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ABSTRACT

We develop a new approach to measuring changes in consumer welfare due to changes in the price of owner-occupied housing. In our approach, an agent's welfare adjustment is defined as the transfer required to keep expected discounted utility constant given a change in current home prices. We demonstrate that, up to a first-order approximation, there is no aggregate change in welfare due to price increases in the existing housing stock. This follows from a simple market clearing condition where capital gains experienced by sellers are exactly offset by welfare losses to buyers. Welfare losses can occur, however, from price increases in new construction and renovations. We show that this result holds (approximately) even in a model that accounts for changes in consumption and investment plans prompted by current price changes. We estimate the welfare cost of house price appreciation to be an average of $127 per household per year over the 1984-1998 period.

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1 Introduction

There has been tremendous house price appreciation in the United States during the latter part of the 1990s. At the national level, house prices have risen at an average annual rate of 7 percent since 1995. Some regions, particularly those with a heavy concentration of high-tech firms, saw double digit increases in house prices during the peak of the most recent economic expansion (see Table 1). This price appreciation significantly strengthened the balance sheets of existing homeowners. A recent study by Canner, Dynan, and Passmore (2002) estimated that households extracted approximately $130 billion in equity in 2001 and the first half of 2002. On the negative side, however, the 7 percent annual house price appreciation in the late 1990's significantly outpaced the growth in per capita income of 2 percent for the nation as a whole over this time period. Local governments in metropolitan areas with the sharpest price appreciation, such as Austin, Boston, and San Francisco, routinely cite housing affordability as their principle constraint on future economic growth. More generally, households in the lower tail of the income distribution are now less able to afford housing than they were a decade ago. This lack of affordability is troubling to policy makers, as homeownership is often associated with a variety of positive social outcomes (see Green and White (1997) and DiPasquale and Glaeser (1999)).

This paper is about the welfare effects of changes in the price of housing. The sheer size of housing in the average household's consumption bundle makes it imperative to understand the effects of changing prices on consumer welfare. Shelter comprises 32% of the total consumer price index (CPI). Owner-occupied housing is also an asset which occupies a large portion of the typical household's portfolio. According to the 1998 Survey of Consumer Finances, the value of stocks owned by households was $7.8 trillion, while the value of primary residences was $9.4 trillion.

To our knowledge, there has been relatively little work on measuring the welfare effects of house price changes. Most measures of housing affordability are calculated as percentages of a target population with sufficient income to afford the median-priced house at the current interest rate. These indexes, however, are difficult to interpret because they abstract away from, amongst other things, household preferences and household wealth. In addition, affordability indexes display volatility that is inherited from the variables used in their construction, such as interest rates and prices. By contrast, homeownership rates, the variables that affordability indexes are supposed to predict, are among the least volatile of the urban economic series (see Glaeser and Shapiro (2002)).

The body of work most closely related to ours is devoted to developing better measures of the cost of housing and house price inflation. Current practices at the Bureau of Labor Statistics (BLS) reflect the important research of Kearl (1979), Dougherty and Van Order (1982), and Poterba (1984) in this area. In constructing its owner-occupied shelter index, the BLS aims to measure changes in the user cost, or the fair rental value of owner-occupied housing. The user cost can be interpreted as the bribe required to compensate a household for a unit decrease in housing services, in a given time period, holding asset ownership fixed. While the user cost is a good measure of the cost of housing services (the intended purpose of the BLS), there are two reasons that make it unsatisfactory as a measure of the welfare effects of house price changes. First, the user cost calculation assumes that households can adjust their consumption of housing services costlessly, and therefore does not account for behavior changes in periods following changes in prices. If there were no cost to adjusting consumption of housing services, then all consumption adjustments would occur immediately. However, due to transaction costs, one potential effect of an increase in current housing prices might be to lead a household to plan to sell its house nine years into the future instead of ten. In our opinion, such behavior is an important feature of household housing choice, and should be included in the welfare measure.

A second problem with using the user cost as a welfare measure is that it does not include the effect of house price changes on household assets. Due to moral hazard problems with rental housing, as well as tax incentives, households that wish to consume high levels of housing services have strong incentives to also own the home as an asset. In that case, changes in the relative price of housing impact both sides of the household's budget constraint. As a result, households with high levels of housing consumption may be made better off by realized increases in prices. Similarly, households that intend to increase their consumption of housing in the future may be made worse off by increases in current house prices.

In this paper, we develop welfare measures using a dynamic model of housing consumption and investment decisions. In the model, consumers maximize expected discounted utility by choosing investments in housing, consumption of a composite commodity, and real savings. The household's current stock of housing and the current price of housing enter into the decision problem as state variables. We measure the change in consumer welfare due to changes in house prices as the transfer required to keep lifetime expected utility constant under the new prices. Thus, we extend the notion of a cost of living adjustment to a dynamic setting with durable goods, and also include in the welfare calculations the effects of changes in housing wealth that accompany changes in house prices.

Using this dynamic framework, we derive a simple yet striking result. In our model, to a first order approximation, there are no aggregate welfare effects due to price changes in the current stock of owner-occupied housing. The intuition behind this result depends on a simple market clearing condition. If the price of housing goes up, consumers who are selling their houses are made better off while consumers who are buying those houses are made worse off. Since the number of buyers of existing houses must equal the number of sellers, the welfare benefits and losses to each group offset. There can, however, be changes in welfare due to additions to the stock of housing, or to changes in the price of renovating and upgrading the current stock of housing. Using our model, we construct a measure of aggregate welfare changes from house price appreciation. Over the period 1984-1998, we find that U.S. households were made worse off by an average of $127 per year.

The outline of the paper is as follows. First, we develop a simple model of housing consumption and investment, and derive an expression for the fair rental price of housing—or the user cost. Second, we derive a welfare adjustment that fully takes into account the dynamics of housing choice. Third, we construct an aggregate welfare index for housing and illustrate some of its important characteristics. Fourth, we list some caveats and discuss the limitations to our approach. The fifth section concludes the paper.

2 The user cost of capital

The *user cost of capital* was first developed by Hall and Jorgenson (1967). Their original paper showed how capital investment depended on tax policy through a marginal condition. The user cost, as they defined it, was the opportunity cost of investing in capital goods. Housing, as a durable good, fits nicely into the framework outlined by Hall and Jorgenson, and many authors have exploited the user cost formula to study housing demand and price dynamics.[1] Dougherty and Van Order (hereafter DV) were among the first to recognize that the user cost could be a good measure of inflation in the cost of housing services. They note that the user cost is a marginal rate of substitution of housing consumption for other consumption. Further, in a competitive economy, the user cost should be equal to the rental price of a single unit of housing services charged by a profit-maximizing landlord. Thus, the inherently difficult task of measuring an unobservable marginal rate of substitution is replaced by the much easier task of measuring rents.

Following the logic in DV, the BLS changed its procedure for measuring inflation of housing costs in 1983. The BLS currently measures changes in the cost of owner-occupied units by constructing a rental price index (the owners' equivalent rent index). The BLS forms a sample of 36,000 owners for two year intervals and queries owners about the implicit rental value of their house and which housing services would be included in this rent. The BLS then measures changes in rental rates for actual rental units and re-weights these observations to construct the owners' equivalent rent index.[2] This method of measuring housing inflation represented a great improvement over previous methods, which simply measured changes in house prices.

The theoretical underpinnings of the user cost are easy to demonstrate, and also permit us to make a distinction between simple measures of changes in costs, and changes in welfare. For simplicity and for comparison with previous work, we begin by assuming that households have no uncertainty about future prices.[3] Consider an economy in which there are two goods, a composite commodity, c_t, and a housing good, h_t, with relative price, q_t. At each period $t = 1, ..., T$, households choose how much of the composite commodity to consume, c_t, how many bonds to buy that mature in the following period, b_{t+1}, and what level of housing consumption to carry into the next period, h_{t+1}. The household's investment in housing services is denoted x_t. The household has real income y_t, and saves (or dissaves) s_t. The period interest rate

[1] See Kearl (1979), Poterba (1984) and (1991), DiPasquale and Wheaton (1994), and Crone, Nakamura, and Voith (2000).
[2] See the BLS website for more detail on constructing rental indices: http://stats.bls.gov/cpifact7.htm.
[3] The analysis and notation in this section follows that of Dougherty and Van Order (1982).

on bonds is i_t. All income is taxed at a constant rate θ. The inflation rate for the composite commodity is constant at π. Houses depreciate at constant rate δ per period.

The household maximizes its discounted utility subject to the constraints,

$$c_t + q_t x_t + s_t = (1-\theta)y_t + (1-\theta)i_t b_t, \tag{1}$$

$$b_{t+1} - b_t = s_t - \pi b_t, \tag{2}$$

$$h_{t+1} - h_t = x_t - \delta h_t. \tag{3}$$

Equation (1) is the period budget constraint. Real expenditures on consumption, investments in housing, and real savings must equal total real income. Equation (2) provides the transition law for savings. Each period, savings is equal to the difference in bondholdings from the previous period, net of inflation. It will be assumed throughout that households are not credit-constrained. Equation (3) describes the transition law for housing. Each period, housing investment is equal to the difference between the current stock holdings and stock holdings from the period before, net of depreciation.

Households maximize discounted utility. Let $u(h, c)$ be the period utility function for this household. The household's value function can be written recursively as

$$V_t(h_t, b_t, q_t, y_t) = \max_{h_{t+1}, b_{t+1}} \{u(h_t, c_t) + \beta V_{t+1}(h_{t+1}, b_{t+1}, q_{t+1}, y_{t+1})\} \quad \text{subject to (1)-(3).} \tag{4}$$

It is straightforward to show that the first-order and envelope conditions imply that,

$$\frac{\frac{\partial u(h_t,c_t)}{\partial h}}{\frac{\partial u(h_t,c_t)}{\partial c}} = q_{t-1}\left(i_t(1-\theta) - \pi - \frac{\Delta q_t}{q_{t-1}}\right) + q_t\delta. \tag{5}$$

where $\Delta q_t = q_t - q_{t-1}$.

Equation (5) is the marginal rate of substitution of housing for the composite good with respect to the period utility function. It represents the user cost of capital in our model. In order to have an extra unit of housing services at time t, the consumer invests x_{t-1} at time $t-1$ into the stock of housing. The opportunity cost of this investment increases as the expected return on time $t-1$ savings goes up (as reflected by i_t and $-\pi$) and as the rate of depreciation increases. The opportunity cost falls with the rate of housing appreciation.

In this model, the user cost of capital is derived as the marginal rate of substitution between housing and other goods, keeping the period return function constant. DV suggest that this is "...an appropriate measure of housing cost on the grounds that it is a measure of the dollar value of the bribe necessary to get home-owners to give up one unit of housing." While we agree that the user cost is a good measure of the flow value of the housing asset, changes in the user cost can give a misleading picture of the change in aggregate welfare due to a change in relative prices. The reason is that the user cost fails to account fully for the fact that housing is not merely a consumption good, but is also an investment good that enters into the household's portfolio of assets. After an increase in price, households that own their homes will be better off. Indeed, this assumption underpins the empirical literature that looks for changes in consumption following changes in housing wealth.[4] Similarly, renters who eventually plan to buy are made worse off by the change in relative prices.

Another confounding problem with the use of a marginal rate of substitution to make a welfare calculation is the fact that this exercise uses a static approach to measure something that is inherently dynamic in nature. The user cost is suitable for measuring the dollar value of the bribe necessary to give up one unit of housing for one period. Or, equivalently, the user cost is the dollar value of the bribe necessary to keep single period utility constant under different relative prices. This approach does not take into account expectations for future values of the state variables in the economy, such as interest rates or other variables that influence a household's tenure choice. A more appropriate way to tackle the welfare question is to ask, given the current state of the economy, what is the dollar value of the bribe necessary to keep lifetime expected utility constant? Given an expression for this welfare adjustment, it is then possible to aggregate and compute a welfare index for the economy.

3 A simple dynamic model

The standard definition of an *exact cost of living adjustment* (e.g., Diewert (1976)) is the difference of expenditure functions in two periods at a constant level of utility, but with changing prices. Our approach to measuring changes in welfare differs in two crucial ways. First, we focus on dynamics. We keep the value function—not the period return function—constant. Second, we explicitly recognize that housing is both an investment and a consumption good. When relative prices change, both the set of feasible purchases as well as the household's budget constraint are affected. Formally, our welfare adjustment for period t, which we denote as w_t, is defined in equations (6) and (7),

$$w_t = y'_t - y_t, \text{ such that} \tag{6}$$

$$V_t(h_t, b_t, q'_t, y'_t) = V_t(h_t, b_t, q_t, y_t), \tag{7}$$

where V_t is defined in equation (4). In this section, we have dynamics, but no uncertainty. Thus, in this exercise we are studying how lifetime expected utility changes after a price change that lasts a single period. After this price change, prices revert back to their old level. The welfare adjustment is a dollar value, expressed as a difference between two income levels y' and y that makes the household indifferent between relative prices q'_t and q_t.

[4] See Case, Quigley, and Shiller (2001), Englehardt (1996), Hoynes and McFadden (1994).

Up to a first order approximation, the welfare adjustment can be written as a solution to the following equation,

$$\begin{aligned} \Delta V &\approx \frac{\partial V_t(h_t, c_t, q_t, y_t)}{\partial q_t} \Delta q_t + \frac{\partial V_t(h_t, c_t, q_t, y_t)}{\partial y_t} \Delta y_t, \text{ where} && (8) \\ \Delta q_t &= q_t' - q_t \text{ and } \Delta y_t = y_t' - y_t. && (9) \end{aligned}$$

We apply the Envelope Theorem to compute the partial derivatives of the value function in q_t and y_t,

$$\begin{aligned} \frac{\partial V_t(h_t, c_t, q_t, y_t)}{\partial q_t} &= -\frac{\partial u(h_t, c_t)}{\partial c} x_t, && (10) \\ \frac{\partial V_t(h_t, c_t, q_t, y_t)}{\partial y_t} &= \frac{\partial u(h_t, c_t)}{\partial c}(1-\theta). && (11) \end{aligned}$$

It follows from equations (8)-(11) that if we want to keep discounted expected utility constant (that is, $\Delta V = 0$), then up to a first order approximation of the value function, it must be the case that,

$$\begin{aligned} \frac{\partial u(h_t, c_t)}{\partial c}(1-\theta)\Delta y_t &= \frac{\partial u(h_t, c_t)}{\partial c} x_t \Delta q_t, && (12) \\ (1-\theta)\Delta y_t &= x_t \Delta q_t. && (13) \end{aligned}$$

Equations (6) and (13) imply the welfare adjustment is given by

$$w_t = \frac{x_t \Delta q_t}{(1-\theta)}. \tag{14}$$

Equation (14) has a very different interpretation than equation (5) for computing the welfare adjustment. If nominal house prices are increasing ($\Delta q_t > 0$), then the welfare adjustment is positive for those households that are increasing their stock of housing, and negative for those households that are decreasing their stock of housing. If a household increases its stock of housing by x_t, then the welfare adjustment is the change in real income needed to afford the increase in prices. If the household is decreasing its stock of housing, then the welfare adjustment is negative. This makes sense because those households that are decreasing their stock of housing (i.e., planning to sell) are made better off by price increases. All other things held equal, welfare adjustments are higher under higher marginal tax rates. This is because of the interest rate deduction. Finally, a household that makes no change to its housing stock experiences no immediate change in its welfare. This is one of the most important features of the model—welfare gains and losses are experienced only when changes in prices alter housing consumption plans. In the next section we extend this result to cover the cases where changes in prices can alter the path of the economy's state variables and, thus, alter consumption plans far into the future.

Note that our approach differs from the user cost approach, where expected capital gains reduce overall housing service costs one-to-one in every period, regardless of the timing of consumption plans. In most real world housing markets, consumers do not buy and sell homes frequently. Holding all else fixed (including expected future relative prices), changes in the relative price of housing today should leave utility unchanged for those who do not adjust their housing stock. This idea is reflected in equation (14).

3.0.1 Aggregate welfare adjustment

Suppose that there are I households in the economy and that the investment in housing services by household i is $x_{i,t}$. We define the aggregate welfare adjustment (W_t) as,

$$W_t = \sum_i \frac{x_{i,t}\Delta q_t}{(1-\theta)}. \tag{15}$$

The aggregate welfare adjustment is the sum of the welfare adjustments in equation (14) for all of the households in the economy.

In order to characterize the aggregate welfare effect, we make the following simplifying assumption about the economy:

A1. Investment in housing can be obtained by purchasing existing stock (x^o), purchasing new stock (x^n), or by renovating existing stock (x^r), so that

$$x_{i,t} = x^o_{i,t} + x^n_{i,t} + x^r_{i,t}. \tag{16}$$

This assumption is essentially an accounting identity that represents the only way an agent can adjust his housing consumption.

An important feature of housing markets is that investment in existing stock is accomplished through trade between owners. Any investment in existing stock by agent $i$is perfectly offset by a sale by some agent j. These offsetting investments lead to an important aggregation result,

$$\sum_i x^o_{i,t} = 0, \text{ because } -x^o_{i,t} = x^o_{j,t} \text{ for all buyer-seller pairs}(i,j). \tag{17}$$

The aggregate welfare adjustment due to changes in prices of the existing housing stock is zero. The intuition behind this result is straightforward. Suppose that household A sells a home worth \$100,000 to household B. Suppose that, in nominal terms, the price of housing has increased by \$5,000 over the past year. Then, in nominal terms, the welfare adjustment for household A is -\$5,000 and the welfare adjustment for household B is \$5,000. The aggregate adjustment is zero. The implication of this result is that any aggregate welfare adjustment must come from changes in the housing stock from new construction and/or renovations. We formalize this observation as follows. Let $X_t^n = \sum_i x_{i,t}^n$ and $X_t^r = \sum_i x_{i,t}^r$ be the aggregate housing services from new housing and renovations and repairs. Then the aggregate change in welfare is given by,

$$W_t = \frac{(X_t^n + X_t^r)\Delta q_t}{1-\theta}. \tag{18}$$

Equation (18) has important consequences for the measurement of welfare. The change in welfare attributable to a change in relative prices is given by the value of the total investment in new stock plus the dollar value of the renovations prompted by the change in prices. There may be enormous changes in welfare for individual households who buy and sell the existing stock, but most of these welfare effects will be offset by equal but opposite welfare effects experienced elsewhere in the economy. Since new construction each year represents a small fraction of the existing stock in most countries, and renovation costs in any given year represent a small fraction of the total value of the houses being renovated, basing welfare transfers on a welfare index such as the CPI will overcompensate a large proportion of the economy.

In Figure 1 we see estimates of W_t for the U.S. data. The new construction series is the historical cost of privately-owned new residential housing, published by the Bureau of Economic Analysis (BEA). The renovation series is an historical cost series derived from the fixed asset tables, also published by the BEA. Since we do not know the actual distribution of tax rates for the population of homeowners, we assume $\theta = 0$ and interpret the derived series W_t as a lower bound for the actual welfare costs of housing price changes. The figure shows a series trending upwards as house prices have risen over time. Negative year-over-year growth rates in the welfare index tend to track the U.S. real estate cycle, with declines in the index mainly representing declines in new construction. Between 1984 and 1998, the average amount required to compensate households for changes in house prices was \$127.

3.1 Generalizations

A simplifying assumption made in the previous section was that changes in house prices today convey no information about the house prices in the future. In this section we allow for a richer model where changes in the current price convey information about the evolution of prices in the future.

We now assume that house prices follow a Markov Chain, $F_q(q_{t+1}|q_t)$. We also assume that income, interest rates, and inflation follow Markov chains $F_y(y_{t+1}|y_t)$, $F_i(i_{t+1}|i_t)$, and $F_\pi(\pi_{t+1}|\pi_t)$, and that a household lives for T periods.[5] Finally, we assume that there is a fixed cost, f, for adjusting the stock of housing if $x_t \neq 0$. We let $1\{x_t \neq 0\}$ denote the indicator function for the event that the stock of housing services has

[5]For simplicity, we assume that these processes are independent. However, it would not greatly complicate things to allow them to be dependent.

been adjusted. This last assumption alters the budget constraint to

$$c_t + q_t x_t + f1\{x_t \neq 0\} + s_t = (1-\theta)y_t + (1-\theta)i_t b_t. \tag{19}$$

To simplify notation, we gather the state variables into a state vector $\omega_t = (h_t, b_t, q_t, y_t, i_t, \pi_t)$ and define $G(\omega_t|\omega_{t-1})$ to be the Markov chain describing the evolution of the entire state vector. The household's Bellman equation can now be written as,

$$\begin{aligned} V_t(\omega_t) &= \max_{h_{t+1}, b_{t+1}} \left\{ u(h_t, c_t) + \beta \int V_{t+1}(\omega_{t+1}) dG(\omega_{t+1}|\omega_t) \right\}, & (20) \\ & \quad \text{subject to (19), (2), and (3).} & (21) \end{aligned}$$

Now consider a price level change from $q_t = q'$ to $q_t = q''$. We define the dynamic welfare adjustment in a similar way to the last section. It is the transfer (in real terms) necessary to keep the value function constant. Intuitively, welfare adjustments in a dynamic setting will come from three different sources. First, changes in prices may change planned expenditures on housing. Even if households do not change their housing investment plans after a change in prices, their future planned expenditures are likely to be different. This effect can be thought of as an income effect. Second, changes in prices may alter savings decisions. Price increases make existing owners more wealthy, possibly causing them to reduce their savings and increase consumption. Third, changes in relative prices can cause households to substitute between housing and the consumption good. This effect can be likened to a substitution effect. Our dynamic welfare adjustment has three terms that reflect all of the different ways that households can alter their behavior following a change in prices. In the appendix we show that, up to a first order approximation, the dynamic welfare adjustment is,

$$\begin{aligned} w_t = & \frac{1}{1-\theta} \sum_{s=0}^{T} \beta^s ((E[q_{t+s} x_{t+s} | q_t = q''] - E[q_{t+s} x_{t+s} | q_t = q']) \\ & + E[s_{t+s} - (1-\theta) i_{t+s} b_{t+s} | q_t = q''] - E[s_{t+s} - (1-\theta) i_{t+s} b_{t+s} | q_t = q']) \\ & - \frac{\alpha_1}{\alpha_2} \sum_{s=0}^{T} \beta^s \sum_{r=1}^{s} (1-\delta)^{s-r} (E[x_{t+r} | q_t = q''] - E[x_{t+r} | q_t = q'])). \end{aligned} \tag{22}$$

This expression has three terms. The first term

$$\frac{1}{1-\theta} \sum_{s=0}^{T} \beta^s (E[q_{t+s} x_{t+s} | q_t = q''] - E[q_{t+s} x_{t+s} | q_t = q'])$$

illustrates, once again, that households that adjust housing consumption (i.e., x_{t+s} for some s) after relative price changes will experience changes in their welfare. This welfare adjustment is the after tax discounted expected value of the difference between the planned expenditures on housing consumption under the two different relative price levels. We emphasize that the sequence of planned housing investments in the equation above reflects optimal decision-making given existing prices (either q' or q''). Households that keep housing consumption constant over their lifetimes do not directly benefit (or lose) from price changes. Any direct benefit (loss) from price changes comes from an eventual purchase or sale, and is discounted to the present.

It is possible that households experience an indirect change in their welfare even if they do not change housing consumption. This indirect channel comes primarily from the second term,

$$\frac{1}{1-\theta}\sum_{s=0}^{T}\beta^{s}\left(E\left[s_{t+s}-(1-\theta)i_{t+s}b_{t+s}|q_t=q''\right]-E\left[s_{t+s}-(1-\theta)i_{t+s}b_{t+s}|q_t=q'\right]\right)$$

which represents the after-tax expected discounted value of the difference in planned real savings under the two different relative price levels. If relative prices increase (decrease) it may be optimal for the household to lower (raise) its savings rate to account for the change in wealth that has just occurred. The exact adjustment to optimal savings plans depends on the household's preferences. Impatient and less risk averse households will generally reduce their savings following an increase in prices, while risk averse households may not alter savings decisions a great deal in the face of changes in relative prices.

The third term

$$-\frac{\alpha_1}{\alpha_2}\sum_{s=0}^{T}\beta^{s}\sum_{r=1}^{s}(1-\delta)^{s-r}\left(E\left[x_{t+r}|q_t=q''\right]-E\left[x_{t+r}|q_t=q'\right]\right),$$

represents the change in discounted utility that results from changes in consumption of housing services due to the price change. For example, if relative prices increase, it may be optimal for the household to reduce its housing consumption. The third term measures the utility effect of this change, discounted to the present. As before, the exact amount of this adjustment will depend on household preferences, as is evidenced by the $\frac{\alpha_1}{\alpha_2}$ term, which is the marginal rate of substitution of housing consumption for nonhousing consumption (see appendix for the derivation). Note that this term is different from the first term, which measured the differences in cost associated with optimal housing investment under two different prices. This term only becomes important if changes in the relative price of housing cause a substitution effect.

There is some debate in the literature on the magnitude of the elasticity of savings with respect to housing prices. Englehardt (1996) argues that this elasticity is small, while Hoynes and McFadden (1994) find that households adjust savings in an asymmetric way, increasing savings slightly when house prices decline, but leaving their savings rates unaltered after price increases. While this issue is not completely resolved (see Case, Quigley, and Shiller (2001)) we use this evidence as justification for ignoring the second term, which yields the following expression for the dynamic welfare adjustment,

$$\begin{aligned} w_t &= \frac{1}{1-\theta}\sum_{s=0}^{T}\beta^{s}\big((E\left[q_{t+s}x_{t+s}|q_t=q''\right]-E\left[q_{t+s}x_{t+s}|q_t=q'\right]) \\ &\quad -\frac{\alpha_1}{\alpha_2}\sum_{r=1}^{s}(1-\delta)^{s-r}\left(E\left[x_{t+r}|q_t=q''\right]-E\left[x_{t+r}|q_t=q'\right]\right)\big). \end{aligned} \tag{23}$$

3.1.1 The aggregate welfare adjustment

As before, we define the aggregate welfare adjustment (W_t) as the sum of the welfare adjustments for the individual households. Suppose that credit markets clear and that supply must equal demand in the market where existing homes are traded. Then, the main result of the previous section holds approximately in the general case. That is, it is approximately true that any aggregate change in welfare can only be due to changes in the price of new housing and changes to the housing stock. This is because the effects of price changes for the existing housing stock on the cost of living of both buyers and sellers are still offsetting.

In the first term of (23), it is easy to see that price changes for the existing stock of housing exactly offset. The same is true for the second term if all individuals have the same marginal rate of substitution between housing consumption and consumption of the composite commodity ($\frac{\alpha_1}{\alpha_2}$).[6] In that case, we have that

$$W_t = \frac{1}{1-\theta}\sum_{s=0}^{T}\beta^s\left(E(q_{t+s}(x^n_{t+s}+x^r_{t+s})|q'') - E(q_{t+s}(x^n_{t+s}+x^r_{t+s})|q')\right) \tag{24}$$
$$-\frac{1}{1-\theta}\sum_{s=0}^{T}\beta^s\sum_{r=1}^{s}(1-\delta)^{s-r}\left(E\left[x^n_{t+r}+x^r_{t+r}|q_t=q''\right] - E\left[x^n_{t+r}+x^r_{t+r}|q_t=q'\right]\right)$$

If it is not the case that all individuals have the same marginal rates of substitution, then (24) holds approximately so long as the housing stock does not shift among households in any systematic way.[7]

In this more general setting, agents that sell their houses when prices increase realize a capital gain. Thus, the dynamic welfare adjustment does bear a resemblance to the traditional user cost. However, unlike the user cost, agents do not necessarily experience changes in welfare because of the event that house prices have increased. These capital gains-related changes in welfare are realized only to the extent that they influence some eventual sale. The impact of the final sale on equation (23) depends on how distant in time the sale is expected to be.

For households trading within the set of existing housing stock, the aggregate impact on welfare is approximately zero. Welfare adjustments are approximately offset among current and future buyers and sellers. Note that price changes may have a large distributional impact. Households that own their housing are benefited by price increases at the expense of those that do not yet own their housing.

[6]Note that, in principle, this could involve trades between households that are alive today and households that have not been born by the current period.

[7]For example, if households with low marginal rates of substitution increased their housing stock relative to those with high marginal rates of substitution as a result of a price change, then this term would include some effect of prices on the existing stock of housing.

4 Caveats and extensions

In this section we discuss some of the limitations of our modeling framework and how they might bias our results. One important simplifying assumption is that credit constraints are not binding. Credit constraints may bind for some individuals in many local real estate markets. More importantly, young households looking to transition from rental markets to the owner-occupied market are probably the most likely to face binding constraints. A rapid increase in prices may force some of these households out of the market for owner-occupied housing because they lack the necessary resources to qualify for a mortgage or to come up with a downpayment.[8] While we do not attempt to measure the overall welfare loss due to binding credit constraints — doing so would require a sufficiently more complex model — we believe that our current approach leads us to understate the overall change in welfare due to price increases in the aggregate. Clearly, this is an important area for future research.

A second important simplifying assumption we make is in equation (8), in which we use a first order approximation to the value function when computing the welfare adjustment. While this is probably an innocuous assumption for small changes in home prices, it is not innocuous when price changes are large. If households are facing credit constraints, then large increases in prices may prevent the constrained households from investing x_t in new housing. Additionally, we may expect a substitution effect to take place if there are dramatic changes in relative prices. Using a first order approximation also allows us to abstract away from risk in our calculations. If we wanted to allow for risk, we could instead use a second order Taylor series. Many of the results could easily be restated for this case, but at the cost of much more notation.

A third important point is that we abstract away from mortgages. Instead we assume that individuals borrow on the bond market in order to purchase housing. Adding mortgages and the choice of financing packages into our analysis would greatly complicate the model with, in our opinion, little to gain.

A final and important caveat is that, while price changes do not result in aggregate changes in the welfare in the existing stock of housing, this is far from true at a disaggregated level. Individual households moving into an area after an episode of rapidly increasing prices have to pay more for their houses. Housing inflation involves a redistribution of income between those buying homes and those selling their homes. While there is no aggregate change in welfare, there are potentially large individual losses and gains in welfare.

5 Conclusions

In this paper we develop an alternative approach to measuring changes in the cost of housing services. Using a simple model of rational forward looking agents, we develop a cost of living, or welfare adjustment, to

[8] Typically, mortgages are priced nonlinearly, with a large discrete jump in interest rates for loans with downpayments below a certain level.

compensate households for changes in housing prices. The welfare adjustment is defined as the amount of the consumption good necessary to keep a household's value function constant after a change in prices. Our welfare adjustment has an important property when aggregated across all individuals in the economy. We show that the only changes in aggregate welfare due to house price changes come from new construction and renovation of the existing stock. By far the large majority of the housing transactions in the United States involve existing stock. As a result, over the period 1984-1998, the average welfare loss per household due to house price changes was only $127 per year.

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6 Derivation of the Cost of Living Adjustment for General Model

Linearizing the utility function by using a first order Taylor approximation around (h_0, c_0), we write utility as:

$$\begin{aligned} u(h,c) &= u(h_0,c_0) + \frac{\partial u}{\partial h}(h_0,c_0)(h-h_0) + \frac{\partial u}{\partial c}(h_0,c_0)(c-c_0) \\ &= \alpha_o + \alpha_1 h + \alpha_2 c \\ &= \alpha_o + \alpha_1 h + \alpha_2 \left((1-\theta)y_t + (1-\theta)i_t b_t - s_t - q_t x_t - f1\{x_t \neq 0\}\right), \end{aligned} \tag{25}$$

Let $\omega_t = (h_t, b_t, q_t, y_t, i_t, \pi_t)$ and let $\overrightarrow{\omega}_{t,s} = (\omega_t, ..., \omega_{t+s})$. It follows that up to a first order approximation,

$$\begin{aligned} \frac{\Delta V_t}{\Delta q_t}\Delta q_t &= \sum_{s=0}^{T} \beta^s \int (\alpha_o + \alpha_1 h_{t+s} + \alpha_2[(1-\theta)y_{t+s} + (1-\theta)i_{t+s}b_{t+s} \\ -s_{t+s} - q_{t+s}x_{t+s} - f1\{x_{t+s} &\neq 0\}] \left(f\left(\overrightarrow{\omega}_{t,s}|q_t = q''\right) - f\left(\overrightarrow{\omega}_{t,s}|q_t = q'\right)\right) d\overrightarrow{\omega}_{t,s}. \end{aligned} \tag{26}$$

Because α_o is a constant and it is multiplied by the difference between two densities, it drops out of the equation. Because y_t evolves independently of the other state variables, it also drops out of the equation. We also assume that the household is not exactly on the boundary between investing and not investing and that the housing price change is small enough that the household does not move from zero housing investment to nonzero investment. Thus, the fixed cost term also drops out of the equation. We also recognize that,

$$h_{t+s} = (1-\delta)^s h_t + \sum_{r=1}^{s} (1-\delta)^{s-r} x_{t+r}$$

Similarly to above, because it is constant for all s the h_t term in this expression drops out. That leaves us with,

$$\begin{aligned} \frac{\Delta V_t}{\Delta q_t}\Delta q_t = \sum_{s=0}^{T} \beta^s \int (\alpha_1 \sum_{r=1}^{s} (1-\delta)^{s-r} x_{t+r} + \alpha_2 \left((1-\theta)i_{t+s}b_{t+s} - s_{t+s}\right) \\ -\alpha_2 q_{t+s}x_{t+s}) \left(f\left(\overrightarrow{\omega}_{t,s}|q_t = q''\right) - f\left(\overrightarrow{\omega}_{t,s}|q_t = q'\right)\right) d\overrightarrow{\omega}_{t,s}. \end{aligned} \tag{27}$$

$$\begin{aligned} \frac{\Delta V_t}{\Delta q_t}\Delta q_t = \sum_{s=0}^{T} \beta^s \alpha_2 \left(E\left[(1-\theta)i_{t+s}b_{t+s} - s_{t+s}|q_t = q''\right] - E\left[(1-\theta)i_{t+s}b_{t+s} - s_{t+s}|q_t = q'\right]\right) \\ +\alpha_1 E[\sum_{r=1}^{s} (1-\delta)^{s-r} x_{t+r}|q_t = q''] - E[\sum_{r=1}^{s} (1-\delta)^{s-r} x_{t+r}|q_t = q'] + \\ \alpha_1 E[\sum_{r=1}^{s} (1-\delta)^{s-r} x_{t+r}|q_t = q''] - E\sum_{r=1}^{s}[(1-\delta)^{s-r} x_{t+r}|q_t = q'] \\ -\alpha_2 \left(E\left[q_{t+s}x_{t+s}|q_t = q''\right] - E\left[q_{t+s}x_{t+s}|q_t = q'\right]\right)). \end{aligned} \tag{28}$$

Up to a first order approximation, giving a household a temporary increase in income of Δy_t changes the value function as follows:

$$\frac{\Delta V_t}{\Delta y_t}\Delta y_t = \alpha_2(1-\theta)\Delta y_t \tag{29}$$

Using the approximation from (8), gives us,

$$\begin{aligned}\Delta y_t \quad = \quad & \frac{1}{1-\theta}\sum_{s=0}^{T}\beta^s(E\left[s_{t+s}-(1-\theta)i_{t+s}b_{t+s}|q_t=q''\right]-E\left[s_{t+s}-(1-\theta)i_{t+s}b_{t+s}|q_t=q'\right] \\ & -\frac{\alpha_1}{\alpha 2}(E\left[\sum_{r=1}^{s}(1-\delta)^{s-r}x_{t+r}|q_t=q''\right]-E\left[\sum_{r=1}^{s}(1-\delta)^{s-r}x_{t+r}|q_t=q'\right] \\ & +(E\left[q_{t+s}x_{t+s}|q_t=q''\right]-E\left[q_{t+s}x_{t+s}|q_t=q'\right])).\end{aligned} \tag{30}$$

A Tables and Graphs

Table 1: Annualized House Price Changes for Select Metropolitan Areas

	1980-1990	1990-2000	1995-2000
Chicago	6%	4%	5%
Los Angeles	8%	1%	5%
New York	11%	3%	7%
Phoenix	2%	5%	6%
San Francisco	9%	5%	12%

Source: Office of Federal Housing Enterprise Oversight

Figure 1: Yearly Fall in Per Household Welfare