Home Price Sensitivity to Capital Market Factors: Analysis of ZIP Code Data

Authors
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Abstract
To what extent do capital market factors affect home prices? This paper examines quarterly changes in median sales prices for homes across more than 3,000 U.S. ZIP Codes in 203 metropolitan areas from 2001 to 2006 to investigate home price sensitivity to returns on U.S. stocks and bonds. The findings reveal that home-price changes are positively related to returns on stocks and bonds, on average. They also show that home prices in higher priced ZIP Codes have greater exposure to capital market risk factors, consistent with higher levels of wealth and capital market participation, on average, among owners of higher priced homes.

Home prices and changes in home prices vary by location and market conditions, hedging and arbitrage in housing remain costly and largely infeasible, and for individual homeowners exposure to housing price risk is largely non-diversifiable. Because of these characteristics, the market for homes is relatively inefficient compared to markets for financial securities. Nevertheless, households must evaluate the risks and returns implicit in their homes when making personal financial decisions such as whether to buy or rent, how expensive a house to purchase, how much mortgage financing to utilize and at what terms, and how to condition allocations in stock or bond portfolios on housing-related wealth.

In particular, equilibrium asset pricing theory and empirical evidence suggest that returns to both capital market investments and real estate investments are integrated (e.g., Quan and Titman, 1999). Due to such integration, household portfolio allocation decisions should be made conditional on exposure to housing-related factors. For example, a homeowner should consider his or her personal investment in a home and the sensitivity of its value to capital market movements when allocating a retirement savings portfolio among asset categories such as stocks and bonds. Indeed, many studies model how home-related wealth might condition investment decisions by households (e.g., Palia, Qi, and Wu, 2009). In contrast, there are few empirical studies that document city-specific, neighborhood-specific, or home-specific measures of home price risk and how it correlates with financial market risk factors.

In this study, we explore the sensitivity of changes in U.S. home prices observed at the ZIP Code level to financial market factors. Specifically, we measure home
price changes using quarterly median sales-price data for homes in 3,309 ZIP Codes associated with 203 metropolitan statistical areas for 2001 to 2006. We then estimate sensitivity of ZIP Code level home price changes to quarterly returns to common stocks and U.S. Treasury securities using an estimation specification that addresses time series issues associated with autocorrelation of home price changes and non-synchronicity relative to returns on financial securities. We also investigate whether households in ZIP Codes characterized by higher priced homes have greater exposure of home values to capital market prices. Specifically, higher priced homes are associated with higher levels of household wealth, ceteris paribus, and wealthier households tend to have greater stock market participation. In addition, higher priced housing areas are more likely to be populated by residents (corporate executives, for instance) whose human capital and income is more likely to be affected by capital market factors. Consequently, we hypothesize that demand for high price housing and therefore equilibrium housing price movements would tend to be more sensitive to capital market pricing factors than for low price housing areas.

Our empirical results support our hypotheses. First, although there is a great deal of cross-sectional dispersion, our estimates of sensitivities of home price changes to capital market factors are positive on average. In other words, stock returns and bond returns are positively associated with home price changes across our ZIP Codes, on average. Furthermore, our empirical results are consistent with our hypothesis on the relation between home price levels and capital market sensitivity of home price changes. Specifically, changes in home prices for ZIP Codes characterized by higher priced homes are more sensitive to movements in both stock prices and bond prices. This finding is consistent with higher levels of capital market participation and a greater degree of sensitivity of household wealth to security markets among residents of ZIP Codes characterized by higher priced homes.

Our results complement those of Jud and Winkler (2002), who find that contemporary and lagged changes in the value of the S&P 500 positively affect annual home price movements for 130 American cities from 1984 to 1998. However, our results contrast with those reported by Cannon, Miller, and Pandher (2006). Cannon, Miller, and Pandher utilize annual median home price data across 7,234 U.S. postal ZIP Codes for 155 metropolitan statistical areas for 1996 to 2003. They calculate annual changes in median home prices across these ZIP Codes, and then for each ZIP Code they estimate sensitivity in annual home price changes to the S&P 500 stock index; they do not include a pricing factor based on bond returns or other measures of interest rates. Their estimates of stock market sensitivities based on their eight-year time series regressions are negative, on average. Furthermore, the results reported by Cannon, Miller, and Pandher indicate that home price sensitivity to the stock market is negatively related to ZIP Code level median home prices, a finding opposite to both their expectations and to the empirical results we report.

The remainder of this study is organized as follows. The next section reviews literature on how home prices respond to capital market prices. The third section
discusses the design of our study, data, methods, and hypotheses. The fourth section presents the results. The final section provides a brief conclusion.

Home Prices and Capital Market Returns

Equilibrium asset pricing theory and empirical evidence suggest that returns to both capital market investments and real estate investments are related. In particular, household wealth is exposed to risks inherent in local housing markets, as well as to risks from investments in equity markets. Quan and Titman (1999) show that changes in the value of commercial real estate are positively related to stock returns across 17 countries. Jud and Winkler (2002) investigate a pooled sample of annual home price index changes for 130 American cities from 1984 to 1998; their results suggest that a cumulative two-year change of 10% in the real value of the S&P 500 would increase real home prices by 1.6% after controlling for changes in mortgage interest rates and MSA-level measures of changes in income, population, and constructions costs. Kullman (2003) finds evidence that returns to residential real estate condition returns to financial securities, suggesting integration of pricing between financial markets and housing markets.

Because housing markets and financial markets are somewhat integrated, household portfolio allocation decisions should be made conditional on exposure to housing-related factors. In a hypothetical world characterized by a single-factor capital asset-pricing model, a homeowner might ask: “What is the beta on my house?” In the real world, a homeowner might ask: “Given my personal investment in my home and the sensitivity of its price to capital market movements, should I allocate my retirement savings portfolio more toward stocks or bonds?” Indeed, various studies—largely theoretical—investigate how home-related wealth might condition investment decisions by households (Flavin and Yamashita, 2002; Benjamin, Chinloy, and Jud, 2004; Cocco, 2004; Yao and Zhang, 2005; Kullman and Siegel, 2007; Piazzesi, Schneider, and Tuzel, 2007; Palia, Qi, and Wu, 2009). The theoretical models in such studies typically assume that homeowners observe key variables such as the sensitivity of home price appreciation to future shocks to their income and changes in personal wealth due to returns on portfolios of financial securities. Because of dispersion of such sensitivities across geography and home-specific characteristics, information on central tendencies across all homes or even homes within a state or city may not be sufficiently useful to homeowners, as sub-market trends are often not captured by trends for wider geographic areas (Goetzmann and Spiegel, 1997).

There are few empirical studies, however, that document city-specific, neighborhood-specific, or home-specific measures of home price risk and how it correlates with exposure to financial market risk factors.1 A recent study by Cannon, Miller, and Pandher (2006) relies on annual median home price data across 7,234 U.S. postal ZIP Codes for 155 metropolitan statistical areas for the eight-year period from 1996 to 2003. In their sample they find that less than 20%
of the variation in ZIP Code level home price changes is captured by city-specific effects, leaving substantial dispersion in home price trends among neighborhoods as proxied by ZIP Codes.\(^2\)

Cannon, Miller, and Pandher (2006) calculate annual changes in median home prices across these ZIP Codes and then estimate so-called housing betas relative to annual returns to the S&P 500 stock index.\(^3\) Because the authors examine price changes at an annual frequency over merely eight years with a correspondingly small number of degrees of freedom, each ZIP Code-specific beta coefficient is estimated very noisily, that is, with a high degree of sampling variance. For example, they report that the mean (median) housing beta estimate is \(-0.077\) (\(-0.093\)), but beta estimates range from a minimum of \(-2.075\) to a maximum of \(2.235\) across their sample ZIP Codes (see Table 1, p. 528). Nevertheless, the authors appeal to the asymptotic properties associated with making these noisy estimates across more than 7,000 individual time series, especially when beta estimates across ZIP Codes can be grouped based on ZIP Code level characteristics and inferences made with respect to measures of central tendency across these sub samples.

Cannon, Miller, and Pandher (2006) suggest that ZIP Codes characterized by higher home prices would display greater sensitivity to stock market movements because households in high priced areas would be more likely to have wealth exposed directly or indirectly to capital market risk factors. Specifically, they suggest the following implicit hypothesis (p. 550):

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Houses in zip codes [sic] that are more sensitive to the stock market, presumably in wealthier neighborhoods, have the potential of greater price appreciation when the stock market is doing well. When the stock market is rising, some households in these stock-sensitive markets have more income and wealth due to the positive impact of the market on professional and managerial compensation (e.g., bonuses, equity and stock options). Some of this wealth may be transferred into housing ...
```

\(^4\)

We discern two somewhat unsatisfactory aspects in the reported findings of Cannon, Miller, and Pandher (2006), however. First, their estimates of housing betas are negative, on average, across all ZIP Codes and when sorted by home price level into deciles. Indeed, their Table 7 (p. 540) suggests that more than 70% of all ZIP Code-specific housing beta estimates are negative. This result is in sharp contrast to the findings of Jud and Winkler (2002), who report that home prices across 130 cities are positively affected by changes in stock prices. Second, the housing beta estimates in Cannon, Miller, and Pandher appear to be inversely related to home price levels, counter to the notion that household wealth and exposure to capital market risk increases with home prices on average. Specifically, when they report how their estimated housing betas vary across ZIP Codes that have been divided into deciles on the basis of home price, they show
an overall trend of more negative betas, on average, as home price increases. Exhibit 1 illustrates the nature of this relation as reported in Panel B of Table 7 (Cannon, Miller, and Pandher, p. 540).

In short, despite all the seemingly intuitive discussion by Cannon, Miller, and Pandher (2006) of an expectation of more positive stock market sensitivity among ZIP Codes characterized by higher home prices, their results suggest more negative stock market sensitivity as price level increases.

**Exhibit 1 | Housing Betas and Median Home Prices by ZIP Code as Reported by Cannon, Miller, and Pandher [2006]**

Notes: Cannon, Miller, and Pandher (2006) estimate ‘housing betas’ as sensitivities of annual changes in median home prices observed for 7,234 ZIP Codes to changes in the S&P 500 stock index according to their Equation (2) (p. 538):

\[ R_{ZIP,T} - R_{F,T} = \alpha_{ZIP} + \beta_{ZIP}(R_{S&P,T} - R_{F,T}) + e_{ZIP,T} \]

where \( R_{ZIP,T} \) equals the annual change in median home price for ZIP Code ZIP in calendar year \( T (T = 1996–2003) \), \( R_{F,T} \) equals the annualized risk-free rate, and \( R_{S&P,T} \) is the annual return on the S&P stock-price index. The exhibit shows the average equity market beta across ZIP Codes that have been sorted into deciles based on median home price. The vertical lines show a range-like measure; the endpoints for these vertical lines correspond to the average values of beta estimates for the third and eighth deciles of betas within each home-price decile. The data for this exhibit are from Table 1 (p. 528) and Table 7 (p. 540) in Cannon, Miller, and Pandher.
Data, Methods, and Hypotheses

In this study, we investigate the sensitivity of home prices to capital market pricing factors. We also investigate whether sensitivity to capital market factors is higher for areas characterized by higher priced homes. Similar to Cannon, Miller, and Pandher (2006), we employ home price data at the ZIP Code level, but our data are quarterly over 2001 to 2006 for 3,309 ZIP Codes associated with 203 metropolitan statistical areas. Our six years of quarterly data provide some advantages over the eight years of annual data utilized by Cannon, Miller, and Pandher. Foremost, for each ZIP Code’s time series of changes in median home prices, we have 24 quarterly observations. The greater number of observations increases our degrees of freedom for estimating capital market factor sensitivities, facilitates investigation of more than one explanatory variable, and permits adjustment for additional time series problems inherent in quarterly home price data. In particular, we can estimate the sensitivity of home price changes to returns on stocks and changes in interest rates as measured by returns on U.S. Treasury instruments. Given the dramatic fall and then rise in interest rates over our sample period, it seems especially important to estimate home price sensitivity to stock price movements while also controlling for effects attributable to interest rate changes.

Home Price Data for U.S. ZIP Codes

We utilize quarterly median sales prices for single-family homes reported by U.S. postal ZIP Code. Our home price database by U.S. ZIP Code was purchased from American Real Estate Solutions. After excluding ZIP Codes with missing quarterly data, our data set includes 3,309 ZIP Codes for which quarterly median home price observations are available between the fourth quarter of 2000 and the fourth quarter of 2006. For each of these calendar quarters we calculate ZIP Code-specific housing returns as the percentage change in median home price compared to the prior calendar quarter. Thus, our ZIP Code level quarterly home price changes are computed similarly to the annual changes analyzed by Cannon, Miller, and Pandher (2006).

We acknowledge that measuring returns to home ownership by observed changes in median home prices at the ZIP Code level remains primitive in many respects. As discussed below, using median sales price data introduces some problematic time series properties. In addition, total returns to housing include both implied capital gains (home appreciation), the value assigned to housing services, and changes in the value of imbedded options such as the value of delay or other timing options (Cauley and Pavlov, 2002). Total return and its components may vary across locations, by home price levels, and by market conditions, and returns based on observed prices may reflect biases due to illiquidity and other unobserved variables (Sunderman and Birch, 2003; Lin and Vandell, 2007). And finally, of course, is the fact that even within ZIP Codes homes vary on quality of
construction, age, square footage, and other home-specific measures that affect price. Our premise is merely that ZIP Code level measures of price changes based on median sales prices, which are readily observable in contrast to individual home-specific measures of value for homes that do not sell, can inform inferences on home price sensitivity to capital market factors, as well as or better than measures based on larger market segmentations such as cities or states.

Exhibit 2 displays some descriptive statistics on this sample of ZIP Codes. We refer to the Federal Information Processing Standards (FIPS) state/county codes and the metropolitan statistical area (MSA) definitions from the Office of Management and Budget (OMB) to assign ZIP Codes to MSAs throughout the U.S. The 3,309 ZIP Codes in our sample are distributed across 203 MSAs, with sample MSAs comprising from as few as one to as many as 137 ZIP Codes with median home price data. The mean (median) number of sample ZIP Codes per MSA is 16.3 (8). The number of metropolitan areas (ZIP Codes) across regions is as follows: Northeast: 36 metropolitan areas (473 ZIP Codes); Southeast: 48 (768); Midwest: 56 (1,152); West 63 (916). The compound annual rate of median home price appreciation over the 2001 to 2006 period has a mean (median) of 9.3% (9.0%), with a standard deviation of 6.4%. These high annualized rates of nominal price appreciation in part reflect the tremendous growth in home prices for many areas over our sample period. The high annualized rates of change also in part reflect the fact that the median prices we observe are not quality-adjusted, and as newly constructed homes have entered the housing inventory there has no doubt been a secular increase in average home quality that has increased median prices observed in home sales data, particularly in areas that have experienced above average rates of new home construction.
Exhibit 3 illustrates additional distributional aspects of the ZIP Code level home price sample. In particular, Panel A of Exhibit 3 shows that a disproportionate number of our sample MSAs comprises a small number of ZIP Codes. Specifically, there are 63 MSAs with fewer than five ZIP Codes with median home price data, and an additional 58 MSAs with only five to nine ZIP Codes with home price data. Panel B shows that the seven cities with 60 or more ZIP Codes that account for 666 or 20.1% of the sample ZIP Codes; the rest of the sample ZIP Codes are distributed roughly uniformly across MSAs comprising different numbers of component ZIP Codes. Finally, Panel C shows the distribution of end-2000 median home prices across the sample ZIP Codes. While there are a small number of low price ZIP Codes (36 ZIP Codes with median prices of less than $50,000) and high price ZIP Codes (38 ZIP Codes with median home prices greater than $1 million), the bulk of the sample comprises ZIP Codes with seemingly moderate median home prices. In particular, about 58% of the sample ZIP Codes are characterized by end-2000 median home prices between $150,000 and $500,000.

**Estimating Capital Market Pricing Sensitivities**

We are interested in how changes in capital market conditions affect observed changes in median home prices across our sample of ZIP Codes. We measure capital market conditions by returns to U.S. stocks and interest rates changes through their effect on returns to U.S. Treasury securities. We measure equity market movements as total returns on the value-weighted market portfolio of U.S. equities as calculated by the University of Chicago’s Center for Research in Security Prices (CRSP) and as reported on Kenneth French’s data library website. To convert monthly returns to quarterly returns, we compound over calendar quarters.

To control for the effect of interest rate changes, we measure returns to U.S. bonds by constructing a hypothetical return to the 10-year U.S. Treasury note using yield data available from the Federal Reserve Economic Data (FRED) website maintained by the Federal Reserve Bank of St. Louis. Specifically, FRED provides daily yields on a constant maturity 10-year Treasury note, and we observe this yield on the last day of each calendar quarter. We then calculate the price change on a hypothetical 10-year Treasury issued at par with a coupon equal to the prior quarter’s constant maturity 10-year yield price that is subsequently re-priced at the constant maturity 10-year Treasury yield reported at the end of the current calendar quarter. We add a pro-rated coupon payment to the price change to arrive at a quarterly total return calculation. An alternative to using this total return series would be to use the simple difference in quarterly yields to maturity, i.e., $\Delta Yield$. The correlation between our return series and quarterly yield changes is nearly $-1.0$, so the choice is immaterial to the results. Similarly, the reported results hold if we measure interest rate changes using mortgage interest rates as reported by FRED.
Exhibit 3 | Information on Distributions of Sample ZIP Codes and Home Prices

Panel A: Number of ZIP Codes per City

Panel B: Number of ZIP Codes per City

Panel C: Median Home Prices 2000:Q4 (thousands)
For each ZIP Code we estimate sensitivities of changes in median home prices to stocks and bonds according to the following equation:

\[
R_{ZIP,t} - R_{F,t} = \alpha_{ZIP} + \phi_{ZIP}^{1}(R_{ZIP,t-1} - R_{F,t-1}) \\
+ \phi_{ZIP}^{-2}(R_{ZIP,t-2} - R_{F,t-2}) + \beta_{ZIP}^{0}(R_{M,t} - R_{F,t}) \\
+ \beta_{ZIP}^{-1}(R_{M,t-1} - R_{F,t-1}) + \beta_{ZIP}^{-2}(R_{M,t-2} - R_{F,t-2}) \\
+ \tau_{ZIP}^{0}(R_{B,t} - R_{F,t}) + \tau_{ZIP}^{-1}(R_{B,t-1} - R_{F,t-1}) \\
+ \tau_{ZIP}^{-2}(R_{B,t-2} - R_{F,t-2}) + \varepsilon_{ZIP,t},
\]

(1)

where \( R_{ZIP,t} \) is the percent change in median home price at ZIP Code ZIP for quarter \( t \), \( R_{F,t} \) is the quarterly risk-free rate, \( R_{M,t} \) is the quarterly return on the CRSP value-weighted equity portfolio, and \( R_{B,t} \) is the quarterly total return on 10-year U.S. Treasury notes. Similar to Cannon, Miller, and Pandher’s (2006) utilization of annual data, we estimate versions of Equation (1) independently for each sample ZIP Code. We acknowledge that the sampling variances on any single times series’ coefficient estimates are likely to be large, and we appeal to the asymptotic properties of our large cross-section of more than 3,000 U.S. ZIP Codes in making our inferences. In particular, we investigate central tendencies of coefficient estimates for subsamples characterized by home price level.

In Equation (1) we include two lagged quarterly changes in median home prices to address potential autocorrelation in home price changes. We also include two lags in each of the respective equity and bond pricing factors. The lagged variables on the right-hand side of Equation (1) address the time series properties of the price data and resulting implications for estimation. First, home price changes measured using median sales prices at the ZIP Code level are likely to display significant autocorrelation. Observed autocorrelation can be due to both fundamental factors and measurement biases. Fundamental factors include the tendency for some housing markets to display short-term momentum in home price movements, while others show fundamental mean reversion (Case and Shiller, 1989, 1990; Gu, 2002; Capozza, Hendershott, and Mack, 2004). Autocorrelation in observed changes in median home prices could also be induced by changes in the characteristics of home sales and their cross-sectional composition within a ZIP Code. Specifically, if the distribution of homes sold within a ZIP Code for a particular calendar quarter were skewed positively in terms of unobserved quality dimensions (e.g., date and quality of construction) relative to all homes within the ZIP Code, the current quarter’s observed median home price and price change relative to the prior quarter would be biased upwardly, and the subsequent period’s observed price change would tend to be biased downwardly. The opposite would occur if a quarter’s sample of home sales were skewed to below average quality for homes within a ZIP Code. This kind
of measurement error attributable to composition effects within an area, similar to so-called bid-ask price bounce errors in daily closing stock price observations, would tend to induce negative autocorrelation in home price changes across calendar quarters (Prasad and Richards, 2008).

A second disadvantage of using quarterly home price data is greater severity in estimation biases attributable to non-synchronous pricing in housing markets versus financial markets. This non-synchronicity may in part be behavioral in that changes in household wealth attributable to the capital market may not immediately translate into changes in demand for housing that affect home prices in equilibrium. In addition, we observe stock and bond prices on a daily basis, and our stock and bond pricing factors are constructed on a strict quarter-end to quarter-end basis. In contrast, homes are sold throughout a calendar quarter with identification of the median price of all home sales based on all such sales within a quarter, and prices are usually negotiated several weeks or months before actual transactions dates. Consequently, our ZIP Code level median home prices are likely to be stale relative to the prices underlying our capital market pricing sensitivities. Estimates of capital market pricing sensitivities are likely to be biased downwardly in the presence of such non-synchronicity (Dimson, 1979).

Fortunately, the longer time series of quarterly observations also provides additional degrees of freedom to accommodate methods that address these data characteristics. First, lagged changes in home prices in our estimated equations help correct for fundamental or measurement error-induced autocorrelation. Second, including lagged capital market factors allows for capital market returns from prior quarters to affect home prices in the current quarter. Third, we attempt to control for non-synchronicity biases by estimating so-called “Dimson betas” that require inclusion of lagged capital market return factors (Dimson, 1979). Specifically, we calculate factor pricing sensitivities for the equity market and bond market pricing factors as the sum of the estimated factor sensitivities on the same-quarter and lagged capital market factors as follows:

\[
\hat{\beta}_{ZIP} = \hat{\beta}_{ZIP}^0 + \hat{\beta}_{ZIP}^{-1} + \hat{\beta}_{ZIP}^{-2},
\]

\[
\hat{\tau}_{ZIP} = \hat{\tau}_{ZIP}^0 + \hat{\tau}_{ZIP}^{-1} + \hat{\tau}_{ZIP}^{-2}.
\]

Again, calculating factor sensitivities as the sum of the current and lagged estimates factor sensitivities helps reduce biases associated with non-synchronous pricing in the market for homes versus the markets for stocks and bonds.

**Hypotheses**

Foremost, we are interested in the extent to which ZIP Code level home price changes are related to capital market pricing factors. Consequently, we test
hypotheses on the factor sensitivities we estimate via variations on Equations (1), (2), and (3). First, we hypothesize that these factor sensitivities—as measured by $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$ as defined by Equations (2) and (3)—will tend to be positive, reflecting integration in pricing between markets for financial securities and the market for real assets.

Second, we hypothesize that these factor sensitivities will increase with median home prices across ZIP Codes. We categorize our sample ZIP Codes by median home price observed immediately prior to our sample period in the fourth quarter of 2000, in contrast to Cannon, Miller, and Pandher (2006), who measure median home price as the average over their eight-year sample period. We do so to avoid a bias for classifying ZIP Codes that experience higher than (lower than) average price appreciation over our sample period as high (low) priced ZIP Codes, which could induce a potentially spurious relation between price levels and returns to housing. Our prediction of a positive relation between home price levels and capital market sensitivities is based on the premise that households in ZIP Codes characterized by high-priced homes are more likely to have financial wealth that is directly exposed to capital market risks or human capital and income that is indirectly exposed to such risks. Wealth changes induced by capital market returns for such households are likely to affect more strongly demand and equilibrium prices in ZIP Codes characterized by higher priced homes.

### Results

**Estimates of Capital Market Pricing Factor Sensitivities**

Exhibit 4 documents the coefficients estimated in six different specifications derived from Equation (1). The first three specifications summarized in columns (1), (2), and (3) of Exhibit 4 exclude autoregressive terms based on prior quarters’ home price changes but include the equity risk factors, bond risk factors, or both. The mean point estimates for $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$ in columns (1) and (2), respectively, are 0.018 and 0.026; the cross-sectional $t$-tests on these means suggest that they do not differ materially from zero. In contrast, column (3) provides joint estimates of sensitivity to equity and bond returns. The specification in column (3) provides point estimates for $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$ of 0.077 ($t = 4.56$) and 0.253 ($t = 5.29$), respectively. The results in column (3) suggest that controlling for interest rate risk can be important when investigating the magnitude of equity market risk, and vice versa. In terms of economic significance, the estimates in column (3) suggest that if excess equity market returns were +10%, median home price changes across sample ZIP Codes could be expected to average +0.8% larger than usual. Similarly, if the excess quarterly return on Treasury notes were +5%, then median home prices could be expected to increase by 1.3% more than usual on average across sample ZIP Codes.\(^{11}\)

Estimations of Equation (1) shown in columns (4), (5), and (6) of Exhibit 4 include autoregressive terms based on prior quarters’ home price changes. The mean point
## Exhibit 4 | Sensitivities of ZIP Code Level Home Price Changes to Capital Market Factors

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</tr>
<tr>
<td></td>
<td></td>
<td>(-0.91)</td>
<td>(4.70)</td>
<td>(0.99)</td>
<td>(9.51)</td>
<td></td>
</tr>
<tr>
<td>$\hat{\beta}_{ZIP}$</td>
<td>$\sum_{j=2}^{0} \hat{\beta}_{ZIP}^j$</td>
<td>0.018</td>
<td>0.077</td>
<td>0.025</td>
<td></td>
<td>0.177</td>
</tr>
<tr>
<td></td>
<td>(1.63)</td>
<td>(4.56)</td>
<td>(1.71)</td>
<td></td>
<td>(9.10)</td>
<td></td>
</tr>
<tr>
<td>$\hat{\tau}_{ZIP}$</td>
<td>$\sum_{j=2}^{0} \hat{\tau}_{ZIP}^j$</td>
<td>0.026</td>
<td>0.253</td>
<td>0.237</td>
<td>0.674</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.78)</td>
<td>(5.29)</td>
<td>(6.19)</td>
<td></td>
<td>(12.36)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: For up to 3,309 U.S. ZIP Codes we estimate the sensitivity of quarterly changes in medium home prices to capital market pricing factors based on returns on stocks and bonds for 2001 to 2006. Specifically, we estimate versions of Equation (1):

$$ R_{ZIP,t} - R_{t} = \alpha_{ZIP} + \phi_{ZIP}^1 (R_{ZIP,t-1} - R_{t-1}) + \phi_{ZIP}^2 (R_{ZIP,t-2} - R_{t-2}) + \beta_{ZIP} (R_{M,t} - R_{t}) + \beta_{ZIP}^1 (R_{M,t-1} - R_{t-1}) + \beta_{ZIP}^2 (R_{M,t-2} - R_{t-2}) + \tau_{ZIP}^0 (R_{RF,t} - R_{t}) + \tau_{ZIP}^1 (R_{RF,t-1} - R_{t-1}) + \tau_{ZIP}^2 (R_{RF,t-2} - R_{t-2}) + \epsilon_{ZIP,t}, $$

where $R_{ZIP,t}$ is the percentage change in median home price at ZIP Code $ZIP$ for quarter $t$, $R_t$ is the quarterly risk-free rate, $R_{M,t}$ is the quarterly return on the CRSP value-weighted equity portfolio, and $R_{RF,t}$ is the quarterly return on 10-year U.S. Treasury notes. The exhibit reports the mean coefficients estimates across all sample ZIP Codes. For columns (1)–(3), the number of ZIP Codes is 3,309. For columns (4)–(6), the number of ZIP Codes is 3,292. The numbers in parentheses are cross-sectional $t$-statistics that test whether the cross-sectional mean coefficient estimate differs from zero.
estimates for $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$ in columns (4) and (5), respectively, are 0.025 and 0.237; the cross-sectional $t$-tests on these means suggest material sensitivity to bond returns but only marginally positive average sensitivity to equity returns. In contrast, column (6) provides joint estimates of sensitivity to equity and bond returns. The specification in column (6) provides mean estimates for $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$ of 0.177 ($t = 9.10$) and 0.674 ($t = 12.36$), respectively. These average point estimates are materially larger than those estimated without the autoregressive home price changes. In terms of economic significance, the estimates in column (6) of Exhibit 4 suggest that if excess equity market returns were +10%, median home price changes could be expected to be +1.8% larger than usual; this figure is remarkably similar to the level of economic significance report by Jud and Winkler (2002). Similarly, if the excess return on Treasury notes were +5%, then median home prices could be expected to increase by 3.4% more than usual, on average. The results in column (6) versus those in column (3) suggest that on average negative autocorrelation in median home price changes (likely due to measurement issues rather than fundamental mean reversion) can confound identification of capital market pricing sensitivities. Specifically, including two quarters of prior home price changes as in column (6) more than doubles the estimated capital market sensitivities as shown in column (3).13

Additional information with regard to the estimations reported in Exhibit 4 is found in Exhibit 5. Panels A and B of Exhibit 5 show scatter plots of estimates of $\hat{\beta}_{ZIP}$ versus $\hat{\tau}_{ZIP}$ across sample ZIP Codes, as well as simple least squares lines of best fit. These scatter plots suggest a positive relation between sensitivities to equity market and bond market movements across U.S. ZIP Codes. Given this empirical relation and volatile interest rate environment in the U.S. over our 2001 to 2006 sample period, it seems likely that controlling for interest rate risk might be critical in detecting equity market risk.

**Home Price Levels and Capital Market Sensitivities**

We next investigate how our estimates of capital market pricing sensitivity vary by home price level. Exhibits 6 and 7 provide information on the central tendencies observed in capital market pricing factors across ZIP Codes that have been sorted by median home price level at the start of our sample period into quintiles of equal sample size. In particular, Panels A and B of Exhibit 6 report the mean and median values for $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$ after sorting the sample of ZIP Codes by median home price. These panels indicate generally higher mean and median values for both equity market sensitivity and bond market sensitivity in ZIP Codes characterized by higher priced homes versus ZIP Codes characterized by lower priced homes.

Results shown in Panels A and B of Exhibit 7 come full circle by comparing how the positive relation between housing betas and home price level revealed by our analysis compares with the evidence reported by Cannon, Miller, and Pandher (2006) and previously illustrated in Exhibit 1. Specifically, in contrast to Exhibit 1,
Exhibit 5 | Relationship between Equity and Bond Market Sensitivities for Home Price Changes

**Panel A:** $\hat{\beta}_{ZIP}$ versus $\hat{e}_{ZIP}$ (estimated without autoregressive home price terms)

**Panel B:** $\hat{\beta}_{ZIP}$ versus $\hat{e}_{ZIP}$ (estimated with autoregressive home price terms)
### Exhibit 6 | Capital Market Pricing Sensitivities by Home Prices

<table>
<thead>
<tr>
<th>ZIP Codes Sorted by Median Home Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Price</td>
</tr>
<tr>
<td>-----------</td>
</tr>
</tbody>
</table>

#### Panel A: Mean (median) values of $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$ estimated without autoregressive home price terms

$$\hat{\beta}_{ZIP} = \sum_{j=2}^{0} \hat{\beta}_{ZIP}^j$$

<table>
<thead>
<tr>
<th></th>
<th>0.075</th>
<th>0.092</th>
<th>0.071</th>
<th>0.115</th>
<th>0.181</th>
<th>3.85</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.045)</td>
<td>(0.091)</td>
<td>(0.159)</td>
<td>(0.249)</td>
<td>(6.35)</td>
</tr>
</tbody>
</table>

$$\hat{\tau}_{ZIP} = \sum_{j=2}^{0} \hat{\tau}_{ZIP}^j$$

<table>
<thead>
<tr>
<th></th>
<th>0.015</th>
<th>0.122</th>
<th>0.187</th>
<th>0.388</th>
<th>0.551</th>
<th>2.94</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.056)</td>
<td>(0.066)</td>
<td>(0.222)</td>
<td>(0.457)</td>
<td>(0.647)</td>
<td>(4.08)</td>
</tr>
</tbody>
</table>

#### Panel B: Mean (median) values of $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$ estimated with autoregressive home price terms

$$\hat{\beta}_{ZIP} = \sum_{j=2}^{0} \hat{\beta}_{ZIP}^j$$

<table>
<thead>
<tr>
<th></th>
<th>0.082</th>
<th>0.211</th>
<th>0.141</th>
<th>0.183</th>
<th>0.267</th>
<th>2.74</th>
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<tbody>
<tr>
<td></td>
<td>(0.162)</td>
<td>(0.154)</td>
<td>(0.175)</td>
<td>(0.229)</td>
<td>(0.268)</td>
<td>(2.61)</td>
</tr>
</tbody>
</table>

$$\hat{\tau}_{ZIP} = \sum_{j=2}^{0} \hat{\tau}_{ZIP}^j$$

<table>
<thead>
<tr>
<th></th>
<th>0.592</th>
<th>0.580</th>
<th>0.631</th>
<th>0.625</th>
<th>0.940</th>
<th>1.94</th>
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<tbody>
<tr>
<td></td>
<td>(0.517)</td>
<td>(0.453)</td>
<td>(0.474)</td>
<td>(0.639)</td>
<td>(0.931)</td>
<td>(1.53)</td>
</tr>
</tbody>
</table>

**Notes:** For up to 3309 U.S. ZIP Codes we estimate the sensitivity of quarterly changes in medium home prices to capital market pricing factors based on returns on stocks and bonds for 2001 to 2006 as per Equation (1):

$$R_{ZIP,t} - R_{F,t} = \alpha_{ZIP} + \phi_{ZIP}(R_{ZIP,t-1} - R_{F,t-1}) + \phi_{ZIP}(R_{ZIP,t-2} - R_{F,t-2}) + \beta_{2ZIP}(R_{M,t} - R_{F,t}) + \beta_{2ZIP}(R_{M,t-1} - R_{F,t-1}) + \beta_{2ZIP}(R_{M,t-2} - R_{F,t-2}) + \tau_{2ZIP}(R_{ZIP,t-1} - R_{F,t-1}) + \tau_{2ZIP}(R_{ZIP,t-2} - R_{F,t-2}) + e_{ZIP,t}.$$  

In Panels A and B we sort ZIP Codes by median home prices observed at end-2000 into quintiles and calculate mean (median) values of $\hat{\beta}_{ZIP}$ and $\hat{\tau}_{ZIP}$, calculated as the sum of the contemporaneous and lagged factor pricing sensitivities associated with returns on U.S. stocks and bonds, respectively.
Exhibit 7 | Home Price Sensitivity to Capital Market Factors across Zip Codes Sorted by Median Home Price

Panel A: Median $\hat{\beta}_{ZIP}$ and interquartile range by home price quintile ($\hat{\beta}_{ZIP}$ estimated without autoregressive home price terms)

Panel B: Median $\hat{\beta}_{ZIP}$ and interquartile range by home price quintile ($\hat{\beta}_{ZIP}$ estimated with autoregressive home price terms)
Exhibit 7 | (continued)
Home Price Sensitivity to Capital Market Factors across Zip Codes Sorted by Median Home Price

Panel C: Median $\hat{\gamma}_{ZIP}$ and interquartile range by home price quintile ($\hat{\gamma}_{ZIP}$ estimated without autoregressive home price terms)

Panel D: Median $\hat{\gamma}_{ZIP}$ and interquartile range by home price quintile ($\hat{\gamma}_{ZIP}$ estimated with autoregressive home price terms)
which is based on figures reported by Cannon, Miller, and Pandher, Panels A and B of Exhibit 7 show that estimates of equity market risk in ZIP Code level home price changes are increasing in home-price levels. Panels C and D of Exhibit 7 show a similar relation for exposure to interest rate risk as measured by sensitivity to 10-year Treasury note returns. In short, prices for homes appear more sensitive to capital market movements in ZIP Codes characterized by higher priced homes. These findings are consistent with the notion that households in high price ZIP Codes are likely to be exposed to greater capital market risks, either through their capital market investments or human capital investments (e.g., executive talent) whose returns are influenced by capital market factors.

Regression Analysis

Exhibit 8 shows results from cross-sectional regression analysis of the determinants of capital market sensitivities. The dependent variable in these cross-sectional regression equations is alternatively $\hat{\beta}_{ZIP}$ (Panel A) or $\hat{\tau}_{ZIP}$ (Panel B), both estimated for each sample ZIP Code from the full version of Equation (1). The primary explanatory variable is $\log(Price_{ZIP})$, the log of the median home price for each respective ZIP Code as observed at the end of 2000. As shown in column (1) of each regression specification, capital market sensitivities across ZIP Codes increase with the log of median home price. In Panel A, the coefficient on $\log(Price_{ZIP})$ is 0.087 ($t$-stat = 3.09); this coefficient suggests that for a ZIP Code characterized by a median home price of $500,000, sensitivity to equity market returns as measured by $\hat{\beta}_{ZIP}$ is about 0.08 larger than a ZIP Code characterized by a median home price of $200,000. In Panel B, the coefficient on $\log(Price_{ZIP})$ is 0.198 ($t$-stat = 2.51); this coefficient suggests that for a ZIP Code characterized by a median home price of $500,000, sensitivity to bond returns as measured by $\hat{\tau}_{ZIP}$ is about 0.18 larger than a ZIP Code characterized by a median home price of $200,000.

The coefficients on $\log(Price_{ZIP})$ retain statistical and economic significance in the presence of additional explanatory variables in columns (2) through (6) of Panels A and B of Exhibit 8. We include these additional variables to investigate whether the price level effect we document proxies for city-specific or regional economic variables. MSA-specific variables are per capita investment income (from dividends, interest, and rent) as a percentage of personal income at year-end 2000, log of population as of year-end 2000, and log of median per capita income at year-end 2000. Some specifications also include regional indicators for ZIP Codes located in the East, South, Midwest, and West regions of the U.S.

We are particularly interested in the effects of per capita investment income as a proportion of total income across MSAs. This variable has sometimes been used as a direct measure of average financial market participation or investor sophistication across cities (e.g., Pirinsky and Wang, 2006). Consequently, we expect that ZIP Codes in cities where investment income is high would experience greater sensitivity of home prices to capital market movements. This hypothesis
### Panel A: Dependent variable is equity market sensitivity as measured by $\beta_{ZIP} = \sum_{i=1}^{n} \beta_i^{ZIP}$

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln(\text{Price}_{ZIP})$</td>
<td>0.087</td>
<td>0.076</td>
<td>0.091</td>
<td>0.062</td>
<td>0.057</td>
<td>0.071</td>
</tr>
<tr>
<td></td>
<td>(3.09)</td>
<td>(2.66)</td>
<td>(2.88)</td>
<td>(1.88)</td>
<td>(1.74)</td>
<td>(1.85)</td>
</tr>
<tr>
<td>$\text{Investment income}_{\text{MSA}}$</td>
<td>—</td>
<td>0.926</td>
<td>0.866</td>
<td>—</td>
<td>0.914</td>
<td>0.900</td>
</tr>
<tr>
<td></td>
<td>(2.12)</td>
<td>(1.88)</td>
<td>(1.89)</td>
<td>(1.78)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln(\text{Pop}_{\text{MSA}})$</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.001</td>
<td>—</td>
<td>—</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(−0.03)</td>
<td></td>
<td>(−0.04)</td>
</tr>
<tr>
<td>$\ln(\text{PCI}_{\text{MSA}})$</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>−0.137</td>
<td>—</td>
<td>−0.090</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(−1.04)</td>
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<td>(−0.66)</td>
</tr>
<tr>
<td>Regional indicators</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Panel B: Dependent variable is bond market sensitivity as measured by $\tau_{ZIP} = \sum_{i=1}^{n} \tau_i^{ZIP}$

<table>
<thead>
<tr>
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<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln(\text{Price}_{ZIP})$</td>
<td>0.198</td>
<td>0.180</td>
<td>0.176</td>
<td>0.315</td>
<td>0.299</td>
<td>0.348</td>
</tr>
<tr>
<td></td>
<td>(2.51)</td>
<td>(2.25)</td>
<td>(1.98)</td>
<td>(3.41)</td>
<td>(3.23)</td>
<td>(3.24)</td>
</tr>
<tr>
<td>$\text{Investment income}_{\text{MSA}}$</td>
<td>—</td>
<td>1.486</td>
<td>1.203</td>
<td>—</td>
<td>3.117</td>
<td>2.684</td>
</tr>
<tr>
<td></td>
<td>(1.21)</td>
<td>(0.93)</td>
<td>(2.30)</td>
<td>(1.89)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln(\text{Pop}_{\text{MSA}})$</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.052</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(−0.91)</td>
<td></td>
<td>(−0.97)</td>
</tr>
<tr>
<td>$\ln(\text{PCI}_{\text{MSA}})$</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>0.332</td>
<td>—</td>
<td>−0.009</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>(0.90)</td>
<td></td>
<td>(−0.02)</td>
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<tr>
<td>Regional indicators</td>
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<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Notes:** This exhibit shows the results from cross-sectional ordinary least squares regressions of 3,292 ZIP Code-specific estimates of capital market sensitivities to ZIP Code level and city level factors. The dependent variables in panels A and B are the ZIP Code level estimates of equity market and bond market sensitivities based on equations (2) and (3), respectively, from estimations of equation (1). Explanatory variables include $\ln(\text{Price}_{ZIP})$ — the log of the median home price observed for each ZIP Code as of 2000:Q4, $\text{Investment income}_{\text{MSA}}$ — the ratio of per capita investment income to personal income for the metropolitan statistical area (MSA) in which the ZIP Code is located as of 2000:Q4, $\ln(\text{Pop}_{\text{MSA}})$ — the log of total 2000:Q4 population of the MSA, and $\ln(\text{PCI}_{\text{MSA}})$ — the log of 2000:Q4 per capita income of the MSA. Estimations reported in columns (4)–(6) include indicator variables for Midwest, West, East, and South regions of the U.S. We estimate but do not report the intercept terms. The figures reported in parentheses below the coefficient estimates are t-statistics.

It appears to be borne out in the results shown in Panel A of Exhibit 8, as coefficients on $\text{Investment income}_{\text{MSA}}$ are positive across all specifications. Coefficients on $\text{Investment income}_{\text{MSA}}$ are also positive across specification shown in Panel B, but the estimates differ reliably from zero only when regional indicator variables are included in columns (5) and (6). The coefficient estimate for $\text{Investment income}_{\text{MSA}}$
in column (6) of Panel A of 0.900 (t-stat = 1.78) suggests that a one standard deviation increase in Investment income_MSA would result in a 0.045 increase in sensitivity to equity returns as measured by $\hat{\beta}_{ZIP}$. The corresponding coefficient in Panel B (2.684, t-stat = 1.89) suggests that a one standard deviation increase in Investment income_MSA would result in a 0.134 increase in sensitivity to bond returns as measured by $\hat{\tau}_{ZIP}$. MSA-specific measures of population and per capita income, in contrast, do not appear to condition either of our two measures of capital market sensitivity.

**Conclusion**

This study analyzes the sensitivity of ZIP Code level changes in home prices to capital market risk factors derived from equity and bond prices. In particular, we investigate whether changes in median home prices for over 3,000 U.S. ZIP Codes associated with 203 metropolitan areas from 2001 to 2006 are sensitive to the returns on U.S. stocks and U.S. Treasury securities. Cannon, Miller, and Pandher (2006) conduct a related analysis using annual median home price data for more than 7,000 ZIP Codes from 155 cities and annual changes in the S&P 500 from 1996 to 2003. Cannon, Miller, and Pandher motivate their analysis in part by presuming that wealthier households in areas with higher priced homes are more likely to have material exposure to stock market risk due to their financial investments and investments in human capital related to managerial careers. The prima facie evidence documented in Cannon, Miller, and Pandher appears inconsistent with this premise, however, as their estimates of housing betas are negative on average and appear to be inversely related to home-price levels.

Our six years of quarterly home price data across more than 3,000 ZIP Codes provide additional degrees of freedom that permit estimation of factor sensitivities to both equity and bond market movements across our sample. The time series properties of our home price data also require that we make additional allowances for challenges such as autocorrelation in home price changes and non-synchronous pricing in housing markets versus financial markets. After making such allowances, we obtain results that are consistent with home prices being positively exposed to capital market risk factors on average across the U.S. Furthermore, exposures to both equity and bond return factors appear to increase with home price levels across our sample. This result is consistent with the notion that the market for higher valued homes is more sensitive to capital market movements than the market for lower valued homes, likely as a result of greater direct and indirect exposure to capital market risks among wealthier households.

We suggest several avenues for future research. In particular, our data are from a time period in which home prices for many parts of the U.S. rose faster than underlying economic fundamentals might have suggested (Wheaton and Nechayev, 2008; Beracha and Hirschey, 2009). Extending our analysis beyond 2006 to the troubled period of 2007 to 2009 appears valuable as this latter period is characterized not only by falling home prices in many areas of the U.S. but
also by extreme capital market volatility. Also, the relation between area-specific financing trends, such as expansion of subprime lending or securitization of mortgages, and other factors that condition home price trends appears to be a fruitful avenue for future research (e.g., see Mian and Sufi, 2008).

Endnotes

1 Jud and Winkler (2002) report in their endnote 10 (p. 44) that they investigate a specification with distinct effects of S&P 500 changes on annual changes in home price indexes for each MSA in their sample, but they do not report the results.

2 Among other references for the practice of utilizing ZIP Code areas as an appropriate sub-city division, Cannon, Miller, and Pandher (2006) cite Goodman and Thibodeau (2003), who show that identifying housing submarkets based on ZIP Codes results in property pricing prediction errors only slightly more dispersed than dividing areas by measures based on school districts and school district quality.

3 Specifically, Cannon, Miller, and Pandher’s (2006) Equation (2) is:

\[
R_{ZIP,T} - R_{F,T} = \alpha_{ZIP} + \beta_{ZIP}(R_{S&P500,T} - R_{F,T}) + \epsilon_{ZIP,T},
\]

where \( T = 1996, 1997, \ldots, 2003 \), and where ZIP varies across 7,234 postal ZIP Codes (pp. 538–39).

4 Cannon, Miller, and Pandher (2006, pp. 520–21) make similar suggestions: “For example, neighborhoods with higher priced homes where households tend to be employed in managerial occupations may be more sensitive to changes in the stock market through an income/wealth effect.” ... “One possible explanation follows from the degree to which household income and wealth in various submarkets is sensitive to the wider economy, whose leading indicator is the stock market. Houses in ZIP Codes that are more sensitive to the stock market have the potential of greater appreciation in states of the stock market that provide those households with higher income and wealth (when, e.g., higher corporate profits increase compensation, bonuses, and stock options to managers).”

5 In some specifications we require up to two quarters of lagged within-ZIP home returns. This leads to attrition of only seventeen of our sample ZIP Codes in the affected specifications.

6 http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

7 http://research.stlouisfed.org/fred2/.

8 We conducted augmented Dickey-Fuller tests on each of our time series variables and found them to be stationary. Specifically, we reject unit roots at substantially better than the 1% level of significance for both the equity return factor \( (R_{M,T} - R_{F,T}) \) and the T-bond return factor \( (R_{B,T} - R_{F,T}) \). For our more than 3000 ZIP Code-specific time series of median home price changes \( (R_{ZIP,T} - R_{F,T}) \) we reject a unit root at the 1% level of significance for 96% of the time series; we reject a unit root at the 5% level of significance for 99% of the time series. In short, our time series appear to be stationary,
and further corrective prescriptions for cointegration among time series with unit roots are not merited.

9 As discussed below, we also investigate longer lag structures, both for within-Zip Code price changes and stock and bond returns. Our reported results are not affected by the inclusion of additional lagged variables on the right-hand side of Equation (1).

10 To paraphrase the comments of one discussant of this paper: “If today my portfolio were to increase in value dramatically, it might take a few months for my spouse to talk me into buying a bigger house.”

11 At year-end 2003 (the middle of our sample period) a +5% quarterly return on a 10-year Treasury would be consistent with about 50 basis point drop in yield to maturity over a calendar quarter.

12 The standard errors underlying the reported t-statistics may be biased downward due to correlation in home price changes for ZIP Codes within an MSA. We also averaged estimates for  and  across ZIP Codes within each MSA, and then computed t-tests across the 203 MSAs. Our inferences hold for this alternative procedure. For example, for the estimation summarized in column (6) of Exhibit 4, the MSA-level average  and  are 0.123 (t-test = 2.15) and 0.592 (t-test = 4.39), respectively.

13 We also estimate but do not report extensions to Equation (1) that include additional lags in home price changes or capital market pricing factors, as well as indicator variables for quarterly seasonality in home price changes. For instance, coefficients on additional three- and four-quarter lagged home price changes are negative but materially smaller in absolute magnitude than the first two lagged quarters. Coefficients on three- and four-quarter lagged capital market factors are positive but indistinguishable from zero at the 10% level. Inclusion of seasonal indicator variables does not affect inferences on capital market sensitivities. More importantly, in these additional unreported specifications the estimates for  and  are nearly the same as those reported in Exhibit 4, and their conditional distributions do not differ materially from those we report in subsequent exhibits.

14 Dependent variables in Exhibit 8 are calculated using the estimated coefficients from the specification summarized in column (6) of Exhibit 4. Regression results using estimates of  and  derived without autoregressive lags of home price changes [see column (3) of Exhibit 4] are similar to results reported in Exhibit 8.

15 We thank one of our referees for suggesting these additional specifications.

16 We obtain these variables from the Regional Economic Information System (REIS) provided by the Bureau of Economic Analysis. We also extended these regression specifications to include the 2000–2006 growth rates in per capita income and population by MSA. In these additional unreported specifications, the results with respect log(PriceZIP) and other explanatory variables are qualitatively similar to those we report in Exhibit 8.

17 Investment income is distributed with a mean of 0.193 and a standard deviation of 0.050 across the 203 MSAs in our sample.

References


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