outlying observations were then purged from the dataset. Such observations were determined within each city or town using the following equation:

$$(Price_{t+n} - Price_t)/(Price_t * n)$$

Where $Price_{t+n}$ is the sales price of the second transaction at time t+n, $Price_t$ is the sales price of the first transaction at time t, and n equals the number of quarters between the two sales. Any observation in a city or town lying more than three standard deviations outside the mean of this equation was considered an outlier.

After completing the above steps, repeat sales could be determined. Further data editing was required, however, after matches were identified. Those observations where the buyer and seller had the same surname were considered non-armslength transactions and were deleted. In addition, on those properties where a pair of sales occurred in the same year, the first sale was eliminated. These observations appeared most commonly among condominiums and were determined to be primarily the result of pre-construction speculative purchases where an investor placed a downpayment on a property prior to construction, thus locking in a price. After completion of construction, the investor closed on the property and then turned around and sold it at a substantial profit.

Properties on which three or more sales occurred required special attention in order to reduce sales to price relatives and thereby minimize the problem of correlated residuals. For example, if three sales occurred on a property (t, t', t") three price relatives exist: t => t'; t => t"; and t' => t". Bailey, Muth and Nourse (1963) discussed computational methods for minimizing the problem of correlated residuals. They concluded that there were few such observations in their Saint Louis dataset, thus chose not to use a weighted regression method to correct the data. In this study, all nonsequential price relatives (t = > t") were eliminated, and only the true paired transactions (t = > t'; t' = > t") were included. This step was important because nearly 3 percent of the properties sold were sold three times. Thus, failure to correct the data for price relatives would have biased the results.

Inflation Adjustment

After completing the steps above, the data were in a workable form. However, one primary step remained: adjusting appreciation in values for inflation. Prices of single-family homes used in the pooled time-series cross-sectional model (Pindyck and Rubinfeld 1981) developed here were deflated using the Boston area Consumer Price Index for all goods and services. Although some may argue that the CPI for shelter would be a more appropriate deflationary index, the total CPI was determined to be more appropriate as it resulted in comparable deflation of both housing prices and income.

Figure 4.4 illustrates the differential rates of growth in total CPI and the CPI for shelter in both the nation and the Boston area. Growth in the shelter component of the CPI has outpaced increases in the CPI for all goods and services both nationally and within the region. This shelter component was the driving cause of the rising cost of living during the study period. In Boston, this was felt even more strongly, with the general cost of shelter rising over 50 percent between 1983 and 1989. Nationally this rate of expansion was also substantial, exceeding 33 percent. Utilizing the resulting real increases in

FIGURE 4.4

CONSUMER PRICE INDEX

1980 - 1988

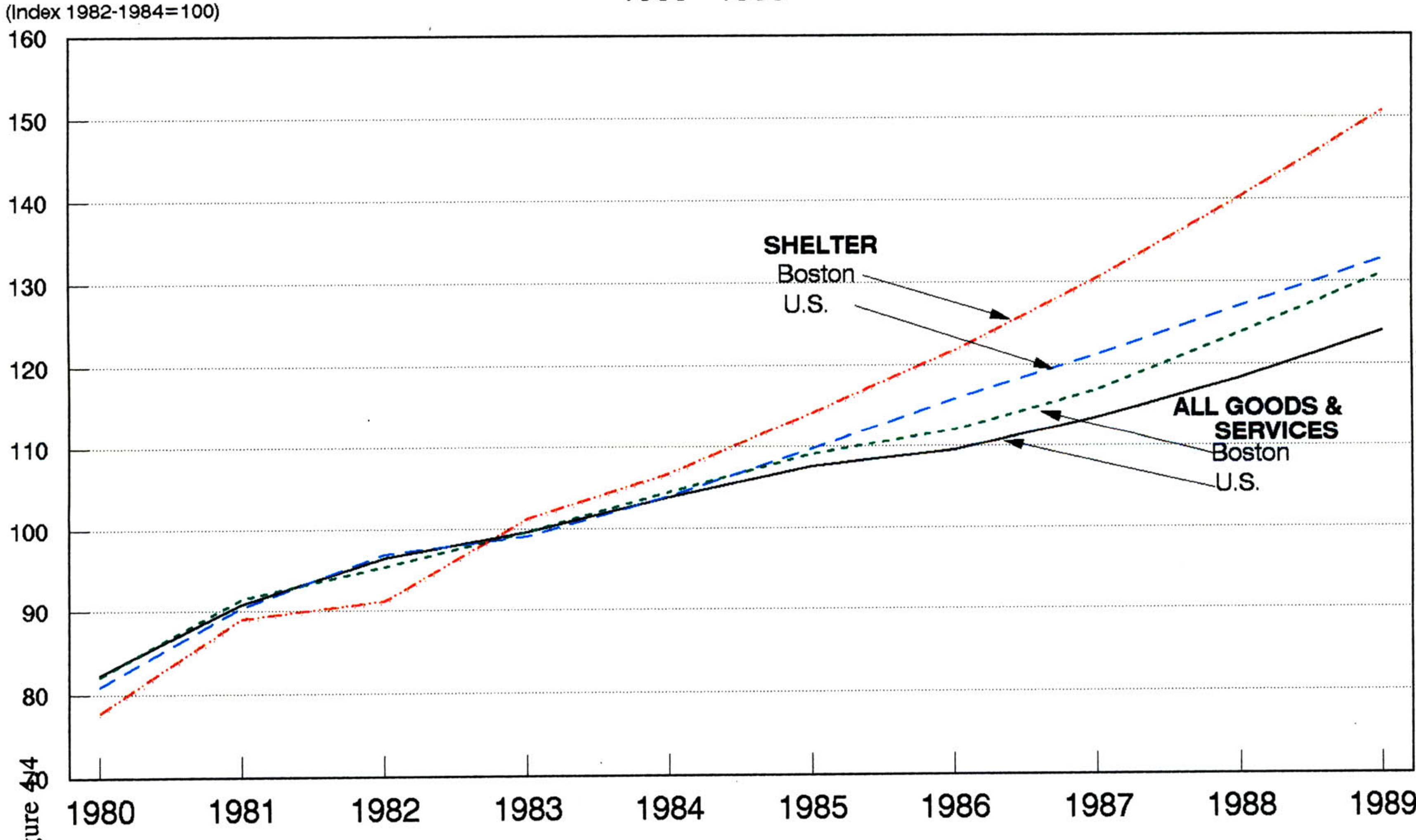


Figure 4.4

housing prices, determined after deflating the data, the WRS model was run, and the dependent variable, real annual appreciation in housing prices by community, was estimated. In the second stage of this analysis, a number of determinants were used to explain variations in appreciation rates across time and space.

VARIABLES CHOSEN TO ELUCIDATE HOUSING PRICE DIFFERENCES

A number of the determinants discussed in the literature review in Chapter Two were included in this model. These determinants fell under three of the four categories discussed above: fiscal determinants, locational determinants, and population characteristics. The variables examined in each of these categories are listed in Table 4.2. As mentioned previously, utilization of the WRS methodology implicitly controls for variations in property characteristics. Provided no major improvements are made to a home, the building and lot size and a number internal characteristics remain constant. Thus the fourth category of variable, structural characteristics, has been eliminated from this explanatory model.

The selected variables, within the three categories of variables described, are discussed individually below. Each of the variables was estimated over both time and space. A total of 103 individual or combined towns were included in the final dataset, for the seven year period, 1983 through 1989.

TABLE 4.2 VARIABLES EXAMINED

Variable	Definition
Fiscal Determinants:	
TXRT	• Effective Property Tax Rate.
TXDIFF	• A dummy variable indicating those towns which have instituted differential tax rates for commercial and industrial property.
PCTCOLL	• Percentage of public school students attending four-year colleges.
Locational Determinants:	
RESPCT	• Ratio of Residential property plus open space assessed value to total assessed value.
INDPCT	• Ratio of industrial property assessed value to total assessed value.
DENSITY	• Population per acre.
RESCONST	• Value of residential building contracts per residential parcel.
TRNSTIME	• Weighted time to employment center via public transit.
AUTOCBD	• Commuting time to the Boston CBD via automobile.
AUTOTHER	• Commuting time to Outlying Employment Centers via automobile
Population Characteristics/Demographic Determinants:	
HHINC	• Median household income.
UNEMP	• Unemployment Rate.

PCTWHITE	• White residents as a percent of total population.
HHOLDS	• Number of households.
AGE2534	• percentage of the total population between twenty-five and thirty-four.
AGE3544	• percentage of the total population between thirty-five and forty-four.
AGE4554	• percentage of the total population between forty-five and fifty-four.

Financial and Fiscal Determinants

National Level

National level variables have greatly influenced the demand for housing by altering the price component of the demand equation. These components vary across time. However, within a metropolitan area they do not vary substantially across town or type of housing and their value is limited in this pooled time-series cross-sectional analysis.

Local Level

Effective Property Tax Rates

Two studies have evaluated the relationship between property tax rates and housing prices within the Boston area, and their findings support the tax capitalization theory. Michaels and Smith (1990) examined 85 towns in suburban Boston utilizing a hedonic model on properties sold between 1977 and 1981. Their study included a property tax variable which was determined to be negative and significant at the 1 percent level. Case (1986) also found a significant negative relationship between home appreciation and property tax rates in his WRS analysis of five Boston area municipalities.

This study also expects to discern a negative correlation due both to changes in property tax rates across time (Proposition 2-1/2) and variability across location. Effective tax rates, which control for variations in assessment rates, as discussed previously, were utilized in this study. A problem exists, however, because separate assessed values and tax rates were provided for residential, open space, commercial, industrial, and personal property, while equalized values were only available at an aggregate level.

Massachusetts tax law (Appendix C) permits a locality to shift a portion of the tax burden from residential to commercial and industrial property. Generally, a referendum is presented to the residents of a locality and their input provides the Town Council, who must vote on the measure, the information necessary to approve or revoke the referendum. The law allows a town to tax commercial and industrial property at a rate up to 50 percent greater than would otherwise be levied on the properties. The additional revenue is offset by a decrease in the rate assessed to residential property and open space in the town. Thus, equalized tax rates do not account for the possibility of differential tax rates across property types and will overstate residential tax rates in localities that have implemented the law. The cities and towns that have adapted this law and the year instituted are listed in Table 4.3. A dummy variable will be included in this model in order to account for differential tax rates. This variable will be discussed in more detail in the following section.

TABLE 4.3 LOCALITIES WITH DIFFERENTIAL TAX RATES

LOCALITY	YEAR	LOCALITY	YEAR
Andover	1985	Ashland	1988
Avon	1982	Bedford	1982
Beverly	1982	Billerica	1985
Boxboro	1982	Braintree	1986
Brockton	1984	Brookline	1982
Burlington	1982	Cambridge	1984
Canton	1983	Carver	1983
Chelmsford	1987	Chelsea	1983
Concord	1984	Dedham	1983
Everett	1985	Framingham	1982
Gloucester	1982	Haverhill	1983
Holbrook	1983	Hudson	1983
Lawrence	1982	Lexington	1982
Lowell	1984	Lynn	1984
Malden	1983	Marlboro	1982
Maynard	*	Medford	
Medway	1983	Methuen	1988
Middleboro	1984	Milford	
Newton	1982	North Reading	1984
Norwood	1982	Peabody	1984
Quincy	1984	Randolph	1983
Revere	1984	Salem	1983
Saugus	1982	Somerville	1986
Somerville	1986	Stoneham	1988
Stoughton	1982	Sudbury	
Swampscott	1983	Taunton	
Tewksbury	1985	Wakefield	1983
Waltham	1983	Watertown	
W. Bridgewater	1988	Westford	1988
Weymouth	1982	Wilmington	1983
Winchester	1982	Woburn	1984

* If no year is indicated, the differential rate was adopted prior to 1982.

Effective property tax rates were calculated using data provided by the Massachusetts Department of Revenue (DOR). Cities and towns in Massachusetts are required to reassess properties bi-annually, and the state makes corresponding bi-annual adjustments to the assessed value in order to determine the equalized or full value assessment. Dividing equalized value by the tax levy for a particular year should thus result in the equalized property tax rate. In towns with similar characteristics that were grouped together in this study, equalized values and tax levies were summed prior to computation of the tax rate.

Dummy Variable for Differential Tax Rates

In order to account for the institution of differential tax rates between residential and non-residential (commercial and industrial) property, a dummy variable was introduced into the model. This variable was assigned a value of one in cities and towns that had invoked this law. If the law was implemented during the study period, a value of zero was assigned prior to the year of implementation, at which time the variable assumed the value one. The expected sign for this variable is uncertain as the magnitude of the differential varies by locality, and the towns employing the differential rate appear to fall into two categories: those utilizing this differential partially as a disincentive to business entry, and those with large commercial and industrial bases.

The attractiveness and effect of such a law will vary depending on the ratio of commercial and industrial assessed value to the total assessed value as well as on the magnitude of the differential in assessment rates. In primarily residential localities, the effect will be minimal and may serve as a disincentive to entry, or an incentive to relocate a business. If a town desires to maintain its residential character it may choose to invoke the law in order to discourage firms from entering.

In a locality with a substantial commercial and industrial tax base the effects of a differential tax law will be significant. If a business derives substantial benefit by locating within a particular municipality, it may choose to remain, given the increased tax rate, because no alternative communities are deemed adequate substitutes. However, if a substitute locality exists and the firm chooses to relocate, the municipality which invoked the law will lose employment opportunities for its resident labor force.

Educational Quality

As indicated in Chapter Two, many studies have examined per pupil educational expenditures as a measure of local services. A problem inherent in utilizing this variable is that in many urban areas expenditures are as high or higher than in the suburbs, but the additional per pupil expenditures are not always translated into higher quality education. For example, per pupil expenditures in 1986-87 were $4,982 in Boston, $4,966 in Brookline, and $4,913 in Newton. Although these expenditures were comparable, school quality in Brookline and Newton is generally considered among the best in the nation, as opposed to Boston where school quality is not held in such high regard. This supports the Hamilton (1975) argument that property taxes may act as an excise tax in urban areas because the costs of attaining educational systems of comparable quality in urban areas greatly exceeds that of suburban locations. Furthermore, because the majority of property tax receipts are allocated to educational expenditures, a high correlation may exist between these two variables, thus alternative (demographic) means of modelling educational quality have been examined here.

One possible demographic measure of educational quality is average SAT scores. However, not all students take the SAT and the percentage of students taking this test varies dramatically across cities and towns. In cities considered in this model, the percentage of students taking the SAT in 1988 varied from a low of 25 percent in Chelsea and Somerville, to a high of 99 percent in Wellesley, Weston, and the Dover-Sherborn Regional School District (Pantridge 1989). Thus, true average scores may be artificially inflated in many areas where a lower percentage of students, most likely with greater potential, are taking the SAT.

High-school drop-out rates were also considered as a determinant of educational quality. These data were calculated by the State Department of Education. Unfortunately, because of redefinition of "drop-out", data available prior to 1987 were not comparable to post 1987 data. The earlier data include students under sixteen, whereas the later definition include only students sixteen and over. Furthermore, "drop-out" rates exhibited a high correlation (65 percent) with the educational determinant chosen in this model, the percentage of high-school graduates attending four-year colleges.

The percentage of students going on to either public or private four year colleges was employed as a proxy for educational quality. This variable was expected to be a better measure than those above, although some correlation with income could be expected. Annual data were obtained from the Massachusetts Department of Education. A number of towns belong to regional school districts. If these towns had a significant number of repeat sales (100 or more) and could be represented individually in the model, the school district's data was used for the locality. In combined cases, if one of the towns belonged to a regional school district, the town's share of graduates and college attendees was determined to equal the ratio of the town's number of households to all households within the district. For these cases, and for combined towns with their own schools, the percentage attending college was estimated as the ratio of the sum of high school graduates attending college to the sum of all high school graduates.

Locational Factors

The second major category of determinants is locational factors. Because of difficulty in compiling zoning data for such a large number of localities, this study utilized surrogate measures of zoning.

Percent Residential

Residential land use and open space are highly valued attributes and thus were expected to positively influence growth in housing prices. The percentage of total assessed value (excluding personal property) devoted to residential use and open space was employed as a proxy for the percent of residential land or open space in a town. This variable may underestimate the amount of residential land use in a town because assessed value is based on the value of land and buildings, and commercial buildings usually have a greater floor area ratio, or more building per square foot of land, than do residential structures. Regardless, a strong positive relationship with housing prices was anticipated.

Percent Industrial

In contrast, as discussed in Chapter Two, industrial property was expected to exhibit a negative relationship with housing values, due to negative externalities such as pollution and noise. Industrial property as a percent of the total assessed value was utilized to test the validity of this assumption.

Density

In certain regions of the country, as one moves from the suburbs to exurban areas the effects of lower density may be offset by declining property values resulting from decreasing accessibility. The overall effect in this model, however, was predicted to be positive. The communities included here all fall within a reasonable distance to major employment centers. Furthermore, open space was limited and highly valued in the Northeast in general, and the Boston area specifically, and families had to choose between locating in expensive crowded suburbs and relatively less crowded exurban areas. Thus, although the absolute change in housing prices in suburbs was likely to exceed that in exurban areas, the percentage change in the outlying areas was expected to predominate.

Estimates of average density by town were computed by dividing population estimates by the total land area, in acres, of the town. In combined towns, population and land area values were summed prior to computation of density.

Residential Construction

Housing starts varied significantly across time and location. Locational variation may have bene partially attributed to zoning restrictions and/or lack of available land for development within certain communities. A second factor affecting housing starts is market expectations or market psychology.

In the Boston area, inflationary expectations of consumers and producers played a major role in market fluctuations. Case and Shiller (1988) illustrated this in their survey of home-buyers in boom (Anaheim and San Francisco) and post-boom (Boston and Milwaukee) markets. When asked to explain changes in housing prices and/or their trends, consumers disproportionately referred to psychology of the housing market in the Boston area as opposed to other markets. In Boston 18 percent of respondents considered market psychology to be the primary cause of recent changes in home prices, as compared with 5.4 percent, 7.1 percent and 0.8 percent in Anaheim, San Francisco and Milwaukee, respectively.

Quantifying the effects of market psychology is more difficult in transactions models, as opposed to surveys. The Boston market had been characterized as a victim of substantial overbuilding. This was primarily evident in the condominium market during 1989 and 1990 as excess supply and a weakening economy resulted in the bankruptcy of many developers and a large number of units being auctioned off at a fraction of their original cost.

The relationship between construction, as measured by housing starts, and price appreciation is complex. First, of course, construction is a component of supply. That is, at any moment, the number of houses offered for sale is the sum of existing for sale units and new for sale units. Thus, one would expect a negative relationship between starts and prices, ceteris paribus. On the other hand, developers are also likely to be attracted to precisely those areas that have experienced the most rapid rates of appreciation. In addition, expectations of further growth in prices and/or demand could influence both home buyers and developers. For both these reasons, one might anticipate finding a positive relationship between starts and appreciation. Which of these two effects dominates is likely to change over time.

This study examined the real value of residential permits per existing residential parcel in a given year in an attempt to gauge market psychology. In order to better estimate the supply effect of construction, the housing start variable was lagged by one year. Thus it more closely approximates actual additions to the stock, and consequently a negative relationship is expected to predominate in this analysis. As discussed in Chapter Three, increases in home prices gained momentum in the early and mid 1980s, and thus a number of speculators attempted to "cash in" on the opportunity. Consequently, housing permits rose so sharply, that eventually, spurred by a weakening economy and excess supply, price appreciation collapsed. The strength of this relationship may be weakened somewhat in that appreciation in home prices in lower density exurban towns was likely to initially be accompanied by building in those areas. However, those communities that allowed building to get out of hand were most likely hit hardest when the magnitude of the excess supply became evident. Residential permits per existing residential parcel were examined with a lag of one year, as the lag between issue of a permit and completion of construction was anticipated to be close to a year.

Residential construction was calculated using the U.S. Census Estimates of Building Permits and Values obtained from the DOR and deflated using the Boston CPI for all goods and services. The impact of the level of construction was expected to vary depending on the residential stock that existed in a town at the time of permit issue. For example, assume average per unit construction costs of $100,000. In a town with 5,000 units, a residential construction contract valued at $50 million would increase total units by 10 percent, while a locality with 50,000 existing units would only realize a 1 percent increase in units. Thus to make comparisons among municipalities more relevant, the ratio of the value of residential permits to the existing total number of residential parcels was calculated.

Accessibility

Most previous studies that have included an accessibility variable have employed distance to the CBD as the variable. The Boston area, however, not only has numerous employment nodes (e.g. Boston, Route 128 high-tech corridor, and other urban centers), but also various means and quality of transportation access (Massachusetts Turnpike vs. congested Southeast Expressway; MBTA railways, subways, and ferries). Thus, a more appropriate measure of accessibility would attempt to quantify the variations in public transit availability and service quality as well as transit via automobile to major employment nodes. Anas and Eum (1984, 1986) utilized measures including the natural logarithm of distance (+) and bus miles [(+) length of bus routes crossing a community] to the Chicago CBD. In addition they measured accessibility as the number of work trips from a community using automobile (-), public transit (+), and rail (-) to the CBD. Thus they accounted for various modes of transportation but again limited employment to the central business district.

Using commuting time by automobile from each study community to six major employment centers for 1980 and 1988, and public transit time to the two nodes for which data were available, this study quantified access more accurately than past studies. In order to account for changes in the availability of public transportation over time, data was also collected on the year of major public transit improvements and the areas affected by these improvements.

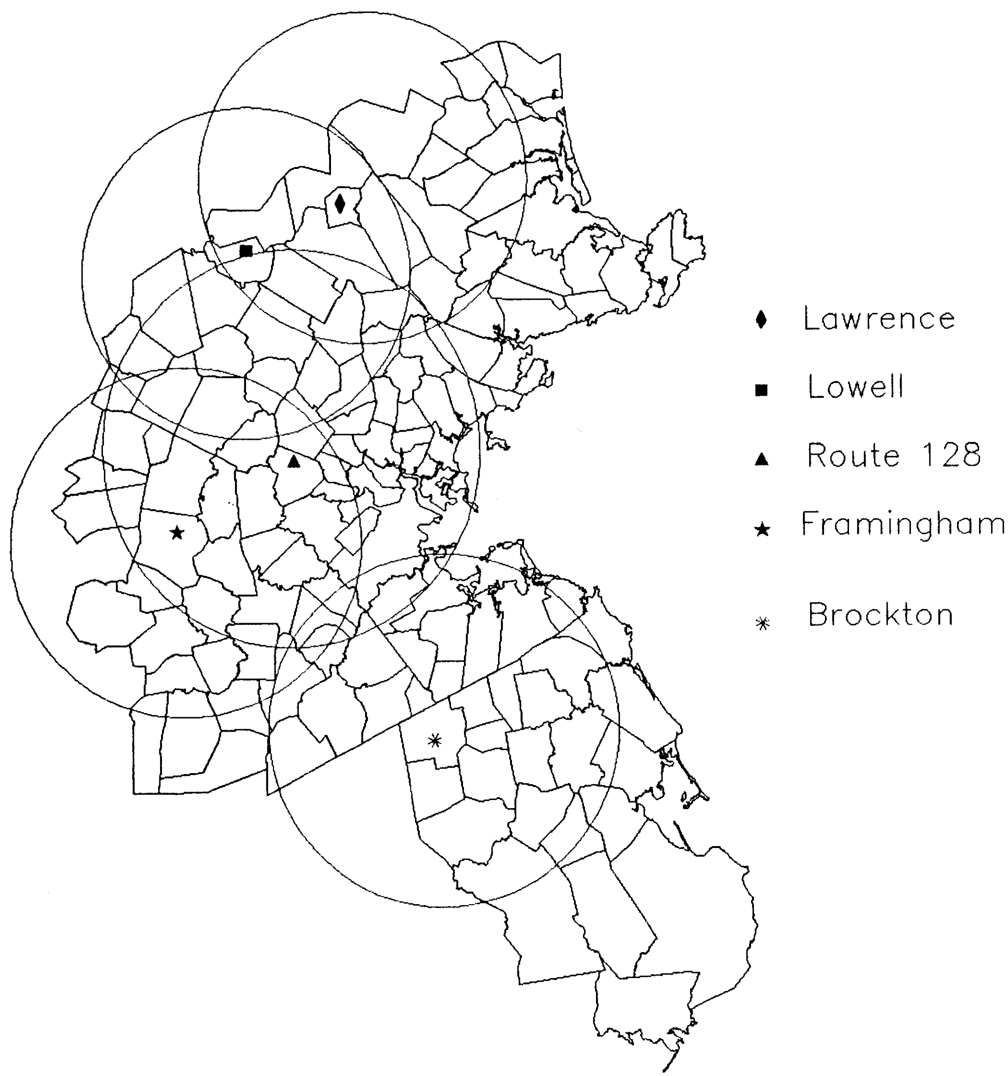
Accessibility data was provided by the Central Transportation Planning Study (CTPS) in the form of a time-distance matrix from over 800 traffic analysis zones (TAZs) to six primary employment locations. Their methodology is discussed in Appendix D. These matrices were provided for both automobile and public transportation, in 1980 and 1988. As discussed earlier, Boston contains multiple employment centers. In order to estimate primary locations, employment levels of various areas were examined and the six primary areas, or those with the highest number of workers, were determined. These areas included Boston's Financial District, Route 128 between the Massachusetts Turnpike and Route 2, Route 9 in Framingham, and the centers of Brockton, Lawrence, and Lowell. Figure 4.5 illustrates the approximate location of these areas. The circle surrounding each work location is an estimate of the boundary within which an employment center principally draws its employees. The Boston Financial District is assumed to draw a substantial number of employees from each residential location.

Automobile

Employment zones and towns of residence may consist of multiple TAZs. Thus aggregation to the appropriate level was computed using a simple average of commuting time for the relevant areas. Automobile transportation data were derived by CTPS using average weekday trip times, and distances were calculated along the major road

FIGURE 4.5

Employment Centers Outside of the City of Boston



networks between locations. Adjustments were made by CTPS for improvements in road-networks, however no major highway improvements were completed during the study period, therefore linear interpolation for the interim years was deemed appropriate.

Automobile access was included in the model as two separate variables. The first variable, access time to the five employment zones outside the Boston CBD, was measured using a simple average of commuting time to each employment location. This was determined to be appropriate because of the comparable size of each of these employment locations. The Boston CBD was included separately in the model because employment located in this area exceeded the sum of employment in all the exterior employment nodes.

Public Transit

Public Transportation data were estimated by CTPS using a.m. peak hour travel time. However, these data were only available for the Financial District and the Route 128 corridor. Due to the extreme differences in employment size in these two locations, this variable was computed using a weighted average of access time. The Boston district was assigned a weight of 0.9 while the high-tech 128 area was given a weight of 0.1. These weights approximate the ratio of employment at each destination.

Primary changes in these data were due to additions to the base service provided. The major service improvements included expanded commuter rail service along the South

Shore to Franklin, improvements to the Needham commuter rail line, expansion of the Red Line subway both south and west of the city, completion of a modernized Orange Line subway and increased commuter ferry service to Hull. For towns not affected by these public transportation improvements, travel times were interpolated for the interim years and the average annual change for all locations was determined. For areas affected by improvements in public transit, any decline in commuting time was assumed to occur in the year the improved service first became available.

Population Characteristics

The third major category of determinants considered was population characteristics and demographic factors. In this section I discuss these components and clarify the methodology utilized to develop these elements.

Department of Revenue - CACI Adjustment Methodology

A problem inherent in time-series analysis when using demographic data for explanatory variables is the lack of available current and detailed data. Given the dramatic changes that occurred across the Boston area during the 1980s, and the intent here to model these changes, 1980 Census data was determined to be obsolete. In addition, 1990 Census data was not yet available. The choice made was to use comparable data aggregated from various state, local, public and private data sources. For data that was not available annually, interpolation was used to estimate annual values. The final model included annual values of population characteristics in a particular locality to explain the annual rate of appreciation in single-family home prices in that locality.

Data for the demographic variables used in the model were compiled from 1980 Census information, 1990 estimates provided by the Massachusetts Department of Revenue (DOR), and data published by CACI for 1986, 1988 and 1990 at the Zip Code level of aggregation for all states in the country. CACI's methodology is presented in Appendix E1. Because of the DOR's familiarity with the area, their estimates were expected to be more accurate than CACI's, thus for variables on which DOR data was available, growth rates for the 1980 to 1990 period were determined using the CACI zip code level data aggregated to the town level, by weighing variables by the number of households in the zip code area. These growth rates were then compared with the DOR data estimates for the decade. Finally, the CACI rates were adjusted to reflect the DOR's estimates. For example, if CACI showed population growth rates in town A between 1980 and 1986, 1980 and 1988, and 1980 and 1990, as 4 percent, 6 percent and 8 percent, respectively; and the DOR data reflected a rate of 10 percent between 1980 and 1990; CACI rates would be inflated, multiplying them by the DOR rate, 10 percent, then dividing by the 1980 to 1990 CACI estimate, 8 percent. Therefore, adjusted rates of population growth for 1986, 1988, and 1990, would be 5 percent, 7.5 percent and 10 percent, respectively. Detailed variable by variable methodology is presented in Appendix E2.

Data for the interim years, 1981-1985, 1987, and 1989 were interpolated using a constant rate of growth. Although one may argue that interpolation should be made exclusively from the more precise decennial state data, this would fail to accurately illustrate the rapid changes occurring during this time period, and would be unlikely to appropriately portray changes in the dependent variable. Annual data would be most appropriate, but were either unavailable or too costly to compile. Furthermore, computation of growth rates in housing prices for the Boston Metropolitan area as a whole indicated growth during the 1982 to 1985 period, a slight downturn in the market during 1986, and acceleration in this decline in 1988. Thus interpolation between these years was deemed appropriate.

Real Median Household Income

In this study I examined median household income and expected to find of a positive relationship between appreciation in home values and income. As discussed previously, average income measures are not recommended because individuals, families or households with outlying high incomes will tend to skew the income measure. Homeowners' median income was most appropriate but was unavailable. Therefore, median household income was used as it was the most accurate measure available.

CACI data on median household income was utilized. Income levels per zip code were weighted by the number of households in the zip code area, and zip codes were aggregated to the town level. The resulting income levels were then deflated using the Average Annual CPI for all goods and services for the Boston Metropolitan area, and data for the interim years was interpolated. For combined cities and towns, income figures were weighted by the estimated number of households in each jurisdiction.

Unemployment Rate

Employment varied widely across time and space, and increasing employment was presumed be positively correlated with home prices. Across time, changes in employment have been explained as both the primary cause and result of the housing boom in the Boston Metropolitan Area. During the mid 1980s, the region had some of the lowest unemployment rates in the nation. Toward the end of the decade, weakening of the regional economy spurred by cutbacks in defense spending, declines in construction, banking and other industries, resulted in a decline in employment, and consequently rising rates of unemployment and outmigration. This, accompanied by over building, translated into a softer housing market and depressed home prices. The relationship was likely to persist across space as well as time. Cities and towns with higher unemployment rates are often considered less desirable, thus lower rates of housing appreciation were expected.

Rates of unemployment were chosen because levels of employment were only available by location of work, and the unit of analysis of interest here was place of residence. Unemployment rates were obtained from the Massachusetts Department of Employment and Security, Local Area Employment Statistics. Estimates for those towns combined in the study were calculated using the ratio of the sum of the number unemployed to the sum of the labor forces in the corresponding towns.

Racial Composition

In this study, as in previous studies, I expected to discern a negative relationship between changes in home values and changes in the racial composition of a community. In order to evaluate this relationship data on the percentage of whites in a community was used. These data were compiled from CACI data. Values for joined towns were weighted by their annual estimated population.

Number of Households

The relationship existing between the number of households and housing prices has traditionally been positive, as these additional households require roofs over their heads, thus increasing demand and putting upward pressure on prices. In this study, a positive relationship was also expected, particularly in exurban areas where the increase in the number households during the study period exceeded that of more developed urban and suburban areas. As discussed earlier, households are a more appropriate measure than changes in population, due primarily to unconventional patterns of household formation by baby-boomers. The number of households in a locality during a given period was determined using CACI data. The ratio of population to number of households was calculated in order to approximate household size in a given year. Linear interpolation was implemented to approximate average household size for the intervening years. These figures were then applied to the population estimates to determine the number of households per town per year.

Age Cohorts

As explained above, the aging children of the postwar baby-boom had a substantial impact on changes in housing demand and thus in the demand for single family homes during the 1980s. This study examined the percentage of town residents in the primary starter and trade-up home buying age groups, 25-34, 35-44, 45-54. The percentage distribution of individuals falling into each of these cohorts was deemed more appropriate than the number of individuals because of potential multicollinearity of the later with the household variable. Calculation of these data in grouped towns were made by summing population per age group in the towns and dividing by the total town population. Adjustments to reflect the more precise DOR data were calculated using the CACI-DOR adjustment methodology described above.

The percentage of individuals in the 25-34 year-old age group was expected to be negatively correlated with housing price appreciation as these individuals tend to be "starting out" and were more likely to reside in rental non-family households, in more densely populated urban locations with easy access to employment and entertainment. In addition, their lower income bracket may deny them the opportunity to be selective in choosing a location of residence.

The 35-44 year-old age cohort was characterized by trade-up buyers, often with young families, who desire proximity to open space and quality services more than the younger cohort. Thus rates of housing price appreciation were anticipated to be positively correlated with the percentage of the population falling into this category. However, because of their increased demand for many of the locational factors described previously, a high degree of association with these locational factors was possible.

The 45-54 year-old age group also consisted primarily of trade-up buyers moving up the corporate ladder and thus into more spacious homes and localities. Characteristics of this group were expected to be similar to the 35-44 year-old age group and thus higher rates of appreciation were anticipated in areas where this cohort comprised a substantial proportion of total population. Once again, however, multicollinearity was a concern, not only between this cohort and various locational factors, but also with the 35-45 year-old age cohort.

Table 4.4 summarizes the variables included in the model, as well as the definitions of these variables, and their expected signs. In Chapter Five I discuss the outcome of the WRS regression model and resulting dependent variable. In addition, I discuss the results of the explanatory model of housing price appreciation, examining the model fit and variables eliminated from the model due either to a large degree of multicollinearity with other variables and/or an insignificant t-statistic. I follow this discussion with a discussion of the model results, expanding on those variables where the results were counter-intuitive.

TABLE 4.4

MODEL FORMULATION

Variable	Definition	Expected Sign
Fiscal Determinants:		
TXRT	• Equalized Property Tax Rate	(-)
TXDIFF	• A dummy variable indicating those towns which have instituted differential tax rates for commercial and industrial property.	(?)
PCTCOLL	• Percentage of public school students attending four-year colleges	(+)
Locational Determinants:		
RESPCT	• Ratio of Residential property plus open space assessed value to total assessed value	(+)
INDPCT	• Ratio of industrial property assessed value to total assessed value	(-)
DENSITY	• Population per acre	(-)
RESCONST	• Value of residential building contracts per residential parcel	(+)
TRNSTIME	• Weighted time to employment center via public transportation	(-)
AUTOCBD	• Commuting time to the Boston CBD via automobile	(-)
AUTOTHER	• Commuting time to Outlying Employment Centers via automobile	(-)

Population Characteristics/Demographic Determinants:

HHINC	• Median household income	(+)
UNEMP	• Unemployment Rate	(-)
PCTWHITE	• White residents as a percent of total population	(+)
HHOLDS	• Number of households	(+)
AGE2534	• percentage of the total population between twenty-five and thirty-four	(-)
AGE3544	• percentage of the total population between thirty-five and forty-four	(+)
AGE4554	• percentage of the total population between forty-five and fifty-four	(+)

CHAPTER 5

MODEL RESULTS

In Chapter Four I discussed the variables to be included in this regression analysis of the determinants of disparities in housing price appreciation rates. In this chapter I interpret the results obtained, beginning with the outcome from the WRS regression model used to estimate the dependent variable. After examining the dependent variable, I focus my attention on the descriptive model of rates of appreciation in housing values. In the interest of time, and due to the complex relationship between the explanatory variables, simple linear regression was determined to be the most appropriate model form. Furthermore, in this study I utilized either the absolute value (number of households, household income) or the percent (unemployment rate, percent of the population in various age groups) of all explanatory variables for each year; no differencing between years or growth rates were considered. Further refinements and alternative analyses are described in Chapter Six.

HOUSING PRICE APPRECIATION INDEX: WRS REGRESSION RESULTS

The initial WRS model was run on quarterly repeat sales data by town. However, at this level of disaggregation a high degree of autocorrelation was detected, through use of the Durbin-Watson test statistic. This problem was particularly significant in those localities with few observations, or repeat sales. Thus, the WRS model was run on annual data. The results of the annual model were much less spurious, although towns with close to 100 repeat transactions still exhibited fairly volatile rates of growth and decline. Using this annual model specification, the level of fit as measured by the R-squared statistic, was consistently high, exceeding 75 percent in most cases. Furthermore, these results were not polluted to as significant a degree by the effects of autocorrelation. In the vast majority of towns, first order autocorrelation remained below 10 percent.

MODEL SPECIFICATION

The bulk of this chapter is devoted to describing the results of a number of alternative specifications of a basic regression equation. The dependent variable is the town-specific annual rate of appreciation in home price discussed above. Since the analysis covers seven years and 103 towns, there are 721 total observations.

The correlation matrices between the dependent variable and each of the explanatory variables across space and time dimensions are presented in Tables 5.1 a and 5.1 b. The full correlation matrix is presented in Appendix F. Analysis of correlation among variables divulged three model specifications of primary interest. In the first model all variables were included. The results of the full model including all variables were difficult to interpret due to the intricate relationships between variables mentioned above, and the added complexity of analysis across the dimensions of both time and space. In the second model the effective property tax variable (TXRT) was eliminated due to an unduly high and counterintuitive positive correlation between this variable and the dependent variable. A final model specification was examined because of the substantial degree of multicollinearity between explanatory variables. This model included the explanatory variables within each group of multicollinear variables that exhibited the highest correlation with the dependent variable, and the lowest correlation with the other variables specified in this sub-model.

Tables 5.2a contains the basic model with all variables, run with all 721 observations as well as the same model run with three alternate subsets of the data: cities only, non-cities only, and exurbs only. Table 5.2b presents the same four regressions without the property tax variable. Table 5.2c presents regressions for the same four categories of cities (full sample, cities, non-cities and exurbs) with the reduced set of variables. Tables 5.3a-5.3c present the full model, the model without tax rates, and the model corrected for multicollinearity run separately with the data for each of the seven years.

Cities and towns in this region were classified into subcategories because of their diversity. One subgroup consisted of all localities excluding some of the larger, more urban cities. These eliminated cities (Brockton, Chelsea, Haverhill, Lawrence, Lowell, Lynn, Methuen, Quincy, and Revere) were then aggregated into a separate subgroup of their own. A final subgroup included less densely populated municipalities generally located on the periphery of the study area. Any town with an average automobile

Table 5.1 a — Correlation of Explanatory Variables with the Rate of Housing Price Appreciation by Year

Explanatory Variable	1983	1984	1985	1986	1987	1988	1989
# OBS.	26,815	29,354	30,501	29,059	28,814	26,449	23,665
TXRT	0.0877	0.0963	0.2473	-0.0808	0.1254	0.1607	-0.1317
TXDIFF	0.1270	0.0284	-0.0400	-0.0449	-0.0280	-0.1255	*
PCTCOLL	0.0381	-0.1547	-0.3125	0.0011	-0.0643	-0.0400	0.1025
RESPCT	0.0904	-0.1829	0.1608	-0.0412	0.0411	0.1051	0.0763
INDPCT	-0.0443	0.0927	-0.1951	0.0133	-0.0199	-0.0853	-0.1025
DENSITY	0.0967	0.1478	0.2176	0.0115	0.0356	-0.0402	0.0583
RESCONST	-0.0681	-0.1117	-0.0621	0.0508	0.0062	-0.0511	0.0662
TRNSTIME	-0.1024	0.1171	-0.0591	-0.0572	-0.0080	0.0175	-0.0574
AUTOCBD	-0.0928	-0.0383	0.0278	-0.0584	0.0897	0.0410	-0.0851
AUTOTHER	0.0654	-0.0697	0.2272	-0.0581	0.1918	0.1172	0.0264
HHINC	0.0137	-0.1323	-0.3636	-0.0043	-0.0779	-0.0124	0.1688
UNEMP	0.0259	0.0827	0.3120	0.0838	0.1054	0.0940	-0.2710
PCTWHITE	0.2785	-0.1242	-0.0586	-0.0450	0.1231	-0.1247	0.1756
HHOLDS	0.0511	0.1193	0.1109	-0.6756	-0.0230	0.0357	0.0307
AGE2534	-0.0846	0.0738	0.1519	-0.0551	0.0554	0.0346	-0.0740
AGE3544	0.0021	-0.0853	-0.1417	-0.1086	0.0861	0.0787	0.0438
AGE4554	0.0748	-0.0157	-0.2026	-0.1083	0.1234	-0.0068	0.0904

* Data for 1989 was not available

Table 5.1 b. — Correlation of Explanatory Variables with the Rate of Housing Price Appreciation by Type of Community

Explanatory Variable	All Localities	Excludes Cities	Cities Only	Exurban
# OBS.	194657	160513	34144	90155
TXRT	0.5345	0.5193	0.6781	0.4807
TXDIFF	0.0975	0.0611	0.2690	-0.0341
PCTCOLL	-0.1246	-0.1349	-0.0987	-0.1408
RESPCT	0.0095	0.0321	-0.1594	0.0594
INDPCT	-0.0126	-0.0298	0.1392	-0.0998
DENSITY	0.0532	0.0448	0.0625	-0.0690
RESCONST	-0.3784	-0.3606	-0.4969	-0.3878
TRNSTIME	0.0092	0.0197	-0.0353	0.0544
AUTOCBD	-0.0850	-0.0726	-0.1511	-0.1017
AUTOTHER	-0.0655	-0.0539	-0.1679	-0.0295
HHINC	-0.0612	-0.0528	-0.1380	-0.0639
UNEMP	0.2145	0.2508	0.1126	0.2446
PCTWHITE	0.0503	0.0611	0.0759	0.1228
HHOLDS	0.0125	0.0146	-0.0617	-0.0707
AGE2534	-0.1003	-0.0934	-0.3128	-0.1389
AGE3544	-0.1948	-0.1898	-0.2331	-0.1357
AGE4554	-0.0490	-0.0522	-0.0060	-0.0613

Table 5.2 a Regression Results by Type of Community (Includes All Variables)

Explanatory Variable	All Localities	Excludes Cities	Cities Only	Exurban
R^2	38.5	35.4	75.8	37.7
Adj. R^2	38.5	35.4	75.8	37.7
INTERCEP	-0.6067	-0.5813	4.6930	-0.4545
	(-49.66)	(-39.8)	(51.56)	(-20.38)
TXRT	0.0159	0.0162	0.0095	0.0159
	(222.71)	(182.68)	(64.76)	(123.39)
TXDIFF	0.0095	-0.0034	0.0146	-0.0183
	(16.62)	(-5.23)	(11.34)	(-19.09)
PCTCOLL	-0.0468	-0.0617	0.0515	-0.0514
	(-15.91)	(-19.55)	(4.19)	(-12.78)
RESPCT	0.0215	0.0438	-1.4547	-0.1278
	(4.3)	(7.96)	(-46.76)	(-12.57)
INDPCT	-0.0387	-0.0115	-0.6412	-0.3615
	(-5.65)	(-1.54)	(-12.73)	(-30.47)
DENSITY	0.0009	-0.0008	-0.0456	-0.0486
	(7.67)	(-5.96)	(-64.79)	(-72.77)
RESCONST	-0.0166	-0.0140	-0.0400	-0.0166
($000)	(-105.2)	(-81.67)	(-90.79)	(-73.38)
TRNSTIME	0.0010	0.0009	0.0044	0.0003
	(46.08)	(37.73)	(13.18)	(11.6)
AUTOCBD	-0.0008	-0.0010	-0.0144	-0.0023
	(-17.48)	(-18.9)	(-33.73)	(-28.9)
AUTOTHER	-0.0002	-0.0001	-0.0027	-0.0002
	(-5.78)	(-2.13)	(-11.24)	(-4.92)
HHINC	0.0016	0.0017	-0.0110	0.0006
($000)	(26.32)	(23.88)	(-39.55)	(6.63)
UNEMP	0.0003	0.0052	-0.0488	0.0015
	(1.06)	(18.3)	(-85.48)	(4.23)
WHTPCT	0.0045	0.0039	-0.0238	0.0071
	(37.85)	(28.18)	(-37.61)	(31.97)
HHOLDS	-0.0012	0.0002	0.0012	0.0028
	(-32.43)	(3.31)	(5.74)	(23.4)
PCT2534	-0.2418	-0.3003	-1.8249	-0.3509
	(-24.13)	(-25.86)	(-18.25)	(-23.39)
PCT3544	-0.2088	-0.1514	-2.8183	-0.2797
	(-15.13)	(-9.57)	(-43.36)	(-12.68)
PCT4554	-0.1198	-0.1457	7.2526	-0.1284
	(-5.47)	(-5.88)	(63.91)	(-3.62)

Table 5.2 b Regression Results by Type of Community (Excludes Property Tax Rates)

Explanatory Variable	All Localities	Excludes Cities	Cities Only	Exurban
R^2	22.6	21.8	70.6	27.2
Adj. R^2	22.6	21.8	70.6	27.2
INTERCEP	-0.3956	-0.1079	5.6932	-0.2051
	(-28.95)	(-6.82)	(59.9)	(-8.54)
TXDIFF	0.0202	0.0095	0.0020	-0.0145
	(31.67)	(13.53)	(1.46)	(-14.02)
PCTCOLL	-0.1557	-0.1673	0.0277	-0.1333
	(-47.86)	(-49.03)	(2.13)	(-31.08)
RESPCT	0.0957	0.1183	-1.7636	-0.1550
	(17.12)	(19.6)	(-54.14)	(-14.1)
INDPCT	0.0416	0.0613	0.0892	-0.3985
	(5.42)	(7.47)	(1.71)	(-31.07)
DENSITY	0.0023	0.0017	-0.0638	-0.0312
	(18.54)	(11.64)	(-93.11)	(-44.27)
RESCONST	-0.0229	-0.0198	-0.0360	-0.0236
($000)	(-131.22)	(-105.95)	(-108.77)	(-99.86)
TRNSTIME	0.0012	0.0012	0.0063	0.0003
	(47.52)	(46.89)	(17.73)	(8.84)
AUTOCBD	-0.0012	-0.0011	-0.0227	-0.0026
	(-23.65)	(-19.67)	(-52.62)	(-29.27)
AUTOTHER	-0.0003	-0.0004	0.0001	-0.0003
	(-7.7)	(-9.19)	(0.45)	(-5.95)
HHINC	0.0033	0.0036	0.0041	0.0024
($000)	(49.65)	(47.98)	(-38.17)	(24.2)
UNEMP	0.0135	0.0187	-0.0485	0.0096
	(51.06)	(62.13)	(-80.21)	(25.82)
WHTPCT	0.0052	0.0017	-0.0289	0.0088
	(39.59)	(11.11)	(-43.48)	(36.38)
HHOLDS	0.0008	-0.0004	0.0001	0.0004
(000)	(-19.18)	(-6.15)	(11.83)	(3.47)
PCT2534	-0.2945	-0.2805	-1.8723	-0.4829
	(-26.21)	(-21.95)	(-17.68)	(-29.84)
PCT3544	-0.4893	-0.4408	-4.5967	-0.4478
	(-31.75)	(-25.45)	(-73.64)	(-18.81)
PCT4554	-0.3809	-0.3963	10.8300	-0.5617
	(-15.52)	(-14.54)	(103.1)	(-14.73)

Table5.2 c Regression Results by Type of Community (Includes Select Variables)

Explanatory Variable	All Localities	Excludes Cities	Cities Only	Exurban
R^2	35.3	33.1	52.7	35.0
Adj. R^2	35.3	33.1	52.7	35.0
TXRT	0.0165	0.0171	0.0153	0.0157
	(237.11)	(204.2)	(114.71)	(126.78)
PCTCOLL	-0.0072	-0.0340	-0.1472	-0.0627
	(-3.47)	(-14.91)	(-12.96)	(-21.83)
RESPCT	0.0838	0.1051	-0.5534	0.1617
	(30.64)	(36.73)	(-38.84)	(33.4)
DENSITY	-0.0057	-0.0054	-0.0094	-0.0408
	(-72.12)	(-57.24)	(-45.56)	(-85.47)
RESCONST	-0.0158	-0.0150	-0.0216	-0.0190
($000)	(-107.54)	(-94.13)	(-50.98)	(-94.72)
AUTOCBD	-0.0008	-0.0008	-0.0012	-0.0025
	(-35.72)	(-30.41)	(-22.96)	(-56.15)

TABLE 5.3 a REGRESSION RESULTS BY TIME PERIOD (INCLUDES ALL VARIABLES)

	1983	1984	1985	1986	1987	1988	1989
R^2	29.92	21.87	32.34	19.06	16.9	19.6	24.8
Adj R^2	29.88	21.82	32.3	19.01	16.9	19.6	24.8
INTERCEP	-1.9238	0.8593	0.2838	0.0531	-0.7296	0.2770	-0.2940
	(-81.51)	(29.49)	(12.08)	(2.45)	(-37.53)	(16.25)	(-18.07)
TXRT	0.0047	-0.0008	0.0069	-0.0064	0.0036	0.0054	-0.0031
	(30.88)	(-3.92)	(29.6)	(-29.1)	(12.71)	(28.05)	(-16.26)
TXDIFF	0.0288	-0.0129	-0.0125	-0.0275	0.0121	-0.0257	0.0000
	(33.6)	(-9.8)	(-10.48)	(-23.49)	(10.95)	(-28.47)	(0)
PCTCOLL	0.1136	-0.2237	-0.0239	0.0621	0.0125	-0.0842	-0.0984
	(22.92)	(-34.66)	(-4.35)	(13.2)	(2.94)	(-19.92)	(-21.77)
RESPCT	0.0594	-0.2645	0.2542	-0.1205	0.0155	0.1004	-0.0468
	(7.23)	(-24.84)	(28.62)	(-13.82)	(1.96)	(15.04)	(-7.31)
INDPCT	0.1183	-0.2339	0.0385	-0.0624	0.0125	0.0952	-0.0066
	(10.34)	(-16.28)	(3.29)	(-5.32)	(1.18)	(10.78)	(-0.7)
DENSITY	0.0071	0.0024	0.0005	-0.0032	0.0044	-0.0053	0.0051
	(39.82)	(10.22)	(2.43)	(-16.93)	(24.74)	(-35.3)	(32.67)
RESCONST	0.0002	-0.0121	0.0133	0.0114	-0.0021	-0.0021	0.0028
($000)	(0.42)	(-22.6)	(27.58)	(31.39)	(-8.61)	(-9.47)	(18.38)
TRNSTIME	-0.0004	0.0032	-0.0003	-0.0002	-0.0005	0.0004	0.0005
	(-11.44)	(68.62)	(-8.68)	(-6.24)	(-16.1)	(14.13)	(18.95)
AUTOCBD	0.0017	-0.0028	-0.0019	-0.0013	0.0009	-0.0025	0.0000
	(22.23)	(-29.22)	(-21.82)	(-15.27)	(11.65)	(-43.61)	(-0.24)
AUTOTHER	0.0008	-0.0001	0.0016	-0.0002	0.0012	0.0010	0.0012
	(14.16)	(-0.9)	(26.97)	(-3.25)	(22.96)	(25.45)	(27.85)
HHINC	0.0042	0.0016	-0.0036	0.0018	0.0011	0.0012	0.0019
($000)	(36.48)	(11.25)	(-30.63)	(16.48)	(11.89)	(15.27)	(22.64)
UNEMP	0.0119	-0.0061	0.0057	0.0305	0.0098	0.0140	-0.0209
	(26.52)	(-7.59)	(7.5)	(41.37)	(20.65)	(27.37)	(-40.22)
WHTPCT	0.0161	-0.0048	-0.0040	0.0036	0.0035	-0.0066	0.0034
	(79.77)	(-18.57)	(-18.46)	(17.6)	(18.69)	(-42.12)	(24.33)
HHOLDS	0.0018	0.0006	-0.0022	0.0024	-0.0003	-0.0004	0.0012
(000)	(28.74)	(6.96)	(-30.38)	(34.09)	(-4.35)	(8.07)	(24.7)
PCT2534	0.0369	-0.0058	0.2406	-0.2226	0.3685	0.3401	-0.1046
	(1.96)	(-0.25)	(13.23)	(-13.94)	(23.74)	(25.05)	(-7.18)
PCT3544	-0.6592	0.4409	0.1833	-0.5320	0.3004	0.3954	-0.3130
	(-27.59)	(13.53)	(7.36)	(-24.36)	(13.27)	(19.87)	(-14.94)
PCT4554	-0.0810	0.2954	0.7643	-0.9803	0.8630	0.6054	-0.1678
	(-2.06)	(5.69)	(19.15)	(-28)	(25.25)	(20.88)	(-5.52)

TABLE 5.3 b REGRESSION RESULTS BY TIME PERIOD
(Excluding Property Tax Rates)

	1983	1984	1985	1986	1987	1988	1989
R^2	27.4	21.8	30.4	16.7	16.4	17.2	24.0
Adj R^2	27.4	21.8	30.3	16.6	16.4	17.2	23.9
INTERCEP	-1.6415	0.8197	0.4863	-0.1134	-0.6652	0.4111	-0.3769
	(-74.12)	(29.99)	(21.32)	(-5.34)	(-35.35)	(24.75)	(-24.26)
TXDIFF	0.0244	-0.0138	-0.0023	-0.0369	0.0157	-0.0198	0.0000
	(28.37)	(-10.6)	(-1.99)	(-32.39)	(14.68)	(-22.18)	(0)
PCTCOLL	0.0904	-0.2194	-0.0430	0.0777	-0.0035	-0.1132	-0.0827
	(18.13)	(-34.48)	(-7.77)	(16.38)	(-0.86)	(-27.19)	(-18.61)
RESPCT	0.0415	-0.2608	0.2900	-0.1831	0.0477	0.1312	-0.0534
	(4.98)	(-24.58)	(32.47)	(-21.36)	(6.35)	(19.62)	(-8.31)
INDPCT	0.1023	-0.2291	0.0428	-0.1346	0.0460	0.1400	-0.0248
	(8.78)	(-16)	(3.61)	(-11.56)	(4.47)	(15.87)	(-2.62)
DENSITY	0.0080	0.0022	0.0010	-0.0037	0.0044	-0.0051	0.0049
	(44.51)	(9.52)	(4.82)	(-18.96)	(24.83)	(-33.31)	(31.56)
RESCONST	0.0011	-0.0120	0.0139	0.0092	-0.0019	-0.0017	0.0026
($000)	(2.62)	(-22.4)	(28.46)	(25.45)	(-7.7)	(-7.63)	(17.24)
TRNSTIME	-0.0004	0.0032	-0.0005	-0.0001	-0.0006	0.0003	0.0006
	(-12.06)	(68.75)	(-12.26)	(-1.86)	(-16.52)	(11.53)	(20.28)
AUTOCBD	0.0015	-0.0029	-0.0015	-0.0018	0.0009	-0.0024	-0.0001
	(18.72)	(-29.55)	(-17.51)	(-20.5)	(11.69)	(-40.56)	(-1.57)
AUTOTHER	0.0010	-0.0001	0.0016	-0.0001	0.0013	0.0012	0.0011
	(17.97)	(-1.22)	(25.64)	(-1.57)	(25.36)	(30.43)	(26.11)
HHINC	0.0035	0.0017	-0.0044	0.0023	0.0012	0.0012	0.0019
($000)	(30.35)	(12.15)	(-37.57)	(21.19)	(12.42)	(15.55)	(22.74)
UNEMP	0.0100	-0.0052	-0.0002	0.0347	0.0100	0.0117	-0.0201
	(22)	(-6.74)	(-0.22)	(47.21)	(21.07)	(22.85)	(-38.59)
WHTPCT	0.0152	-0.0048	-0.0038	0.0038	0.0030	-0.0073	0.0037
	(74.64)	(-18.4)	(-17.49)	(18.37)	(16.4)	(-46.5)	(26.62)
HHOLDS	0.0019	0.0006	-0.0018	0.0019	-0.0002	-0.0005	0.0012
(000)	(29.56)	(6.9)	(-24.66)	(27.7)	(-2.72)	(8.74)	(23.96)
PCT2534	-0.0621	0.0102	0.1060	-0.1521	0.3979	0.3563	-0.1079
	(-3.29)	(0.45)	(5.94)	(-9.5)	(25.85)	(25.88)	(-7.37)
PCT3544	-0.6177	0.4361	0.0984	-0.4705	0.2844	0.4547	-0.3527
	(-25.44)	(13.39)	(3.92)	(-21.33)	(12.54)	(22.64)	(-16.86)
PCT4554	-0.1539	0.3215	0.6325	-0.8941	0.9243	0.5158	-0.1064
	(-3.85)	(6.24)	(15.72)	(-25.26)	(27.24)	(17.63)	(-3.5)

TABLE 5.3 c

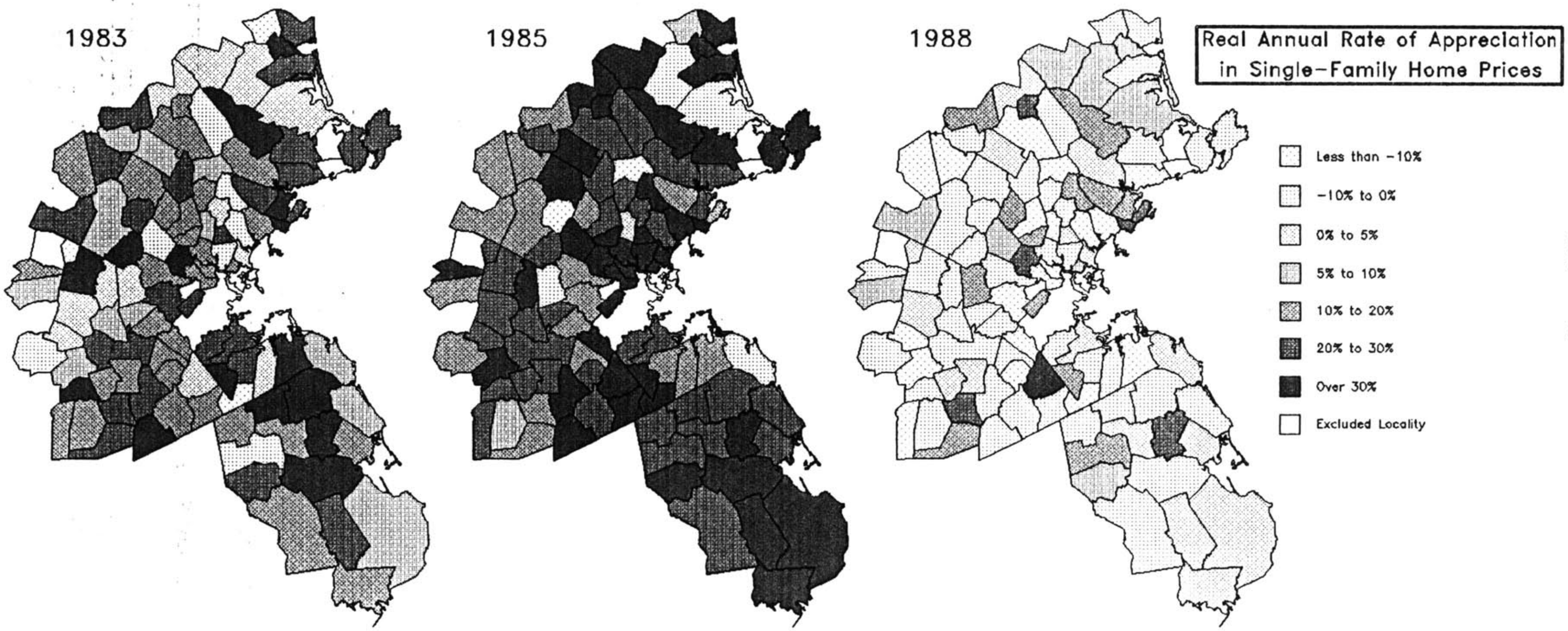
REGRESSION RESULTS BY TIME PERIOD
(Includes Select Variables)

	1983.0000	1984.0000	1985.0000	1986.0000	1987.0000	1988.0000	1989.0000
R^2	3.2	5.6	21.8	2.8	3.1	5.4	3.8
Adj R^2	3.2	5.6	21.8	2.8	3.1	5.4	3.8
INTERCEP	0.0276	0.3991	-0.0251	0.2330	-0.0770	-0.1383	-0.0523
	(4.3)	(50.41)	(-3.83)	(35.18)	(-12.87)	(-26.86)	(-9.52)
TXRT	0.0020	-0.0017	0.0048	-0.0044	0.0035	0.0054	-0.0027
	(12.33)	(-8.13)	(23.43)	(-21.85)	(12.99)	(28.22)	(-12.9)
PCTCOLL	0.0265	-0.0386	-0.1661	-0.0282	0.0127	-0.0227	0.0320
	(6.64)	(-8.48)	(-43.7)	(-8.0)	(3.91)	(-7.55)	(10.07)
RESPCT	0.0844	-0.1283	0.2473	-0.0299	0.0340	0.0799	0.0130
	(16.94)	(-21.53)	(51.61)	(-6.05)	(7.77)	(21.21)	(3.21)
DENSITY	0.0008	0.0031	0.0037	0.0005	0.0018	-0.0018	0.0021
	(4.84)	(16.21)	(24.01)	(3.22)	(13.79)	(-14.89)	(15.56)
RESCONST	-0.0025	-0.0025	0.0069	0.0054	-0.0002	-0.0020	0.0027
($000)	(-5.65)	(-5.05)	(16.25)	(15.98)	(-0.94)	(-9.71)	(17.59)
AUTOCBD	-0.0001	0.0004	0.0003	-0.0004	0.0006	-0.0004	0.0001
	(-3.21)	(7.74)	(6.05)	(-10.04)	(17.85)	(-12.07)	(1.83)

commuting time to the Boston CBD of more than forty minutes, and a density of less than four persons per acre was included in this category.

Thematic mapping tools were employed to try and sort out some of the complexity of the regression model caused by relationships between variables across the dimensions of both time and space. Initially, the rates of appreciation in housing prices by community for each year obtained from the WRS model were examined (Figure 5.1). Subsequent to this analysis of the dependent variable, a number of the explanatory variables were mapped by locality over time. The spatial analysis of the dependent variable exhibited appreciation rates somewhat lower to the West of Boston, especially between Route 2 and Route 9. This divergence from the general trend may be partially explained by relatively higher rates of appreciation in these western suburbs in earlier periods not incorporated into this analysis. Furthermore, the base price of housing in these areas commonly exceeded that of neighboring communities. Thus, although the percentage increase in property values remained lower, the dollar value of appreciation may have surpassed that of other areas. In the following section of this chapter I present my interpretations of the model results. I analyze the relationships within each of the three major categories of determinants: financial and fiscal factors, locational factors, and demographic determinants. I support the validity of these interpretations with thematic maps which, as discussed earlier in this chapter, enhance the understanding of the spatial and time-series relationships between variables.

FIGURE 5.1


1983
1985
1988
Real Annual Rate of Appreciation in Single-Family Home Prices
Less than -10%
-10% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 30%
Over 30%
Excluded Locality

In order to aid in interpretation of which of the various model forms I am referring to, given the array of models to be discussed here, I will consistently refer to the specifications as model formulations. These model formulations are: (1) including property tax rates; (2) excluding property tax rates; (3) and including only the variables exhibiting the most significant relationship with the dependent variable. The subclassification of municipalities into type (cities, excluding cities, and exurban) will be referred to here as type-specific models. The models in which the time-series component was eliminated, and the data separated by year, will be consistently referred to as time-period models. In the following section I examine the fit of the various models and the effects of each of the explanatory variables on the dependent variable, annual housing price appreciation rates.

Overall Model Fit

In the full regression model (Table 5.2a, column 1) 38.5 percent of the variation in the dependent variable, rate of appreciation in housing prices (ANNGRWTH), was explained. In this model all the determinants, excluding rates of unemployment, exhibited a statistically significant (at 1 percent) relationship with the dependent variable. As discussed previously and as reflected in Table 5.2 a, property tax rates (TXRT) displayed a highly unexpected significant positive impact on the dependent variable. In order to get a better grasp of the impact of TXRT it was eliminated from the second model formulation. As apparent from the results in Table 5.2b, a substantial amount of the explanatory power of the model was lost through the elimination of the TXRT variable. The measure of fit (Adjusted R-Squared) declines by nearly one-half, thus only 22.6 percent of the variation in ANNGRWTH was explained by the model when TXRT was eliminated. In this model, however, all of the remaining variables are significant at the .01 level. The sharp rise in the t-statistic for UNEMP is due to its correlation with the TXRT variable.

In the final submodel examined only six of the original seventeen variables were included but the fit of the model is not seriously impaired. The Adjusted R-squared indicated that 35.3 percent of the variation in ANNGRWTH could be explained with the model. A loss of only 3.2 percent of the explanatory power with just over one third as many variables included.

In the type-specific submodel specifications excluding cities and including only exurban area similar trends were depicted. The predictive ability of these models did not decline substantially with the decline in observations. Furthermore, in both submodels relatively little explanatory power was lost by eliminating the multicollinear variables. In the model excluding cities only 2.3 percent of the explanatory value is lost as the R-Squared and Adjusted R-Squared from 35.4 percent to 33.1 percent, while the exurban model exhibited a decline of only 2.7 percent from a level of 37.7 percent to 35.9 percent. In both of these model-formulations of the type-specific submodels all variables were statistically significant at .01. Similar to the full model, removal of TXRT from these type-specific models caused a sharp reduction in their predictive value, especially in the model excluding cities.

In the type-specific city model a different set of relationships was evident. In the full model-formulation for cities, the TXRT variable contributed less to the models explanatory power than in the other models, and DENSITY, UNEMP, and RESCONST all had more significant coefficients than TXRT. The explanatory power of the city model was exceedingly high, 75.8 percent. Because of the reduced efficiency of the TXRT variable and augmented explanatory power of other variables, especially UNEMP, which was not included in the model controlling for collinearity, little explanatory power was lost when TXRT is eliminated and the Adjusted R-Squared is reduced only 3 percent to 72.8 percent. In contrast, the reduction in fit of the other submodel was substantial.

Controlling for time through the time-period models sharply reduced the explanatory value of the TXRT variable. Thus little was lost when the TXRT variable is eliminated. In these time-period models both the sign and significance of the parameter estimates, as illustrated through the t-statistic, varied from period to period. Furthermore, as would be expected, in those years where the market was either primarily rising (1983 - 1985) or falling (1989) the fit is best. When time was controlled for, the fit of the model in which multicollinearity was eliminated sharply reduced in all years except the boom year of 1985. In the next section of this chapter I look more closely at the effects of each of the explanatory variables on the dependent variable rate of appreciation in single-family home prices.

Fiscal Determinants

Effective Property Tax Rates

As discussed in Chapter Two, according to the Tiebout theory housing prices should be lower in municipalities with higher property tax rates, all other things being equal. The discussion of expected results in Chapter Four was consistent with the Tiebout theory, as a negative relationship between tax rates and the real rate of appreciation in housing prices was predicted. In the original full model formulation examined, the observed relationship between tax rates and rates of housing price appreciation was strong and positive. In fact, the strength of the positive correlation between these two variables exceeded that of any other explanatory variable with housing price appreciation.

Although these results initially appeared counter-intuitive, and perhaps erroneous given the theory of tax capitalization, by delving deeper into the relationship between these variables the likely cause of the counterintuitive results was revealed. The tax rate variable maintained a strong positive relationship with the dependent variable across all type-specific models. The strength of this relationship appeared strongest in urban communities, while outlying communities exhibited the weakest relationship. Thus cross sectional analysis of this variable lent little to the interpretation of these incongruous results.

Analysis of the tax rate variable over time, however, was quite revealing. As mentioned in Chapter Four, effective tax rates were calculated using data available biannually from the State. Taxes levied by a locality increase annually, thus basing property tax rates on the same assessed value for two consecutive years will cause the tax rate to exhibit a biannual jump. Examination of the full model results including all explanatory variables revealed this trend, as the parameter estimates for tax rates and their corresponding t-statistics display annual volatility in their sign.

Effective tax rates were utilized in an attempt to control for variations among communities in the assessment ratio, as some localities base assessment on less than full property value. Utilization of this surrogate tax measure, however, did not perform as anticipated. Although the effective tax rate accounted for explicit variations in the rate of assessment between communities, it failed to account for implicit variations in assessment rates due to discrepancies in the timing and accuracy of reassessment among communities.

As discussed in the previous chapter, Massachusetts law requires reassessment of all properties within a community on a biannual basis. However, there is nearly a two year lag between the reassessment period, and the time when reassessed values are incorporated in to the tax base. Thus if properties were reassessed in 1986, reassessed values would not be reflected in a change in the tax base until fiscal year 1988. This explains the failure of the parameter estimate to exhibit a negative coefficient in 1988 because, as housing prices were generally declining during that period, reassessment increased the tax base of most communities, and thus a lower tax rate was required to cover local expenditures. In contrast, in 1989 a negative relationship was exhibited between TXRT and ANNGRWTH because as housing prices continued to decline, municipalities faced with rising expenses, and a constant tax base from the previous year, resorted to increased property tax rates as a means to balance their budgets.

In order to lend credence and understanding to the time-period relationship between these property tax and appreciation variables, comparisons were made between rates of increase in the assessed values of residential property and actual rates of housing price appreciation. This was done by indexing both variables, assessed value and housing price appreciation rates, to their 1983 levels, and then analyzing the ratio of the indexed assessed value to indexed appreciation rates. In equilibrium, this ratio would maintain a value of one. If property values are underassessed, the ratio would decline below unity, while overvaluation of property by the governing body would cause the rate to exceed one. The results of this analysis revealed a general decline in this ratio through 1988, accompanied by rising property tax rates. In 1988 a reversal occurred and in many communities the value of the ratio greatly exceeded one. The discrepancy between assessed value and appreciation was even larger than apparent from the ratio of these indexes, as the appreciation rates examined were real rates of appreciation, while the assessed values were expressed in nominal form.

Figure 5.1 clearly exhibits the magnitude of the variation between 1985 and 1988. In 1985, when rates of housing price appreciation were at their peak, properties were considerably underassessed in most localities. However, the revaluation which occurred in 1986 and was instituted in many communities in 1988, caused the change in the assessed value to exceed the actual market appreciation rate. This was caused by the lag effect of using the 1986 assessed values, because in 1988 property values had begun to decline, thus the 1986 assessed values overstated true property values as of 1988. One may argue that the index ratio used here would be more appropriate if based on the equalized property value, rather than the assessed value. In this study it was determined that, although the equalized value included commercial property, utilizing it to compute the effective property tax rate was the only alternative to the base property tax rate. However, using the actual equalized property value as a proxy for residential property value could sharply bias any comparison between this variable and actual housing price appreciation rates, depending on the change in the of commercial property to residential property within a locality over time. However, in order to substantiate the validity of the results obtained in the index, I examined the ratio of indexed equalized property value to rates of housing price appreciation, and found that the magnitude in both the decline and the later (1988) rise of the ratio to exceed its amplitude when utilizing indexed assessed property values in the numerator.

Figure 5.2 exhibits the effect of this rise in reassessed value on property tax rates. In nearly all communities where the indexed ratio exceeded one in 1988, property tax rates dropped dramatically. This figure also exhibits a spatial distinction in this ratio. During 1985, in communities west of the city of Boston, the ratio between indexed assessed value and indexed rates of home price appreciation remained closer to equilibrium. This trend also held true for effective property tax rates which also were not as volatile as in the western suburbs. As Figure 5.3 depicts, a relatively larger share of communities with lower tax rates were evident in the western suburbs of Middlesex and Norfolk Counties than were evident elsewhere. These lower tax rates were particularly evident between Route 2 and Route 9 where rates of housing price appreciation were generally lower. This trend may be partially attributable to generally higher initial property values and amenities in these western suburban localities where structural amenities tend to be considerable.

Finally, Figure 5.3 demonstrates an urban effect. As Hamilton (1975) concluded, property tax capitalization does not hold in urban areas. The more urban municipalities just north and west of Boston exhibited some of the highest property tax rates in the early and mid 1980s. These rates, however, did not appear to impact appreciation, as these higher taxed localities maintained a respectable rate of appreciation, especially during mid-decade.

FIGURE 5.2

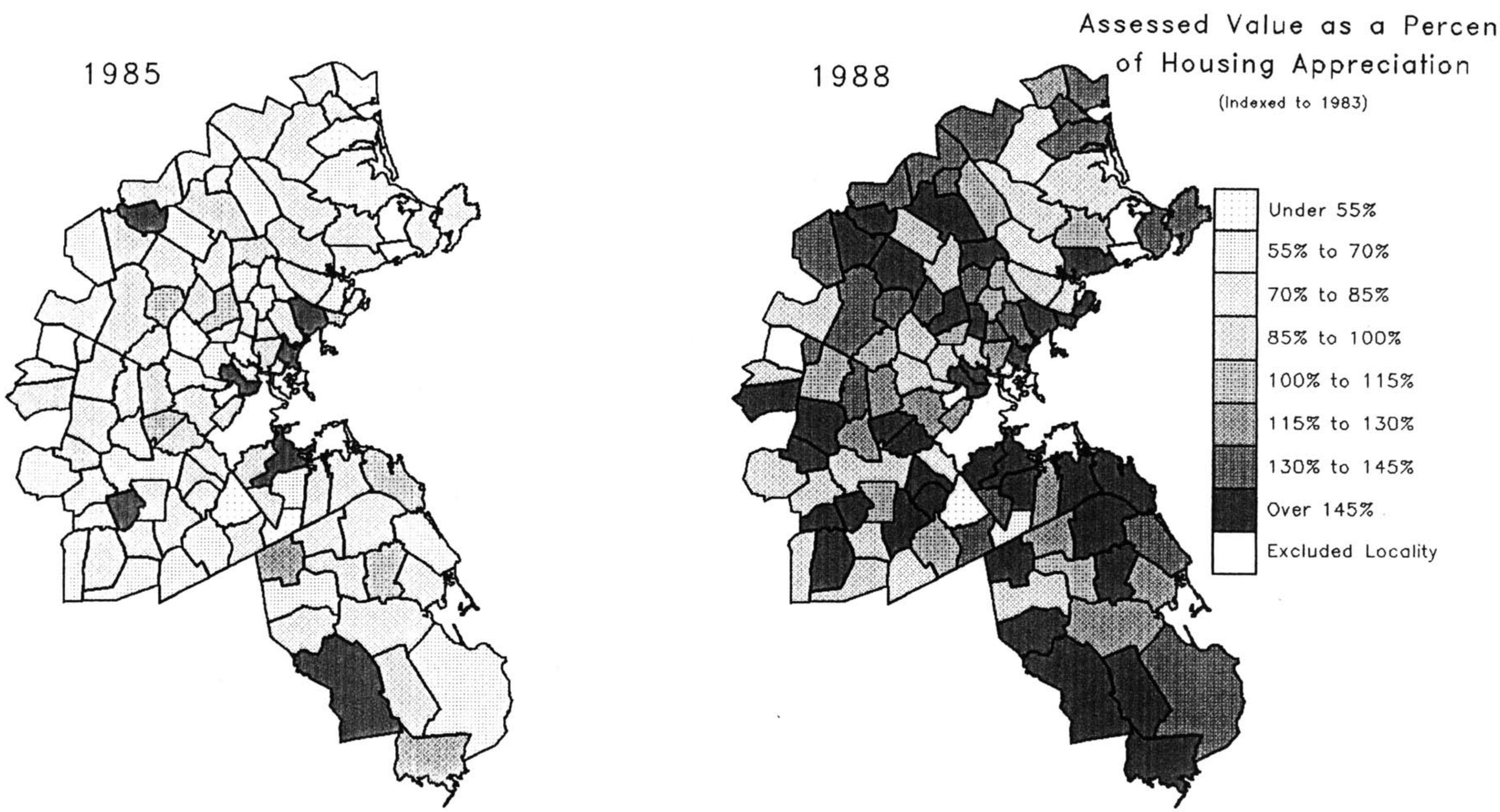
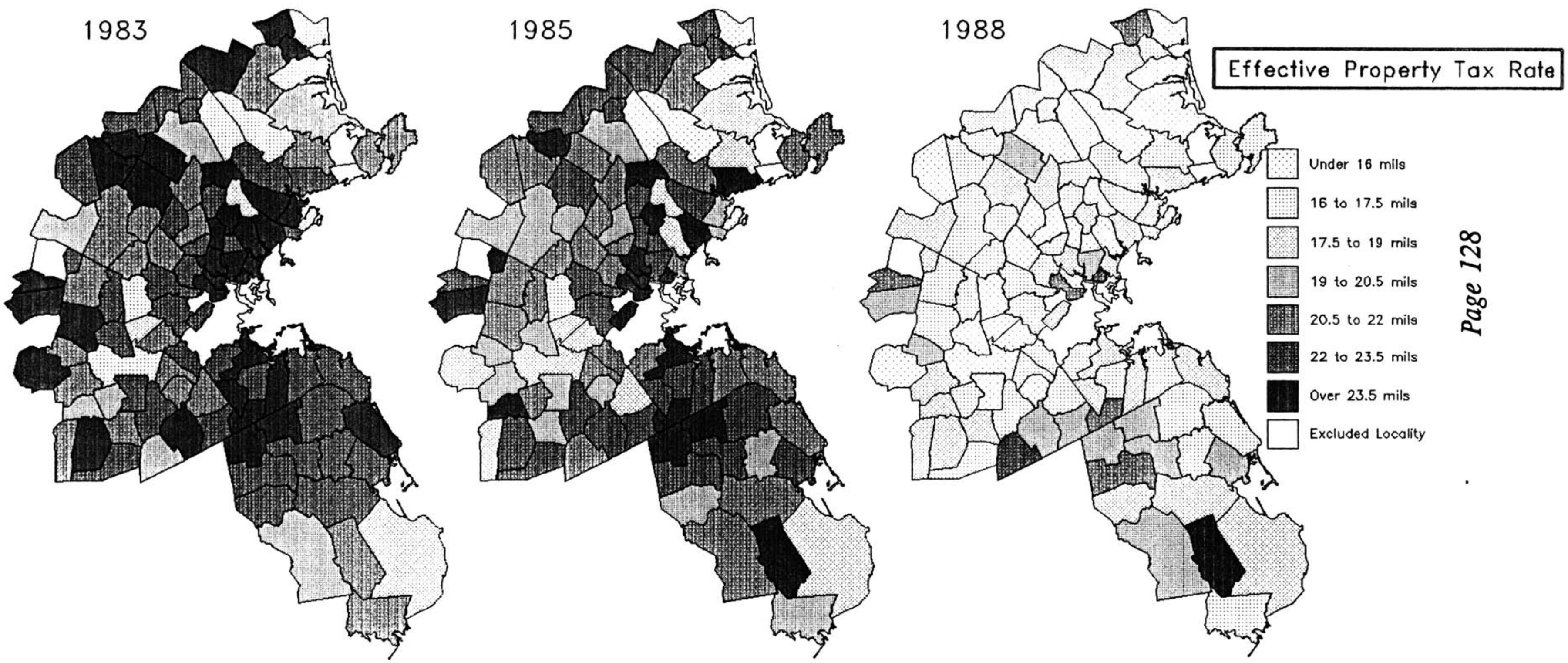

1985
1988
Assessed Value as a Percent
of Housing Appreciation
(Indexed to 1983)
Under 55%
55% to 70%
70% to 85%
85% to 100%
100% to 115%
115% to 130%
130% to 145%
Over 145%
Excluded Locality

FIGURE 5.3


1983
1985
1988
Effective Property Tax Rate
Under 16 mils
16 to 17.5 mils
17.5 to 19 mils
19 to 20.5 mils
20.5 to 22 mils
22 to 23.5 mils
Over 23.5 mils
Excluded Locality

The interplay of endogenous factors affecting the tax rate variable was far more complex than with any of the other variables. Thus a summary of these factors is especially appropriate. The primary deficiency of the tax variable appeared to be due to two lag factors: The first lag factor was a result of the biannual measure of equalized property value computed by the State; the second factor was apparently induced because of nearly a two year lag between reassessment and adjustment of the tax base to reflect these reassessed values. In addition to these lag factors, other causes of the unanticipated relationship between the tax rate variable and the rate of appreciation in home values were evident. In communities west of the city rates of housing price appreciation were lowest, due either to a higher base and/or higher pre-study rates of appreciation. In addition, these localities maintained some of the lowest property tax rates in the study area. Furthermore, more urban localities in close proximity to Boston demonstrated high rates of appreciation, accompanied by high property tax rates. This apparent relationship lent supports to the Hamilton variation of the Tiebout hypothesis which concludes that the tax capitalization theory does not hold in urban areas.

Dummy Variable for Differential Tax Rates

As discussed in the last chapter, the expected sign of the dummy variable coefficient for differential tax rates was ambiguous. This was due to uncertainty over whether differential tax rates (TXDIFF) were used primarily as an exclusionary zoning tool, or as a tax on commercial and industrial land use. The correlation between TXDIFF and the real average annual rate of housing price appreciation (ANNGRWTH) confirmed that the later of these two potential relationships was most apparent. TXDIFF displayed a high positive correlation with the percentage of industrial land use (INDPCT) within a locality. Given this relationship with INDPCT one would expect a negative relationship to ANNGRWTH. However, in the full model formulation a positive coefficient on ANNGRWTH existed. In the matrix of correlations between the explanatory variables and ANNGRWTH (Table 5.1 a,b), the relationship between TXDIFF and ANNGRWTH was positive.

In the type-specific submodels this positive relationship was strongest in urban localities. This may have been partially attributable to a larger percentage of commercial land in urban areas, which tends not to exhibit the same negative externalities as industrial land use. Alternatively, this positive relationship may have resulted from higher rates of appreciation in urban areas. The significance of the relationship between TXDIFF and ANNGRWTH was strengthened in all of the type-specific models. In the full model and the urban type-specific model the relationship was strongly positive, while in exurban localities the relationship appeared strongly negative. In the type-specific model excluding cities, a negative relationship also existed, but to a lesser extent than in exurban areas. The cause of the substantial positive strength of the relationship in the full and urban models may have been partially due to multicollinearity between TXDIFF and INDPCT, as the sign on the coefficient of this variable changed in urban areas, and the negative relationship in the full model was enhanced.

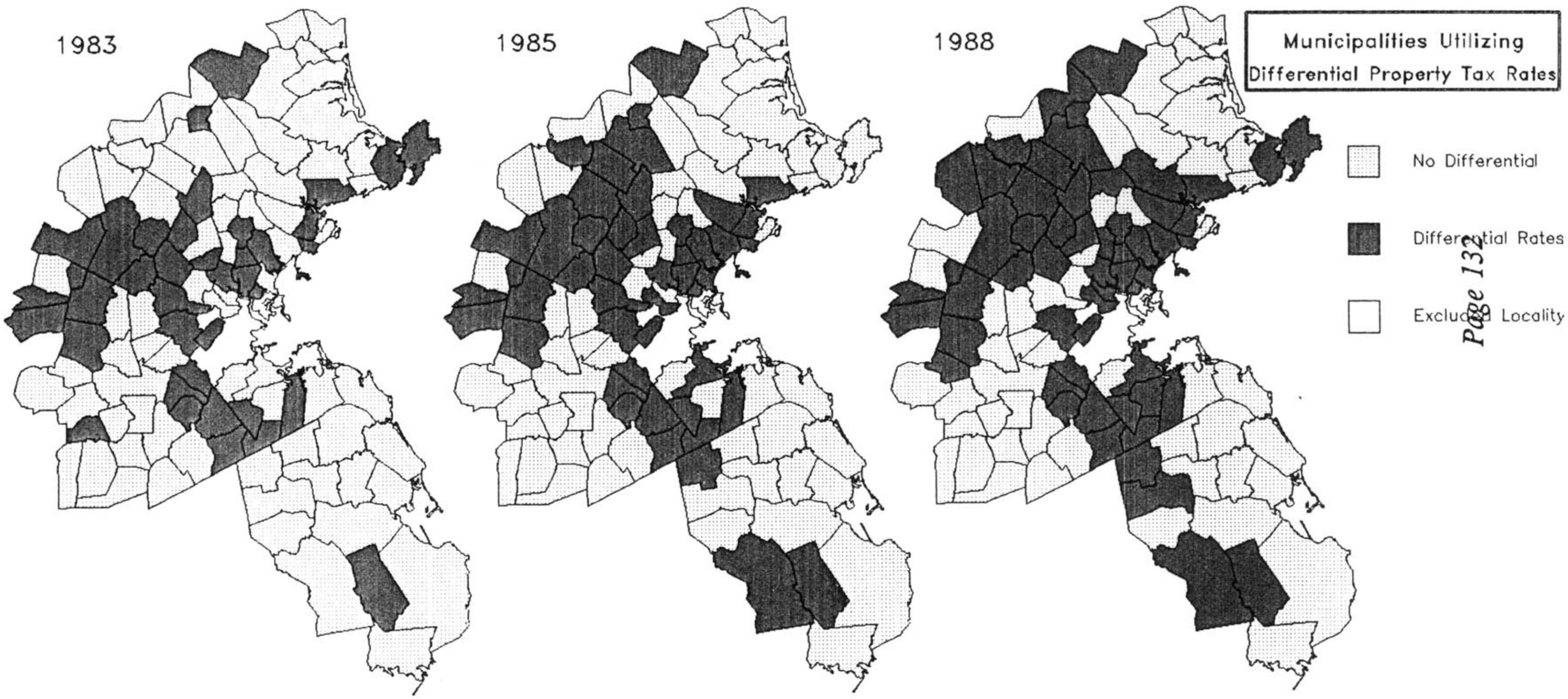
The relationship between rates of housing price appreciation (ANNGRWTH) and TXDIFF fluctuated in the time-period models, revealing little about the cause of the consistently positive coefficient evident in the overall and type-specific models. In fact, in the simple correlation matrix a positive relationship only exists during the first two study years, 1983 and 1984. Specification of the time-period full model formulation by year also depicted a generally negative coefficient on the TXDIFF variable, with the exceptions being 1983 and 1987. Thus, overall it appeared that the positive effect was induced primarily by the relationship of TXDIFF with appreciation in urban areas and its high degree of correlation with INDPCT. Further analysis of this later relationship will be discussed in the section on the INDPCT variable.

The negative relationship between TXDIFF and ANNGRWTH in exurban areas, as well as its converse relationship in urban areas is clarified by Figure 5.4. As this map indicates. those exurban communities exhibiting the highest rates of appreciation in property values during the period generally had nor invoked differential tax rates. In contrast, as indicated by both Figure 5.4 and Table 4.4 in the last chapter, most of the cities in the type-specific city model instituted the differential tax provision during the 1983 to 1985 period, when housing prices were rapidly rising.

Education

In the full model formulation the relationship exhibited between education and rates of housing price appreciation (ANNGRWTH) was also initially counterintuitive, with

FIGURE 5.4


1983
1985
1988
Municipalities Utilizing
Differential Property Tax Rates
No Differential
Differential Rates
Excluded Locality

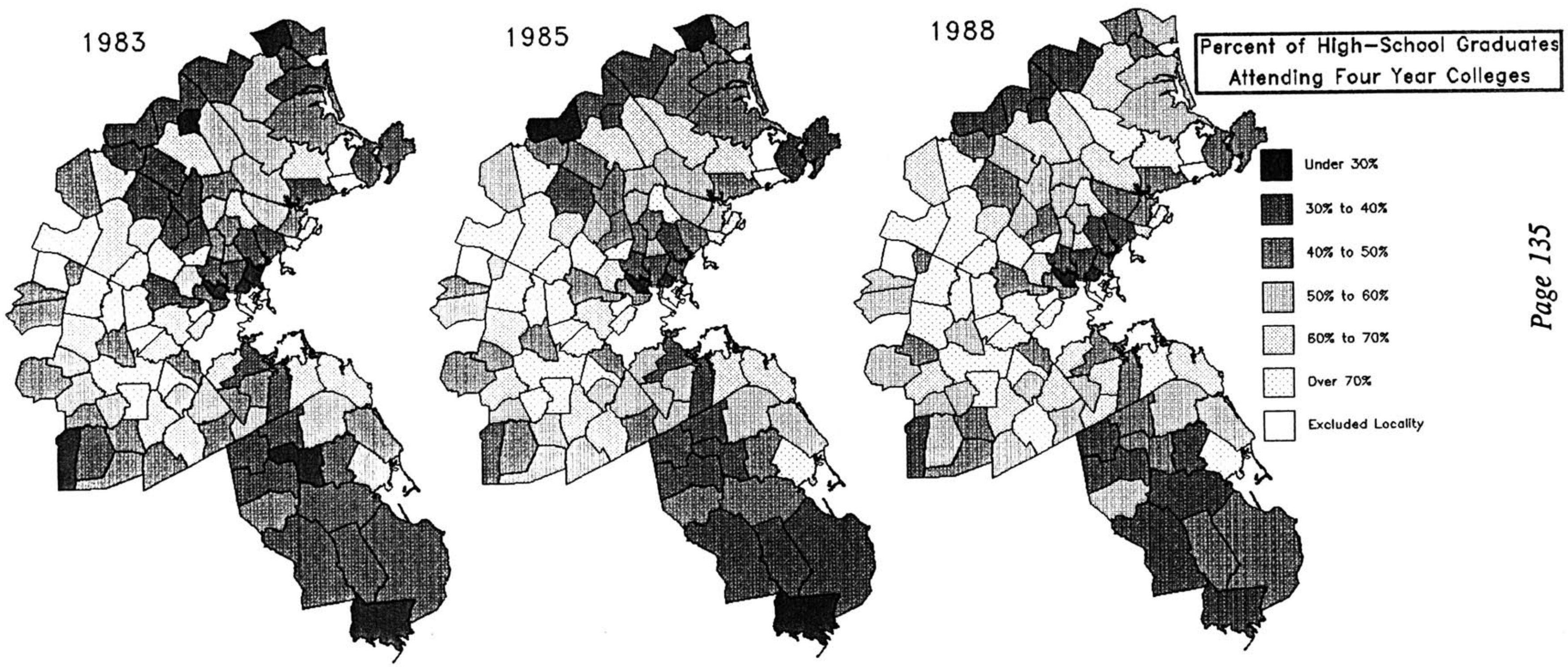
appreciation rates apparently higher in municipalities where fewer high-school students pursued a college education (PCTCOLL). Upon closer scrutiny of this variable, however, much was revealed about the true cause of this seemingly anomalous relationship.

The type-specific analysis lent little to the understanding of the unexpected results obtained for the PCTCOLL variable. In the simple correlation matrix the relationship between PCTCOLL and ANNGRWTH remained consistently negative, with the strongest negative relationship exhibited in the outlying or exurban towns. In both the type-specific and full models, the negative relationship between PCTCOLL and ANNGRWTH persisted, with the city model being the lone exception. As evident from the correlation matrix presented in Appendix F, this variable was highly positively correlated with household income (HHINC) and the older age categories (AGE3544, AGE4554) which are generally associated with increased affluence. PCTCOLL also displays a negative relationship with the rate of unemployment. However, as this matrix also showed, all variables generally associated with more affluent communities exhibit a negative relationship with rates of appreciation. This fact, and the fact that generally, both ANNGRWTH and PCTCOLL were increasing over time caused me to focus on the time-series effect for an answer to the unanticipated relationship between these variables.

Time-period analysis of this variable did, in fact, clarify the cause of the negative relationship between ANNGRWTH and PCTCOLL. The strongest negative association exhibited between these variables in the simple correlation matrix (Table 5.1b) occurred in 1985. A significant negative relationship also was evident in 1984. This negative relationship persisted in all three model formulations, with the negative coefficient of the PCTCOLL variable most significant in the third model formulation where most of the multicollinearity was eliminated. The two years when the correlation was strongest, 1984 and 1985, were the peak years of the market boom. During this time period the real estate market in the study area was generally considered a 'gold mine' and gentrification and consequent displacement of the generally less highly educated urban and rural poor ensued.

The PCTCOLL variable also exhibits a negative relationship with ANNGRWTH late in the decade, although this negative relationship was caused by a different set of factors. During the entire study period PCTCOLL continued to rise in most communities. However, in the last two years of the decade this rise was accompanied by a decline in prices, resulting in a negative relationship between PCTCOLL and ANNGRWTH. Figure 5.5 helps clarify the relationship between these variables. As discussed previously, the western suburbs exhibited the lowest rate of housing price appreciation in the area overall. However, this area to the west of Boston consistently maintained the largest proportion of high-school graduates pursuing high education. During the mid 1980s ANNGRWTH was strongest in the areas where the level of education was lowest, particularly in the southern portion of Plymouth County, and the more urban communities just north of Boston. During the later part of the decade most areas

FIGURE 5.5


1983
1985
1988
Percent of High-School Graduates
Attending Four Year Colleges
Under 30%
30% to 40%
40% to 50%
50% to 60%
60% to 70%
Over 70%
Excluded Locality

suffered from declining property values. However, those communities where property values continued to rise were located primarily to the far north and south of Boston, where PCTCOLL was proportionally lower than in the western suburbs. The examination of the locational factors presented in the following section further assisted in the interpretation of the distinct impacts of the explanatory variables across the dimensions of both time and space.

Locational Factors

Percent Residential

The relationship between rates of housing price appreciation (ANNGRWTH) and the percentage of total assessed value classified as either residential or open space (RESPCT) was positive, as anticipated in Chapter Four. This positive relationship, exhibited in the simple correlation matrix of type-specific models (Table 5.1a), was strongest in the outlying or exurban areas, while the relationship in cities was negative. The negative relationship evident in cities may have been a function of the percentage of commercial property within a city, a variable excluded from this model. The more dense urban cities with a higher proportion of commercial and industrial property, as opposed to residential property, may have been considered more desirable during the period, thus the negative relationship. In the full-type-specific model formulation, both cities and exurban areas displayed a negative relationship between RESPCT and ANNGRWTH. The deviation in the magnitude and significance of the sign of the coefficient on RESPCT in exurban areas may have been caused by the strong negative relationship between this variable and the industrial property variable discussed in the following section.

The correlation between RESPCT and ANNGRWTH remained primarily positive over time (Table 5.1b). In 1984 and 1986, however, the relationship was negative. This again may be explained by an urban gentrification phenomena, especially in 1984 but also in 1986, when the corresponding coefficient on industrial property was strong and positive and other variables indicative of urbanization such as density, minority population, and number of households all displayed a strong positive relationship with ANNGRWTH. In both of these years, a negative sign for RESPCT was also consistently exhibited throughout all model formulations (Table 5.2, 5.3), and the significance of this negative relationship increased when the tax rate (TXRT) variable was eliminated from the model. This rise in significance was caused by the consistently strong negative relationship between the RESPCT and TXRT variables. Analysis of the spatial relationship between RESPCT and ANNGRWTH revealed no particular trends, thus these maps were not included.

Percent Industrial

As discussed earlier in this chapter, the percentage of total assessed value classified as industrial (INDPCT) exhibited a substantial degree of collinearity with both the differential tax rate variable (TXDIFF) and the variable conveying the percentage of total assessed value classified as either residential or open space (RESPCT). Furthermore, the correlation of INDPCT with rates of appreciation in housing prices (ANNGRWTH) was lower than with the two variables with which it is closely related (RESPCT, TXDIFF) (Table 5.1a). The INDPCT variable exhibited a negative relationship with ANNGRWTH in all type-specific models except for the city model. This relationship was consistent with expectations. The positive relationship in the city model may have been due to consistent undervaluation or undesirability of properties in these more highly industrial localities prior to the boom of the mid-1980s. During the decade, urban revitalization occurred in highly industrial areas such as Lowell, and to a lesser extent, Lawrence.

In the full model formulation INDPCT consistently maintained a negative relationship with ANNGRWTH (Table 5.2a). This relationship was strongest in the exurban type-specific model, but a negative coefficient was also exhibited in the city model, most likely due to the multicollinearity between INDPCT and both RESPCT and TXDIFF discussed above. When the tax rate (TXRT) variable was eliminated from the model, the coefficient remained negative only in the exurban areas (Table 5.2b). This again may be explained by correlation between INDPCT and RESPCT.

The correlation of INDPCT with ANNGRWTH remained primarily negative over time, as would be expected (Table 5.1b). However, as discussed above, this variable exhibited a positive relationship with ANNGRWTH in 1984 and 1986, probably due to urban gentrification. In the time-period models the relationship remained the same as in the correlation matrix (Tables 5.3a-c). The only variation occurred in 1989, and may be explained by two factors: (1) the lack of the TXDIFF variable during that year, with which INDPCT was highly correlated; (2) and the positive correlation between INDPCT and RESPCT. As with the RESPCT variable, no significant spatial relationship was exhibited in the map of INDPCT,thus this map was not included here.

Density

The relationship between density and appreciation in housing values was positive in all type-specific correlation matrices excluding exurban areas (Table 5.2a-c). The exurban effect was consistent with expectations, as open space is a valued attribute, and thus for an individual or family choosing to locate far outside the city, a prime motivating factor may be the abundance of open space in the area. In more urban settings it appears that more densely populated areas are often desirable. Although this is inconsistent with original expectations it is not necessarily counterintuitive, for reasons opposite those expected in exurban areas. Some individuals may opt for the vibrancy of urban life, and more densely populated urban areas tend to be larger, and often maintain a more vibrant character as well as a wider array of cultural and entertainment facilities. Thus the only truly unexpected relationship existed in suburban communities.

It is interesting to note that the coefficient on the INDPCT variable, when examined in the full regression model formulation, displayed a negative coefficient in all of the sub-models, but retained a positive impact on ANNGRWTH when all localities were included (Table 5.2a). This may be due to the significant correlation of DENSITY with other variables specified in this model. Elimination of the tax rate (TXRT) variable altered the impact of the DENSITY variable, weakening its negative impact in all but the city model, where the coefficient gained in negative strength (Table 5.2b). Once again these altered relationships may be attributable to the effects of multicollinearity between DENSITY and TXRT, as well as between DENSITY and Households (HHOLDS), and HHOLDS and TXRT, as more urban areas exhibit higher density, and generally higher tax rates. In the final model formulation using only a subset of the variables with the most descriptive power (Table 5.2c), the coefficient on density remains large and negative in all three type-specific models. This effect is the effect originally anticipated, but here may be caused more by the relationship between TXRT and DENSITY than through a negative relationship with appreciation rates.

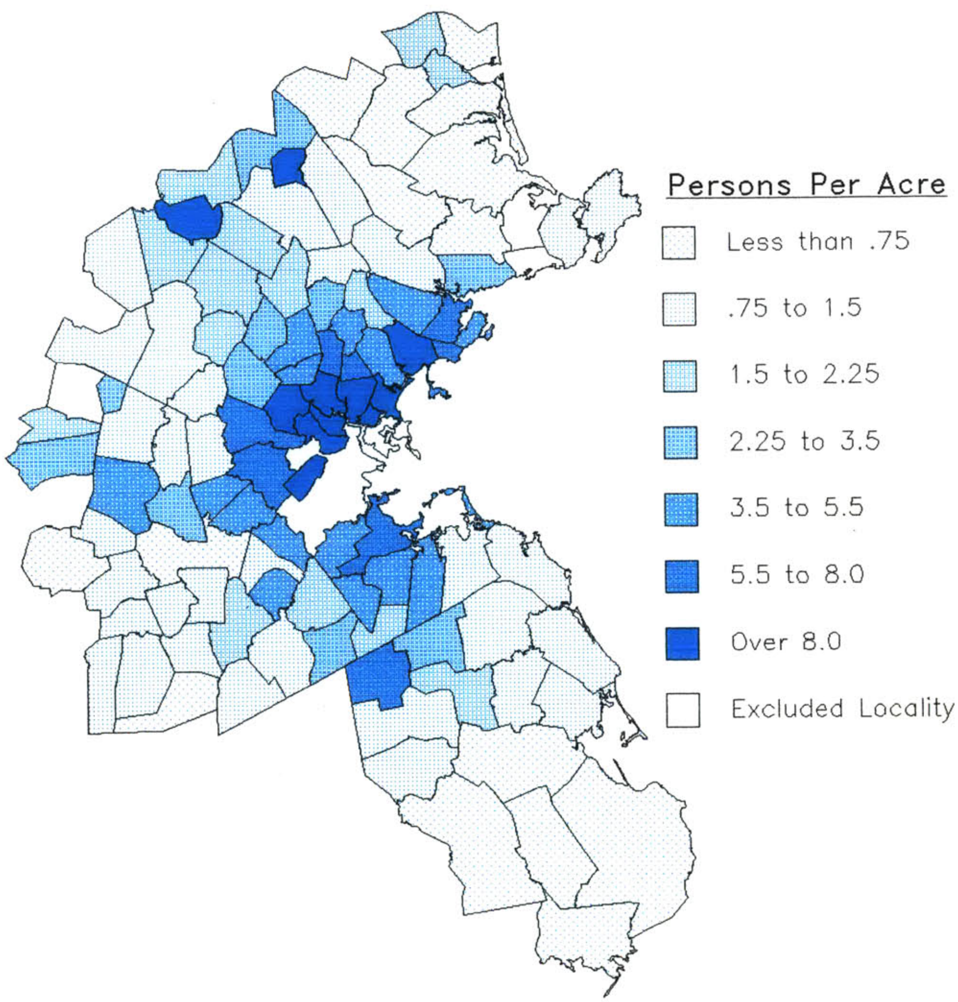
Analysis of the correlation of the DENSITY variable over time with ANNGRWTH again depicted gentrification and high appreciation during the mid 1980s (Table 5.1b). In 1984 and 1985 the correlation between these two variables was extremely high and positive, with a weakening of this relationship occurring as the market weakened in general, and the expected negative sign apparent in 1988. Once again, however, the results of the alternative model formulations are more difficult to interpret, due to a high degree of multicollinearity between DENSITY and other explanatory variables. However, in the regression model including only the most significant variables, the relationship remained similar to that exhibited in the correlation matrix (Table 5.3c). This was likely due to a significant weakening in the explanatory powers of the TXRT variable when controlling for time.

As outlined in Chapter Four, a strong negative relationship between the density variable and ANNGRWTH was initially anticipated. However, this expectation was not supported by the model results, largely due to the effects of gentrification in many localities. In order to more appropriately dissect the cross-sectional and time-series effect of DENSITY, the spatial relationship between DENSITY and ANNGRWTH was examined utilizing thematic mapping tools. Figure 5.6 displays a map of density by community during 1985. Overall, the level of density did not vary substantially within communities over time. Thus the impact of this variable must have been caused by the perceived desirability of a community, given its relatively constant density, over time.

As one would expect, density was highest in the most urban areas surrounding the city of Boston, while 'fingers' of higher density extended from Boston to the west, northwest, and south. These 'fingers' correspond to highway access. The map of density clarifies the locational relationships discussed above. In the exurban areas, primarily to the far south but also to the north, low density was accompanied by higher rates of appreciation, thus the negative relationship between these variables in the exurban type-specific model (Table 5.2). The strong positive urban effect was again largely attributable to the cities and towns lying just north and west of Boston where both density and appreciation rates were high. A less distinctive relationship was evident in the suburbs. However, ANNGRWTH does appear generally higher in close

FIGURE 5.6

DENSITY - 1985



proximity to the northwestern and southern access route, where density tends to be higher.

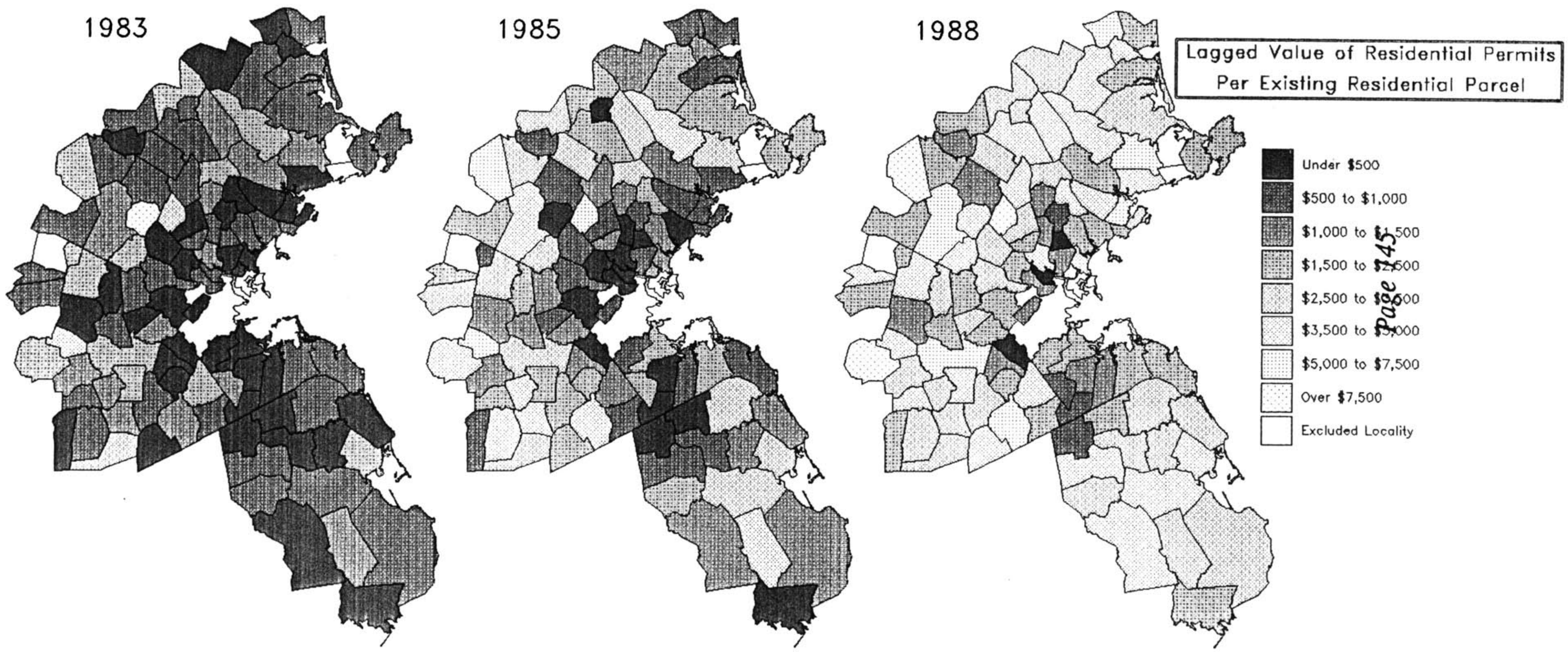
Housing Permits

In Chapter Four I stated my expectation of a negative relationship between the value of housing permits issued per parcel within a community (RESCONST), and rates of housing price appreciation (ANNGRWTH). The relationship exhibited in both the correlation and regression results consistently confirmed these expectations, with the strongest negative relationship evident in the type-specific city model (Table 5.2a-c). This added strength of relationship in the cities may be due to the fact that in the most desirable cities, or those exhibiting the highest rates of appreciation, less urban land was available for development, and land that was available did not necessarily achieve its highest and best use through residential development. This variable is important in that it not only maintains the strong expected results, but exhibits a low correlation with most other variables, excluding tax rates and the 25-34 year-old age cohort variable.

Controlling for time revealed intuitive results, and also the effect of the Boston area housing surplus on the market. In the first half of the decade the correlation between RESCONST and ANNGRWTH was negative (Table 5.1b). This would be expected as higher rates of appreciation generally were not accompanied by an instant response in development, and apparently those communities with less development experienced higher ANNGRWTH. The building boom really took off in 1985 and 1986 and, given a lag of one year, as was used here, both construction and appreciation continued along a positive course, although weakening substantially. By 1988 a surplus in the housing stock was evident and, although construction continued, housing values began to decline, and the relationship once again becomes negative. Finally, by 1989, the health of the region was seriously impaired, development as well as appreciation abated, and a strong positive relationship was once again apparent. In the three variations of the model formulation (including all variables, excluding property tax rates, and including only the most significant variables), a slightly different relationship appeared to hold over time periods (Table 5.3a-c). The coefficient on RESCONST was consistently strong and positive in 1985, 1986 and 1989, while in other years the relationship was either negative, or less strongly positive. The cause of the change in the sign of this variable during 1985 was uncertain.

In order to put the differential rates of development and their relationship with appreciation into clearer perspective, the value of residential permits per existing residential parcels were mapped by community for 1983, 1985 and 1988 (Figure 5.7). As demonstrated elsewhere in this chapter, the western suburban phenomena appears evident. During 1983 communities west of the city generally exhibited higher values of RESCONST then more urban communities, and communities to the south. The value of development far north of the city was fairly mixed. In mid decade, developers recognized the potential for profit through residential development and thus the pace of suburban and exurban development picked up in most regions. However, the pace of

FIGURE 5.7


1983
1985
1988
Lagged Value of Residential Permits
Per Existing Residential Parcel
Under $500
$500 to $1,000
$1,000 to $1,500
$1,500 to $2,500
$2,500 to $3,500
$3,500 to $5,000
$5,000 to $7,500
Over $7,500
Excluded Locality

development in the more urban regions where appreciation remained high did not pick up considerably. By 1988 the amount of residential development was extremely high in all but a few cities and towns. However, during this period it also became evident that development had gone too far and, given the weakening economy, the market would be unable to absorb the addition of this residential property to the total housing stock, thus causing prices to decline.

Accessibility

The three transit variables: automobile commuting time to the Boston CBD (AUTOCBD), automobile commuting time to the suburban employment centers (AUTOTHER), and commuting time via public transit to Boston and the Route 128 employment area (TRNSTIME) are considered in this section. In the last chapter the formulation of these variables was discussed and their expected impact on rates housing prices appreciation was predicted to be negative. However, multi-collinearity may alter these results. AUTOCBD displayed a substantial positive relationship with both of the other two accessibility variables (Appendix F). The cause for the high correlation with TRNSTIME was that 90 percent of those utilizing public transit as a means of commuting were attributed to the CBD market. The relationship between AUTOTHER and AUTOCBD was due to the fact that Boston is located in the center of the study area, while the other employment centers are outside Route 128. Thus, while auto access may be better in close proximity to a particular employment center, the weighted automobile commuting time (AUTOTHER) from within the Route 128 area is typically lower.

In the simple correlation matrix, both the automobile transit modes displayed the expected negative relationship with ANNGRWTH (Table 5.1a). The strength of the negative relationship of the AUTOCBD variable with ANNGRWTH appeared highest in the type-specific exurban model, and lowest in the city model. In contrast, the relationship between AUTOTHER and ANNGRWTH was the opposite, with the negative correlation strongest in the type-specific city model and weakest in the exurban model. The correlation exhibited between the public transit variable and ANNGRWTH was counterintuitive. TRNSTIME actually displayed a positive correlation with ANNGRWTH in all the type-specific submodels excluding the city model.

In the three regression model formulations, TRNSTIME consistently exhibited a positive relationship to rates of appreciation (Table 5.2a-c). The change from a negative to positive relationship in the type-specific model for the cities may have been caused by multicollinearity between this variable and the AUTOCBD variable, as discussed above. Both the AUTOCBD and AUTOTHER variables maintained a negative coefficient in the various model formulations. In the model where tax rate (TXRT) was eliminated, however, the effect on the city model specification was somewhat odd, with the coefficient on AUTOCBD substantially increasing its negative relationship with ANNGRWTH, while the coefficient on AUTOTHER, became positive, although insignificant. The cause of these differential impacts on the coefficients of the automobile accessibility variable in cities may have been due to the relatively high negative correlation between AUTOCBD and TXRT when compared with AUTOTHER's correlation with TXRT, and the correspondingly high correlation between the two automobile transit variables. Thus elimination of the TXRT variable increased the explanatory power of AUTOCBD to such a high degree that it more than compensated for the negative relationship between AUTOTHER and ANNGRWTH.

In the time-period model correlation matrix (Table 5.1b), the relationship between each of these transit variables and ANNGRWTH vacillated in an unpredictable fashion. TRNSTIME displayed a positive relationship with ANNGRWTH only during 1984 and 1988, thus the positive relationship between TRNSTIME and ANNGRWTH in the full model formulation appeared odd. The AUTOCBD variable exhibited a positive relationship in 1985, 1987 and 1988, while the correlation of AUTOTHER with ANNGRWTH remained largely positive throughout the study period, only exhibiting a negative relationship in 1984 and 1986. The strength of the positive relationship between AUTOTHER and ANNGRWTH was due primarily to rapid appreciation in housing values in southern Plymouth county. Given that these secondary employment nodes were located primarily north (Lawrence, Lowell) and west (Framingham, Route 128) of Boston, with Brockton being the only employment node south of the city, southern Plymouth county had the poorest accessibility overall to outlying employment centers. The failure to include major employment centers located outside the study area but in close proximity to southern Plymouth county, such as Providence and Fall River, may have contributed to this unexpected high positive correlation. Similarly, the positive coefficient on AUTOCBD may have been explained by the strength in the rate of growth of housing prices in both southern Plymouth County, and northern Essex County, both of which had long commuting times to Boston (Tables 5.2 and 5.3).

Population Characteristics

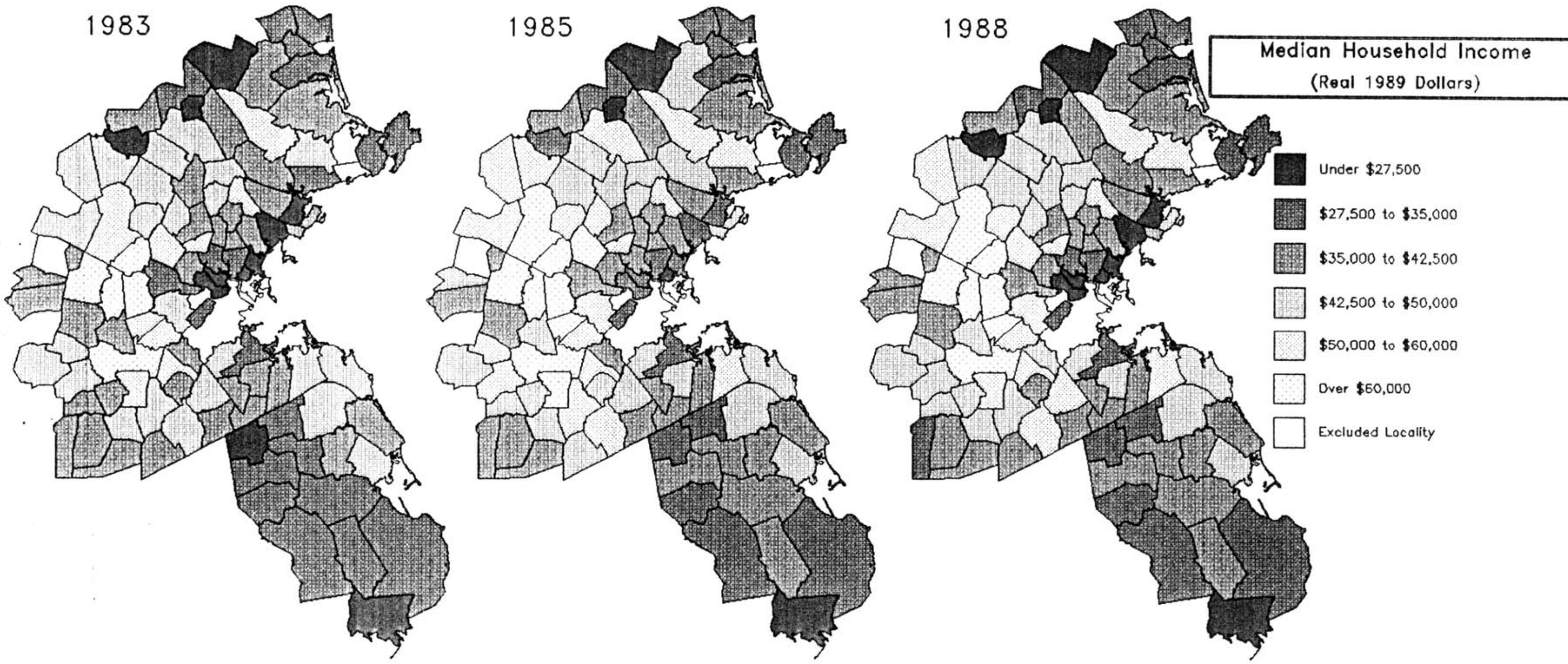
Median Household Income

The consistently negative correlation between median household income (HHINC) and appreciation in home prices (ANNGRWTH) did not conform with the original expectations of the behavior of this variable as discussed in Chapter Four. However, given the negative relationship discerned between the rate of appreciation in housing values and other wealth measures, the correlation results depicting a negative relationship between HHINC and ANNGRWTH was no surprise. The strength of this negative relationship was most substantial in the city sub-model correlation matrix, again indicative of a gentrification effect, as those localities where income was lowest experienced the highest rates of appreciation in home prices (ANNGRWTH). In the regression models the relationship between HHINC and ANNGRWTH exhibited in all type-specific models (Table 5.2a), except the city model, appeared to be opposite of the correlation results. However, this was determined to be due primarily to a high correlation with the percentage of high-school students attending four-year colleges (PCTCOLL) and a relatively higher correlation between PCTCOLL and ANNGRWTH in all but the city model. Elimination of the tax rate (TXRT) variable caused the coefficients and significance of these variables to increase in all but the urban model, with the largest increase apparent in the exurban type-specific model (Table 5.2b)

The relationship depicted between HHINC and ANNGRWTH in the time-period correlation matrices (Table 5.1b) remained largely negative throughout the period, although the significance of this negative relationship was most apparent during the boom years of 1984 and 1985, when investment in both urban and exurban localities with generally lower HHINC was widespread. As the boom turned to bust, less speculation occurred and investment in lower income communities declined as the perceived risk of such investment increased. In the time-period regression models examined (Table 5.3a,b), however, HHINC generally appeared to be positively related to ANNGRWTH. This was primarily caused by high positive correlation between HHINC and PCTCOLL and HHINC high negative correlation with the rate of unemployment. In order to ascertain the explanatory power exhibited by HHINC a regression model was run eliminating this variable. The results conveyed by this model indicated little additional explanatory power was gained by its inclusion, due to the exceedingly high correlation between HHINC and a number of other variables.

Figure 5.8 helps clarify the relationship of HHINC across time and space. As this figure depicts, HHINC was consistently higher in the western suburbs where appreciation was lowest. Furthermore, in southern Plymouth county and the more urban communities just north of Boston HHINC was generally low but appreciation in home values in these areas was among the highest in the region. In addition, the poorer large cities to the far north of Boston (Haverhill, Lawrence, Lowell, Methuen), all included in the city sub-model, displayed relatively low HHINC, while appreciation, especially

FIGURE 5.8


1983
1985
1988
Median Household Income
(Real 1989 Dollars)
Under $27,500
$27,500 to $35,000
$35,000 to $42,500
$42,500 to $50,000
$50,000 to $60,000
Over $60,000
Excluded Locality

in 1985, but also to a lesser degree in 1988, was comparatively high. This shed more light on the substantially higher negative correlation between HHINC and ANNGRWTH in the city model.

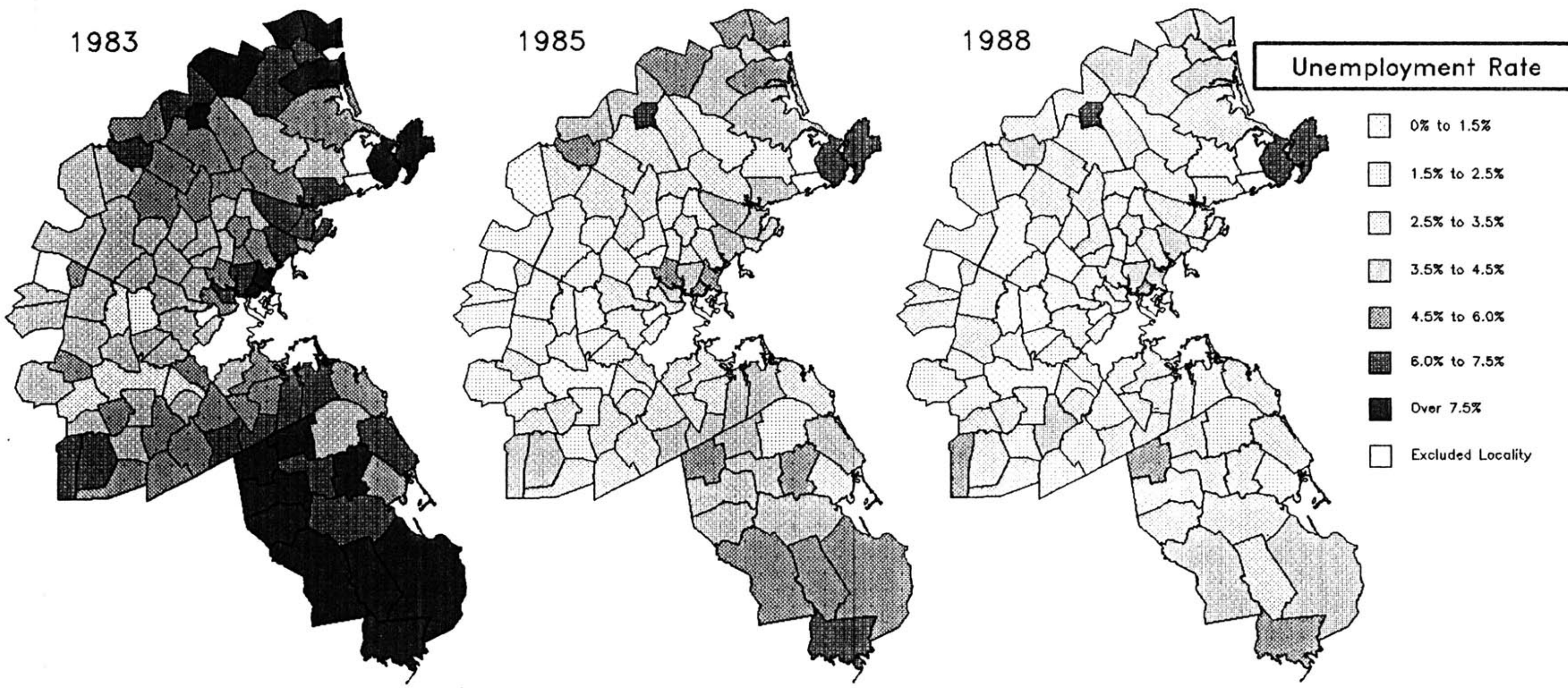
Unemployment

Although a negative relationship was initially expected between the rate of unemployment (UNEMP) and the rate of appreciation in housing prices (ANNGRWTH), UNEMP exhibited a by now somewhat intuitive positive relationship with appreciation, due primarily to the gentrification effect. The correlation between UNEMP and rates of appreciation in home values (ANNGRWTH) was consistently positive in the type-specific models (Table 5.1a), although the relationship was weakest in the city model. In the regression model formulation including all variables, the sign and significance of UNEMP varied dramatically due to the high positive correlation of this variable with density, number of households, and the 25 to 34 year-old age cohort, and a high negative correlation between UNEMP and the older age cohorts and the indicators of wealth (income, education, and percentage white) (Table 5.2a). In fact, because of this high degree of multi-collinearity, elimination of UNEMP from the regression model did not reduce the models explanatory power at all.

In the time period correlation matrix (Table 5.1b) UNEMP retained a positive relationship with ANNGRWTH in all years except 1989. The strength of this relationship was highest at the peak of the market in 1985, again largely due to gentrification and speculative purchases of apparently undervalued properties in poorer communities. As the decade progressed UNEMP continued to decline, partially driven by both the commercial and residential development boom, and also by the rise in construction and service jobs that accompanied this boom. When reality hit and the construction market collapsed, unemployment increased. Thus in 1989 the relationship became negative, as real estate prices, then declining, were accompanied by rising unemployment rates and the Boston area entered into its first recessionary period since 1983. The regression results for each time period (Table 5.3a-c) are not impacted as substantially by the effects of multicollinearity as in the type specific models. In fact, when UNEMP was eliminated from the annual models, in all but the peak boom periods of 1984 and 1985, between two and five percent of the models explanatory value was lost.

Mapping of the UNEMP variable, as with other explanatory variables, helped elucidate the variables impact across both time and space. As Figure 5.9 illustrates, rates of unemployment generally declined in the region through 1988. However, once again the western suburbs, where ANNGRWTH was substantially lower, maintained the lowest rates of unemployment in the region. In contrast, communities in southern Plymouth County, northern Essex County, and the more urban localities just north of Boston maintained higher, although declining, rates of UNEMP accompanied by generally higher ANNGRWTH. This relationship was less significant in Essex County than in either Plymouth county or the urban area to the north of Boston.

FIGURE 5.9


1983
1985
1988
Unemployment Rate
0% to 1.5%
1.5% to 2.5%
2.5% to 3.5%
3.5% to 4.5%
4.5% to 6.0%
6.0% to 7.5%
Over 7.5%
Excluded Locality

Percentage White

White population as a percentage of total population within a community (PCTWHITE) was one of the few variables that consistently displayed the positive relationship originally anticipated. The strength of this relationship, as shown by the correlation matrix (Table 5.1a), was greatest in the exurban type-specific model, although a strong positive relationship was also exhibited in the city model. Including other variables in the regression analysis altered the magnitude of this relationship, and it appeared to gain strength in all but the city type-specific model where both the magnitude and direction of this relationship were altered (Table 5.2a-c). This change may have been due again to the effects of multi-collinearity, as the PCTWHITE variable exhibited a substantial positive correlation with the 35-44 and 45-54 year-old cohorts (AGE3444, AGE4554), as well as with the median household income variable (HHINC), and a strong negative correlation with the unemployment rate (UNEMP), industrial assessment as a percent of total assessed value (INDPCT), and the number of households within a community (HHOLDS).

The time-period analysis revealed volatility in the relationship between PCTWHITE and ANNGRWTH. In the three primary boom years, 1984, 1985 and 1986, the correlation was negative and could be anticipated given the relatively higher rates of appreciation in poorer communities, where the minority population was generally higher (Table 5.1b). A negative relationship was also exhibited in 1988, however, and the cause of this relationship was uncertain. In the regression models formulations both including and excluding property tax rates (Table 5.3 a,b), the relationship between PCTWHITE and ANNGRWTH held in most years, although in 1986, when the negative correlation was weakest, the coefficients in the regression analysis became positive, most likely due to the effects of multi-collinearity.

Number of Households

The expected relationship between the number of households in a community (HHOLDS) and the rate of appreciation in housing prices (ANNGRWTH) was positive, as discussed in Chapter Four. In the correlation matrix (Table 5.1), however, HHOLDS bore a weak and volatile relationship with ANNGRWTH. This variable also exhibited a positive relationship with density, which is considered a more appropriate measure since it accounts for land area within a community. In the correlation matrices including all localities and the type-specific matrix excluding large cities, the relationship between HHOLDS and ANNGRWTH was positive, but just over 1 percent, while the city and exurban matrices displayed a negative relationship. In the exurban analysis this relationship was consistent with the density relationship. While the relationship between density and ANNGRWTH in the cities was opposite that of the HHOLDS and ANNGRWTH relationship. This may be explained in that the sample of urban communities was small and land area varied dramatically between communities. For example, although density was actually much higher in Lawrence than in Haverhill, the number of households in Lawrence was much lower due to its smaller size.

In the regression model formulations (Table 5.2a-c), the relationship between HHOLDS and ANNGRWTH was not consistent with the relationship exhibited in the correlation matrix, again due to multicollinearity between HHOLDS and other variables. In order to interpret the true significance of this variable in the regression models, HHOLDS was eliminated from any of the locational-specific submodels and the overall model and little explanatory value was lost.

In the time-period correlation matrix the HHOLDS variable exhibited a strong positive relationship with ANNGRWTH in the boom years of 1984 and 1985 (Table 5.1b). Given a similar relationship between density and ANNGRWTH and the market speculation and appreciation that was occurring in urban areas where the number of HHOLDS were generally high, the positive correlation was anticipated. In the time-period regression model formulations the problems of multicollinearity between HHOLDS and other variables such as DENSITY and unemployment clouded the true relationship between HHOLDS and ANNGRWTH (Table 5.3a-c). Once again, when the HHOLDS variable was eliminated from the model little explanatory value was lost in any year.

Age Cohorts

The final category of demographic variables analyzed were the 25-34, 35-44 and 45-54 year-old age cohorts. Preliminary expectations, based on past research, were that a negative relationship would be displayed between the 25-34 year-old age cohort

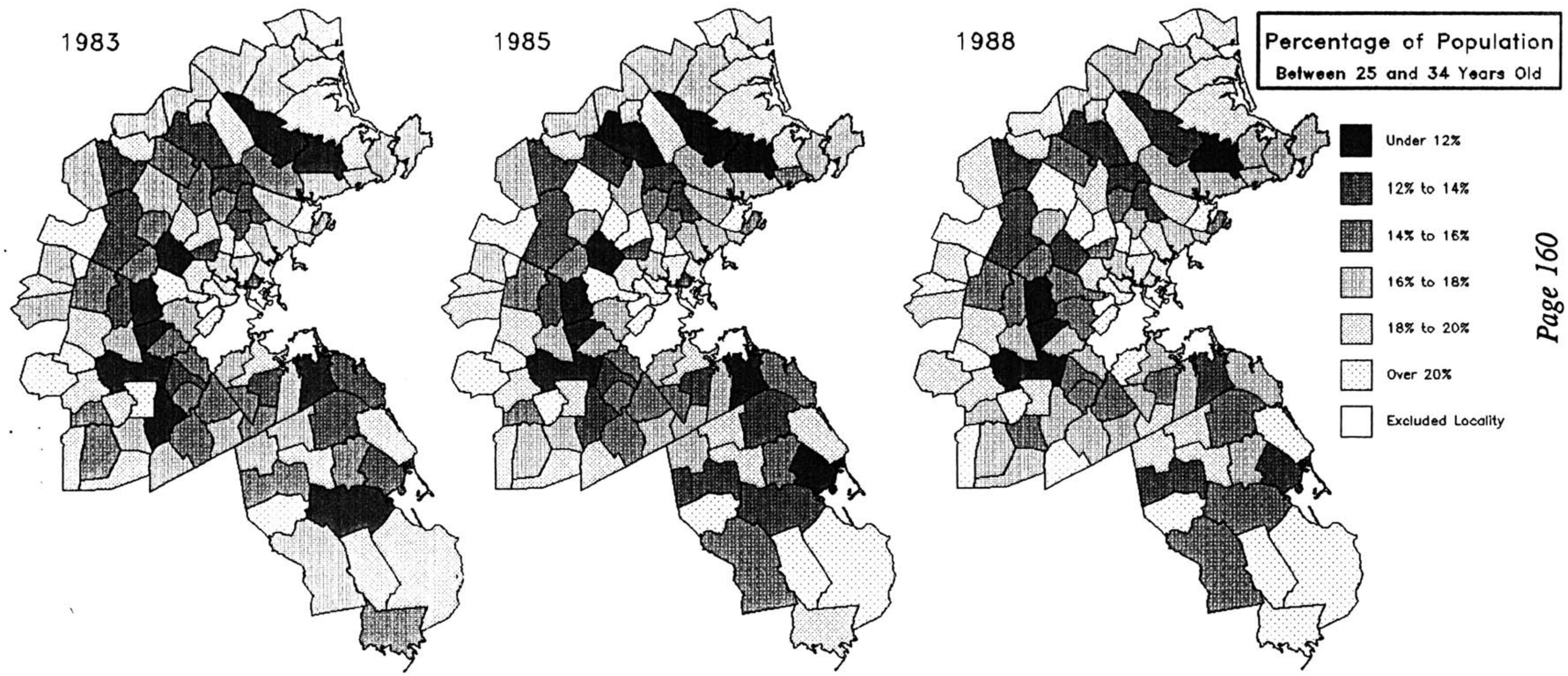
(AGE2534) and ANNGRWTH, while a positive relationship was anticipated between ANNGRWTH and each of the two older age cohorts. In both the full model and the type-specific correlation matrices (Table 5.1), all three of these age variables were negatively correlated to the rate of appreciation in home values. The most consistently significant negative relationship existed between the 35-44 year-old age group (AGE3544) and ANNGRWTH, while the oldest cohort exhibited the weakest negative relationship.

In the type-specific city model, the negative relationship between the youngest age group and the appreciation rate was strongest, this may be due to a 'yuppie' effect in cities, where a strong positive relationship existed between the education variable (PCTCOLL) and AGE2534, as opposed to a negative correlation in the other type-specific models. In contrast, a sharply weaker relationship with education existed among the older two age groups in cities compared to other areas. In the regression models the magnitude of the relationship of these variables changed due both to a consistently high positive correlation between the 35-44 and 45-54 year-old age groups and, in all but the city model, a significantly high negative correlation between the 25-34 and 45-54 year-old age cohorts. This change was aided further by a high degree of correlation between these variables and other variables specified in the model. As with many of the other explanatory variables demonstrating a high degree of multicollinearity, elimination of these three variable only slightly reduced (.3 percent) the explanatory power of the regression model.

Analysis of these three variables in each time-period contributed little to the understanding of their impact. However, in the peak boom years of 1984 and 1985 the two older age cohorts, generally associated with greater wealth, exhibited strong negative correlations with ANNGRWTH (Table 5.1b), while the younger age group, which was highly correlated with variables representing less affluence such as higher rates of unemployment, exhibited a significant positive relationship with ANNGRWTH. Given the impact of speculation and gentrification apparent throughout these model results, particularly in 1984 and 1985, these results are not spurious. In 1986 all three age groups were negatively correlated with appreciation, while in the final three years of the decade the 34-44 year-old age cohort maintained a positive relationship with ANNGRWTH and both the sign and magnitude of the relationship of the other two age group variables fluctuates.

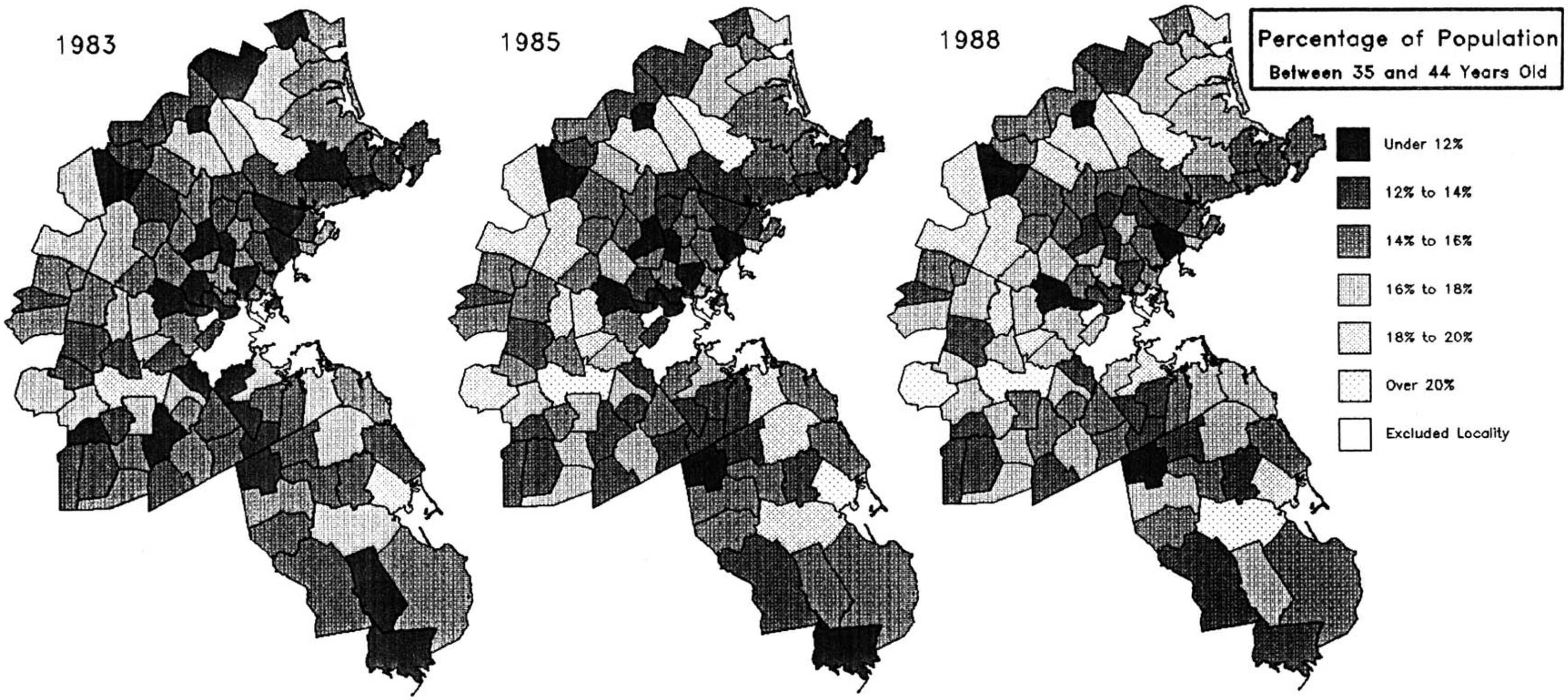
Once again thematic maps (Figures 5.10 a-c) aided in the interpretation of the data. Particularly when cross-referencing these maps with time period correlation and regression data. The correlation between the percentage of population in the older two age categories varies together, and these maps show this relationship. Furthermore, the percentage of the population in the 25-34 and 45-54 year old age groups exhibited a negative relationship. These maps also show the relatively high concentration of the two older age groups in the western suburbs, where appreciation was lower overall. A high concentration of the youngest age group is observed in the northern and southern exurban areas where appreciation was generally higher than in other areas.

FIGURE 5.10 a



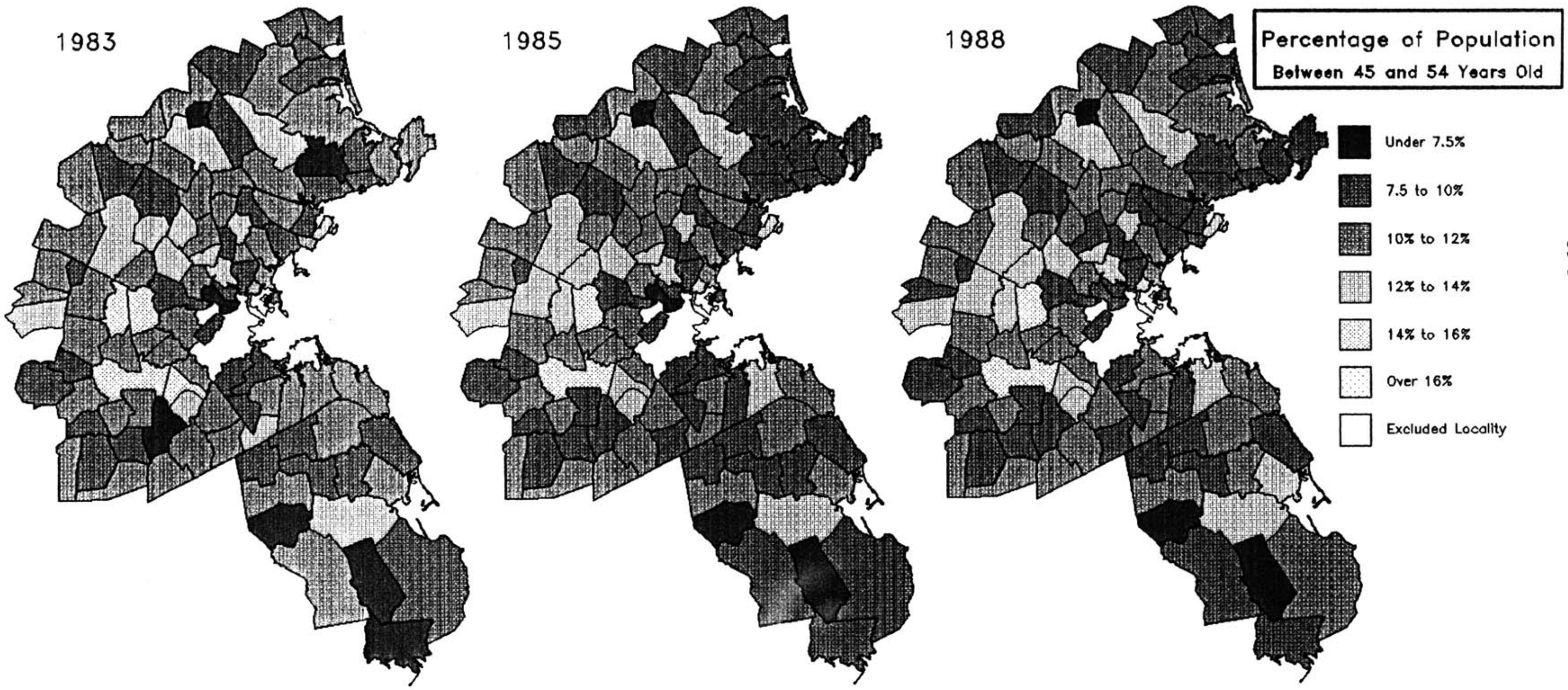
1983
1985
1988
Percentage of Population
Between 25 and 34 Years Old
Under 12%
12% to 14%
14% to 16%
16% to 18%
18% to 20%
Over 20%
Excluded Locality

FIGURE 5.10 b



5.10b

FIGURE 5.10 c



5.10c

CONCLUSIONS

In summary, the relationships discerned in this study between the explanatory variables and the real rate of appreciation in single-family home prices did not consistently exhibit the anticipated effects. Upon closer inspection of these relationships over time, over type of locality, and physically over space it appeared that the speculation that occurred in the real estate market, especially during the middle of the decade, caused appreciation in housing values universally, with the highest rate of appreciation exhibited in areas considered undervalued and often more risky investments.

During periods of inordinate market activity, as was evident in Boston during the decade, undervalued properties were considered a 'gold mine' for both speculative and long-term investment purposes. An alternative form of analysis of this data that may prove interesting, would be to consider the change in the fiscal, locational, and demographic factors as explanatory variables in the model. This would enable interpretation of the effects that speculative investment has on change in the overall characteristics of a community. This alternative and other possible research questions will be discussed in the Chapter Six.

CHAPTER 6

CONCLUDING REMARKS

In the model results presented in the preceding chapter, many of the explanatory variables did not exhibit the expected relationship with rates of housing price appreciation. The cause of these discrepancies varied. Some deviations were attributable to a time effect, some to a locational effect, and for some variables the origin of these unexpected results was uncertain. In this chapter I examine tactics that may be employed in future research to discern the reasons behind these counterintuitive results. Furthermore, I discuss potential improvements to the model specified, and alternative research questions of interest.

The chapter is divided into six major sections. In the first section I address the usefulness of the model and the results obtained in Chapter Five. In the second section I discuss potential improvements to the database utilized. The focus of the third section is on methods of ameliorating the problems with the model specified in Chapter Five. In the fourth section I consider explanatory variables that have not been included here, yet may exhibit significant descriptive power. In the fifth section I highlight questions of interest for future models. I close this chapter with my concluding remarks.

USEFULNESS OF THE MODEL

This analysis has shed light on the problems and peculiarities that accompany speculation in the residential real estate market. As has been demonstrated in this analysis, the unmonitored rate of residential real estate development occurring in the Boston area during the 1980s was one of the primary causes of the market's ultimate downturn, due to overbuilding. This has implications for developers, who should thoroughly evaluate market potential prior to undertaking a development project. Furthermore, it has strong implications for municipalities: It has been demonstrated that in periods of decline, communities in which development and density were highest prior to the market downturn suffered most. Thus, although the potential increase in property tax revenues generated through development may be attractive to a community, particularly those c communities with fiscal problems, the long run implications of such additions should be thoroughly contemplated, as the increase in density may negatively impact market prices, and if the market should weaken during the course of development this negative impact will be even more significant.

This study is also useful in that it provides a unique analysis across the dimensions of both time and space. Such disaggregate analysis has rarely been attempted before. Furthermore, accompanying this research with the thematic mapping capabilities of GIS has enlightened the spatial and locational characteristics of growth and decline in a market. Making such relationship much easier to discern.

IMPROVEMENTS TO THE EXISTING DATA

The repeat sales examined in this thesis consisted of a near census of housing units that sold more than once within the study area from 1982 to 1990. However, this measure did not account for improvements to an existing structure. Rosen and Smith (1986) examined the resale housing market and concluded that in 1982 real expenditure on improvements to existing homes equalled approximately 25 percent of the value of expenditures on new construction of single-family homes.

Although no specific estimate is available for the Boston area, improvements to the existing housing stock in this region were also substantial. Preceding and during the study period gentrification was evident, and displacement due to gentrification was a planning issue of concern in the area. Due to lack of available open land for development in many communities, individuals and real estate developers capitalized on the opportunities availed through improvements to the existing housing stock. Although this trend was most conspicuous in densely populated urban area, such as neighborhoods in the city of Boston, it was actually widespread. These improvements, if unaccounted for, inflate the real rate of housing price appreciation. This is due to variations in a structure's attributes resulting from improvements; precisely what this study attempted to control for by employing the WRS method. A more appropriate model specification would exclude improved properties, by examining records of building permits, and extricating all transactions on which records of improvements were found or adding the cost estimates found on these building permits to the base property value. This would eliminate much of the expected artificial inflation. However, it is a substantial data collection task and would not prove comprehensive, as many individuals do not file building permits on interior work that can be completed unnoticed. Such interior improvements as a remodeled kitchen or bath will increase the value of a home.

The model detailed in Chapter Four might also have been augmented by use of the McConnell Land Use Maps created at the University of Massachusetts at Amherst for the Massachusetts GIS project (MASSGIS). These maps would more accurately define zoning within a locality. This land use measure would be a more precise measure of land use than the residential percent (RESPCT) and industrial percent (INDPCT) variables utilized here. Improvements of the model might also have been realized by incorporating land changes that have altered potential land use within cities and towns over time.

Specification of non-armslength transactions in this model was limited to buyers and sellers with the same surname. In addition to extracting these properties, removal of non-armslength transactions, as defined by the local assessor and available through each locality, would have improved the accuracy of the data.

IMPROVEMENTS TO THE MODEL SPECIFIED

Aside from improvements that may result through more detailed data clean-up as discussed above, the model fit might have been strengthened by conducting a more comprehensive analysis of the data at hand. Due to time limitations only a few model specifications could be tested. As the correlation matrices in Appendix F demonstrate, many variables exhibit a substantial degree of multicollinearity. By altering the form of some variables, not only might a better fit with the dependent variable have been discerned, but the degree of collinearity with other descriptive variables might have been minimized. Such alterations include converting the absolute measure of household income (HHINC) or number of households (HHOLDS) to a rate of growth. More complete residual analysis would also provide a basis for the checking of assumptions such as heteroscedasticity, and for possible variable transformations.

The correlation of some explanatory variables with the dependent variable may have been augmented through transformations. The effective property tax rate exhibited a counterintuitive positive relationship with appreciation. This was due both to the significance of the time effects caused by the lag in full value reassessment, and higher appreciation rates in more highly taxed urban areas, which may be partially controlled for by eliminating improved properties. In addition to eliminating these improved properties, as discussed above, adjusting tax rates to account for the difference between actual assessment and full value assessment may alter the model fit. However, the positive relationship between rates of housing price appreciation and property tax rates may ensue in urban areas. This would be in accordance with the Hamilton modification of the Tiebout hypothesis which concluded that traditional tax capitalization of property taxes is not apparent in cities and large urban areas.

A further improvement to the model specification might have been obtained by combining age groups, particularly the 35-44 and 45-54 year-old cohorts which were highly correlated. Similarly, due to high correlation, a better accessibility measure might have been developed by merging the three variables incorporated in this model; automobile commuting time to the central business district (AUTOCBD), automobile commuting time to other employment centers (AUTOTHER), and commuting time via public transit to either the 128 corridor or the Boston CBD (TRNSTIME). The resulting single variable could be computed by weighing each transit mode by the number of employees utilizing that mode of transit in each employment area.

In Chapter Five I attempted to explain differential rates of growth and counterintuitive results through disaggregation of the data, and examination of differences over time, as well as type of locality (urban, suburban, exurban). Due to time constraints, my analysis of these disaggregate models was minimal. A more intuitive understanding of the model results may have been obtained through closer scrutiny of each of these disaggregate models. In addition, further decomposition of the data, such as examination of the time effect within each type of locality may have enhanced the study results. This could be accomplished by employing a more comprehensive pooled time-series cross-sectional model (Pindyck and Rubinfeld, 1981). In such a model the explanatory variables would be broken down by year, thus a matrix of **(n * t)** explanatory variables would be incorporated into the model, where **n** equals the current matrix of explanatory variables and **t** equals the number of time periods. This model would further distinguish between locational and time effects which interact and thus were an impediment in this study. However, a significant number of degrees of freedom would be lost, thus offsetting some of the potential improvements in explanatory power. Thematic maps similar to those exhibited in Chapter Five would prove to be useful tools for analysis in such a disaggregate model.

ADDITIONAL VARIABLES OF INTEREST

A number of variables not designated in this model have been demonstrated by others to differentially impact rates of housing price appreciation. These variables may have contributed more to the model than originally anticipated. Many of these variables were introduced in the literature review in Chapter Two. In this section I review those variables, and introduce other explanatory variables that may have been considered.

Fiscal Factors

I did not examine the effects of the National level fiscal variables in this study, however, their effect over time may be of interest. During the 1980s alleged redlining occurred in the Boston Metropolitan Area. This was induced both by difficulty in obtaining mortgages on some properties, and differential mortgage rates on properties across neighborhoods with similar household income levels but variations in other demographic characteristics such as racial composition. Thus mortgage interest rates may exhibit a locational effect. Although the evidence of discriminatory lending practices provided in the Federal Reserve Bank of Boston study (Bradbury, Case, Dunham, 1989) was confined to neighborhoods within the city of Boston, such lending patterns are also likely to vary between cities and towns, as well as within a city or town. This variation may depend somewhat on the perceived desirability of an area, thus cross-sectional analysis of mortgage interest rates may prove insightful.

In this study I employed the percentage of students in a locality pursuing higher education, as a proxy for educational quality, assuming that per capita educational expenditures may not be the optimal measure. Given the unexpected relationship between the percentage of college attendees in a locality, (PCTCOLL) and appreciation in housing prices, analysis of per capita educational expenditures may prove fruitful. This variable may either serve to explain the untenable results obtained, or provide a better proxy for education than initially anticipated, especially in suburban locations. In addition to analysis of municipal educational expenditures, inclusion of payments for other public goods and services such as Police, FIRE, Recreational Facilities, and debt service may enhance the model's explanatory power.

Locational Amenities

A number of locational amenities that might have elucidated the differential rates of housing price appreciation were not incorporated into this study. However, these variables may be of interest in future model specifications. One primary factor is water access. Previous studies have demonstrated that localities on the seacoast or with lake access often endure higher rates of housing appreciation than localities lacking such amenities. Given that the Boston Metropolitan Area abuts the Atlantic Ocean, and contains a significant number of interior fresh water lakes and ponds, consideration of the influence of such amenities may prove interesting.

As discussed in Chapter Two, housing price appreciation should vary positively with the percent of a municipalities housing stock that is owner occupied. Initially, I intended to utilize single-family units as a percent of total units in order to approximate owner occupancy in this study. However, given my limited time frame, inconsistency in the data available prohibited inclusion of this variable. Others have found owner occupancy to be an important determinant of appreciation, thus in future research I would attempt to rectify the data problems in order to incorporate a measure for occupancy into this model.

<u>**Demographic Factors**</u>

Numerous demographic factors were not but may be of interest in subsequent research. In Chapter Two I discussed the negative impact crime rate has been found to have on rates of housing price appreciation. This variable might have exhibited significant explanatory power if specified in this model. In addition to the crime rate variable, the percentage of residents within a locality that fall below the poverty line or some other measure of poverty would likely contribute to the models explanatory power. Poverty rates, as with crime rates, are expected to negatively impact rates of housing price appreciation. A third demographic variable not utilized in this model that should exhibit an adverse relationship to rates of housing appreciation is vacancy rates within a community. These three variables, however, are likely to be highly collinear, thus should not be included simultaneously in an alternative model specification.

OTHER MODEL SPECIFICATIONS

Aside from inclusion of additional variables into the existing model, a wealth of alternative research questions could be posed utilizing the database developed. As mentioned above, future research might expand on disaggregate analysis, incorporating a subset of communities, and including hedonic characteristics for individual properties. These data could then be compared with the weighted repeat sales model to evaluate the performance of the WRS model during a boom period. Furthermore, such a disaggregate model would reveal differential rates of appreciation that occurred within a locality. Given that the population within a locality is not homogeneous, and in many cases, particularly with large towns and cities, may exhibit extreme demographic variety, such a disaggregate analysis would be enlightening. In this study utilization of geographic information systems (GIS) was limited to thematic mapping as a tool for analysis. Specifications of a more disaggregate model may rely more explicitly on the full capabilities of GIS tools, including address matching to allow for more disaggregate spatial measures.

The City of Boston was excluded from this model. However, analysis of the City at the neighborhood level would also be of interest. Such micro-level analysis would enable further testing of the validity of the Tiebout hypothesis of tax capitalization, as well as provide the framework for a comparison of neighborhood level price changes.

Another area of interest not dealt with explicitly in this model is comparison of single family home and condominium markets over space and time. Ad mentioned in the introduction to this study, during the late 1980s and early 1990s, overbuilding in the Boston market became increasingly evident. Numerous foreclosures resulted insolvency of many New England area financial institutions which had overextended their assets into speculative real estate development. This financial crisis has been characterized as disproportionately affecting the condominium market. Addressing the magnitude and spatial characteristics of the differential impacts on single-family homes and condominiums may prove to be of significant interest.

CONCLUDING REMARKS

In summary this thesis has proved a valuable addition to both the planning and development world. It is important because such a comprehensive analysis of both spatial and time series trends has not been conducted before. Furthermore, few housing market studies have utilized thematic mapping tools for spatial analysis. These tools contributed substantially to the understanding of relationships across the dimensions of both time and space. In this study I found some interesting and unexpected relationships between rates of appreciation in housing prices during periods of both market growth and decline. Many of the initially counterintuitive results could be discerned, however, given the size and complexity of the database, a wealth of potentially important information remains to be grasped from this data through future research efforts.

APPENDIX A:
WRS METHODOLOGY*

The quarterly growth rates of housing prices was estimated using the following functional form:

$$P_j = P_i(1+r_o)^{D}0(1+r_1)^{D}1(1+r_2)^{D}2........(1+r_n)Dn$$

Where

- i = the quarter of the first sale
- j = the quarter of the second sale
- P_i = the price of the first sale
- P_j = the price of the second sale
- r_k = the growth rate in quarter k
- D_k = a dummy variable equal to 1 if the period of time between the sales included quarter k, otherwise equal to 0.

$$Ln(P_j) = Ln(Pi) + D_0\,Ln(1+r_0)\;_+\;D_1\,Ln(1+r_1) + D_2\,Ln(1+r_2) + D_n\,Ln(1+r_n)$$

The model is estimated as:

$$Ln(P_j/P_i) = \beta_0 D_0 + \beta_1 D_1 + \beta_2 D_2 + \ldots + \beta_n D_n$$

Solving for r - the quarterly rate of appreciation:

$$\beta_0 = Ln(1+r_0)$$

$$(1+r_0) = e^{\beta}$$

$$r_0 = e^{\beta}0 - 1$$

Annualizing this growth rate for use as our dependent variable:

1982 growth rate = $(1+r_0)(1+r_1)(1+r_2)(1+r_3)$
1983 growth rate = $(1+r_4)(1+r_5)(1+r_6)(1+r_7)$
.
.
1989 growth rate = $(1+r_2 9)(1+r_3 0)(1+r_3 1)(1+r_3 2)$

* See Case, 1986.

APPENDIX B:

OBSERVATIONS LOST THROUGH DATA CLEAN-UP

In this appendix I list the total number of observations and the rremaining observations after each data clean-up step, by county.

	ESSEX	MIDDLESEX	NORFOLK	PLYMOUTH	SUFFOLK
TOTAL	95,997	179,536	91,658	79,604	81,891
MTG>SP	88,924	168,403	86,365	72,567	77,448
EXDUP	88,675	167,715	85,620	72,313	77,247
CORADD	88,498	166,877	85,573	72,246	76,996
NONRES	81,371	150,722	77,975	65,462	65,382
TOTSF	51,423	89,890	46,716	41,841	27,552
TOTCONDO	10,886	32,565	16,608	3,892	28,807

MTG>SP - Number of observations remaining after those with mortgages greater than the sale price of the property were eliminated.

EXDUP - Number of observations after excluding all exact duplicates, prior to address clean-up

CORRADD - Number of observations remaining after address correction and elimmination of additional duplicates detected.

NONRES - Number of observations remaining after eliminating all nonresidential transactions.

TOTSF - The total number of single family sales within a community.

TOTCONDO - The total number of condominium transactions within a community.

APPENDIX C

MASSACHUSETTS PROPERTY TAX LAW

In the November 1978 general elections voters approved a Constitutional Amendment, Article 112 which authorized the legislature to prescribe a differential property tax classification system in the general laws. Chapter 797 of the Acts of 1979 inserted two sections into the general laws to implement this classification system. General Laws Chapter 59, Section 2A provides for the definitions of the classification of properties. This includes residential, commercial, industrial, open space, and personal property. The second portion of the law, Chapter 40 Section 56, defines the formula for the amount of shift of property tax burden that is allowed. Amendments to the definitional portion of the law, Chapter 59, Section 2A include the following:

- Acts of 1980 Chapter 261 Sections 10-12.
- Acts of 1982 Chapter 369 and 661
- Acts of 1989 Chapter 653 Section 40

Amendments to the formula of the allowable shift that can be made include:

- Acts of 1980 Chapter 261 Section 2
- Acts of 1981 Chapter 419
- Acts of 1982 Chapter 369 Sections 1 and 2
- Acts of 1983 Chapter 79 Section 1
- Acts of 1989 Chapter 718 Section 2

APPENDIX D

CENTRAL TRANSPORTATION PLANNING STUDY (CTPS) ACCESSIBILITY MODEL DEVELOPMENT

The access measure to major employment nodes utilized in this thesis was obtained from the Central Transportation Planning Study (CTPS). CTPS has developed a time-distance matrix, for over 850 traffic analysis zones (TAZ) within the Boston Metropolitan Area using MINUTAB software. The assumptions and procedures employed by CTPS in the initial development of the time-distance matrix as well as the methodology administered in this thesis for amassing TAZs to the community level, will be discussed in this appendix.

Automobile Transit

CTPS computed travel time by automobile using a measure of road capacity based on the width of the road, number of lanes, and impediments to movement such as traffic lights and stop signs. The level of service (LOS), which is a standard transportation measure of congestion, was then incorporated into the model in order to develop estimates of travel time per road link. Travel time data were based on average weekday traffic, which may underestimate actual peak hour travel times. The margin of error in actual peak hour travel times introduced by using this average, varies by location, depending on the difference between average weekday congestion, and the level of actual peak hour congestion that occurs on these roads.

Automobile transportation, either to a rapid transit 'Park and Ride' or to an employment centroid was confined to the major street network. Short-cuts on peripheral roads cutting through neighborhoods were not considered. Travel paths were developed along the road network with the total time and distance from one TAZ to another TAZ comprising the sum of the time and distance for each road link traversed. MINUTP software builds these paths using weighted travel times, and outputs the optimal route by comparing all feasible alternative paths. The commuter is assumed to opt for that path which minimizes his/her commute. Running assignment models on MINUTP they were then able to establish the volume and hence the real commute time, not the weighted measure used in establishing travel paths.

Public Transit

Estimates of public transit time employed the more appropriate measure, peak hour travel. A variety of assumptions were incorporated into these estimates. These assumptions can be separated into the three segments of a typical commute: (i) From the location of residence to the public transit departure point (OVTT); (ii) while on public transit; (iii) and from the public transit destination to the location of employment (IVTT).

For transportation to the transit station two modes were appraised; on foot and via automobile. For commuters walking to the transit station a pace of 2.5 miles per hour was assumed. In addition, the total distance from the TAZ centroid of residence to the transit/bus stop was limited to .5 miles. Automobile transit to the public transit station was considered an option only if a 'Park and Ride' commuter lot was available at the transit stop. Furthermore, automobile commute time from the TAZ of residence to the TAZ of transit departure was limited to 60 miles, a fairly generous limitation. If no 'Park and Ride' facility was available,the model assumed automobile transit to the public transit station did not occur. This is an erroneous assumption, and caused significant problems in Plymouth county where many commuters were served by private bus transit where no public parking facility is available. In these localities, only those commuters within walking distance, or a .75 mile radius of the transit departure point were assumed to utilize this transit. To correct for this problem an estimate of automobile transportation to the public transit station was added to the public transit commute time in order to develop a proxy for access from all communities.

The study area was served by five modes of transit: rapid transit via the subway system, local bus service, public express bus service, private express bus service and commuter rail service. Commuters were assumed to make their choice of service depending not only on commute time, but also on the transit fare and parking costs. Commute time via rapid transit, local bus and commuter rail was based on actual estimates, while express bus service was assumed to be running according to the published schedules, which generally underestimate actual commuting time.

Transfers between public transit modes were permitted, but limited. No more than four transfers were allowed, and transfers were only allowed from/to local bus service to/from any other service, from rapid transit to rapid transit, and from/to commuter rail to/from rapid transit. The total travel time was limited to 200 minutes.

Manipulation of Data Utilized

The model developed by CTPS included an 850 x 850 matrix of travel times and distances between TAZs. A subset of this matrix was included in this model. This subset consisted of travel time (not distance) from every TAZ within a town or city included in the study, to any TAZ within an employment centroid. TAZs were aggregated to the town or employment node level by averaging the travel times and distances from any centroids within a locality, to all centroids within each other locality. For example, if locality A, the community of residence, consisted of TAZs A1 through A5, while locality B, the employment location, consisted of TAZs B1 through B5, a matrix of 5 x 5 or 25 travel times and distance measures existed for each mode of transportation. Herein, travel time within a residential community and within an employment center was calculated as the mean of travel times between the TAZs within the locality. Travel time from location of residence (A) to location of employment (B) was computed as the simple average of travel times from every TAZ in community A to every TAZ in employment center B. Thus, a single measure for each mode of transportation was amassed from the data. This travel time from A to B can be expressed as :

$$\Sigma\Sigma(T_{ij})/mn$$

Where: T_{ij} = Travel time from i to j.
n = Number of TAZs in location of residence A.
m = Number of TAZs in location of employment B.

The summary of methodology presented in this appendix is intended to be fairly comprehensive. However, if more complete documentation of the model employed by CTPS is desired, it may be obtained directly from the agency.

APPENDIX E1

CACI UPDATE METHODOLOGY*

All updates begin with the decennial census. From the 1980 census summary tape files, CACI has compiled detailed demographic profiles from which projections are prepared for every county, census tract, and minor civil division (MCD) in the United States. Updates to the current year and five year projections are calculated for the total population and select characteristics include age, sex and race; for households and families; for a variety of income measures, including household and family income distributions and per capita income.

Projections are prepared initially for counties, census tracts in counties that are tracted, and MCDs or census county divisions (CCDs) outside tracted areas. From this geographic distribution, data for MSAs, ADIs, DMAs, Zip Codes, and places are retrieved and summarized. Updates and projections are revised annually.

DEMOGRAPHIC UPDATES METHODOLOGY

Total Population

*** Reprinted, by permission, from CACI, <u>1990 Sourcebook of Zip Code Demographics</u>.**

Construction of the population projections begins with the 1980 census counts and an annual postcensal estimate series for states and counties that is produced jointly by the Census Bureau and States through the Federal State Cooperative Program for Population Estimates. County and state estimates represent an average of different (state-specific) methods that employ an array of variables to monitor local population change. CACI's 1990 updates are based upon July 1, 1988 population estimates (U.S. Census, CPR P-26).

CACI collects the projections that are produced by the States' demographers to build the county projection base. Aside from being the only source of county population projections, the States' series are considered the best source of information about local population trends. The States' projections are adjusted to be consistent with the 1988 county estimates and controlled to national population projections (U.S.Census CPR, P-25, 1989).

Tracts and MDCs

Projections for subcounty areas are derived from a combination of models that are based upon size and history of population change. Census counts from 1970 and 1980 and a special point estimate developed for 1985 establish the historic trend lines from which population change is projected in most areas.

To calculate 1985 estimates, CACI constructed a detailed model of place growth and decline over time. It is common for small places to experience periods of rapid growth or decline. In fact, a period of rapid growth is often followed by a plateau. Other areas may experience a stable trend of population change over time. To capture these variations, CACI's mid-decade model was keyed to population size and the history of change. This stratification establishes 70 possible patterns of growth and determined the single most likely estimate of population for tracts and MCDs in 1985.

Population trends are weighted to emphasize current, post-1980 change over 1970-1980 trends. Special censuses for tracts and MCDs and the latest (1988) population estimates for MCDs have also been incorporated to supplement the postcensal trend lines. In fact, where a 1988 estimate is available for a subcounty area, the post-1980 trend replaced the 1970-1980 trend.

Four models are applied to project tract/MCD populations, including two ratio techniques and two mathematical extrapolations that employ exponential rates and linear change. The ratio techniques express the population of tracts/MCDs as a share of the county population. One model maintains a constant 1980 ratio of tract/MCD population to the county total; the other model projects the change in the ratio over the projection interval.

Ratio techniques have the advantage of controlling subcounty populations to target county population totals directly, which keeps the sum of the parts equal to the whole and precludes unreasonable growth or decline in the tract/MCD populations. These models may also increase the reliability of the subcounty projections since projections for larger areas are typically more accurate. However, ratio methods do not account for the variation of subcounty trends from county population change. In other words, if the population of the county is expected to increase more rapidly in the future, then all of the subcounty projections will reflect this trend.

Two other techniques are added to account for subcounty variations directly - exponential and linear extrapolation. The extension of past rates of change, which are calculated on the assumption of continuous compounding (exponential rates) is the most common method of extrapolation. Linear extrapolation of the arithmetic change in small area populations is added as a check on possibly unreasonable projections which can result from projecting rates. In both techniques, CACI has added checks on the extrapolations.

The results of the four methods are subsequently averaged. As noted, each method has its own advantages and disadvantages. The ratio techniques relate the tract/MCD projections directly to the counties, but do not account for discrepant subcounty trends adequately. The extrapolation formulas explicitly account for subcounty trends, but ignore the reality of county change. An average of methods does not necessarily produce the smallest errors, but it is likely to reduce the occurrence of outliers, extremely high or low projections. Totals for subcounty areas are finally controlled to the county projections.

Population Characteristics

The population by age and sex is projected via a cohort survival model that calculates the components of population change separately, by age and sex. The 1980 population for each tract and MCD is carried forward by applying projected national survival rates. Births are projected from area-specific, child-woman ratios. Migration is computed as a residual, the difference between the survived population and the independent projections of tract/MCD totals. The 1980 age-sex distributions of the group quarters population are maintained, however, by type of group quarters. The populations of college dormitories, military barracks, and various institutions have unique age-sex distributions that are unlikely to change like the household population. Projections by race are based upon local distributions by race and projected rates of change by race for larger geographic areas. Totals are consistent with 1980 census tabulations.

Households and Families

Size and distribution of households and families are projected from the 1980 census data and recent estimate and projections from the Census Bureau. Detailed household and family characteristics are available from the 1980 census for local areas. These distributions are updated with information from the March 1989 Current Population Survey, which measures regional changes in household and family composition, and combined with independent projections of households and families to track local changes in composition.

INCOME UPDATE METHODOLOGY

Data Sources

To estimate household income, CACI uses several government and independent sources, including: (i) the Bureau of Economic Analysis (BEA), U.S. Department of Commerce; (ii) the National Planning Association Data Service (NPA Data Service), Washington D.C.; and (iii) the U.S. Bureau of the Census' Current Population Survey (CPS).

Treatment of Inflation

CACI's projection base is the income reported in the 1980 census. Technically, 1980 income data represent 1979 income because the Census Bureau measures income received in the "last year" before the census. Therefore, 1980 income is actually expressed in 1979 dollars. Similarly, CACI's 1990 income updates represent income received in 1989 and expressed in 1989 dollars. Rates from 1980-1990 show nominal growth, which includes inflation.

Income Methods

Every year, the BEA releases new personal income data for every county in the U.S. This data is the best source on intercensal income estimates. NPA Data Service updates the BEA's data to the current year and forecasts the income for counties with an econometric model. The model incorporates conditions in the local labor markets, including employment by type and by industry, and the components of personal income.

CACI derives rates of change in income for every county in the U.S. from personal income. First these rates are applied to CACI's demographic projections to generate a preliminary distribution of household income. These income estimates are compared to the most recent (regional) data available from March 1989 Current Population Survey. Second, the CPS is used to check and adjust the income estimates, producing final income distributions for every census tract or MCD in a county. This two-step process ensures that the data reflect current trends in labor markets, industry, the economy, and households.

ZIP CODE UPDATE METHODOLOGY

The building blocks of CACI's ZIP Code geography are the census tracts or, in nontracted areas, minor civil divisions (MCDs). ZIP Code boundaries are constantly changing; tract/MCD boundaries provide a comparatively stable base for the development of annual updates.

The Area Apportionment Method

To estimate the population of ZIP Codes, the boundaries of the ZIP Code are overlaid on tract/MCD boundaries. If a census tract falls wholly within the boundaries of a ZIP Code, one hundred percent of the tract's total population is allocated to that ZIP Code. If only forty percent of the area of a census tract falls inside the boundaries of ZIP Code A, and sixty percent falls inside ZIP Code B, the tract population will be allocated between the two ZIP Codes in proportion to the split areas. CACI refers to this technique as the "Area Apportionment Method".

This appendix summarizes the basic methodological steps taken by CACI to develop their ZIP Code level demographic estimates. Further information about methodology is available through the CACI publications, or directly from the organization.

APPENDIX E2

EXPLANATORY VARIABLE CALCULATIONS

1990 data from CACI included revised 1980 population statistics, while data available from CACI prior to 1990 and DOR data included dated estimates of 1980 figures. Therefore, although DOR rates of growth were anticipated to be more accurate, these rates were applied to the CACI 1990 data. Initially, all 1986 and 1988 CACI data was adjusted to the 1980 updated Census figures by multiplying them by the following:

$$(1+((NEW80 - OLD80) / OLD80))$$

Where: NEW80 = Revised 1980 Census Figures
OLD80 = Original 1980 Census Figures

POPULATION

Although population was not utilized directly in the model, other variables (density, age groups, households) relied on accurate population estimates. Therefore, measurement of this variable was essential.

Population estimates were made using the following functional form for each town.

$$STPOPCNG = (STPOP90 - STPOP80) / STPOP80$$
$$CACIPOPCNG = (CACIPOP90 - CACIPOP80) / CACIPOP80$$
$$POPINDX = STPOPCNG / CACIPOPCNG$$

Annual Population Growth Rates were then computed:

GRP8086=(1+(((CACIPOP86 - CACIPOP80) / CACIPOP80) * POPINDX))^(1/6)
GRP8688=(1+(((CACIPOP88 - CACIPOP86) / CACIPOP86) * POPINDX))^(1/2)
GRP8890=(1+(((CACIPOP90 - CACIPOP88) / CACIPOP88) * POPINDX))^(1/2)

Thus actual population estimates by town were computed as:

POP81 = POP80 * GRP8086
POP82 = POP81 * GRP8086
.
.
.
POP86 = POP85 * GRP8086
POP87 = POP86 * GRP8688
POP88 = POP87 * GRP8688
POP89 = POP88 * GRP8890
POP90 = POP89 * GRP8890

Where:

STPOP__ = DOR population estimates for the year indicated
CACIPOP__ = CACI population estimates for the year indicated
STPOPCNG = The change DOR population estimates during the decade, 1980-1990.

CACIPOPCNG = The change CACI population estimates during the decade,1980-1990

POPINDX = DOR estimates as a percentage of CACI estimates.

GRP____ = Annualized population growth rates between the years indicated.

POP__ = Population estimates used in this study for the year indicated.

HOUSEHOLDS

Household estimates were computed as follows:

Persons per household were determined:

CACIPH80 = CACIPOP80 / CACIHH80
CACIPH86 = CACIPOP86 / CACIHH86
CACIPH88 = CACIPOP88 / CACIHH88
CACIPH90 = CACIPOP90 / CACIHH90

Annualized Growth Rates were computed:

GRH8086=(1+((CACIPH86 - CACIPH80) / CACIPH80))^(1/6)
GRH8688=(1+((CACIPH88 - CACIPH86) / CACIPH86))^(1/2)
GRH8890=(1+((CACIPH90 - CACIPH88) / CACIPH88))^(1/2)

Thus updated population per household figures could be estimated as follows:

POPHH81 = CACIPH80 * GRH8086
POPHH82 = POPHH81 * GRH8086
.
.
.
POPHH86 = POPHH85 * GRH8086
POPHH87 = POPHH86 * GRH8688
POPHH88 = POPHH87 * GRH8688
POPHH89 = POPHH88 * GRH8890
POPHH90 = POPHH89 * GRH8890

Number of Households were then estimated multiplying population per household by estimated population:

HHOLD80 = POPHH80 * POP80
.
.
.
HHOLD90 = POPHH90 * POP90

Where:

CACIHH__ = CACI household estimates for the year indicated.

CACIPH__ = Estimates of persons per household utilizing CACI for the year indicated.

GRH____ = Annualized rates of growth in persons per household between the years indicated.

POPHH__ = Updated estimates of persons per household for the year indicated.

HHOLD__ = Estimated number of households for the year indicated.

HOUSEHOLD INCOME

No DOR data were available for household income therefore this variable was simply deflated by the CPI in 1989 dollars for all goods in services in the Boston Metropolitan Area:

Adjusted CPI:

ADJCPI80 = CPI80 / CPI89
ADJCPI86 = CPI86 / CPI89
ADJCPI88 = CPI88 / CPI89
ADJCPI90 = CPI90 / CPI89

Deflated Household Income:

DEFHHY80 = CACIHHY80 * ADJCPI80
DEFHHY86 = CACIHHY86 * ADJCPI86
DEFHHY88 = CACIHHY88 * ADJCPI88
DEFHHY90 = CACIHHY80 * ADJCPI80

Annual Real Household Income Growth Rates:

GRY8086=(1+((DEFHHY86 - DEFHHY80) / DEFHHY80))^(1/6)
GRY8688=(1+((DEFHHY88 - DEFHHY86) / DEFHHY86))^(1/2)
GRY8890=(1+((DEFHHY90 - DEFHHY88) / DEFHHY88))^(1/2)

Adjusted Real Household Income:

HHINC81 = DEFHHY80 * GRY8086
.
.
.
HHINC86 = HHINC85 * GRY8086
HHINC87 = HHINC86 * GRY8688
HHINC88 = HHINC87 * GRY8688
HHINC89 = HHINC88 * GRY8890
HHINC90 = HHINC89 * GRY8890

Where:

CPI__ = CPI for all goods and services in the Boston Metropolitan Area for the year indicated.

ADJCPI__ = CPI for all goods and services in the Boston Metropolitan Area for the year indicated indexed to $ 1989.

CACIHHY__ = CACI estimated household income for the year indicated.

DEFHHY__ = Deflated household income values for the year indicated.

GRY8086__ = Annualized real growth rates in household income between the periods indicated.

HHINC__ = Estimated real household income for the year indicated.

AGE GROUPS

DOR data was provided by city for 1980 census population counts per age group and totals and 1990 estimates. CACI provided data on the percentage of individuals that belonged to various age cohorts. Adjustments to this data were computed as follows:

CACI data was first adjusted to reflect state estimates of rates of growth by age cohort:

$$STAGECNG_C = (STAGE90_C - STAGE80_C) / STAGE80_C$$
$$CACIAGECNG_C=((CACIAGE90_C*CACIPOP90)-(CACIAGE80_C*CACIPOP80))/(CACIAGE80_C*CACIPOP80)$$
$$AGEINDX_C = STAGECNG_C) / CACIAGECNG_C$$

Annual Age Group Growth Rates were then computed:

$$GRAG8086_C = (1+(((CACIAGE86_C - CACIAGE80_C) / CACIAGE80_C) * AGEINDX_C))\hat{}(1/6)$$
$$GRAG8688_C = (1+(((CACIAGE88_C - CACIAGE86_C) / CACIAGE80_C) * AGEINDX_C))\hat{}(1/6)$$
$$GRAG8890_C = (1+(((CACIAGE90_C - CACIAGE88_C) / CACIAGE80_C) * AGEINDX_C))\hat{}(1/6)$$

Thus population per age cohort per town were computed as:

$$AGE81_C = AGE80_C * GRAG8086_C$$
$$AGE82_C = AGE81_C * GRAG8086_C$$

.

.

.

$$AGE86_C = AGE85_C * GRAG8086_C$$
$$AGE87_C = AGE86_C * GRAG8688_C$$
$$AGE88_C = AGE87_C * GRAG8688_C$$
$$AGE89_C = AGE88_C * GRAG8890_C$$
$$AGE90_C = AGE89_C * GRAG8890_C$$

Percentage of the total population per age cohort:

$$PCTAGE80_C = AGE80_C * POP80_C$$

.

.

.

$$PCTAGE90_C = AGE90_C * POP90_C$$

Where:

c = the age cohort (25-34, 35-44, or 45-54).

STAGE__ = DOR population estimates per age cohort for the year indicated.

CACIAGE__ = CACI estimates of the percentage of the population in the indicated cohort for the indicated year.

STAGECNG = The change DOR population estimates per age cohort during the decade, 1980 - 1990.

CACIAGECNG = The change CACI population estimates per age cohort during the decade, 1980 - 1990.

AGEINDX = DOR age cohort estimates as a percentage of CACI estimates.

GRAG____ = Annualized population growth rates per age cohort between the years indicated.

AGE__ = Estimated population counts per age cohort for the year indicated.

PCTAGE__ = Estimated percentage of the population per age cohort for the year indicated.

APPENDIX F:

CORRELATION MATRIX

	ANNGRWTH	TXRT	TXDIFF	PCTCOLL	RESPCT	INDPCT	DENSITY
ANNGRWTH	1.00000	0.53454	0.09747	-0.12458	0.00947	-0.01257	0.05321
	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
TXRT	0.53454	1.00000	0.19356	-0.36620	-0.14746	0.10881	0.27861
	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
TXDIFF	0.09747	0.19356	1.00000	-0.14135	-0.40658	0.32071	0.30392
	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
PCTCOLL	-0.12458	-0.36620	-0.14135	1.00000	0.33220	-0.23873	-0.31421
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
RESPCT	0.00947	-0.14746	-0.40658	0.33220	1.00000	-0.81990	-0.23257
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
INDPCT	-0.01257	0.10881	0.32071	-0.23873	-0.81990	1.00000	0.05572
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001
	194657	194657	194657	194657	194657	194657	194657
DENSITY	0.05321	0.27861	0.30392	-0.31421	-0.23257	0.05572	1.00000
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
	194657	194657	194657	194657	194657	194657	194657
RESCONST	-0.37842	-0.37544	-0.20887	0.14789	0.08207	0.02950	-0.28619
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	194350	194350	194350	194350	194350	194350
TRNSTIME	0.00922	-0.10134	-0.25226	-0.02614	0.17667	-0.02569	-0.61688
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	192369	192369	192369	192369	192369	192369	192369
AUTOCBD	-0.08495	-0.12547	-0.30836	-0.15975	0.15704	-0.01410	-0.63326
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	192369	192369	192369	192369	192369	192369	192369
AUTOTHER	-0.06546	-0.06406	-0.28975	-0.25703	0.21922	-0.17115	-0.38854
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	192369	192369	192369	192369	192369	192369	192369
HHINC	-0.06117	-0.33412	-0.23167	0.80260	0.31221	-0.18256	-0.46869
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
UNEMP	0.21448	0.41179	0.00618	-0.59827	-0.13679	0.08632	0.14094
	0.0001	0.0001	0.0064	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657

	RESCONST	TRNSTIME	AUTOCBD	AUTOTHER	HHINC	UNEMP
ANNGRWTH	-0.37842	0.00922	-0.08495	-0.06546	-0.06117	0.21448
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
TXRT	-0.37544	-0.10134	-0.12547	-0.06406	-0.33412	0.41179
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
TXDIFF	-0.20887	-0.25226	-0.30836	-0.28975	-0.23167	0.00618
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0064
	194350	192369	192369	192369	194657	194657
PCTCOLL	0.14789	-0.02614	-0.15975	-0.25703	0.80260	-0.59827
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
RESPCT	0.08207	0.17667	0.15704	0.21922	0.31221	-0.13679
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
INDPCT	0.02950	-0.02569	-0.01410	-0.17115	-0.18256	0.08632
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
DENSITY	-0.28619	-0.61688	-0.63326	-0.38854	-0.46869	0.14094
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
RESCONST	1.00000	0.20855	0.27873	0.13278	0.22837	-0.29461
	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192062	192062	192062	194350	194350
TRNSTIME	0.20855	1.00000	0.83881	0.55157	-0.01346	0.23516
	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
	192062	192369	192369	192369	192369	192369
AUTOCBD	0.27873	0.83881	1.00000	0.77042	-0.11441	0.27964
	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001
	192062	192369	192369	192369	192369	192369
AUTOTHER	0.13278	0.55157	0.77042	1.00000	-0.28321	0.30884
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001
	192062	192369	192369	192369	192369	192369
HHINC	0.22837	-0.01346	-0.11441	-0.28321	1.00000	-0.65038
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001
	194350	192369	192369	192369	194657	194657
UNEMP	-0.29461	0.23516	0.27964	0.30884	-0.65038	1.00000
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
	194350	192369	192369	192369	194657	194657

	WHTPCT	HHOLDS	PCT2534	PCT3544	PCT4554
ANNGRWTH	0.05032 0.0001 194657	0.01252 0.0001 194657	-0.10031 0.0001 194657	-0.19477 0.0001 194657	-0.04895 0.0001 194657
TXRT	-0.15450 0.0001 194657	0.26689 0.0001 194657	0.07145 0.0001 194657	-0.38747 0.0001 194657	-0.22352 0.0001 194657
TXDIFF	-0.19679 0.0001 194657	0.37233 0.0001 194657	0.11311 0.0001 194657	-0.27601 0.0001 194657	-0.04768 0.0001 194657
PCTCOLL	0.09916 0.0001 194657	-0.28930 0.0001 194657	-0.34703 0.0001 194657	0.47181 0.0001 194657	0.45774 0.0001 194657
RESPCT	0.22457 0.0001 194657	-0.28529 0.0001 194657	-0.24643 0.0001 194657	0.30990 0.0001 194657	0.06242 0.0001 194657
INDPCT	-0.06407 0.0001 194657	0.09856 0.0001 194657	0.20863 0.0001 194657	-0.20136 0.0001 194657	-0.03409 0.0001 194657
DENSITY	-0.44025 0.0001 194657	0.73212 0.0001 194657	0.27614 0.0001 194657	-0.38850 0.0001 194657	-0.21333 0.0001 194657
RESCONST	0.17261 0.0001 194350	-0.31843 0.0001 194350	-0.02394 0.0001 194350	0.40196 0.0001 194350	0.15207 0.0001 194350
TRNSTIME	0.11200 0.0001 192369	-0.46361 0.0001 192369	-0.06147 0.0001 192369	0.08750 0.0001 192369	-0.08132 0.0001 192369
AUTOCBD	0.07315 0.0001 192369	-0.43531 0.0001 192369	0.02354 0.0001 192369	0.07558 0.0001 192369	-0.15676 0.0001 192369
AUTOTHER	0.12709 0.0001 192369	-0.25722 0.0001 192369	0.04353 0.0001 192369	0.04336 0.0001 192369	-0.22238 0.0001 192369
HHINC	0.29180 0.0001 194657	-0.48547 0.0001 194657	-0.48988 0.0001 194657	0.58351 0.0001 194657	0.53527 0.0001 194657
UNEMP	-0.20128 0.0001 194657	0.16174 0.0001 194657	0.08749 0.0001 194657	-0.45515 0.0001 194657	-0.32921 0.0001 194657
WHTPCT	1.00000 0.0000 194657	-0.52139 0.0001 194657	-0.19895 0.0001 194657	0.42348 0.0001 194657	0.39065 0.0001 194657
HHOLDS	-0.52139 0.0001 194657	1.00000 0.0000 194657	0.29818 0.0001 194657	-0.42489 0.0001 194657	-0.28613 0.0001 194657
PCT2534	-0.19895 0.0001 194657	0.29818 0.0001 194657	1.00000 0.0000 194657	-0.32360 0.0001 194657	-0.53181 0.0001 194657
PCT3544	0.42348 0.0001 194657	-0.42489 0.0001 194657	-0.32360 0.0001 194657	1.00000 0.0000 194657	0.57431 0.0001 194657
PCT4554	0.39065 0.0001 194657	-0.28613 0.0001 194657	-0.53181 0.0001 194657	0.57431 0.0001 194657	1.00000 0.0000 194657

	ANNGRWTH	TXRT	TXDIFF	PCTCOLL	RESPCT	INDPCT	DENSITY
WHTPCT	0.05032	-0.15450	-0.19679	0.09916	0.22457	-0.06407	-0.44025
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
HHOLDS	0.01252	0.26689	0.37233	-0.28930	-0.28529	0.09856	0.73212
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
PCT2534	-0.10031	0.07145	0.11311	-0.34703	-0.24643	0.20863	0.27614
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
PCT3544	-0.19477	-0.38747	-0.27601	0.47181	0.30990	-0.20136	-0.38850
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657
PCT4554	-0.04895	-0.22352	-0.04768	0.45774	0.06242	-0.03409	-0.21333
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194657	194657	194657	194657	194657	194657	194657

	RESCONST	TRNSTIME	AUTOCBD	AUTOTHER	HHINC	UNEMP
WHTPCT	0.17261	0.11200	0.07315	0.12709	0.29180	-0.20128
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
HHOLDS	-0.31843	-0.46361	-0.43531	-0.25722	-0.48547	0.16174
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
PCT2534	-0.02394	-0.06147	0.02354	0.04353	-0.48988	0.08749
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
PCT3544	0.40196	0.08750	0.07558	0.04336	0.58351	-0.45515
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657
PCT4554	0.15207	-0.08132	-0.15676	-0.22238	0.53527	-0.32921
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	194350	192369	192369	192369	194657	194657

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