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Randal Verbrugge, U.S. Bureau of Labor Statistics

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THE PUZZLING DIVERGENCE OF RENTS AND USER COSTS, 1980–2004

BY RANDAL VERBRUGGE*

Bureau of Labor Statistics

This paper demonstrates that, in the context of U.S. housing data, rents and *ex ante* user costs diverge markedly—in both growth rates and levels—for extended periods of time, a seeming failure of arbitrage and a puzzle from the perspective of standard capital theory. The tremendous volatility of even appropriately-smoothed *ex ante* annual user cost measures implies that such measures are unsuitable for inclusion in official price statistics. The divergence holds not only at the aggregate level, but at the metropolitan-market level as well, and is robust across different house price and rent measures. But transactions costs matter: the large persistent divergences did not imply the presence of unexploited profit opportunities. In particular, even though detached housing is readily moved between owner and renter markets, and the detached-unit rental market is surprisingly thick, transactions costs would have prevented risk-neutral investors from earning expected profits by buying a property to rent out for a year, and would have prevented risk-neutral homeowners from earning expected profits by selling their homes and becoming renters for a year. Finally, computing implied appreciation as a residual yields a house price forecast with huge errors; but either longer-horizon or no-real-capital-gains forecasts—which turn out to have similar forecast errors—imply a far less divergent user cost measure which might ultimately be useful for official price statistics. Some conjectures are offered.

1. INTRODUCTION

Housing price dynamics are central to understanding inflation, consumption, and the evolution of wealth. Yet measurement of housing costs is controversial. Many official statistical agencies, including the U.S. Bureau of Labor Statistics (BLS), use a rental equivalence approach to measuring cost inflation for homeowners. Many commentators in the financial press implicitly prefer a house price approach: between 1995 and 2004, the owners-equivalent-rent (OER) subindex of the CPI rose by about 30 percent, but the Office of Federal Housing Enterprise Oversight (OFHEO) house price index rose by over 61 percent, a divergence which many commentators viewed as "perverse" and unacceptable.[1] Conversely, since

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*Correspondence to Randal Verbrugge, Division of Price and Index Number Research, Bureau of Labor Statistics, 2 Massachusetts Ave NE, Washington DC 20212, USA (verbrugge.randal@bls.gov).

[1]More recently, the complaint has been that OER inflation is too high, given the cooling in house prices.

housing is a durable capital good which provides a flow of services over time and which has an active secondary market, many economists prefer a user-cost approach (see Prescott, 1997).[2]

In standard Jorgensonian capital theory, a durable good's rental cost will equal its *ex ante* user cost. This paper is the first to demonstrate that, in the case of U.S. housing data, rents and *ex ante* user costs diverge markedly, for extended periods of time, an evident failure of arbitrage, and a puzzle from the perspective of the standard theory.

Prior to this paper, it was known that *ex post* user cost measures are typically *much* more volatile than the corresponding rent measures (see, e.g. Gillingham, 1983). Indeed, *ex post* homeowner user cost measures are so volatile that, given their large weight in consumer price indexes, their monthly movements would dominate these price index movements. But in many contexts, such *ex post* measures of user costs are not the most interesting or relevant measure, for several reasons. First, *ex post* user costs can be negative. Second, decisions are made on the basis of *ex ante* rather than *ex post* user costs. Third, rents should equal *ex ante* rather than *ex post* user costs. Such reasons have prompted some (e.g. Diewert, 2008) to suggest that, for the purposes of constructing official statistics, *ex ante* user cost measures are superior. *A priori*, one would have expected a much tighter linkage between rents and *ex ante* user costs. For example, *ex ante* measures might have turned out to be far less volatile than *ex post* measures, since they involve expected rather than actual home price appreciation.

This paper constructs several estimates of *ex ante* user costs for U.S. homeowners, and compares these to rents. Since there is no accepted model of house price dynamics, a forecasting approach to expected appreciation is used. There are four novel findings. First, a significant volatility divergence remains even for *ex ante* user cost measures which have been smoothed in a manner that mimics the implicit smoothing in rent data. Indeed, the volatility of smoothed quarterly aggregate *ex ante* user cost growth is about ten times greater than that of aggregate rent growth. This large volatility probably rules out the use of standard *ex ante* annual user costs as a measure of the costs of homeownership.

The second novel finding is perhaps more surprising: not only do rents and user costs diverge in the short run, but the gaps persist over extended periods of time. In other words, the divergence between rents and user costs is not simply a high-frequency phenomenon. This temporal divergence is true both for the U.S. as a whole, and—to greater and lesser extents—for ten major metropolitan areas in the U.S. Formal cointegration tests reject cointegration in nearly all cases. The divergence between rents and user costs is disconcerting, and suggests that the standard theory is deficient.

One way to interpret this divergence is that rent dynamics are enigmatic. In particular, rents do not appear to respond very strongly to their theoretical determinants. This is explored in greater depth in a companion paper, Verbrugge (2007b), and accords with findings of earlier work by Follain *et al.* (1993),

[2]User costs are used frequently in interarea and international comparisons (Heston, 2004; Katz, 2004), are used in Iceland to compute shelter costs (Guðnason, 2004, 2005), are in use by the Bureau of Economic Analysis (Diewert, 2008), and have been frequently proposed or used as measures of consumption (see, e.g. Landefeld and McCulla, 2000).

DiPasquale and Wheaton (1992) and Blackley and Follain (1996). These studies focus on structural models of the rental housing market—the latter two estimate multiple-equation structural models—and each concludes that it is difficult to find strong evidence that changes in user costs influence rents.[3] Another way to interpret this divergence is that—contrary to the view of Himmelberg *et al.* (2005)—if the standard frictionless model applies, house price dynamics make no sense. (In that sense, this paper is related to the large literature on real estate market efficiency; but this paper does not rely on very-long horizon forecasts to draw its conclusions, and focuses on the issue that is most relevant for inflation dynamics.)

Despite this novel divergence finding, the third novel finding is that there were evidently no unexploited profit opportunities. The detached-unit rental market is surprisingly thick, and detached housing is readily moved between owner and renter markets, so the capital specificity issue highlighted by Ramey and Shapiro (2001) should not play a big role. However, the large costs associated with real estate transactions would have prevented risk-neutral investors from earning expected profits by using the transaction sequence *buy–earn rent on property–sell*, and would have prevented risk-neutral homeowners from earning expected profits by using the transaction sequence *sell–rent for one year–repurchase*. The large wedges offer a partial explanation of the significant divergences: rents and user costs might evolve somewhat independently until their divergence becomes large. Another way to put this is that the owner-occupied and rental markets are segmented. This possibility is explored in Verbrugge (2007b).

The final novel finding provides a hint at a resolution. Any reasonable forecast of annual house price appreciation yields the conclusions above. Thus, the expected house price appreciation that is implied by equating *ex ante* user costs to rents must yield a terrible forecast; indeed it does, suggesting persistently overoptimistic appreciation expectations in the early 1980s, and entirely missing the post-1995 run-up of house prices. Long horizon forecasts behave somewhat similarly. This is intriguing, because the existence of large transactions costs implies that the margin of indifference between renting and owning has an implied horizon much longer than one year. Furthermore, rent inflation for continuing tenants is notoriously subdued, suggesting that landlords' planning horizons also exceed one year. In environments with significant transactions costs, neither the theory of landlord behavior, nor of user costs, is fully developed. Nonetheless, several longer-horizon forecasts in otherwise standard *ex ante* user cost measures were explored, to see if they would lead to less rent-user cost divergence. The corresponding user cost measures, though still quite volatile, do feature far less divergence from rents. Thus, longer horizons, and a rationalization for rent inflation stickiness, might help explain the puzzles highlighted herein; and long-horizon forecasts might provide a basis for a modified user cost measure suitable for official price statistics.

Finally, what distinguishes this paper from the recent work of Himmelberg *et al.* (2005)? That paper is focused on explaining house price dynamics, and asks whether these have been driven by bubbles or fundamentals. However, it does not directly address the issue of rents versus user costs, since that study's measure of

[3]In contrast, Green and Malpezzi (2003) find a stronger relationship between rents and user costs.

expected appreciation is a one-sided 15-year moving average. This measure may be sensible in other contexts, but is unsuitable for the purpose of comparing rents to annual user costs, since it cannot reflect the covariance between interest rates and expected appreciation at higher frequencies.

The outline of the sequel is as follows. Section 2 describes the data. Section 3 discusses the theory and the construction of the user cost measures. Section 4 presents empirical evidence. Section 5 then explores the "arbitrage" question: given the divergences observed, were profits possible in expectation? Section 6 explores the use of alternative appreciation measures, and the differences these make. Section 7 offers some conclusions.

2. Data and Data Issues

Data used are the Conventional Mortgage Home Price Indexes (CMHPIs) for the U.S. and for ten U.S. metropolitan areas, the U.S. Census "constant-quality" new home price index, the average contract rate on commitments for 30-year conventional fixed-rate first mortgages in the U.S., the one-year T-bill interest rate, the CPI OER and rent indexes for all-U.S. and for ten metropolitan areas, confidential post-1987 U.S. CPI microdata, and the U.S. Census rental vacancy rate.

2.1. *House Price Indexes*

The house price indexes, and their construction, are discussed in more detail in an unpublished Appendix.[4] The closely-related OFHEO and CMHPI price indexes differ significantly from the Census new home price index. However, while the distinctions might be important in some contexts—such as in answering the question, "Was there a bubble in U.S. home prices?" (see McCarthy and Peach, 2004)—the answer to the question "Do rents and user costs diverge?" is unchanged, as will be evident below.

2.2. *Interest Rate; Marginal vs. Average User Cost*

A key component in a user cost series is the interest rate. The choice of the interest rate is contentious. In one view, the interest rate used in a particular agent's user cost should correspond to his idiosyncratic opportunity cost of capital—the rate at which future nominal returns are discounted. However, the work of Wang *et al.* (2005) implies that the appropriate discount rate is rather the rate which corresponds to risky housing investment; in other words, it should contain the risk premium relevant for mortgages. The interest rate should arguably also contain a default premium, reflecting the purely idiosyncratic part of the return, i.e. the part that is orthogonal to aggregate housing risk. These considerations suggest the use of the mortgage interest rate, which contains both a risk premium and a default premium. Further lending support to this view is the fact that actual debt in the house must be financed at a mortgage interest rate. This choice is also convenient in that it leads to a simpler user cost expression. Fortunately, in the present analysis the resolution of this contentious issue appears not

[4]The Appendix is available on the BLS website: see https://www.bls.gov/ore/orecatlg.htm.

to matter. In particular, the basic character of the results is not affected if the T-bill interest rate—a rate which contains neither a risk nor a default premium—is used in place of the mortgage interest rate.[5]

A second issue related to the interest rate is that of marginal versus average user cost. A quarterly user cost measure U_t will most naturally be a *marginal* user cost, i.e. it will incorporate the current period home price and the current period interest rate. However, rent indexes generally do *not* share this temporal feature. Instead, these indexes are averages constructed from a sample of all extant rent contracts, rather than from a sample of *new* contracts each period. Thus, these indexes are implicitly temporally aggregated, being averages of contracts that were renewed this month, renewed last month, and so on. Additionally, there is an *explicit* temporal aggregation in BLS rent indexes; see Ptacek and Baskin (1996), Poole and Verbrugge (2007), and Verbrugge (2007a) for details on the construction of these indexes.

Fortunately, it is straightforward to transform the marginal user cost series into a temporally aggregated average series which approximately matches the temporal structure of the rent indexes. If one assumes that all rental contracts are renewed on an annual basis (as most are), and that renewal dates (and new contract dates) are distributed uniformly across all quarters, the user-cost series can be put on the same temporal basis by replacing the current user cost with a one-sided five-quarter moving average.[6] This transformation will clearly impact the volatility of the user cost series, but will *not* influence its lower-frequency dynamics.

2.3. *Rent-of-Shelter Indexes*

The goal of this paper is to compare estimated user costs to rents. Ideally, one wants to construct a measure of user costs that is as comparable as possible to the rental data. Thus, at a minimum, the type of quality adjustment on the rent series should be similar to that on the user cost series, and the type of structures for which rents are obtained should be similar to those for which user costs are estimated. As discussed in the Appendix, along both of these dimensions of comparability, neither the CPI OER indexes nor the CPI rent indexes are perfect matches to the home price indexes used. To address these data comparability issues (and to develop a rent index that is more directly comparable to the repeat-sales house price indexes), a monthly rent index using a post-1987 CPI rent microdata set comprised of rents only of single detached dwellings was constructed. The details of the construction are in the Appendix. However, just as in the case of home price indexes, the answers to the questions being posed in this paper are the same, regardless of which rent-of-shelter index is used.

The BLS has made numerous improvements to its shelter indexes over the past quarter-century. While these improvements make the present and future CPI

[5]Housing is a risky investment, but renting carries rent risk; the risk premium choice is open to question. Upon assuming a neoclassical frictionless framework, Campbell *et al.* (2006) find a significant and time-varying housing premium, which could be interpreted as a risk premium. But there is no accepted model for risk premia.

[6]The smoothed series S_t is constructed from U_t as $S_t = (1/8)\{U_t + U_{t-4}\} + (1/4)\{U_{t-1} + U_{t-2} + U_{t-3}\}$.

more accurate, *historical* price index series are not adjusted to consistently reflect all of these improvements. Crone *et al.* (2006) provide some guidance about adjusting CPI rent-of-shelter indexes; this work followed their suggestions. Details are available in the Appendix.

3. User Costs

In principle, the *ex ante* user cost is simply the expected annual cost associated with purchasing a house, using it for one period, and selling it at the end of the period.[7] Given the presence of risk-neutral landlords, perfect competition, and under the assumption of no transactions costs, this should equal the market rent for an identical home. This paper focuses on annual user costs, since most rental contracts are annual and most rent changes occur on an annual basis. The annual user cost is also the measure appropriate to answering a question facing newly-arriving residents: should I delay purchasing by one year?

The following annual user cost formula, which ignores the preferential tax treatment given to homeowners,[8] is standard.[9]

$$\begin{aligned} U_t &= P_t^h\left(i_t + \gamma - E\pi_t^h\right) \\ &:= P_t^h \psi_t \end{aligned} \tag{1}$$

where P_t^h is the price of the home; i_t is a nominal interest rate;[10] γ is the sum of depreciation, maintenance and repair, insurance, and property tax rates (and potentially a risk premium)—all assumed constant, with $\gamma = 7\%$;[11] π_t^h is the four-quarter constant-quality home price appreciation between now and one year from

[7]In this section, transactions costs and financing constraints (such as minimum down payments) are ignored. The relationship between market rents and user costs which takes such complications into consideration has yet to be fully explored. (However, work has begun: see Martin, 2004; Díaz and Luengo-Prado, 2008; Luengo-Prado *et al.*, 2008.) The standard frictionless theory, which builds upon Jorgenson (1963, 1967), Hall and Jorgenson (1967), and Diewert (1974), implies that rents equal user costs, and is exposited in Gillingham (1980, 1983) and Dougherty and Van Order (1982). For more details and extensive discussion about user costs and other housing measures, see Diewert (2008). Wedges resulting from taxes and transactions costs are considered in Section 5.

[8]Two other user cost measures, which explicitly incorporate these tax preferences, were also investigated in previous versions of this paper, and are reported in the Appendix. Results were unaffected. Section 5 considers user costs facing financial investors; there, taxes are explicitly considered.

[9]See, e.g. Katz (1983, 2004), Diewert (2008), Green and Malpezzi (2003), or Glaeser and Shapiro (2003). These standard approximations ignore a small cross term and are all end-of-period user costs, easily transformed into beginning-of-period user costs by dividing by $(1+i_t)$, or to middle-of-period user costs by dividing by the square root of this term (Katz, 2004). For the present purposes, this choice turns out to be inconsequential.

[10]See Section 2 on the choice of the appropriate interest rate. Both the average current 30-year mortgage rate, and the average one-year T-bill rate, were explored. This choice turns out to be inconsequential.

[11]BEA estimates of the depreciation rate are smooth and remain in the range 0.015–0.016. Census estimates of maintenance and repairs imply modest variation outside of a strong seasonal. The true depreciation rate varies by location and value, since structures depreciate but land does not. Increasing γ has little effect on the conclusions.

now; and E represents the expectation operator. As Diewert (2008) points out, one may interpret $\left(i_t - E\pi_t^h\right)$ as a period-t real interest rate.[12,13] Since house price data are quarterly, this gives rise to a quarterly user cost series.[14]

Rather than using a crude proxy, instead a *forecast* for $E\pi^h$ was constructed, as described below. This choice is crucial, for four reasons. First, expected home price appreciation is extremely volatile; setting this term to a constant is strongly at odds with the data, and its level of volatility is central to this study. Second, $E\pi^h$ and its evolution vary considerably across cities. Third, the properties of $(i - E\pi^h)$ are central to user cost dynamics, yet these properties have not been formally studied; to reiterate, setting $E\pi^h$ to a constant—or even to a long moving average—would be inappropriate for this study, since this choice suppresses the correlation between i and $E\pi^h$. Finally, the post-1996 surge in $E\pi^h$ was well above its 15-year average, implying that the rent/user cost ratio rose dramatically; such movements are the focus of this study. A *single*-year appreciation rate is used since we are considering the *one-year* user cost.[15]

Note that the user cost consists of two terms which are multiplied together: property value P_t^h, and the parenthetical expression ψ_t. Movements in ψ_t are dominated by changes in the gap between interest rates and expected home price appreciation. One would not expect ψ_t to exceed 20 percent, nor to drop to 0 percent; thus, over long periods of time, user costs must track home prices. However, variations in ψ_t are *strongly* amplified, since the term is multiplied by the home price. Put differently, unless interest rates and home price appreciation move almost perfectly in sync with each other—i.e. unless expected home price appreciation is driven only by interest rates—one should expect user costs to be highly volatile. The larger is γ, the less volatile are user costs. Furthermore, as Himmelberg *et al.* (2005) point out, the smaller is ψ, the more sensitive it is to changes in i.

To construct user cost measures for each region, one must forecast four-quarter-ahead home price appreciation, π_t^h, for each city or region. The forecasting approach settled upon here (after a fairly intensive search) combines three forecasts: one based only upon the previous annual appreciation rate, a second based only upon three lags of quarterly changes in home prices, and a third which derives from a four-lag vector autoregression (VAR) in π_t^h and i_i. In each case, only information actually available to agents at time t is used for time t forecasts; coefficient estimates are updated each quarter to reflect the newly-available information.

[12]A common mistake is to base the user cost measure upon an expression such as $(r + \gamma - E\pi^h)$, where r is a *real* interest rate. This is erroneous, as can be understood by comparing two riskless economies which differ only in their rate of inflation. Of course, $(i - E\pi^h) = (i - E\pi) - (E\pi^h - E\pi)$.

[13]Simple user cost measures which proxy $E\pi^h$ with $E\pi$ (i.e. which substitute expected inflation) are often proposed; see, e.g. Cournède (2005) and OECD (2005). Iceland uses such a measure (Guðnason, 2004, 2005). This measure, which corresponds to an assumption of no real capital gains even in the short run, is explored below. As will be evident, this assumption is at odds with the data. Outside of steady state, there is no reason to believe that expected inflation equals expected home price appreciation.

[14]Note that some authors refer to ψ alone as the user cost.

[15]However, longer-horizon forecasts are explored in Section 6.

In particular, in each quarter t, three regressions are run. The first specification is given by

$$\pi_t^h = \alpha_1 + \beta_1 \pi_{t-4}^h + e_{1,t}$$

where $\pi_t^h := \ln p_t^h - \ln p_{t-4}^h$. The concomitant forecast is given by

$$\hat{\pi}_{1,t+4}^h = \hat{\alpha}_1 + \hat{\beta}_1 \pi_t^h.$$

The second specification is given by

$$\pi_t^h = \alpha_2 + \beta_2^1 \vartheta_{t-4}^h + \beta_2^2 \vartheta_{t-5}^h + \beta_2^3 \vartheta_{t-6}^h + e_{2,t}$$

where $\vartheta_t^h := \ln p_t^h - \ln p_{t-1}^h$. The concomitant forecast is given by

$$\hat{\pi}_{2,t+4}^h = \hat{\alpha}_2 + \hat{\beta}_2^1 \vartheta_t^h + \hat{\beta}_2^2 \vartheta_{t-1}^h + \hat{\beta}_2^3 \vartheta_{t-2}^h.$$

The third specification, as noted above, is a bivariate VAR; from this regression, the third inflation forecast, $\hat{\pi}_{3,t+4}^h$, is simply the 4th-step-ahead forecast of π_t^h. The combined forecast takes the simple average of these three forecasts:[16]

$$\hat{\pi}_{t+4}^h = \frac{1}{3}\left(\hat{\pi}_{1,t+4}^h + \hat{\pi}_{2,t+4}^h + \hat{\pi}_{3,t+4}^h\right). \tag{2}$$

For some cities and some time periods, to ensure that the user cost expression (1) remained sensibly bounded below, an alternative "censored" forecast was used. This censored forecast equaled $\hat{\pi}_{t+4}^h$ except when the inequality $\left(i_t + \gamma - \hat{\pi}_{t+4}^h\right) < 0.005$ held, in which case the forecast was set to $\hat{\pi}_t^h = i_t + \gamma - 0.005$.

Other forecasting approaches were examined, but none provided more reasonable forecasts. In Section 6, the sensitivity to the forecasting approach is explored.

Note that, though commonly practiced or suggested, it is inappropriate to smooth these forecasts: if expectations about future house price inflation are volatile, then this should be reflected in *ex ante* user costs. Smoothing forecasts using two-sided filters is especially inappropriate, since this implicitly grants the forecaster with information from the future, and distorts parameter estimates (see Ashley and Verbrugge, forthcoming). The only smoothing which might be justified in this context is the smoothing outlined in Section 2.2. This procedure transforms a marginal user cost series into a temporally "averaged" user cost series, in order to mimic the temporal structure of the BLS rent indexes.

[16]Prior to 1983, only the univariate forecasts are combined. While more complicated forecast combination techniques are available, a common finding in the literature on forecast combination is that equal-weighted forecasts perform quite well and are difficult to beat; see, e.g. Clemen (1989) and Stock and Watson (1999).

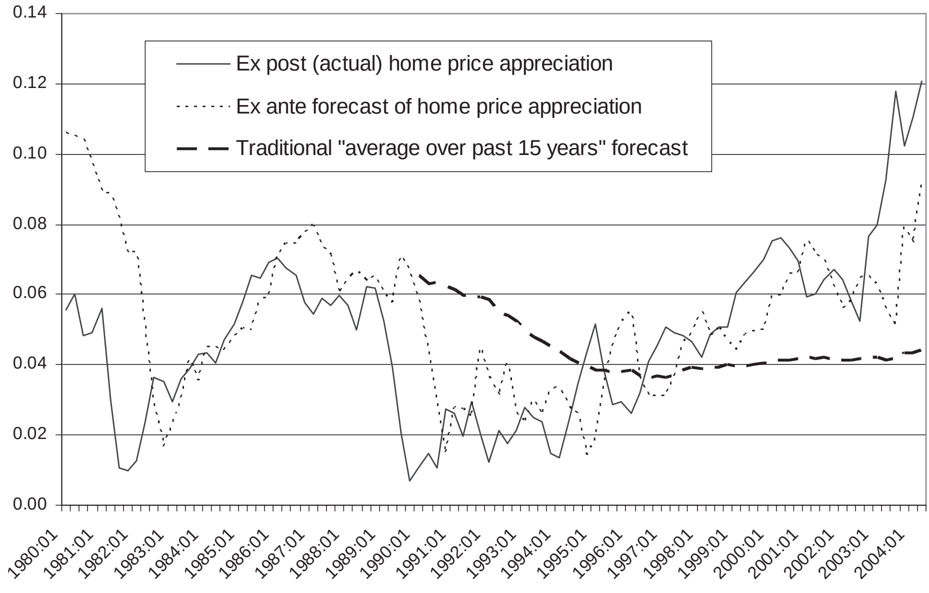

Figure 1. Forecast of Home Price Appreciation (all-U.S.)

4. Results

4.1. *Forecast Adequacy*

Figure 1 displays the actual home price appreciation (using CMHPI), and its forecasted value. The forecast lags the actual home price appreciation, particularly early in the sample. This reflects a surprising amount of persistence of this series, which is well-documented (see, e.g. Case and Shiller, 1989) and evident at all aggregation levels. Home price appreciation has a significant forecastable component, and periods of home price appreciation tend to be followed immediately by periods of similar home price appreciation. In keeping with this, both anecdotal and survey evidence (e.g. Case *et al.*, 2003) suggest that homebuyers' appreciation expectations appear to be simple extrapolations of recent appreciation rates. Figure 1 suggests that the forecast series is not unreasonable, if one bears in mind that 1980 comes on the heels of very high nominal appreciation rates. This reasonable performance contrasts sharply with that of other traditional measures, such as the average appreciation rate over the past 15 years, plotted for 1990 onwards.[17] Note that, contrary to what one might expect, the forecast series is *not* appreciably smoother than the actual home price appreciation series. Unless i comoves perfectly with this series, user costs will be correspondingly volatile.

[17]A one-sided four-quarter moving average, as in Krainer (2003), is a much better approximation. Other measures, such overall CPI inflation, are investigated in Section 6.

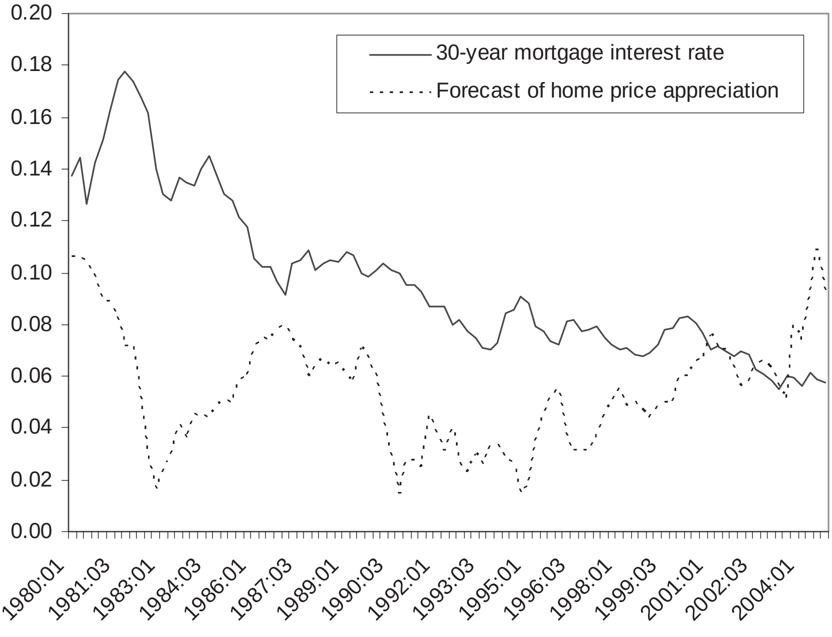

Figure 2. Gap Between Interest Rate and Expected Appreciation

4.2. *Comovement of Interest Rates and Expected Appreciation*

Figure 2 displays the mortgage interest rate along with the aggregate appreciation forecast. It is clear that these series do *not* move perfectly in sync with each other. As Bosworth (in Brookings Institution, 2003) pointed out, liquidity constraints imply that when interest rates fall, the scope and size of approved mortgage loans rise, increasing housing demand—which naturally generates an inverse correlation between price appreciation and interest rate changes. But surprisingly, interest rates are only weakly related to future house price appreciation: a regression of expected (aggregate) home price appreciation on a constant and the mortgage interest rate yielded a coefficient estimate of 0.09, with a standard error of 0.07. Coefficient estimates across regions varied significantly; in the Midwest, this estimate was –0.15, with an estimated standard error of 0.05.[18]

As suggested in Section 3 above, the induced volatility in ψ_t implies that user costs will be highly volatile. This will be further indicated below.

4.3. *Rent/User Cost Divergence*

Figure 3 compares the movement in the two aggregate rental series, versus the movement in aggregate user costs. The user cost series are constructed using (1), using either CMHPI (and CMHPI-based appreciation forecasts) or the Census

[18]Gallin (2006) finds that, for *three*-year-ahead changes, the tax-adjusted interest rate has predictive power for both rent changes and house price changes. Such price responses may reflect the “long and variable lags” which Fratantoni and Schuh (2003) attribute to regional housing dynamics and aggregation.

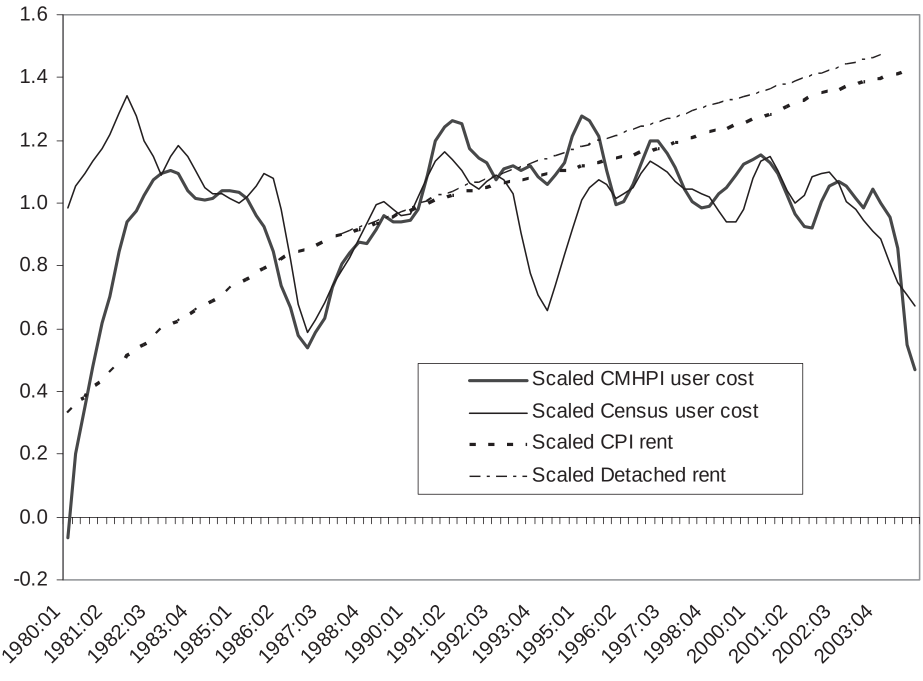

Figure 3. Log User Cost versus Log Rent

index (and Census index-based appreciation forecasts). Each series is logged, and user costs are smoothed as described in Section 2.2 to mimic the implicit smoothing in BLS rent series. Then the log user cost series and the log CPI rent series are shifted by a constant so that each has an average value of 1.0. Finally, the log detached rental series is shifted by a constant so that its value in 1988:1 equals that of the CPI rent series.

This graph provides no evidence in favor of the hypothesis that user costs and rents are equivalent measures of the cost of housing services.[19] Over this period we see a large and fluctuating divergence: rents rise steadily and smoothly, while user costs do not even appear to share this trend, and fall dramatically near the end of the period. The relative price of homeownership thus fell, in keeping with the uptick in homeownership and *contra* the views of financial commentators. Since housing *prices* increased steadily over this period, the deviation between rents and user costs is due to the movements in ψ_t, movements which rents did not respond to; see Verbrugge (2007b). Seemingly small changes in interest rates or expected appreciation can have very large effects on user costs, since these often represent large *percentage* changes in ψ_t.[20] To give a sense of their importance, note that if

[19]One reviewer suggested that *expected* rental revenue—which falls below rents, due to the potential for vacancy—might be the appropriate counterpart to user cost. An expected rent series was thus constructed; it is somewhat more volatile and has a slightly smaller trend, but this only reduced the divergence a little.

[20]Recall that $\Delta \ln(U_t) \equiv \Delta \ln P_t^h + \Delta \ln \psi_t$.

one counterfactually imposed a "pessimistic" expected appreciation of 0 percent in the final period, the scaled CMHPI user cost index would rise to a level 26 percent *above* the scaled rent index.

Similar lengthy divergence is visible, to a greater or lesser extent, in each of the ten cities that were examined, and across the four Census regions; see Figure 4a–d, in which series are treated as in Figure 3. In Figure 4a, it is evident that this divergence is somewhat less pronounced for the Midwestern cities of Chicago, Cleveland and Detroit. Conversely, it is evident in Figures 4b and 4c that large and persistent divergences occurred for seven other major metropolitan areas.[21] Divergences are greater for the Northeast and West than for the South and Midwest. Although rents and user costs appear to share the same long run trend, formal cointegration tests reject this hypothesis; see Verbrugge (2007b).

Over the period 1980–2004, nominal aggregate home prices (measured by the CMHPI) rose by 125 percent[22] (or, as measured by the Census price index, by 92 percent), nominal aggregate CPI rents rose by 100 percent, and the CPI-U-RS rose by 82 percent.

4.4. *Inflation Volatility Comparison*

The implied quarterly *inflation* series are compared next. This comparison is crucial for statistical agencies that produce inflation statistics, since the rental equivalence method takes rent *inflation* in neighboring rental markets—adjusted for costs of utilities and so on—to be an accurate measure of *inflation* in homeowner shelter costs; in other words, the relevant comparison is growth rates.[23] Not only are the respective *means* of these two series different (rent inflation being, on average, well above user cost inflation over this period), their *volatility* is also strikingly different. In particular, the volatility in the inflation rate of smoothed aggregate user costs is over ten times larger than that in aggregate rents—see Figure 5 for a graphical depiction.[24] The divergence would be even greater on a monthly basis. As owner-occupied housing typically possesses a large weight in consumer price index formulas, this level of volatility would essentially render such indexes useless—such volatile movements in housing costs would drive the entire index on a month-to-month basis, likely drowning out the signal in noise. Further evidence underscoring this point is given in Section 6.

[21]Divergences are more pronounced if the one-year T-bill interest rate is used in place of the 30-year mortgage interest rate. Perhaps the more pronounced divergence for coastal cities results from reduced availability of land, and from greater legal restrictions such as zoning laws, both of which limit equilibrating forces. Davis and Heathcote (2007) point out that house price dynamics will differ depending upon land's share of the value; this share is smaller in the Midwest.

[22]Individual cities had different experiences; e.g. prices in Boston rose by 206 percent, but in Houston by only 64 percent.

[23]Accordingly, Díaz and Luengo-Prado's (2008) claim that the use of rental equivalence imparts bias into the CPI is premature. In their model, user costs are systematically lower than rents, but they do not investigate growth-rates.

[24]As noted earlier, similar temporal and volatility divergences were observed between rents and the two CPI-U experimental ex-post user cost indexes, which were constructed in 1979 (with a start date of 1967) and published through 1983. Both of these measures used five-year appreciation rates. See Bureau of Labor Statistics (1980). The large rent-to-price volatility noted by Phillips (1988a, 1988b) is only about one-fifth as large.

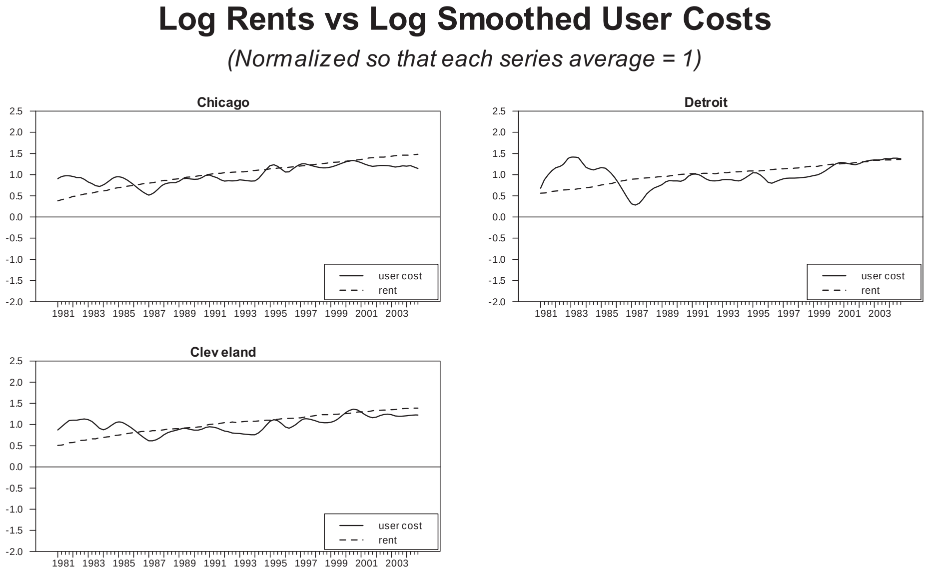

Figure 4a. Cities in the Midwest

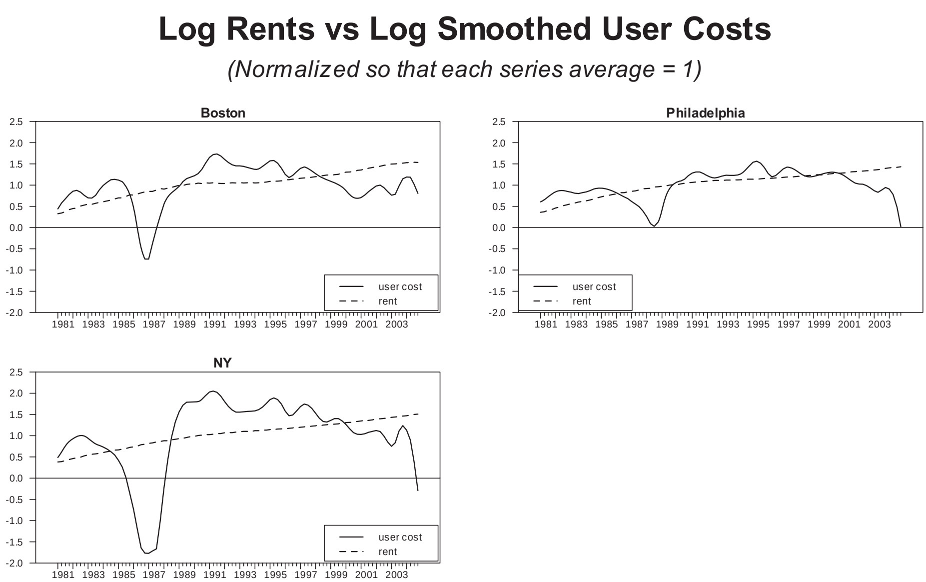

Figure 4b. Cities in the Northeast

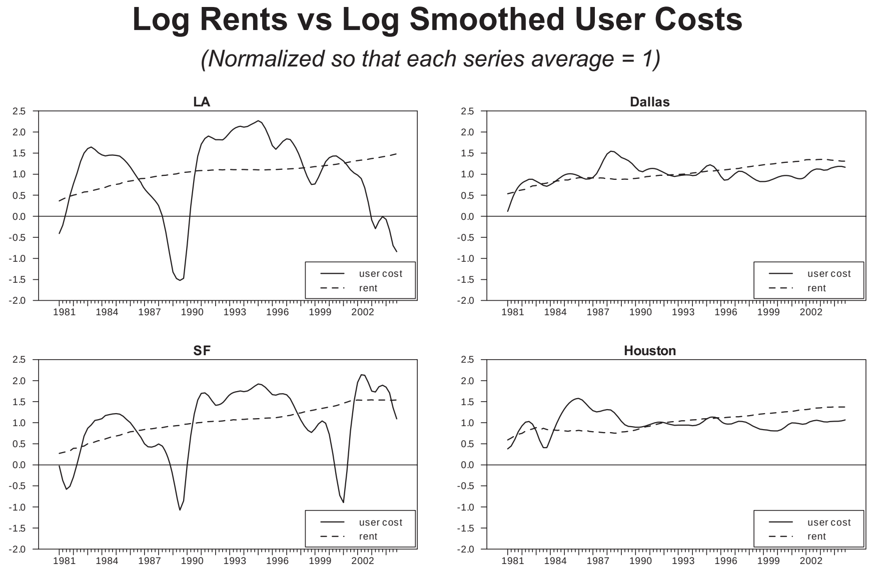

Figure 4c. Cities in California and Texas

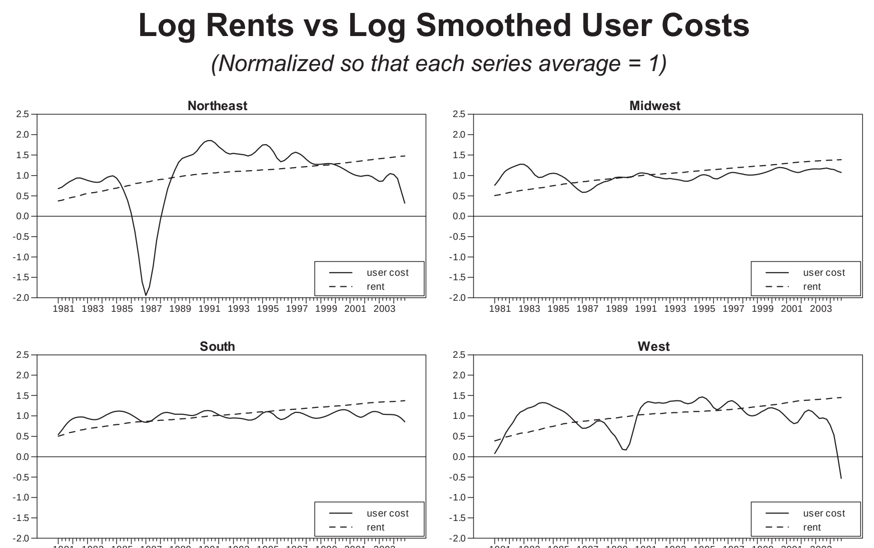

Figure 4d. Census Regions

5. Do Transactions Costs Prevent Expected Arbitrage Gains?

For each of the ten metropolitan areas investigated, there was at least one extended period of time during which user costs and rents diverged significantly. This naturally raises two questions: First, did these divergences imply the existence of unexploited profit opportunities for a prospective landlord? (In other words, for any of the cities, was there a time during which a risk-neutral agent might have

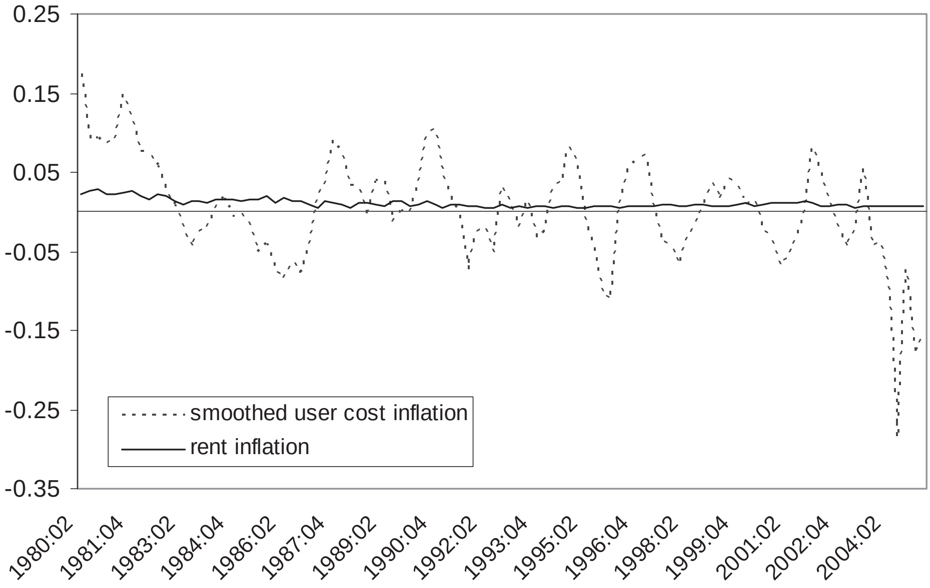

Figure 5. Volatility of User Cost versus Rent

purchased a house, rented it out for a year, and then re-sold the house, to make profits in expectation?[25]) The second question applies to current homeowners: Was there a time during which a homeowner would have been better off to sell her house, rent an identical structure for a year, then repurchase her house? Since over one-quarter of rental housing is single-family (Green and Malpezzi, 2003), and detached housing can readily move between owner and renter markets, the capital specificity which limits adjustment in other markets (Ramey and Shapiro, 2001) should not here hinder a rapid elimination of profit opportunities.

However, large real estate transactions costs stand in the way of exploiting predictable price movements (see, e.g. Case and Shiller, 1989; Quigley, 2002). But were these large enough? Or were there periods of time during which the real estate market was "out of equilibrium," i.e. were there periods of time during which risk-neutral investors were not "arbitraging away" profits?

One requires *level* data relating rents to house prices in order to answer this question. Quarterly Consumer Expenditure Survey (CE) data between 1982 and 2002 were used to obtain cross-sections (over time) of reported rental equivalences, property values, and number of rooms for owner-occupied structures, for five cities. Then, on a semi-annual basis for each city,[26] the CE data were used to

[25]The practice of buying real estate with the intent to quickly re-sell is called "flipping," and is sufficiently common that there exist tutorials of various kinds. It is always possible to posit appreciation expectations which validate any decision *ex post*, but the question being asked here is whether the same is true for appropriately disciplined appreciation expectations.

[26]Households remain in the CES for five quarters, but only the second interview from each household is used. Regressions were conducted annually for each city, with a first-half-year dummy variable. A small number of egregious outliers were removed. See Garner and Verbrugge (2008a) for more details on CE data; that study uses CE data to construct rents and user costs, and finds divergences similar to those found in Section 4.

estimate the log rent level based upon the property value and number of rooms of the structure. These coefficients were used, after applying the log bias adjustment, to form estimated rent *levels* associated with a structure whose property value, and number of rooms, were approximately at the median. Taking these estimated rents as true market prices, after-transactions-costs and after-tax measures of the returns to the sets of transactions noted above were constructed. The following question was then asked: Were profits ever possible in expectation?

Constructing such measures requires a careful accounting of the various tax wedges facing different agents. As above, appreciation forecasts were constructed, and the federal tax rate facing a family of four at twice the median income was used. It was assumed that homeowners would avoid capital gains taxes (since it is unlikely that the capital gains enjoyed by a "median" homeowner would be large enough to be taxed), but that financial investors would not avoid these taxes. It was assumed that transactions costs of 8 percent of the value for selling—primarily real estate commissions, as well as moving costs—and 2 percent of the value for purchasing—to reflect appraisals and other closing costs. Note that selling costs might be higher for homeowners, if they risk the loss of a social network or a school district which is a good fit.

We first consider the situation facing prospective landlords. An investor who purchases a house at t and resells it a year later has end-of-period user costs approximately equaling

$$(3)\qquad P_t^h\left[i_t\left(1-\tau_t^{Fed}\right)+\tau_t^{prop}\left(1-\tau_t^{Fed}\right)+\hat{\gamma}+tc_{buy}+tc_{sell}-\left(1-tc_{sell}-\tau_t^{K+}\right)E\pi_t^h\right]$$

where tc_{buy} refers to the transactions costs faced when purchasing a house, tc_{sell} for the transactions costs faced when selling the house, and τ_t^{K+} refers to the tax rate on capital gains. A financial investor would compare (3), appropriately discounted, to the after-tax discounted rental earnings she would earn on the property. As noted above, the work of Wang *et al.* (2005) implies that the appropriate interest rate to use in the discount factor is the mortgage interest rate. Thus, the user cost (3) is discounted by $\left(1+\left(1-\tau_t^{Fed}\right)i_t\right)$, which will slightly *understate* costs. As for post-tax rent revenues, the 12 monthly rent payments are also crudely discounted, so that the present value of rental earnings is approximated with

$$(4)\qquad \left(1-\tau_t^{Fed}\right)\frac{1}{2}\left(1+\frac{1}{\left(1+\left(1-\tau_t^{Fed}\right)i_t^{T-bill}\right)}\right)rent_t.$$

Here, rental earnings are assumed to be discounted at the one-year T-bill rate. A rational financial investor would purchase a house, rent it out for a year, and resell it if (4) exceeded (3) at time t. Note that (4) *overstates* the expected gains from rents, since the possibility of vacancy is ignored.

We next consider the situation facing homeowners. The present value of user costs facing an itemizing homeowner who intends to stay in her house this year is approximately given by

$$(5) \qquad \left(\frac{1}{\left(1+\left(1-\tau_t^{Fed}\right)i_t^{Tbill}\right)}\right)P_t^h\left(i_t\left(1-\tau_t^{Fed}\right)+\tau_t^{prop}\left(1-\tau_t^{Fed}\right)+\breve{\gamma}-E\pi_t^h\right).$$

This cost-of-staying is compared to the total cost facing an owner who sells her house, rents an identical structure for a year, then repurchases her house. This total cost, discounted, equals

$$(6) \qquad \frac{1}{2}\left(1+\frac{1}{\left(1+\left(1-\tau_t^{Fed}\right)i_t^{Tbill}\right)}\right)rent_t+P_t^h\left[tc_{sell}+\frac{tc_{buy}\left(1+E\pi_t^h\right)}{\left(1+\left(1-\tau_t^{Fed}\right)i_t^{Tbill}\right)}\right].$$

The first term in (5) is the present value of rental costs, and the second comprises the present value of the transactions costs the homeowner would face.

The various user costs and discounted after-tax rental earnings are plotted in Figure 6a–e for the five cities investigated. In these figures, "investor user cost" graphs equation (3), "post-tax rent earning" graphs (4), "owner user cost" graphs (5), and "cost to switch to renter for 1 year" graphs (6). Clearly, transactions costs form a huge wedge. Regarding investors, (3) always exceeds (4) by a large margin: for each city and over the entire period, costs were always *well* above benefits. In other words, there is no evidence of unexploited expected profits for prospective landlords. Regarding homeowners, (5) always exceeds (6), with one exception: for Los Angeles, there was a single year, 1994, during which a homeowner should have sold her house, rented for a year, and repurchased her house. For every other time period, and for the entire period for the other four cities, a homeowner was always better off remaining in his house.

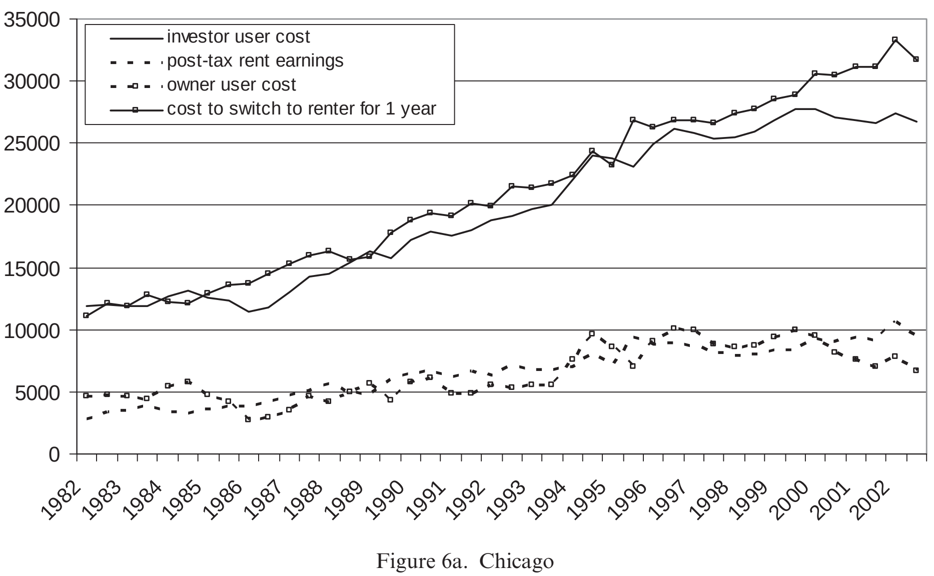

Figure 6a. Chicago

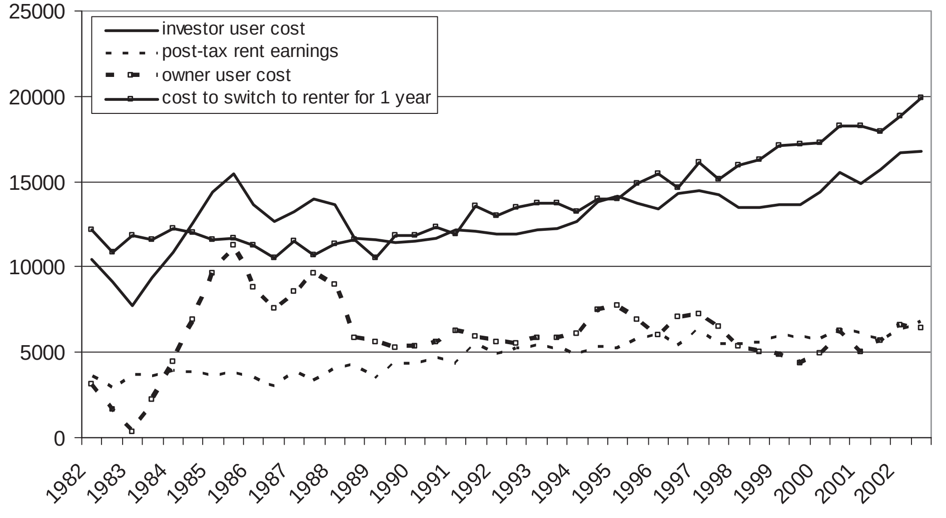

Figure 6b. Houston

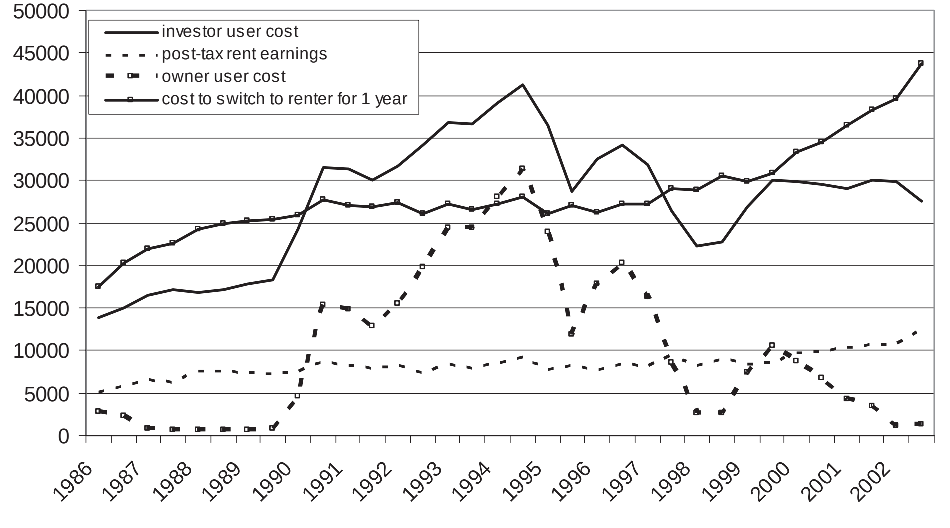

Figure 6c. Los Angeles

Thus, there was no evidence of unexploited profits, either for prospective landlords, or (with one exception) for current homeowners. This conclusion is only underscored when one bears in mind that, as noted in Case and Shiller (1989), there is substantial idiosyncratic variation in individual house prices. This makes these prices much less predictable than citywide indexes, and thus makes the hypothetical transaction sequences studied here much more risky. Arbitrage forces are evidently bound to be weak over one-year horizons.

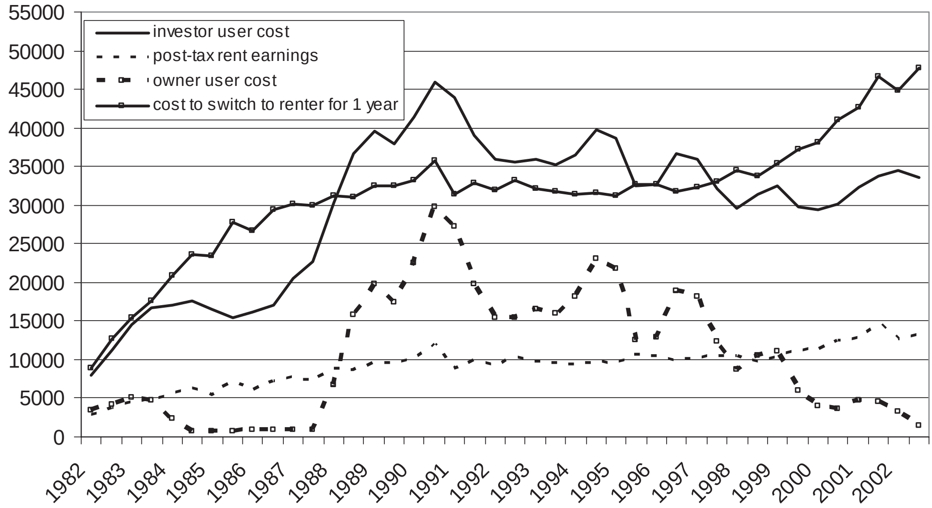

Figure 6d. New York City

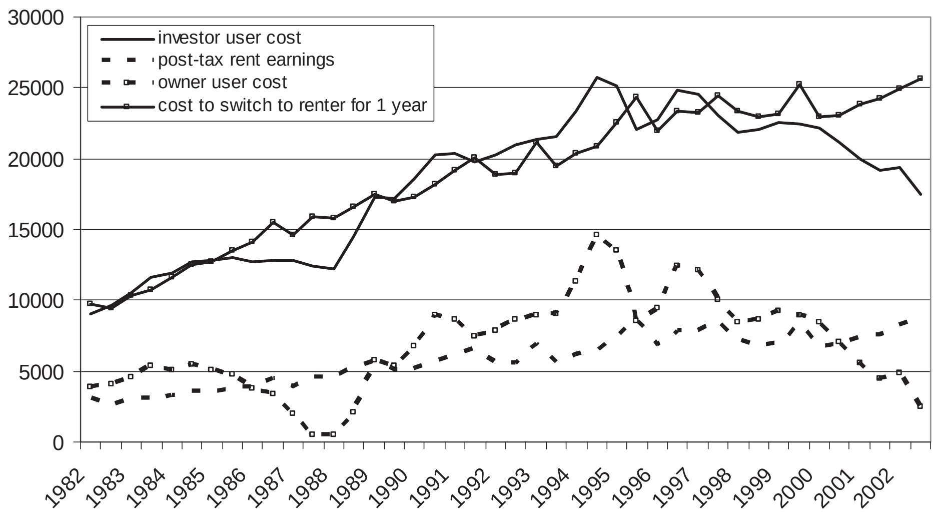

Figure 6e. Philadelphia

6. Other Appreciation Measures: A Hint at a Resolution

The divergence between user costs and rents does not appear to hinge crucially upon the appreciation measure used, as long as the measure does not depart markedly from actual appreciation. Figure 7 plots user costs computed using three different "forecasting" models: the preferred forecasting method utilized above, perfect foresight (which amounts to computing *ex post* user costs), and fitted values from the following regression specification, estimated over the entire period 1980:1–2004:4:

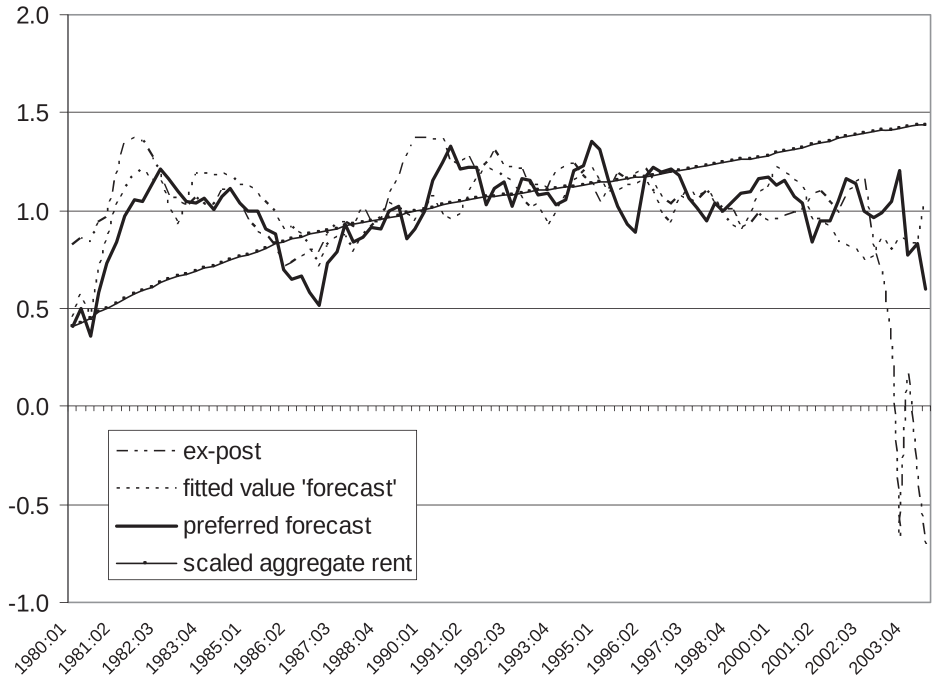

Figure 7. Sensitivity to Forecast Model

(7) $$\pi_t^h = \alpha_1 + \beta_1 \pi_{t-4}^h + \beta_2 i_t + e_{1,t}.$$

Each series runs from 1980:1 to 2004:2. As can be seen, while using alternative "forecasts" does impact the user cost series appreciably, it does not alter the basic conclusions regarding the divergence of rent and user cost.

However, other appreciation measures might be considered. Indeed, one can *impose* equality—i.e., no divergence—simply by constructing the theoretically-implied appreciation, i.e. by setting rents equal to *ex ante* user costs and solving this equation for expected appreciation.[27] The divergence of "implied appreciation" from the forecast used might provide clues about the divergence between rents and the user cost measure being studied.

Furthermore, *longer-horizon* expected appreciation measures have been proposed in user cost approximations (e.g. Diewert, 2008)—and Iceland's shelter price index could be interpreted this way.[28] The standard theory applies to a frictionless

[27]Jonathan Heathcote encouraged me to complete my pursuit of this question, and Mark Bils encouraged me to present the results. Subsequently, two anonymous referees prompted a more thorough investigation of various appreciation measures, and their comments greatly enhanced the analysis and discussion in this section.

[28]Iceland's index is a simple user cost, with expected inflation replacing expected house price appreciation (see Guðnason 2004, 2005). This corresponds to an assumption of no real capital gains in housing, which is perhaps not so unreasonable when considering very long horizons (see, e.g. Eichholtz, 1997). Poterba (1992) makes this assumption, and it was used by the OECD in its recent user cost estimates (OECD, 2005).

economy, in which continuous asset rebalancing occurs. But long-horizon advocates correctly point out that, owing to large transactions costs—and the wedges highlighted in the previous section—the expected tenure for homeowners is much longer than one year; indeed, it is actually closer to a decade. Thus, the forecasting horizon of the typical owner is far longer than one year. The expected tenure for renters, while shorter, is still about four years. This suggests that the margin of indifference between homeownership and renting has an implied horizon longer than the one-year horizon of a rental contract.[29] On this basis, one could argue on behalf of a longer horizon forecast in an otherwise standard user cost expression. A second line of argument in favor of long-horizon forecasts derives from postulated landlord behavior: landlords might use long-run appreciation measures in their own cost calculations, and form rents on that basis.[30] However, this explanation requires a theoretical justification for rent inflation stickiness. One such justification is sketched out in Diewert (2008): landlords, reflecting the preferences of tenants, may attempt to minimize volatility in rent changes.[31] A desire to avoid rent inflation volatility leads directly to the use of long-run appreciation rates in landlord user cost calculations.

The argument for placing long-horizon forecasts in standard user cost formulas is not airtight, since transactions costs fundamentally alter the dynamic decision problem facing both households and landlords, leading to complex and idiosyncratic user cost expressions that appear to pose difficult measurement problems; see Martin (2004), Díaz and Luengo-Prado (2008), and Luengo-Prado *et al.* (2008). Still, longer-horizon forecasts must enter such user cost expressions in *some* manner, so it is of interest to see how the rent-user cost comparison fares when they enter in the simplest manner.

Thus, three additional appreciation measures were investigated. Two were two long-horizon forecasts, and the last was a forecast of overall inflation. The first long-horizon forecast was particularly simple: a ten-year moving average of house price appreciation.[32] The second was a four-year house price appreciation forecast. Both the four-year forecast and the inflation forecast were constructed using the methods outlined in Section 3.[33] These measures are depicted in Figure 8, alongside the preferred annual forecast and the implied appreciation measure.

[29]The question of the appropriate horizon for comparing renting to homeownership is discussed in Sinai and Souleles (2005). I am indebted to my referees for references and for phrasing in this section.

[30]This suggestion is due to Tim Erickson (private communication).

[31]Rent stickiness is particularly great for continuing tenants; see Genesove (2003) and Gordon and van Goethem (2008). Rent control, which surprisingly impacts aggregate rent inflation, may provide a partial explanation; see Poole and Verbrugge (2007). Diewert and Nakamura (2008) also suggest that the *fear* of rent control imposition acts as a potential explanation of rent inflation stickiness.

[32]As CMHPI data are only available from 1975 onwards, the MA(10) series before 1985 was imputed using the growth rate of the National Association of Realtors median house price series.

[33]The four-year forecast consists of a five-year moving average prior to 1987:2; subsequently, this MA(5) model receives a weight of 0.5, and the remaining weight is equally split between a real-appreciation forecast (which was converted to a nominal basis by adding a two-year moving average of lagged inflation), and a direct forecast of nominal four-year appreciation based upon four-year-appreciation and inflation, each lagged four years. The inflation forecast is computed exactly analogously to the annual appreciation forecasts.

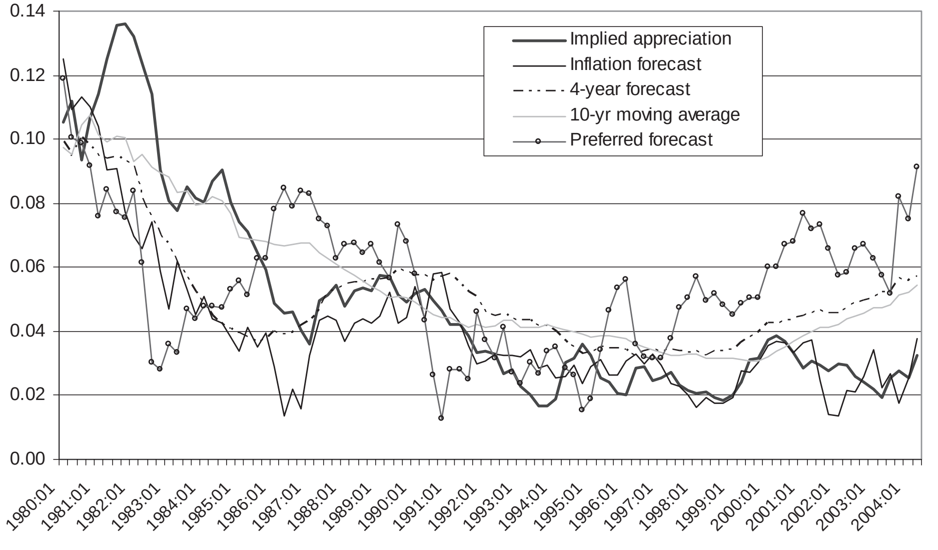

Figure 8. Alternative Appreciation Measures Compared

There are several notable features. First, the inflation forecast is broadly similar to the implied appreciation measure both initially and after 1987. Second, the four-year forecast and the ten-year moving average are both fairly smooth. Third, the four-year forecast—reflecting predictable real appreciation in housing—lies persistently above the inflation forecast (with brief exceptions) after 1987, with a marked divergence opening up after 2000. This corresponds to the period of time during which the price/rent ratio in the U.S. (and in many other countries) was rising; see Girouard *et al.* (2006) and Davis *et al.* (2008).[34] Fourth, the ten-year moving average behaves as one would expect, and sluggishly reflects the predictable appreciation. Fifth, all four alternative appreciation measures—implied appreciation, the two long-run forecasts, and expected inflation—are terrible annual forecasts, diverging from the preferred forecast significantly and persistently.

These alternative appreciation measures are theoretically questionable proxies for the $E\pi^h$ term in a simple annual user cost. But if the goal is to approximate low-frequency movements in rents, each—to a varying degree—represents an improvement.[35] Figure 9 plots the implied user cost series using these measures. All series are scaled as in Figure 3, and user costs are smoothed as in Section 2.2.

These alternative user costs measures are far less volatile and evolve much more closely to rent than do the standard measures in Figure 3; the sum of squared

[34]Heston and Nakamura (2008) emphasize the decline in the rent/price ratio as price rises. Changes in the rent/price ratio, either cross-sectionally or over time, likely translate into changes in the rent/user cost ratio.

[35]Johannessen (2004) attempted something similar using data from Norway, and found much larger divergence.

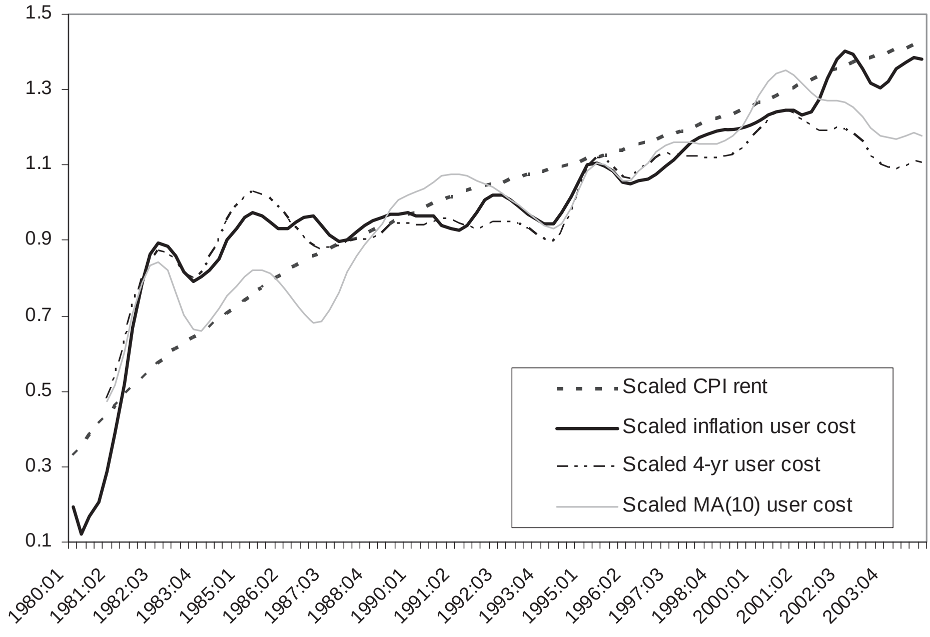

Figure 9. User Costs with Alternative Appreciation Measures

deviations from rent are approximately 1.2 for the inflation user cost, 1.3 for the MA(10) user cost, 2.6 for the four-year user cost, versus 10.8 for the annual user cost.

Still, there are significant and persistent divergences, which derive from deviations between the respective appreciation measures and implied appreciation. The user cost series remain disappointingly volatile: for example, the implied volatility of housing services inflation in the inflation user cost series, after smoothing as in Section 2.2, is still roughly five times larger than that implied by the aggregate rent series.[36] This can be quantitatively important. To illustrate this, note that the four-year user cost and the MA(10) user cost imply that inflation in homeowner costs was about –17 percent between 2000:4 and 2003:4, reflecting predictable real appreciation. In contrast, CPI rent inflation was +11 percent. In the U.S., the overall CPI weight for owner-occupied housing is roughly 0.24; but even given Canada's or Sweden's weight of 0.16, moving from the rent measure to either of these alternative measure would have resulted in moving from an overall CPI inflation contribution of +0.6 percent to a contribution of –0.9 percent, *three years in a row*. In each smoothed user cost series, increases or declines of 5 percent in a *single quarter* occur in almost 10 percent of the periods; changes of this magnitude would probably swamp all other influences in the overall CPI.

[36]This is also true if one constructs an alternative inflation user cost by replacing the forecast of inflation with a two-year moving average of inflation, then smoothes this as in Section 2.2. Eiglsperger (2006) also calls attention to high volatility in the OECD (2005) estimates. Smooth appreciation forecasts evidently do not necessarily imply smooth user costs. Iceland practices interest-rate smoothing; see Guðnason and Jónsdóttir (2008).

Thus, while long-horizon forecasts do lead to better-behaved user cost measures, there remain both practical and theoretical reasons to prefer a rent-based approach to homeowner cost measurement, when this is feasible. When it is not, this research suggests that a very long horizon appreciation forecast (such as a long moving average), or an inflation forecast, should be used in the user cost formula. But this work also suggests that the resulting index may still be too volatile. The conclusion offers some practical suggestions for statistical agencies.

7. Conclusions

What is the per-period cost of owning a durable good? For long-lived durable goods, there are two commonly-proposed measures: rents, and user costs. In the simple frictionless theory, these measures are equivalent. Yet it is demonstrated here that, in the U.S. housing data, these measures diverge markedly, over extended periods of time.

However, despite this divergence, the large costs associated with real estate transactions would have prevented risk-neutral agents from making profits in expectation. Arbitrage is evidently rather slow.

This is an interesting and important puzzle, and further research is needed to understand what drives rents, and why they diverge from user costs. Verbrugge (2007b) finds that the response of rents to changes in user costs is economically small. One could point to several possible reasons. Landlords might set rents based upon long-run user cost measures, as discussed in Section 6—although rents are still smoother than smoothed long-run user costs. There are pricing frictions in rental markets, perhaps resulting from asymmetric information between landlords and tenants and/or implicit insurance to tenants; but the theory has yet to be fully developed. Construction is inherently slow, and hinges upon the availability of suitable land, permits, and so on. It is costly to convert structures between owned and rental properties. Information frictions related to search and to distinguishing permanent from transitory movements could also slow down adjustment. Smith and Smith (2006) emphasize the weakness of the mechanisms which would correct inefficiency in the housing market. One might conjecture that the non-specificity of detached housing would allow these structures to be moved rather readily between the owner and renter markets, to take advantage of transitory profit opportunities. But as noted in Section 5, the sizable real estate transactions costs have a first-order impact on adjustment.

Many potential explanations of divergence can be ruled out. One might argue that some of the divergence is attributable to errors in construction of various indexes. Along these lines, it would be of interest to compare the results here with those obtained using hedonic regression models of both rents and house prices. Work in progress (with Joshua Gallin) is investigating a hedonic rent index constructed from CPI microdata. But other work which finds similar results based upon entirely different data sources—particularly Garner and Verbrugge (2008a)—suggests that index construction errors cannot account for this divergence. It is possible that inappropriate aggregation, even at the level of a city, might mask a much tighter relationship at the micro level. Poole and Verbrugge (2007) find that rent inflation can vary dramatically within a single city, and

Hwang and Quigley (2006) emphasize the micro-spatial dimension in home prices.[37] Garner and Verbrugge (2008b) explore this possibility using CE micro-data, which include both prices and rents for each structure; their results suggest that aggregation is not the culprit—though any such study will have to use aggregated expected appreciation measures of one form or another.

A different measurement detail is not quite so easy to dismiss. The above analysis hinges upon an assumption that expectations are formed via a forecasting approach. While there is abundant evidence in favor of this hypothesis, and while home price appreciation is extremely persistent, one might nonetheless argue that rational agents admit the possibility of rational bubbles, and hence—during periods in which bubbles are suspected—would reduce their appreciation forecast via attaching positive probability to a bubble burst. This point was made more generally by Matthew Shapiro,[38] who noted that determining the *correct* measure of expected appreciation would be challenging. The correct measure derives not from a statistical forecasting exercise, but rather from applying the correct model to the data. In other words, "fundamentalist" forecasts are required, i.e. forecasts of home price appreciation should hinge upon the true underlying structural factors . . . as difficult as these may be to determine.[39] This fundamentalist model will likely distinguish between land price and structure price dynamics. But until the profession agrees upon the correct model of house price dynamics—which does not appear likely in the near future—forecasting approaches are probably the best one can do.

What about a more sophisticated user cost measure? This paper demonstrates that if the standard frictionless model applies, and a forecasting approach to expectations is approximately correct, then either rents or house price dynamics make no sense. However, there are important frictions in real estate markets, and these alter user costs. Would the user-cost measures derived from more realistic (current-generation) models featuring adjustment costs have similar dynamics? Presumably such user costs will differ from the frictionless user costs outlined in Section 3 in that, in place of the expected appreciation term, there will be a term reflecting the *average probability of adjustment and realization of the after-costs capital gain*. However, many of the same forces—home prices, interest rates, and expected home price appreciation—will continue to be important determinants of user cost dynamics. Home price appreciation is extremely persistent, and mortgage interest rates are not that tightly related to this appreciation. A substantial reduction in volatility of user costs would appear to require substantial negative correlation between the probability of moving and the gap between interest rates and expected appreciation. This does not seem plausible. For example, consider a period of sluggish interest rates and a sudden increase in home price appreciation, such as occurred during 2003. Standard user cost measures fall dramatically during such episodes; only an equally large *decrease* in the probability of moving

[37]In this regard, an interesting extension of this paper would be to apply these methods to the Korean data set exploited in Hwang *et al.* (2005).

[38]Private communication, December 2005.

[39]Martin (2006) provides a structural model of house price dynamics, with some surprising implications. Glaeser and Gyourko (2007) also provide a dynamic rational expectations model of house price dynamics.

would keep a more realistic user cost measure from falling dramatically. On the other hand, user costs are idiosyncratic, so compositional effects brought about by a shifting margin might move in the opposite direction. This underscores the need for continued research on user costs.

Finally, the findings of this study suggest that statistical agencies responsible for compiling price statistics should use rental equivalence as their measure of homeowner user costs, when this is feasible. Residential real estate is typically a composite good: the structure, a depreciating capital good which delivers a flow of consumption services over a long period of time; and land, an appreciating asset. But financial assets are considered out-of-scope for most price indexes—consumer price indexes seek to track inflation in *current* consumption costs—which suggests that the financial aspects of homeownership are also out-of-scope. A focus on pricing the flow of services, but separating out the financial aspects, leads rather immediately to the idea of estimating the value of those services using the prices of market analogues. Reinforcing this conclusion is the perplexing nature of asset price dynamics. To the extent that these dynamics are poorly understood by current theory, it is difficult to convincingly defend the use of one appreciation imputation over against another. Furthermore, standard measures of *ex ante* user costs are highly volatile, even if they are smoothed to mimic the implicit smoothing in the CPI rent series; this volatility alone probably renders them unsuitable in a price index. Longer horizon forecasts ameliorate this problem, but do not completely resolve it.

Of course, in some countries the rental equivalence method may not be practicable. To price the service flow from an owned dwelling, then, a user cost approach is necessary. In that case, this research suggests using a very long horizon appreciation forecast (such as a long moving average), or an inflation forecast, in the user cost formula. The resulting estimates are still likely to be excessively volatile, so a statistical agency might have to resort to further alterations of some sort. Two possibilities are using longer moving averages of marginal user costs (perhaps justified by appealing to the high level of price and rent stickiness experienced in Europe),[40] or smoothing interest rates, as is the practice of Iceland (see Guðnason and Jónsdóttir, 2008).

Appendix

The Appendix is available on the BLS website: see https://www.bls.gov/ore/orecatlg.htm.

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Randal Verbrugge
Division of Price and Index Number Research
Bureau of Labor Statistics
2 Massachusetts Ave NE
Washington, DC 20212
Email: verbrugge.randal@bls.gov

A.1 House Prices

a) The OFHEO and CMHPI price indexes

To compute homeowner user costs, one must use a measure of home prices. The most widely-used US home price data series are the OFHEO house price indexes, and the Freddie Mac CMHPIs. Each of these quarterly indexes uses a common data set (described below) to construct an index using a weighted repeat sales method (see Case and Shiller, 1987, 1989); the OFHEO index construction is described in Calhoun (1996), and the CMHPI construction is described in Stephens et al. (1995). These indexes behave similarly. Each is available at several levels of disaggregation.

The common data source consists of repeat mortgage transactions – both purchases and refinancings – for single family homes in a database of loans purchased or securitized by Freddie Mac and Fannie Mae. These comprise approximately 60% of all loan originations. However, the housing stock of the US is not completely represented in this data; in particular, neither the lower end nor the upper end of the market is fully represented. The lower end is not fully represented because: a), lower-valued properties are not as frequently sold (e.g., some drop out of the housing stock); b), such low-value transactions are more easily accomplished without mortgage financing; and c), such transactions are more likely to make use of government-insured loans. The upper end is not fully represented both because such transactions are less likely to use conventional mortgage loans, and because the size of the associated mortgages can lie above the conforming loan limits (loan amount restrictions) in the agencies.[1]

Repeat-sales methodologies limit the extent to which changes in the composition of the sample can influence the estimated index – since only price *changes* on the *same property* are used in estimating the index. But there are four potential sources of bias.

First, as Gallin (2003, 2004) and McCarthy and Peach (2004) point out, these repeat-sales indexes are not constant-quality price measures, in that these methods do not control for changes in the physical characteristics of the home, such as improvements, additions, or deterioration. McCarthy and Peach (2004) note that inflation in the repeat sales indexes has roughly matched the inflation of the median new home built; since the quality of new homes sold has clearly increased over time, they argue that the repeat sales indexes are hopelessly contaminated by unmeasured quality change. (Baker (2004) conversely notes that, between 1991 and 2002, spending on improvements did not increase as a percentage of the value of the housing stock; his take on the evidence is that such spending could not account for more than 1% of home price appreciation. Gallin (2004) also notes that BEA estimates on improvements and depreciation suggest that these measures are roughly equal.[2]) Second, refinancings comprise more than 80% of the data, which is problematic since: a), appraisers might have an upward bias; and b), low appraisals are less likely than high appraisals to result in loan closure. Empirical evidence on appraisal bias is reviewed in Leventis (2006); however, as this author points out, an upward bias in appraisals does not necessarily bias the index movement. The argument is straightforward: to enter into the repeat-sales data, a given residence must appear twice, either as an appraisal or as a sale. There are four possible transactions pairs: (sale, sale), (sale, appraisal), (appraisal, sale), (appraisal, appraisal). Upward bias in appraisals would only lead to error for pairs of the second and third types: they would lead to an erroneously high value increase for pairs of the second type, but lead to an erroneously *low* value increase for pairs of the third type. Still, there may be selection bias: Case, Pollakowski and Wachter (1997) note that homes which are resold more often tend to

[1] Greenlees (1982ab) studied the implications of truncation in FHA data.
[2] Neither depreciation nor improvements is likely to be estimated completely accurately. The relevant depreciation rate for the present study would be an admixture of (significant) structural depreciation and (negligible) land depreciation; BEA improvements data do not measure the implicit labor cost of do-it-yourself home improvements.

have greater price appreciation; and using 1971-1995 Miami metropolitan microdata, Gatzlaff and Haurin (1997) find that the repeat-sales methodology created an upward bias of 0.33 percentage points a year. Finally, the variance assumptions underlying the repeat-sales methodology might lead to bias: Dreiman and Pennington-Cross (2004) demonstrate that these assumptions violate the data and create an upward bias of between 0.1 and 0.6 percentage points a year. (Haurin, Hendershott and Kim (1991) also find the repeat-sales indexes to be upward-biased.) To take account of these potential biases, following the conservative adjustments of Gallin (2004), I reduce the growth rate of the repeat-sales-based indexes by 0.3 percentage points a year. However, this choice is not consequential for inference.

Unlike CPI rent indexes, OFHEO/CMHPI home price indexes are simple averages, i.e. they are not expenditure-weighted.

b) The Census Bureau's "constant quality" housing price index

An alternative measure of *aggregate* house price inflation is the Census new house price index. This is an index which uses hedonic regression techniques to estimate a price index for constant-quality *newly-constructed* homes over time; independent variables include numbers of bedrooms and bathrooms, air conditioning, and so on. Coefficient estimates are allowed to vary by Census region.

Using this index to construct a measure of user costs might be problematic for three reasons. First, such an index cannot be fully representative, since new homes comprise only a small fraction of the housing stock. Second, Census hedonic methods do not account for differences in building materials. Third, the price of each house includes the value of the land; since the land used for new construction might well vary in value over time (e.g., as building occurs further and further away from the central city, or as lot sizes change), the price index is shifted by an unknown amount. (Put differently, the hedonic regressions used to estimate the index do not and cannot control for differences in the "quality of land.") Davis and Heathcote (2005) demonstrate that land's share of the house price is quite large. Baker (2004), among others, argues that there is a significant downward bias, i.e. that the land bundled with recently-constructed new homes is less desirable than that bundled with housing built in earlier periods. Conversely, McCarthy and Peach (2004) conversely argue that "fill-in development" has grown in the last decade, and that land prices are influenced by many factors, such as crime, local government and school quality, and so on.

A.2 Rent-of-Shelter Indexes

a) Comparability of official CPI indexes to house price indexes

The CPI shelter indexes are described in some detail in Ptacek and Baskin (1996) and in Poole, Ptacek and Verbrugge (2005). They are not perfectly comparable to the home price indexes described above. Both CPI shelter indexes are constructed based upon data from many types of rental properties, not just the more limited set of structures found in the data underlying the home price indexes. Furthermore, the CPI rent data include the rents of a modest number of rent-controlled apartments. In addition, CPI rent indexes do not treat utilities symmetrically with owner-occupied housing. (The CPI's OER indexes control for latter two problematic issues, but are shorter time series. For more details on the theory and practice of utilities adjustment for OER series, see Verbrugge 2007a.) Finally, the CPI adjusts for quality changes in the dwellings whose rents are being tracked.

b) Detached shelter index

To address these data comparability issues (and to develop a rent index that is more directly comparable to the repeat-sales house price indexes), I constructed a monthly rent index using a post-1987 CPI rent microdata set comprised of rents only of single detached dwellings. AHS data indicates that well over half of the entire US housing stock is comprised of this type of structure, and over one-quarter of rental housing is single-family (Green and Malpezzi 2003). In theory, then, the dwellings whose rents are tracked by this index should be similar to the dwellings whose prices are tracked by the repeat-sales price indexes.

To explain how the detached rent index was constructed, we must first recall some aspects of BLS rent collection. Periodically, the BLS selects a new sample for rent-collection in a particular city, and divides this sample into six subsamples ($i = 1,...,6$) or "panels," each panel corresponding to one of the first six months of the year. Rent data on each housing unit in a panel is collected every six months; thus, for example, rent data for a unit in the January panel is collected every January and July. A unit continues in the panel until an entirely new sample is drawn, or until the unit in question drops out of the sample. Only six-month rent *changes* are used to construct the CPI rent index.

Since panel *i* units never appear in panel *j*, it is impossible to construct a single rent index using methods identical to those used in constructing repeat-sales indexes. (Put differently, there is no information linking the level of the index in February to that in January; there is only information linking the level of the index in February to that in the previous August.) In principle, however, similar assumptions and methodology could be used to construct six separate rent indexes – one corresponding to each sample – which should all share the common national market rent trend over the period.

However, to date, attempts to adapt this method to the CPI rent data have proved unsatisfactory. Instead, I constructed six detached rent index series using a related method. It is fairly standard practice in the housing literature to characterize individual house prices as arising from a stochastic process in which the average rate of change is represented by a market index, and the dispersion and volatility of individual house prices around this market index are modeled as log-normal diffusion processes. (Indeed, this assumption forms the basis of the repeat-sales method.) The corresponding assumption for rents would be that the log of the rent of an individual home *i* at time *t* equals a market rent B_t plus an idiosyncratic Gaussian random walk $H_{i,t}$ plus an idiosyncratic white noise component $N_{i,t}$, as in

$$\ln\left(rent_{it}\right) = B_t + H_{i,t} + N_{i,t}$$

This implies that

$$\begin{aligned}\ln\left(rent_{i,t+6}\right) - \ln\left(rent_{i,t}\right) &= B_{t+6} - B_t + H_{i,t+6} - H_{i,t} + N_{i,t+6} - N_{i,t} \\ &= B_{t+6} - B_t + v_{i,t+6}\end{aligned}$$

where $v_{i,t}$ is white noise.

Under this assumption, the national average of 6-month rent changes for sample *j* should be a reasonable estimate of the change in the national market rent over that period. (The monthly sample size is on the order of 1000 observations.) Thus, in constructing the six detached-rent indexes, the average 6-month change in panel *j* was used to move index *j* forward every six months. (As in the repeat sales method, this limits the extent to which changes in the composition of the sample can influence the estimated index.)

The six series were then merged into a single series by selecting the initial index number for each series to minimize the sum of squared changes in the resulting combined series. Then the aging-bias adjustment, and an approximate adjustment for vacancy bias (from Crone, Nakamura and Voith (2000), were applied. After transforming this detached-home monthly index into the quarterly frequency, its appearance is broadly similar to the CPI rent index.

c) Adjustments to historical series

The BLS has made numerous improvements to its shelter indexes over the past quarter-century. While these improvements make the present and future CPI more accurate, *historical* price index series are not adjusted to consistently reflect all of these improvements. For example, two quantitatively important improvements were introduced in the 1980s. In 1983, the BLS removed a bias related to the treatment of vacant rental units; and in 1988, the BLS began to adjust for the effects of age and deterioration in rental units. Also, in constructing its OER indexes between 1987 and 1995, the BLS employed a Sauerbeck formula, which introduced a "chain-drift" bias into these indexes. Armknecht, Moulton, and Stewart (1995) estimate that the bias was about 0.5% per year.

However, the findings in this paper are basically unchanged whether one applies the adjustments suggested in Crone, Nakamura and Voith (2000), or the more extensive adjustments suggested in Crone, Nakamura and Voith (2006), which are given below.

CPI Rent Indexes		CPI OER Indexes
* -84:	$1.19\pi + .36\%$	83-84: $1.19\pi+.36\%$
*85-87:	$1.018\pi + .36\%$	85-86: $1.018\pi+.36\%$
*88-93:	1.018π	87: $1.018\pi+.36\%+.5\%$
		88-93: $1.018\pi+.5\%$
		94-95: $\pi+.5\%$

A.3 Tax-Corrected User Costs

Two alternative user cost measures are constructed, based the user cost formula below, which explicitly takes account of the preferential tax treatment given to homeowners (and assumes that the homeowner is itemizing):

$$\begin{aligned} usercost_t &= P_t^h\left(i_t\left(1-\tau_t^{Fed}\right)+\tau_t^{prop}\left(1-\tau_t^{Fed}\right)+\breve{\gamma}-E\pi_t^h\right) \\ &:= P_t^h\psi_t^\tau \end{aligned} \tag{6}$$

Here, τ_t^{prop} is the property tax rate, τ_t^{Fed} is the marginal federal income tax rate, and $\breve{\gamma}$ now no longer includes the property tax rate.

The two measures use different measures of taxes. In the first of these, I assume – following Glaeser and Shapiro (2002) – that the federal income tax rate is fixed at 0.25, and that the property tax is 2%. I assume that the sum of depreciation, maintenance and insurance costs, $\breve{\gamma}$, equals 5% (results are insensitive to these choices). The second user cost measure computed using expression (6) is identical to this one, except that it uses the actual marginal federal income tax rate facing a family of four with twice the median income.[3] The key results are insensitive to these choices, as will be clear below. For the present purpose, I ignore state taxes; these would change the dynamics of the user cost, but would not alter the basic findings of this paper.

Figure 10 presents the estimates of the three different aggregate user cost measures, using the aggregate CMHPI as the measure of home prices. Recall that the first user cost measure ignores deductibility, the second assumes fixed tax rates over the period, and the third assumes that the relevant federal tax rate is the marginal rate facing a family of four with twice the median income. They tell the same story. After 1980, following a period of very low user costs, user costs rose rapidly, driven – as is evident in Figure 2 above – by rising interest rates and falling expected appreciation rates. The rise in user cost between 1987 and 1990 resulted primarily from a decline in expected home price appreciation, not the direct tax-deductibility impact of the reduction in marginal tax rates resulting from the 1986 tax reform act. (Nominal interest rates rose a bit between 1987 and 1988, but then resumed their steady downward trend. By 1990, interest rates were about equal to their value in late 1986.) Since 1981, despite rising home prices, user costs – while volatile – have displayed no upward trend at all: the steady upward trend in home prices has been effectively "cancelled out" by a reduction (over this period) in the gap between the mortgage interest rate and the expected home price appreciation. (Indeed, over the recent period, expected appreciation in housing prices has caused user costs to plummet.) In contrast, rental prices *have* risen steadily over this period. Thus, the relative price of homeownership to renting has fallen substantially over the period. The decline in

[3] These tax rates were constructed, and graciously shared, by Elaine Maag; see Maag (2003).

the relative price of homeownership is consistent with the concurrent uptick in homeownership rates.[4]

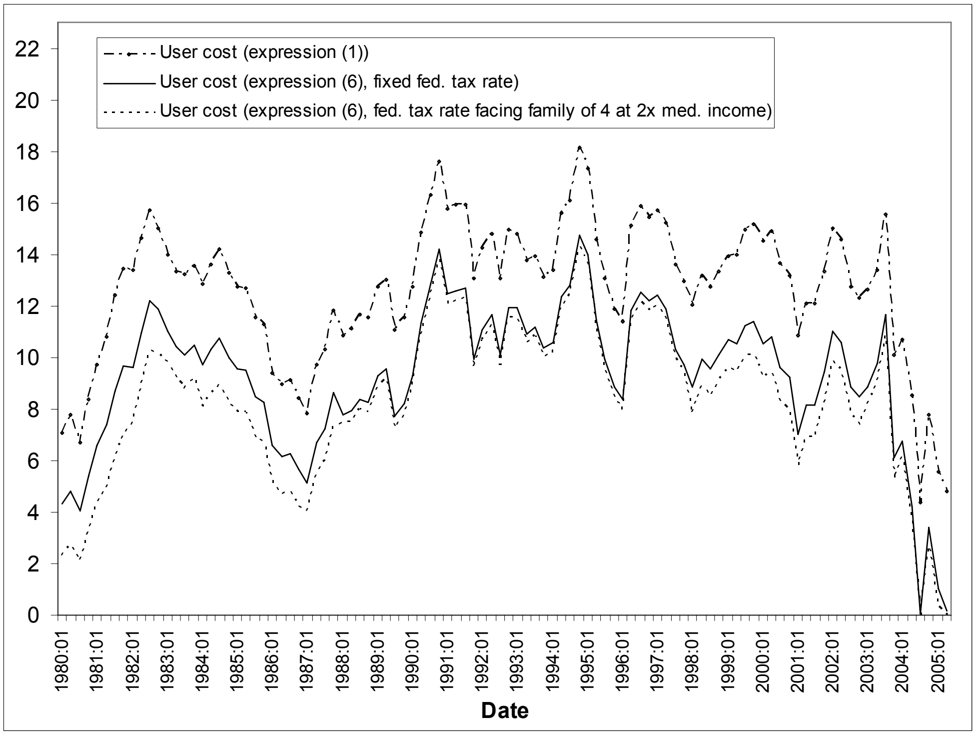

Figure 10: Alternative user cost measures (all-US)

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[4] Chambers, Garriga and Schlagenhauf (2004) attribute this to innovations in the mortgage market. The explanations are complementary, since demand is not unrelated to appreciation.

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