Amenity-Based Housing Affordability Indexes

Lynn Fisher
Department of Urban Studies and Planning
Center for Real Estate
Massachusetts Institute of Technology
lfisher@mit.edu

Henry Pollakowski*
Center for Real Estate
Massachusetts Institute of Technology
pollak@mit.edu

Jeffrey Zabel
Economics Department
Tufts University
jeff.zabel@tufts.edu

Most recent draft: September 16, 2007

* Corresponding author.

We thank Ryan McCann, Sheharyar Bokhari, Jessica Haurin, Andrew Jakabovics and Farooq Pasha for their help in compiling the data and generating the affordability indices presented in this paper. Also, we are indebted to the Warren Group and the Central Transportation Planning Staff (CTPS) of Boston for their data contributions. We thank Richard Arnott, Kyung-Hwan Kim, Tony Yezer, and participants at the 2006 AREUEA Mid-year Meetings in Washington DC, the 2006 AREUEA International meetings in Vancouver, and the 2006 Regional Science Association meetings in Toronto for helpful comments.

Abstract

The recent substantial increases in house prices in many parts of the United States have served to highlight housing affordability for moderate income households, especially in high-cost, supply-constrained coastal cities such as Boston. For a variety of reasons, average housing prices in such cities are unlikely to dramatically decline. In Massachusetts, for example, stringent town-level land use restrictions render construction of (higher-density) housing for moderate income households nearly infeasible. Moreover, a first-best solution of region wide relaxation of stringent local controls is not on the horizon. This paper thus examines the *distribution* of housing opportunities by location, quality, and price/rent facing new entrants and other marginal households deciding whether to stay or leave. In particular, we examine the renting and owning affordability implications for households earning between 50 and 80 percent of area median income. We develop a new measure of *area affordability* that characterizes the supply of housing that is affordable to different households in different areas of the Boston metropolitan region. Key to our approach is the explicit recognition that the price/rent of a dwelling is affected by its location. Hence, we adjust our index to account for job accessibility, school quality, and safety. This adjustment is based on obtaining implicit prices of these amenities from a hedonic price equation. Housing at prices/rents that are unaffordable in the absence of location factors, for example, may be deemed affordable once its strong job accessibility is considered. We use data from a wide variety of sources to rank 141 towns in the greater Boston metropolitan area based on their adjusted affordability. Taking households earning 80 percent of area median income as an example, we find that consideration of town-level amenities leads to major adjustments in our affordability measure. Our methodology thus makes transparent amenity-adjusted, town-level affordability of rental and owner stock. The results can support a flexible menu of policy options to increase affordability.

Key Words: housing affordability; housing price index; employment accessibility index; location amenities

1. Introduction

The recent substantial increases in house prices in many parts of the United States have served to highlight housing affordability issues for moderate income households, especially in high-cost, coastal cities such as Boston, MA (Goodman and Rodda, 2005). During the period 1998-2005, house prices in the Boston metropolitan area nearly doubled. For a variety of reasons, average housing prices in such cities are unlikely to dramatically decline. These high housing prices are particularly relevant to potential new entrants and other marginal households deciding whether to stay or leave. Many workers may choose not to locate in places such as Boston, even when their economic contribution to the area would have been positive.

In Massachusetts, for example, strong town-level land use restrictions render construction of (higher-density) housing for moderate income households nearly infeasible. A first-best solution of region wide relaxation of stringent local controls is not on the horizon. In order to make the nature of affordability issues more transparent and this consider other policies, this paper thus examines the affordable rental and owner stock of housing for households earning between 50 and 80 percent of area median income in the Boston metropolitan area. To do this, we examine the *distribution* of housing opportunities by location, quality, and price/rents facing new entrants.

The existing literature does not address this important intrametropolitan issue. The existing housing stock must be examined by location and with respect to the affordability-relevant households. Typical measures of affordablility do not adequately address the actual supply of "affordable" units in a geographic area or anticipate the spatial implications of where the supply of housing is located. We thus develop a new measure of *area affordability* that characterizes the supply of housing that is affordable to different households in different areas of a metropolitan region. By focusing on area affordability, we recognize that the price of a house is affected by its location since this price includes the value of the services provided by local amenities. Hence, we adjust our index to account for job accessibility, school quality, and safety. This adjustment is based on obtaining implicit prices of these amenities from a random effects hedonic price equation. Housing at prices/rents that are unaffordable in the absence of location factors, for example, may be deemed affordable once its strong job accessibility is considered.

This paper focuses on characteristics of the supply of affordable housing in a metropolitan area. In doing so, we introduce a new methodology for assessing the supply of affordable housing and contribute to the literature that examines linkages between land use regulation and housing markets. Our emphasis is on the *distribution* of housing units. The premise here is that in housing markets that are not highly regulated, high housing costs should induce not only more housing development, but also more housing available at lower cost due to development and redevelopment at higher densities. When the market cannot adjust due to high levels of land use regulation, affordability problems are exacerbated.

Location effects house prices because price includes the value of services provided by local amenities. Moreover, this bundle of employment opportunities and local amenities varies considerably across a region. The existing literature does not address this important intrametropolitan issue. Typical measures of affordability fail to adequately address the actual supply of "affordable" units in a geographic area and anticipate the spatial implications of housing supply. Similarly, considerable recent research has only considered *average* housing costs in coastal markets. Recent studies have dealt with explanations, including demand factors and supply regulation (Gyourko, Meyer, and Sinai, 2006; Wheaton, 2006; Glaeser and Gyourko, 2002; Quigley and Raphael, 2005; Saks, 2005.)[1] In general, these studies fail to offer a major "correction" in housing prices in these cities. We thus develop a new measure of *area affordability* that characterizes the supply of adequate housing across a metropolitan region that is affordable to households across the income spectrum. Our affordability index accounts for job accessibility, school quality, and safety.

By introducing a new methodology for assessing the supply of affordable housing, we contribute to the literature that examines linkages between land use regulation and housing markets. Our emphasis is on the *distribution* of housing units. The premise here is that in housing markets that are not highly regulated, high housing prices/rents should induce more housing development along with redevelopment at higher densities. When this cannot occur, affordability problems are exacerbated.

The methodology developed here addresses private housing for working households. While housing for the poorest in society is an important area of policy and study, such housing is of necessity tied to direct public subsidy. At the other end of the income spectrum, large increases in house prices have benefited existing homeowners. Therefore our concern regarding affordability is with respect to new entrants to the market: the young, the immigrant and the household who wishes to transfer to a new job in the metropolitan area, specifically households earning 50% of area median income or more.

We address several weaknesses in the extant literature on affordability. First, we incorporate both rental and owner-occupied stock in our assessment of affordable units. Rental housing is often the most affordable option to households but is frequently neglected in the affordability literature in favor of owner-occupied housing. Second, we make adjustments for the quality of housing location in terms of the various public amenities provided. .

Since the price/rent of a dwelling is affected by its location in that it includes the value of the services provided by local amenities, a simple comparison of prices (or rents) across areas may not be an accurate measure of relative affordability. One area may appear to be less affordable because it provides more services like job accessibility, school quality, and safety. Further, the goal of affordable housing policy should be to not only provide adequate structure for households but also to supply units that are accessible to jobs, are in safe areas, and have decent schools. Hence, we adjust our index to account for job accessibility, school quality, and safety. This adjustment is based on obtaining implicit prices of these amenities/disamenities from a hedonic price equation. Housing at prices/rents that are unaffordable in the absence of location factors, for example, may be deemed affordable once its strong job accessibility is considered. We use data from a wide variety of sources to rank 141 towns in the greater Boston metropolitan area based on their adjusted affordability. Our methodology makes transparent amenity-adjusted, town-level affordability of rental and owner stock, and can support a menu of policy options to increase affordability.

---

[1] Glaeser and Gyourko (2002) provide evidence that the high house prices on the east and west coasts are due to the impact of zoning and other land-use controls on the supply of housing. Quigley and Raphael (2005) link the high level of regulation that affects land-use and residential construction to the high house prices in California. Recently, the concerns about land use regulation and high house prices have also been empirically linked to labor markets. Saks (2005) shows that places with more land use regulations have weaker housing supply responses to demand shocks in the long run and higher house prices. In turn, she also shows that the response to a demand shock for labor is dampened in places with highly constrained housing supplies.

Housing policy has been an important part of the activities of state and local governments. In addition, concerns about the ability of metropolitan areas to compete for firms, jobs and human capital that will continue to fuel economic growth have made housing a priority of other public and private organizations not traditionally concerned with housing. In some places, judicial and legislative demands require housing plans and/or a measure of an area's housing affordability. In Massachusetts, New Jersey, California and other states, residential housing developers may sometimes pursue strategies that result in the development of affordable housing when local areas fail to meet some measure of affordability. Thus, an affordability index can be a useful tool for state and local governments and other housing-related organizations. As such, this index needs to be flexible to meet the uses of these different agencies (Bogdon and Can 1997). Our index can be applied to different sizes and types of households with different income levels. Hence, we believe our index has an appropriate level of flexibility to make it useful in a broad range of housing policy applications.

In Section 2, we introduce the concept of area affordability and contrast it with the existing academic research on affordability. In Section 3, we provide the theory underlying our affordability index. Hedonic price equations are specified that provide implicit prices of town-level amenity values, and these implicit prices are then used to adjust effective rents to measure affordability. In Section 4, we apply our index to the greater Boston metropolitan area. This section includes a discussion of the many data issues that arise in constructing our index, along with an examination of the empirical results. We discuss the policy implications of our results in Section 5 and conclude in Section 6.

2. Affordability

The most frequently cited measures of affordability relate to house prices and incomes, typically at the metropolitan area level. Typical measures relate the income of a hypothetical median household and a hypothetical median price dwelling. While house price indexes have become increasingly available for metropolitan areas (Office of Housing Enterprise Oversight (OFHEO), Case-Shiller-Weiss), they are not useful for the focused examination of affordability presented here. Gyourko and Linneman (1993) and Gyourko and Tracy (1999) complement our work by comparing the distribution of real house prices and incomes over time as a way of measuring the discrepancy between house price changes and income changes. While this big-picture view is instructive, it is not related to the spatial approach taken here.

Rental housing affordability is typically viewed in terms of rent burdens. While these are useful for a big-picture look at how much is paid for housing by less well off households, they reflect choices made (often under duress) rather than the existence of appropriate opportunities considered in this study. In this sense, some households may not appear to have an affordability problem because they consume less than adequate amounts of housing. Other households may incur high rent burdens in an effort to obtain location amenities such as those considered in this paper.

Most importantly, rent burdens measure outcomes for households in place. They do not measure the spatial opportunity set facing households. Rent burden measures all focus on the demand side of the market without matching demand with the supply of appropriate housing units. Bogdon and Can (1997) present a good review of studies that attempt to characterize the supply side of the market. They criticize the extant literature on supply for its focus on simply the price of units and not the size, condition, location and neighborhood characteristics of the stock.

Some commentators use the ratio of an area's median income to median house price to judge if an area is affordable. This ratio contains little information and is potentially misleading. Neither the distribution of the dwellings nor the distribution of the marginal households is portrayed. Further, consumption of housing services per household has risen over the last decade as the overall level of income has risen (particularly at the upper end of the income distribution). In other words, median house prices have risen partly as a response to the new supply of higher quality units. The median house price in many well-to-do areas is likely to reveal little about the distribution of other, acceptable housing units that cost less than the median.

Some of the median-ratio statistics are also created by using individual town median house price and the same town's median income. Those who already live in the town are "affording" to do so, and in the case of homeowners have made major gains during periods of substantial price increases. The appropriate households to consider consist of the metropolitan-wide distribution of households who need to live *somewhere.* With the increase in income inequality over the last decade and for any given housing stock, those at the lower end of the income distribution may have a difficult time finding affordable housing.

What then does it mean for a town or other small geographic area to be affordable? In the next section, we propose a measure that represents the proportion of housing that is "affordable" by a certain portion of the income distribution. One can hence think of some towns being affordable to certain parts of the income distribution but not other parts. "Affordable" is defined as a housing expenditure to income ratio of less than 30%.[2] However, certain units will not be included as affordable if they do not meet minimal adequacy standards. Incorporating locational goods into this consideration also serves to limit the eligible units on a town-wide basis.[3]

3. Theory

In this section, we develop the theory underlying the town-level affordability index. First, we develop a framework from which one can calculate inter-jurisdictional price indices using hedonic models. After providing some background about generating different types of indices, we generate the specific set of affordability measures. This section thus develops a hedonic framework for obtaining implicit prices of town-level amenities, and then demonstrates the use of these implicit prices to adjust the apparent affordable stock by town.

3.1 Inter-jurisdictional Price Indices

Following Sieg, et al (2002), (henceforth SSBW), one can generate a price index for housing even though housing is heterogeneous. The key assumption is that housing enters the utility function in a separable function that is homogeneous of degree one. Further, this allows one to generate an interjurisdictional price index that is consistent with locational equilibrium theory. Let the individual utility function depend on non-housing composite consumption, C and housing, H. Assume one city with a total of J jurisdictions. H is heterogeneous and is a function of structural characteristics, S, and locational amenities, L_j that vary across jurisdictions. Locational amenities include accessibility to jobs, school quality, and safety. Initially we will assume that S and L_j are

[2] Cranston-Gonzalez National Affordable Housing Act defines affordable housing act defines affordable rental housing as rent that does not exceed 30 percent of the adjusted income (HUD)

[3] It would be desirable to obtain information below the town level so that part of the town might meet minimal standards while other parts do not. Otherwise, the entire stock of housing in a given area will be affected by a town-wide measure of amenities. We believe that in the Boston area where we consider 141 different towns, this will be less of an issue. However, in areas with large jurisdictions, the application of adjustments for local amenities will need additional data and attention.

each one-dimensional (it is a straightforward generalization to allow both S and L to be multi-dimensional). We can express H as H(S, L_j). Note that this formulation differs from SSBW because we include L_j in H. That is, consistent with Zabel (2004), we view the services associated with housing to emanate both from the housing structure and from the locational amenities. Assume that both U and H are Cobb-Douglas then

$$U(C,H) = C^{1-b}H^{b} = C^{1-b}\left(S^{a}L_{j}^{1-a}\right)^{b}. \tag{1}$$

Thus, we assume that housing enters the utility function in a separable function that is homogeneous of degree one. Assuming a static-equivalent setting, an individual chooses how to allocate her income, y, to C and H subject to the budget constraint

$$C + pH = y \tag{2}$$

where the price of non-housing consumption is normalized to one and where p is the price of a unit of housing services. Assume that the individual maximizes utility subject to equation (2). Solving the budget constraint for C and substituting into the utility function (1) gives the indirect utility function

$$V = \text{Max: } U(y - pH, H). \tag{3}$$

Then if the prices for a unit of S and L_j are q_1 and q_2, the indirect utility function is

$$V = \frac{By}{\left(Aq_1^{a}q_2^{(1-a)}\right)^{b}} = Byp^{-b} \tag{4}$$

where $B = b^{b}(1-b)^{1-b}$, $A = a^{a}(1-a)^{1-a}$, and $p = Aq_1^{a}q_2^{(1-a)}$. Thus, even though housing is heterogeneous, the indirect utility only depends on the price index p and income y.

The sub-expenditure function for housing can be derived as

$$E(q_1, q_2, H) = Aq_1^{a}q_2^{1-a}H = pH = pS^{a}L_j^{1-a}. \tag{5}$$

Thus, expenditures on housing can be expressed as the product of the price index p and the quantity index H. Taking logs of (5) gives

$$\ln E = \ln p + a\ln S + (1-a)\ln L_j \tag{6}$$

Let $P_{ij}(S_{ij}, L_j)$ be the value of a house i in jurisdiction j with structural characteristics S_{ij} and amenities L_j. The value or price of the house represents the present discounted value of the flow of services provided by the dwelling in a given location. In equilibrium (when utility is maximized and the market clears), the minimum expenditure for this house will be equal to the (discounted value of the) market price for that house. Substituting into equation (6) gives the house price hedonic

$$\ln(P_{ij} \cdot r) = \ln p + a\ln S_{ij} + (1 - a)\ln L_j$$

or, (7)

$$\ln P_{ij} = \beta_0 + \beta_1 \ln S_{ij} + \beta_2 \ln L_j$$

where r is the discount (or interest) rate. Since p and r are fixed they will be part of the constant, β_0.

SSBW decompose S_{ij} into observable and unobservable structural characteristics S_{1ij} and S_{2ij}. Further, they do not explicitly recognize locational amenities but, instead, lump all such amenities into a town fixed effect. Invoking these assumptions, (7) becomes

$$\ln P_{ij} = \beta_j + \beta_{11} \ln S_{1ij} + u_{ij} \quad (8)$$

where $u_{ij} = \beta_{12} \ln S_{2ij}$.

SSBW interpret the βj's, the town fixed effects, as interjurisdictional house prices. Note that, in essence, what they are estimating is $\hat{\beta}_2 \ln L_j$ from equation (7). Hence, this can be interpreted at the appropriate price index. So at least for this simple example, by estimating equation (7) or (8), we can extract the town-level amenity (price) index $\hat{\beta}_2 \ln L_j$.

One problem with the SSBW approach is that the town fixed effects may be a function of land-use regulations that restrict supply. In which case the correlation between the βj's and the amenities will be less than one and the ranking of towns by the βj's and by L_j might be quite different.

3.2 Different Types of House Price Indices

Zabel (1999) points out that house price indices are used for many purposes and are differentiated by what housing characteristics are held constant. When generating such indices using house price hedonics, Zabel shows that in order to obtain an unbiased estimate of any of these indices, it is crucial to include all house price determinants as regressors.

The simplest interjurisdictional house price index is just the mean (or median) of prices in each jurisdiction,

$$\overline{P}_j = n_j^{-1} \cdot \sum_{i=1}^{n_j} P_{ij} \quad j = 1,\ldots, J. \quad (9)$$

Another type of index is based on the following expression

$$F_j(P_m) = 100 \cdot n_j^{-1} \cdot \sum_{i=1}^{n_j} I_{Pm}(P_{ij}) \quad (10)$$

where $$I_{Pm}(P_{ij}) = \begin{cases} 1 \text{ if } P_{ij} \le P_m \\ 0 \text{ otherwise} \end{cases}.$$

This is the percentage of units with price less than or equal to some fixed price P_m, i.e., the empirical CDF (times 100) evaluated at P_m.

The interjurisdictional house price index associated with equation (8) is the fixed effect from this regression (i.e. the jurisdictional mean residual)

$$\overline{P}_j\left(S_j\right) = \overline{P}_j - \hat{\beta}_1 \overline{S}_j = \overline{\hat{u}}_j = n_j^{-1} \cdot \sum_{i=1}^{n_j} \left(P_{ij} - \hat{\beta}_1 S_{ij}\right). \tag{11}$$

This is consistent with a price index that accounts, i.e. holds constant, S (see Zabel [16]). The comparable version of the index in equation (10) that holds constant S is

$$F_j(P_m \mid S_m) = 100 \cdot n_j^{-1} \cdot \sum_{i=1}^{n_j} I_{P_m}\left(P_{ij} - \hat{\beta}_1 (S_{ij} - S_m)\right). \tag{12}$$

where S_m is some fixed (market) value of S against which all units are compared. Note that this amounts to comparing the adjusted unit price, $P_{ij} - \hat{\beta}_1 S_{ij}$, to a fixed price that is adjusted for a fixed structural component, $P_m - \hat{\beta}_1 S_m$. For example S_m might be set to the average value of S in the data.

Now suppose we explicitly include L_j in the house price hedonic as in (7). The version of the index in (10) that holds constant both S and L_j is

$$F_j(P_m \mid S_m, L_m) = 100 \cdot n_j^{-1} \cdot \sum_{i=1}^{n_j} I_{Pm}\left(P_{ij} - \hat{\beta}_1 (S_{ij} - S_m) - \hat{\beta}_2 (L_j - L_m)\right) \tag{13}$$

where L_m is a fixed value of the locational amenity against which units in different jurisdictions are compared.

3.3 Area Affordability Index

The affordability index is a form of price index that measures the ability of some income group to rent/purchase housing in a town. Most indices are measured at the mean price level or at some other point in the price distribution such as the median. The index generated here measures the proportion of units that are affordable by a particular income group. Thus it is equal to $F_j(P_{max})$ in equation (10) evaluated at the highest price that is "affordable" by the income group, P_{max}.

As such, this index does not account for structure or locational amenities. Thus one town might have more affordable housing than another because it provides fewer locational amenities or because it has lower quality units. Our approach adjusts for structural differences in units across jurisdictions by excluding inadequate units from the initial housing distribution (see Section 4 and in Appendix 2). In this sub-section, we discuss how we account for differences in locational amenities across jurisdictions. An important locational amenity is job accessibility. Inexpensive housing that is far from jobs should not be considered affordable since it provides few opportunities for employment and hence does not provide the income needed to pay the rent or mortgage. Aslund, Östh, and Zenou (2006) find that residents in locations with poor accessibility in 1990-91 were less likely to be employed in 1999; if job accessibility is doubled in these locations in 1990-91, the probability of unemployment in 1999 decreases by 2.9 percentage points. Thus poor accessibility can have long-term negative impacts on employment.

One way of valuing job accessibility is in terms of commuting costs; the better the accessibility the lower the commuting costs. Given that commuting costs are being capitalized into the rental/house price then, all things equal, a house in a town with better accessibility to jobs will have a higher price than the house in a town with worse accessibility. The appropriate affordability index then depends on the distribution of prices in a town controlling for its commuting costs. Assume that L_{1A} is the location with the average accessibility. We adjust the price of units to reflect the implied commuting cost of that location relative to the average location. In other words, we rewrite equation (10) as,

$$F_j(P_m \mid L_{1A}) = 100 \cdot n_j^{-1} \cdot \sum_{i=1}^{n_j} I_{Pm}\left(P_{ij} - \hat{\beta}_1\left(L_{1j} - L_{1A}\right)\right) \qquad (14)$$

Notice that housing unit prices are thus adjusted downwards or upwards depending on whether the location of the town in which the unit is located is better or worse than average. Making this adjustment will alter the affordability rankings in favor of towns with high levels of accessibility.

Next we consider adjusting the affordability index for other locational amenities (e.g. school quality and safety). The policy implication of amenities that do not represent "hard" costs to the housing occupants must be considered. In arguing that we should adjust the price of housing to reflect commuting, we assume that all workers incur some costs of transportation to work. With respect to amenities like school quality, however, our concern is with respect to a sufficient quality of that amenity in terms of what society believes to be a reasonable level. To this end, we assume that a reasonable level of these goods to be at or above the mean level of provision across jurisdictions. Hence in places with below average town amenities, like school quality, households incur either an implicit or explicit cost from residing in that town. However, we assume that expenditures on above-average school quality (by purchasing housing in that school district) are discretionary expenditures and hence should not be used to adjust the area affordability. Implicit costs from below-average schools may be associated with a lower rate of human capital acquisition that can result in lower labor market earnings. Explicit costs may be revealed in the decision to send children to private school or by hiring tutors due to ineffective schooling.

Therefore, for non-commuting amenities we propose to adjust a town's price distribution if the quality of a particular amenity is below average, but to make no adjustment to prices in places where amenities are above average. Let there be two locational amenities; L_{1j} is accessibility and L_{2j} is school quality. Define that average of school quality to be L_{2A}. Then, define I_{2j} as a variable indicating whether school quality is below average,

$$I_{2j} = \begin{cases} 1 \text{ if } L_{2j} < L_{2A} \\ 0 \text{ otherwise} \end{cases} \qquad (15)$$

Thus if we also consider school quality as an additional locational amenity in addition to commuting, equation (14) becomes,

$$F_j(P_m \mid L_{1A}, L_{2A}) = 100 \cdot n_j^{-1} \cdot \sum_{i=1}^{n_j} I_{Pm}\left(P_{ij} - \hat{\beta}_1(L_{1j} - L_{1A}) - I_{2j} \cdot \hat{\beta}_2\left(L_{2j} - L_{2A}\right)\right) \quad (16).$$

Notice that the last term, $I_{2j} \cdot \hat{\beta}_2\left(L_{2j} - L_{2A}\right)$, is always less than or equal to zero (assuming that $\hat{\beta}_2 > 0$); prices/rents will be adjusted upward in towns with lower than average school quality and be unchanged for towns with greater than or equal to average school quality.

4. Application: Housing Affordability in the Boston Metropolitan Area

We apply the affordability index to the Boston metropolitan area for 2006. First we discuss the data we use and the many related issues surrounding the construction of the area affordability indices. Then we present example of indices for (one of many) household incomes (as a percent of area median income (AMI)) and family sizes.

4.1 Data Issues

First, we need to obtain the distribution of prices in the towns in the Boston metropolitan area. We include both rental units and owner occupied units. The main source of data is the 2000 Census. Appendix 1 describes the process for calculating the total and affordable stock of housing and the updating of prices/rents to 2006 levels. Three data issues that must be addressed in the process of generating the affordability index are addressed in Appendix 2: 1) defining and excluding inadequate structural units, 2) excluding small units from the 4- person index, and 3) generating the accessibility index.

In order to determine the total stock of affordable housing, we need to combine owner occupied and rental units into one price distribution. To do this, we obtain the imputed rent by making the transformation based on the user-cost of owner-occupied housing (Poterba, 2002). Because we focus on the ability of a household to obtain a unit of housing in a particular place, we exclude the anticipated costs of housing depreciation and maintenance as well as future expected house price appreciation that are normally incorporated in the user-cost calculation. We do so because these are future costs and benefits that are not incurred until and unless a household can afford the explicit costs of purchasing the owner occupied asset. Out index is intended to summarize opportunities faced by new entrants. We continue to include property taxes because this cost is normally held in escrow and is effectively incurred on a monthly basis (when mortgage financing is used). We also modify the user-cost formula to account for the facts that the tax impact of itemizing is the incremental value relative to taking a standard deduction and that one can deduct state taxes and charitable contributions when itemizing.

$$R' = \left(i + \tau_p\right)P - \tau\left[\left(i + \tau_p\right)P + c + s_t - sd\right] \quad (17)$$

where

R’	= Imputed Rent for owner-occupied housing
i	= Mortgage rate = 6.41% (Freddie Mac 30-year fixed rate, annual average 2006)
τ_p	= Property tax rate
P	= House price
τ	= marginal tax rate = 15% for 2-person, 80% AMI household income taking standard deduction

c = Charitable contributions = 2% of income
s_t = State taxes
sd = Standard deduction = \$10,000.

We can then use the imputed rents to combine the owner-occupied housing with rental housing into one price distribution.

Given the single distribution of rental and owner-occupied prices, we calculate the unadjusted affordability index as the percentage of units that are affordable for a family with a given household income and size. Next, we adjust the affordability index for the town-level amenities; accessibility, schooling, and safety. To make these adjustments, we need to obtain the appropriate amenity coefficient estimates from the house price hedonic. It is important to emphasize that the three amenity coefficient estimates are the *only* coefficients that are used in making our affordability adjustments.[4]

We estimate separate hedonic regressions for 2005-2006 using transactions data for single-family houses and condominiums from the Boston metropolitan area. We use data on unit structural characteristics from the Warren Group, which in turn gathers its data from city and town assessors.

Town-level data on employment and commute times are used to construct the job accessibility index (Figure 1). The index is defined as

$$index_{town\_i} = \sum_{j \neq i} \frac{e_{town\_j}}{\left(d_{town\_j}\right)^{1.5}}$$

This is a standard gravity index that measures access to employment as a function of commuting time to each job. The town level employment data, commuting data, and methodology are described in Appendix 2. The index value for any given town is the sum of employment in each destination town in the region divided by commuting time to that town. In Figure 1 we see that the Boston area remains strongly monocentric. About half of all employment is located in the central area. Suburban subcenters account for much of the remaining employment.

The regression that we use includes the following structural characteristics: age, the number of bathrooms and bedrooms,[5] lot size and its square, interior size and its square, and whether the

[4] Given that our emphasis is on appropriately tabulating the affordable stock by town, our approach differs from that of Lerman and Reeder (1987). Lerman and Reeder use national American Housing Survey (AHS) microdata for renters to determine which households can afford a minimum hedonic bundle. Of course, AHS data do not allow for inclusion of location-specific attributes. But more importantly, such an analysis is not place-oriented - - it lends itself to a demand-side analysis, implicitly assuming that the minimum hedonic bundle considered affordable for a poor household will be provided by the market. In contrast, our approach focuses on supply considerations facing a household earning 50 to 80 percent of area median income in a spatial, supply-restricted setting. Starting with the 2000 Census and making appropriate adjustments, we calculate (for a given household income and type) affordable stock, then adjust for disadvantages with regard to town-level amenities. Lerman and Reeder's goal is to indicate which poor households should receive subsidies. Our goal is to make transparent the affordable stock in a spatial setting, setting the stage for a variety of focused policies.

[5] One problem with the sales data is that the number of bedrooms is often unreported; in some cases for all observations is a town. In order to keep these observations in the dataset, we impute values for the number

house is a cape, colonial or ranch style for single-family houses and whether it is a town-house for condominiums. We also include population density and the percent of open space in the town. The three town-level variables that we use to adjust town-level affordability are the accessibility index, the sum of the 10^{th} grade English and math MCAS scores[6], and a composite safety measure. Data on school scores are obtained from the Massachusetts Department of Education. Data on the variables employed to construct the composite safety variable are obtained from several sources described in Appendix 2.

The definitions of the variables and summary statistics are provided in Table 1. The city of Boston is excluded due to data limitations and the fact that a much larger portion of the housing stock is public or subsidized housing than is found in the surrounding areas. This fact, combined with considerable inadequate stock, poor school scores, and high crime rates, makes comparisons with most other jurisdictions problematic. The final 2005-2006 dataset used for hedonic estimation includes observations for 57,834 single-family transactions in 141 towns in the Boston metropolitan area and 22,525 condominium transactions in 133 towns (for eight towns there were no condo sales). Table 2 presents the regression results. We transform the sales prices into imputed rents so that the coefficient estimates can be directly applied to make adjustments to the affordability index. We estimate the model using random effects to account for the correlation of the error terms for houses in the same town. All structure variables are significant at the 1% level and of the expected sign where the sign can be reasonably be hypothesized. Further, increases in accessibility, school quality, and safety significantly increase imputed rents.

We use the coefficient estimates for the relevant town-level variables to adjust the imputed rents in each town. Since the relationship between imputed rent and town-level variable is specified as log-log, the coefficients from Table 2 are multiplied by the sample mean imputed rent and divided by the sample mean of the corresponding amenity. These adjustments are given in Table 3. As discussed in Section 3.3, we make adjustments compared to the mean accessibility level so that the effective imputed rents in towns with greater/less than average accessibility will be lowered/raised. For school quality, we make adjustments for towns below the mean values of these variables and no adjustment for towns with values above the mean. We do this because we consider the mean value to be adequate for affordable housing and anything above average to be more than adequate. Likewise, for our safety variable (which measures lack of safety), we only make adjustments for towns on the "unsafe" side of the mean.

Note that, in principle, observed rents and imputed rents (especially for condominiums) should be comparable. But this is not the case in the Boston housing market. For example, the weighted averages of the town-level median annual rent and the imputed rent from owner-occupied housing for 2006 (updated from 2000 Census) are \$11,200 and \$21,500. This is an approximate rent-to-price ratio of 0.52. Further, using the Warren Group transactions data for 2006, the median imputed annual rental prices for condominiums and single family houses are \$17,500 and \$25,800; a condo-to-single-family price ratio of 0.68. Shiller (2006) claims that owner-occuped dwellings are irrationally over-priced relative to rental dwellings. Case (2006) suggests that another possible explanation is the large increase in household wealth coming from the housing

---

of bedrooms. We do this by regressing the number of bedrooms on the other structural characteristics for observations with at least one bedroom. We then replace the observations with a missing value with the predicted value from the bedrooms regression.

[6] The MCAS scores are actually recorded as the percentage of students who score in the proficient or advanced categories.

equity gained from the recent substantial increases in house prices. Households then use this wealth to buy higher priced housing.

In Table 3 we note that the adjustment value for accessibility that comes from the single-family regression are approximately more than 150% higher than the values that come from the condo regression. The adjustment values for school quality and safety that comes from the single-family regression are about twice as large as the values that come from the condo regression. We use the adjustment values from the condo regression since we believe that these are more accurate estimates of the costs that families seeking affordable housing should expect to pay for these amenities. Our view is that single-family housing prices in a metropolitan area such as Boston are in part driven by the demand of households with higher incomes than those we consider here. Condos are also more comparable to rental units and we wish to use the implicit prices to adjust actual rents as well as owner occupied imputed rents.

4.2 Results

In this section, we present the results for the area affordability index for the Boston metropolitan area. To generate the index, we need to determine how many of the existing units are affordable. We use the rule that units with rent (or rental-equivalent) that is no more than 30% of household income are affordable (to that household). We calculate two indices – for 2-person and 4-person households earning 80% of area median income. We then generate an overall affordability index by taking a weighted average of these two indices based on the fact that 75% of the population is 1-3 person households (2-person) and 25% is households with 4 or more members (4 person). Note that this is our benchmark index; one of the advantages of our index is that it indices can be constructed for any relevant household size/income combination.

We provide the results for the overall index in Table 4. The total stock – owner and rental – by town is presented in column (1). Column (2) presents the percentage of this stock that is affordable prior to our adjustments and column (3) gives the ordinal ranking of towns based on this index. Column (4) presents the percentage of the stock affordable after we have made our amenity-based adjustments and column (5) gives the ranking based on this adjusted index. We use the amenity value (quantity multiplied by adjustment factor) to adjust the price distributions in each town. The adjustment factors are given in Table 3. We make the adjustment for accessibility relative to mean (household weighted) town accessibility. This leads to both positive and negative accessibility adjustments in which 51 towns receive positive adjustments. The adjustments range in value from approximately a $960 increase in effective annual rent (Plymouth) to a $2900 annual reduction in effective rent for the most accessible town (Cambridge). In the case of the Plymouth, this accessibility penalty contributes substantially to altering a subset of seemingly affordable dwellings to unaffordable status. In the case of Cambridge, some seemingly unaffordable dwellings are deemed affordable.

For school quality we make adjustments up to the household-weighted mean and no adjustments for towns with values greater than the mean. For safety, where a higher score represents a lower level of safety, we only make adjustments for towns that are below the mean. That is, in both cases we only apply penalties. These individual amenity values and their total are presented in columns (6) – (9) of Table 4. These adjustments range in value from $0 to $7200 (Lawrence) annual increases in effective rents due to below average school quality, and from $0 to $3200 (Chelsea) annual increases for below-average safety ratings.

Adjusting for amenities can make a substantial difference in the affordability rankings of towns as seen by households earning 80 percent of area median income. Haverhill is ranked 5th by the unadjusted index but only 21st when adjustments are made, particularly for school quality and safety. Lowell (school quality and safety) falls from 1st (unadjusted) to 19th (adjusted). On the other hand, Watertown rises from 51st (unadjusted) to 17th (adjusted) and Waltham from 33rd (unadjusted) to 5th (adjusted) on the strength of their accessibility to jobs. The top five affordable towns are, in order, Marlborough, Milford, Hudson, Dracut, and Waltham. Only one of these - - Dracut - - is even in the top ten in the unadjusted indices.

Overall, once we account for job accessibility, school quality and safety, the adjusted affordable stock relevant to households earning 80 percent of area median income represents 79% of the unadjusted affordable stock – a 21% decrease.

To see the spatial effect of adjusting the affordability index for accessibility, school quality, and safety, we provide maps of the Boston metropolitan area that display the two indices: Figure 2 is the unadjusted index and Figure 3 is the adjusted index. In particular, note the dramatic decline in affordability that some of the southernmost towns experience once adjustments are made.

It is also important to note the contribution of rental housing to the overall stock of affordable housing. Rental housing comprises 56% of the total (adjusted) Boston metro area affordable stock for households at 80 percent of area median income. Table 5 lists the total stock and total share of adjusted affordable housing (relative to the total housing stock) by tenure for the 35 most affordable towns. The towns that rank in the top 20 affordable shares for each tenure category are shown in bold. In these most affordable towns, there is variation in the share of their affordable stocks by tenure. For example, Dracut's affordable stock is dominated by owner-occupied housing, while Woburn has a fairly equal distribution and Waltham's affordable stock is dominated by rental housing.

Even after making our adjustments, we observe a striking geographic dispersion of towns that are more or less affordable. The accessibility index developed here has only a 20% simple correlation with the ex ante affordable share of housing by town. This is not a result to be expected unless severe location-specific constraints have been place on development and redevelopment. We thus conjecture that much of the remaining variation in the location of affordable housing in the region is related to the stringent land use regulation that exists in the Boston area. The swath of low affordability (less than 10% of the stock affordable) in the fairly close-in affluent western suburbs in Figure 3 stands out in particular. These towns generally have better than average accessibility; however, such accessibility-based adjustments to the distribution of annual rents did not yield much change in the housing stock judged as affordable. This is because there are few dwellings in these locations with low enough prices/rents to be affected by the adjustments.

5. Policy Implications

The index provides a rich framework for considering affordability in a supply-constrained housing market. It provides an improved methodology for assessing the inventory of adequate housing that is affordable to different households at a certain level of location-related quality. It does not require that the dwelling units be subsidized or otherwise linked to a public program, but attempts to assess the full distribution of privately owned housing that meets certain standards of not only structural adequacy, but also of town quality that are crucial in terms of opportunities faced by households. Thus the index allows towns and policymakers to better understand the affordability of towns relative to their peers in a more comprehensive manner. In addition, this methodology calls for a broader discussion and refinement of the criteria by which society judges the suitability of affordable housing, especially with respect to schools and other local amenities.

This index explores patterns far beyond the average. Policy decisions made with "average" or "aggregated" measures of affordability are unlikely to succeed, at best, and risk squandering limited housing resources, at worst. Consider policies that establish a single rent or "sticker" price as affordable for a household at some income level – without an accounting for the opportunity costs and benefits of residing in any given location. Such policies fail to account for the opportunity costs and benefits of residing in any given location. For example, in the density override program in place in Massachusetts, developers must offer an affordable unit of newly developed housing at a rent of approximately $1100 per month for a 4 person household. This rent is set regardless of location. Therefore, applying our adjustments to monthly rent based on employment and school opportunity and safety, a unit in Wilmington would be worth approximately $400 more than a unit in Everett (low school quality, high accessibility, low safety) but approximately $125 less than the same unit in Belmont (high accessibility, above-average schools, above average safety). If $1100 was a firm cut-off for the expenditure that a household should make on housing, then the "affordable" unit provided in Everett for a sticker price of $1100 a month is, in fact, not affordable to the targeted household. A household incurs an additional $400 in costs per month from living in Everett despite the amount they write in their rent check each month. The cost incurred at that particular location is the net effect of poor schools and poor safety less the gains from being located near many job opportunities.

Next consider a town with limited affordable housing and struggling schools. Policies based largely on a narrow affordability measure would likely direct housing investments here. However, without some prior (if not simultaneous) efforts to improve the overall desirability of the area for firms and households, the necessary improvements in school performance are doubtful – again leaving the overall affordability problem unchanged. If a household has a fixed amount to spend, then accounting for job accessibility, school quality and safety matters for the utility of the unit to the targeted households. As an extreme case, consider the town of Lawrence. The cost of having the lowest quality schools contributes to a drop in the rankings from 2nd (unadjusted) to 117th (adjusted). Economic development may be as important as additional housing investment in this place because as it stands, there is an extraordinarily high opportunity cost for households who locate in Lawrence. Therefore, the affordability of the area might be improved not by building additional housing but by improving the school system and other public amenities, as well as other economic development efforts.

Some towns are categorized as unaffordable by the index because they are located far away from jobs. Such places with low job accessibility costs are not good candidates for affordable housing investment, either. The literature on spatial mismatch predicts inferior labor market outcomes for individual households who reside further from jobs due to higher search costs. Search intensities are further worsened when households do not have access to a private vehicle (Patacchini and Zenou [9]). From a regional perspective, spreading out households far away from jobs may also raise the cost of labor thereby reducing the competitiveness of the region.

Alternatively, the high amenity but unaffordable towns should be seriously considered as places that are worthy of additional affordable housing investment. In fact, these are exactly the places where high market rate unit prices or rents are most likely to be able to subsidize the affordable units in mixed-income developments. This can occur under density bonus programs such as Chapter 40B in Massachusetts when existing zoning is sufficiently restrictive. This program provides density overrides to developers who agree to set aside 25% of a project's units for moderate income households. While the affordable units are only 25 % of the total, the legislation also works to augment the supply of new multifamily housing units. Given the stringent town-level zoning regulations, most new multifamily rental housing in the Boston area gets built in this manner.

Our index also has the potential for controlling for factors other than job accessibility, school quality, and safety if it is felt that a particular demographic group responds to different locational characteristics. For example, senior citizens might not be as interested in living in towns with high accessibility and good schools as they are in towns that have greater levels of safety. This should make our index particularly useful since it can be applied to a broad range of affordable housing policies.

6. Conclusions

This paper develops a new measure of affordable housing stock in a metropolitan area. When we consider town-specific amenities, we see major changes in effective affordability. For households earning 80 percent of area median income, we find substantial shifts in affordability away from towns with poor job accessibility, poor schools, and lack of safety.

These results are obtained from an effort to address housing affordability for moderate income households in high-cost, supply-constrained coastal cities such as Boston. In Massachusetts, stringent town-level land use restrictions render construction of (higher-density) housing for moderate income households nearly infeasible. A first-best solution of region wide relaxation of stringent local controls is not on the horizon. This paper thus examines the renting and owning affordability implications for households earning between 50 and 80 percent of area median income. To do this, we examine the *distribution* of housing opportunities by location, quality, and price/rents facing new entrants and other marginal households deciding whether to stay or leave. We develop a new measure of *area affordability* that characterizes the supply of housing that is affordable to different households in different areas of the Boston metropolitan region.

Key to our approach is the explicit recognition that the price/rent of a dwelling is affected by its location. Hence, we adjust our index to account for job accessibility, school quality, and safety. This adjustment is based on obtaining implicit prices of these amenities from a hedonic price equation. Housing at prices/rents that are unaffordable in the absence of location factors, for example, may be deemed affordable once its strong job accessibility is considered. Our methodology makes transparent amenity-adjusted, town-level affordability of rental and owner stock, and can support a menu of policy options to increase affordability.

The affordability index developed in this paper suggests that not all places are equal. While policies that require towns to bear their "fair share" of a region's affordable housing are politically popular, the implications for households, the regional economy and society generally are less favorable than a policy which better accounts for the implications of location. While it should be of no surprise to anyone that location matters, this work strengthens our understanding of location in the linkages between housing, opportunity and regional economic success.

By introducing our new concept of area affordability, we place emphasis on location since price/rent includes the value of the services provided by the local amenities. Further, the goal of affordable housing policy should be to not only provide suitable structure for households but also to supply units that are accessible to jobs, are in safe areas, and have decent schools. Examining this amenity-adjusted index in the Boston metropolitan area, it is clear that local amenities make a substantial difference in the relative affordability of towns. We demonstrate that town affordability for households earning 80 percent of area median income changes substantially for a great many.

Our approach supports a menu of policy options in response to the particular affordability problem uncovered in our index. For example, towns that are not affordable because of inadequate schools may require alternate forms of investment prior to new housing development. Such investment would aim to improve the overall desirability of the area for firms and households, which may in turn improve school performance. Also, towns that are categorized as unaffordable by the index because they are located far from jobs may not good candidates for affordable housing investment. Building new units far from jobs may also raise the cost of labor thereby reducing the competitiveness of the region in attracting and retaining firms. This ability to produce multiple options for dealing with the lack of affordable housing should make our index particularly useful to policymakers seeking a more flexible approach for dealing with affordability issues in supply-constrained high-cost areas such as Boston.

References

Aslund, O. and Y. Zenou. 2006. How Important is Access to Jobs? Old Question – Improved Answer. IZA Discussion Paper No. 2051.

Bogdon, A. . 1997. Can, Indicators of Local Housing Affordability: Comparative and Spatial Approaches. *Real Estate Economics* 25: 43-80.

Case, K.E. 2006. Land and Property Price Appreciation in Selected U.S. Cities: A Historical Analysis, paper prepared for Land Policies for Urban Development, Lincoln Institute for Land Policy, Cambridge, MA.

Glaeser, E. and J. Gyourko 2002. The Impact of Zoning on Housing Affordability NBER Working Paper 8835.

Goodman, J. and D. Rodda. 2005. Recent House Price Trends and Homeownership Affordability. U.S. Department of Housing and Urban Development. Office of Policy Development and Research accessed at http://www.huduser.org/publications/affhsg/ RecentHousePrice.html.

Gyourko, J. and P.D. Linneman. 1993. The affordability of the American dream: an examination of the last thirty years. *Journal of Housing Research* 1: 39-72.

Gyourko, J., Mayer, C., and T. Sinai. 2006. Superstar Cities. NBER Working paper 12355.

Gyourko, J. and J. Tracy. 1999. A look at real housing prices and incomes: some implications for housing affordability and quality. *Economic Policy Review*, Federal Reserve Bank of New York .63-77.

Lerman, D.L. and W.J. Reeder. 1987. The affordability of adequate housing. *American Real Estate and Urban Economics Association Journal* 15.

Patacchini, E. and Y. Zenou. 2005. Spatial mismatch, transport mode, and search decisions in England. *Journal of Urban Economics* 58: 62-90.

Poterba, J. 2002. Taxation and housing: old questions, new answers. *American Economic Review* 82: 237-242.

Quigley, J. and S. Raphael. 2005. Regulation and the high cost of housing in California. *American Economic Review* 95:323-329.

Saks, R. 2005. Job Creation and Housing Construction: Constraints on Metropolitan Area Employment Growth. Finance and Economics Discussion Series 2005-49, Federal Reserve Board, Washington D.C..

Shiller, R. . 2006. Long-term perspectives on the current boom in home prices.*Economists' Voice* 1-11.

Sieg, H., Smith, V.K., Banzhaf, H.S. and R.Walsh. 2002Interjurisdictional housing prices in locational equilibrium *Journal of Urban Economics* 52 : 131-153.

U.S. Department of Housing and Urban Development, "Cranston-Gonzalez National Affordable Housing Act, Title II" accessed at www.hud.gov/offices/cpd/affordablehousing/lawsandregs/laws/home/homelaws.pdf.

Wheaton, W. 2006. The Housing Bubble (?): A Time Series Analysis for 50 Markets. working paper, MIT.

Zabel, J.E. 1999. Controlling for quality in house price indices. *Journal of Real Estate Finance and Economics* 19: 223-241.

Zabel, J.E. 2004. The demand for housing services. *Journal of Housing Economics* 13: 16-35.

Appendix 1
Creating the Total and Affordable Stock of Housing in the Boston Metropolitan Area

In this appendix, we outline the process for compiling the dataset of the stock and prices of owner-occupied and rental housing in the Boston metropolitan area for 2005.
There are three distinct elements that go into creating the stock numbers:

1. Census 2000 units
2. New owner-occupied construction
3. New rental units

1. Total Stock

Metro Area Definition

The Boston metro area includes the following: Suffolk County, Essex County, Norfolk County (Plainville is not technically part of the metro area but is kept), Middlesex County less Ashby, Plymouth County less Wareham, Marion, Mattapoisett, and Rochester. Also included are the following parts of Worcester County: Southborough and Milford and the following parts of Bristol County: Mansfield, Easton, Taunton, Raynham and Norton.

Existing Stock (Data Source: Census 100% Housing Count)

The baseline count of housing units is the 100% count of units reported in Summary File 3 of the 2000 Decennial Census by town (we use "county subdivisions" as defined by the Census).

New Owner-occupied Stock (Data Source: The Warren Group)

To add new owner-occupied stock to the Census baseline, we aggregate new sales by town using data from the Warren Group.

New Rental Units (Data Source: DHCD's Subsidized Housing Inventory)

We requested the current Subsidized Housing Inventory from the Department of Housing and Community Development (DHCD). SHI units that did not go through the comprehensive permitting process (set out by Massachusetts Chapter 40B Law, which provides zoning overrides for mixed-income developments, and accounts for almost all new rental housing affordable at 80% of area median income) are often undated. To avoid double counting, we use only comprehensively permitted developments. While this runs the risk of an undercount, over counting, by including undated units, would be less accurate. In addition, because we are using Warren Group data to track owner-occupied units (above), we will only add rental units from the SHI.

2. Affordable Stock

This section deals with determining the stock of rental and owner-occupied housing that is affordable for the target households (50-80% AMI). We include both types of tenure in the indexes, but the methodology used to generate the current distributions of rents and values differs by tenure type as a function of the data available for adjusting the 2000 reported values. The steps described below explain how we adjusted the reported distributions in each town to reflect current prices and rents.

How We Differ from DHCD's Subsidized Housing Inventory

DHCD maintains a state-wide list of housing units developed through the various subsidy programs which it uses to determine whether a given town has reached the statutory minimum (either 10% of total stock or a certain percentage of new units in the pipeline) that would exempt a town from state zoning overrides under chapter 40B of the Massachusetts General Code. For the state's purposes, publicly owned units that are not open to the general public are counted, including units in nursing homes and those controlled by the Department of Mental Health. In addition, the 40B statute counts all units in a mixed-income development, even though generally only 25% of the units are set aside for moderate-income households. Most importantly, the state does not consider the presence of market-rate units that are affordable to moderate-income households in determining whether a town is providing its affordable share. For all these reasons, the state-reported count of affordable units is inappropriate for our index.

Existing Rental Units

Using Table H62 from the Census 2000 Summary File 3, we build a matrix of unit counts by gross rent by town for the metropolitan area. Since data on changes in rents is inadequate, we are not able to calculate rent adjustments at the town level. We use, instead, the Rent of Primary Residence component of the Bureau of Labor Statistics' Consumer Price Index for the Boston metropolitan area. We use the change in the CPI from April 2000 to April 2006 to inflate the rent ranges to 2006 dollars. Assuming a maximum 30% of a household's income is allocated to housing costs, we count the number of units whose inflated rents fall below 30% of 80% of the Boston Metropolitan AMI to measure the number of currently affordable rental units in existence as of 2000.

New Rental Units

The method for counting new affordable rental units is an extension of the method of counting all new rental units. Based on the assumption that all new market rental construction will be priced above the affordable rent expenditure, we simply count new rental developments in the SHI and take the units in the new developments that are set aside as affordable for households earning below 80% of AMI.

Existing Owner-occupied Housing

Data on changes in house prices are far more comprehensive than for the rental market. To update the Census reported 2000 house values to 2006 values, we use a combination of the Case-Shiller-Weiss repeat sales indexes (CSW) and data on price appreciation from Zillow.com. The CSW data is zip-code level data and is available from 2000 through 2004. For towns with multiple zip codes, we took the average inflation across the zip codes over the four years. For towns with no index value reported, we used the inflation rates from adjacent zip codes with similar housing stocks. To inflate values from 2004 to 2005, we used the 1-year appreciation rates available at the town level from Zillow.com. Appreciation rates for 2005 to 2006 were calculated using a hedonic regression based on sales data from Warren Group. After deriving the current distribution of house values, we calculated imputed rents for each home using equation (17).

New Owner-occupied Housing

Using assessors' files from The Warren Group, we inflate non-2006 sales to 2006 dollars as described above. It is unnecessary to use the SHI to find new affordable owner-occupied units because the Warren Group data is based on mortgage transactions and we assume that all for-sale affordable units were purchased using some form of financing.

Appendix 2
Data Issues

In this appendix, we address the following four data issues that arise in the process of generating the affordability index:

1. Defining and excluding inadequate structural units
2. Excluding small units from the 4- person index
3. Generating the Accessibility Index
4. Generating the town level Safety Measure

1. Defining and excluding inadequate structural units

Identifying inadequate housing typically involves looking for specific defects such as a lack of complete plumbing or kitchen facilities, leaking roofs, holes in interior floors, and unconcealed wiring (Lerman and Reeder [8]). For this purpose we use the adequacy variable ZADEQ provided in the 1998 Metropolitan American Housing Survey. The lowest level of geographic area provided in the public version of the AHS is a "zone". There is data for 26 zones in the Boston metropolitan area.

Some of the towns in our dataset are not included in the AHS data. Thus we need to predict the percentage of inadequate units for these towns. We do so by imputing the percent inadequate from a zone whose income, population and employment characteristics are similar.

Separate percentages of inadequate stock are calculated for rental and owner-occupied housing. Before testing individual units for affordability, the appropriate number of inadequate units is removed from the distribution of housing for both tenure types. This is done only for units from the 2000 Census; we assume that all housing built since 2000 is adequate.

2. Excluding small units from the 4- person index

We adjust the index for 4-persion households by excluding units that are too small (i.e. units with less than two bedrooms). The Census data includes the joint distribution of bathrooms and rent for rental stock. The Census provides the distribution of bathrooms and home values for owner-occupied stock, but not the joint distribution. Using Warren Group data we calculate the percentage of owner-occupied units that have 0 or 1 bedrooms. In towns where this percentage is higher than the percentage of 0/1 bedroom units in the Census data, we exclude enough of the largest units (in terms of interior square feet) in the Warren Group data so that the percentage of 0/1 bedroom units is equal to that in the Census. For these 0/1 bedroom units, we determine how many fall in each price range used in the 2000 Census. Using this information we can derive the appropriate distribution of 0/1 bedroom units in the Census counts. We remove these units from the total number of units in each price range to derive the distribution of owner-occupied units that are available to 4-person households.

In cases where a town had no 0/1 bedroom sales, we match these towns with similar towns and apply the same distribution proportionally. To do this, we sort the data by the percentage of units with 0/1 bedrooms in the census data (census_pct_01) and then choose the town that is in the Warren Group data that is within two towns in terms of census_pct_01 and is closest in average price (from the 2000 Census).

This adjustment did not work for all of the towns with no 0/1 bedroom units sales. In these cases we make the assumption that the 0/1 bedroom units are the least expensive and remove them from bottom of price distribution.

3. Generating the Accessibility Index

To measure accessibility to employment we generate a gravity index that is a function of commuting time to each job location. The data on employment comes from the Massachusetts Department of Labor's ES-202 data, which provides annual average employment for each of Massachusetts's municipalities. Note that the ES-202 data counts employment in each place; it is not a measure of local unemployment. The data on commuting times is generated by the Boston Metropolitan Planning Organization, which divides the region into 986 Traffic Analysis Zones (TAZs). For each of the nearly 1 million origin/destination (O/D) pairs, we have been given values for the morning rush hour commute using personal vehicles and mass transit (with separate data sets for walking to transit and driving to transit). In building the accessibility index, we have assumed that commuters will choose the shortest mode. Most towns have multiple TAZs. For each destination town for a given originating TAZ, we averaged the commute times to the destination TAZs within the town. (Where the origin and destination TAZs were the same, we assumed a travel time of 5 minutes; these were averaged in with the other O/D TAZ pairs.) To aggregate to the town level for the origins, we averaged the commute times to a given destination town from all the TAZs in the originating town. Thus, we end up with town-town commuting times. The index value for any given town is the sum of employment in each destination town in the region divided by commuting time to that town.

$$\mathrm{ACCESS_i} = \sum_{i,j=1}^{n} \frac{\mathrm{employment_j}}{(\mathrm{commute_{ij}})^{1.5}}$$

4. Generating the town level Safety Measure

We construct a measure of a town's safety by conducting a principle components analysis on the following variables: violent crime, property crime, contaminated sites per square mile, and the percentage units within ½ a block of buildings with bars on the windows. The first three variables are reported in the 2005 edition of The Best Places to Live Boston. The final variable is calculated at the zone level from the 1998 Metropolitan American Housing Survey. The principle component explains 48.14% of the variance between the variables

Table 1
Variable names, descriptions and descriptive statistics, Property transactions 2005 & 2006

		Single Family		Condominium	
Name	Description	Mean	Standard Deviation	Mean	Standard Deviation
LSTSLPR	Sale Price	486619	329519	302891	176665
ImputedRent	Imputed Rent	30596	19996	19349	10611
Age10~30	House Age 10-30 years old	0.137	0.344	0.422	0.494
Age30~50	House Age 30-50 years old	0.249	0.432	0.215	0.411
AgeGr~50	House Age >50 years old	0.512	0.500	0.195	0.397
Bathrooms2SFam	2 Bathrooms - Single Family	0.259	0.438		
Bathrooms3PlusSFam	3+ Bathrooms - Single Family	0.331	0.471		
HalfBath	Half Bath - Single Family	0.785	0.411		
Bathrooms2Condo	2 Bathrooms - Condominium			0.250	0.433
Bathrooms3PlusCondo	3+ Bathrooms - Condominium			0.211	0.408
BEDROOMS	No. of Bedrooms	3.236	0.871	1.881	0.784
LIVINGAREA	Interior Living Area (sq. ft.)	1860	905	1189	540
LOTSIZAC	Lotsize (acres)	13888	42422		
TownHouse	Town House			0.073	0.259
Cape	Cape	0.065	0.246		
Colonial	Colonial	0.136	0.342		
Ranch	Ranch	0.098	0.297		
Density	Popluation Density	2914	2914	4791	4618
pctopespace	Percent Open Space in Town	1683	873	1533	863
Access_town_stand	Standardized Accessibility Index	1.082	0.453	1.286	0.661
SCHOOL	School Score Measure	146	29	137	29
SAFETY	Safety Measure	0.215	1.580	0.890	1.979
YEARDUMMY	Sold in 2006	0.457	0.498	0.455	0.498

SCHOOL is the sum of the percent of grade 10 students with a sufficient or advanced score on the MCAS math and English exams.

Table 2
Greater Boston House Price Hedonic Statistics (Dependent Variable: LnImputedRent)

Variable	Single Family		Condominium	
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error
Age10to30	-0.0546***	[0.0056]	-0.0899***	[0.0056]
Age30to50	-0.0940***	[0.0059]	-0.185***	[0.0067]
AgeGreaterThan50	-0.153***	[0.0060]	-0.113***	[0.0071]
Bathrooms_2SFam	0.0549***	[0.0039]		
Bathrooms_3PlusSFam	0.108***	[0.0047]		
HalfBath	0.0634***	[0.0046]		
Bathrooms_2Condo			0.0676***	[0.0051]
Bathrooms_3PlusCondo			0.0785***	[0.0064]
BEDROOMS	0.0192***	[0.0022]	0.0164***	[0.0032]
LIVINGAREA	0.000282***	[0.0000074]	0.000800***	[0.000021]
LivingAreaSq	-0.000000778***	[0.00000012]	-0.0000109***	[0.00000062]
LOTSIZEAC	0.000000548***	[0.00000013]		
LotSizeACSq	-1.33E-09	[1.28e-09]		
TownHouse			-0.00262	[0.0088]
Cape	-0.0023	[0.0063]		
Colonial	0.0202***	[0.0056]		
Ranch	0.0305***	[0.0058]		
Density	0.0000287***	[0.0000034]	0.0000342***	[0.0000055]
pctopenspace	0.0000319***	[0.0000060]	0.0000368***	[0.0000098]
LnAccess_town_stand	0.148***	[0.019]	0.104***	[0.031]
LnSCHOOL	0.648***	[0.039]	0.477***	[0.062]
SAFETY	-0.0264***	[0.0060]	-0.0241**	[0.010]
YEARDUMMIE	0.0790***	[0.012]	0.0447**	[0.018]
Constant	6.252***	[0.20]	6.463***	[0.31]
Observations	57834		22525	
Number of townid	276		266	
R-squared	0.563		0.657	

Table 3
Adjustment values for town amenity levels

	Regression coefficient (elasticity)	Imputed house/condominium rent (mean; $)	Weighted amenity level (mean)	Imputed rent effect (adjustment value; $)
ACCESSIBILITY				
Single family	.148	31,735	1.082	4,192
Condominiums	.104	19,833	1.286	1,562
SCHOOL QUALITY				
Single family	.648	31,735	145.795	136
Condominium	.477	19,833	136.659	68
SAFETY				
Single family	-.0264	31,735	.215	-806
Condominium	-.0241	19,833	.890	-467

Note: Values in 2006 constant dollars. SAFETY is a measure of a town's lack of safety; therefore a positive SAFETY score reflects lack of safety.

Table 4
Share of affordable stock by town with town amenity adjustments, Metropolitan Boston Area, YEAR, N=141
All households at 80 percent Boston Metropolitan Area Median Income

		Unadjusted Index		Adjusted Index		Annual adjustment to unit cost ($)[1]			
	Total stock	Share	Rank	Share	Rank	Access-ibility	School quality	Safety	Total
Town	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Marlborough	12985	43.5%	17	42.7%	1	-145.5	0.0	0.0	-145.5
Milford	9679	44.3%	12	41.3%	2	-388.5	-277.9	0.0	-666.4
Hudson	6570	43.6%	16	40.6%	3	-255.1	-345.5	0.0	-600.6
Dracut	9652	50.0%	8	38.9%	4	-466.0	-1494.2	0.0	-1960.1
Waltham	21564	34.3%	33	37.6%	5	1310.7	-413.1	0.0	897.6
Methuen	15245	52.9%	4	37.2%	6	-320.0	-2575.2	0.0	-2895.3
Taunton	18439	51.5%	7	37.0%	7	-673.1	-2507.7	-404.6	-3585.3
Whitman	4763	43.6%	15	35.4%	8	-386.2	-277.9	-607.5	-1271.6
Rockland	5703	40.6%	22	34.9%	9	-389.4	-615.8	0.0	-1005.2
Woburn	13546	32.3%	42	34.8%	10	1062.6	-210.4	-330.4	521.9
Amesbury	5635	36.8%	28	34.8%	11	-612.6	0.0	0.0	-612.6
Norwood	10718	33.6%	37	34.3%	12	269.4	-142.8	0.0	126.6
Stoughton	9297	37.4%	27	34.0%	13	6.7	-413.1	-257.7	-664.0
Quincy	33431	44.6%	11	34.0%	14	734.9	-2575.2	-320.3	-2160.6
Framingham	24119	33.4%	38	33.4%	15	92.4	-75.2	-17.0	0.2
Maynard	3948	36.6%	29	33.2%	16	-59.0	-683.3	0.0	-742.3
Watertown	10834	29.0%	51	33.1%	17	1965.8	-345.5	-589.4	1030.9
Plainville	2673	34.3%	34	32.2%	18	-504.5	0.0	0.0	-504.5
Lowell	33581	56.7%	1	32.0%	19	-60.0	-3656.3	-1710.6	-5426.9
Billerica	12503	31.5%	44	31.6%	20	161.0	-142.8	0.0	18.2
Haverhill	20540	52.2%	5	31.0%	21	-525.2	-2845.5	-1017.7	-4388.4
Foxborough	5779	32.0%	43	30.8%	22	-302.6	0.0	0.0	-302.6
Gloucester	10904	39.0%	25	30.8%	23	-666.5	-1359.0	-356.5	-2381.9
Weymouth	20070	39.2%	24	30.7%	24	-146.5	-1629.3	0.0	-1775.8
Salem	13978	39.7%	23	30.5%	25	-29.8	-2169.8	-499.7	-2699.3
Lynn	28919	51.5%	6	30.3%	26	187.5	-3859.0	-1355.0	-5026.6
Malden	19001	41.0%	21	30.3%	27	951.0	-2845.5	-585.4	-2479.8
Arlington	15163	26.1%	65	30.3%	28	1386.9	0.0	0.0	1386.9
Medford	16493	31.5%	45	30.1%	29	1650.0	-1494.2	-476.5	-320.6
Stoneham	7584	27.0%	62	30.1%	30	1031.4	-210.4	0.0	821.0
Abington	5255	36.6%	30	29.9%	31	-310.6	-7.7	-1192.3	-1510.5
Natick	11675	28.3%	55	29.9%	32	334.2	0.0	0.0	334.2
Holbrook	3868	43.4%	18	29.2%	33	-4.2	-2237.4	0.0	-2241.6
Beverly	13981	30.6%	46	29.1%	34	-146.2	0.0	-265.7	-411.9
Millis	2824	30.3%	47	29.1%	35	-240.2	0.0	0.0	-240.2

Everett	11663	48.9%	9	28.8%	36	1030.1	-3386.0	-2074.7	-4430.7
Braintree	11857	27.9%	59	28.6%	37	357.5	0.0	-203.5	154.0
Brockton	30375	54.3%	3	28.6%	38	-94.4	-2777.9	-1871.5	-4743.8
Norton	5670	33.1%	39	28.5%	39	-558.8	-413.1	0.0	-971.9
Revere	15302	44.0%	13	28.4%	40	625.0	-2710.4	-1545.0	-3630.3
Carver	2866	34.2%	36	28.0%	41	-957.5	-7.7	0.0	-965.2
Ashland	5567	28.8%	52	28.0%	42	-185.4	0.0	0.0	-185.4
Mansfield	7626	29.3%	50	27.8%	43	-368.9	0.0	-92.2	-461.1
Danvers	8802	28.6%	53	27.1%	44	69.5	-142.8	-294.7	-367.9
Kingston	3783	32.6%	41	27.0%	45	-816.7	-683.3	0.0	-1500.1
Peabody	16590	35.1%	32	26.8%	46	167.1	-1899.6	-119.6	-1852.0
Newburyport	6905	28.3%	56	26.8%	47	-617.5	0.0	0.0	-617.5
Winthrop	5854	34.3%	35	26.7%	48	73.6	-1832.0	-543.6	-2302.0
Merrimac	1983	28.4%	54	26.3%	49	-638.9	-7.7	0.0	-646.6
Chelmsford	11881	26.9%	63	26.2%	50	-143.3	0.0	0.0	-143.3
Salisbury	2762	42.9%	19	26.1%	51	-721.1	-1426.6	-1570.0	-3717.7
Melrose	9455	23.8%	77	25.6%	52	846.7	-210.4	0.0	636.4
Tewksbury	9409	25.2%	68	25.5%	53	42.9	0.0	0.0	42.9
Groveland	2095	27.6%	60	25.3%	54	-500.5	-7.7	0.0	-508.1
Wakefield	8722	24.1%	75	25.0%	55	718.4	-480.6	0.0	237.8
Marshfield	8595	28.1%	57	25.0%	56	-838.0	0.0	0.0	-838.0
Dedham	8185	24.5%	71	24.8%	57	731.0	-683.3	0.0	47.7
Bridgewater	7007	30.1%	49	24.5%	58	-555.8	-345.5	-581.1	-1482.5
Boxborough	1699	24.3%	72	24.0%	59	-400.6	0.0	0.0	-400.6
Wilmington	7124	22.2%	80	23.7%	60	406.2	0.0	-118.8	287.4
Somerville	24438	37.4%	26	23.6%	61	2294.7	-3318.5	-2249.4	-3273.2
West Bridgewater	2212	30.1%	48	23.5%	62	-341.1	0.0	-962.5	-1303.6
Brookline	18339	17.6%	94	23.4%	63	2244.3	0.0	-140.8	2103.5
Littleton	2854	24.6%	70	23.3%	64	-320.5	0.0	0.0	-320.5
Burlington	8294	19.5%	88	23.1%	65	926.3	0.0	-143.4	782.9
East Bridgewater	4260	26.3%	64	22.5%	66	-558.4	0.0	-320.4	-878.8
Berlin	832	25.2%	67	22.5%	67	-532.8	0.0	-69.7	-602.5
Franklin	9786	24.2%	73	22.4%	68	-448.3	0.0	0.0	-448.3
Randolph	10394	41.4%	20	21.9%	69	147.0	-3250.9	0.0	-3103.9
Rockport	3107	23.2%	78	21.7%	70	-815.3	0.0	0.0	-815.3
Cambridge	33055	27.4%	61	21.3%	71	2914.1	-2305.0	-2436.6	-1827.5
Plymouth	18238	33.0%	40	21.2%	72	-959.9	-1696.9	0.0	-2656.7
Walpole	7865	21.4%	84	21.1%	73	-70.5	0.0	0.0	-70.5
Middleborough	6642	36.2%	31	21.0%	74	-752.5	-1832.0	-741.5	-3326.0
Medway	4115	22.6%	79	20.9%	75	-400.4	0.0	0.0	-400.4
Easton	6849	22.2%	81	20.2%	76	-301.3	0.0	-338.6	-639.9
Belmont	7975	15.8%	97	19.9%	77	1765.8	0.0	0.0	1765.8

Essex	1112	20.3%	86	19.5%	78	-634.1	0.0	0.0	-634.1
Ipswich	4810	21.0%	85	19.0%	79	-634.3	0.0	0.0	-634.3
Pembroke	5787	25.3%	66	19.0%	80	-729.3	-548.2	0.0	-1277.5
Nahant	1452	19.3%	90	18.8%	81	-365.4	0.0	-59.1	-424.5
Georgetown	2793	19.6%	87	18.2%	82	-432.2	-7.7	0.0	-439.9
Hamilton	2477	19.4%	89	17.9%	83	-495.4	0.0	0.0	-495.4
Wrentham	3426	19.2%	91	17.9%	84	-378.3	0.0	0.0	-378.3
North Andover	8752	18.4%	92	17.7%	85	-185.8	-75.2	0.0	-261.0
Saugus	8893	28.1%	58	17.5%	86	402.0	-1899.6	-861.4	-2358.9
Raynham	4086	24.1%	74	17.5%	87	-541.0	-345.5	-1258.2	-2144.7
Swampscott	4779	18.1%	93	17.5%	88	-30.3	0.0	-155.5	-185.9
Acton	6885	17.5%	95	17.2%	89	-169.3	0.0	0.0	-169.3
Newbury	2384	21.8%	82	16.6%	90	-654.7	-1426.6	0.0	-2081.3
Canton	7350	15.8%	98	16.1%	91	110.2	0.0	0.0	110.2
Rowley	1823	21.5%	83	15.9%	92	-596.2	-1426.6	0.0	-2022.8
Hanson	3084	24.8%	69	15.8%	93	-666.2	-277.9	-651.7	-1595.9
Westford	6787	16.5%	96	15.4%	94	-417.4	0.0	0.0	-417.4
Avon	1601	43.7%	14	14.6%	95	94.2	-3994.2	-1187.6	-5087.6
Newton	26222	11.8%	110	14.4%	96	1498.9	0.0	0.0	1498.9
Stow	2189	15.0%	99	14.2%	97	-296.3	0.0	0.0	-296.3
Hull	4047	24.1%	76	14.1%	98	-750.5	-2372.5	0.0	-3123.0
Andover	10790	13.9%	103	13.9%	99	-0.2	0.0	0.0	-0.2
Holliston	4600	14.5%	101	13.8%	100	-290.8	0.0	0.0	-290.8
Hopkinton	4509	14.7%	100	13.7%	101	-435.9	0.0	0.0	-435.9
Reading	7939	11.8%	111	13.6%	102	752.1	0.0	0.0	752.1
Sharon	5581	13.9%	102	13.5%	103	-173.3	0.0	0.0	-173.3
Manchester	1998	13.7%	105	13.2%	104	-496.9	0.0	-8.3	-505.2
North Reading	4509	12.3%	107	12.9%	105	175.2	0.0	0.0	175.2
Medfield	3818	12.7%	106	12.5%	106	-130.1	0.0	0.0	-130.1
Southborough	3038	12.2%	108	11.6%	107	-192.4	0.0	0.0	-192.4
Hanover	4442	12.0%	109	10.7%	108	-484.9	0.0	0.0	-484.9
Norfolk	2845	11.0%	112	10.1%	109	-390.9	0.0	0.0	-390.9
Marblehead	7757	10.9%	113	10.0%	110	-366.3	0.0	-275.4	-641.7
Winchester	7063	8.1%	118	9.6%	111	1248.1	0.0	0.0	1248.1
Scituate	6554	10.8%	114	9.5%	112	-785.7	0.0	0.0	-785.7
Milton	8043	8.2%	117	9.5%	113	733.7	-210.4	0.0	523.4
Hingham	6810	9.9%	115	9.0%	114	-447.5	0.0	0.0	-447.5
Lawrence	20779	55.4%	2	8.8%	115	-102.1	-7237.4	-2157.3	-9496.8
Bedford	4406	8.0%	119	8.8%	116	504.6	0.0	0.0	504.6
Westwood	4713	7.3%	120	8.0%	117	482.9	0.0	0.0	482.9
Harvard	1616	9.0%	116	7.8%	118	-641.8	0.0	0.0	-641.8
Middleton	2417	13.8%	104	7.5%	119	-120.1	-2710.4	0.0	-2830.5

Lincoln	1798	7.1%	122	7.5%	120	652.7	0.0	0.0	652.7
Needham	9986	5.9%	126	6.9%	121	863.1	0.0	0.0	863.1
Cohasset	2477	7.2%	121	6.8%	122	-749.6	0.0	0.0	-749.6
Topsfield	1930	6.7%	125	6.3%	123	-294.5	0.0	0.0	-294.5
Duxbury	4575	6.8%	124	5.7%	124	-791.3	0.0	0.0	-791.3
Concord	5484	5.5%	127	5.6%	125	132.8	0.0	0.0	132.8
Weston	3663	5.2%	129	5.5%	126	754.4	0.0	0.0	754.4
Lexington	10631	4.1%	134	5.4%	127	966.9	0.0	0.0	966.9
Wellesley	8226	4.7%	133	5.2%	128	776.4	0.0	0.0	776.4
Norwell	3241	5.4%	128	5.1%	129	-527.3	0.0	0.0	-527.3
Chelsea	9537	46.1%	10	5.0%	130	844.1	-5750.9	-3249.0	-8155.9
Plympton	743	7.1%	123	4.5%	131	-860.1	-683.3	-313.9	-1857.4
Wenham	1171	4.7%	132	4.4%	132	-340.6	0.0	0.0	-340.6
West Newbury	1310	4.8%	131	4.3%	133	-590.8	-7.7	0.0	-598.5
Bolton	1387	5.1%	130	4.3%	134	-614.1	0.0	0.0	-614.1
Lynnfield	3817	3.8%	136	4.0%	135	332.6	0.0	-41.4	291.2
Sudbury	5559	3.9%	135	3.8%	136	-95.8	0.0	0.0	-95.8
Wayland	4501	3.6%	137	3.8%	137	275.3	0.0	0.0	275.3
Sherborn	1297	3.3%	138	3.2%	138	-142.1	0.0	0.0	-142.1
Boxford	2384	2.5%	139	2.2%	139	-446.7	0.0	0.0	-446.7
Carlisle	1457	2.0%	140	2.0%	140	-115.8	0.0	0.0	-115.8
Dover	1713	1.6%	141	1.6%	141	29.1	0.0	0.0	29.1

Note: [1] Negative adjustments indicate a worsening of affordability of housing units due to the particular amenity.

Table 5

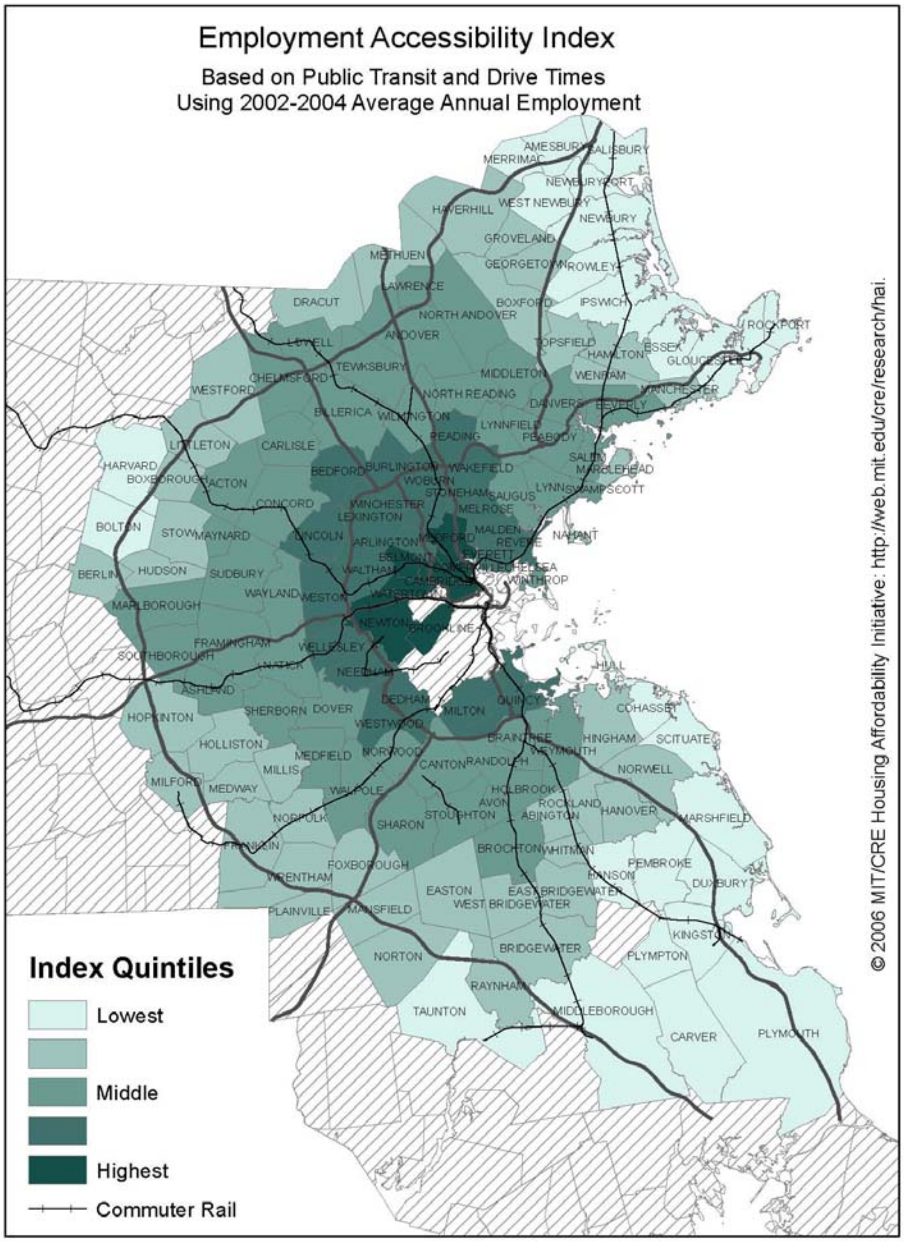
Top 35 Most Affordable Towns
Share of affordable stock by town, by tenure, Boston Metropolitan Area, YEAR=2006, N=35

		Adjusted Affordable Shares			Total Stock		
	Town	Owner Occupied	Rental	All Housing	Owner Occupied	Rental	All Housing
1	Marlborough	**30.69%**	**58.33%**	**42.75%**	7322	5663	12985
2	Milford	**33.87%**	**54.35%**	**41.33%**	6152	3527	9679
3	Hudson	**34.85%**	**53.11%**	**40.61%**	4499	2071	6570
4	Dracut	**34.67%**	**51.62%**	**38.86%**	7265	2387	9652
5	Waltham	19.60%	**50.38%**	**37.56%**	8982	12582	21564
6	Methuen	**29.33%**	**56.25%**	**37.22%**	10776	4469	15245
7	Taunton	**19.67%**	**58.51%**	**36.97%**	10228	8211	18439
8	Whitman	**28.11%**	**54.06%**	**35.39%**	3426	1337	4763
9	Rockland	**26.44%**	**55.20%**	**34.92%**	4021	1682	5703
10	Woburn	**27.55%**	45.00%	**34.80%**	7917	5629	13546
11	Amesbury	**20.53%**	**58.40%**	**34.75%**	3519	2116	5635
12	Norwood	**23.12%**	47.67%	**34.31%**	5831	4887	10718
13	Stoughton	**26.35%**	**55.04%**	**34.04%**	6808	2489	9297
14	Quincy	**26.32%**	39.59%	**33.98%**	14124	19307	33431
15	Framingham	**21.99%**	46.31%	**33.38%**	12820	11299	24119
16	Maynard	**26.68%**	47.63%	**33.24%**	2710	1238	3948
17	Watertown	7.88%	44.15%	**33.05%**	3317	7517	10834
18	Plainville	19.61%	**61.85%**	**32.23%**	1875	798	2673
19	Lowell	**21.86%**	37.94%	**32.00%**	12402	21179	33581
20	Billerica	**28.11%**	48.77%	**31.64%**	10368	2135	12503
21	Haverhill	18.44%	47.50%	30.96%	11688	8852	20540
22	Foxborough	19.45%	**58.80%**	30.82%	4109	1670	5779
23	Gloucester	17.67%	47.24%	30.81%	6058	4846	10904
24	Weymouth	19.28%	**51.16%**	30.71%	12874	7196	20070
25	Salem	7.20%	45.03%	30.54%	5356	8622	13978
26	Lynn	17.38%	38.41%	30.34%	11090	17829	28919
27	Malden	19.30%	35.81%	30.34%	6302	12699	19001
28	Arlington	9.40%	**51.33%**	30.27%	7615	7548	15163
29	Medford	17.53%	41.15%	30.09%	7718	8775	16493
30	Stoneham	18.73%	**49.77%**	30.09%	4810	2774	7584
31	Abington	18.44%	**60.11%**	29.91%	3808	1447	5255
32	Natick	**20.25%**	**51.22%**	29.86%	8051	3624	11675
33	Holbrook	**26.93%**	36.47%	29.17%	2958	910	3868
34	Beverly	13.27%	**49.69%**	29.11%	7902	6079	13981

35	Millis	**20.57%**	**57.37%**	29.06%	2172	652	2824

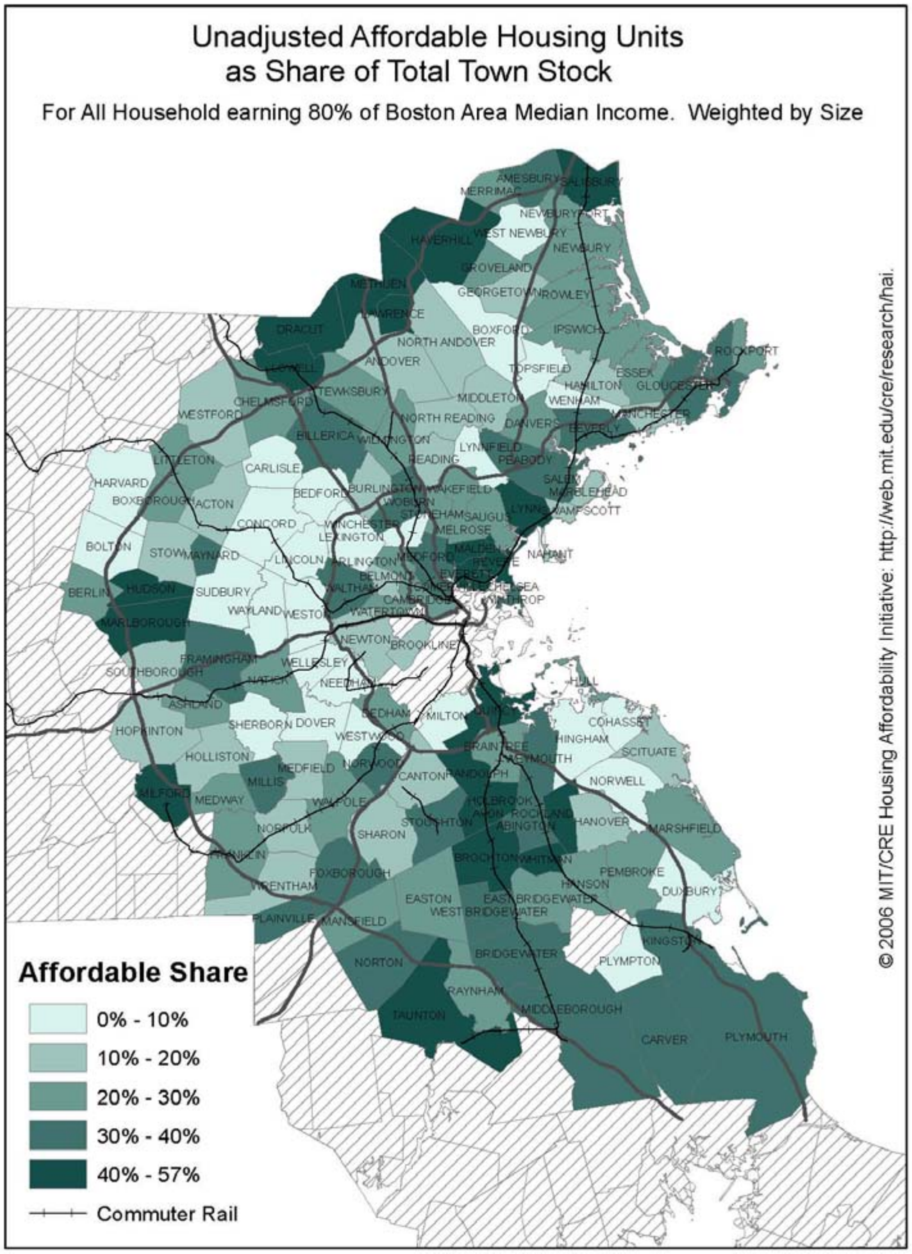
Note: All households at 80 percent Boston Metropolitan Area median income.
Ranked by total affordable share; top 20 towns, by tenure, in bold.

Figure 1



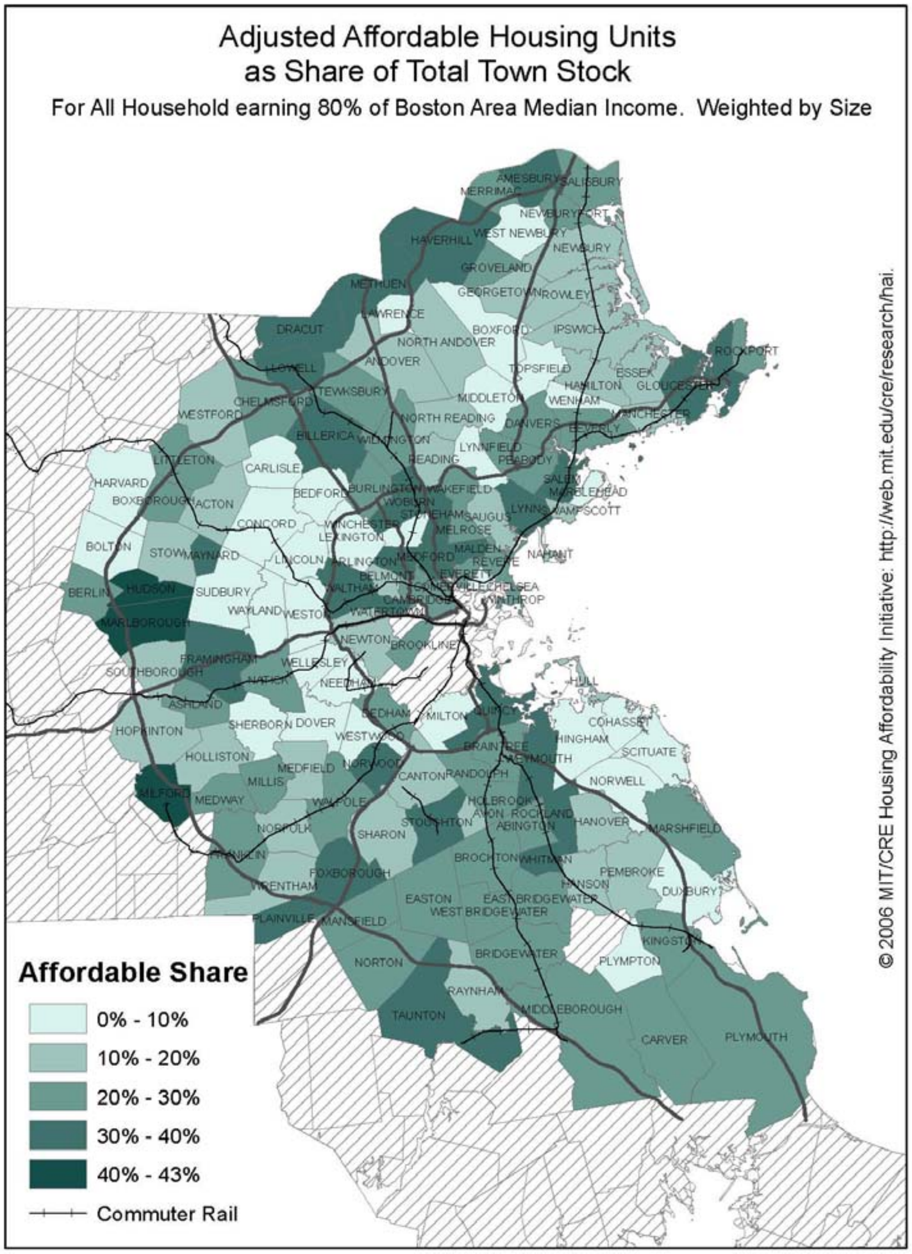
Employment Accessibility Index
Based on Public Transit and Drive Times
Using 2002-2004 Average Annual Employment
Index Quintiles
Lowest
Middle
Highest
Commuter Rail
© 2006 MIT/CRE Housing Affordability Initiative: http://web.mit.edu/cre/research/hai.
MERRIMAC
HAVERHILL
WEST NEWBURY
NEWBURY
GROVELAND
METHUEN
DRACUT
NORTH ANDOVER
IPSWICH
ROCKPORT
TOPSFIELD
ESSEX
TEWKSBURY
MIDDLETON
WENHAM
WESTFORD
NORTH READING
DANVERS
BILLERICA
LYNNFIELD
CARLISLE
HARVARD
ACTON
CONCORD
SAUGUS
MELROSE
BOLTON
STOW
MAYNARD
LINCOLN
NAHANT
BERLIN
HUDSON
SUDBURY
WAYLAND
WINTHROP
FRAMINGHAM
NATICK
HULL
HOPKINTON
SHERBORN
DOVER
MILTON
COHASSET
HOLLISTON
MEDFIELD
HINGHAM
SCITUATE
MILLIS
NORWELL
MILFORD
MEDWAY
WALPOLE
HANOVER
SHARON
STOUGHTON
NORFOLK
FOXBOROUGH
PEMBROKE
EASTON
WEST BRIDGEWATER
PLAINVILLE
NORTON
PLYMPTON
TAUNTON
CARVER

Figure 2



Unadjusted Affordable Housing Units
as Share of Total Town Stock
For All Household earning 80% of Boston Area Median Income. Weighted by Size
Affordable Share
0% - 10%
10% - 20%
20% - 30%
30% - 40%
40% - 57%
Commuter Rail
© 2006 MIT/CRE Housing Affordability Initiative: http://web.mit.edu/cre/research/hai.

Figure 3


Adjusted Affordable Housing Units
as Share of Total Town Stock
For All Household earning 80% of Boston Area Median Income. Weighted by Size
Affordable Share
0% - 10%
10% - 20%
20% - 30%
30% - 40%
40% - 43%
Commuter Rail
© 2006 MIT/CRE Housing Affordability Initiative: http://web.mit.edu/cre/research/hai.