features

Evaluating the Risk of Housing Investment

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abstract

This article evaluates the patterns of housing risk and returns in Greensboro, NC, and Houston, TX. It shows the price risk facing the average homeowner is high and varies substantially among cities. The return on an individual housing transaction is positively associated with national returns, but the association is not strong, which indicates a high level of nonsystematic risk in housing transactions. The probability of a loss on sale in the average housing transaction is found to be large and inversely related to national housing returns and to local employment growth. It also is strongly influenced by location and other housing features.

Households in the United States have long tended to concentrate their wealth in housing. In 2001, 68% of U.S. households were homeowners, according to the Federal Reserve's *Survey of Consumer Finances.*[1] The net worth of the median homeowner household was $171,700. The value of the median household's primary residence was $123,000, and its housing equity was $53,000, or about 31% of its total net wealth.

The risk confronting households holding large amounts of undiversified real estate has been recognized by Case, Shiller, and Weiss, and by Caplin et al.[2] Case, Shiller, and Weiss propose the establishment of cash-settled real estate futures and options markets to allow better hedging and diversification. Caplin et al. urge the creation of partnership markets for housing equity. In December 2004, the Chicago Mercantile Exchange announced it was proceeding to offer futures contracts based on the cost of housing in different major cities in the United States.[3]

This article focuses on assessing the risk of housing investment. Although most homeowners consider housing to be a consumption good, it is clear that housing also represents an investment. Although imputed rent is consumed when a homeowner occupies a house, this benefit is excluded from the risk and return analysis in this study.

When judged on the basis of movements in aggregate price indexes, housing appears to be a relatively low-risk investment. For example, the Office of Federal Housing Enterprise Oversight (OFHEO) produces a series of aggregate price indexes for existing housing that are often used to assess current housing trends. Drawing on annual data from the national OFHEO House Price Index for 1975–2003 yields the series of capital gain returns shown in Table 1 for one-, three-, five-, seven-, and ten-year holding periods.

1. Ana M. Aizcorbe et al., "Recent Changes in U.S. Family Finances: Evidence from the 1998 and 2001 Survey of Consumer Finances," *Federal Reserve Bulletin* (January 2003): 1–32.
2. Karl E. Case Jr., Robert J. Shiller, and Allan N. Weiss, "Index-Based Futures and Options Markets in Real Estate," *Journal of Portfolio Management* 19, no. 2 (Winter 1993): 83-92; Andrew Caplin et al., "Household Asset Portfolios and the Reform of the Housing Finance Market," *TIAA-CREF Research Dialogues* (February 1999).
3. Chicago Mercantile Exchange, "CME and MARCO Securities Research to Explore Development of Futures Contracts Based on Housing Prices," M2PressWIRE, December 6, 2004.

Table 1 shows that between 1975 and 2003 there were 28 one-year holding periods (*n*). The average one-year capital gain return to housing investment (ignoring transaction costs) was 5.7% with a standard deviation of 3.2% and a coefficient of variation (CV) of 0.52.[4] The risks and returns for housing investment decline with longer holding periods, as shown in Table 1.[5]

When compared to common stocks over the same periods, housing investment appears to have substantially lower risk. Comparing Tables 1 and 2, housing investment has lower risks and returns for almost all corresponding holding periods shown, the exceptions being the CVs for housing with 7- and 10-year holding periods, which are higher than the equivalent CVs for stocks.

The risks and returns shown in Tables 1 and 2 are associated with national portfolios of houses and stocks. For stocks, this is appropriate because stock investors can purchase shares in funds that hold such portfolios; however, for housing investors, purchase of shares in a national housing portfolio is not possible. Most housing investors are able to purchase a share only in the house they occupy. This means that housing investors have no way of diversifying away the nonsystematic risk of housing investment.

To evaluate the patterns of housing risk and returns, this study examines samples of repeat-sale, single-family homes in Greensboro, NC (1975–2003), and in Houston, TX (1989–2004). The first section of this article reviews the literature on housing risks and returns, and the second section examines the pattern of housing risks and returns. The third section estimates a series of housing return models to explore the determinants of returns. The fourth section presents a probit model to examine the factors that influence the probability of loss, and the final section provides a summary and evaluation of the results.

Literature Review

A number of past studies have examined the risks and returns of housing market investment, including papers by Coyne, Goulet, and Picconi; Alberts and Kerr; Hendershott and Hu; Peiser and Smith; Webb and Rubens; Miller and Sklarz; Case and Shiller; Ermer, Cassidy, and Sullivan; Harris; and Jud and

Table 1 Holding Period Risks and Returns for Housing, 1975–2003 (Capital Gains Only)

	Holding Periods (Years)				
	1	**3**	**5**	**7**	**10**
Ave. Return	5.7%	5.6%	5.3%	5.0%	4.8%
Std. Dev.	3.2%	2.9%	2.3%	1.8%	1.5%
CV	0.56	0.52	0.44	0.36	0.31
n	28	26	24	22	19

Computed using annual data for the national OFHEO House Price Index.

Table 2 Holding Period Risks and Returns for Stocks, 1975–2003 (Capital Gains Only)

	Holding Periods (Years)				
	1	**3**	**5**	**7**	**10**
Ave. Return	9.8%	10.0%	11.1%	11.4%	11.5%
Std. Dev.	13.6%	9.1%	6.0%	3.8%	2.2%
CV	1.39	0.91	0.54	0.33	0.19
n	28	26	24	22	19

Computed using annual data for the S&P 500 Index.

4. Standard deviation is a measure of variability. It is defined as:

$$\sigma = [\sum_{t=1}^{n} (r_t - \bar{r})^2]^{0.5},$$

where r_t = is the holding period return at time *t* and $\bar{r}$ is the average return for all similar holding periods. The average return is calculated as:

$$\bar{r} = \frac{\sum_{t=1}^{n} r_t}{n}$$

The coefficient of variation (CV) is risk per unit of return, or $\sigma/\bar{r}$. In the financial literature, the standard deviation and the coefficient of variation are used as measures of investment risk, and the average is the typical value of a set of values, sometimes called the mean.

5. The national OFHEO House Price Index is tabulated quarterly from 1975.1 through 2003. Table 1 shows assumed holding periods only for 10 years and less.

Winkler.[6] Most of these studies have assessed the risks and returns of housing investment using aggregate indexes of market prices.

Case and Shiller relate the price risk of an individual house to the movements in a metropolitan statistical area (MSA) price index.[7] They show that a relatively low percentage of the variation in the price of an individual house can be accounted for by the variation in the MSA-wide price index.

Goetzmann investigates the risk and return in an investment portfolio using the weighted repeat sales to produce a quality-adjusted housing price index.[8] He finds that investing in an individual house has about twice the risk of a well-diversified portfolio (investing in a regional or inter-regional portfolio).

Englund, Hwang, and Quigley study the investment implications of housing choices using housing prices in Stockholm.[9] Their quarterly data consists of one-family houses in eight regions of Sweden from January 1981 to August 1993. The analysis consists of optimal portfolio analysis of real estate stocks, a general stock portfolio, T-bills, bonds, and houses. The results of their study suggest that return losses get larger with increasing portfolio shares in housing by an average of several percent. An efficient portfolio would include no housing for short holding periods, but for longer periods, low-risk portfolios would include between 15% and 50% housing.

Using data for five cities, Eichholtz, Koedijk, and de Roon use a mean-variance framework to examine residential property holdings.[10] They find that residential real estate provides significant diversification benefits, and that most U.S. investors have the optimal diversification benefits by allocating about 30% of their investment portfolio to residential real estate. However, neither stocks nor bonds are found to be a good hedge for housing.

Flavin and Yamashita, using housing price data from the Panel Study of Income Dynamics (PSID), estimate the risk and return to investments in residential real estate.[11] They confirm the absence of a positive correlation between housing and financial asset returns. Also, the inclusion of housing as an asset in the household wealth portfolio is found to dramatically improve the unconstrained mean-variance performance of the household portfolio. The PSID housing price data is based on annual household estimates of the value of their housing, not actual transactions. For the 1968–1992 period, Flavin and Yamashita estimate the average capital gain return to housing from the PSID data at 6.59% with a standard deviation of 14.24%.

Patterns of Housing Risk and Return

The total risk of housing investment theoretically can be decomposed into market risk (systematic risk) and house-specific risk (nonsystematic risk) as shown in the following equation:

$$\text{Total housing risk} = \text{market risk} + \text{house-specific risk} \quad (1)$$

Market risk is that portion of total risk that is related to factors that systematically affect the returns for most homes, such as inflation, recession, and high interest rates. Market risk is measured in Table 1. House-specific risk is that portion of total risk that is related to factors that are specific to a particular house and its location, such as its structural characteristics, neighborhood environment,

6. Thomas J. Coyne, Waldemar M. Goulet, and Mario J. Picconi, “Residential Real Estate Versus Financial Assets,” *Journal of Portfolio Management* 7, no. 1 (Fall 1980): 20–24; William W. Alberts and Halbert S. Kerr, “The Rate of Return From Investing in Single-Family Housing,” *Land Economics* 57, no. 2 (May 1981): 230–242; Patric H. Hendershott and Sheng Cheng Hu, “Inflation and Extraordinary Returns on Owner-Occupied Housing: Some Implications for Capital Allocation and Growth,” *Journal of Macroeconomics* 3, no. 2 (Spring 1981): 177–203; Richard B. Peiser and Lawrence B. Smith, “Homeownership Returns, Tenure Choice and Inflation,” *AREUEA Journal* 13, no. 4 (Winter 1985): 343–60; James R. Webb and Jack H. Rubens, “Tax Rates and Implicit Rates of Return on Owner-Occupied Single-Family Housing,” *Journal of Real Estate Research* 2, no. 1 (Winter 1987):11–28; Norman G. Miller and Michael A. Sklarz, “A Comment on ‘Tax Rates and Implicit Rates of Return on Owner-Occupied Single-Family Housing,’” *Journal of Real Estate Research* 4, no. 1 (Spring 1989): 81–84; Karl E. Case and Robert J. Shiller, “Forecasting Prices and Excess Returns in the Housing Market,” *AREUEA Journal* 18, no. 3 (Fall 1990): 253–273; Charles M. Ermer, Steven M. Cassidy, and Michael J. Sullivan, “Modeling Returns to Owner-Occupied Single-Family Residences,” *Journal of Economics and Finance* 18, no. 2 (Summer 1994): 205–217; Jack Harris, “Investment Performance of Owner-Occupied Housing” (paper presented at the annual meeting of the American Real Estate Society, Naples, FL, April 2002); G. Donald Jud and Daniel T. Winkler, “Returns to Single-Family Owner-Occupied Housing,” *Journal of Real Estate Practice and Education* 8 (forthcoming).

7. Karl E. Case and Robert J. Shiller, “Prices of Single-Family Homes Since 1970: New Indexes for Four Cities,” *New England Economic Review* 22, no. 2 (September/October 1987): 45–56.

8. William N. Goetzmann, “The Single Family Home in the Investment Portfolio,” *Journal of Real Estate Finance and Economics* 6, no. 3 (May 1993): 201–222.

9. Peter Englund, Min Hwang, and John M. Quigley, “Hedging Housing Risk,” *Journal of Real Estate Finance and Economics* 24, no. 1/2 (January-March 2002): 167–200.

10. Piet M. A. Eichholtz, Kees G. Koedijk, Frans A. de Roon, “The Portfolio Implications of Home Ownership” (manuscript, Maastricht University and University of Amsterdam, 2002).

11. Marjorie Flavin and Takashi Yamashita, “Owner-Occupied Housing and the Composition of the Household Portfolio,” *American Economic Review* 92, no. 1 (March 2002): 345–362.

public services, infrastructure, local governmental regulations, and taxes.

To assess the risk of single-family housing investment, this article draws on two samples of repeat home sales. The first sample is Greensboro, North Carolina (Guilford County).[12] This sample consists of 18,942 repeat sales of single-family homes that were bought and sold in Greensboro from 1975 through 2003. The data was taken from the master appraisal file maintained by the Guilford County Tax Assessor's Office. The geographic distribution of repeat sales in the county is illustrated in Figure A-1 of the Appendix.

The second sample is Houston, Texas (Harris County), from 1989 through 2004. This data was obtained from the Harris County Appraisal District. The sample contains 92,485 repeat sales. Unlike the Greensboro sample, the Houston sample is not geocoded and contains only a limited number of property attributes. The Appendix presents Table A-1, which contains descriptive statistics for all variables used in the analysis for both samples.

Capital gain returns for discrete holding periods were calculated for each of the properties, as follows:[13]

$$r_{i,t} = (p_{i,t+n} / p_{i,t})^{1/n} - 1 \qquad (2)$$

where:

$r_{i,t}$ = annualized return for the ith property purchased in year t;

$p_{i,t}$ = sale price of the ith property in year t;

n = the number of years between the year of purchase t and the year of sale $t + n$.

The holding period return for an individual property ($r_{i,t}$), was calculated by dividing the sales price ($p_{i,t+n}$) by the purchase price ($p_{i,t}$), taking the nth root, and subtracting one. The result is the annualized compounded return on the property held over n years.

The distribution of capital gain returns is shown in Figure 1 for Greensboro and in Figure 2 for Houston. They suggest that the total risk of investment in a single-family home in Greensboro or Houston is higher than the market risk shown in Table 1. In Greensboro, while the average return is 5.59%, the standard deviation of returns is 13.13% and the coefficient of variation is 2.35. In Houston, the average return is 4.8%, the standard deviation 5.36%, and coefficient of variation is 1.12. In both cities, the standard deviation of returns is greater than the average return. However, the coefficient of variation indicates that the risk per each percentage return is more than double in Greensboro compared to Houston. In contrast, in Table 1, where risk and return are tabulated from the aggregated OFHEO national price index, the standard deviation is substantially less than the average return, resulting in very low risk as indicated by the small coefficient of variation.

Also shown in Figures 1 and 2 are the Jarque-Bera statistics that provide a test for whether the observed distributions of housing returns are normally distributed. The Jarque-Bera statistic is distributed as χ^2 with 2 degrees of freedom. The associated *Probability* is the probability that the Jarque-Bera statistic exceeds (in absolute value) the observed value under the null hypothesis. The small probabilities shown in Figures 1 and 2 suggest rejection of the hypothesis of normal distribution.

To further examine the risk of housing investment, the risks and returns of investment for one-, three-, five-, seven-, and ten-year holding periods were tabulated, corresponding to the holding periods shown in Table 1. The results are shown in Table 3.

Table 3 shows that the average one-year capital gain return to housing investment in Greensboro (ignoring transaction costs) was 6.46%, with a standard deviation of 25.32% and a coefficient of variation (CV) of 3.92. In Houston, the average one-year

12. Guilford County is located in the Piedmont area of North Carolina, in the northern center of the state. It lies astride I-40, which connects the state east and west from Wilmington to Knoxville and I-85, which extends south from Washington through the county and on to Atlanta. The county's two main cities are Greensboro and High Point. The population of Guilford County in 2000 was 421,048, making it the third-largest county in the state, behind Mecklenburg (Charlotte) and Wake (Raleigh). From 2000 through 2003, county population grew 3.0%, lagging North Carolina's overall increase of 4.4%. The countywide unemployment rate was 5.2% in July 2004, compared to the statewide rate of 5.0%. In the second quarter of 2004, there were 219,444 persons employed in the county (from the household survey). From 1990 through 2003, employment in Guilford County rose 1.0% annually, trailing the 1.3% increase in employment recorded for North Carolina as a whole. During this period, the county sustained large employment losses in the manufacturing sector. Manufacturing employment, which accounted for 15.4% of employment in 2003, fell 1.8% annually from 1990 through 2003, recording large losses in the apparel, textile, and furniture sectors.

13. In the calculation of the annualized returns, an effort was made to exclude those properties where there was substantial change in the attributes of the property from time t to $t + n$; however, it cannot be certain that all such transactions have been excluded. Nonetheless, the number of such properties is likely to be small, and therefore, have a minimal impact on the findings.

Figure 1 **Distribution of Capital Gains Returns on Single-Family Homes in Greensboro, NC (1975–2003)**

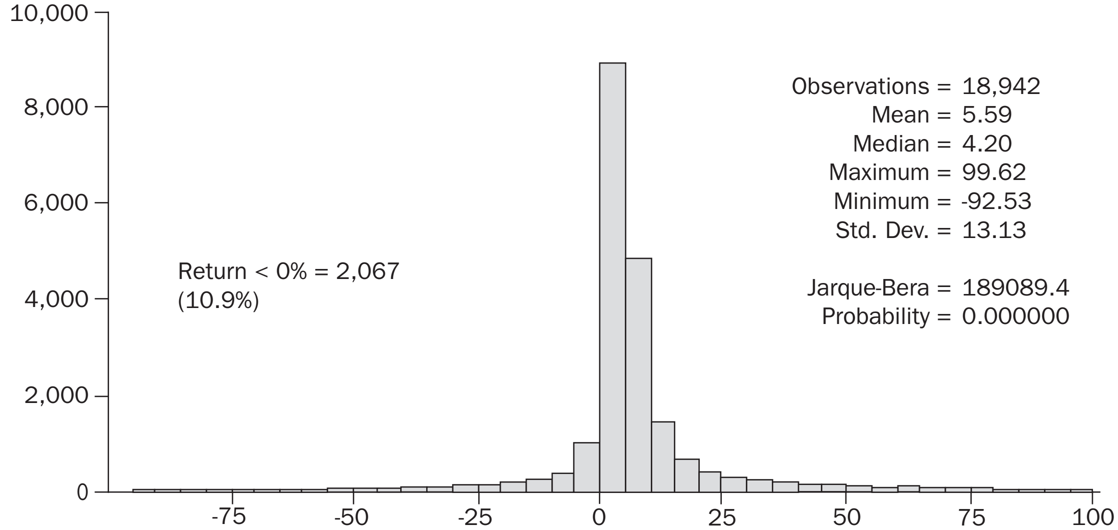


Figure 2 **Distribution of Capital Gains Returns on Single-Family Homes in Houston, TX (1989–2004)**

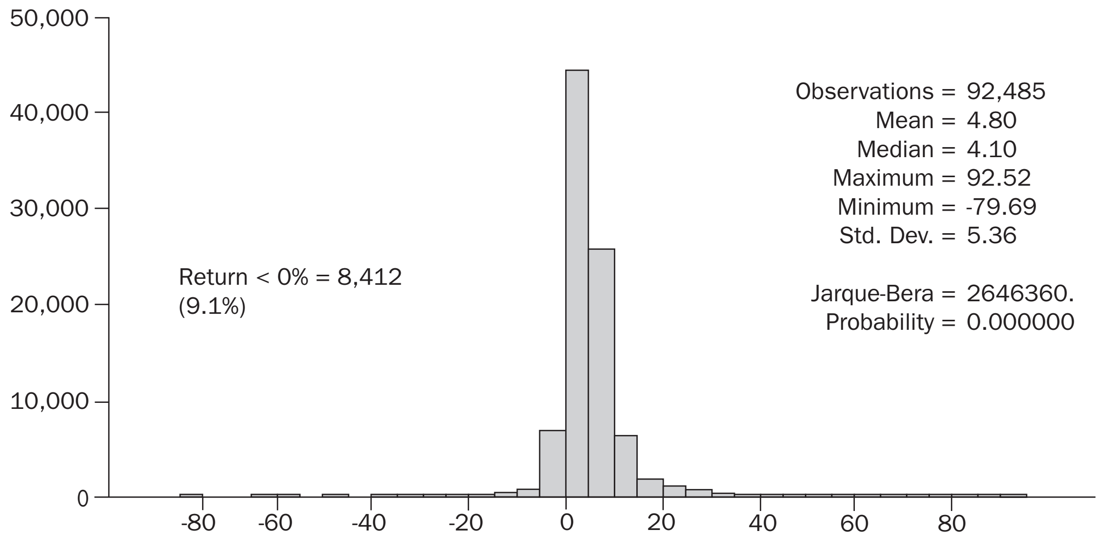


Table 3 **Holding Period Risks and Returns for Housing in Greensboro, NC (1975–2003) and Houston, TX (1989–2004) (Capital Gains Only)**

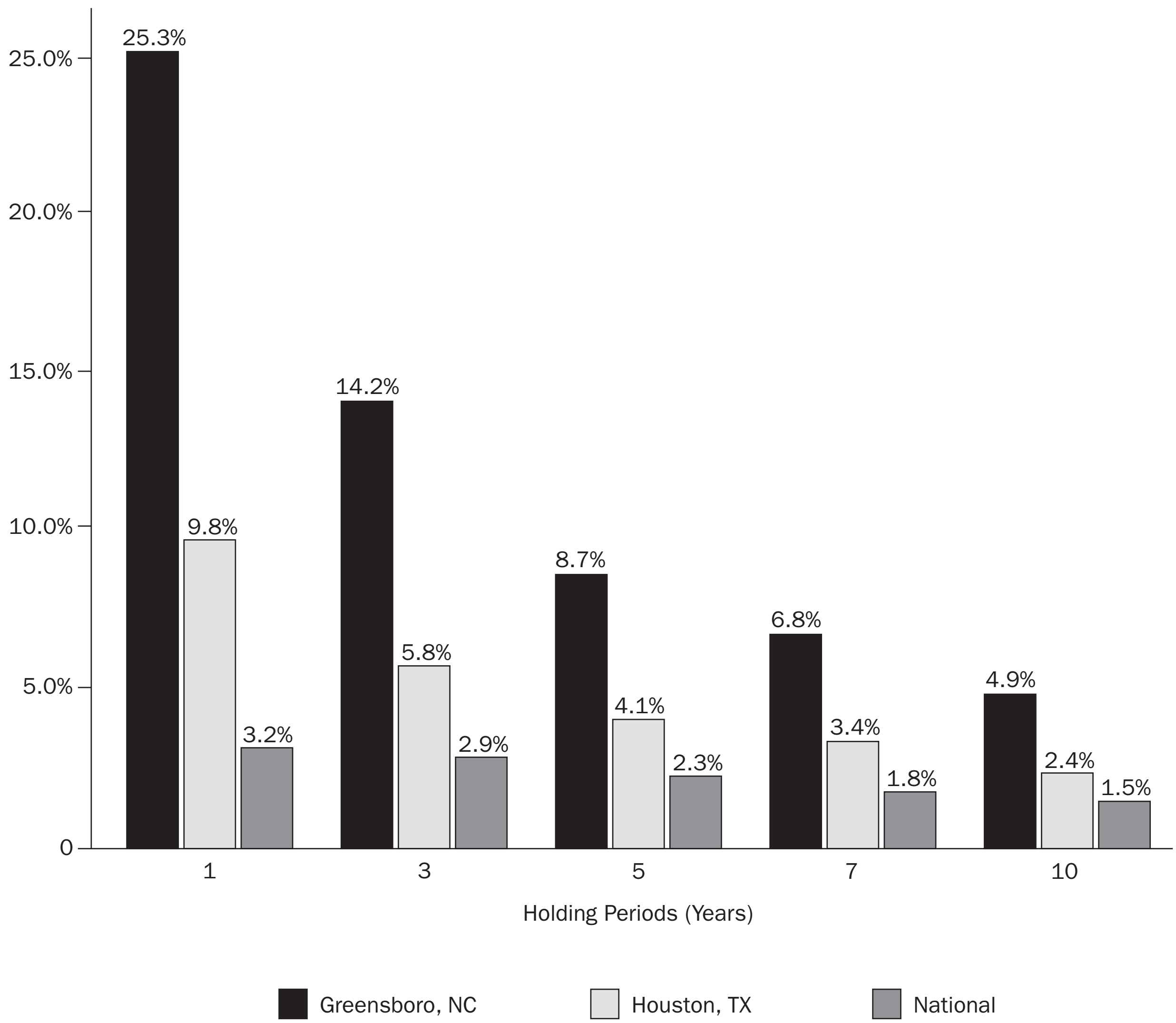
	Holding Periods (Years)				
	1	**3**	**5**	**7**	**10**
Greensboro, NC					
Ave. Return	6.46%	6.30%	4.85%	4.94%	4.53%
Std. Dev.	25.32%	14.15%	8.71%	6.78%	4.92%
CV	3.92	2.25	1.80	1.37	1.09
No. of Repeat Sales	2,106	2,233	1,672	1,253	738
Houston, TX					
Ave. Return	6.62%	5.23%	4.57%	4.07%	3.92%
Std. Dev.	9.80%	5.78%	4.06%	3.38%	2.40%
CV	1.48	1.11	0.89	0.83	0.61
No. of Repeat Sales	10,778	26,039	19,916	13,629	7,095

capital gain return was 6.62%, with a standard deviation of 9.80% and a CV of 1.48. The Houston sample suggests substantially less risk than Greensboro.[14] For comparison, Flavin and Yamashita using the PSID data reported an average return of 6.59% and a standard deviation of 14.24%.[15]

As in Table 1, the risk of housing investment declines with longer holding periods. However, the risk of housing investment in Greensboro (measured by the standard deviation of returns or the coefficient of variation) is substantially higher than the level of market risk shown in Table 1 for every holding period. In Houston, risks by holding period also are higher, but much lower than Greensboro.

Figure 3 plots the risk of the OFHEO index measured by the standard deviation of returns (market risk) against the standard deviation of returns in the Greensboro and Houston samples (total risk). For longer holding periods the differential between total and market risk declines, but total risk is still substantially higher than market risk even with a ten-year holding period.

Figure 3 Total Risk Versus Market Risk



14. The Greensboro sample has more risk than the Houston sample even when restricted to 1989–2003, almost the same time span as the Houston sample. Here the average return in Greensboro was 5.07%, with a standard deviation of 13.45% and a CV of 2.65. There were 7,256 repeat sales in the Greensboro sample during this period.

15. Flavin and Yamashita.

Models of Housing Returns

To further explore the relationship between total risk and market risk, a series of single-factor return models for specific holding periods (n) were estimated. The models are defined as follows:

$$r_{i,t} = \alpha + \beta RN_t + \varepsilon_{i,t} \quad (3)$$

where:

RN_t = annualized return for the average of all properties nationally that were purchased in year t and sold after n years[16]

$\varepsilon_{i,t}$ = a random error term

The estimated return models are shown in Table 4; t-values appear in parenthesis below the estimated beta coefficients, and F-values are shown in parenthesis below the R^2 statistics. The models are estimated using the White adjustment of heteroskedasticity.[17] The estimated return models for five-, seven-, and ten-year holding periods are statistically significant at the 0.01 level and above.

Looking first at Greensboro, the models for one- and three-year holding periods are not statistically significant. For the five-, seven-, and ten-year holding period models, the estimated beta coefficients are positive, but less than one. For these holding periods, the beta coefficients indicate that housing returns in Greensboro tend to move in the same direction as returns nationally, but less so, on average, than in other markets nationwide. The size of the estimated beta coefficients tends to rise with longer holding periods. However, in every case, the betas are less than one, indicating that the level of market risk in Greensboro is below that for housing markets nationally.

In the Houston sample, all of the models are statistically significant and all of the beta coefficients are positive. The magnitude of the estimated betas rises with the length of the holding period except for the ten-year holding period, which drops. The estimated betas suggest that housing investment in Houston has more market risk than in Greensboro except for the ten-year period, but for all holding periods except the seven-year period, market risk in Houston is below the national average.

The R^2 statistics for all of the estimated equations in both Greensboro and Houston are all low, indicating that market risk accounts for a very small fraction of the total risk of housing investment. The R^2 statistics for Greensboro are highest with the ten-year holding-period model; however, even in this case, it is only 0.0613. Overall, the R^2 statistics are substantially higher in the Houston sample.

To try to increase the explanatory power of Equation (2), a multifactor return model was estimated using the Greensboro sample. A similar multifactor model could not be estimated using the Houston sample because data for the additional variables

Table 4 Determinants of Housing Returns

	Greensboro, NC				Houston, TX			
Holding Period (n)	Constant	β	R^2	N	Constant	β	R^2	N
1	6.9462	-0.0553	0.0001	2,106	4.0047	0.4660	0.0137	10,778
		(-0.5789)	(0.3060)			(12.2436)	(149.94)	
3	6.6918	-0.0639	0.0002	2,233	1.5899	0.6731	0.0650	26,039
		(-0.5774)	(0.3752)			(42.6013)	(1,812.30)	
5	3.1603	0.3226	0.0061	1,672	0.4587	0.8316	0.1728	19,916
		(3.0573)	(10.2495)			(64.4651)	(4,162.22)	
7	1.2793	0.7433	0.0348	1,253	-0.3629	1.0101	0.2356	13,629
		(6.6067)	(45.0684)			(64.7500)	(4,202.53)	
10	0.5262	0.8268	0.0613	738	1.2782	0.6370	0.0708	7,095
		(6.8298)	(48.1033)			(23.2482)	(541.64)	

16. The inclusion of RN_t on the right hand side of Equation (3) captures the effects of inflation and interest rate trends as they affect the overall return to housing nationally.

17. Halbert White, "A Heteroskedasticity-Consistent Covariance Matrix and a Direct Test of Heteroskedasticity," *Econometrica* 48, no. 4 (May 1980): 817–838.

were not available. In addition to RN_t, the new variables included the following:[18]

$HP_{i,t}$ = the holding period for the ith property, or n
$CEMP_t$ = annualized growth in employment in the Greensboro/Winston-Salem/High Point MSA from year t when the home was purchased until it was sold n years later
$HVAL_{i,t}$ = average value of homes in the neighborhood (zip code)
$AGE_{i,t}$ = the age of the ith property when purchased
$SQFT_{i,t}$ = the square footage of the ith property in 1,000s
$ATYP_{i,t}$ = a measure of the *atypicality* of the ith property[19]
$GSO_{i,t}$ = a dummy variable equal to one if the ith property was located in Greensboro
$HIPT_{i,t}$ = a dummy variable equal to one if the ith property was located in High Point

The results for the multifactor return model are shown in Table 5. The model is estimated using the White adjustment of heteroskedasticity. All of the estimated coefficients are statistically significant at the 0.01 level or above.

The R^2 is 0.081, indicating that the model with the additional variables still explains only 8.1% of the variation in housing returns and that the unsystematic risk of housing investment is quite large.

The estimated coefficient on RN_t is positive, but less than one, indicating that Greensboro housing investment is positively associated with returns nationally. However, housing returns in Greensboro are less sensitive to housing return movements nationwide, when compared to housing returns in other housing markets including Houston. The growth in local employment is a positive and significant determinant of housing returns. The coefficient on holding period is negative, showing that returns fall with longer holding periods. This is the same pattern shown in Table 1.

The coefficients on age, square footage, and atypicality are interesting. Returns appear to rise with age and size of the home, but returns are lower for homes that are more atypical. These results suggest the importance of structural characteristics, layout, and design as determinants of returns.

The coefficient on neighborhood housing values is negative, showing that returns tend to be lower in neighborhoods where housing values are highest. Similarly, the coefficients for location in Greensboro and High Point are negative, indicating lower returns in these cities. The statistical significance of the neighborhood and city variables confirms the importance of location as a strong determinant of housing returns.

Assessing the Probability of Loss

Another way to measure the risk of housing investment is the percent of repeat sales that resulted in a loss, where a loss is defined as: $p_{t+n} - p_t < 0$. For

Table 5 Determinants of Housing Returns, Greensboro, NC

Variable	Coefficient	*t*-value
Constant	9.188	9.10
RN_t	0.191	4.32
$CEMP_t$	0.211	3.56
$HP_{i,t}$	-0.185	-9.65
$HVAL_{i,t}$	-0.018	-4.76
$AGE_{i,t}$	0.059	9.96
$SQFT_{i,t}$	1.266	8.21
$ATYP_{i,t}$	-14.171	-17.11
$GSO_{i,t}$	-2.749	-3.50
$HIPT_{i,t}$	-4.088	-5.03
R^2	0.081	
N	18,942	

18. The means and standard deviations of all variables used in the analysis are shown in Appendix Table A-1. Appendix Table A-2 provides variable definitions. Neither a time-trend variable nor a variable for year of second sales was included in the expanded model because each one is collinear with RN_t.

19. To measure the *atypicality* ($ATYP_{i,t}$) of a particular property, an index is developed which takes the absolute value of the deviation of the property's actual sale price from its predicted price on final sale. The index is defined as follows:

$$ATYP_{i,t} = \sum_{i=1}^{n} | p_i a_i - \hat{p} a_i |$$

The hedonic price equation used to construct the index along with sample statistics are shown in Appendix Table A-3 and Table A-4. Table A-3 shows the estimated regression equation and Table A-4 shows the sample statistics.

the entire Greensboro sample of 18,942 observations, 10.9% of the transactions resulted in a loss. In Houston, 9.1% of transactions resulted in a loss. For most homeowners, this is an important statistic because they are likely to assess the risk of an investment by the probability of loss, rather than the variation of returns.

The foregoing assessment of the probability of loss ignores transaction costs. If it is assumed that transaction costs are approximately 7% for an average residential repeat sale, the loss (*LOSS7*) can be defined as: $0.93 * p_{t+n} - p_t < 0$.[20] Using this estimate of transaction costs, 21.0% of the repeat sales in Greensboro and 23.4% in Houston resulted in losses.

To explore the determinants of loss on sale, a probit model is estimated using the Greensboro data in which the dependent variable was defined as $LOSS_{i,t}$, a dummy variable equal to 1 if the property sold for less than its purchase price, and 0 otherwise. The independent variables included all those in Table 5 discussed above.

The estimated probit model is shown in Table 6. The model is estimated using the Huber/White procedure for robust standard errors. The probability of loss is positively and significantly related to the following variables: (1) the atypicality of the property, and (2) location in the cities of Greensboro and High Point. The probability of loss is negatively and significantly associated with the following variables: (1) local employment growth, (2) holding period, (3) neighborhood property values, (4) age, and (5) size of the structure. Interestingly, the loss probability is not significantly related to the growth in housing prices nationally.

For housing investors, the results indicate that investments in atypical houses carry substantially more risk. Housing investment risk is less in cities where employment is rapidly expanding. Risk also is lessened with longer holding periods of larger, older homes in neighborhoods with higher overall property values.

The interpretation of the coefficient values in Table 5 is complicated by the fact that estimated coefficients from a probit model cannot be interpreted as the marginal effect on the dependent variable. The marginal effect of an independent variable (x) on the conditional probability of loss (L) is given by:

$$\delta E(L \mid x, \beta)/\delta x_j = f(-x'\beta)\beta_j \quad (4)$$

where $f(x) = dF(x)/dx$ is the density function associated with F. The marginal effects of each independent variable on the probability of loss are shown in the third column of Table 6. This approach is not appropriate for dummy variables. The marginal effects of the dummy variables are analyzed by comparing the probabilities that result when the variables take on their two different values with those that occur with the other variables held at

Table 6 Probit Model of the Probability of Loss (Dependent Variable = $LOSS_{i,t}$)

Variable	Coefficient	Marginal Effect	z-Statistic
Constant	-0.910	n.a.	-6.51
RN_t	-0.004	-0.002	-0.96
$CEMP_t$	-0.050	-0.020	-7.20
$HP_{i,t}$	-0.072	-0.029	-18.17
$HVAL_{i,t}$	-0.004	-0.002	-6.96
$AGE_{i,t}$	-0.005	-0.002	-6.65
$SQFT_{i,t}$	-0.117	-0.047	-4.49
$ATYP_{i,t}$	1.880	0.748	26.75
$GSO_{i,t}$	0.391	0.047	3.27
$HIPT_{i,t}$	0.679	0.105	5.58
N	18,942		
Log likelihood	-5,139.09		
Restr. log likelihood	-6,528.87		
LR statistic (9 d.f.)	2,779.57		

20. Transaction costs include mortgage origination fees, brokerage charges, and other closing costs involved in the purchase and sale of residential property. The largest of these costs is sales commissions; a recent article in *The Wall Street Journal Online* estimated that the average sales commission is 5.1% of the selling price. Kelly A. Spors, "What You Need to Know About Commission Rates," *The Wall Street Journal Online*, September 20, 2004, http://www.realestatejournal.com/buysell/agentsandbrokers/20040920-spors.html. While the estimate of 7% in the present study is difficult to verify empirically, it represents the authors' best judgment of the burden borne by the average homeowner.

their sample means.[21] Atypicality of the property has the largest positive marginal effect on the probability of loss, while size and holding period have the largest negative marginal effects. A one-year increase in holding period reduces the probability of loss by 2.9%.

Table 7 presents an alternative probit model where the loss variable is calculated to consider transactions costs as discussed above. Here loss is defined as: $LOSS7_{i,t} = 1$, if $0.93*p_{t+n} - p_t < 0$, and 0 otherwise.

As in Table 6, the model in Table 7 is estimated using the Huber/White procedure for robust standard errors. The probability of loss is positively and significantly related to the following variables: (1) the atypicality of the property, and (2) location in High Point. The probability of loss is negatively and significantly associated with the following variables: (1) the growth rate in housing values nationally, (2) local employment growth, (3) holding period, (4) neighborhood property values, (5) age, and (6) size of the structure. Again, the atypicality of the property has the largest positive marginal effect on the probability of loss, while holding period has the largest negative marginal effect. A one-year increase in holding period in this case reduces the probability of loss by 5.0%.

For housing investors the results are clear: investments in atypical houses carry substantially more risk. Housing investment risk is less in cities where employment is rapidly expanding and also when housing returns are increasing nationwide. In comparison to the probit model with no transaction costs, risk is lessened to an even greater extent for longer holding periods as well as for older homes. But, while risk is still less for large houses and for homes in neighborhoods with higher overall property values, these variables have less effect than in the probit model with no transactions costs.

Summary and Evaluation

The foregoing analysis of housing risk in Greensboro and Houston shows that the price risk facing the average homeowner is high and may vary widely among cities across the country. Further research needs to focus more closely on the extent and determinants of the variation in risk levels among cities.

The analysis shows that the return on an individual housing transaction is positively associated with national returns, but the association is not strong, which indicates a high level of nonsystematic risk in housing transactions. Factors such as local employment growth and characteristics of the house's location and other features are very important in explaining individual housing returns.

The probability of loss on sale in the average housing transaction is large. The probability is inversely related to holding period, housing returns nationally, and local employment growth. It also is strongly influenced by location and other features.

The analysis presented here is drawn from just two metropolitan areas. Whether the pattern of results reported is found to apply generally in other area across the county is a topic that merits additional inquiry.

Table 7 Probit Model of the Probability of Loss (Dependent Variable = $LOSS7_{i,t}$)

Variable	Coefficient	Marginal Effects	*z*-Statistic
Constant	0.244	n.a.	2.42
RN_t	-0.039	-0.015	-9.81
$CEMP_t$	-0.047	-0.018	-8.78
$HP_{i,t}$	-0.126	-0.050	-32.66
$HVAL_{i,t}$	-0.002	-0.001	-4.45
$AGE_{i,t}$	-0.007	-0.003	-10.82
$SQFT_{i,t}$	-0.068	-0.027	-3.72
$ATYP_{i,t}$	1.480	0.583	25.72
$GSO_{i,t}$	0.105	0.025	1.31
$HIPT_{i,t}$	0.291	0.073	3.51
N	18,942		
Log likelihood	-8,134.90		
Restr. log likelihood	-9,726.32		
LR statistic (9 d.f.)	3,182.85		

21. William H. Greene, *Econometric Analysis* (New York: Macmillan Publishing Co., 1990), 704–705.

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Appendix

Figure A-1 Repeat Sales of Single-Family Homes in Guilford Co., NC (1975–2003)

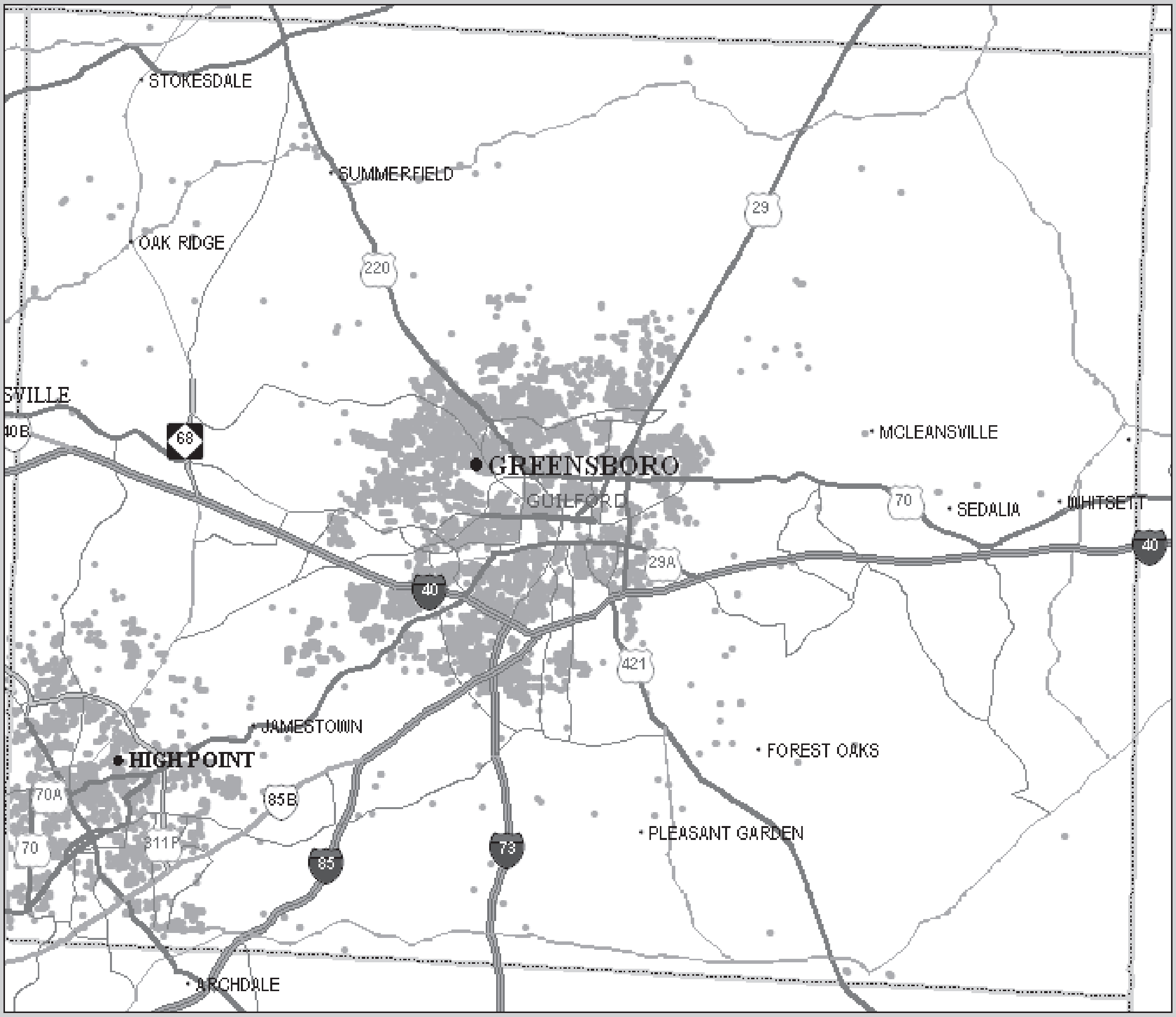

Table A-1 Sample Statistics

Greensboro, NC (n = 18,942: 1975–2003)

	$r_{i,t}$	$LOSS_{i,t}$	$LOSS7_{i,t}$	RN_t	$CEMP_t$	$HP_{i,t}$	$HVAL_{i,t}$	$AGE_{i,t}$	$SQFT_{i,t}$	$ATYP_{i,t}$	$GSO_{i,t}$	$HIPT_{i,t}$
Mean	5.59	0.11	0.21	5.82	2.91	6.19	114.68	31.75	1.64	0.22	0.77	0.21
Median	4.20	0.00	0.00	5.13	2.83	5.00	107.10	30.00	1.46	0.15	1.00	0.00
Std. Dev.	13.13	0.31	0.41	3.07	2.31	4.58	29.07	19.98	0.71	0.25	0.42	0.41

Houston, TX (n = 92,485: 1989–2004)

	$r_{i,t}$	$LOSS_{i,t}$	$LOSS7_{i,t}$	RN_t	$CEMP_t$	$HP_{i,t}$	$HVAL_{i,t}$	$AGE_{i,t}$	$SQFT_{i,t}$	$ATYP_{i,t}$	$GSO_{i,t}$	$HIPT_{i,t}$
Mean	4.80	0.09	0.23	4.92	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Median	4.10	0.00	0.00	4.83	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Std. Dev.	5.36	0.29	0.42	1.99	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Table A-2 Variable Definitions

Variable Name	Definition
GSO	Location in Greensboro
HIPT	Location in High Point
HVAL	Ave. neighborhood home value (zip code)
Brick	Brick veneer construction
Central Air Conditioning	Central air conditioning
# of Bedrooms	Number of bedrooms
# of Bathrooms	Number of bathrooms
# of Fireplaces	Number of fireplaces
Age	Age of structure
Square Feet	Square feet
Golf Course	Location on a golf course
Front Feet	Front feet
Depth of Lot	Depth of lot
Quality	Quality index used by tax appraiser

Table A-3 Hedonic Price Equation Used to Calculate the *Atypicality* Index (Dependent Variable = Log(*Price*))

Variable	Coefficient	*t*-value
Intercept	8.4818	337.84
1976	0.0804	4.30
1977	0.1424	8.08
1978	0.2518	14.52
1979	0.2550	14.79
1980	0.3506	19.78
1981	0.3403	18.57
1982	0.3837	20.81
1983	0.5285	30.63
1984	0.5949	35.34
1985	0.6933	41.66
1986	0.8186	48.55
1987	0.8556	49.64
1988	0.8891	51.58
1989	0.8941	51.67
1990	0.9297	53.49
1991	0.9524	54.12
1992	0.9807	57.15
1993	1.0167	59.89
1994	1.0452	62.16
1995	1.0944	64.18
1996	1.1426	66.91
1997	1.2463	73.38
1998	1.2594	74.99
1999	1.2911	77.23
2000	1.3135	77.70
2001	1.3672	81.71
2002	1.3933	86.96
2003	1.3909	84.20
GSO	0.1121	9.31
HIPT	0.0156	1.26
HVAL	0.0032	43.20
Brick	0.0648	16.72
Central Air Conditioning	0.1325	27.20
# of Bedrooms	0.0259	6.88
# of Bathrooms	0.0380	8.57
# of Fireplaces	0.0655	33.89
Age	-0.0036	-33.72
Square Feet	0.0002	41.09
Golf Course	0.1225	2.93
Front Feet	0.0004	5.53
Depth of Lot	-0.0001	-2.17
Quality	0.1852	46.48
R^2	0.6642	
N	51,215	

Note: The hedonic index equation is estimated on the basis of a sample of 51,215 residential properties sold in Greensboro, NC, between 1975 and 2003. Data from the master appraisal file of the Guilford County Tax Assessor's Office.

Table A-4 **Sample Statistics of Properties Used to Estimate Hedonic Equation in Table A-3**

Variable	Mean	Standard Deviation
1976	0.021	0.144
1977	0.028	0.166
1978	0.031	0.174
1979	0.032	0.176
1980	0.028	0.164
1981	0.024	0.152
1982	0.023	0.150
1983	0.032	0.177
1984	0.037	0.190
1985	0.040	0.197
1986	0.037	0.189
1987	0.033	0.178
1988	0.033	0.178
1989	0.032	0.177
1990	0.031	0.175
1991	0.029	0.169
1992	0.034	0.182
1993	0.036	0.187
1994	0.039	0.193
1995	0.036	0.186
1996	0.036	0.186
1997	0.037	0.189
1998	0.040	0.197
1999	0.042	0.201
2000	0.040	0.195
2001	0.042	0.201
2002	0.060	0.237
2003	0.047	0.212
GSO	0.749	0.433
HIPT	0.223	0.416
HVAL	111.085	29.621
Brick	0.420	0.494
Central Air Conditioning	0.757	0.429
# of Bedrooms	3.049	0.697
# of Bathrooms	1.647	0.690
# of Fireplaces	2.456	1.253
Age	28.746	21.103
Square Feet	1637.040	738.351
Golf Course	0.002	0.045
Front Feet	82.262	27.157
Depth of Lot	163.620	43.777
Quality	3.195	0.635
Log(*Price*)	11.096	0.719
N	51,215	

Year indicates year of sale.