The Price-to-income Ratio and the Quality of Life

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Abstract

This paper argues that a cross-city comparison of price-to-income ratios can exaggerate the bubble in high QOL (quality of life) cities. The theory is based on Roback (1982). In high QOL cities people are willing to pay high housing rents and get paid lower wages. This would lead to higher price-to-income ratios even if there were no bubble or irrational expectation on future price growth. We test the theory using data. The challenge is that expected price growth rate may be correlated with QOL across cities. We use our model to disentangle these two effects. Our empirical results show that the QOL bias is significant.

JEL classification: R19, R39

Keywords: Housing Bubble; Price-to-income ratio; Quality of Life.

1 Introduction

The price-to-income ratio has been widely used as a measure for housing market bubble. They assume that there is a reasonable range of housing price that local income can support. They conclude that there is a bubble in housing market if housing price goes up out of

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the range. For example, Demographia (2010) classifies areas with price-to-income ratios greater than 4.5 as severe bubble areas. The bubble is considered to be driven by irrational expectation on future housing price increase.

This paper argues that a cross-city comparison of price-to-income ratios can exaggerate the bubble in high quality of life (QOL) cities. Our theory is based on Roback (1982), which explains wage and rent variations across cities as functions of local consumption and production amenities. QOL can affect the price-to-income ratios through two channels. First, QOL can affect the ratio directly. Workers are willing to pay higher rents and accept lower wages in order to live in high QOL cities (e.g., mild climates, coastal locations). Because housing rent and wage directly affect housing price and income, this leads to higher price-to-income ratios in these cities. Second, QOL can affect the ratio indirectly through production amenities. Suppose that QOL and production amenities are correlated. The productivity effect of on the price-to-income ratio is ambiguous, because high productivity tend to raise both wages and rents. The price-to-income ratios would overstate the bubble in high QOL cities, if both direct and indirect effect affect the price-to-income ratios in the same direction or the direct effect dominates the indirect effect. We call this combined effect of the direct and indirect effects by the fundamental effect, in order to distinguish it from the expectation (or bubble) effect. Note that the expectation of future price growth - a necessary condition for the bubble - does not play any role in the fundamental effects.

Due to the indirect effect, it remains an empirical question whether the price to income ratios would go up with QOL after controlling for expected future price increase. We take the theory to data and estimate this QOL effect. To begin with, our data show a strong positive correlation between QOL and the price-to-income ratio. However, this correlation may occur due to a correlation between QOL and price growth expectation: people may expect price to go up faster in higher amenity cities. We need to disentangle the QOL effect and the expectation effect in accounting for price-to-income ratios. Our model suggests that the QOL effect can be separately estimated by looking at *rent-to-income* ratios instead of price-to-income ratios. The intuition is that rent-to-income ratios respond to the QOL effects, but not to price growth expectation. Our empirical analysis confirms that the QOL effect is significant.

A common problem among all bubble indicators is that it is virtually impossible to distinguish between irrational and rational price expectations. For example, if a city is expected to grow quickly in size, people can rationally expect its housing price to go up in the future and inflates housing price today. This is not considered a bubble but still raises all bubble indicators. This paper does not distinguish between the irrational and ration expectation either. Instead, we show that, conditional on price growth expectation, the price-to-income ratio increases with QOL. Thus, if one naively uses the price-to-income ratio as a bubble indicator without controlling for the QOL effect, it would overstate the bubble in high QOL cities.

Our theory is an immediate application of Roback (1982), and the mechanism may not be surprising to most housing economists. Our contribution is not to provide a theory that has been unknown to the profession, but instead to highlight the mechanism by providing a rigorous economic model and tesing it with data. A few other papers have pointed out the limitations of price-to-income ratio. For example, Gallin (2006) shows that house price and income are not cointegrated even over a long time span. Himmelberg *et al.* (2005) argue that price-to-income ratios should not be compared over time without controlling for interest rate change.

There is a large literature on housing price bubbles, most of them testing whether there are bubbles in local housing markets. Fraser *et al.* (2008) examine housing price bubbles in New Zealand, using a dynamic present value model to calculate fundamental values. Hui & Yue (2006) test housing price bubbles in Beijing and Shanghai, using time series econometrics techniques such as Granger causality tests and impulse response analysis. Kim & Suh (1993) test housing price bubbles in Korea and Japan, by modeling expected future price into demand equation. Park *et al.* (2010) examine the impact of government policies to stablize housing prices in Seoul.

The remainder of the paper is structured as follows. Section 2 presents the model and its theoretical implications. Section 3 presents our estimation strategy, data, and results. Section 4 concludes.

2 Theory

This section provides the model and its theoretical implications. The model is based on the idea of Roback (1982), who shows how wage and housing rent are determined as functions of consumption amenities (i.e., QOL) and production amenities. In order to pin down housing price, we add landlords who decide whether or not to purchase housing.

2.1 Model

There are numerous cities indexed by $s \in S \subset \mathbb{N}$. Cities differ exogenously in their consumption amenities A, production amenities O, and expected future housing price growth rate e. There are two commodities: a composite good and housing. The composite good is freely tradable with zero transportation cost while housing must be locally provided. The zero transportation cost for the composite good implies that its equilibrium price would be same across all cities. We normalize this price to 1 and use the composite good as the numeraire.

Workers are homogeneous and freely mobile across cities with zero moving cost. A worker first chooses a city in which to live and then chooses her consumption bundle consisting of composite good q and housing h. Their utility function $U(q, h; A)$ is increasing in consumption amenities A. Each worker supplies one unit of labor. The decision of a worker can be summarized by the following maximization problem:

$$\max_s V\left(r_s, w_s; A_s\right)$$

where

$$V\left(r_s, w_s; A_s\right) \equiv \max_{q,h} U(q, h; A_s) \text{ subject to } q + r_s h = w_s$$

where r_s, w_s, and A_s are housing rent, wage, and consumption amenities in city s. We obtain $\partial V/\partial w > 0$, $\partial V/\partial r < 0$, and $\partial V/\partial A > 0$, using the envelope theorem. In other words, the utility of workers living in city s increases as local wage increases, rent falls, or consumption amenity level increases.

Because workers can move across cities with zero cost, they get the same utility across all cities in equilibrium. This leads to the following equilibrium condition:

$$V(r_s, w_s; A_s) = \bar{u} \text{ for } s \in S \tag{1}$$

where $\bar{u}$ is the common equilibrium utility level in the economy.

Each city has numerous firms producing composite goods. All firms use identical constant returns to scale technology and thus we can consider one aggregate firm for each city that behaves as a perfectly competitive firm. We assume that the aggregate firm uses labor n and buildings h which come from the same stock of housing as the workers' housing. Its production function F is increasing in production advantage O. The decision of a firm in city s can be summarized by the following maximization problem:

$$\max_{n,h} F\left(n, h; O_s\right) - w_s n - r_s h$$

where n and h are employed labor and housing.

The market for the composite good is perfectly competitive and each firm thus makes zero profit in equilibrium. Because the firms use the same constant returns to scale technology, the zero profit condition is equivalent to unit cost being equal to unit output price:

$$C(r_s, w_s; O_s) = 1 \text{ for } s \in S \tag{2}$$

where C is the unit cost function. We obtain $\partial C/\partial r > 0$ and $\partial C/\partial w > 0$ because housing and labor are production inputs. We obtain $\partial C/\partial O < 0$ because firms can produce the composite good more efficiently as the local productivity O increases.

Absentee landlords decide whether to purchase housing or not in each city.[1] If they purchase housing, they rent it out to workers and firms. They can also earn capital gain if housing price increases. The cost of owning housing is the interest payment for housing price. Under this simple formulation the following condition holds in equilibrium.

$$i - e_s = \frac{r_s}{p_s} \text{ for } s \in S. \tag{3}$$

However, other factors may enter the landlords' decision such as depreciation and risk premium. To account for other factors without complicating the model, we assume a capitalization rate function k at which landlords are indifferent between buying and not buying housing.

$$k(i, e_s) = \frac{r_s}{p_s} \text{ for } s \in S. \tag{4}$$

where we assume $\partial k/\partial i > 0$ and $\partial k/\partial e < 0$. These assumptions mean that landlords are willing to pay higher prices to purchase housing if price appreciation expectation is higher or interest rate is lower. Note that condition (3) is a special case of condition (4).

We are ready to define the equilibrium of our model. An equilibrium consists of wage w_s, rent r_s, and housing price p_s for each city $s \in S$ satisfying the equilibrium conditions (1), (2), and (4).[2]

[1] We could allow workers and firms to make the purchase decision. However, we chose to have landlords separate from workers and firms, to preserve the very popular Roback model for workers and firms. This makes our model easier to follow.

[2] We do not explicitly model housing supply to keep our model simple. We can do this because housing supply does not affect housing prices, rents, or wages due to the free mobility assumption. See Lee & Li (2010) for an example where housing supply is explicitly modeled into the Roback model.

2.2 Theoretical Implications

This section derives theoretical implications. There are three factors affecting the price-to-income ratio for a city: consumption amenities (*i.e.*, QOL) A, production amenities O, and expected future housing price growth rate e. We begin by deriving the partial effect of each factor on the price-to-income ratio.

When we derive the partial effect of a factor, we assume the other two factors are constant, take the total derivatives of equilibrium conditions (1), (2), and (4), and then derive the partial derivative of the price-to-income ratio with respect to the factor. We obtain the following partial derivatives.

$$\begin{aligned}
\frac{\partial \log\left(\frac{p}{w}\right)}{\partial \log e} &= -\frac{ep}{r}\frac{\partial k}{\partial e}. \\
\frac{\partial \log\left(\frac{p}{w}\right)}{\partial \log A} &= \frac{A\frac{\partial V}{\partial A}\left(r\frac{\partial C}{\partial r} + w\frac{\partial C}{\partial w}\right)}{rw\left(-\frac{\partial V}{\partial r}\frac{\partial C}{\partial w} + \frac{\partial C}{\partial r}\frac{\partial V}{\partial w}\right)} \\
\frac{\partial \log\left(\frac{p}{w}\right)}{\partial \log O} &= \frac{O\left(-\frac{\partial C}{\partial O}\right)\left(r\frac{\partial V}{\partial r} + w\frac{\partial V}{\partial w}\right)}{rw\left(-\frac{\partial V}{\partial r}\frac{\partial C}{\partial w} + \frac{\partial C}{\partial r}\frac{\partial V}{\partial W}\right)}.
\end{aligned}$$

Because $\partial V/\partial w > 0$, $\partial V/\partial r < 0$, $\partial V/\partial A > 0$, $\partial C/\partial w > 0$, $\partial C/\partial r > 0$, $\partial C/\partial O < 0$, and $\partial k/\partial e < 0$, we obtain the following result.

Proposition 1 *a) The price-to-income ratio is increasing in future price growth expectation.*

$$\frac{\partial \log\left(\frac{p}{w}\right)}{\partial \log e} > 0$$

b) The price-to-income ratio is increasing in consumption amenities.

$$\frac{\partial \log\left(\frac{p}{w}\right)}{\partial \log A} > 0$$

c) The price-to-income ratio can be increasing or decreasing in production amenities, de-

pending on parameter values.

$$\frac{\partial \log \left(\frac{p}{w}\right)}{\partial \log O} > 0 \text{ if and only if } w\frac{\partial V}{\partial w} > -r\frac{\partial V}{\partial r}.$$

Proposition 1 shows that the price-to-income ratio depends on three factors: expectation on future price growh, consumption amenities, and production amenities. Proposition 1.a) shows that the price-to-income ratio is higher in cities with higher expectation on future price growth. This is consistent with the common interpretation of price-to-income ratio as a bubble indicator, even though it is impossible to distinguish whether this speculative expectation is irrational or not. Proposition 1. b) and c) show that the price-to-income ratio is also affected by fundamentals - consumption and production amenities. Proposition 1. b) shows that the price-to-income ratio may be higher in high QOL cities. Proposition 1. c) shows that the price-to-income ratio can be higher or lower in high productivity cities.

The goal of this paper is to show that the price-to-income ratios tend to overestate the speculative expectation in high QOL cities and thus the ratios have to be discounted in these cities. This is equivalent to showing that the fundamental effect (i.e., the combined effect of consumption amenities and production amenities) on the price-to-income ratios is positive in high QOL cities. Proposition 1.b) show that the partial effect of QOL (i.e., consumption amenities) is positive, but this is not enough because the QOL may be positively or negatively correlated with productivity. If the combined effect of QOL and productivity is negative in high amenity cities, it is possible that the price-to-income ratio understates the price growth expectation in high QOL cities. Thus, it is an empirical question whether the price-to-income ratio overstates the speculative expectation in high QOL cities.

Proposition 2 *Suppose that production amenities O depends on consumption amenities A. The fundamental effect of consumption and production amenities on the price-to-income* *ratios may be positive or negative in high QOL cities. More precisely,*

$$\frac{\partial \log\left(\frac{p}{w}\right)}{\partial \log A} + \frac{\partial \log\left(\frac{p}{w}\right)}{\partial \log O}\frac{\partial \log O}{\partial \log A}$$

can be positive or negative.

3 Empirical Analysis

This section tests if the fundamental effect in high QOL cities is positive. We need to do more than showing a positive correlation between price-to-income ratios and QOL scores across cities because QOL may be also correlated with expectation on future price increase; people may expect price to go up faster in high QOL cities. Thus, we need to control for the expectation effect to test the fundamental effect we are interested in. We use our model to show that *rent-to-income* ratios separately estimate this effect from the expectation effect. This result is intuitive because rent-to-income ratios depend on QOL but not on expectation. We test whether rent-to-income ratios are positively correlated with QOL scores.

We need data on consumption amenity scores across cities as well as incomes, housing prices, and housing rents. We use a standard data set (Integrated Public Use Microsample (IPUMS)) for incomes, housing prices, and housing rents. However, there are no universally accepted QOL scores for cities. The two most popular ones - *Cities Ranked & Rated* and *Places Rated Almanac* - assign scores to various city characteristics (e.g., climate, crime, education) and combine these subscores to provide composite QOL scores. We run our test using the two popular rankings. As an additional robustness check, we also run the test using only climate scores from *Cities Ranked & Rated* and *Places Rated Almanac* to avoid potential endogeneity problems in city characteristics.

3.1 Estimation Strategy

We begin by presenting our estimation strategy. We first show how the price-to-income ratio changes as consumption amenities A increases, when consumption amenities A can be correlated with production amenthat O and future price increase expectation e. When we allow expectation e and productivity O to depend on consumption amenities A, we obtain the following:

$$\frac{d\log\left(\frac{p}{w}\right)}{d\log A}=\frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log A}+\frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log O}\frac{d\log O}{d\log A}+\frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log e}\frac{d\log e}{d\log A}. \tag{5}$$

where the first two firms on the right hand side are the fundamental effect in high QOL cities and the last term is the expectation effect correlated with QOL. Note that we use total derivative $d\log\left(\frac{p}{w}\right)/d\log A$ instead of partial derivative $\partial\log\left(\frac{p}{w}\right)/\partial\log A$ in order to capture the indirect effects as well as the direct effect of QOL A change.

The total derivative $d\log\left(\frac{p}{w}\right)/d\log A$ in equation (5) captures the simple correlation between the price-to-income ratio and QOL. The equation shows that the correlation can be positive simply because price growth expectation is positively correlated with QOL, which is captured by the third term in the right hand side. In order to show that the fundamental effects, captured by the first two terms in the right hand side, is positive, we have to separately estimate the expectation effect.

The following Lemma and Proposition show that the expectation effect can be separately estimated by regressing log price-to-rent ratio on log consumption amenity level and that the fundamental effect can be estimated by regressing log rent-to-income ratio on log consumption amenity level.

Lemma 3

$$\frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log e}\frac{d\log e}{d\log A}=\frac{d\log\left(\frac{p}{r}\right)}{d\log A} \tag{6}$$

Proof.

$$\begin{aligned}
\frac{d\log\left(\frac{p}{r}\right)}{d\log A} &= \frac{\partial\log\left(\frac{p}{r}\right)}{\partial\log A}+\frac{\partial\log\left(\frac{p}{r}\right)}{\partial\log O}\frac{d\log O}{d\log A}+\frac{\partial\log\left(\frac{p}{r}\right)}{\partial\log e}\frac{d\log e}{d\log A}\\
&= -\frac{\partial\log k\left(i,e_s\right)}{\partial\log A}-\frac{\partial\log k\left(i,e_s\right)}{\partial\log O}\frac{d\log O}{d\log A}+\frac{\partial\log\left(\frac{p}{w}\frac{w}{r}\right)}{\partial\log e}\frac{d\log e}{d\log A}\\
&= \frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log e}\frac{d\log e}{d\log A}+\frac{\partial\log\left(\frac{w}{r}\right)}{\partial\log e}\frac{d\log e}{d\log A}\\
&= \frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log e}\frac{d\log e}{d\log A}.
\end{aligned}$$

We obtain the second line by applying equation (4), the third line because $k\left(i,e_s\right)$ does not depend on A or O, the fourth line because w/r does not depend on e. ■

Proposition 4 *The fundamental impact of QOL change on the price-to-income ratio can be estimated by the change in rent-to-income ratio.*

$$\frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log A}+\frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log O}\frac{\partial\log O}{\partial\log A}=\frac{\partial\log\frac{r}{w}}{\partial\log A} \tag{7}$$

Proof. By plugging equation (6) into the fundamental equation (5), we obtain the following:

$$\begin{aligned}
\frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log A}+\frac{\partial\log\left(\frac{p}{w}\right)}{\partial\log O}\frac{\partial\log O}{\partial\log A} &= \frac{d\log\left(\frac{p}{w}\right)}{d\log A}-\frac{\partial\log\left(\frac{p}{r}\right)}{\partial\log e}\frac{\partial\log e}{\partial\log A}\\
&= \frac{d\log\left(\frac{p}{w}\right)}{d\log A}-\frac{\partial\log\left(\frac{p}{r}\right)}{\partial\log A}=\frac{\partial\log\frac{r}{w}}{\partial\log A}.
\end{aligned}$$

■

The right hand side in equation (7) is the first two terms in equation (5), which captures the fundamental effect on the price-to-income ratio as QOL increases. This effect includes both the direct effect on QOL change and the indirect effect through production amenity O change correlated with QOL change. Equation (7) suggests that we can estimate the QOL effect by regressing $\log(r/w)$ on $\log A$. The intuition is that rent-to-income ratios do not depend on price growth expectation but respond to the fundamental effects such as QOL and production amenities.

3.2 Data

Cities Ranked & Rated (Sperling & Sander, 2007) provides QOL scores for 373 US metropolitan areas.[3] For each metropolitan area, they determine composite QOL scores by aggregating scores for ten categories: economy & jobs, cost of living, climate, education, health & health care, crime, transportation, leisure, arts & culture, and one subjective category. (See Table A.1 in the Appendix for more details on how they calculate these scores.)

The composite scores from *Cities Ranked & Rated* do not correspond directly to our consumption amenities A. The consumption amenities in our model correspond to QOL without considering income and housing cost, while the QOL composite scores in the book take them into account. Thus, we regenerate the consumption amenities score using their subcategory scores. We remove the economy & jobs and cost of living categories and generate QOL scores using the other categories. Although the book does not provide the weights used to produce their composite scores, we can back out these weights by regressing their logged composite score on logged score for each category. (See Table A. 2 for its regression table.) To get a feel for the new QOL scores we generated, we report them for the top 20 cities and bottom 10 cities in Table 1. The differences between the QOL scores in the book and the new QOL scores are clear in cities like San Francisco. According to our definition, San Francisco has a high consumption amenity score and is ranked the second. However, because San Francisco has a high housing price, the QOL score in the book is not as high and this city is ranked the 73rd.

The *Places Rated Almanac* (Savageau, 2007) provides QOL scores for 379 metropolitan areas. It rates a city in nine categories: housing, jobs, ambience, crime, transportation,

[3] Scores are reported at primary metropolitan statistical area (PMSA) levels.

education, health care, recreation and climate. (See Table A.3 for details on how these scores are calculated.) Again, we generate new QOL scores using the seven categories excluding housing and job categories. Unlike the *Cities Ranked & Rated*, the *Places Rated Almanac* puts equal weight on each category when calculating their composite score and we use the same weighting scheme. We report the new QOL scores for the top 20 cities and bottom 10 cities in Table 1.

Housing price, housing rent, and income data come from Census 2000 Integrated Public Use Microdata Series (IPUMS) 5 percent sample by Ruggles *et al.* (2010). Because housing quality and human capital distribution vary across cities, we run hedonic and Mincer regressions to control for these heterogeneities; we run quantile regressions as we are interested in median values; price-to-income ratio is defined as the ratio of median housing price to median income.

For housing price and rent we use IPUMS data. To control for quality differences we run hedonic regressions and calculate estimated price for a representative house. For housing price we regress housing values on housing characteristics and metropolitan area dummy variables using owner-occupied units. For housing rent we regress annual gross rents on housing characteristics and metropolitan area dummy variables using rented units. Both regressions are weighted by census-household weights. The housing characteristics dummy variables include the number of rooms (9 dummies), the number of bedrooms (4), age (8), the number of units in the structure (5), plumbing facilities (2), kitchen or cooking facilities (2), house acreage (2), and acreage of property (7), in addition to 283 metropolitan area dummies. Using the coefficient estimates, we generate housing prices and rents across cities for a benchmark house for each city, one with four rooms, two bedrooms and complete plumbing and kitchen facilities, with one unit in the structure, built in the 1970s, and on a property size less than 1 acre. We present the hedonic regression tables in Appendix A. 4.

For personal income we use IPUMS data. To control for heterogeneity among workers we run a Mincer regression and calculate wage for a representative worker across cities. We regress total personal income on personal characteristics and metropolitan area dummies, using workers who are aged 25 to 55 and worked more than 30 hours per week and more than 26 weeks per year. We weight the regression by census-person weights. The personal characteristics dummies include educational attainment (12 dummies), industry (9), occupation (9), sex (2), marital status (4), veteran status (2), race (5), citizenship (2), and English fluency (2). With the estimates we generate median income for a benchmark worker who is a 40 year old male, has 4 years of college education, is married but spouse can be absent, can speak English, is not a veteran, or a minority, and has a professional job (in 0-99 occupation group) in the service industry (800-800 industry group). We include the Mincer regression table in Appendix A. 5.

Table 2 presents a summary statistics for these variables. Average house price is \$77,269, with a minimum of \$36,404 in McAllen-Edinburg-Pharr-Mission, TX and a maximum of \$309,905 in San Jose, CA. Average rent per month is \$549, with the minimum of \$346 in Johnstown, PA and the maximum of \$1,201 in San Jose, CA. Average individual income is \$46,795, with the minimum of \$36,295 in McAllen-Edinburg-Pharr-Mission, TX and the maximum of \$71,846 in Stamford, CT. Average price-to-income ratio is 1.62, with a minimum of 1.00 in Beaumont-Port Arthur-Orange,TX, and a maximum of 4.97 in Santa Cruz, CA. Table 3 shows the top and bottom 20 cities with respect to price-to-income ratio; the mean is 11.43, and the mean annual rent-to-income ratio is 0.14.

3.3 Estimation Result

We run our test using each of the two sets of QOL indices: *Cities Ranked & Rated*, and *Places Rated Almanac*. We also run the test using only climate scores for cities from *Cities Ranked & Rated* and *Places Rated Almanac.* As mentioned above, we use climate scores as additional robustness checks, because other city characteristics used to generate QOL scores (e.g., education, crime, healthcare, and transportation) may have endogeneity problems. The results are presented in Table 4.

In row (A) of Table 4, we show the QOL elasticity of the price-to-income ratio. We regress log price-to-income ratio on log QOL scores and report the coefficients. The results show a strong correlation between the price-to-income ratio and the amenity scores. For every 1 percent increase in the QOL index, the price-to-income ratio tends to increase by 0.57 (t-statistic: 11.7) percent with *Cities Ranked & Rated*, by 0.32 (7.7) percent with *Places Rated Almanac*, by 0.05 (2.8) percent with *Cities Ranked & Rated* climate scores, and by 0.08 (5.1) percent with *Places Rated Almanac* climate scores.

However, as equation (5) shows, some of these correlations may be driven by the correlation between QOL and expectation on future housing price growth. Equations (6) and (7) suggest that the QOL effect can be captured by subtracting the QOL elasticity of price-to-rent ratio from that of the price-to-income ratio or simply by calculating the QOL elasticity of rent-to-income ratio.

In row (B) of Table 4, we show the QOL elasticity of the price-to-rent ratio. The results show a significant correlation between QOL scores and the price-to-rent ratios. This indicates that people expect housing price to increase more in higher QOL cities. For every 1 percent increase in the QOL index, price-to-rent ratio tends to increase by 0.26 (6.6) percent with *Cities Ranked & Rated*, by 0.14 (4.6) with *Places Rated Almanac*, by 0.01 (0.9) percent with *Cities Ranked & Rated* climate scores, and by 0.03 (3.0) percent with *Places Rated Almanac* climate scores.

In row (C) of Table 4, we show the QOL elasticity of the rent-to-income ratio that captures the QOL effect on the price-to-income ratio after controlling for the expectation effect. The results show the QOL effect on price-to-income ratio is significant. For every 1 percent increase in the QOL index, rent-to-income ratios tend to increase by 0.31 (13.2) percent with *Cities Ranked & Rated*, by 0.18 (8.5) percent with *Places Rated Almanac*, by 0.04 (4.5) percent with *Cities Ranked & Rated* climate scores, and by 0.05 (5.9) percent with *Places Rated Almanac* climate scores.

4 Conclusion

This paper argues that a direct comparison of price-to-income ratios can overstate the bubble in high QOL cities. It is well-known among economists that price-to-income ratios cannot be compared across cities because fundamental ratios may differ across cities. This paper provides one explicit mechanism that makes these ratios incomparable across cities and tests this particular mechanism. Our empirical test shows that the QOL effect is significant.

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Table 1) QOL Scores for Top 20 and Bottom 10 Cities

*Cities Ranked & Rated**			*Places Rated Almanac **		
QOL Rank	Metropolitan Area	QOL Score	QOL Rank	Metropolitan Area	QOL Score
1	Nassau-Suffolk, NY	81	1	San Francisco, CA	87
2	San Francisco-San Mateo-Redwood City, CA	79	2	Pittsburgh, PA	85
3	Santa Ana-Anaheim-Irvine, CA	78	3	Seattle-Bellevue-Everett, WA	85
4	Napa, CA	77	4	San Jose-Sunnyvale, CA	83
5	San Jose-Sunnyvale-Santa Clara, CA	77	5	Philadelphia, PA	83
6	Charlottesville, VA	77	6	Newark-Union, NJ-PA	83
7	Bridgeport-Stamford-Norwalk, CT	77	7	Boston-Quinsy, MA	82
8	Oxnard-Thousand Oaks-Ventura, CA	76	8	New York, NY-NJ	82
9	Los Angeles-Long Beach-Glendale, CA	75	9	Washington, DC-VA-MD-WV	82
10	Boulder, CO	75	10	Portland-Vancouver, OR-WA	82
11	Philadelphia, PA	75	11	San Diego, CA	80
12	Edison, NJ	73	12	Providence, RI-MA	79
13	San Diego-Carlsbad-San Marcos, CA	73	13	Nassau-Suffolk, NY	79
14	New York-White Plains, NY	73	14	Baltimore-Towson, MD	79
15	New Haven-Milford, CT	73	15	Rochester, NY	79
16	Winchester, VA-WV	72	16	Santa Ana-Anaheim-Irvine, CA	79
17	Ann Arbor, MI	72	17	Madison, WI	79
18	Santa Barbara-Santa Maria, CA	72	18	Minneapolis-St. Paul, MN-WI	78
19	San Luis Obispo-Paso Robles, CA	72	19	Virginia Beach-Norfolk, VA-NC	77
20	Bethesda-Gaithersburg-Frederick, MD	72	20	Richmond, VA	77
⋮	⋮	⋮	⋮	⋮	⋮
364	Alexandria, LA	27	370	Michigan City-La Porte, IN	22
365	Danville, IL	26	371	Morristown, TN	22
366	Farmington, NM	25	372	Elkhart-Goshen, IN	21
367	Clarksville, TN-KY	25	373	Elizabethtown, KY	21
368	Decatur, AL	25	374	Warner Robins, GA	20
369	Florence, SC	24	375	Sumter, SC	19
370	Sumter, SC	24	376	Danville, IL	17
371	Morristown, TN	24	377	Rocky Mount. NC	16
372	Gadsden, AL	24	378	Pine Bluff, AR	16
373	Pine Bluff, AR	18	379	Goldsboro, NC	15

* We adust original data to fit our purpose. See text for details.

Table 2) Summary Statistics

	Obs	Mean	Std. Dev	Min		Max	
Median Home Price	283	$77,269	$35,184	$36,404	McAllen-Edinburg-Pharr-Mission, TX	$309,905	San Jose, CA
Median Rent	283	$549	$119	$346	Johnstown, PA	$1,201	San Jose, CA
Average Individual Income	283	$46,795	$5,040	$36,295	McAllen-Edinburg-Pharr-Mission, TX	$71,846	Stamford, CT
Price-to-income ratio	283	1.62	0.55	1.00	Beaumont-Port Arthur-Orange,TX	4.97	Santa Cruz, CA
Price-to-annual rent ratio	283	11.43	2.40	7.95	San Antonio, TX	24.35	Santa Cruz, CA
Annual rent-to-income ratio	283	13.99%	1.90%	10.38%	Decatur, AL	21.97%	San Jose, CA

Table 3) Price-to-income ratios: Top and Bottom 20 Cities

Metropolitan Area	Price-to-income Ratio
Santa Cruz, CA	4.97
San Jose, CA	4.73
Santa Barbara-Santa Maria-Lompoc, CA	4.24
Honolulu, HI	3.97
San Francisco-Oakland-Vallejo, CA	3.87
Salinas-Sea Side-Monterey, CA	3.72
Stamford, CT	3.68
Santa Rosa-Petaluma, CA	3.35
Los Angeles-Long Beach, CA	3.28
San Luis Obispo-Atascad-P Robles, CA	3.05
Ventura-Oxnard-Simi Valley, CA	3.04
San Diego, CA	2.99
Santa Fe, NM	2.80
Boston, MA-NH	2.68
New York-Northeastern NJ	2.60
Seattle-Everett, WA	2.56
Yolo, CA	2.44
Barnstable-Yarmouth, MA	2.37
Eugene-Springfield, OR	2.27
Danbury, CT	2.27
⋮	⋮
San Antonio, TX	1.19
Lubbock, TX	1.18
Wichita Falls, TX	1.18
Dothan, AL	1.18
Abilene, TX	1.18
Anniston, AL	1.18
Wichita, KS	1.17
Galveston-Texas City, TX	1.15
Decatur, IL	1.14
Macon-Warner Robins, GA	1.14
Jamestown-Dunkirk, NY	1.13
Gadsden, AL	1.12
Waco, TX	1.10
Albany, GA	1.10
Houston-Brazoria, TX	1.09
Brownsville-Harlingen-San Benito, TX	1.07
Flint, MI	1.05
McAllen-Edinburg-Pharr-Mission, TX	1.00
Odessa, TX	1.00
Beaumont-Port Arthur-Orange,TX	1.00

Table 4) The QOL Elasticities of Price-to-Income Ratio, Price-to-Rent Ratio, and Rent-to-Income Ratio

	Cities Ranked & Rated	*Places Rated Almanac*	Climate scores	
			Cities Ranked & Rated	*Places Rated Almanac*
Number of Observations	267	269	266	268
QOL elasticity of **price-to-income ratio (A)**	0.57 (11.7)	0.32 (7.7)	0.05 (2.8)	0.08 (5.1)
R-squared.	0.34	0.18	0.03	0.09
QOL elasticity of **price-to-rent ratio (B)**	0.26 (6.6)	0.14 (4.6)	0.01 (0.9)	0.03 (3.0)
R-squared.	0.14	0.18	0.00	0.03
QOL elasticity of **rent-to-income ratio (C)**	0.31 (13.2)	0.18 (8.5)	0.04 (4.5)	0.05 (5.9)
R-squared.	0.40	0.21	0.07	0.11

Note) t-statistics in parentheses

Table A 1) Categories and Data: *Cities Ranked & Rated*

Category		Data
Economy & Jobs	Income	Per capita income, Household income, Household income < $25K, Household income > $75K, Household income growth
	Employment	Unemployment rate, Recent job growth, Projected future job growth, White collar, Blue Collar
	Employing Industry	Largest employing industry, Percent manufacturing, Percent public sector employment, Percent construction employment
Cost of Living	Indexes and Taxes	Cost of living index, Buying power index, Income tax rate, Sales tax rate, Property tax rate
	Housing	Median home price, Home price appreciation, Median rent, Homes owned, Home price ratio
	Necessities	Food index, Housing index, Utilities index, Transportation index, Healthcare index, Miscellaneous cost index
Climate	Temperature	Avg January low, Avg July high, Annual days > 90o F, Annual days < 32o F, Annual days < 0o F
	Precipitation	Annual inches precipitation, Annual days precipitation, Annual inches snowfall, Annual days rain > 0.5 inches, Annual days snow > 1.5 inches
	Comfort & Hazards	July relative humidity, Annual days mostly sunny, Tornado risk score, Annual days with thunderstorms, Hurricane risk score
Education	Achievement	High school degree, 2-year college degree, 4-year college degree, Graduate/professional degree
	Public Schools	Expenditure per pupil, Student/teacher ratio, Attending public school, State SAT score, State CAT score
	Higher Education	No. 2-year college, No. 4-year college/universities, No. highly ranked universities
Health & Healthcare	Hazard & Illness	Air-quality score, Water-quality score, Pollen/allege score, Cancer mortality per capita, Depression days per month, Stress Score
	Health Care	Physicians per capital, Hospital beds per capita, Cost per doctor visit, No. teaching hospitals, Cost per dental visit
Crime	Crime	Violent crime rate, Change in violent crime rate, Property crime rate, Change in property crime rate
Trans-portation	Commute	Average commute time, Percent commute > 60 minutes, Commute by auto, Commute by mass transit, Work at home, Mass transit miles per capita
	Intercity Services	Major airport within 60 miles, Size of regional airport, Daily airline activity, Amtrack service
	Automotive	Insurance: annual premium, Gas: cost per gallon, Daily vehicle miles per capita
Leisure	Dining & Shopping	Restaurant rating, Outlet mall score, No. Starbucks, No. warehouse club
	Entertainment	Professional sports rating, College sports rating, Zoo/aquarium rating, Amusement park rating, Botanical garden/arboretum rating
	Outdoor Activities	Golf-course rating, Ski-area rating, Sq. miles inland water, Miles of coastline, National park rating
Arts & Culture	Media & Library	Arts radio rating, No. public libraries, Library volumes per capita
	Performing arts	Classical music rating, Ballet/dance rating, Professional theater rating, University arts programs rating
	Museums	Overall museum rating, Art museum rating, Science museum rating, Children's museum rating
Subjective Category	Physical attractiveness: Physical setting and overall appearance, attractiveness and functionality of the downtown core	
	Heritage: Metropolitan area with well-preserved historic districts and public buildings	
	Overall ease of living: Ease of living incorporates crowdedness, attitude and friendliness of people, and simplicity of infrastructure	

Table A 2) Regression to Infer Weight on Each Category in *Cities Ranked & Rated*

Independent variable: Log (total score)	
Log (score of variable)	Coefficient (t-stats)
Economy & Job	0.11 (6.3)
Cost of Living	0.11 (6.3)
Climate	0.17 (11.6)
Education	0.12 (6.0)
Health & Health care	0.09 (5.0)
Crime	0.09 (5.9)
Transportation	0.12 (8.2)
Leisure	0.10 (4.9)
Arts & Culture	0.12 (6.2)
Subjective	0.08 (5.2)
Adjust R-squared	0.996
Obs.	333

Table A 3) Categories and Data: *Places Rated Almanac*

	Category	Data
Ambience	Restaurants	Percentage of a metro area's eateries weighted by AAA, Number of rated eateries weighted by AAA diamonds
	Bookstores	Per capita sales as reported by the latest Census of Retail Traded (estimated sale figures for college textbooks are excluded)
	History	Number of historic landmarks and contributing buildings and the land area these official districts occupy
	Performing Arts Calendar	Annual number of touring artist appearances in campus and civic auditorium and the number of performance of resident orchestras and opera companies
	People	Various demographic descriptions
Housing	Utilities	Estimated monthly utility bills
	Property taxes	Local value of a starter house times the state's average effective tax rate for residential property
	Mortgage	Six percent, 25-year loan on the Starter House, after a ten percent downpayment
Jobs		Each area's forecasted number of new jobs get twice the weight as the percent rate of new job growth and twice the weight of how many of expected jobs are higher paying ones. A metro area's final score is a percentiles of a scale of 0 to 100 corresponding to its rank
Crime		The average of the rates for violent and property crime for the latest 5 years (property crimes get one-tenth the weight of violent crimes): the results are scaled into percentile scores
Transporta-tion		Connectivity (60%), commute (30%), centrality (10%)
Education	School Support	Average number of students per full-time equivalent class room teacher with its average instructional expense figure for students indexed against local personal income
	Private School Option	Products of the number of school in the three main sectors of private K-12 schooling - Catholic, Other Religious and Nonsectarian- and their enrollments, indexed against the average figure for all metro areas
	Library Popularity	Annual circulation/Number of books the library owns
	College Town	Enrollments weighted by number of years of typical attendance to get the highest degree offered
	College Options	Variety of higher education institutions
Healthcare	General/Family Practitioners	Per 100,000 physicians in family practice
	Medical Specialists	Per 100,000 physicians who concentrate on specific medical disciplines
	Accredited General Hospital Beds	Beds set up for neonatal, pediatric, general medical-surgical, cardiac and intensive care
	Physician Residency Program	
	Hospital Services	
Recreation		*Places Rated* considers twelve items grouped into Common Denominators, Crowd Pleasers, and Outdoor Assets
Climate		*Places Rated* considers multiple data elements, including monthly high and low temperatures, wind speeds, humidity, darkness, clear days, partly cloudy days, cloudy days, thunderstorms, fog, and precipitation in the form of ran and snow

Table A 4) Hedonic Quantile Regression: House price and rent*

Explanatory (Dummy) Variables**	House Price Coefficient (t-stats)	Housing Rent Coefficient (t-stats)
Constant	10.09 (2.1 E+19)	8.08 (1.2 E+04)
No of rooms : 2	0.15 (3.2 E+17)	0.06 (140.6)
No of rooms : 3	0.24 (5.2 E+17)	0.03 (71.5)
No of rooms : 4	0.20 (4.1 E+17)	0.06 (128.2)
No of rooms : 5	0.31 (6.5 E+17)	0.14 (260.4)
No of rooms : 6	0.46 (9.5 E+17)	0.22 (404.7)
No of rooms : 7	0.60 (1.2 E+18)	0.29 (495.2)
No of rooms : 8	0.83 (1.7 E+18)	0.33 (553.7)
No of bedrooms: 2	-0.03 (9.5 E+16)	0.08 (176.7)
No of bedrooms: 3	0.06 (1.9 E+17)	0.23 (502.0)
Built in 1940-1949	0.01 (1.2 E+17)	-0.01 (58.5)
Built in 1950-1959	0.10 (1.7 E+18)	0.02 (89.9)
Built in 1960-1969	0.17 (2.8 E+18)	0.05 (293.2)
Built in 1970-1979	0.23 (3.9 E+18)	0.10 (586.6)
Built in 1980-1989	0.35 (5.7 E+18)	0.18 (954.9)
Built in 1990-1994	0.48 (6.5 E+18)	0.26 (1,018.9)
Built in 1995 or later	0.57 (8.3 E+18)	0.34 (1,334.6)
1 family house, attached	-0.18 (2.1 E+18)	-0.06 (249.2)
2 family building	0.21 (1.2 E+18)	-0.05 (147.6)
3-9 family building	- -	-0.06 (189.9)
More than 10 family building	-0.02 (1.4 E+17)	-0.04 (139.4)
With complete plumbing (shared or non shared)	0.16 (5.7 E+17)	0.14 (229.0)
Kitchen_yes	0.20 (5.9 E+17)	0.02 (35.2)
House on 10 acres or more	0.17 (2.1 E+18)	-0.10 (166.8)
City or suburan lot or rural lot less than 1 acre	0.10 (7.1 E+17)	0.07 (217.1)
Non-city, non-suburban, 10+ acres	0.26 (1.8 E+18)	- -
Condominium	-0.03 (2.5 E+17)	- -
Pseudo R -squared	0.30	0.19
Obs.	3,168,972	1,445,720

* We do not report coefficients for 283 MSA dummies due to space constraint.

** To prevent perfect multicollinearity we drop the following variables: one (no) room, one (no) bed room, built in 1939 or earlier and unknown years, other 5 dummies of acreage of property and non-condominium.

Table A 5) Mincer Quantile Regression: Wage*

Explanatory (Dummy) Variables**	Personal Wage	Explanatory (Dummy) Variables**	Personal Wage
	Coefficient (t-stats)		Coefficient (t-stats)
Constant	8.29 (1,569.2)	Occupation, 1950 basis 200<= < 300	0.18 (66.6)
Educational attainment [detailed]	-0.04 (10.5)	300<= <400	-0.12 (43.7)
020<= < 030	0.00 (0.1)	400<= <500	0.08 (27.2)
030<= < 040	0.03 (12.6)	500<= <600	-0.03 (10.2)
040<= < 050	0.07 (26.6)	600<= <700	-0.14 (50.5)
050<= < 060	0.08 (33.2)	700<= <800	-0.23 (82.0)
060<= < 070	0.26 (117.5)	800<= <900	-0.15 (48.4)
070<= < 080	0.39 (169.9)	>= 900	0.04 (14.9)
090<= < 100	0.45 (195.1)	Separated	-0.10 (99.4)
100<= < 110	0.63 (276.0)	Divorced	-0.03 (62.9)
110<= < 120	0.83 (355.9)	Widowed	-0.01 (4.8)
Industry, 1950 basis 200<= < 300	0.20 (113.1)	Veteran	0.02 (27.6)
300<= < 400	0.32 (183.0)	Age (non-dummy)	0.05 (249.1)
400<= < 500	0.29 (163.9)	Age-squared (non-dummy)	0.00 (201.6)
500<= < 600	0.36 (199.0)	Single race identification 20<= <30	-0.13 (205.0)
600<= < 700	0.08 (46.0)	30<= <40	-0.11 (55.8)
700<= < 800	0.26 (143.6)	40<= <50	-0.09 (96.4)
800<= < 900	0.15 (87.1)	others	-0.14 (28.4)
>= 900	0.32 (181.5)	English Speaking: Yes	0.31 (291.6)
Female	-0.33 (799.2)	Born abroad of American parents and naturalized citizen	-0.03 (38.4)
Pseudo R-squared	0.23		
Obs.	3,621,877		

* We do not report coefficients for 283 MSA dummies due to space constraint.

** To prevent perfect collinearity we drop the following variables: Educational attainment [detailed] : 000<= < 010 & 080<= < 090, Industry_1950 basis : 000<= <200, Male, Occupation 1950 basis : 100<= < 200, Married, Single race identification [detailed] : 10<= <20