Household Expenditures, Wages, Rents*

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Abstract: We provide new evidence from the 1980, 1990, and 2000 Decennial Census of Housing that the expenditure share on housing is constant over time and across U.S. metropolitan areas (MSA). Consistent with this observation, we consider a model in which identical households with Cobb-Douglas preferences for housing and numeraire consumption choose an MSA in which to live and MSAs differ with respect to income earned by residents. We compute constant-quality wages and rental prices for a sample of 50 U.S. MSAs. Given estimated wages, the calibrated model predicts that rental prices should be more dispersed than observed.

1 Introduction

We document that renting households spend a constant fraction of income on housing expenditures in each of the top 50 Metropolitan Statistical Areas (MSAs) in 1980, 1990, and 2000. When household preferences are chosen to yield constant expenditure shares in equilibrium, a standard model of location choice predicts that the relative price of any two locations is independent of housing supply in any location. The model also predicts that the relative price of housing of any two MSAs disproportionately reflects differences in incomes of those MSAs. Specifically, when calibrated to match data on expenditure shares, the model implies that each percentage point differential in wages across any two MSAs leads to more than a four percentage point differential in rental prices of those MSAs. Given data on wages, we show the model predicts more dispersion in rental prices across MSAs than we observe. In other words, without appealing to amenities, supply constraints, workers with heterogeneous abilities or preferences, or "consumer-city" type arguments, we show a standard model of location choice can easily predict rental prices observed in New York and San Francisco given wages in those locations. In fact, we are left asking: Why aren't rental prices higher in New York and San Francisco?

Our finding that expenditure shares are constant has important implications for the modeling of consumption and housing in utility. Specifically, this finding provides support for the assumption of Cobb-Douglas preferences for consumption and housing. These preferences are common in macroeconomic models with a housing or home-production sector.[1] The use of Cobb-Douglas preferences is much less common in the field of urban economics and local public finance, although recent models that have assumed these preferences in utility have been capable of matching certain cross-sectional facts. For example, Eeckhout (2004) shows that a multi-city model where households have Cobb-Douglas preferences for consumption and housing can replicate key features of the size distribution of places; and, Lucas and Rossi-Hansberg (2002)

[1]For example, see Davis and Heathcote (2005), Fisher (1997, 2007), Gervais (2002), Iacoviello (2005), Gomme et. al. (2001), Greenwood et. al. (1995), and Kiyotaki et al. (2007).

assume Cobb-Douglas preferences in their within-city model of the allocation of land to production and residential use.

The structure of our paper is as follows. In section 2, we use micro data from the last three Decennial Census of Housing (DCH) surveys to document that the housing expenditure share of renting households has been remarkably constant over time and across U.S. metropolitan areas. We emphasize that our use of renter data is essential for the computation of expenditure shares for housing: Rental payments made by homeowners are never observed. Rather, only mortgage payments for homeowners are observed, and mortgage payments can vary across households even if the implicit rents on underlying housing units are identical.[2] In each of the three DCH surveys (1980, 1990, and 2000), our estimate of the housing expenditure share by renting households does not vary widely across MSAs despite significant variation in average income. The expenditure share on housing is also remarkably stable over time within each MSA, despite sometimes sizeable changes over time to real rental prices. In summary, in section 2 we make the case for Cobb-Douglas preferences for consumption and housing.

In section 3, we consider the implications of a Cobb-Douglas preference assumption for the equilibrium distribution of house prices across MSAs. We study a simple multi-location model similar to that of Eeckhout (2004) where identical households costlessly choose an MSA in which to live as well as housing in that MSA and numeraire consumption. MSAs differ with respect to income earned by residents. There is a fixed stock of perfectly divisible housing units in each MSAs. Given our estimate of the expenditure share on housing of 24 percent, we show the difference in log rental prices of two MSAs must equal 4.2 ($= 1/0.24$) times the difference in log per-capita income. Equivalently, if income growth in any MSA outpaces growth in average income (across MSAs) by 1 percentage point, rental prices in that MSA will outpace the average growth in rental prices by 4.2 percentage points. Thus, in a multi-city model where identical households

[2]For example, consider two units in different locations, but with the same rental price. If rental growth is expected to occur at a relatively fast pace in the first unit, the price of the housing unit and thus the mortgage payment (holding debt-value ratios constant) will be higher in that unit than in the second unit.

have Cobb-Douglas preferences for housing and consumption, rental prices in an MSA will not, in general, increase at the same rate as income in that MSA.

The economics of the result that rental prices disproportionately reflect income differentials are straightforward. Because expenditure shares are constant across locations in equilibrium, households living in high-wage MSAs spend more on both goods. Relative to households living in low-wage MSAs, households living in high-wage MSAs consume a greater quantity of numeraire; the equilibrium condition that all MSAs provide the same level utility ensures that these households consume a smaller quantity of housing. Suppose that in equilibrium the ratio of rental prices is equal to the ratio of wages in any two MSAs. The constancy of expenditure shares implies that the quantity of housing consumed is identical across MSAs, a contradiction. It follows that in equilibrium, the ratio of rental prices across any two MSAs must be greater than the ratio of wages in those MSAs.

We also show in this section that when agents have Cobb-Douglas preferences for consumption and housing, the relative price of housing in any two MSAs is completely independent of the total supply of housing in any MSA. That is, contrary to the results of Gyourko et. al. (2006) and others, housing supply does not determine the relative price of housing in San Francisco or any other high-priced area. This result is not the outcome of a calibration of local housing stocks and wages, but is an analytical result derived directly from the model. The equilibrium condition that agents are indifferent across locations requires that indirect utility be identical everywhere. This requirement determines relationships between rental prices and wages in any two locations that are independent of the total quantity of housing in any location. Of course, the level of rents in every location is determined by market-clearing conditions for housing – implying the level of housing supply in any location affects the level of rents everywhere.

In section 4, we use DCH data to compute constant-quality wages and rental prices for the MSAs in our sample. We then calibrate our model and compare model-predicted rental prices for each MSA to data. We show that the model predicts too much dispersion in rental prices. That is, the model predicts that rental prices of many high-wage MSAs should be higher than currently observed. In other words, we find that

San Francisco is a relatively cheap place to live, given the consumption opportunities afforded in this high-wage MSA.

In section 5 of the paper, we study a dynamic version of our model to explore its predictions for the price of housing (as compared to the price of rents). Specifically, we use the result that rental prices disproportionately reflect differences in income to study (as an extreme example from our data) differences in the price of a house in San Francisco and Pittsburgh. A back-of-the-envelope calculation suggests that, as of the year 2000, the difference in house prices in San Francisco and Pittsburgh is rationalizable if incomes are expected to increase one-half percentage point per year more rapidly in San Francisco than in Pittsburgh. Such expectations are well within historical experience of the past 20 years.

2 Evidence on Expenditure Shares

In this section, we study rental expenditures on housing services made by renting households. We study renters because their expenditures on housing services – rents – are observable. Rents paid by homeowners, in contrast, are fundamentally not observable: Homeowners make mortgage payments, not rental payments.

Verbrugge (2006) and others have argued that expenditures on housing services by homeowners can be proxied as the product of a current mortgage rate and current house value. This estimate may not reflect the current rental price of the house because house prices reflect the expected present value of current and future rents. House prices and mortgage payments can vary across areas, even if current rents are identical, as long as households have different expectations about the growth rate of future rents.[3]

[3]House prices and mortgage payments can also vary across locations if the the location-specific risk component of housing assets varies across MSAs. Recent theory (Ortalo-Magné and Prat 2007) and evidence (Campbell et. al. 2008) suggests that these risk-premia may significantly vary across MSAs.

We construct an estimate of the expenditure share on housing by renting households using micro data from the Decennial Census of Housing (DCH) files.[4] The first three columns of Table 1 list the median of the ratio of annual gross rent (rent including utilities) to total household wage and salary income that we derive from the DCH for the top 50 MSAs by population in 2000, for renter households with nonzero wage and salary income and nonzero rental payments, for the years 1980, 1990, and 2000. These MSAs account for about 46 percent of the population in 1980-2000. The total proportion of the population living in this set of MSAs has remained about fixed, although population has shifted among MSAs.

The data in Table 1 show that, measured at the median, the estimated expenditure share on housing is remarkably stable across MSAs and over time. In any given year, the expenditure share, measured at the median, is nearly constant across MSAs at about 0.24 with a standard deviation of about 0.02 (shown in the bottom two rows). The fact that expenditure shares remain constant over time in each MSA, and constant across MSAs in each year, is not due to lack of cross-sectional variation of income or time-series variation in real rental prices. The fourth column of Table 1 reports, by MSA, the average household wage and salary income in 2000 for renter households with an expenditure share on housing within 1 percentage point of the MSA-median. The standard deviation of this measure, \$5,867, is 17 percent of the MSA-average, \$35,425. The right-most column of Table 1 reports growth of real rental prices in each MSA from 1980-2000.[5] The reported expenditure share in each MSA is nearly constant over time in every MSA, despite the sometimes large increases in the real relative price of

[4]These data are available at the Integrated Public Use Microdata Series (IPUMS) web site, http://usa.ipums.org/usa/. We exclude farm households, households living in group quarters, and households living in mobile homes, trailers, boats, tents, vans, or “other” from the DCH data.

[5]Growth in real rental prices is computed as growth in nominal rental price per unit less consumer price inflation excluding housing services and household operation. Nominal rent per unit is computed in 1980 and 2000 using DCH data and a hedonic regression approach described later in the paper. Consumer prices less housing services and household operation increased by 84 percent over the 1980-2000 period according to data from the NIPA.

rental units shown in this column. For example, the real relative price of rents in San Jose, CA more than doubled from 1980 to 2000.

The 25th and the 75th percentiles of the distribution of expenditure shares within each MSA are also stable across MSAs and over time. Shown in Table 1a, the average across MSAs of the 25th and 75th percentiles of the expenditure shares are 17 and 36 percent and the standard deviation of these estimates are about 2 and 4 percentage points, respectively. Within each MSA, the expenditure share on rent is decreasing with household income in that MSA. One possibility is that expenditures truly fall with income, and that our finding that the median of the expenditure share is nearly constant across time and places is a coincidence. We do not share this view, and in the remainder of this section we argue that the negative correlation of income and expenditure shares within MSAs is not necessarily at odds with a constant expenditure share on housing. The reason is that we do not compute an exact measure of expenditure shares, because we divide rental expenditures by wage and salary income and not by consumption, which is unobserved. The gap between consumption and income is key to explaining why expenditure shares fall with income.

Suppose that consumption is equal to permanent income, and that observed income for person i is equal to permanent income for that person, $\bar{w}_i$, times a deviation of income from permanent income, e_i, such that

$$w_i = \bar{w}_i \; e_i. \tag{1}$$

We assume that the median of e_i is 1. This would occur, for example, if the natural log of e_i was Normally distributed with mean 0 and some variance σ^2.

Now suppose that each person spends a constant fraction of their permanent income on rent, such that

$$\frac{x_i}{\bar{w}_i} = \alpha, \tag{2}$$

where r_i is the rental expenditure of person i. The observed expenditure share is a random variable with a distribution of

$$\frac{x_i}{w_i} = \left(\frac{x_i}{\bar{w}_i}\right)\left(\frac{\bar{w}_i}{w_i}\right) = \alpha\left(\frac{1}{e_i}\right). \tag{3}$$

When $e_i > 1$, implying income is higher than permanent income, the observed expenditure share will be less than α and vice-versa. An unbiased estimate of α is the median of equation (3), since the median value of e_i is equal to 1, by assumption.

With the assumptions we have made, the distribution of observed expenditure shares is independent of the distribution of permanent income, and only depends on the distribution of the deviation of income from permanent income. If the distribution of the deviations of income from permanent income is similar across MSAs, then the distribution of our estimated expenditure shares will also be similar across MSAs. This may be the reason why the inter-quartile range of the expenditure share is stable across MSAs and over time.

An easy way to show that the distribution of expenditure shares is independent of the distribution of permanent income given the assumptions we have made, is to assume that there are only two levels of permanent income, $\bar{w}_{i,1}$ and $\bar{w}_{i,2}$, and that the probability a person has permanent income equal to $\bar{w}_{i,1}$ is p. If the distribution of deviations is independent of the level of permanent income, then the distribution of expenditure shares is independent of p, $\bar{w}_{i,1}$, and $\bar{w}_{i,2}$:

$$\begin{aligned} & p\left(\frac{x_{i,1}}{w_{i,1}}\right) + (1-p)\left(\frac{x_{i,2}}{w_{i,2}}\right) \\ = \; & p\,\alpha\left(\frac{1}{e_i}\right) + (1-p)\,\alpha\left(\frac{1}{e_i}\right) \\ = \; & \alpha\left(\frac{1}{e_i}\right) . \end{aligned} \tag{4}$$

Thus, the fact that income is not equal to permanent income is sufficient to cause measured expenditure shares to fall with observed income, as they do in the data. In fact, given our assumptions it can be shown that the correlation of the *inverse* of the expenditure share (w_i/x_i) with observed income w_i should equal 1. In our data, the correlation of the inverse of the expenditure share with observed income varies by MSA, but the average is about 0.7.

If deviations of (w_i/x_i) from average are truly reflective of differences in current income from permanent income, then we should expect to see e_i vary in a particular way with age. Assuming that income over the life-cycle is hump-shaped, with a peak somewhere around age 55, we should expect to find that e_i increases with age until peak earnings years, somewhere around age 55, and then declines after that. To test this, we compute deviations of $\log(w_i/x_i)$ from its average – these deviations are exactly equal to $\log(e_i)$ – and then regress the deviations on age of the primary wage earner of the household, with age lumped into 5 year bins (except for the bins corresponding to the youngest and oldest ages). The coefficients from these regressions for all three DCH years are shown in Figure 1. The coefficients on each age bin are broadly comparable across years, and the coefficients behave as expected, rising until about age 55 and then declining.[6]

As a final check on the independence of expenditures of housing from permanent income, we study panel data from the Consumer Expenditure Survey (CEX) made available for download by Aguiar and Hurst (2008).[7] For households where the household head is between the ages of 25 and 55, we run a regression using quarterly CEX data from 1982q1 to 2003q2 of log rental expenditures – including owner-equivalent rent for homeowners – on instrumented log total outlays[8] with controls for date, age, cohort, marital status, household size, and number of children. The coefficient on total nondurable expenditures from this regression is is 0.986 with a standard error of 0.009. Depending on the set of instruments, the set of control variables, whether or not we use total outlays or total nondurable expenditures as the regressor, and the age range of the CEX sample, it is possible to generate coefficients on spending in the range of $\{0.90, 1.10\}$. Our point is not to argue that the CEX data strongly suggest that 1.0 is the exact estimate, but that the CEX data suggest the income elasticity of rental expenditures is at or near 1.0.[9]

[6]This evidence is in line with the findings of Fernandez-Villaverde and Krueger (2005).

[7]In a discussion of our paper, Erik Hurst suggested this approach, and kindly provided both data and Stata programs (with the caveat that any mistakes are our own). The CEX data are available at Mark Aguiar's web site: http://www.markaguiar.com/aguiarhurst/lifecycle/datapage.html.

[8]The instruments are log nominal income, nominal income squared and cubed, and education dummies. We instrument total expenditures because (a) rent is a component of total expenditures, implying a correlation of the two variables if rent is measured with error, and because (b) both rent and total expenditures are determined jointly.

[9]This point has also been made by Piazzesi et. al. (2007).

When the evidence from the CEX is combined with the evidence from the 1980, 1990, and 2000 DCH that at the median, renters spend roughly a constant fraction of their income on rent regardless of location or rental prices, we conclude that expenditure shares on rents are independent of time, location, rental prices, and income. We use this evidence as justification for the assumption that households have Cobb-Douglas preferences for consumption and housing services in our equilibrium model of location choice described in the next section of the paper.

3 Model with Constant Expenditure Shares

Eeckhout (2004) specifies a multi-city environment where households have Cobb-Douglas preferences over consumption and housing in order to study the size distribution of places. We use a similar framework, but focus on the cross-sectional distribution of housing rents.

3.1 Environment

We consider an economy with N MSAs indexed by $i = 1, \ldots, N$. The economy is populated by a measure μ of identical agents. The decision problem of agents in this economy is static and thus we suppress time subscripts. Any agent who lives in MSA i produces w_i units of food, the numeraire consumption good. There are H_i units of divisible housing in MSA i owned by a measure zero of agents who behave competitively in the rental housing market.

Agents choose in which MSA to live, how much food to consume and how much housing to rent. Given a set of housing rental prices for each MSA, $\{r_i\}_{i=1,N}$, agents choose the MSA i, food consumption c and housing h that solve the following problem:

$$\max_{i,c,h} \quad c^{1-\alpha}\ h^{\alpha} \tag{5}$$

$$\text{subject to} \quad c + r_i\ h \leq w_i, \tag{6}$$

with $0 < \alpha < 1$. All agents who choose the same MSA i choose the same numeraire and housing levels $c_i = (1 - \alpha)\ w_i$ and $h_i = \alpha\ w_i / r_i$.

An allocation is fully characterized by the set of food consumption and housing chosen by agents in each MSA , $\{c_i, h_i\}_{i=1,N}$ and the measures of agents living in each MSA, $\{n_i\}_{i=1,N}$. An equilibrium in this economy is a set of rental prices $\{r_i\}_{i=1,N}$, and an allocation such that: (1) Agents maximize their utility taking the rental prices as given; (2) In every MSA that is occupied, the housing market clears; i.e., $n_i \; h_i = H_i$ if $n_i > 0$; (3) No household wants to move, i.e. all agents derive the same utility whatever MSA they choose.

We restrict our attention to sets of parameters such that all MSAs are occupied in equilibrium. Rearranging the market clearing conditions and summing over all MSAs yield:

$$\sum_{i=1}^{N} n_i = \sum_{i=1}^{N} H_i/h_i = \mu. \tag{7}$$

The condition that agents are indifferent between living in MSAs i and j means:

$$\left[(1-\alpha)\, w_i\right]^{1-\alpha} \left[h_i\right]^{\alpha} = \left[(1-\alpha)\, w_j\right]^{1-\alpha} \left[h_j\right]^{\alpha} \tag{8}$$

where we replace food consumption using the solution to the agents' utility maximization problem. Rearranging, we obtain:

$$\frac{h_i}{h_j} = \left(\frac{w_i}{w_j}\right)^{\frac{\alpha-1}{\alpha}} . \tag{9}$$

Combining this equation with equation (7) yields the equilibrium housing in each MSA:

$$h_i = \frac{\left(\sum\limits_{k=1}^{N} H_k \; w_k^{\frac{1-\alpha}{\alpha}}\right)}{\mu \; w_i^{\frac{1-\alpha}{\alpha}}} . \tag{10}$$

Plugging this equation into the solution to the agent's optimal housing choice then yields the equilibrium rental prices:

$$r_i = \frac{\mu \; \alpha \; w_i^{\frac{1}{\alpha}}}{\left(\sum\limits_{k=1}^{N} H_k \; w_k^{\frac{1-\alpha}{\alpha}}\right)} . \tag{11}$$

The equilibrium measures of households for each MSA are then trivial to obtain:

$$n_i = \frac{\mu \; H_i \; w_i^{\frac{1-\alpha}{\alpha}}}{\left(\sum\limits_{k=1}^{N} H_k \; w_k^{\frac{1-\alpha}{\alpha}}\right)} . \tag{12}$$

3.2 Predictions

The model predicts that the optimal expenditure share on housing is constant at α in every MSA. Equations (11) and (12) can be combined to show that at the aggregate level, the model produces a constant ratio of rental expenditures to income,

$$\frac{\sum_i r_i H_i}{\sum_i n_i w_i} = \alpha \ . \tag{13}$$

The model also predicts that the ratio of average rental price per unit to aggregate per-capita income is independent of the dispersion of income across MSAs. Rather, the ratio of average rental price per unit to aggregate per-capita income is equal to the expenditure share on housing divided by the average quantity of housing consumed per-household:

$$\frac{\left(\frac{\sum_i r_i H_i}{\sum_i H_i}\right)}{\left(\frac{\sum_i n_i w_i}{\sum_i n_i}\right)} = \alpha \left(\frac{\sum_i H_i}{\mu}\right)^{-1} . \tag{14}$$

The model also predicts that the ratio of rental prices between any two MSAs i and j depends disproportionately on the ratio of their incomes. Working with equation (11), it is easy to show that

$$\frac{r_i}{r_j} = \left(\frac{w_i}{w_j}\right)^{\frac{1}{\alpha}} \ . \tag{15}$$

The intuition behind this result is straightforward. In equilibrium, the following condition must hold to ensure that agents are indifferent to living in any two MSAs i and j:

$$c_i^{1-\alpha} h_i^{\alpha} = c_j^{1-\alpha} h_j^{\alpha} \ . \tag{16}$$

Now, suppose that residents of city i earn more income than residents in city j. This implies (from Cobb-Douglas preferences) that c_i is larger than c_j. However, if $c_i > c_j$ then $h_i < h_j$ for equation (16) to hold. Since consumption and housing are complements in utility, rental prices must be relatively high in the high-income MSA.

Equation (15) also implies that the supply of housing in MSA i or j does not affect the relative rental price of housing, r_i/r_j. Thus, according to the model, San Francisco is not expensive relative to, say, Pittsburgh because of supply restrictions enacted in San Francisco or growth policies in Pittsburgh. Of course, the supply of housing in MSA i, H_i, determines the rental price of housing r_i through the term $\left(\sum_{k=1}^{N} H_k \, w_k^{\frac{\alpha}{1-\alpha}}\right)$ in equation (11), just as the supply of housing in any other MSA. The model predicts that changes in the supply of housing in any MSA affects the price level of housing in every MSA. However, with Cobb-Douglas preferences, the relative price of housing of any two MSAs is independent of the level of supply in any MSA.

The result that the relative price of housing between any two cities is independent of supply in any city depends critically on the assumption of Cobb-Douglas preferences. Consider, for example, a multi-city model like the one we have studied, but the specification that agents receive quasi-linear utility of consumption and housing in that city of the form $c - 1/h$.[10] It is easy to show that agents optimally set $h_i = \sqrt{\frac{1}{r}}$ in any MSA i given a standard budget constraint of $c_i + r_i h_i = w_i$. This implies that the expenditure share on housing, $r_i h_i / w_i$, is not constant across MSAs but equal to $\sqrt{r_i}/w_i$.

After substitution, indifference across any two MSAs i and k requires:

$$\frac{w_i - w_k}{2} = \frac{1}{h_i} - \frac{1}{h_k} \,. \tag{17}$$

After substituting $h_k = H_k/n_k$, summing over all k MSAs, and rearranging terms we uncover

$$\frac{w_i \sum_{k=1}^{N} H_k - \sum_{k=1}^{N} w_k H_k + 2\mu}{2 \sum_{k=1}^{N} H_k} = \frac{1}{h_i} \,, \tag{18}$$

where μ is the total population living in all k MSAs. Since $\sqrt{r_i} = 1/h_i$, the relative price of MSAs i and j is

$$\left(\frac{w_i \sum_{k=1}^{N} H_k - \sum_{k=1}^{N} w_k H_k + 2\mu}{w_j \sum_{k=1}^{N} H_k - \sum_{k=1}^{N} w_k H_k + 2\mu}\right)^2 = \frac{r_i}{r_j} \,. \tag{19}$$

[10]Two recent papers that assume quasi-linear preferences for consumption and housing (or land) are Van Nieuwerburgh and Weill (2007) and Coen-Pirani (2008).

Thus, when agents have quasi-linear utility, changes in the supply of housing in any MSA affect the relative price of housing between any two MSAs, unlike the results with Cobb-Douglas utility.

4 Model Fit

After taking logs of equation (15), and recognizing that equation (15) holds for any j, the following expression links rental prices and wages in MSA i to the average across all MSAs:

$$\log(r_i) - \frac{1}{N}\sum_{j=1}^{N}\log(r_j) = \frac{1}{\alpha}\left[\log(w_i) - \frac{1}{N}\sum_{j=1}^{N}\log(w_j)\right] . \tag{20}$$

Given this, we define $\bar{r}$ and $\bar{w}$ such that

$$\bar{r} = \exp\left(\frac{1}{N}\sum_{j=1}^{N}\log(r_j)\right) \tag{21}$$

$$\bar{w} = \exp\left(\frac{1}{N}\sum_{j=1}^{N}\log(w_j)\right) \tag{22}$$

and construct a predicted rental value in each MSA, $\widehat{r}_i$, as

$$\widehat{r}_i = \bar{r}\left(\frac{w_i}{\bar{w}}\right)^{\frac{1}{\alpha}} . \tag{23}$$

We test the model by setting $\alpha = 0.24$ and comparing the predicted value to the observed value r_i for the year 2000.[11]

In order to operationalize equation (23), we need to compute a standardized measure of income, w_i, appropriate for each MSA. To do this, we turn to micro data from the 2000 DCH. On an MSA-by-MSA basis, we run a Mincer-style regression of the log of reported wage and salary income for any person that worked at least 40 weeks in the previous year on a constant and a set of human capital variables. These variables include gender, age variables in 5-year bins, and categorical variables for educational attainment (nothing or missing, less than high school degree, high school degree, some

[11] Qualitatively, the results for 1980 and 1990 are identical to those that we document for 2000.

college, college degree or more). These log wage regressions capture about 30 percent of the variation in log wages within each MSA.

By regressing wages on age and education variables, we control for the variation in within-MSA wages that is attributable to differences in human capital. We use wage and salary income, rather than a broader measure that includes transfer or capital income, to focus on income-earning potential that is location specific. We consider only income of persons working 40 weeks or more the previous year to abstract from differences in average wages across MSAs that are attributable to differences in the number of part-time workers.

To compute a standardized wage that holds age and human capital constant across locations, we multiply the estimated regression coefficients in each MSA by the the fraction of workers for the entire U.S. that are appropriate for each dummy variable in the regression. Once we have computed this standardized wage for a representative full-time worker in each MSA, we multiply by 1.53 to compute average household income in that MSA; this is the average number of full time workers in each household, for all households that include at least one full time worker.

Our procedure to estimate constant quality rental prices r_i consistently across MSAs is conceptually similar. On an MSA-by-MSA basis, we regress the level of gross rents paid by renting households on available characteristics of the housing unit and the method and time of commute (home to work) of the highest income earner in the household. For housing-unit characteristics, we include categorical variables describing the number of rooms, the number of bedrooms, the year the unit was built, and the total number of units in the building in which the unit is located, and from these categorical variables, we generate a full set of dummy variables. For the method of commute of the household's highest income earner, we subdivide responses into three dummy variables corresponding to the use of private automobiles, public transportation, or walking/biking. For commute time of the highest income earner, we use the recorded response.[12] These rent regressions capture about 25 percent of the variation in reported rental expenditures within each MSA.

[12]We create a separate dummy variable for households with a recorded commute of zero minutes.

Using the regression coefficients for each MSA, we predict the level of rent, by MSA, for a four-room, two-bedroom unit located in a 5-9 family building, where the primary wage earner commutes 15 minutes by private auto. The building itself is assumed to have been built between 1960 and 1969. These are the median readings of these variables for our sample of renting households in the U.S.

Our estimates of standardized wages and rental prices, w_i and r_i, for the year 2000 are listed in the first two columns of Table 2, which is sorted in descending order by standardized wages. Rental prices are high in high-wage places: The correlation of rental prices and wages is 0.81. The third and fourth columns of the table show predicted rental prices based on equation (23), $\widehat{r}_i$, and the difference of the observed and predicted rental rate, denoted e_i. These two columns show that the model predicts *too much* dispersion in rental prices given the observed wage dispersion. The correlation of e_i and w_i is -0.92. Rental prices are not high enough in high-wage places and rental prices are too high in low wage places.

We perform two sensitivity analysis to ensure that this finding of a negative correlation is a robust feature of data. First, we eliminate home-owners from our regressions and computations of MSA-average wages, so that MSA-specific calculations of r_i and w_i are from exactly the same samples of renting households. Second, and separately, we include only households where (a) the primary respondent of the household has moved to a different metropolitan area within the past 5 years and (b) the previous metropolitan area of residence is directly identifiable. Although our estimates of w_i change in the first analysis, and w_i and r_i both change in the second analysis, in both analyses we find that the correlation of e_i and w_i is approximately -0.9.

One question that arises is whether a small change in α more closely aligns predicted rental rates with observed rental rates. It is possible to show that potentially reasonable changes to α are not sufficient to drive the correlation of e_i and w_i to zero. For example, at $\alpha = 0.35$, the correlation of e_i and w_i is -0.65. When $\alpha = 0.52$, the correlation falls to zero.

Thus, our finding that w_i and e_i are negatively correlated seems quite robust, since in economic terms, expenditure shares of fifty percent are far from the 24 percent we estimate. However, it some fraction of consumption is produced locally, and the prices of locally-produced consumption goods are correlated with wages, then wages after accounting for variation in consumption prices are likely less dispersed than nominal wages (Albouy 2007). If wages are less dispersed, predicted rental prices will also be less dispersed holding α constant.

Data on local consumption prices in 2000 by MSA is available from the 2000 ACCRA (American Chamber of Commerce Researchers Association) Cost of Living Index, as published by the Council for Community and Economic Research. ACCRA participants collect price-level data on 59 non-housing items, grouped broadly into 5 non-housing categories – Grocery (26 questions), Utilities (6), Transportation (2), Health care (5), and Miscellaneous (20). The questions range from the price of a box of Corn Flakes (Grocery) to the average price per game of bowling on Saturday evening between 6 and 10 pm (Miscellaneous).[13] For each of these 5 categories, ACCRA constructs a local price level based on the sample of prices of the individual items, and sets the average price level across sampled MSAs for each of the 6 categories to 100. ACCRA also reports expenditure shares for each of the categories in 2000: Grocery (0.16), Utilities (0.08), Transportation (0.10), Health Care (0.05), and Miscellaneous (0.33).

To explicitly incorporate local prices in our model, and in a manner that is consistent with the construction of the ACCRA data, we assume that households have Cobb-Douglas preferences over a bundle of S consumption goods and housing. That is, utility in city i is assumed to be of the form

$$\left(\prod_{s=1}^{S} c_{i,s}^{\beta_s}\right) h_i^{\alpha} \ , \tag{24}$$

and households are subject to the budget constraint

$$\sum_{s=1}^{S} p_{i,s}\ c_{i,s} \ + \ r_i h_i \ \leq \ w_i \ , \tag{25}$$

where we assume that $\sum_{s=1}^{S} \beta_s + \alpha = 1$. With Cobb-Douglas preferences, households optimally choose constant expenditure shares on the bundle of all consumption items and housing, $p_{i,s} c_{i,s} = \beta_s w_i$ and $r_i h_i = \alpha w_i$.

[13]The complete list of questions is available at *http://www.coli.org/SurveyForms/PricingSurveyForm.pdf*.

Given the assumptions, in equilibrium the following relationship holds between rental prices, wages, and consumption prices in any two MSAs i and j:

$$\left(\frac{r_i}{r_j}\right) = \left(\frac{\widetilde{w_i}}{\widetilde{w_j}}\right)^{\frac{1}{\alpha}}, \tag{26}$$

where

$$\widetilde{w_k} = \frac{w_k}{\prod_{s=1}^{S} p_{k,s}^{\beta_s}}. \tag{27}$$

After adjusting nominal wages for consumption prices, as in equation (27), we predict rental prices using an equation like (23), with w_k replaced by $\widetilde{w_k}$ and with $\bar{r}_i$ and $\bar{w}_i$ appropriately redefined.

We compute $\prod_{s=1}^{S} p_{i,s}^{\beta_s}$ for 48 of our 50 MSAs, the exceptions being Buffalo, NY and Bakersfield, CA.[14] We match the ACCRA metropolitan division codes to the relevant MSAs, but for about 10 of the larger MSAs, the ACCRA survey only covers a subset of metropolitan divisions within the MSA. We suspect this distinction is probably not of quantitative importance, except perhaps for the New York MSA, in which we find the level of consumption prices is about 13 percent higher than the next-most pricey MSA, San Francisco.[15] We assume households consume a basket of $S = 5$ consumption items – groceries, utilities, transportation, health care, and miscellaneous – and proportionately rescale each of the 5 ACCRA expenditure shares so that the sum $\sum_{s=1}^{5} \beta_s = 0.76$, which yields a 24 percent expenditure share on housing.

For the MSAs in our sample, Table 3 shows nominal wages, w_i, our estimate of consumption prices, $p_i = \prod_{s=1}^{S} p_{i,s}^{\beta_s}$ (after a simple rescaling such that the average of p_i across MSAs is equal to 1.0), wages after adjusting for prices as in equation (27), $\widetilde{w_i}$, actual rental prices, r_i, and predicted rental prices after wages have been adjusted for consumption prices, $\widetilde{r_i}$. Like Table 2, Table 3 is sorted in descending order of nominal wages. The correlation of nominal wages and consumption price levels (p_i) is high,

[14] ACCRA also does not provide consumption price data for San Jose but in this case we set the consumption prices equal to those in San Francisco.

[15] In the New York MSA, the only included metropolitan division (of four in total) is the "New York-White Plains-Wayne" division.

0.54. Even so, Table 3 shows that, on average, rental prices are still too low in places that offer relatively high wages after accounting for consumption prices: At $\alpha = 0.24$, the correlation of the gap between actual and predicted rental prices, e_i, and adjusted income, $\widetilde{w_i}$, shown in Table 3 is -0.74. Further, the value of α required to set this correlation to zero is 0.76.

A final and related point is that we are aware we can more accurately predict rental prices given the distribution of wages if we are willing to redefine household utility. Ignoring variation in local consumption prices, suppose utility in city i is defined as $z_i c_i^{1-\alpha} h_i^{\alpha}$. In equilibrium, indifference across MSAs requires

$$\frac{r_i}{r_j} = \left(\frac{z_i \; w_i}{z_j \; w_j} \right)^{\frac{1}{\alpha}} . \tag{28}$$

Whatever z_i is, assuming $\alpha = 0.24$, it must be negatively correlated with wages. It could perhaps be a “quality of life” variable, as in Kahn (1995), Rappaport (2006), or Albouy (2007), or perhaps could be related to congestion externalities linked to density. Rather than tell a story about z_i, we note the following: Without z_i, a simple model of location choice that reproduces the observation that housing expenditure shares are constant across locations predicts that rental prices of the highest-wage MSAs are higher that currently observed.

5 Extension: House Prices in San Francisco and Pittsburgh

Given that households in this model have no savings, then the dynamic version of this model is equivalent to the repeated static model. To add dynamics to the baseline model, index rents and wages by time. The ratio of rental prices in any two MSAs at time t is

$$\frac{r_{i,t}}{r_{j,t}} = \left[\frac{w_{i,t}}{w_{j,t}} \right]^{\frac{1}{\alpha}} . \tag{29}$$

Suppose now that wages in MSA i increase at rate $1+g_i$ and wages in MSA j increase at rate $1+g_j$, where g_j does not have to equal g_i. This implies:

$$\frac{r_{i,t+1}}{r_{j,t+1}} = \left[\frac{w_{i,t}\,(1+g_i)}{w_{j,t}\,(1+g_j)}\right]^{\frac{1}{\alpha}} = \left(\frac{r_{i,t}}{r_{j,t}}\right)\left(\frac{1+g_i}{1+g_j}\right)^{\frac{1}{\alpha}} . \tag{30}$$

Denote the growth rate of rents in MSA i as γ_i and the growth rate of rents in MSA j as γ_j. Then equation (30) implies

$$\frac{1+\gamma_i}{1+\gamma_j} = \left(\frac{1+g_i}{1+g_j}\right)^{\frac{1}{\alpha}} . \tag{31}$$

In words, for each percentage point that income in i outpaces income in j, rental prices in i outpace rental prices in j by approximately $1/\alpha$ percentage points. Assuming $\alpha = 0.24$, then each percentage point differential in wage growth translates to a 4.2 percentage point differential in rental growth.

The intuition that small differences in income can lead to much larger differences in rental prices might help explain why the ratio of house prices to incomes vary widely across the country. According to data from the 2000 DCH, in 2000 the ratio of house value to income was roughly 4.6 in San Francisco and 2.6 in Pittsburgh.[16] A more traditional metric of valuation studied in real-estate finance is the ratio of housing rents to house prices, the "rent-price" ratio. Campbell et. al. (2008) show that the rent-price ratio for owner-occupied housing was 5.2% for Pittsburgh and 3.2% in San Francisco in 2000.

According to the classic dividend discounting model, the rent-price ratio is simply a required return less an expected rate of growth. Suppose the required return to housing is the same in both areas.[17] Then, the available data suggest that in 2000, the expected growth rate of rents was 2.0 (=5.2 - 3.2) percentage points per year higher

[16]For example, according to data from the 2000 DCH, (2007), the median single-family house was valued at about $325,000 in San Francisco whereas a similar structure was valued on average at about $115,000 in Pittsburgh. In the same year, wage and salary income for the median homeowner in Pittsburgh was about $45,000 and about $70,000 in San Francisco.

[17]Of course, an argument that can be made is that housing in San Francisco is less (more) risky and thus requires a lower (higher) return than Pittsburgh.

in San Francisco than in Pittsburgh. Equation (31) tells us that each percentage point differential in income growth leads to a 4.2 percent differential in rental growth. Thus, income growth need only be 0.5 percent per year faster in San Francisco than in Pittsburgh to generate a 2 percentage point per year differential in rental growth. Obviously, we do not know if this is a reasonable expectation going forward from 2000, however it is well within recent historical experience. According to the 1980 and 2000 DCH, over the 1980-2000 the wage and salary income of renters within 1 percentage point of the median expenditure share in San Francisco increased by 1.8 percentage points per year more rapidly than the wage and salary income of renters within one percentage point of the median expenditure share in Pittsburgh.[18]

6 Conclusions

We use micro data from the 1980, 1990, and 2000 DCH to document that the expenditure share on housing is remarkably constant across MSAs and over time. We study the equilibrium properties for housing rents of a simple model consistent with this observation. A key distinguishing feature of our general spatial equilibrium model, relative to many papers in the urban economics and local public finance literatures, is our use of Cobb-Douglas preferences. This assumption yields a constant housing expenditure share in equilibrium, consistent with the evidence we uncover. The same assumption has been used to explain the distribution of population across places (Eeckhout 2004) and to study the internal structure of cities (Lucas 2001 and Lucas and Rossi-Hansberg 2002).

Our multi-location model predicts that in the aggregate, the ratio of rental price-per-unit to per-capita income is constant as long as the aggregate stock of housing per capita is also constant. This is a common result of macroeconomic models when households have Cobb-Douglas utility. We show that this result does not hold at the

[18] The average income of renters within one percentage point of the median expenditure share in Pittsburgh was \$14,089 in 1980 and \$31,872 in 2000. The estimates for San Francisco are \$16,277 in 1980 and \$52,422 in 2000.

MSA level; instead, rental prices disproportionately reflect income differentials. We conclude that the intuition – commonly assumed by policy-makers and housing-market commentators – that local house price indexes should increase at the same rate as local per-capita income is incorrect whenever income growth differs across MSAs.

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Figure 1: 1980, 1990, 2000 DCH: Coefficients of Regression Output of Age on the Deviations of Log Inverse of Expenditure Share

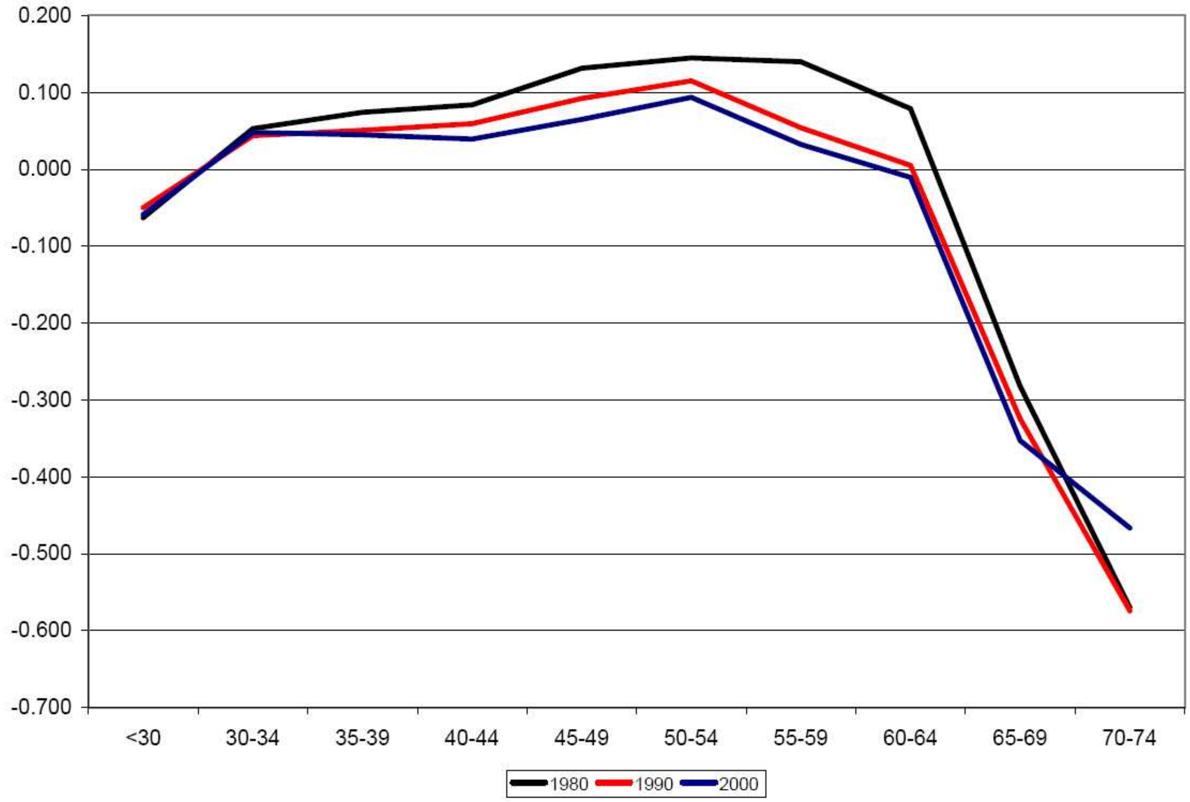

Table 1
Median Ratio of Rental Expenditures to Wage and Salary Income, 1980, 1990, and 2000,
Average Income around Median Ratio (2000), Growth in Real Rental Prices (1980-2000)

	Median Ratio			HH Inc. at Median	Real Rent Growth,
MSA	1980	1990	2000	Rent-Income (2000)	1980-2000
Albany-Schenectady-Troy	0.21	0.23	0.23	$32,035	15.9%
Atlanta-Sandy Springs-Marietta	0.24	0.25	0.25	$37,304	24.6%
Austin-Round Rock	0.27	0.25	0.25	$35,948	42.2%
Bakersfield	0.28	0.25	0.25	$29,860	2.7%
Baltimore-Towson	0.23	0.23	0.23	$35,076	34.8%
Boston-Cambridge-Quincy	0.24	0.26	0.24	$43,284	53.4%
Buffalo-Niagara Falls	0.20	0.22	0.23	$32,368	21.2%
Charlotte-Gastonia-Concord	0.23	0.24	0.24	$39,772	27.5%
Chicago-Naperville-Joliet	0.21	0.23	0.23	$38,677	33.5%
Cincinnati-Middletown	0.21	0.22	0.20	$35,685	5.6%
Cleveland-Elyria-Mentor	0.21	0.22	0.23	$34,058	4.8%
Columbus	0.22	0.23	0.23	$31,981	37.8%
Dallas-Fort Worth-Arlington	0.24	0.24	0.24	$36,540	32.7%
Denver-Aurora	0.25	0.24	0.26	$36,804	19.2%
Detroit-Warren-Livonia	0.21	0.22	0.22	$36,719	6.9%
Fresno	0.25	0.27	0.26	$28,924	13.3%
Grand Rapids-Wyoming	0.19	0.24	0.21	$28,742	16.8%
Greensboro-High Point	0.24	0.23	0.22	$32,231	23.8%
Houston-Sugar Land-Baytown	0.23	0.22	0.23	$35,205	7.4%
Indianapolis-Carmel	0.21	0.23	0.23	$33,158	8.4%
Jacksonville	0.27	0.24	0.25	$31,737	4.2%
Kansas City	0.21	0.22	0.22	$36,521	21.7%
Las Vegas-Paradise	0.29	0.27	0.27	$34,275	19.6%
Los Angeles-Long Beach-Santa Ana	0.25	0.29	0.27	$38,494	36.9%
Louisville-Jefferson County	0.22	0.23	0.21	$33,518	4.6%
Miami-Fort Lauderdale-Pompano Beach	0.27	0.29	0.29	$29,604	24.7%
Milwaukee-Waukesha-West Allis	0.20	0.23	0.22	$33,662	12.5%
Minneapolis-St. Paul-Bloomington	0.24	0.25	0.23	$37,011	19.1%
Nashville-Davidson-Murfreesboro-Franklin	0.23	0.24	0.24	$31,590	23.8%
New Orleans-Metairie-Kenner	0.24	0.25	0.24	$28,713	24.4%
New York-Northern New Jersey-Long Island	0.22	0.24	0.24	$45,805	38.6%
Orlando-Kissimmee	0.26	0.27	0.27	$33,704	40.9%
Philadelphia-Camden-Wilmington	0.22	0.24	0.23	$38,491	32.9%
Phoenix-Mesa-Scottsdale	0.28	0.26	0.26	$34,026	9.1%
Pittsburgh	0.21	0.21	0.22	$31,872	10.5%
Portland-Vancouver-Beaverton	0.27	0.24	0.25	$33,893	19.3%
Riverside-San Bernardino-Ontario	0.26	0.28	0.27	$35,622	17.8%
Sacramento-Arden-Arcade-Roseville	0.25	0.28	0.26	$35,352	39.0%
St. Louis	0.22	0.23	0.22	$33,966	4.2%
Salt Lake City	0.24	0.23	0.27	$32,980	23.2%
San Antonio	0.22	0.24	0.24	$30,686	14.1%
San Diego-Carlsbad-San Marcos	0.29	0.30	0.28	$36,050	38.5%
San Francisco-Oakland-Fremont	0.26	0.28	0.25	$52,422	70.8%
San Jose-Sunnyvale-Santa Clara	0.24	0.26	0.25	$58,680	110.4%
Seattle-Tacoma-Bellevue	0.25	0.25	0.26	$39,303	33.8%
Syracuse	0.24	0.24	0.24	$28,248	16.6%
Tampa-St. Petersburg-Clearwater	0.26	0.25	0.25	$32,972	22.9%
Tucson	0.26	0.29	0.26	$30,111	-2.6%
Tulsa	0.23	0.22	0.23	$29,600	1.2%
Washington-Arlington-Alexandria	0.23	0.26	0.24	$47,994	46.4%
Average	0.24	0.25	0.24	$35,425	24.2%
Standard Deviation	0.02	0.02	0.02	$5,867	19.5%

Table 1a

25th and 75th Percentiles of Ratio of Rental Expenditures to Wage and Salary Income, 1980, 1990, and 2000

	1980		1990		2000	
MSA	25th	75th	25th	75th	25th	75th
Albany-Schenectady-Troy	0.15	0.33	0.16	0.33	0.15	0.35
Atlanta-Sandy Springs-Marietta	0.17	0.35	0.19	0.38	0.17	0.37
Austin-Round Rock	0.19	0.44	0.18	0.37	0.18	0.40
Bakersfield	0.17	0.36	0.17	0.41	0.16	0.40
Baltimore-Towson	0.16	0.34	0.16	0.35	0.16	0.35
Boston-Cambridge-Quincy	0.17	0.35	0.18	0.40	0.16	0.37
Buffalo-Niagara Falls	0.14	0.29	0.15	0.33	0.16	0.37
Charlotte-Gastonia-Concord	0.17	0.37	0.17	0.34	0.17	0.35
Chicago-Naperville-Joliet	0.14	0.31	0.16	0.34	0.16	0.36
Cincinnati-Middletown	0.15	0.29	0.15	0.33	0.14	0.31
Cleveland-Elyria-Mentor	0.15	0.32	0.15	0.32	0.16	0.36
Columbus	0.16	0.31	0.16	0.33	0.16	0.34
Dallas-Fort Worth-Arlington	0.17	0.33	0.18	0.35	0.17	0.34
Denver-Aurora	0.18	0.37	0.18	0.35	0.18	0.39
Detroit-Warren-Livonia	0.15	0.31	0.16	0.35	0.14	0.33
Fresno	0.16	0.39	0.19	0.44	0.18	0.40
Grand Rapids-Wyoming	0.14	0.32	0.17	0.35	0.15	0.33
Greensboro-High Point	0.16	0.36	0.17	0.35	0.15	0.32
Houston-Sugar Land-Baytown	0.16	0.34	0.16	0.32	0.16	0.34
Indianapolis-Carmel	0.15	0.32	0.16	0.32	0.15	0.34
Jacksonville	0.18	0.39	0.18	0.35	0.18	0.37
Kansas City	0.15	0.33	0.16	0.33	0.16	0.32
Las Vegas-Paradise	0.20	0.47	0.19	0.38	0.17	0.41
Los Angeles-Long Beach-Santa Ana	0.17	0.39	0.20	0.45	0.18	0.44
Louisville-Jefferson County	0.14	0.32	0.16	0.36	0.15	0.31
Miami-Fort Lauderdale-Pompano Beach	0.19	0.43	0.20	0.45	0.19	0.45
Milwaukee-Waukesha-West Allis	0.15	0.30	0.17	0.35	0.15	0.34
Minneapolis-St. Paul-Bloomington	0.17	0.34	0.18	0.37	0.17	0.34
Nashville-Davidson-Murfreesboro-Franklin	0.16	0.33	0.17	0.34	0.17	0.35
New Orleans-Metairie-Kenner	0.16	0.38	0.17	0.41	0.17	0.40
New York-Northern New Jersey-Long Island	0.15	0.33	0.16	0.37	0.15	0.38
Orlando-Kissimmee	0.18	0.37	0.19	0.39	0.19	0.42
Philadelphia-Camden-Wilmington	0.16	0.34	0.18	0.36	0.16	0.35
Phoenix-Mesa-Scottsdale	0.20	0.45	0.19	0.40	0.18	0.39
Pittsburgh	0.15	0.31	0.14	0.33	0.15	0.37
Portland-Vancouver-Beaverton	0.18	0.41	0.17	0.34	0.18	0.38
Riverside-San Bernardino-Ontario	0.18	0.41	0.20	0.42	0.18	0.43
Sacramento-Arden-Arcade-Roseville	0.17	0.37	0.20	0.41	0.17	0.39
St. Louis	0.16	0.35	0.16	0.33	0.16	0.35
Salt Lake City	0.17	0.40	0.17	0.34	0.17	0.39
San Antonio	0.16	0.34	0.18	0.35	0.17	0.36
San Diego-Carlsbad-San Marcos	0.20	0.45	0.21	0.46	0.19	0.44
San Francisco-Oakland-Fremont	0.18	0.39	0.19	0.41	0.17	0.39
San Jose-Sunnyvale-Santa Clara	0.18	0.36	0.20	0.39	0.18	0.39
Seattle-Tacoma-Bellevue	0.18	0.36	0.18	0.36	0.18	0.39
Syracuse	0.16	0.37	0.17	0.35	0.16	0.38
Tampa-St. Petersburg-Clearwater	0.18	0.41	0.19	0.37	0.18	0.37
Tucson	0.19	0.40	0.20	0.42	0.19	0.44
Tulsa	0.18	0.36	0.15	0.34	0.16	0.35
Washington-Arlington-Alexandria	0.16	0.33	0.19	0.36	0.17	0.35
Average	0.17	0.36	0.17	0.37	0.17	0.37
Standard Deviation	0.02	0.04	0.02	0.04	0.01	0.03

Table 2

Wages (w_i), observed rents (r_i), predicted rents ($\hat{r}_i$), and error ($e_i = r_i - \hat{r}_i$), 2000

MSA	w_i	r_i	$\hat{r}_i$	e_i
San Jose-Sunnyvale-Santa Clara	$73,095	$1,266	$2,005	-$739
San Francisco-Oakland-Fremont	$65,618	$1,030	$1,279	-$249
New York-Northern New Jersey-Long Island	$65,272	$797	$1,251	-$454
Washington-Arlington-Alexandria	$63,868	$825	$1,143	-$318
Boston-Cambridge-Quincy	$62,209	$887	$1,024	-$137
Chicago-Naperville-Joliet	$61,805	$727	$997	-$269
Detroit-Warren-Livonia	$61,750	$680	$993	-$313
Philadelphia-Camden-Wilmington	$59,862	$748	$873	-$125
Dallas-Fort Worth-Arlington	$59,476	$612	$849	-$237
Los Angeles-Long Beach-Santa Ana	$58,933	$867	$818	$50
Atlanta-Sandy Springs-Marietta	$58,703	$655	$804	-$149
Houston-Sugar Land-Baytown	$58,678	$606	$803	-$197
Seattle-Tacoma-Bellevue	$58,612	$785	$799	-$14
Baltimore-Towson	$58,351	$694	$784	-$90
Charlotte-Gastonia-Concord	$57,836	$625	$756	-$131
Denver-Aurora	$57,676	$633	$747	-$115
Minneapolis-St. Paul-Bloomington	$57,272	$655	$726	-$71
Sacramento-Arden-Arcade-Roseville	$56,525	$613	$687	-$74
Austin-Round Rock	$56,389	$672	$680	-$9
Cincinnati-Middletown	$55,831	$519	$653	-$134
Las Vegas-Paradise	$55,831	$636	$653	-$17
Phoenix-Mesa-Scottsdale	$55,813	$622	$652	-$30
Indianapolis-Carmel	$55,437	$562	$634	-$72
San Diego-Carlsbad-San Marcos	$55,296	$754	$627	$127
Kansas City	$55,152	$633	$620	$12
Cleveland-Elyria-Mentor	$55,128	$544	$619	-$75
Riverside-San Bernardino-Ontario	$55,034	$593	$615	-$22
Portland-Vancouver-Beaverton	$54,878	$617	$607	$10
Milwaukee-Waukesha-West Allis	$54,463	$625	$589	$37
Louisville-Jefferson County	$53,942	$447	$565	-$118
Columbus	$53,773	$602	$558	$44
St. Louis	$53,678	$548	$554	-$5
Grand Rapids-Wyoming	$53,477	$504	$545	-$42
Jacksonville	$53,000	$561	$525	$36
Nashville-Davidson-Murfreesboro-Franklin	$52,972	$538	$524	$14
Greensboro-High Point	$52,696	$509	$513	-$4
Tampa-St. Petersburg-Clearwater	$52,505	$622	$505	$117
Bakersfield	$52,436	$459	$502	-$43
Salt Lake City	$52,086	$584	$489	$96
Albany-Schenectady-Troy	$51,569	$642	$469	$174
Tulsa	$51,329	$502	$460	$42
Orlando-Kissimmee	$50,795	$634	$440	$194
Miami-Fort Lauderdale-Pompano Beach	$50,172	$722	$418	$304
Syracuse	$49,600	$557	$399	$158
San Antonio	$49,505	$560	$395	$165
Fresno	$48,902	$509	$376	$134
New Orleans-Metairie-Kenner	$48,863	$569	$374	$194
Buffalo-Niagara Falls	$48,657	$593	$368	$225
Pittsburgh	$48,496	$538	$363	$175
Tucson	$46,576	$512	$307	$206
Average	$55,596	$644	$679	-$35
Standard Deviation	$5,118	$145	$296	$187

Table 3

Wages (w_i), consumption prices ($p_i = \prod_{s=1}^{S} p_{i,s}^{\beta_s}$), adjusted wages ($\tilde{w}_i$), observed rents ($r_i$), predicted rents based on adjusted wages ($\tilde{r}_i$), and error ($e_i = r_i - \tilde{r}_i$), 2000

MSA	w_i	p_i	$\tilde{w}_i$	r_i	$\tilde{r}_i$	e_i
San Jose-Sunnyvale-Santa Clara	$73,095	1.13	$64,650	$1,266	$1,184	$82
San Francisco-Oakland-Fremont	$65,618	1.13	$58,037	$1,030	$755	$275
New York-Northern New Jersey-Long Island	$65,272	1.26	$51,954	$797	$476	$321
Washington-Arlington-Alexandria	$63,868	1.04	$61,679	$825	$973	-$148
Boston-Cambridge-Quincy	$62,209	1.08	$57,514	$887	$727	$160
Chicago-Naperville-Joliet	$61,805	1.02	$60,576	$727	$903	-$175
Detroit-Warren-Livonia	$61,750	0.99	$62,625	$680	$1,037	-$357
Philadelphia-Camden-Wilmington	$59,862	1.04	$57,481	$748	$726	$22
Dallas-Fort Worth-Arlington	$59,476	0.98	$60,838	$612	$919	-$307
Los Angeles-Long Beach-Santa Ana	$58,933	1.03	$57,166	$867	$709	$158
Atlanta-Sandy Springs-Marietta	$58,703	0.97	$60,640	$655	$907	-$252
Houston-Sugar Land-Baytown	$58,678	0.94	$62,416	$606	$1,023	-$417
Seattle-Tacoma-Bellevue	$58,612	0.98	$59,509	$785	$838	-$53
Baltimore-Towson	$58,351	0.95	$61,279	$694	$947	-$253
Charlotte-Gastonia-Concord	$57,836	0.97	$59,900	$625	$862	-$237
Denver-Aurora	$57,676	0.98	$58,642	$633	$789	-$156
Minneapolis-St. Paul-Bloomington	$57,272	1.02	$55,919	$655	$647	$8
Sacramento-Arden-Arcade-Roseville	$56,525	1.06	$53,115	$613	$522	$91
Austin-Round Rock	$56,389	0.92	$61,390	$672	$954	-$283
Cincinnati-Middletown	$55,831	0.96	$58,197	$519	$764	-$245
Las Vegas-Paradise	$55,831	1.01	$55,195	$636	$613	$23
Phoenix-Mesa-Scottsdale	$55,813	0.98	$57,125	$622	$707	-$85
Indianapolis-Carmel	$55,437	0.95	$58,430	$562	$777	-$215
San Diego-Carlsbad-San Marcos	$55,296	1.06	$52,061	$754	$480	$273
Kansas City	$55,152	0.99	$55,686	$633	$636	-$3
Cleveland-Elyria-Mentor	$55,128	1.03	$53,721	$544	$547	-$3
Riverside-San Bernardino-Ontario	$55,034	1.07	$51,660	$593	$465	$128
Portland-Vancouver-Beaverton	$54,878	0.99	$55,247	$617	$615	$2
Milwaukee-Waukesha-West Allis	$54,463	0.96	$56,938	$625	$697	-$72
Louisville-Jefferson County	$53,942	0.96	$56,197	$447	$660	-$213
Columbus	$53,773	0.96	$55,801	$602	$641	-$39
St. Louis	$53,678	0.96	$55,669	$548	$635	-$86
Grand Rapids-Wyoming	$53,477	1.00	$53,334	$504	$531	-$27
Jacksonville	$53,000	0.95	$55,692	$561	$636	-$75
Nashville-Davidson-Murfreesboro-Franklin	$52,972	0.93	$57,099	$538	$706	-$168
Greensboro-High Point	$52,696	0.94	$55,998	$509	$651	-$142
Tampa-St. Petersburg-Clearwater	$52,505	0.97	$54,109	$622	$564	$58
Bakersfield	$52,436					
Salt Lake City	$52,086	0.98	$53,279	$584	$529	$55
Albany-Schenectady-Troy	$51,569	1.00	$51,524	$642	$460	$182
Tulsa	$51,329	0.94	$54,800	$502	$595	-$93
Orlando-Kissimmee	$50,795	0.97	$52,288	$634	$489	$145
Miami-Fort Lauderdale-Pompano Beach	$50,172	1.03	$48,939	$722	$371	$351
Syracuse	$49,600	1.01	$48,940	$557	$371	$186
San Antonio	$49,505	0.91	$54,521	$560	$582	-$22
Fresno	$48,902	1.04	$47,086	$509	$316	$193
New Orleans-Metairie-Kenner	$48,863	0.99	$49,518	$569	$390	$179
Buffalo-Niagara Falls	$48,657					
Pittsburgh	$48,496	1.01	$47,874	$538	$339	$200
Tucson	$46,576	0.96	$48,304	$512	$351	$161
Average	$55,596	1.00	$55,845	$649	$667	-$18
Standard Deviation	$5,118	0.06	$4,228	$146	$204	$187