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A Dynamic Housing Affordability Index

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This paper outlines an approach to constructing a Dynamic Housing Affordability Index (DHAI) that reflects the anticipated cost of owner-occupied housing and performs well in tracking changes in the demand for homeownership and other aspects of the housing market. Our index is grounded in the user cost theory and influenced by variations in the price of housing, mortgage interest and property tax rates, property insurance, transaction costs, and depreciation and maintenance. It takes into account the benefits from U.S. income tax deductions for mortgage interest and property taxes, and considers the role of expected house price inflation in reducing the cost of housing. We show that the DHAI is correlated with national and regional consumer sentiment which reflects the demand for owner-occupied housing, regional and metropolitan statistical area (MSA) homeownership rates, housing market characteristics including housing starts, and sales of new and existing housing. There is evidence that the DHAI performs better than other popular measures of affordability.

Keywords
Housing Affordability; Homeownership; User Cost

1. Introduction

This paper develops a new measure of the affordability of owner-occupied housing; specifically, one that incorporates the forward looking aspect of the decisions of households of whether to own or rent. The new measure differs from existing affordability indexes and our empirical work shows that it is correlated with a measure of the demand for homeownership and other aspects of the housing market.

Affordability measures have an ad hoc nature; however, linking a measure to economic theory is desirable. Our review of the literature suggests that a well-founded measure is the "owner cost" of housing. Owner cost combines information about the price of housing and the "user cost" per dollar of investment in housing. We use this concept to guide our development of a new affordability index that builds on existing affordability indexes such as the Housing Affordability Index (HAI) of the National Association of Realtors (NAR). The primary focus of our analysis is the time from the first quarter of 2007 to the third quarter of 2014; however, we also extend our index back to 2003 to capture the boom in the housing market.

Our measure, designated the Dynamic Housing Affordability Index (DHAI), theoretically improves on existing indexes in multiple ways. First, it accounts for the tax benefits of homeownership due to the federal income tax deductions for mortgage interest payments. Existing affordability measures generally ignore the tax benefits for households that itemize deductions and thus tend to understate affordability. Second, our index includes the cost of property taxes and the associated federal tax deduction benefit. Third, our index includes the effect of expected house price changes on the affordability of housing.

The DHAI is in some ways similar to the existing HAI of the NAR and the Housing Opportunity Index (HOI) of the National Association of Home Builders (NAHB). For example, at the national level in the 2003 to 2014 period, the correlation of the DHAI with both indexes is 0.50. Their time trends are similar except early in this period; this difference is due to changing house price expectations. The correlation of the HAI and DHAI for the Census regions is 0.55. The two measures are most dissimilar in the South region, where the DHAI indicates housing is more affordable than does the HAI. The overall correlation of the indexes at the metropolitan statistical area (MSA) level is 0.52 (HAI and DHAI) and 0.59 (HOI and DHAI). The DHAI is higher (thus indicating greater affordability) than the HAI in Boston, Denver, San Diego, San Francisco, and Washington, D.C., which is the result of relatively high expectations of house price appreciation in these metro areas.

We test the correlation of the HAI, HOI, and DHAI with measures of the demand for owner-occupied housing and homeownership rates at the national, regional, and MSA levels. Our indicator of the demand for homeownership is a

consumer sentiment variable obtained from the Survey of Consumers. All of the affordability indexes are significantly correlated with this measure of the demand for homeownership. However, none of the indexes is positively correlated with the national time trend in homeownership from 2003 to 2014, even when credit conditions are taken into consideration. However, all are highly correlated with cross-sectional variations in ownership at the regional and MSA levels. The DHAI is significantly correlated with housing starts and sales of existing and new single family homes, while the HAI and HOI are not during our sample period. The primary difference among the indexes is our inclusion of house price expectations in the DHAI. Our findings suggest that house price expectations are sensible to include in an affordability index of owner-occupied housing.

2. Literature Review and Background

The literature on the affordability of owner-occupied and rental housing is extensive (see Haurin, 2016, for a detailed review of the literature). Purposes identified for affordability measures include: 1) indicating the ability of a typical household to purchase a typical house (or, in some cases, the ability of a typical first-time home buyer to purchase an entry-level house), 2) guiding public policy interventions, especially ones targeted toward making homeownership more affordable to low income households, and 3) indicating the cost of housing relative to the fundamental cost of building a home. These purposes differ greatly. Our focus is to create an affordability measure that varies over time and space, is forward looking, and is related to the ability of households to become and remain homeowners.

Conceptually, the literature contains four approaches to the measurement of housing affordability. One computes the ratio of a measure of annual housing costs to household income. The second approach is based on the concept of "residual income", which is the amount of income left after paying for housing. This value is then compared to an arbitrary standard that lists values of income deemed adequate for non-housing expenses. The third approach compares the current cost of existing housing to the cost of new construction, excluding land. The fourth is based on a measure of "owner cost", which relies heavily on the "user cost" concept derived from the economic theory. User cost represents the cost of owner-occupied housing per dollar of house value.

Measures of affordability based on the ratio of housing costs to income vary from a simple ratio of median house price to median household income to more complex measures such as the HAI. Components of the HAI include the median price of a home, median family income, the mortgage interest rate, and assumptions about the down payment percentage (20 percent), the term of the loan (30 years), and the appropriate percentage of the income of a household that can be spent on housing (25 percent). Criticisms of this measure include its

focus on median values and the omission of certain factors discussed in more detail below.

The residual income approach compares the income of a household that remains after paying for housing expenses to an ad hoc standard of funds required for non-housing expenses. In general, this approach is most appropriate if the focus is on low income households and their ability to obtain shelter. An advantage is that the residual income standards can vary by household size and location. One disadvantage of this approach is that the residual income standards are ad hoc; however, they can be related to the poverty guidelines or other standards such as those used by the U.S. Veteran's Administration. Another problem with this approach is the acceptance of the amount of housing expenditures of a household as the appropriate amount. For example, a household that voluntarily chooses to spend a high (low) proportion of its income on housing due to its strong (weak) preferences for housing rather than other consumer goods could be judged to have unaffordable (affordable) housing simply due to its consumption choice. One fix for this problem is suggested by Stone (2006), which involves detailed specifications of the "appropriate" amount (or minimal amount) of housing for a household, then pricing this set of housing characteristics and developing a cost estimate.[1] The result is that the residual income approach is both complicated and somewhat arbitrary.

Glaeser and Gyourko (2003) state "To us, a housing affordability crisis means that housing is expensive relative to its fundamental costs of production—not that people are poor." They argue that house prices are the appropriate measure, not housing expenditures. They assert that affordability should be measured as the ratio of house prices to housing construction costs.[2] An advantage of this measure is that its components are exogenous, not influenced by the choices of a household. However, the exclusion of income from the index changes the commonly accepted concept of affordability.

The literature about owner and user costs is extensive (Rosen and Rosen 1980; Hendershott and Shilling 1982; Titman 1982; Hendershott and Slemrod 1983; Poterba and Sinai 2008).[3] The ratio of owner costs to rental costs has been successfully used to predict the likelihood of a household becoming a homeowner for the first time, and the aggregate homeownership rate and its changes in a locality, region, or nation (Linneman and Wachter 1989; Bourassa 1995; Haurin et al. 1997; Díaz and Luengo-Prado 2008).

We argue that all of the components of owner costs deserve attention when creating an affordability index of owner-occupied housing. A commonly used

[1] The pricing could be accomplished by using a hedonic price model.
[2] Their measure of construction costs excludes land costs, which likely reflect the amount of local amenities.
[3] A review of this literature from an international perspective is in Bourassa et al. (2015).

simplified expression of owner cost for the U.S., assuming itemization of deductions on federal income taxes, is:

$$\text{Owner Cost} = V\left(\left(r + t_p\right)\left(1 - t_y\right) + d + T / h_e - \pi_e\right) \tag{1}$$

where V is a measure of the constant-quality price of owner-occupied housing.[4] The mortgage interest rate is r, t_p is the property tax rate on housing, d includes annual depreciation, maintenance and hazard insurance costs, T is the transaction cost of buying and selling a dwelling, h_e is the expected duration of stay (holding period) in the dwelling, and π_e is the expected rate of house price appreciation. This equation simplifies the owner cost by assuming that the opportunity cost of equity financing is the same as the cost of debt. It also assumes that mortgage interest and property taxes are fully deductible from income taxes. Thus, their cost is reduced by t_y, which is the marginal income tax rate of a household. The tax rate varies with income. For the tenure choice decision of a household, the appropriate tax rate in (1) may be lower than the marginal tax rate; for example, it is zero for households that use the standard deduction. Regarding the decision of how much housing to consume, the marginal tax rate is the appropriate concept.[5] Factors included in owner cost but not included in the HAI measure are property taxes, the federal income tax deduction for mortgage interest and property taxes, depreciation, maintenance, hazard insurance, transaction costs, and expected house price inflation.

The literature discusses the use of median values when constructing housing cost to income ratios. Often noted is the fact that the ratio could be constructed at other percentiles of the house price and income distributions. One concern with these more detailed computations is data availability, especially timely data on the full distribution of household incomes.[6] Another concern about the use of the median house value is that the focal dwelling very likely changes in size over time (Hendershott and Thibodeau 1990). That is, when using median values, the quality and quantity of dwellings are not held constant. Dwelling size increased through 2007, thus the affordability of dwellings that were the median size in 1990 would be understated in 2007. The same issue occurs when comparing affordability across space at a point in time. Specifically, the physical characteristics of median priced dwellings in California very likely differ from those in Ohio. Various methods, usually related to the use of hedonic price indexes and the creation of a constant-quality house price, have

[4] The V term allows the price of housing to vary spatially and intertemporally, but holds the quantity of housing constant. This formulation is standard in the specification of owner costs and solves the problem of the endogeneity of housing expenditures.

[5] In the general case, t_y is referred to as the tenure choice tax rate (Hendershott and Slemrod 1983).

[6] An example of the use of household survey data to measure affordability by taking into account the distribution of incomes and other factors is provided in Bourassa (1996). Unfortunately, surveys and censuses are generally not useful for constructing affordability indexes because they are conducted infrequently.

been proposed as remedies. A final theme in the literature is that measures such as the HAI report as an indicator of affordability for the median income household, while an alternative is to report the percentage of households that are able to meet a specific housing cost to income ratio. For example, one could report the percentage of households in the U.S. that have an income greater than the "required income". Below, we include the HOI of the NAHB in our comparison as it reports this percentage.

The literature has considered many types of factors that could affect housing affordability. Fisher et al. (2009) correctly note that house prices include the value of locational amenities, thus median house prices differ in part because of amenity differences. They argue that housing affordability should not be influenced by variations in local amenity levels. This issue could be addressed by using the hedonic price approach mentioned above, but would require measuring the amount of local amenities in all locations covered by the affordability index. That would be a difficult task. Bourassa (1996) argues that the age and wealth of the household head should be incorporated in affordability measures. Coleman (2008) discusses the impact of inflation on housing affordability, noting the problem with "tilt". The argument is that a high expected rate of inflation results in a high nominal mortgage interest rate. If the mortgage type is a level payment fixed rate mortgage, then a high interest rate results in a relatively high deflated (real) mortgage payment at the beginning of the mortgage, which tends to decrease affordability. Inflation can also be an important factor in affordability as inflation and expected house price inflation are related and price expectations influence owner costs. The Center for Transit-Oriented Development and Center for Neighborhood Technology (2006) and Hamidi, Ewing, and Renne (2016) incorporate transportation costs in a housing affordability measure, noting the well-known trade-off between housing costs and accessibility to work, school, and shopping.

3. Affordability Index Definitions and Data Sources

3.1 DHAI Definition and Measurement

Our measure of affordability is based on the owner cost approach to measuring housing costs. We follow the primary thrust of the literature and define affordability as a ratio of income to the cost of housing by using the assumption that housing is affordable when a household spends 25 percent of its income (y) on housing.[7] Our measure is defined as:

$$DHAI = 100\left(0.25y / \text{Owner Cost of Housing}\right) \tag{2}$$

where y is the median family income and the owner cost is defined in (1).[8] Our definition requires that we measure the price of housing, mortgage interest and

[7] This value can easily be changed; 0.25 facilitates comparison with the HAI.
[8] In our calculations, we use annual measures of income.

property tax rates, household income and income tax rates, depreciation, maintenance, hazard insurance, and annualized transaction costs, and expected house price inflation. We create DHAI measures at the following geographical levels: national, the four census regions, and 20 MSAs. The criteria for our selected MSAs include diversity of location and population size.[9]

The first component of owner cost in (1) is the price of housing. Rather than use the median price of housing, we calculate the constant-quality price. To create cross-sectionally comparable price indexes, we estimated a national hedonic price regression by using data from the 2000 Census (1 percent sample) drawn from the Integrated Public Use Microdata Series (Ruggles et al. 2010).[10] We used the results to create a year-2000 cross-sectionally comparable house price index, with the characteristics of the house set equal to the national median characteristics. The geography for our constant-quality house price indexes includes national, regional, and MSA levels. This year-2000 index was then combined with the Federal Home Finance Agency (FHFA) purchase-only quarterly MSA time series index to create a cross-sectionally and intertemporally comparable index of the price of owner-occupied housing.[11]

Interest rates are derived from the Freddie Mac Primary Mortgage Market Survey for conventional single-family 30-year fixed rate mortgages. Similar to the assumption in the HAI, we assume a single value at all locations at a point in time. The literature on the mortgage interest deduction (MID) is reviewed in Bourassa et al. (2013). Recent empirical literature argues that in localities with an inelastic supply of housing, the MID is capitalized into house prices. The HAI measure includes this capitalization effect of property taxes, if present, because the median house price is included in the HAI calculation. However, the HAI does not include the benefit of the MID in reducing the cost of housing by reducing taxable income. In contrast, the DHAI incorporates both effects of the deduction for mortgage interest.

Property taxes are obtained from Tax Foundation calculations based on the 2007-2009 American Community Survey. We use the effective tax rate (property tax payment divided by house value) for the central county in each MSA. For the census regions and the U.S., we use the national average effective tax rate of approximately 1 percent.

[9] We do not go below the MSA level because the variables required for our index are not available in a timely way for smaller geographies.

[10] Details about the data sources, including web addresses, are provided in Appendix 1. Explanatory variables in the hedonic included the number of rooms and bedrooms, their squares, and a vector of age dummies. The dependent variable was house value as the transformation to logged values performed less well in this data set.

[11] The nine FHFA census divisions were combined into four census regions and using the annual population estimates of the Census Bureau as weights (quarterly population estimates were interpolated).

Household income is required for two reasons. First, income is directly required in the measure of DHAI. Second, we must determine whether households itemize deductions and, if they do, their marginal federal income tax rates; this is required to measure the tax benefit that results from mortgage interest and property tax deductions. We use median family income, although other percentiles could be used depending on data availability. The median incomes for MSAs are from the U.S. Department of Housing and Urban Development income limits database, while those for the Census regions and the U.S. are 1-year estimates from the American Community Survey.

We calculate the marginal income tax rate, t_y, for a household with the median income for that specific location.[12] The marginal income tax rate is derived from the TAXSIM tool of the National Bureau of Economic Research (Feenberg and Coutts 1993). For MSAs, the marginal tax rate is the sum of the federal and state marginal tax rates (using the rates for the state in which the central county of the MSA is located). For the census regions and the U.S., the marginal rates are the federal rates and an assumed 3 percent average state rate. In all cases, we assume a married couple with two dependent children, wage and salary income only, and deductions for state income taxes, mortgage interest, and property taxes. The MID assumes the interest is on a mortgage that finances 80 percent of the value of the constant-quality house at the current interest rate. The property tax deduction is the effective property tax rate multiplied by the constant-quality house value. The TAXSIM program also determines whether the household is eligible to itemize deductions or should take the standard deduction. If they take the standard deduction, then t_y in (1) is set to zero.[13]

Annual depreciation and maintenance costs are assumed to be 2.5 percent of the house value (Harding, Rosenthal and Sirmans 2007). Transaction costs are assumed to be 8 percent of housing costs (Smith et al. 1988; Haurin and Gill 2002) and the expected holding period is assumed to be 15 years (Emrath 2009) with a discount rate of 2 percent, which yields an annualized transaction cost of

[12] A referee commented that there is only a single U.S. tax code and thus relatively little spatial variation in the marginal rate. Our marginal tax rates are typically only 15 percent in MSAs in states that do not tax income (Florida and Texas, in our sample) compared to as high as 31.4% in Washington, DC. Furthermore, during our sample period, there was relatively little intertemporal variation; however, there are periods when the tax code changes substantially and these changes would result in substantial intertemporal variation of the marginal tax rate (one example is the 1986 tax reform).

[13] Our values of the DHAI are based on two assumptions regarding the tax treatment of property taxes and mortgage interest. For households that itemize, we assume that state income taxes, property taxes, and mortgage interest are fully deductible at the marginal tax rate of a median income household. If the standard deduction is optimal, there is no tax benefit of the deductibility of mortgage interest and property taxes; thus we set the tax rate to zero. The median income household itemizes in 61.5 percent of our MSA observations.

0.6 percent.[14] Hazard insurance costs are assumed to be 0.05 percent annually based on median hazard insurance premiums and median house values reported in the National Summary Tables of the 2013 American Housing Survey.

The owner cost measure includes expected house price appreciation. The assumption is that potential and existing homeowners form expectations about the future course of house prices and that their tenure choice decision is influenced by these expectations of future house prices. Thus, in periods when home price expectations are relatively high, buyers perceive that their cost of ownership is lower (and affordability is higher) than do similar home buyers when home price expectations are relatively low (Case and Shiller 2003). These assumptions are similar to those made for any investment good; purchases depend not only on the current price but expected future prices.[15]

Inspection of (1) yields the observation that owner costs linearly change with house price expectations. While this is similar to the relationship of owner costs with depreciation and maintenance costs, those costs are relatively stable. In contrast, house price expectations can change rapidly over time (e.g., within a year), especially during a housing boom or bust. We note that mortgage interest rates also fluctuate, sometimes substantially, over time. For example, from 1990 to 2003, the annual average mortgage interest rate changed by more than one percentage point from one year to the next during about half of the period (Freddie Mac 2015). However, since then, mortgage interest rates have been relatively stable. House price expectations likely are similar, exhibiting substantial fluctuations during periods of housing boom and bust, but being relatively stable otherwise.

One could question the accuracy of the house price expectations of households; however, we argue that this is not a relevant question.[16] Certainly expectations are inaccurate, likely by a large amount just before the turning points in a house price cycle. The relevant question is whether households act on their current expectations. Manski (2004, Section 7) summarizes the use of expectations data to predict behavior, and points out that relatively few studies exist, but there is supportive evidence that expectations matter (see also Kwan and Cotsomitis 2004). Additional evidence that economic actors respond to house price expectations is observed on the supply side of the housing market, where builders begin construction during periods when they expect future prices to be high. However, there is a substantial lag between the start of construction and

[14] Other values could be assumed for duration, but the user cost would vary only by a small amount. Duration varies by marital status, age, and region (Marlay and Fields 2010). In 2004, 46 percent of the current duration of stay of adult homeowners was at least 10 years, the average of course being larger than 10.

[15] A theoretical treatment of housing as an investment good is developed in Henderson and Ioannides (1983).

[16] Manski (2004, Section 6) summarizes various ways that the accuracy of expectations data has been measured.

completion of dwellings. At the end of a boom period, builders are left with large inventories because they did not anticipate the future decline in demand and falling prices. Clearly, they acted on their price expectations even though these expectations turned out to be inaccurate.

A final concern about the use of house price expectations in the computation of an affordability measure involves the timing of the capital gains or losses in house value. If prices are expected to decline, current user cost increases and thus current demand falls. In contrast, if house prices are expected to rise, user cost falls and current demand should rise, but there is a question whether this demand can be expressed by households in the market. The specific concern is about credit constraints. If down payments are relatively low and mortgage payment to income constraints are relatively lax, then high potential demand likely is expressed in increased market demand as it was during the 2000-2006 housing boom. However, if credit markets are tight, then even if a household believes homeownership is the optimal investment due to high expected price increases, it may not be able to express this demand. We conclude that the key issue with this concern is about credit availability, not whether house price expectations are influential. In our empirical work, we address this concern by controlling for credit availability.

Theoretically, it is clear that house price expectations influence owner costs; however, expectations are difficult to measure. We are aware of occasional cross-sectional surveys of house price expectations prior to 2003, and they are for a highly limited number of metro areas (Case et al. 2012). However, given the importance of price expectations to the formation of the house price bubble in 2000 to 2006, surveys began asking about house price expectations in 2007. Our primary source is the Survey of Consumers, a monthly national survey of about 500 respondents.[17] This survey is the source of the well-known Consumer Confidence Index. Two questions were asked about house price expectations, one being for the short run and the other a longer run measure. The short run question is: "By about what percent do you expect prices of homes like yours in your community to go (up/down), on average, over the next 12 months?" The second measure is more relevant for decisions about whether to own a home: "By about what percent per year do you expect prices of homes like yours in your community to go (up/down), on average, over the next 5 years or so?" Our DHAI measure uses the longer term expectations measure. An advantage of this wording of the survey question is that the respondent is directed to estimate the price change for his or her community, not simply nationally. The disadvantage of this data source is that the number of respondents tends to be thin when applied at the sub-regional level. Thus, for our MSA level DHAIs, we use the regional house price expectation of the MSA as an input.[18]

[17] This survey also produces house price expectations for the four Census regions. A defense of the use of survey responses of individuals' expectations in economic research is contained in Manski (2004).

[18] Sample size is also increased when we aggregate the monthly surveys to quarters.

Alternative sources of house price expectations data exist, one being a survey of experts published by the Wall Street Journal (WSJ). The experts are asked about house price expectations over a relatively short time period (1 to 2 years) and are asked only about the national level. The survey started in 2007 and is quarterly.[19] A second panel of 100 experts is surveyed by Pulsenomics (previously the S&P/Case-Shiller survey); however, this quarterly survey began relatively late in 2011. It reports expectations that range from one to five years. A fourth survey of house price expectations also from Pulsenomics began in the first quarter of 2014 and is biannual thereafter. It is large, with about 500 respondents in each of the 20 MSAs. We use the results from two waves of this survey to compare its estimate of price expectations in 10 MSAs to those from the Survey of Consumers.

3.2 HAI Definition and Measurement

The HAI measure of the NAR is defined as (National Association of Realtors 2013):

$$HAI = 100\left(0.25y/12m\right) \tag{3}$$

where m is the monthly payment on a median priced house (V):

$$m = \left(1-0.2\right)V\left(r/12\right)/\left(1-\left(1/\left(1+\left(r/12\right)\right)^{360}\right)\right) \tag{4}$$

In (4), the interest rate is for a 30 year fixed rate conventional mortgage. Other assumptions in the HAI include defining an affordable mortgage payment as 25 percent of the gross monthly income of a household and the household making a 20 percent down payment on the home (i.e., the household has 20 percent equity in the home).

3.3 HOI Definition and Measurement

The NAHB publishes the Housing Opportunity Index (HOI) that measures affordability as the share of home sales "in a metropolitan area for which the monthly income available for housing is at or above the monthly cost for that unit". Monthly income is the median for a metropolitan area and households are assumed to spend 28 percent on housing. Monthly costs include repayment of principal and interest (with additional assumptions including a 10 percent down payment and 30 year fixed rate mortgage), property taxes and insurance. House price is derived from monthly records of sold properties in a locality, and thus not a constant-quality measure.

[19] The correlation of the long run house price expectation measured by the Survey of Consumers and the short run expectation measured by the panel of experts is negative (-0.26). The answers of the experts are studied by Jang (2016).

3.4 Housing Market

The likelihood of a household becoming or being a homeowner depends not only on the demand side attributes specified above but also on various lender specified requirements including the minimal down payment and the maximal debt to income ratio. Any specific assumption about the down payment percentage could be viewed as problematic given it is well-known that typical down payment requirements changed substantially over the 1990-2013 time period. Note that the DHAI measure does not make an assumption about the down payment percentage. A justification is that the full version of the owner cost expression in (1) includes the cost of the amount mortgaged and the opportunity cost of the amount of the down payment. If the mortgage interest rate and the opportunity cost of the down payment are the same, then the percentage down payment is not a relevant factor with respect to the owner cost. Furthermore, owner costs are not a direct function of total debt to income ratio.

We address the issue of changes in the constraints of lenders by including a separate measure of credit market tightness in the estimation of homeownership rates. It has been shown that lender credit requirements were relaxed during the housing boom (Mian and Sufi 2011) and subsequently tightened. We use one of the components of the Zillow Mortgage Access Index to measure the credit environment. Zillow describes this measure as "Using Fannie Mae Loan Acquisition data, we tracked the lowest 10th percentile of borrower credit scores (CS10). CS10 gives a sense of which borrowers were on the cusp of denial in a given month. Rising CS10 values indicate tighter lending standards. For example, in late 2007 we see that borrowers in the bottom 10th percentile of credit scores had a score of approximately 630. By the end of 2008, CS10 would balloon to over 700. Essentially, an individual with a credit score of 630 would have had virtually no chance of being approved for a conforming mortgage at that moment in time. According to CS10, credit remained tight until approximately 2013."[20] The index rose from 2003 to 2004, stabilized, then fell dramatically from 2007 through 2009, stabilized at a low level though 2012, and then increased through the end of our sample period. While this index is not a perfect measure of credit tightness, its general time trend corresponds with casual impressions of changes in the credit market.[21]

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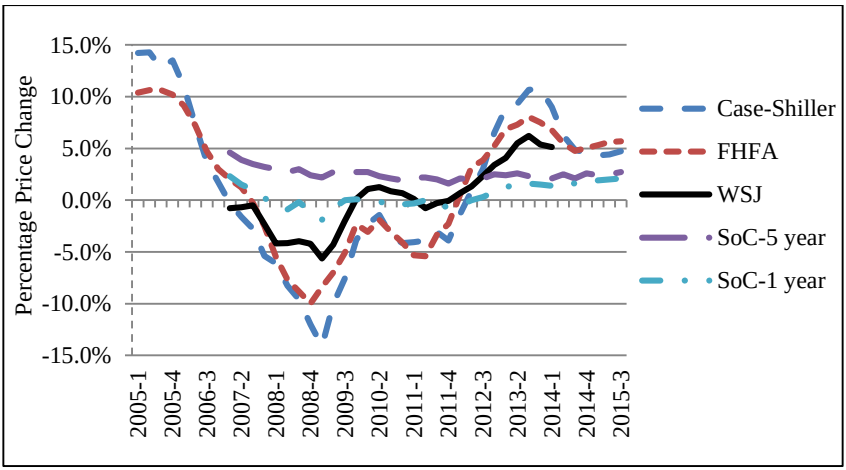
[20] See http://www.zillow.com/research/zillow-mortgage-access-index-9099/. Alternative measures of credit tightness are available from Zillow including 1) "the proportion of loans with 20 percent or more down that are non-conforming (those that cannot be sold to a GSE, meaning the risk must remain on the lender's books)"; 2) a measure of "how many quotes a Zillow Mortgage inquirer with a credit score between 600 and 640 receives compared to an inquirer with a credit score of 760 or higher"; and 3) an overall index based on seven measures. These measures of credit tightness are highly correlated with the credit access variables that we use (-0.94, -0.88, and -0.98 respectively). The CoreLogic Housing Credit Index is also very highly correlated with the Zillow credit access variable.

[21] A separate question is the typical time lag in creating an affordability index. All of the indexes must await the release of component data parts or use estimated values. Income

4. Descriptive Results

Of interest is the relationship of observed and expected house price inflation listed from the survey responses. Figure 1 displays the relationship at the national level, with two measures of observed prices: the FHFA and the S&P/Case-Shiller Price Index and three measures of expected house price inflation: WSJ, and Survey of Consumers 1 and 5 year annual house price changes.[22]

Figure 1 U.S. House Price Expectations and Observed Price Changes



The FHFA and Case-Shiller house price series follow similar paths (their correlation is 0.98), but the Case-Shiller index is more volatile as a result of the different compositions of the surveyed properties.[23] The WSJ price expectations series is less volatile than the observed price indexes and tracks changes in price indexes well (the correlations are 0.91 with Case-Shiller and

data with geographic detail are reported once per year with a substantial lag, FHFA house prices once per quarter with less of a lag, and interest rates monthly without much of a lag. The major difference among index components is that the DHAI requires a measure of house price expectations; however, that reporting lag is only two months.

[22] The Case-Shiller national index is described as "a composite of single-family home price indices covering the nine U.S. Census divisions. As the broadest national measurement of home prices, the index captures approximately 75 percent of U.S. residential housing stock by value" (see http://us.spindices.com/index-family/real-estate/sp-case-shiller). The FHFA index is their "purchase only" index. The Wall Street Journal index is converted from monthly to quarterly and its respondents are asked to predict the 12 month rate of house price change in the FHFA index.

[23] The standard deviations of the quarterly price changes are 7.5 for the Case-Shiller series and 6.1 for the FHFA series.

0.85 with FHFA).[24] However, the WSJ expectations series predicts prices one year ahead, not contemporaneously. Thus, to a large extent, the WSJ panel of experts predicted that the house price change in the coming year would equal the change in the current year. The five-year-ahead Survey of Consumers price expectations index is the least volatile of all of the series.[25] In contrast to the observed pattern of house prices, the predicted average annual change for the coming five year period is always positive. This series is negatively correlated with contemporaneous house price changes (both FHFA and Case-Shiller). However, it is positively correlated with the observed price series lagged one year and highly positively correlated with observed prices lagged two years (0.71 with Case-Shiller and 0.67 with FHFA).[26]

A number of conclusions can be drawn from the above observations. First, the longer term house price expectations of households are relatively stable over time, which addresses one of the concerns of using a user cost type measure of housing affordability given that a user cost measure based on long term house price expectations should be relatively stable. Second, casual observation suggests that long term price expectations track observed house price changes, but with about a two year lag.[27] Third, U.S. households tended to be optimistic about long term changes in house price changes even when house prices were falling.

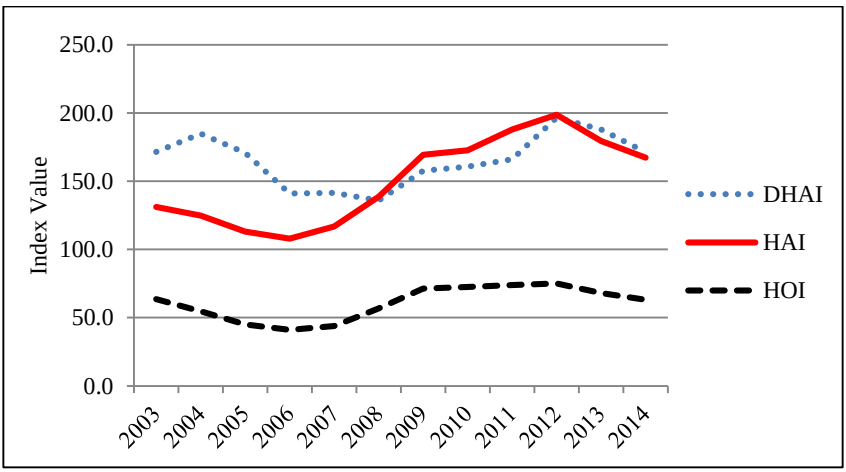
Our comparison of the DHAI with other affordability indexes covers two periods, one from 2007 to 2014 and the other from 2003 to 2014. The advantage of the longer period is that it includes the height of the housing boom as well as the subsequent bust. However, the reporting by the Survey of Consumers of house price expectations started after the boom in 2007. To extend the coverage time, the Survey of Consumers responses were compared with the annual responses from the Case et al. series of four county-level surveys of 10-year-ahead price expectations from 2003 to 2012.[28] The Case et al. (2012) results along with those from the Survey of Consumers are shown in Table 1. The Case et al. estimates tend to be higher. We estimated a simple ordinary least squares (OLS) regression for 2007-2012 with the Survey of Consumers data as the dependent variable and the four series of Case et al. (2012) data as the explanatory variables. The regression results were then used to predict the value

[24] The standard deviation of the WSJ series is 3.2.
[25] The standard deviation of the five-year-ahead Survey of Consumer series is 0.6 and 1.1 for the one-year-ahead series.
[26] The one-year-ahead Survey of Consumer series of price expectations is positively correlated with contemporaneous price changes (0.82 and 0.85).
[27] Simple OLS estimations that relate price expectations and lagged quarterly observations of observed house price changes found that the most significant coefficient occurs for an eight quarter lag.
[28] The four counties listed in Table 1 (Alameda, Orange, Milwaukee, and Middlesex) are the only counties included in the Case-Shiller survey of expectations.

of the Survey of Consumers expectations for 2003-2006. As shown in Table 1 (estimated values are indicated by an *), they peak in 2004-2005, remain high in 2005 and then fall through 2011. These predicted values are sensible and used in the creation of the DHAI for 2003-2006.

Figure 2 presents the time trends of the national DHAI, HAI, and HOI. Given that their measurement differs, rescaled versions are also presented in Figure 3.[29] These rescaled series can be interpreted as percentage changes in the index compared with a 2003 baseline. In general, the national DHAI and HAI measures follow similar time trends, higher in 2003 than 2006, rising through 2012, then falling through 2014. However, they differ in their details as the correlation of the level of DHAI with either of the other indexes is only 0.50 while that of the HOI and HAI is 0.93. This difference between the DHAI and the other indexes is caused by the trend in house price expectations, higher during the boom and lower during the bust. As shown in the figures, the decline in house price expectations resulted in the change in the DHAI, which fell below the HAI in 2008.

Figure 2 U.S. HAI, HOI, and DHAI



Note: The DHAI for 2003-2006 is estimated by using house price expectations data from Case-Shiller .

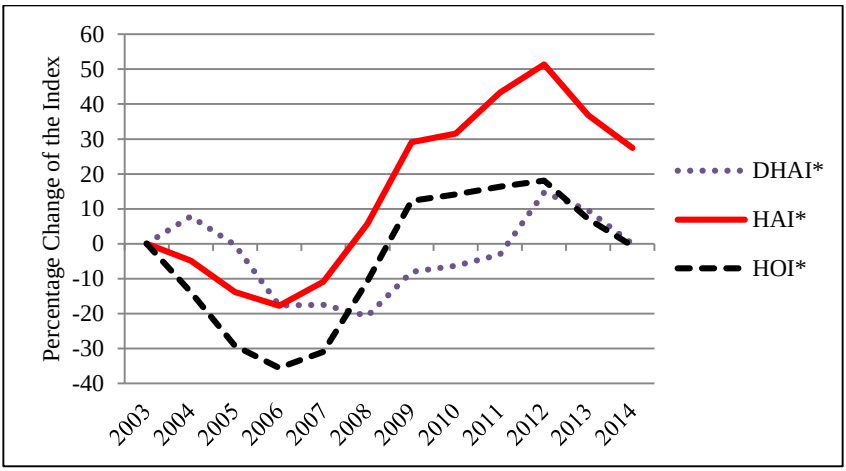
[29] The national and regional DHAIs are reported in Table A-2 in Appendix 2. Components of the index are available from the authors.

Table 1 Comparison of Case et al. with Survey of Consumers House Price Expectations

	Case-Shiller Alameda County Price Expectations	Case-Shiller Orange County Price Expectations	Case-Shiller Milwaukee County Price Expectations	Case-Shiller Middlesex County Price Expectations	Survey of Consumers Price Expectations
2003	0.122	0.115	0.071	0.089	0.041*
2004	0.141	0.174	0.104	0.106	0.048*
2005	0.115	0.152	0.119	0.083	0.048*
2006	0.094	0.095	0.099	0.075	0.044*
2007	0.017	0.122	0.081	0.053	0.038
2008	0.079	0.094	0.072	0.064	0.028
2009	0.085	0.069	0.082	0.062	0.026
2010	0.098	0.057	0.073	0.050	0.023
2011	0.076	0.071	0.047	0.041	0.020
2012	0.054	0.050	0.031	0.031	0.022

Regional DHAIs are depicted in Figure 4 for 2007-2014. Housing is most affordable in the South and Midwest, and least affordable in the Northeast and West regions. This ordering is slightly different than the HAI, which indicates that the Midwest is the most affordable, followed by the South, Northeast, and West. One reason why the DHAI measure shows greater affordability for the South is that house price expectations were greater than in the Midwest during the sample period. The average difference in expectations between these two regions is 0.53 percentage points (2.01 versus 2.54). Thus, households in the South expect greater capital gains on housing, which increases the attractiveness of homeownership. During this period, house price expectations are greater in the Northeast (2.74) and West (3.27) than in the Midwest or South, but these differences are not sufficiently large to offset the house price differential across regions, the net result being lower DHAIs in coastal states.

Figure 3 Rescaled U.S. HAI, HOI, and DHAI



Note: The DHAI for 2003-2006 is estimated by using house price expectations data from Case-Shiller.

The DHAIs for 20 metropolitan areas are displayed in Figures 5 to 8.[30] Substantial differences among areas are evident, generally following the pattern of differences in regional DHAIs. Housing is relatively affordable in Atlanta, Phoenix, Denver, Indianapolis, Columbus, Houston, Phoenix, and Washington, but relatively less affordable in Miami, San Francisco, and San Diego.

A weakness of the Survey of Consumers house price expectations data is the relative thinness of the sample size at the sub-regional level. The Housing Confidence Report survey of Zillow-Pulsenomics is limited to 20 metro areas, but there are 500 respondents per area, likely yielding better estimates of house

[30] The values of the MSA level DHAI are in Table A-3 in Appendix 2.

price expectations at the MSA level. Ten MSAs overlap between our group of 20 and the Pulsenomics survey.[31] In 2014:1, the Pulsenomics average expected house price inflation exceeded our expectations measure by 0.83 percentage points and in 2014:3 by 0.98; thus, we may be underestimating house price expectations in selected MSAs in 2014. Among the ten overlapping areas, in 2014, the use of Pulsenomics house price expectations data would systematically increase the DHAI in seven of our ten metro areas, but would change little in Denver, Philadelphia, and Phoenix.

Figure 4 Regional DHAIs

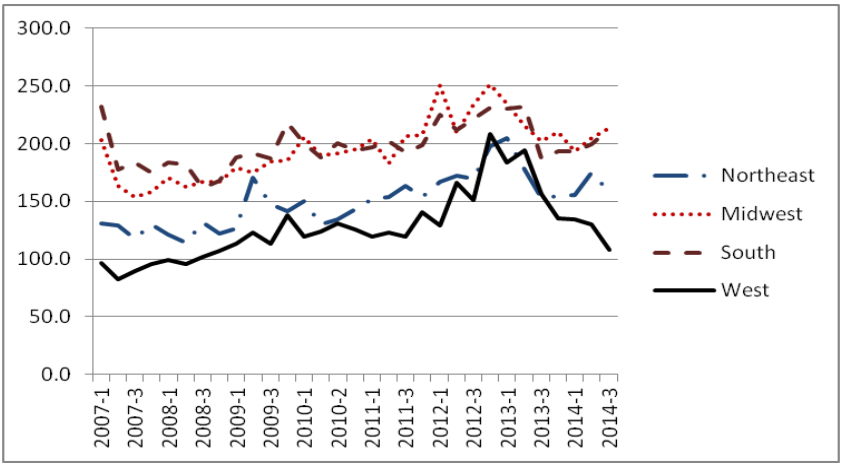
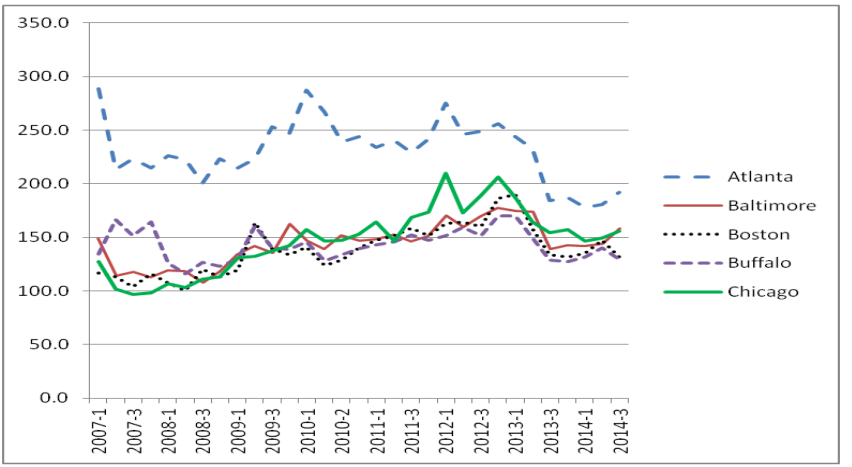


Figure 5 DHAI for Atlanta, Baltimore, Boston, Buffalo, and Chicago



[31] They are Atlanta, Boston, Chicago, Denver, Miami, Philadelphia, Phoenix, San Diego, San Francisco, and Washington.

Figure 6 **DHAI for Columbus, Denver, Houston, Indianapolis, and Miami**

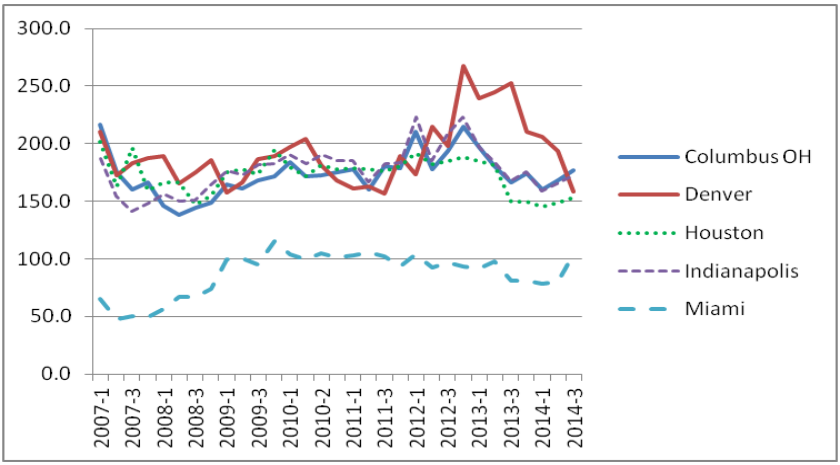


Figure 7 **DHAI for Milwaukee, Philadelphia, Phoenix, Portland, and Providence**

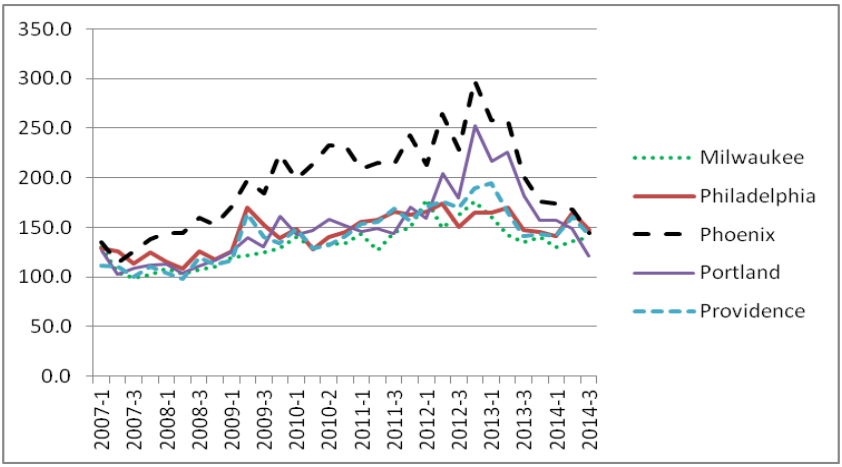
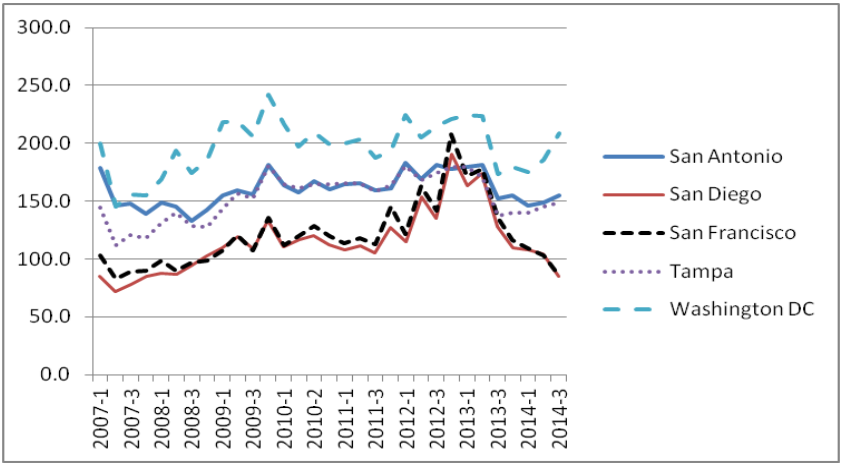


Figure 8 **DHAI for San Antonio, San Diego, San Francisco, Tampa, and Washington, D.C.**



5. The Relationship of Affordability Indexes to Owner-Occupied Housing Demand, Homeownership Rates, and Housing Market Characteristics

We emphasize that we are not estimating structural causal models in this section; rather, we are testing for reduced form relationships between affordability indexes and various housing market indicators. Significant correlations between an index and relevant indicators suggest that the index is achieving its defined purpose.

5.1 National Level

We first relate the national DHAI, HAI, and HOI to a measure of the annual demand for homeownership. We argue that if affordability is high then demand should be high. However, the demand for housing is unobservable. Our proxy for demand is taken from the Survey of Consumers; specifically, it is one of their consumer sentiment measures. The survey question is "Generally speaking, do you think now is a good time or a bad time to buy a house?" with answers "good", "bad", and "don't know". We measure the percentage that answered "good" and call this variable the "Good-time-to-buy". The regression includes only a single affordability index; supply side variables are not introduced.

The regression results on the demand for homeownership from 2003-2014 are displayed in Table 2. The regressions relate DHAI, HAI, or HOI to the national Good-time-to-buy measure in a simple OLS framework. All of the results

indicate that the demand for owner-occupied housing rises as affordability rises.[32] The coefficient of DHAI has the highest level of significance among the three indexes. The HAI is only marginally statistically significant. The elasticity of Good-time-to-buy with respect to DHAI is 0.64.

Table 2 U.S. Regression Results—Demand for Homeownership: 2003-2014

Dependent Variable	Independent Variables	Coefficient	t Statistic	Adjusted R^2
Good-time-to-buy	Constant	**26.62**	**2.94**	0.73
	DHAI	**0.28**	**5.14**	
Good-time-to-buy	Constant	**56.66**	**7.02**	0.22
	HAI	0.11	2.04	
Good-time-to-buy	Constant	**51.48**	**7.08**	0.47
	HOI	**0.35**	**2.99**	

Note: Annual observations. DHAI for 2003-2006 is estimated by using house price expectations data from Case et al. (2012). Coefficients that are statistically significant using the 0.05 criterion are shown in bold.

We next consider whether the affordability indexes are contemporaneously correlated with variations in the national housing market outcomes including the homeownership rate, single family housing starts, and sales of new and existing single family homes during 2003-2014. Housing market outcomes are influenced by both demand and supply side factors and thus we control for credit availability. The evaluation strategy of the three affordability indexes is a simple OLS regression, with the dependent variable being one of the housing market outcomes listed above, and the explanatory variables being the measure of credit availability and one of the affordability indexes. The expected sign of the credit availability index is negative and that of the affordability indexes is positive. The results are listed in Table 3.

A relatively clear pattern emerges in Table 3. The credit access variable performs as expected with a negative coefficient, which often is statistically significant. The DHAI measure of affordability has a positive coefficient and is statistically significant in the new and existing home sales regressions. It is not significant in the single-family housing starts or the U.S. homeownership rate regressions during 2003-2014. In contrast, the HAI measure of affordability is not statistically significant in any regression except in the homeownership regression where it has a negative sign. The HOI measure is also not statistically significant in any regression.[33]

[32] If a quadratic term is included, there is weak evidence that demand rises at a decreasing rate as affordability rises.

[33] A referee suggested including a measure of rents in the housing market outcome equations. If included, it does not change the sign or significance of the DHAI while its coefficient is either not statistically different from zero or unexpectedly negative.

Table 3 Comparison of Relationship of the Affordability Indexes with the U.S. Housing Market: 2003-2014

Housing Market	Constant	Credit Access	DHAI	HAI	HOI	Adjusted R^2
Housing Starts	**10781.6 (10.3)**	**-15.63 (9.4)**	4.07 (1.5)			0.89
Housing Starts	**8707.1 (2.7)**	-10.59 (1.8)		-4.22 (0.7)		0.87
Housing Starts	**10929.7 (4.8)**	**-14.88 (3.5)**			0.34 (0.0)	0.86
Existing Home Sales	**22750.9 (7.2)**	**-33.1 (6.6)**	**28.67 (3.5)**			0.80
Existing Home Sales	28101.1 (2.0)	-36.10 (1.4)		9.29 (0.4)		0.52
Existing Home Sales	**27474.7 (2.9)**	-35.13 (2.0)			22.57 (0.6)	0.53
New Home Sales	**7838.7 (8.5)**	**-12.18 (8.3)**	**6.16 (2.6)**			0.86
New Home Sales	7375.9 (2.1)	-9.72 (1.5)		-1.16 (0.2)		0.75
New Home Sales	**9782.7 (4.3)**	**-14.46 (3.4)**			9.94 (0.9)	0.78
Homeownership Percentage	**93.4 (13.4)**	**-0.03 (3.2)**	-0.02 (0.9)			0.54
Homeownership Percentage	**52.0 (3.6)**	0.04 (1.5)		**-0.08 (3.1)**		0.75
Homeownership Percentage	**92.9 (14.1)**	-0.04 (1.4)			-0.00 (0.0)	0.49

Notes: Annual observations. Numbers in parentheses are t-statistics. Coefficients that are statistically significant using the 0.05 criterion are shown in bold. Housing starts and new and existing home sales are measured in thousands.

The regression coefficients of DHAI imply elasticities, evaluated at mean values, of 1.5 for new home sales and 0.9 for existing home sales. The elasticity of housing starts is 0.7, using the point estimate for valuation (not statistically significant). A 10 point increase in the DHAI implies an annual increase of 41,000 housing starts, 287,000 sales of existing homes, and 62,000 sales of new homes. A 10 point increase could be caused by multiple factors. Examples, using 2014 values for variables in the DHAI formula and assuming a 15 percent tax bracket, include income rising by $4,000, house prices falling by $10,000, house price expectations rising by 0.33 percentage points, or mortgage interest rates falling by 40 basis points.

None of the affordability measures are related to the homeownership rate during 2003-2014. During this time, the ownership rate trended downwards, with little responsiveness to changes in affordability. This may be a reaction to the strong increase in homeownership rates from 1995 to 2003 and the large subsequent increase in the number of foreclosures. Arguably, the homeownership rate is slowly adjusting to the new equilibrium rate.

5.2 Regional Level

Next, we estimate quarterly Good-time-to-buy regressions for the four Census regions for 2007-2014 (Table 4).[34] The coefficients of DHAI and HAI are quite similar, have positive signs, and are statistically significant. This similarity of results may occur due to the shorter time period for this analysis.

Table 4 Regional Regression Results—Demand for Homeownership (N=124): 2007-2014

Dependent Variable	Independent Variable	Coefficient	t Statistic
Good-time-to-buy	Constant	**63.08**	27.0
Adj. R^2 = 0.13	DHAI	**0.06**	4.5
Good-time-to-buy	Constant	**60.56**	30.6
Adj. R^2 = 0.26	HAI	**0.08**	6.6

Note: Quarterly observations. Coefficients that are statistically significant using the 0.05 criterion are shown in bold.

We conduct a number of tests on whether the DHAI and HAI are contemporaneously correlated with housing market outcomes (Table 5). The regional DHAI values are again estimated for 2003-2006 and regression results cover the 2003 to 2014 period.[35] A regional fixed effects model must be used for house sales and starts because their values are not directly comparable between regions, given that the housing stocks differ in size; however, the

[34] The HOI is not available regionally. If regional fixed effects are included, then the results are very similar.
[35] Results are similar if limited to 2007-2014.

homeownership model is OLS as the rates are directly comparable.[36] The same general pattern emerges in Table 5 as for the national market; the DHAI is statistically significantly correlated with regional variations in the housing market, including the homeownership rate. The regional HAI is positively correlated with variations in homeownership but has a negative coefficient for the other housing market outcomes.[37]

5.3 MSA Level

At the MSA level, we analyze quarterly building permits and the homeownership rate (Table 6). Again, the regression model includes regional fixed effects for permits but is pooled OLS for the homeownership rate. The sample size for HAI regressions is about half the size as for the other measure as the HAI has more limited availability at the MSA level (it started in 2006).

In the homeownership regression, the coefficients of all the affordability indexes are positive and statistically significant. The elasticities of homeownership with respect to the affordability indexes are estimated to be small: 0.07 for the DHAI, 0.09 for the HAI, and 0.12 for the HOI (at the means of the variables). The credit tightness index has the expected negative sign in the DHAI and HOI regressions. In the building permits regression, the DHAI coefficient is positive and significant. However, the coefficients for HAI and HOI are negative. The elasticity of building permits with respect to the DHAI is 0.42.[38]

6. Summary and Conclusions

Housing affordability indexes are used by policy makers, real estate practitioners, housing interest groups, households that are considering becoming first-time homeowners, and existing homeowners who are considering changing properties. A well-grounded index will assist these groups in their decision making and better clarify the impact of proposed policies on housing affordability.

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[36] Thus identification is from both time series and cross-sectional variations in the homeownership model, but only time series variations in the other housing outcome models.

[37] If real regional rents are included in the regression, the coefficient of DHAI remains positive and significant, while the coefficient of the rental variable is most often not significantly different from zero.

[38] If an MSA level rent variable is included, it has a positive sign in the building permits equation but is negative in the ownership equation. The coefficient of DHAI remains positive and statistically significant in the permits equation. A referee asked for a version of the regression that included a lagged dependent variable. We used the Arellano-Bond dynamic panel data method, which yields unbiased estimates. In the regional models (starts, new and existing sales) and the permits model for MSAs, the DHAI variables remained statistically significant and had a positive sign in all cases.

Table 5 Regional Housing Market Regression Results: 2003-2014

Housing Market	Constant	Credit Access	DHAI	HAI	Adjusted R^2
Housing Starts	**660.41 (18.1)**	**-1.02 (17.7)**	**0.51 (6.8)**		0.46
Housing Starts	**501.11 (6.8)**	**-0.59 (4.4)**		**-0.33 (2.5)**	0.23
Existing Home Sales	**1245.17 (12.1)**	**-1.69 (10.4)**	**1.08 (5.1)**		0.35
Existing Home Sales	**699.04 (3.6)**	-0.36 (1.0)		**-1.13 (3.3)**	0.01
New Home Sales	**487.65 (17.8)**	**-0.75 (17.4)**	**0.37 (6.5)**		0.40
New Home Sales	**399.57 (7.2)**	**-0.49 (4.9)**		-0.18 (1.8)	0.24
Homeownership Percentage	**91.97 (21.8)**	**-0.05 (8.5)**	**0.07 (14.8)**		0.57
Homeownership Percentage	**136.28 (30.41)**	**-0.12 (16.9)**		**0.09 (18.2)**	0.67

Note: Quarterly observations (N=188). Numbers in parentheses are t-statistics. Coefficients that are statistically significant using the 0.05 criterion are shown in bold. Housing starts and new and existing home sales are measured in thousands. Regional fixed effects are included in all models except homeownership.

Table 6 20 MSA's Housing Market Regression Results: 2007-2014

Housing Market	Constant	Credit Access	DHAI	HAI	HOI	Adjusted R^2
Building Permits	**14561.26 (15.2)**	**-19.83 (12.6)**	**4.43 (2.8)**			0.13
Building Permits	**14416.83 (5.4)**	**-17.16 (4.3)**		**-4.87 (2.3)**		0.01
Building Permits	**11865.99 (8.8)**	**-14.08 (6.0)**			-8.57 (1.7)	0.05
Homeownership Rate	**92.30 (18.6)**	**-0.05 (6.2)**	**0.03 (6.1)**			0.08
Homeownership Rate	**55.84 (2.7)**	0.00 (0.1)		**0.03 (8.4)**		0.18
Homeownership Rate	**109.73 (22.5)**	**-0.08 (10.3)**			**0.12 (12.3)**	0.22

Notes: Quarterly observations. Sample sizes are 620 for DHAI, 320 for HAI, and 618 for HOI regressions. Numbers in parentheses are t-statistics. Coefficients that are statistically significant using the 0.05 criterion are shown in bold. Building permits are measured in thousands. Regional fixed effects are included in the building permits regression.

We argue that current affordability measures are incomplete; they do not account for spatial and inter-temporal variations in some of the components of the costs of homeowners. Examples, depending on the index, include property taxes, the deductibility of mortgage interest and property taxes from federal income tax, depreciation and maintenance. To our knowledge, no existing index includes the impact of expected house price inflation and thus capital gains. We develop a new affordability index that remedies the above shortcomings. It accounts for the expectations of the future course of the housing market. Given that house price expectations are somewhat volatile, the new index is relatively dynamic compared to the HAI of the NAR and thus it is designated as the DHAI.

Our descriptive analysis of the DHAI compared with the HAI and the HOI of the NAHB finds similarities and differences at the national, regional, and MSA levels. The correlation of the two indexes always exceeds 0.5; however, intertemporal and locational differences are found. Specifically, we find that the expected rate of house price inflation varies nontrivially over both time and space. In localities with high expectations, there is a tendency for the DHAI to also be high, thus positively impacting affordability.

The three indexes of affordability are positively correlated with the opinions of households about whether it is a good time to buy a home, which is a proxy for housing demand. None are related to the downward national trend in homeownership rates from 2007 through 2014. However, all are positively correlated with the variations in regional and MSA homeownership rates during this time period. The DHAI has a stronger relationship with housing starts, building permits, and sales of new and existing housing in all geographies.

We recognize that measures of housing affordability contain ad hoc elements. We also conclude that the theoretical construct of owner costs is a useful tool in understanding housing affordability and its relationship with various aspects of the housing market. Given the increase in data availability, better measures of owner costs are feasible. Our evidence suggests that it is important to include the expectations of households of house price changes in the owner cost measure. The result, which we call the DHAI, is clearly related to contemporaneous changes in housing market characteristics including the measures of housing demand, housing starts, building permits, and sales of new and existing housing. This relationship holds at the national, regional, and MSA levels.

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Appendix 1: Data Sources

Table A-1 Data and Sources

Variable	Source	Web site (for datasets)
Building permits	Real Estate Center, Texas A&M University	https://www.recenter.tamu.edu/data/building-permits/
Credit access	Zillow Mortgage Access Index	http://www.zillow.com/research/ zillow-mortgage-access-index-9099/
Depreciation and maintenance costs	Harding, Rosenthal and Sirmans (2007)	
Existing home sales	National Association of Realtors	http://www.realtor.org/topics/existing-home-sales
Hazard insurance rates	U.S. Census Bureau, American Housing Survey 2013, National Summary Tables	http://www.census.gov/programs-surveys/ahs/data/2013/.html
Homeownership rates	U.S. Census Bureau, Current Population Survey/Housing Vacancy Survey	http://www.census.gov/housing/ hvs/data/rates.html
House price indexes	Federal Housing Finance Agency House Price Index (Purchase-Only)	http://www.fhfa.gov/DataTools/Downloads/pages/house-price-index.aspx
House price inflation expectations	Survey of Consumers	http://www.sca.isr.umich.edu
	Zillow-Pulsenomics Home Price Expectations Survey	https://pulsenomics.com/Home-Price-Expectations.html
	Wall Street Journal, Economic Forecasting Survey	http://projects.wsj.com/econforecast
House values and characteristics for hedonic modeling	Integrated Public Use Microdata Series, U.S. Census of Population and Housing 2000, Public Use Microdata Sample (1 percent sample)	http://usa.ipums.org
Housing Starts	U.S. Census Bureau, New Residential Construction	https://www.census.gov/construction/nrs/index.html

(Continued…)

(Table A-1 continued)

Variable	Source	Web site (for datasets)
Marginal income tax rates	National Bureau of Economic Research, TAXSIM	http://www.nber.org/taxsim
Median family income	U.S. Department of Housing and Urban Development, Income Limits (for MSAs)	http://www.huduser.org/portal/datasets/il/il15/index.html
	U.S. Census Bureau, American Community Survey (1-year estimates for Census Regions and U.S.)	http://factfinder.census.gov
Mortgage interest rate	Freddie Mac, Primary Mortgage Market Survey	http://www.freddiemac.com/pmms
New home sales	U.S. Census Bureau, New Residential Sales	https://www.census.gov/construction/nrs/index.html
Population estimates	U.S. Census Bureau, Population Estimates	https://www.census.gov/popest/data/historical/
Property tax rates	Tax Foundation	http://www.taxfoundation.org
Transaction costs	Smith, Rosen and Fallis (1988) Haurin and Gill (2002)	

Appendix 2: HAI and DHAI Indexes for US, Regions, and 20 MSAs

Table A-2 DHAI and HAI for the U.S. and Four Regions

Year	Qtr	U.S. DHAI	DHAI Region			
			Northeast	Midwest	South	West
2003	1	165.5	145.1	193.7	219.2	103.9
2003	2	171.5	150.4	200.7	227.1	107.6
2003	3	171.5	150.4	200.7	227.1	107.6
2003	4	177.5	155.6	207.8	235.1	111.4
2004	1	184	161.3	215.4	243.7	115.5
2004	2	189	165.7	221.2	250.3	118.6
2004	3	189	165.7	221.2	250.3	118.6
2004	4	178	156.1	208.4	235.8	111.7
2005	1	178	156.1	208.4	235.8	111.7
2005	2	174	152.6	203.7	230.5	109.2
2005	3	172	150.8	201.3	227.8	107.9
2005	4	160	140.3	187.3	211.9	100.4
2006	1	152	133.3	177.9	201.3	95.4
2006	2	144	126.3	168.6	190.7	90.4
2006	3	138	121.0	161.5	182.8	86.6
2006	4	130	114.0	152.2	172.2	81.6
2007	1	163.6	131.3	203.3	232.5	96.4
2007	2	136.6	129.5	163.5	177.2	82.5
2007	3	132.8	117.7	153.8	183.6	89.8
2007	4	132.5	130.1	158.3	174.9	95.3
2008	1	138.3	121.4	170.5	183.8	99.3
2008	2	135.6	114.5	162.6	182.0	96.0
2008	3	135.3	132.0	167.4	162.2	102.2
2008	4	134.2	122.5	166.9	167.9	107.4
2009	1	148.8	126.4	179.8	187.9	112.9
2009	2	160.5	170.6	175.2	191.3	123.0
2009	3	155.1	147.4	184.7	187.0	113.3
2009	4	166.5	141.4	185.9	217.8	137.7
2010	1	163.7	150.1	205.6	200.3	119.3
2010	2	158.6	130.3	190.3	188.3	123.5
2010	3	160.7	134.4	191.9	200.9	131.0
2010	4	159.3	143.2	195.5	194.4	125.7
2011	1	160.9	152.0	203.6	196.5	119.2
2011	2	165.4	153.6	183.0	202.4	122.7
2011	3	168.6	163.5	206.6	192.6	119.1
2011	4	170.2	153.8	207.8	198.3	140.8
2012	1	188.7	167.2	250.8	224.8	129.2
2012	2	191.5	172.0	209.4	212.1	165.9
2012	3	192.7	169.5	233.9	221.3	151.4
2012	4	213.4	198.1	251.7	231.2	208.3
2013	1	207.7	204.5	234.3	230.1	183.4
2013	2	204.7	177.6	215.1	232.3	194.3

(Continued…)

(Table A-2 Continued)

Year	Qtr	U.S. DHAI	DHAI Region			
			Northeast	Midwest	South	West
2013	3	170.6	152.7	202.6	187.1	156.3
2013	4	168.3	154.7	210.5	193.7	135.4
2014	1	164.5	155.5	193.9	193.8	134.6
2014	2	177.9	174.6	204.8	200.0	129.6
2014	3	171.5	158.2	214.0	213.0	107.6

Note: 2003-2006 values are estimated by using house price expectations data from Case-Shiller rather than based on house price expectations data from Survey of Consumers.

Table A-3 DHAI for MSAs

Year	Qtr	DHAI MSA						
		Atlanta	Baltimore	Boston	Buffalo	Chicago	Columbus	Denver
2007	1	289.0	149.1	116.9	134.7	127.5	216.4	210.5
2007	2	213.4	114.1	113.5	166.7	101.7	174.9	172.1
2007	3	223.4	117.8	104.1	151.6	97.0	160.4	183.4
2007	4	214.7	113.0	116.2	164.5	98.0	166.1	187.7
2008	1	226.5	119.1	107.5	125.9	106.9	146.5	189.5
2008	2	222.4	118.8	100.3	115.9	103.5	138.5	165.4
2008	3	200.7	107.6	120.6	126.5	111.3	144.3	175.0
2008	4	223.3	118.2	113.2	123.1	113.5	148.5	185.4
2009	1	214.8	134.2	119.9	129.5	130.7	164.5	157.8
2009	2	223.0	141.7	163.8	160.5	132.7	160.9	166.2
2009	3	253.0	135.4	139.3	139.9	137.7	167.9	186.7
2009	4	247.1	162.6	133.9	138.5	142.4	171.6	189.1
2010	1	287.1	146.8	141.2	146.0	157.6	184.0	197.1
2010	2	266.5	139.3	123.9	127.8	146.5	171.2	204.0
2010	3	239.0	152.2	128.8	133.7	147.5	172.8	181.0
2010	4	243.9	146.9	140.3	139.8	153.0	174.9	168.4
2011	1	234.3	148.2	147.4	142.8	164.3	177.7	160.7
2011	2	240.4	152.5	151.4	145.5	146.9	160.4	162.8
2011	3	229.0	146.2	158.7	152.3	168.7	180.4	156.6
2011	4	241.9	151.4	151.5	147.6	173.5	178.9	188.9
2012	1	275.5	170.7	163.0	151.8	209.9	210.4	173.6
2012	2	246.1	159.6	164.3	159.2	173.2	177.6	214.6
2012	3	249.1	169.8	159.8	151.8	189.3	193.4	198.3
2012	4	255.8	177.4	186.1	170.2	206.4	215.2	267.2
2013	1	243.8	174.6	190.1	169.8	187.1	197.3	239.3
2013	2	232.7	173.9	157.8	149.4	164.6	180.4	244.4
2013	3	183.9	139.1	134.1	128.9	154.6	166.4	252.3
2013	4	186.9	142.8	131.8	127.6	157.1	174.3	210.2
2014	1	177.6	141.9	135.5	131.6	146.8	160.5	205.6
2014	2	180.8	144.1	147.3	140.1	149.7	168.2	193.6
2014	3	191.8	158.3	131.7	129.8	156.1	176.7	158.2

(Continued…)

(Table A-3 Continued)

Year	Qtr	DHAI MSA					
		Houston	**Indianapolis**	**Miami**	**Milwaukee**	**Philadelphia**	**Phoenix**
2007	1	202.0	187.1	64.9	129.4	129.2	135.3
2007	2	163.0	154.4	47.8	103.8	125.9	114.0
2007	3	196.6	140.9	50.6	98.6	113.1	125.8
2007	4	159.2	148.5	49.5	101.7	125.1	137.9
2008	1	166.5	156.4	56.7	108.3	115.1	144.4
2008	2	166.2	150.1	67.0	102.7	107.8	143.7
2008	3	146.7	151.0	67.1	107.6	126.2	159.3
2008	4	155.0	163.8	74.3	110.3	118.0	152.2
2009	1	175.5	176.2	99.1	120.1	125.4	170.6
2009	2	177.5	172.6	100.4	121.6	170.3	198.1
2009	3	173.8	181.8	95.1	124.7	152.4	184.6
2009	4	194.8	182.5	115.2	129.3	139.2	223.9
2010	1	179.8	190.8	103.7	140.6	148.2	198.8
2010	2	172.0	182.6	99.3	130.3	128.0	213.7
2010	3	181.1	190.2	105.1	133.3	140.6	232.0
2010	4	178.1	185.3	101.1	134.3	145.6	232.7
2011	1	178.9	185.2	103.2	143.3	155.2	209.3
2011	2	177.8	167.0	105.7	126.8	157.7	215.5
2011	3	176.5	182.6	101.9	145.8	165.9	213.8
2011	4	180.1	183.1	93.5	149.7	163.2	242.3
2012	1	192.1	223.1	103.8	178.5	166.3	213.2
2012	2	182.1	185.2	92.3	149.4	174.0	264.7
2012	3	184.9	208.3	97.0	162.4	150.7	228.8
2012	4	188.3	222.7	93.7	175.7	164.6	298.0
2013	1	184.8	197.0	91.8	160.7	164.8	258.3
2013	2	181.0	183.1	97.8	142.0	169.4	256.7
2013	3	149.5	167.6	80.6	135.2	147.0	202.1
2013	4	149.8	175.8	80.9	140.3	145.3	175.8
2014	1	145.6	158.8	78.6	130.2	141.4	173.9
2014	2	149.2	166.2	80.4	135.7	165.2	167.8
2014	3	152.8	173.2	103.5	139.9	147.3	143.9

(Continued…)

(Table A-3 Continued)

Year	Qtr	DHAI MSA						
		Portland	Providence	San Antonio	San Diego	San Francisco	Tampa	Washington DC
2007	1	126.1	111.7	178.8	84.8	102.9	144.1	199.7
2007	2	102.2	110.0	145.9	71.6	82.6	111.6	145.4
2007	3	109.1	100.4	147.7	78.2	89.0	120.8	156.0
2007	4	112.3	110.6	139.1	84.8	90.0	118.2	154.9
2008	1	112.9	104.2	148.8	88.0	98.5	130.9	169.4
2008	2	104.0	98.1	145.2	86.4	89.9	140.1	193.9
2008	3	111.3	119.7	132.6	94.8	97.0	128.8	173.9
2008	4	117.3	112.4	142.3	102.5	98.7	127.4	186.0
2009	1	125.0	116.1	154.8	109.3	107.1	143.8	217.9
2009	2	139.2	164.0	159.1	119.4	121.0	156.9	219.4
2009	3	130.3	140.3	155.5	108.6	107.8	152.3	205.7
2009	4	161.6	134.1	181.3	133.2	135.8	180.2	242.1
2010	1	142.4	148.2	163.6	110.5	111.8	164.4	216.5
2010	2	146.7	129.0	157.8	116.5	119.7	161.2	196.8
2010	3	158.0	131.5	167.4	119.9	128.2	164.7	209.5
2010	4	152.3	141.6	160.4	112.6	120.1	164.5	199.0
2011	1	145.3	153.7	164.9	108.3	113.4	165.4	199.9
2011	2	149.1	155.7	165.5	111.2	117.9	165.4	203.3
2011	3	143.2	168.5	158.9	105.2	113.1	158.3	187.4
2011	4	169.9	156.5	161.1	127.1	145.4	163.8	193.3
2012	1	159.1	170.6	182.9	114.8	121.3	180.4	224.0
2012	2	204.6	176.0	168.7	153.2	162.6	168.2	205.1
2012	3	179.5	169.5	181.1	135.3	141.3	174.6	215.0
2012	4	252.5	189.9	177.4	190.6	207.8	180.0	220.7
2013	1	217.0	194.9	179.4	163.5	172.0	179.2	224.5
2013	2	226.2	165.0	181.3	173.6	178.0	170.3	223.5
2013	3	182.0	141.4	151.9	128.3	135.6	137.6	173.2
2013	4	157.6	143.0	154.5	109.8	116.0	140.4	179.4
2014	1	156.7	140.7	146.4	107.7	108.8	139.8	175.4
2014	2	148.4	160.4	148.8	104.1	102.7	145.4	185.3
2014	3	121.1	142.3	155.0	85.1	85.2	149.2	209.0