The Stock of Private Real Estate Capital in U.S. Metropolitan Areas: Measurement and Determinants

THE STOCK OF PRIVATE REAL ESTATE CAPITAL IN U.S. METROPOLITAN AREAS: MEASUREMENT AND DETERMINANTS

By

Stephen Malpezzi
James D. Shilling
Yu-Yun Yang

July 28, 1998
Draft, Comments Appreciated

Department of Real Estate and Urban Land Economics
School of Business
The University of Wisconsin
975 University Avenue
Madison, Wisconsin 53706-1323
(202) 262-6007
smalpezzi@bus.wisc.edu

Stephen Malpezzi and James D. Shilling are on the faculty of the Department of Real Estate and Urban Land Economics, the University of Wisconsin-Madison. Yu-Yun (Jessie) Yang is a Ph.D. candidate in Statistics at the University of Wisconsin-Madison.

William Hulcher kindly provided background information on Census of Governments data. Only the authors are responsible for remaining errors.

This research has been supported by the University of Wisconsin's Department of Real Estate and Urban Land Economics, and UW's Center for Urban Land Economics Research. Any errors are the responsibility of the authors.

Introduction

The bulk of the U.S., indeed the world's, capital stock is real estate (Figure 1, see also Ibbotson 1985). As a general proposition, the need for careful measurement of such fundamental data needs no elaboration.

Many recent studies of real estate markets adopt the metropolitan area as the unit of observation. Conversations with developers, investors, and others confirm that market participants often use the metropolitan area as a decision unit. Commercial data providers such as Torto-Wheaton also focus on the metropolitan area as the unit of observation. This is hardly surprising, given that real estate's locational fixity is in fact its defining characteristic. Despite this, hardly any data exists on the stock of real estate capital by metropolitan area.

Many specific examples can be given of potential uses for such data. For example, studies of portfolio allocation can be much improved with such data. In fact, we were motivated to undertake this study in order to construct data needed for Malpezzi and Shilling (1996), for which we required estimates of the real estate capital stock by metropolitan area (MSA). While flow data on real estate investment are readily available from building permits, stock estimates are not, in general, widely available.

In this paper, we describe the construction of estimates of private real estate capital for each of 242 MSAs, annually, for 1982 through 1994. We compute three such series: (1) total private real estate capital (residential and nonresidential); (2) private single family residential capital; and (3) private income property capital (multifamily housing plus nonresidential real estate, or (1) less (2)). We then model the determinants of each series, and use the results to predict the value of the capital stock for a larger set of 295 MSAs.

Previous Literature

To our knowledge, only two previous studies have attempted to measure the real estate capital stock in such a disaggregated fashion. Miles *et al.* (1991) begin with county level tax assessments, and regress them against a set of demographic variables to construct an instrument for the value of real estate in 36 metropolitan areas. The estimates are broken out by retail, office and industrial property types. Miles *et al.* do not include multifamily investment property, and are limited to a small subset of metropolitan areas.

Hartzell *et al.* (1994) apply a similar method to county level data. Sixty-seven counties in 32 metropolitan areas were used. The baseline data were also property tax assessments. Hartzell *et al.* then collected a set of exogenous variables related to population, structure of employment, income, and employment. They used these to construct instrumental variables for each property type. Their regression models were then used to estimate the value of real estate by property type for each U.S. county.

Methodology

Conceptually, the most straightforward method of constructing capital stock data is to undertake a census or appropriately designed survey to collect data on the market values of said stock.

Direct measurement is not, in general, used for the official National Income Accounts (NIA) of capital. NIA measures of real estate capital (and most other tangible capital) are constructed by the so-called "perpetual inventory" method (Young and Musgrave 1980). Given a sufficiently long time series of flow investment data, and knowledge of depreciation, it is possible to solve for an expression representing capital stock at time t, K_t, as a function of previous changes in the stock:

$$K_T = K_0 + \sum_{0}^{T-1} \Delta K_t$$

where initial condition K_0 can itself be estimated by a variant of this method. Obviously ΔK_t is determined by depreciation, which we denote below as δ, and by flow investment, I_t. For a sufficiently long time span between 0 and T, errors in K_0 become unimportant for reliable estimation of K_T.

The official NIA accounts data on the real estate capital stock are based on this method, and can be found in Bureau of Economic Analysis (1993). However, NIA measures, and alternative series such as those constructed by Hulten and Wykoff (1980), are not disaggregated geographically. In this paper we construct and present such measures separately by MSA. Our basic data source is annual BEA building permit data. However, we do not have a sufficiently long time series to reliably apply the true perpetual inventory method, i.e., one where K_0 can be in turn estimated by previous flow data, because the flow data must be long enough that errors in an arbitrarily chosen starting point become unimportant. Given our shorter data span, we need a benchmark of some kind that is a reasonable estimate of K_0.

Every five years there is a Census of Governments (COG). In several COG the Census collected data on (1) the appraised value of private real estate, and (2) recent sales data comprising market values and appraised values. With these data, assessment ratios can be constructed to translate appraised value into an estimate of the value of the private real estate capital stock.[1] If this exercise were done frequently and with sufficient accuracy, the COG data could serve as the basis of a direct estimate of the private real estate capital stock.

Unfortunately the Census stopped collecting data on assessment ratios in 1982. Our general procedure, then, is as follows. We estimate the stock of real estate capital in 1982 in each MSA as:

[1] Assessment ratios are constructed in a straightforward manner. Data on recent sales are collected, including sales price and the assessed value at time of sale. Transactions that are apparently not arms-length are dropped. The average ratio of sales price to assessed value is computed. Separate ratios are constructed for each MSA.

K_{82} = 1982 Census Assessed Value of Property * Assessment Ratio

Thus, 1982 is our benchmark year. Starting in 1983, and for successive years until 1994, we estimate real estate capital in each MSA by (1) multiplying the previous year's capital stock by 1 plus an estimate of inflation in real estate prices, dP_t; (2) subtracting depreciation at rate δ; and (3) adding investment I_t:

$$K_t = (1+dP_t)(K_{t-1} - \delta K_{t-1}) + I_t \quad (t=1983, \ldots 1994)$$

Our inflation rate is from the NIA GNP price deflators, taken from *Economic Report of the President*. Separate inflation rates are used for residential and nonresidential real estate.

We use two separate depreciation rates, one for single family residential and one for income property. Hulten and Wykoff (1980) estimate depreciation rates for 16 categories of income property (nonresidential real estate, and apartments). These rates range from 2.1 percent for shopping centers to 4.1 percent for certain factories (their p. 90). In the absence of good data on the relative shares of these 16 categories, we take the median of the 16 estimates and apply it to income property. The median is 3.4 percent *per annum*. For comparison, the mean of the 16 categories is 3.5 percent.

For single family housing, we use an estimate from Malpezzi, Ozanne and Thibodeau (1987). They report that the average depreciation rate for 30 year old owner occupied units is 0.6 percent *per annum*. However, MOT do not account for units which completely drop out of the stock. Hulten and Wykoff argue that this selectivity seriously biases depreciation rates. They apply an adjustment based on work by Winfrey (1935) to each of their 16 categories. The median ratio between adjusted and unadjusted numbers is 2.4, so we use this ratio as an *ad hoc* adjustment to the MOT result, resulting in an estimated depreciation rate of 1.44 percent.

The permits data are taken from Census' CD-ROM database *USA Counties* 1996. Permit data are used because they are available for small areas. Construction put in place and completions data are only available for a small subsample of locations, but on an annual basis, permits data are highly correlated with actual investment.[2] MSAs are comprised of one or more counties so it is straightforward to sum county permits data to the MSA level. Available permits data are broken out by the value of: (1) all nonresidential private construction, excluding alterations and additions; (2) nonresidential additions and alterations; (3) residential housing units; (4) residential nonhousekeeping units (e.g. motels and dormitories); (5) residential garages and carports; (6) residential additions and alterations. The sum of (1) through (6) is our estimate of the total gross private real estate investment in each county in each year.

Several county permit series start in 1985, but we need data for 1983 and 1984 as well. For data on the value of nonresidential real estate investment, including additions, we adopt the

[2]The correlation is lower with (e.g.) monthly data, since there are lags between permit issuance and actual construction.

following *ad hoc* procedure: construct the ratio between national nonresidential investment in 1983 and 1985, then multiply this ratio times each MSA's 1985 figures to estimate each county's investment in 1983. A similar procedure is used for 1984.

Several series are sparse, and vary quite a bit, especially for smaller counties. Sparse permits data include residential additions, nonhouskeeping residential (e.g. motels), and garages and carports. For imputing these series for 1983 and 1984 we adopt a different *ad hoc* procedure. We simply average the county data from 1985 to 1989, and impute this average value to 1983 and 1984.

As noted above, county permits data are aggregated into metropolitan statistical areas. The definition of an MSA is one or more central cities of 50,000 each, and surrounding counties with substantial economic links to the cities. Thus, we can easily map county data into MSA data. A few caveats are required about this aggregation.

MSA definitions change over time. We use the current (1993) definitions, but the baseline 1982 Census data match up less than perfectly (1) because the definitions have changed, and (2) because even for 1982 definitions, the baseline 1982 Census valuation data were incomplete for some MSAs. Even more common than incomplete Census data were cases when area definitions were ambiguous.[3] In some cases data were so incomplete that we dropped the MSA, and in others we tried to make some reasonable judgement or imputation to match 1982 and 1993 definition.[4] This left us with 242 MSAs for which we were able to reasonably match count permits and COG baseline data. Generally, by the logic of the model above, errors due to such imputations become less serious the further in time we are from the baseline year.[5]

New England data are particularly problematic because some data are provided by MSA and/or county, but other data are presented by New England County Metropolitan Areas (NECMAs). Generally, in New England metropolitan areas are defined by cities and towns rather than by counties. This is New England's little joke on regional economists in the rest of the country. NECMAs are an alternate, county-based definition. The upshot is that matching data from different sources is more difficult in New England than in other regions. In some cases cross checks with population data, etc. indicated that our data sources for permits and 1982 Census value are consistent, or reasonably so. In some cases we simply had to drop the metro area from analysis. In general we are more concerned about the quality of the data from New England. But regression analyses carried out separately with and without these metro areas showed results were robust.

To summarize, the following procedure is used to compute the total stock of real estate capital. We constructed the baseline of total value of all property from the 1982 *Census of Governments*, as described above. For each year forward, we inflated the value of the capital stock

[3]The 1982 data were available to us in printed form, laid out generally by (Standard) Metropolitan Statistical Area. But the format varied somewhat from MSA to MSA, and can be best described as "semi-standardized."

[4]For example, if a subarea of an MSA was we generally imputed an average of other subareas. Since the definitions of and available data for subareas were themselves highly variable, these imputations are subject to error.

[5]But any possible *systematic* errors in permit data, and/or errors in the measurement of depreciation, loom larger as we move forward in time.

by the increase in a weighted average of the residential and nonresidential GNP implicit price deflators.[6] We then subtracted depreciation, and added the value of permits.

We also estimate two sub-categories of real estate capital, single family and income property. The value of the stock of single family housing was constructed as follows. The *Census of Governments 1982* provides us with a separate baseline estimate of the value of single family stock in each MSA. Using a procedure analogous to that for total property described above, we construct estimates of the single family stock. Of course residential inflation and depreciation estimates are used in place of the weighted averages. The permits data we have available on value of housing is not disaggregated by single family and multifamily. But we do have counts of the number of single family and multifamily units built in each location and each period. So we construct the percentage of single family units for each place and time, and multiply this fraction times the corresponding value of housing and residential additions to estimate the value of single family construction. All carport and garage investment is allocated to single family housing.

Once we have estimates of the total stock of real estate in each MSA from 1982 to 1994, and similar estimates of the single family stock, we construct estimates of the income property stock by simple subtraction. Unfortunately there is no consistent COG baseline of value by type of income property, so we cannot disaggregate these data further by property type.

Basic Estimates

Table 1 summarizes our basic results for the capital stock estimates, in levels and per capita, for the beginning and end years of the analysis (1982 and 1994). All units are in millions of current dollars. Table 2 presents the 1994 capital stock data for the top 20 metropolitan areas. Metropolitan areas are ranked by total capital stock, single family capital stock, and income property capital stock. Table 3 presents the analogous information for capital stocks on a *per capita* basis. Figures 2, 3 and 4 present the total single family and income capital stocks graphically. Each circle on the map represents a metropolitan area, and the area of the circle is proportional to the metropolitan area's capital stock. For comparison, Figure 5 presents the analogous map of population.

Most of the Tables and Figures are self explanatory, so we will only highlight a few points in this section. A more detailed look at the data is available at our web site. The actual data for each year between 1982 and 1994 for each metropolitan area studied can be found at wiscinfo.doit.wisc.edu/realestate.

In 1982, the mean total real estate capital stock for the 247 metropolitan areas with the required data was approximately $16.8 billion; the median was significantly less at $5.8 billion. The very large difference between the mean and the median is expected, since the distribution of capital stock across metropolitan areas is highly skewed, with a long tail to the right. In 1982

[6]Conceptually we would prefer a price index that varies by metro area, but no reliable indexes exist for such a wide variety of property types over so many locations.

Los Angeles had an estimated $304 billion in total private real estate capital (1982 data for individual MSAs not shown in tables). The second largest metropolitan area was Chicago with $201 billion, followed by New York ($190 billion) Houston ($164 billion) and Boston ($140 billion).

The median total real estate capital stock for our 247 metropolitan areas rose to $10.1 billion in 1994. Once again the distribution is quite skewed with a mean of $26.9 billion. The ranking of metropolitan areas is, unsurprisingly, fairly stable. In 1994 we estimate the total value of Los Angeles' real estate capital stock at $426 billion (Table 2). Chicago's stock is estimated to be worth $293 billion followed by New York ($238 billion) Houston ($208 billion) and Boston ($200 billion).

The ranking of cities by the single family capital stock is somewhat different. Los Angeles has both the largest population in the country, and some of the highest housing prices, so it is not surprising that the 1994 value of their single family housing stock weighs in at $208 billion, followed by Chicago at $138 billion. Boston's stock is estimated to be worth $121 billion, followed by Washington ($110 billion) and San Francisco ($768 billion). New York drops out of the top league, which is unsurprising given their low rate of home ownership.

Of course large metropolitan areas will have large real estate capital stocks. The capital stock *per capita* adjusts roughly for size, and we present this in Table 1 as well. These figures are also in millions of dollars, so the median per capita capital stock in 1994 is $29,000. The mean is $31,000. This data is also somewhat skewed, though less so than the total capital stock data. The metropolitan areas with the highest stock per capita (Table 3) include Brazoria Texas, with $107,000 in 1994; Longview with $89,000, Bakersfield ($70,000), San Francisco ($64,000) and Odessa ($61,000). We conject that the Texas capital stocks are high because these metropolitan areas have fairly small populations and large petrochemical industries. San Francisco and Bakersfield are high largely because of the extraordinary housing prices in California in recent years.

Comparison to Other Estimates

Estimating the capital stock is difficult and fraught with error. For example Hulten and Wykoff (1980) calculate an alternative capital stock measure for nonresidential manufacturing structures for a number of years in the 60s and 70s, and compare them to official BEA numbers. The Hulten and Wykoff estimates were generally over 50% higher than BEA estimates, although both sets of estimates were carefully and defensibly done.[7]

The most commonly cited statistics on the value of real estate capital are the Bureau of Economic Analysis estimates of fixed reproducible tangible wealth. The BEA produces data on residential and nonresidential structures. However these data suffer from several shortcomings. First of all, they are only generally available for the U.S. as a whole. No geographic dissagregation

[7] Hulton and Wykoff attribute the majority of the difference to different assumptions about depreciation rates.

is found in publicly available data. Secondly, they do not include the value of land. For residential real estate the Federal Reserve does publish separate estimates of land in their balance sheets for the U.S. economy, but once again these are only available in the aggregate.

One study that breaks out estimates of nonresidential real estate by property type and location is Miles *et al.* (1991). As noted above, Miles *et al.* start with county level tax assessments and use an instrumental variables approach to estimate the value of real estate in 36 metropolitan areas. The values of retail, office and industrial property are estimated. They estimate the total value of this commercial real estate to be $1.7 trillion in 1989. Miles *et al.* do not include multifamily investment property. And of course they do not include locations outside these 36 large metropolitan areas.

Hartzell *et al.* (1994) apply a similar method to county level data. As noted above, 67 counties in 32 metropolitan areas were used. The baseline data were from property tax assessments. A number of large metropolitan areas were dropped from analysis including Chicago, New York and Washington D.C., as well as all California counties because of distortions in the assessment process, e.g. by Proposition 13. Hartzell *et al.* then collected a set of exogenous variables related to population, structure of employment, income, and employment. They used these to construct instrumental variables for each property type. Their regression models were then used to estimate the value of real estate by property type in each of the 3,141 counties in the United States. However, their paper only reported results aggregated by region, and their original county estimates are, unfortunately, no longer readily available.

An obvious comparison would be to compare our estimates to the Hartzell *et al.* estimates. Unfortunately such a comparison is not possible. Several comparability issues would arise if we had the unpublished data by location, but the dominant problem is that unfortunately, their disaggregated data was lost during the conversion of computer systems. Still, a comparison of the aggregate results (available in their published paper) is instructive.

Our income property measure and the data presented in Hartzell *et al.* do not match perfectly, but we can make an approximate comparison as follows. Hartzell *et al.* estimate the 1989 value of retail, office, and warehouse space at $2,429 billion. Their estimate of the residential capital stock was $8,703 billion. Unfortunately they do not break out their residential stock into single family and multifamily, and the latter is an important component of the total stock of income property.

We roughly estimate the total single family stock separately as follows. In 1989 there were 69,290,000 single family units in the United States, according the American Housing Survey. The median value of these units was $75,201. In order to estimate the total value of these units we would like to use the average price, which is generally higher than the median for data distribution log normally as are housing prices. Based on the ratio of the average to median house prices from several alternative sources, we adopt a rough rule of thumb that the average house price will be about 20% higher than the median house price. Multiplying out, and adding the value of the 6,908,000 mobile homes (at $14,877 per unit), we come up with an estimated total single family stock worth $6,355 billion.

Subtracting this from the Hartzell *et al.* estimate of total residential stock, we are left with a rough estimate of $2,347 billion for multifamily housing in 1989. Thus the estimated 1989 value of all income property, based on Hartzell *et al.* and the AHS, is the sum of $2,429 billion and $2,347 billion, or $4,776 billion. In 1994 dollars, that would be equivalent to $5,550 billion. Our estimates of the income property capital stock for 242 metropolitan areas is about 55% of this separate estimate for the entire country. Errors are inevitable in any such calculation of the capital stock -- including in any "official" source, or prior estimate, or other potential baseline calculations against which we judge our own. In any event, our estimates seem broadly in line with other data.

A Simple Model of Determinants

In this section we present simple models of the determinants of the investment series, for the beginning and end years of our data (1982 and 1984). There are at least three reasons to undertake such an exercise. First, and most importantly, we can gain some insight into market behavior. Second, we can forecast the value of the stock for missing locations. Third, we can construct an alternative series for our original 242 locations that may "smooth" possible errors.

We examine six dependent variables: total capital stock per capita in 1982 and 1994 (KTOTPC82, KTOTPC94); single family capital stock per capita for in 1982 and 1994 (KSFPC82 and KSFPC94); and the values of income property per capita in 1982 and 1994 (KIPPC82 and KIPPC94). In preliminary regressions, we found that models linear in per capita stocks worked best for total and single family property; and models logarithmic in per capita stocks worked best for income property. By "worked best," we mean few outliers and generally homoskedastic residuals.

The independent variables are listed in Table 4. They are divided into three categories: economic structure, employment classification, and other. After an initial specification search, we settled on the six models presented in Table 5. The number in the parentheses below each parameter estimate is the corresponding p-value. Careful analysis of residuals found no evidence of major specification errors.

Several interesting patterns emerge from equations (1)-(6). A higher growth rate in employment leads to more total capital stock per capita. Its impact on the capital stock per capita for single family is quite significant in 1982, but not for 1994. Higher real incomes (Y82 and Y94) drive investment in all six models. The growth rate of real income per capita has a significant effect in 1994, but the coefficient has the wrong sign. This may be due to collinearity among variables.

The economic structure of each metropolitan area is proxied by a set of employment classification variables. Employment in trade and agriculture are omitted categories. The percentage of owner occupied units (POO80 and POO90) are significant predictors of the total capital stock and of income property, with a negative sign.

Note that we could certainly engineer a better fit (higher R^2) for the same sets of independent variables by using the original capital stock data, instead of capital stock per capita. However, models (1)-(6) readily predict the original capital stock data, by multiplying the predicted capital stock per capita times MSA population. Of course, for the income property stock, since we estimated semi-logarithmic regressions, we exponentiate the predicted value of the dependent variable to obtain estimates of the per capita stock, then multiply times population.

Table 6 shows the correlation coefficients between the predicted capital stock per capita and the actual capital stock per capita, as well as the correlation between the predicted capital stock and the actual capital stock. The latter correlations are all larger than .9; the models perform extremely well in predicting actual capital stock.

Predictions

Table 7 presents basic results for the predicted values of the capital stock. This Table parallels Table 1 above. The first thing to notice is that the set of metropolitan areas is expanded from 247 to 295. There are 48 metropolitan areas for which we lack the dependent variables, but which have all the independent variables required for prediction.

Direct comparison of Tables 1 and 7 is made difficult by the fact that they do not cover the same set of metropolitan areas. But given that 48 additional metropolitan areas are fairly small, it is not surprising that results are generally similar between Tables 1 and 7. The ranking of metropolitan areas is also fairly consistent, which is unsurprising given the high correlation coefficients reported above.

Summary, and Suggestions for Future Research

In this paper we applied a variant of the perpetual inventory method to calculate the value of the stock of private real estate capital for individual U.S. metropolitan areas. The estimates were broken out by single family property, and a residual category of income property. Our results are broadly consistent with other estimates of the real estate capital stock, but ours have the advantage of being disaggregated by location. We have already used these estimates to analyze the location investment decisions of real estate investment trusts and private institutional real estate investors in Malpezzi and Shilling (1997). We have made the individual MSA estimates available at our web site in order to facilitate their use by other researchers.

We also estimated straightforward regression models for the beginning and ending years (1982 and 1994). These yield insights into the determinants of the real estate capital stock, and to permit the forecasting of capital stock for metropolitan areas with insufficient data. We found that the per capita capital stock can be well modeled using basic demographic and income variables, and variables representing the structure of a local area economy. Using these regression results we were able to extend our estimates of the capital stock by an additional 48 metropolitan areas. These predicted values are also available for individual metropolitan areas at our web site.

Additional research in this area could have a high pay off. For example, further disaggregation by property type would be of interest. Previous work by Hartzell *et al.* and others suggests that locational differences among property types would be significant. Further research could also refine some of our assumptions, and hence refine our estimates. For example, we used the best available depreciation estimates for different capital stock types, but we used only one depreciation rate for each property type for all locations. Malpezzi, Ozanne and Thibodeau (1987) showed residential depreciation rates vary significantly by metropolitan area. Further work on location-specific non-residential depreciation would yield more precise estimates of the capital stock. Better estimates of the stock would be a better understanding of the selectivity problem in depreciation estimates caused by demolitions and removals would also be useful.

The results could be improved with additional research on nonresidential real estate price changes by location. Many papers have been written also on housing prices, but much additional work would be needed to have viable metropolitan level price estimates for the income property stock.

References

Arthur Anderson Real Estate Group. Who Owns America? *Urban Land*, October 1991, pp. 30-33.

Bureau of Economic Analysis. *Fixed Reproducible Tangible Wealth in the United States*. Washington D.C.: Department of Commerce, 1993.

Council of Economic Advisors. *Economic Report of the President*. Washington, D.C.: 1996.

Glickman, Norman J., Michael L. Lahr and Elvin K. Wyly. *State of the Nation's Cities: America's Changing Urban Life*. Washington, D.C.: U.S. Department of Housing and Urban Development, 1996

Hartzell, David J., Robert J. Pittman and David H. Downs. An Updated Look at the Size of the U.S. Real Estate Market Portfolio. *The Journal of Real Estate Research*, 9(2), Spring 1994, pp. 197-212.

Hulten, Charles R. and Frank C. Wykoff. Economic Depreciation and the Taxation of Structures in United States Manufacturing Industries: An Empirical Analysis. In Dan Usher (ed.), *The Measurement of Capital*. University of Chicago Press for NBER, 1980.

Ibbotson, Roger G., Laurence B. Siegel and Kathryn S. Love. World Wealth: Market Values and Returns. *Journal of Portfolio Management*, Fall 1985.

Mahoney, Joseph, Shelley McCarron, Mike Miles and C.F. Sirmans. Location Differences in Private and Public Real Estate Investment. *Real Estate Finance*, Summer 1996, pp. 52-64.

Malpezzi, Stephen. Forecasting Metropolitan Multifamily Residential Construction. University of Wisconsin, Center for Urban Land Economics Working Paper, 1996

Malpezzi, Stephen and Stephen K. Mayo. Housing and Urban Development Indicators: A Good Idea Whose Time Has Returned. *Real Estate Economics*, 25(1), 1997, pp. 1-11.

Malpezzi, Stephen and Yu-Yun Yang. Employment, Income and Population in U.S. Metropolitan Areas: Summary of BEA Data. University of Wisconsin, Center for Urban Land Economics Working Paper, 1997.

Malpezzi, Stephen, Larry Ozanne and Thomas Thibodeau. Microeconomic Estimates of Housing Depreciation. *Land Economics*, 63(4), November 1987, pp. 373-85.

Miles, Mike E., John Roberts, Donna Machi and Robert Hopkins. Sizing the Investment Markets: A Look at the Major Components of Public and Private Markets. *Real Estate Finance*, 11(1), Spring 1994, pp. 39-50.

Miles, Mike E., Robert Pittman, Martin Hoesli, Pankaj Bhatnager and David Guilkey. A Detailed Look at America's Real Estate Wealth. *Journal of Property Management*, July/August 1991, pp. 45-50.

Shilling, James D. and Stephen Malpezzi. Institutional Investors Tilt Their Real Estate Holdings Towards Quality, Too. University of Wisconsin, Center for Urban Land Economics Research Working Paper, 1996.

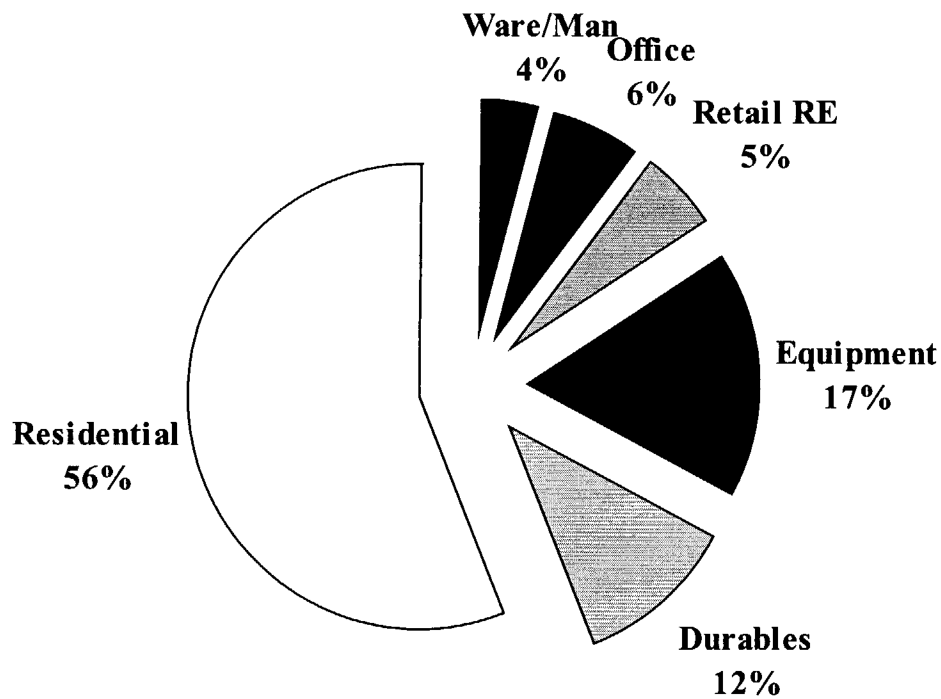
U.S. Department of Commerce, Bureau of the Census. *1982 Census of Governments: Taxable Property Values and Assessment-Sales Price Ratios*. Washington, GC82(2), 1983.

U.S. Department of Commerce, Economics and Statistics Administration. *USA Counties 1996*. CD-ROM Database, Washington D.C., 1996.

Winfrey, R. *Statistical Analyses of Industrial Property Retirements*. Iowa Engineering Experiment Station, Bulletin 125, 1935.

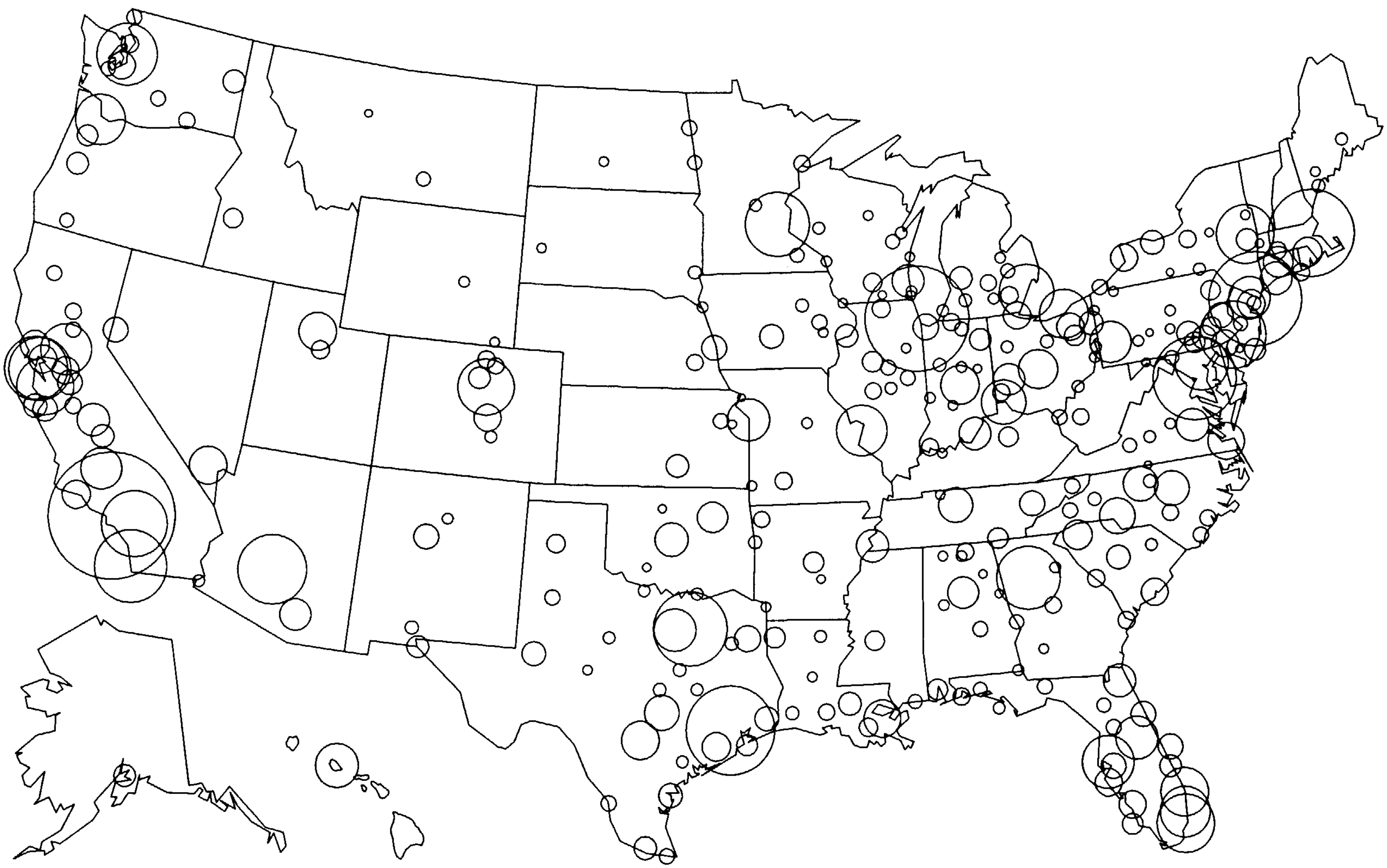
Young, Allan H. and John C. Musgrave. Estimation of Capital Stock in the United States. In Dan Usher (ed.), *The Measurement of Capital*. University of Chicago Press for NBER, 1980.

U.S. Fixed Tangible Wealth

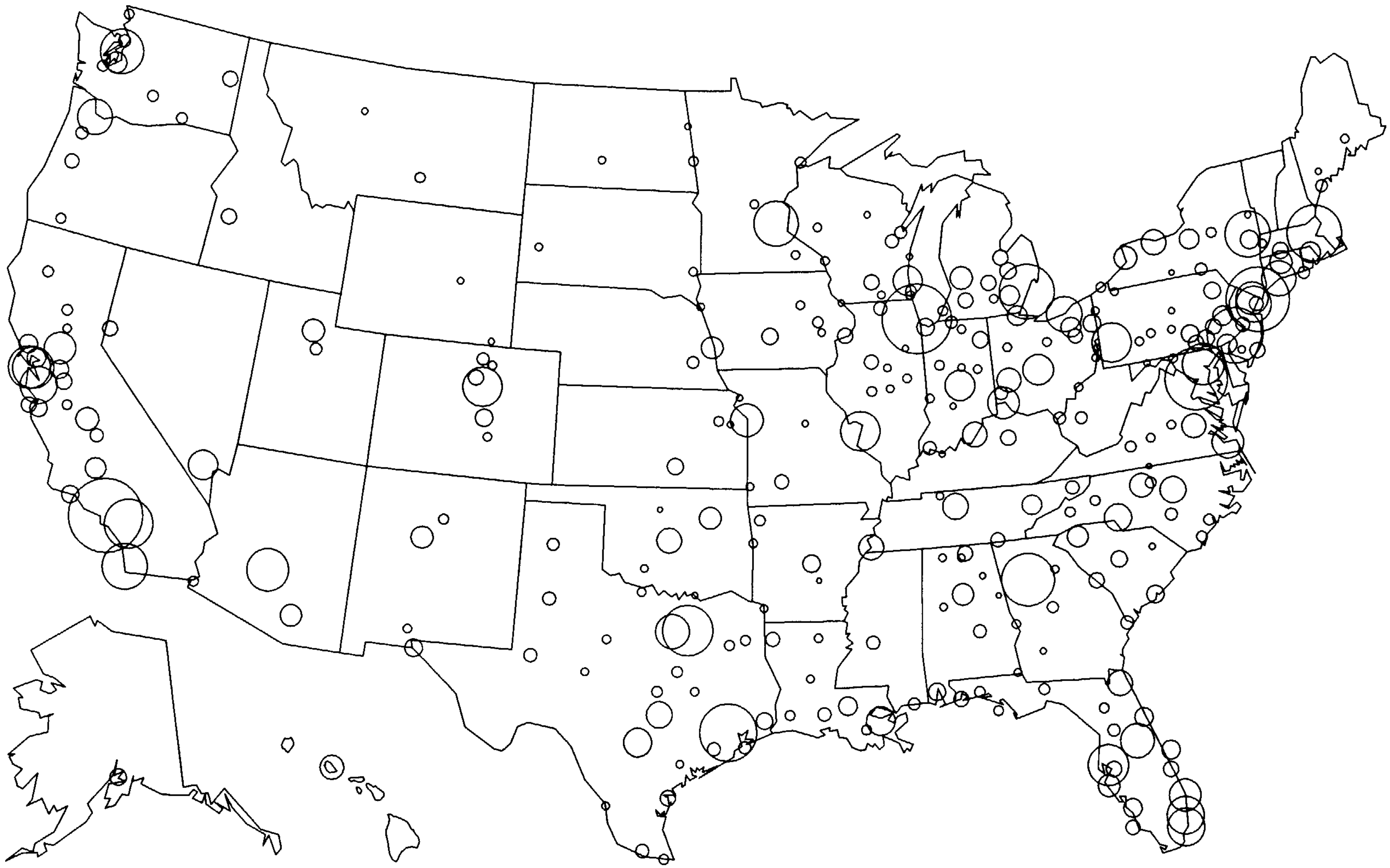


Source: Hartzell, Pittman and Downs 1992

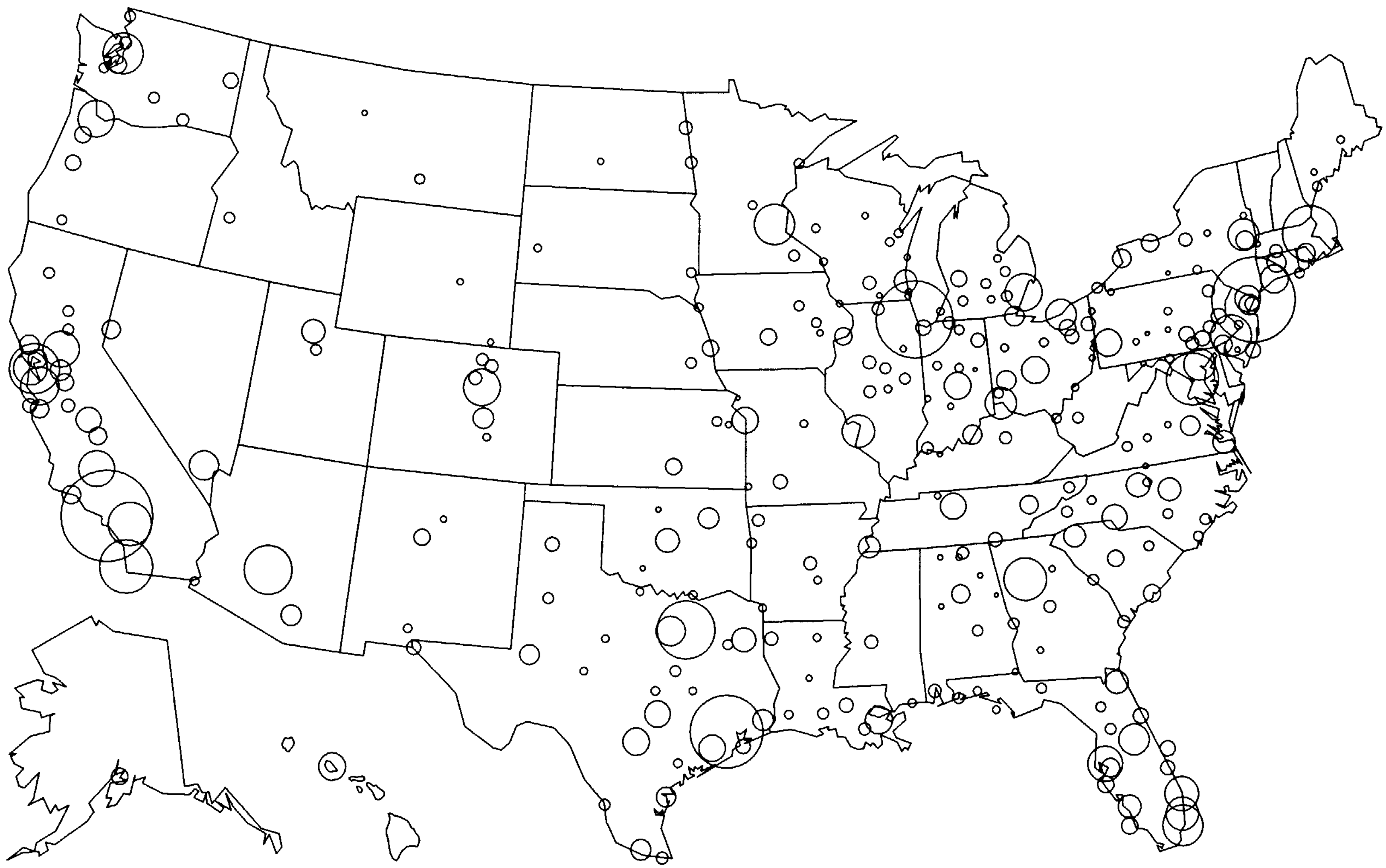
Total Real Estate Capital Stock, 1994



Single Family Capital Stock, 1994



Income Property Capital Stock, 1994



1990 Population for U.S. Metro Areas

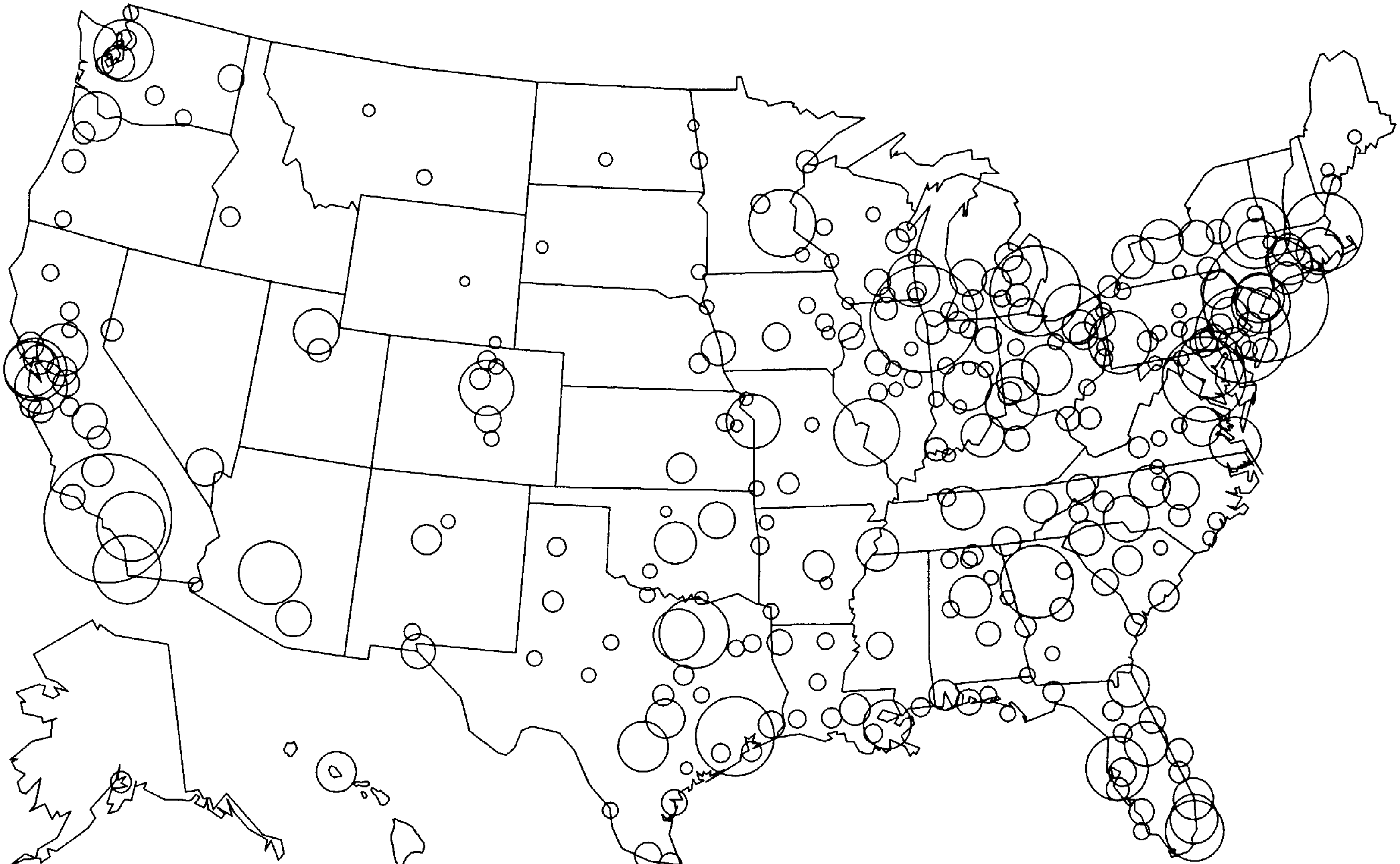


Table 1: Summary Statistics on Real Estate Capital Stock

	Total Real Estate Capital Stock ($Million)			
	Total Capital Stock		Total Capital Stock Per Capita	
	1982	1994	1982	1994
	Original	Original	Original	Original
	KTOT82	KTOT94	KTOTPC82	KTOTPC94
Number of observations	247	247	247	247
Mean	16,789	25,876	0.023	0.031
Standard Deviation	33,108	47,228	0.014	0.013
Maximum	303,751	426,155	0.103	0.107
3rd Quartile	14,989	23,160	0.028	0.036
Median	5,768	10,079	0.020	0.029
1st Quartile	2,815	4,706	0.015	0.023
Minimum	679	1,346	0.002	0.006

	Real Estate Capital Stock for Single Family ($Million)			
	Capital Stock		Capital Stock Per Capita	
	1982	1994	1982	1994
	Original	Original	Original	Original
	KSF82	KSF94	KSFPC82	KSFPC94
Number of observations	242	242	242	242
Mean	8,669	13,411	0.011	0.016
Standard Deviation	16,477	23,561	0.006	0.006
Maximum	158,928	208,497	0.041	0.046
3rd Quartile	7,684	12,554	0.014	0.019
Median	3,132	5,176	0.011	0.015
1st Quartile	1,535	2,283	0.008	0.012
Minimum	227	436	0.001	0.001

	Real Estate Income Property ($ Million)			
	Income Property		Income Property Per Capita	
	1982	1994	1982	1994
	Original	Original	Original	Original
	KIP82	KIP94	KIPPC82	KIPPC94
Number of observations	242	242	242	242
Mean	8,326	12,766	0.012	0.015
Standard Deviation	18,533	25,723	0.010	0.009
Maximum	153,939	217,658	0.091	0.086
3rd Quartile	7,054	11,208	0.014	0.017
Median	2,921	4,625	0.009	0.013
1st Quartile	1,356	2,322	0.006	0.010
Minimum	157	355	0.001	0.004

Table 2: Top 20 Metro Areas, By Stock Variables

	Total Real Estate Capital Stock 1994 $Million		Single Family Stock 1994 $Million		Income Property Stock 1994 $Million
Los Angeles-Long Beach, CA	426,154	Los Angeles-Long Beach, CA	208,497	Los Angeles-Long Beach, CA	217,658
Chicago, IL	292,555	Chicago, IL	137,892	New York, NY	190,031
New York, NY	237,578	Boston, MA	120,751	Chicago, IL	154,663
Houston, TX	207,639	Washington, DC	110,369	Houston, TX	136,833
Boston, MA	200,477	San Francisco, CA	76,787	Dallas, TX	88,836
Washington, DC	184,892	Philadelphia, PA	73,813	Boston, MA	79,726
Dallas, TX	145,041	Houston, TX	70,806	Washington, DC	74,523
San Diego, CA	138,592	Minneapolis-St. Paul, MN	65,849	San Diego, CA	73,915
Phoenix, AZ	126,156	Riverside-San Bernardino, CA	65,762	Oakland, CA	63,817
Philadelphia, PA	119,470	Nassau-Suffolk, NY	64,977	Phoenix, AZ	63,444
Riverside-San Bernardino, CA	115,269	San Diego, CA	64,676	Riverside-San Bernardino, CA	49,507
Minneapolis-St. Paul, MN	108,695	Phoenix, AZ	62,712	Atlanta, GA	48,508
San Francisco, CA	106,399	Seattle, WA	56,962	Philadelphia, PA	45,657
Atlanta, GA	105,312	Atlanta, GA	56,804	Miami-Hialeah, FL	43,543
Oakland, CA	104,479	Dallas, TX	56,204	Minneapolis-St. Paul, MN	42,846
Seattle, WA	99,435	San Jose, CA	50,895	Seattle, WA	42,473
Nassau-Suffolk, NY	90,624	Baltimore, MD	49,126	San Jose, CA	37,679
San Jose, CA	88,573	Denver, CO	47,696	Denver, CO	35,893
Miami-Hialeah, FL	86,656	New York, NY	47,547	Detroit, MI	35,518
Denver, CO	83,589	St. Louis, MO	43,286	Sacramento, CA	35,380

Table 3: Top 20 Metro Areas, By Stock Per Capita

	Total Real Estate Capital Stock $Million Per Capita		Single Family Stock $Million Per Capita		Income Property Stock $Million Per Capita
Brazoria, TX	0.1073	San Francisco, CA	0.0465	Brazoria, TX	0.0856
Longview-Marshall, TX	0.0891	Santa Cruz, CA	0.0384	Longview-Marshall, TX	0.0741
Bakersfield, CA	0.0708	Honolulu, HI	0.0349	Bakersfield, CA	0.0549
San Francisco, CA	0.0644	San Jose, CA	0.0321	Grand Forks, ND	0.0471
Odessa, TX	0.0608	Boulder-Longmont, CO	0.0319	Houston, TX	0.0375
West Palm Beach-Boca Raton-FL	0.0603	Santa Barbara-Santa Maria CA	0.0312	Fort Myers-Cape Coral, FL	0.0361
Santa Cruz, CA	0.0600	West Palm Beach-Boca Raton-FL	0.0303	Reno, NV	0.0321
Grand Forks, ND	0.0592	Santa Rosa-Petaluma, CA	0.0285	West Palm Beach-Boca Raton-FL	0.0320
Honolulu, HI	0.0579	Fort Lauderdale-Hollywood FL	0.0277	Greeley, CO	0.0310
Houston, TX	0.0578	Denver, CO	0.0277	Dallas, TX	0.0307
Reno, NV	0.0573	Wilmington, NC	0.0265	Oakland, CA	0.0292
San Jose, CA	0.0558	Seattle, WA	0.0258	Beaumont-Port Arthur, TX	0.0285
Greeley, CO	0.0556	Reno, NV	0.0253	San Diego, CA	0.0281
Santa Barbara-Santa Maria CA	0.0539	Nassau-Suffolk, NY	0.0249	Corpus Christi, TX	0.0275
Santa Rosa-Petaluma, CA	0.0538	Phoenix, AZ	0.0245	Santa Rosa-Petaluma, CA	0.0265
Boulder-Longmont, CO	0.0500	Minneapolis-St. Paul, MN	0.0244	Salinas-Seaside-Monterey, CA	0.0258
Fort Myers-Cape Coral, FL	0.0497	Fort Collins-Loveland, CO	0.0241	Fargo-Moorhead, ND	0.0257
San Diego, CA	0.0493	Washington, DC	0.0240	Phoenix, AZ	0.0257
Phoenix, AZ	0.0493	Sacramento, CA	0.0237	Bloomington-Normal, IL	0.0256
Denver, CO	0.0485	Melbourne-Titusville-Palm Beach FL	0.0235	Anchorage, AK	0.0254

Table 4. Independent Variables

	Variable Name	Content
	P82, P94	Population, 1982 and 1994
	DP6982, DP8194	Growth Rate of employment, 1969-82 and 1981-94
	SEMSGP82, SEMSGP94	Semi-Standard Deviation of Growth Rate of Population, 1969-82 and 1981-94
Economic Structure" Variables	E82, E94	Employment, 1982 and 1994
	DE6982, DE8194	Growth Rate of Employment, 1969-82 and 1981-94
	SEMSGE82, SEMSGE94	Semi-Standard Deviation of Growth Rate of Employment, 1969-82 and 1969-94
	Y82, Y94	Real Income Per Capita, 1982 and 1994
	DY6982, DY8194	Growth Rate of Real Income Per Capita, 1969-82 and 1981-94
	SEMSGY82, SEMSGY94	Semi-Standard Deviation of Growth Rate of Real Income Per Capita, 1969-82 and 1981-94
Employment Classification Variables	PBUS80, PBUS90	Percentage of Employment in Bus services, 1980 and 1990
	PCON80, PCON90	Percentage of Employment in Construction, 1980 and 1990
	PFIRE80, PFIRE90	Percentage of Employment in FIRE, 1980 and 1990
	PMAN80, PMAN90	Percentage of Employment in Manufacturing, 1980 and 1990
	PMIN80, PMIN90	Percentage of Employment in Mining, 1980 and 1990
	PPERS80, PPERS90	Percentage of Employment in Personal Services, 1980 and 1990
	PPROF80, PPROF90	Percentage of Employment in Professional Services, 1980 and 1990
	PPUB80, PPUB90	Percentage of Employment in Public Administration, 1980 and 1990
	PTRANS80, PTRANS90	Percentage of Employment in Transportation, 1980 and 1990
Demographics	PCTGE65	Metro Percentage of people 65 or older, 1990
	PCT18_64	Metro? Percentage of people 18 to 64, 1990
	PCTCOUPL	Percentage of Married Couples, 1990
Other variables	POO80, POO90	Percentage of Owner Occupied Units, 1980 and 1990
	PTYDIR90	Percentage of Real Transfer Income, Dividends, and Interest, 1990
	REGHAT	Instrumental Variable, Regulation
	RCDUM	Rent Control Dummy, 0=w/o rent control, 1=w/ rent control
	STUDPC	Students Per Capita

Table 5: Determinants of Real Estate Capital Per Capita, 1982 and 1994

		Total Capital Stock Per Capita 1982	Total Capital Stock Per Capita 1994	Capital Stock Per Capita Single-Family 1982	Capital Stock Per Capita Single-Family 1994	Income Property Per Capita 1982	Income Property Per Capita 1994
Dependent Variable		Linear	Linear	Linear	Linear	Logarithmic	Logarithmic
Employment, 1982, or 1994	Coef.	2.180E-09	4.460E-11	5.210E-10	-6.170E-10	1.750E-07	3.729E-08
	S.E.	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.000E-08	5.000E-08
	t	1.52	0.03	0.79	-0.98	2.05	0.73
	Prob > |t|	0.129	0.973	0.430	0.329	0.042	0.465
	Tolerance	0.558	0.517	0.554	0.515	0.554	0.515
Growth Rate of Empolyment, 1969-1982, or 1981-1994	Coef.	0.249	0.170	0.109	0.044	10.50	9.92
	S.E.	0.071	0.092	0.033	0.046	4.24	3.68
	t	3.52	1.85	3.33	0.97	2.48	2.69
	Prob > |t|	0.001	0.066	0.001	0.331	0.014	0.008
	Tolerance	0.293	0.389	0.293	0.399	0.293	0.399
Semi-Standard Deviation 1969-1980, or 1981-1994	Coef.	-0.189	-0.001	0.063	0.076	-9.78	-3.46
	S.E.	0.137	0.182	0.063	0.091	8.14	7.32
	t	-1.38	0.00	1.00	0.84	-1.20	-0.47
	Prob > |t|	0.168	0.998	0.317	0.400	0.231	0.638
	Tolerance	0.453	0.460	0.453	0.533	0.453	0.533
Percentage of Real Transfer Income, Dividends, & Interest, 1980 or 1990	Coef.	0.065	-0.216	0.168	0.018	-10.12	-12.79
	S.E.	0.188	-0.211	0.086	0.102	11.18	8.26
	t	0.34	-1.03	1.95	0.18	-0.91	-1.55
	Prob > |t|	0.732	0.306	0.053	0.858	0.366	0.123
	Tolerance	0.472	0.406	0.477	0.402	0.477	0.402
Real Income, Per Capita 1982, or 1994	Coef.	2.170E-06	1.990E-06	1.180E-06	1.140E-06	6.652E-05	5.885E-05
	S.E.	4.400E-07	3.900E-07	2.000E-07	1.900E-07	2.644E-05	1.544E-05
	t	4.99	5.12	5.77	5.96	2.52	3.81
	Prob > |t|	0.000	0.000	0.000	0.000	0.013	0.000
	Tolerance	0.431	0.354	0.445	0.368	0.445	0.368
Growth Rate of Real Income Per Capita, 1969-1982, or 1981-1994	Coef.	-0.143	-0.597	-0.045	-0.212	-1.43	-25.18
	S.E.	0.146	0.136	0.068	0.067	8.77	5.40
	t	-0.98	-4.38	-0.67	-3.18	-0.16	-4.66
	Prob > |t|	0.328	0.000	0.506	0.002	0.871	0.000
	Tolerance	0.359	0.445	0.386	0.479	0.386	0.479
Semi-Std. Dev, Growth Rate of Real Income Per Capita, 1969-82, or 1981-94	Coef.	0.359	0.199	-0.043	-0.014	19.53	12.87
	S.E.	0.124	0.183	0.057	0.089	7.37	7.20
	t	2.89	1.08	-0.76	-0.16	2.65	1.79
	Prob > |t|	0.004	0.279	0.450	0.875	0.009	0.075
	Tolerance	0.461	0.400	0.467	0.495	0.467	0.495
Percentage of Employment in Bus Service 1980, or 1990	Coef.	-0.142	0.033	-0.033	0.167	-8.25	-4.36
	S.E.	0.062	0.123	0.029	0.060	3.69	4.81
	t	-2.28	0.27	-1.17	2.80	-2.23	-0.91
	Prob > |t|	0.024	0.791	0.242	0.056	0.027	0.366
	Tolerance	0.488	0.359	0.489	0.357	0.489	0.357
Percentage of Employment in Construction 1980, or 1990	Coef.	0.170	0.199	0.015	0.039	6.54	5.28
	S.E.	0.058	0.064	0.027	0.032	3.48	2.51
	t	2.94	3.10	0.54	1.27	1.88	2.10
	Prob > |t|	0.004	0.002	0.587	0.206	0.062	0.037
	Tolerance	0.291	0.580	0.287	0.575	0.287	0.575
Percentage of Employment in FIRE 1980, or 1990	Coef.	-0.094	-0.122	-0.022	-0.077	-4.31	-1.93
	S.E.	0.062	0.054	0.029	0.264	3.70	2.13
	t	-1.52	-2.24	-0.78	-2.93	-1.16	-0.90
	Prob > |t|	0.131	0.026	0.434	0.004	0.246	0.367
	Tolerance	0.352	0.355	0.351	0.352	0.351	0.352

Table 5: Determinants of Real Estate Capital Per Capita, 1982 and 1994 (Continued)

		Total Capital Stock Per Capita 1982	Total Capital Stock Per Capita 1994	Capital Stock Per Capita Single-Family 1982	Capital Stock Per Capita Single-Family 1994	Income Property Per Capita 1982	Income Property Per Capita 1994
Percentage of Employment in Manufacturing 1980, or 1990	Coef.	-0.063	-0.084	-0.024	-0.038	-4.83	-3.50
	S.E.	0.024	0.030	0.011	0.015	1.40	1.17
	t	-2.67	-2.79	-2.26	-2.59	-3.45	-2.98
	Prob > |t|	0.008	0.006	0.025	0.010	0.001	0.003
	Tolerance	0.083	0.094	0.084	0.095	0.084	0.095
Percentage of Employment in Mining 1980, or 1990	Coef.	-0.009	0.014	-0.026	-0.074	-5.22	-0.91
	S.E.	0.046	0.073	0.024	0.042	3.13	3.43
	t	-0.20	0.19	-1.09	-1.74	-1.67	-0.27
	Prob > |t|	0.844	0.852	0.277	0.083	0.097	0.791
	Tolerance	0.474	0.452	0.542	0.554	0.542	0.554
Percentage of Employment in Personal Services 1980, or 1990	Coef.	-0.083	-0.090	-0.028	-0.030	-4.16	-3.35
	S.E.	0.041	0.048	0.019	0.023	2.45	1.86
	t	-2.01	-1.88	-1.48	-1.33	-1.70	-1.81
	Prob > |t|	0.046	0.062	0.141	0.186	0.091	0.073
	Tolerance	0.450	0.434	0.448	0.432	0.448	0.432
Percentage of Employment in Professional Services 1980, or 1990	Coef.	-0.089	-0.075	-0.030	-0.027	-5.44	-3.12
	S.E.	0.032	0.037	0.015	0.177	1.88	1.43
	t	-2.82	-2.04	-2.05	-1.55	-2.89	-2.19
	Prob > |t|	0.005	0.043	0.041	0.124	0.004	0.030
	Tolerance	0.202	0.166	0.204	0.166	0.204	0.166
Percentage of Employment in Public Administration 1980, or 1990	Coef.	-0.084	-0.105	-0.025	-0.036	-5.52	-4.43
	S.E.	0.032	0.036	0.015	0.017	1.90	1.40
	t	-2.63	-2.92	-1.70	-2.10	-2.90	-3.16
	Prob > |t|	0.009	0.004	0.090	0.037	0.004	0.002
	Tolerance	0.365	0.397	0.367	0.396	0.367	0.396
Percentage of Employment in Transportation 1980, or 1990	Coef.	-0.079	-0.074	-0.018	-0.025	-4.34	-3.74
	S.E.	0.051	0.061	0.024	0.031	3.07	2.47
	t	-1.56	-1.21	-0.76	-0.83	-1.41	-1.52
	Prob > |t|	0.121	0.227	0.450	0.405	0.159	0.131
	Tolerance	0.452	0.448	0.445	0.437	0.445	0.437
Percentage of Owner Occupied Units 1980, or 1990	Coef.	-0.035	-0.031	0.001	0.007	-1.99	-1.99
	S.E.	0.014	0.016	0.006	0.008	0.81	0.63
	t	-2.59	-1.95	0.15	0.85	-2.47	-3.14
	Prob > |t|	0.010	0.053	0.880	0.395	0.014	0.002
	Tolerance	0.423	0.352	0.420	0.349	0.420	0.349
Percentage of Married Couples 1990	Coef.	2.000E-04	2.000E-04	1.570E-05	-3.820E-06	1.333E-03	1.068E-03
	S.E.	2.000E-04	3.000E-04	1.000E-04	1.000E-04	1.461E-02	1.005E-02
	t	0.86	0.67	0.14	-0.03	0.09	0.11
	Prob > |t|	0.389	0.501	0.890	0.976	0.927	0.916
	Tolerance	0.367	0.363	0.368	0.360	0.368	0.360
Percentage of People at age 18-64 1990	Coef.	2.000E-04	1.000E-04	3.000E-04	3.000E-04	-1.461E-02	-1.887E-02
	S.E.	3.000E-04	4.000E-04	2.000E-04	2.000E-04	2.079E-02	1.530E-02
	t	0.44	0.26	1.87	1.70	-0.70	-1.23
	Prob > |t|	0.659	0.794	0.064	0.091	0.483	0.219
	Tolerance	0.317	0.272	0.322	0.275	0.322	0.275
w/ or w/o Rent Control	Coef.	-0.001	-0.002	-0.001	-0.002	-0.033	-0.007
	S.E.	0.003	0.004	0.002	0.002	0.206	0.144
	t	-0.25	-0.54	-0.69	-1.16	-0.16	-0.05
	Prob > |t|	0.804	0.591	0.493	0.248	0.872	0.963
	Tolerance	0.585	0.543	0.594	0.560	0.594	0.560
Intercept	Coef.	0.033	0.054	-0.014	-0.012	-0.490	-0.457
	S.E.	0.038	0.043	0.018	0.021	2.283	1.703
	t	0.86	1.24	-0.82	-0.59	-0.22	-0.27
	Prob > |t|	0.389	0.216	0.416	0.559	0.830	0.789
F value		13.73	9.22	9.18	7.86	9.72	9.28
Prob > F		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
R-square		0.55	0.45	0.45	0.42	0.47	0.46
Adjusted R-square		0.51	0.4	0.4	0.36	0.42	0.41
Model SS		0.026	0.019	0.004	0.004	64.593	28.553
Mean Square Error		0.010	0.010	0.004	0.005	0.332	0.154
N		247	247	242	242	242	242

Table 6. Correlation coefficients between the predicted and the actual values

	Total Capital Stock	Capital Stock for single family	Income Property
Between the predicted capital stock per capita and the actual capital stock per capita, 1982 and 1994	.74 and .67	.67 and .64	.69 and .62
Between the predicted capital stock and the actual capital stock , 1982 and 1994	.97 and .98	.92 and .94	.96 and .98

predicted capital stock = predicted capital stock per capita from models (1)-(6) $\times$population of the corresponding year.

Table 7: Summary Statistics on Predicted Real Estate Capital Stock

	Total Real Estate Capital Stock ($Million)			
	Total Capital Stock		Total Stock Per Capita	
	1982 Predicted KTHAT82	1994 Predicted KTHAT94	1982 Predicted KTHPC82	1994 Predicted KTHPC94
Number of observations	295	295	295	295
Mean	14,995	22,776	0.024	0.031
Standard Deviation	29,013	40,882	0.011	0.009
Maximum	264,012	343,878	0.070	0.064
3rd Quartile	12,469	21,573	0.030	0.036
Median	5,888	8,851	0.021	0.029
1st Quartile	2,779	4,141	0.016	0.024
Minimum	504	1,102	0.005	0.009

	Real Estate Capital Stock for Single Family ($Million)			
	SF Capital Stock		SF Stock Per Capita	
	1982 Predicted KSFHAT82	1994 Predicted KSFHAT94	1982 Predicted KSFHPC82	1994 Predicted KSFHPC94
Number of observations	295	295	295	295
Mean	7,685	11,710	0.012	0.015
Standard Deviation	14,231	19,675	0.004	0.004
Maximum	116,261	142,525	0.032	0.030
3rd Quartile	6,669	10,754	0.014	0.018
Median	2,928	4,275	0.011	0.015
1st Quartile	1,330	2,083	0.009	0.013
Minimum	431	677	0.004	0.006

	Real Estate Income Property ($ Million)			
	Income Property		Income Property Per Capita	
	1982 Predicted KIPHAT82	1994 Predicted KIPHAT94	1982 Predicted KIPHPC82	1994 Predicted KIPHPC94
Number of observations	295	295	295	295
Mean	6,674	10,639	0.011	0.014
Standard Deviation	15,049	21,167	0.008	0.006
Maximum	144,434	198,712	0.069	0.039
3rd Quartile	5,785	9,430	0.012	0.016
Median	2,488	3,773	0.008	0.013
1st Quartile	1,071	1,803	0.006	0.010
Minimum	335	622	0.003	0.005