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Do subsidized housing units depreciate faster than unsubsidized ones?

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ABSTRACT

The economics literature provides considerable evidence on the performance of low-income housing programs. One issue that has not been adequately addressed by previous studies is the relative depreciation rates of subsidized and unsubsidized housing units. Simple economic theory suggests that subsidized projects should depreciate more quickly than unsubsidized units, as the rents received by owners of these projects do not depend directly on the condition of their units provided that they meet minimum housing standards. However, many government programs aimed at modernizing subsidized housing projects exist. Whether there is a difference between the depreciation rates of subsidized and unsubsidized housing units is therefore an empirical question. Using panel data from the American Housing Survey, I find that there is no significant difference in the depreciation rates of subsidized and unsubsidized housing units over the period from 1985 to 2005.

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1. Introduction

Low-income housing assistance in the US is delivered in three main ways—housing vouchers, public housing projects, and privately owned subsidized projects. Subsidies in housing voucher programs are tied to assisted households. This allows participants to move between units that meet certain minimum standards without forfeiting their subsidies. In contrast, subsidies in programs of the other two types are tied to specific housing units. Assisted households that move from their dwelling units under these programs lose their subsidies. An important issue in policy discussions is the division of the budget for low-income housing assistance among these three types of assistance. One argument that arises in debates on this issue is that subsidized projects are poorly maintained. This paper examines this argument using panel data from the American Housing Survey (AHS).

Economic theory suggests that the structure of housing subsidy programs might lead to low levels of maintenance in subsidized projects. Under the programs that provide project-based assistance, the revenues received by the entities that own assisted projects are not directly tied to the quality of the units provided; neither the tenant's rent nor the magnitude of the subsidy depends on the condition of the unit as long as it meets minimum program standards. In contrast, owners of units in the private market or units occupied by voucher recipients are able to charge higher rents to occupants of higher-quality units. Economic theory, therefore, suggests that owners of unsubsidized units and units occupied by voucher recipients should be more willing than owners of private subsidized projects and public housing administrators to incur expenditures for maintenance and improvements, as they (unlike the latter two groups) receive financial benefits from increases in unit quality in the form of the increased rents they can charge. Housing units in private and public projects would be expected to experience high rates of depreciation relative to unsubsidized and voucher units as a result of these differences in maintenance.

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This simple analysis ignores an important aspect of reality, namely, subsidies for the maintenance and modernization of public and private housing projects. Owners of private projects and managers of public projects are able to procure federal funds for improving their units from a variety of sources. Through the Public Housing Operating Fund, the Department of Housing and Urban Development (HUD) provides operating subsidies to public housing authorities to assist with their maintenance and operating costs (HUD, 2006b). From FY 1998 to FY 2005, this program provided roughly $26 billion in operating subsidies to public housing authorities, or about $20,000 per dwelling unit (OMB, 2006). Similarly, HUD's Public Housing Capital Fund provides formula-based grants to public housing authorities for "developing, financing, modernization, and management improvements" (HUD, 2006a). From FY 1998 to FY 2005, HUD outlays for the Public Housing Capital Fund totaled $28 billion (OMB, 2006). While the outlays from these programs are used for other objectives in addition to maintenance and modernization, the existence and magnitude of these funds may have a substantial impact on the rate of depreciation of public housing projects.

The HOPE VI program has the potential to alter the average quantity of housing services provided by subsidized units as well. This program was created in 1992 with the goal of addressing the physical condition of severely distressed public housing units. In practice, the primary means of pursuing this goal has been the provision of grants aimed at demolishing such units. In the period from 1996 to 2003, HOPE VI provided 285 such grants worth nearly $400 million to 127 public housing authorities for the demolition of 56,755 public housing units (HUD, 2004). This program may affect the rate of depreciation of subsidized housing units. If the most distressed public housing units depreciate at a rate different than the average rate at which other subsidized units depreciate, then the demolition of these units will alter the overall rate of depreciation among all subsidized housing units. The direction of this effect is not clear *a priori*.

Additional programs exist that may slow the depreciation of units in private subsidized projects. The Low-Income Housing Tax Credit (LIHTC) program was established by the Tax Reform Act of 1986. Under this program, each state chooses private developers to whom it allocates tax credits it receives from the federal government for improving and developing housing projects. The LIHTC is expanding quickly. It is already the second largest low-income housing subsidy program in the United States, and it is growing faster than the Housing Choice Voucher Program, the country's largest low-income housing program. Using the 2004 LIHTC size and growth rate to extrapolate to the present yields an estimate of 2 million LIHTC units receiving allocations through 2007 (NCSHA, 2004, pp. 72–74). Many tax credit projects involve the rehabilitation of projects built under earlier subsidized construction programs and continue to receive subsidies from these programs. Among the LIHTC projects placed in service between 1995 and 2004, 35% received their allocations for the purpose of rehabilitation (Climaco et al., 2006, p. 2). Based on HUD's LIHTC database, I estimate that the average LIHTC acquisition and rehabilitation project contained 58 units in 2008, so this represents a substantial total number of assisted housing units. The owners of LIHTC-assisted projects receive additional rental assistance subsidies on behalf of 39% of their tenants (GAO, 1997, p. 41). The results presented in Buron et al. (2000) indicate that a large proportion of tenants in LIHTC units may receive Section 8 assistance; in their sample of 39 LIHTC properties, three quarters had residents receiving Section 8 assistance. The National Council of State Housing Authorities reports that nine percent of the LIHTC units in service in 2004 received Section 8 project-based assistance, and only 23% received no other federal subsidies at all (NCSHA, 2004, p. 78). Together these results suggest that most LIHTC rehabilitation projects are rehabilitations of projects that already receive subsidies from other sources. It is therefore plausible to assume that the LIHTC has a non-negligible effect on the rate of depreciation among housing units that receive the types of subsidies investigated in this paper.

The Mark-to-Market (M2M) program also affects the condition of many private subsidized projects. This program was implemented in 1997 to address the discovery that the annual payments to owners of many such units exceeded their market rents. (These projects also received upfront development subsidies). In the early 1990s, HUD budget projections indicated that the increasing subsidies allocated to such units were unsustainable given the agency's budget. The M2M program is designed to reduce the subsidies awarded to many of these units as they reach the end of their service agreements. It is unclear *a priori* whether M2M actually reduces HUD expenditures; in addition to lowering monthly subsidies, it typically involves restructuring project owners' FHA mortgages to give them more favorable terms. Hilton et al. (2004, p. xi) predict that the present value of the net savings resulting from the M2M program will be $831 million over the next 20 years. In most cases, M2M projects are signed to new long-term use agreements. Housing projects in the M2M program are given additional subsidies for unit modernization and repairs. Owners of units that receive these subsidies under the M2M program are typically responsible for about 20% of the relevant costs. Properties receiving the full M2M restructuring described above received an average of $2,244 per housing unit through August 2003. The M2M program is large in volume; through July 2003, 27% of all FHA-insured properties receiving Section 8 project-based assistance had entered the program (Hilton et al., 2004). It is important to note that owners of private subsidized projects own their units at the end of their use agreements and can then begin renting them on the private market. These owners may therefore pursue the M2M program and other opportunities for modernization to further their own financial interests.

The relative depreciation rates of subsidized and unsubsidized housing units also depend on the degree to which owners of unsubsidized units have incentives to reinvest in their units. These incentives depend on the anticipated effects on unit market values from additional expenditures on reinvestment. The results in this paper concern the period from 1985 to 2005. During this period, important changes occurred in the United States' housing markets

that may have substantially affected the incentive to reinvest. The rental vacancy rate in the United States rose steadily from 6.3% in the first quarter of 1985 to 10.1% in the first quarter of 2005 (US Census Bureau, 2008b). Over the same time period, the homeownership rate rose from 64.1% to 69.1% (US Census Bureau, 2008a). These factors clearly presented disincentives for the construction of new rental housing units. However, they did not necessarily lead to reduced maintenance of the existing stock. It is also possible that rising incomes might lead renters to increase their demands for housing services irrespective of the fact that their numbers were shrinking. The magnitude of the incentive for reinvestment in private rental housing over this time period is therefore theoretically unclear.

Finally, it is important to note that while the individuals in charge of public housing project units do not reap direct financial benefits if they provide better housing, they do have an incentive to avoid depreciation insofar as it promotes excess vacancies. In particular, the current Public Housing Assessment System includes provisions to reduce the operating subsidy received by a Public Housing authority if it experiences excess vacancies. The Public Housing Management Assessment Systems in effect prior to the institution of the current system in 2000 also contained such provisions. To the extent that public housing agencies care about the magnitude of their operating subsidies, this provides an incentive for them to acquire funds for reinvestment.

Since owners of housing projects are able to acquire funds for improving their units at little cost to themselves, differences in depreciation rates across subsidy types are theoretically ambiguous. Whether subsidized units decline in quality more quickly than unsubsidized ones is, therefore, an empirical question. This paper uses AHS data in an attempt to answer this question. Since the AHS is not drawn from administrative data, it is possible that measurement error exists in its information on subsidy status. This may attenuate the results of this and any other analyses comparing subsidized and unsubsidized units that use AHS data. However, no existing study addresses the relative depreciation rates of subsidized and unsubsidized housing. This paper, therefore, provides important information that has been conspicuously absent in the previous literature.

2. Empirical methodology

The goal of this paper is to measure and compare the depreciation rates of subsidized and unsubsidized housing units. It attempts this task in three ways. First, the relative rates of change in various maintenance-related housing characteristics are compared over time. Second, the results of survey questions that directly inquire about tenants' satisfaction with the maintenance provided in their housing units are presented. Finally, I construct an overall index of the desirability of a housing unit based on a hedonic equation. The mean values of this index for unsubsidized and subsidized units can be tracked over time to determine the average depreciation in the quantity of housing services provided by units of each type.

The estimated hedonic regression takes the following form:

$$\ln(RENT_i) = \alpha + \sum_k \beta_k X_{ik} + \sum_t \sum_m \gamma_{tm} Y_{it} P_{im} + u_i \tag{1}$$

where $RENT_i$ is the market rent received by unit i, the X_{ik} are unit and neighborhood characteristics that affect market rent, Y_{it} is a dummy variable indicating that observation i is in year t, P_{im} is a dummy variable indicating that observation i is in place m, and u_i is a random error that is assumed to satisfy the Gauss–Markov conditions. After this regression is performed for unsubsidized units, the parameter estimates can be used to generate a prediction of the mean market rent of each subsidized unit given its observable characteristics. Goldberger (1968, p. 465) shows that if u_i is distributed as $N(0, \sigma_u^2)$, a consistent estimator of the mean market rent of each unit is given by

$$\widehat{E[RENT_i|X_i, Y_i, P_i]} = e^{\hat{\alpha} + \sum_k \hat{\beta}_k X_{ik} + \sum_t \sum_m \hat{\gamma}_{tm} Y_{it} P_{im} + \frac{1}{2}\hat{\sigma}_u^2} \tag{2}$$

The above theoretical arguments concern not the market rents of subsidized and unsubsidized units, but instead the quantities of housing services that they provide. Netting out the effects of place and time by multiplying (2) by $e^{-\sum_t \sum_m \hat{\gamma}_m Y_{it} P_{im}}$ yields a prediction of the quantity of housing services provided by observation i that is independent of temporal and geographical price differences.

It is well known that estimating a regression of the above type restricts the coefficient estimates on the included housing characteristics to be equal in the two relevant time periods. It is therefore also useful to estimate separate regressions for each year. These regressions take the form

$$\ln(RENT_{it}) = \alpha_t + \sum_k \beta_{kt} X_{ikt} + \sum_m \omega_{mt} P_{imt} + u_{it}, \tag{3}$$

where t indexes time period. Netting out the effects of the P_{imt} as above yields a prediction of the mean market rent of each unit given X_{ikt} that is independent of geographical price differences but not independent of temporal ones. Producing estimates of the quantity of housing services provided by each unit at different points in time requires a temporal price index. The price index used in this analysis is

$$\rho = \frac{\exp\left(\hat{\alpha}_{2005} + \sum_k \hat{\beta}_{k2005} \overline{X}_k + \sum_m \hat{\omega}_{m2005} \overline{P}_m + \frac{1}{2}\hat{\sigma}^2_{u_{2005}}\right)}{\exp\left(\hat{\alpha}_{1985} + \sum_k \hat{\beta}_{k1985} \overline{X}_k + \sum_m \hat{\omega}_{m1985} \overline{P}_m + \frac{1}{2}\hat{\sigma}^2_{u_{1985}}\right)}, \tag{4}$$

where $\overline{X}_k$ and $\overline{P}_m$ designate the pooled sample means of the X_{ik} and P_{im}. Then an estimate of the quantity of housing services provided by each 2005 unit (in 1985 prices that prevailed in the geographical location omitted from regression (3)) is given by

$$\frac{\exp(\hat{\alpha}_{2005} + \sum_k \hat{\beta}_{k2005} X_{ik} + \sum_m \hat{\omega}_{m2005} P_{im})}{\rho}. \tag{5}$$

Corresponding estimates for observations from 1985 do not require division by ρ.

3. Data and variables

The data utilized in this paper are drawn from the American Housing Survey (AHS) national data files from 1985 to 2005. The AHS is a biennial panel survey that collects data on a plethora of characteristics for approximately 70,000 housing units in each data year. The relevant observations for this paper are units rented for cash rent, of which there are approximately 13,000 in each data year.

The basic hedonic regression contains a wide variety of variables presumed to affect market rent. In total, there are 263 explanatory variables: 108 related to place and time, 123 concerned with unit condition and equipment, and 32 indicating neighborhood characteristics. The sample used for the regression contains 18,245 observations on unsubsidized housing units in either 1985 or 2005. The P_{im} used in the estimation of Eq. (1) combine information about the census region, metropolitan status, and metropolitan statistical area (MSA) variables present in the AHS. For units in identified MSAs with sufficient numbers of unsubsidized units, geographical location is taken to be MSA. For units outside of identifiable MSAs or in MSAs with very small numbers of unsubsidized units, geographical location is replaced with a census region-metropolitan status combination. Unless otherwise noted, all predicted quantities of housing services are market rents in 1985 Washington, DC prices, as this corresponds to the omitted place-year interaction dummy variable in the estimation of Eq. (1).

The identification of subsidy status gives some cause for concern. First, the AHS does not include enough information to distinguish fully among the three main types of housing assistance before 1997. Therefore, the relevant depreciation rates are calculated using the more general "subsidized" and "unsubsidized" categories. Since the incentives facing owners of voucher units differ importantly from those facing the individuals in control of public and private subsidized projects, voucher units are eliminated from the "subsidized" category where possible. In particular, units identified as "subsidized" in 1985 that are listed as voucher units after 1997 are excluded. The AHS questions used to determine subsidy status are elucidated in Appendix A. Second, as noted by Shroder (2002, pp. 411–415), when individuals are asked to identify the types of housing subsidies they receive, their responses are often inaccurate. Shroder's analysis is based on AHS data matched with HUD administrative records. The administrative data set used in his analysis did not include a significant portion of HUD-assisted units, so his estimate of the fraction of unsubsidized tenants incorrectly indicating receipt of a subsidy may be too high. However, it is true that survey respondents appear to perform poorly when asked to report the nature of their housing subsidies. This provides another reason for analyzing subsidized units as one broad category, as it is surely easier for respondents to determine whether they receive any housing subsidy at all than to identify their specific subsidy type. However, the existence of measurement error in the subsidy variables in the AHS does bias my estimate of the difference in the depreciation rates of subsidized and unsubsidized housing units toward zero.

4. Results

The simplest exploration of the hypothesis that maintenance-related characteristics degrade more quickly in subsidized units than in unsubsidized ones can be performed by looking at the relative changes in means of these characteristics by subsidy type. Table 1 displays the means of selected housing defects by year and subsidy status for units observed in both 1997 and 2005. It also presents difference-in-differences estimates of the relative change in each variable. The difference-in-differences statistic is the change in the mean of the relevant variable among unsubsidized units from 1997 to 2005 minus this change for subsidized units. A positive value indicates that the associated defect is increasing more quickly (or decreasing more slowly) in unsubsidized units than in subsidized ones. There is no clear pattern in the changes of these maintenance-related variables across subsidy types. Very few of the difference-in-differences estimates are statistically significant, and their signs are not consistent. In fact, only the characteristics of voucher units appear to consistently degrade more quickly than those of unsubsidized units. This is possibly due to the fact that most units that were occupied by voucher recipients in both 1997 and 2005 were probably occupied by the same tenants throughout this period, so the increased opportunities for substantial maintenance available to landlords between tenants may not have existed for these units. Along some dimensions, some subsidized project units appear to do noticeably better than unsubsidized ones. Overall, this procedure gives little reason to believe that subsidized units degrade more quickly with respect to the characteristics listed.

The AHS also contains information that relates to maintenance more directly. Table 2 shows the results of an AHS survey question about tenant satisfaction with maintenance by subsidy type for the 2005 data. This question asked tenants whether they were completely satisfied, partly satisfied, or dissatisfied with building maintenance. The proportion of tenants that answered "dissatisfied" or "partly satisfied" to this question was smallest in unsubsidized housing. However, tenants in voucher units were the least satisfied with the maintenance performed on their units, and the proportion of tenants answering "dissatisfied" was smallest in private project units. The responses to this question may indicate more about overall unit condition than about the quality of maintenance. For example, it seems plausible that tenants in decrepit units might indicate dissatisfaction with maintenance even when substantial measures are taken to prevent these units from degrading further. The results in this table might also reflect differences in tenant expectations; tenants of project units might expect little maintenance, and therefore indicate a reasonable amount of satisfaction even when relatively little maintenance is performed on their units. Nonetheless, this analysis also provides little evidence for

Table 1
Housing defects related to maintenance.

Defect	Unsubsidized units		Voucher units			Public project units			Private project units		
	Percentage (1997)	Percentage (2005)	Percentage (1997)	Percentage (2005)	Diff-in-Diff	Percentage (1997)	Percentage (2005)	Diff-in-Diff	Percentage (1997)	Percentage (2005)	Diff-in-Diff
Roof sags	2.71	2.57	1.41	2.05	−0.78	1.04	1.06	−0.16	0.32	2.12	−1.94
Roof has holes	2.81	2.97	1.41	5.66	−4.09[a]	2.66	1.87	0.95	0.73	1.18	−0.29
Cracks in foundation	2.96	3.22	6.33	6.33	0.26	1.48	2.25	−0.51	1.14	4.16	−2.76[a]
Missing walls/siding	3.37	4.18	1.62	9.52	−7.09[a]	2.50	3.77	−0.46	1.12	3.58	−1.65
Missing roof materials	4.94	4.79	2.79	5.05	−2.41	2.22	4.73	−2.66[a]	1.14	4.48	−3.49[a]
Outside walls slanted	2.15	2.47	1.08	2.05	−0.65	1.27	0.78	0.81	1.18	1.60	−0.10
Windows broken	4.66	5.59	8.57	5.82	3.68	4.67	2.77	2.83[a]	1.55	2.49	−0.01
Cracks in floor	7.47	6.99	7.92	15.12	−7.68[a]	8.98	8.11	0.39	7.53	8.54	−1.49
Holes in floor	1.34	1.41	2.90	4.82	−1.85	1.88	2.05	−0.10	0.80	0.78	0.09
Paint peeling	4.14	4.12	5.56	6.73	−1.19	8.85	5.30	3.53[a]	2.36	4.16	−1.82
Evidence of rodents	11.71	13.53	23.10	23.72	1.20	15.98	15.77	2.03	11.4	10.65	2.57
Outside water leak	10.49	10.03	10.27	18.70	−8.89[a]	7.33	6.73	0.14	5.98	7.92	−2.40
Inside water leak	12.97	12.65	18.83	18.32	0.19	13.15	9.88	2.95[a]	10.86	10.23	0.31
Heat broke down	2.20	3.35	13.00	5.88	8.27[a]	4.83	3.05	2.93[a]	3.88	2.68	2.35
Fuses blew out	10.1	9.49	8.38	16.12	−8.35[a]	7.83	6.90	0.32	7.67	4.68	2.38
N	4595		67			360			237		

Statistics in the table are calculated for rental units that are present in both 1997 and 2005.
The difference-in-differences value is the difference between the change in the mean of each variable for unsubsidized units and this change for the relevant subsidized units.
[a] Indicates significance of the difference-in-differences statistic at the 5% level in a two-tailed *t*-test.

the proposition that subsidized units systematically depreciate faster than unsubsidized units due to differences in maintenance.

Table 3 displays summary statistics on the predicted quantities of housing services provided by subsidized and unsubsidized units in 1985 and 2005 based on the results of estimating Eq. (1). The full hedonic regression results are displayed in Appendix B. The means in Table 3 are based only on units that were in the sample in both 1985 and 2005 because it is infeasible to track units across all data years; housing units are dropped and readmitted to the AHS sample for each data year based on the available budget, and relatively few units complete the AHS interview in each of the intervening years. The difference-in-differences statistic reported in Table 3 is the change in the mean predicted quantity of housing services for unsubsidized units minus the change in this mean for subsidized units. A positive value indicates that unsubsidized units decline in quality more slowly than subsidized ones. As expected, subsidized units provide lower quantities of housing services on average than units in the unsubsidized market, albeit only slighly lower. However, the difference-in-differences value for this period is only 0.1%; there is no significant difference between the depreciation rates of unsubsidized and subsidized units from 1985 to 2005. Table 3 also displays results for the period from 1985 to 1997 and the period from 1997 to 2005. The sample sizes for each set of estimates are different because most units are not observed in every year in the AHS. The predictions for a given pair of years are based only on units that were observed in each of those two years.

During the period from 1985 to 1997, subsidized units declined in quality more quickly than unsubsidized units. However, the reverse was true from 1997 to 2005. One possible explanation for these facts is that the Mark-to-Market program was established in 1997. If the revitalizations performed under this program did indeed have a significant impact on the quality of housing services provided by subsidized housing units, the M2M program could at least partially account for the results observed in Table 3. Regardless of whether this is true, however, these results do not support the hypothesis of a significant difference between the depreciation rates of subsidized and unsubsidized housing units. Comparing units present in different pairs of years and stratifying the analysis by unit age produced similar results.

It has been argued that there may be important differences between the depreciation rates of housing units inside and outside of central cities due to the particular problems inherent to central cities. Tables 4 and 5 replicate the analysis based on Eq. (1) separately for these two categories of units. The results do not differ substantively from the main results presented in Table 3. Both inside and outside central cities, subsidized units depreciated faster than unsubsidized ones from 1985 to 1997 but slightly slower from 1997 to 2005, and neither subsample produced a significant difference in differences statistic for the full 20 year period. However, the differences computed

Table 2
Satisfaction with maintenance.

	Dissatisfied (%)	Dissatisfied or partly satisfied (%)
Unsubsidized units	6.69	27.11
All subsidized units	6.74	28.75
Voucher units	8.62	32.51[a]
Public project units	8.06	30.28[a]
Private project units	5.66	27.14

$N = 9430$ for unsubsidized units, 344 for voucher units, 777 for public project units and 1579 for private project units.
[a] Indicates that an estimate is statistically different from the unsubsidized estimate at the 5% confidence level.

for central cities are all larger than the corresponding differences for units outside these areas. Most notably, from 1985 to 1997, subsidized units depreciated 3.91% faster than unsubsidized units in central cities compared to 1.96% outside them. The difference-in-differences statistics are also slightly larger in central cities for 1997 to 2005 (−0.10 relative to −0.76) and 1985 to 2005 (0.59 relative to 0.49). Together, these estimates suggest that factors that differentially increase the depreciation rate of subsidized housing units relative to unsubsidized ones may disproportionately influence central cities.

Table 6 displays the results of an analysis based on hedonic equations estimated separately for each relevant year. The estimates presented in this table suggest that subsidized units may depreciate relatively slowly. In fact, the difference-in-differences statistic is negative and significant in two of the time periods examined. This suggests that subsidized units may have appreciated substantially relative to unsubsidized ones during the period from 1985 to 2005, particularly after 1997. The two-regression specification yields smaller difference-in-differences statistics than the one-regression model in each of the time periods examined, in large part because it produces slower depreciation rates for subsidized units; Table 6 implies that subsidized units may actually have appreciated on average from 1985 to 2005, whereas the results in Table 3 suggest depreciation during this time. The results of the two-regression analysis depend crucially on the bundle of housing characteristics used to compute ρ, so my preferred estimates are those reported in Table 3. Regardless of which specification one finds more plausible, however, it is clear that neither model provides evidence indicating that subsidized units depreciate faster than unsubsidized ones.

One might worry about selection bias influencing the accuracy of the results presented in this paper. Estimates of depreciation rates will be biased if units depreciating relatively quickly (or slowly) are more likely than average to be removed from the housing stock or the AHS sample. Difference-in-differences estimates will be biased if the incidence of this problem differs across subsidized and unsubsidized units. In the private housing stock, high-quality units sometimes switch from rental to owner-occupied status. For both subsidized and unsubsidized units, it is also the case that the units in the worst condition are often removed from the stock. If the depreciation rates of units at these extremes are different than average, then these facts could potentially affect my results. To investigate this problem, I reproduced the hedonic regression analyses after eliminating the worst 10% of subsidized and unsubsidized units and the best 10% of unsubsidized units as measured by the predicted quantity of housing services provided. The results of these additional analyses did not differ substantively from those presented in Tables 3–6. Furthermore, attrition in the AHS is relatively low. Of the 12,700 rental units of interest in the 1985 AHS data, 10,900 are still present in 2005 (though 3800 do not complete the AHS interview and 1500 have switched to owner-occupied status). For these reasons, it is not likely that selection bias invalidates the analyses performed in this paper.

Table 3
Change in the predicted quantity of housing services, one-regression specification.

	1985–2005		
	1985 Average value	2005 Average value	% Change
Mean predicted housing services (unsubsidized units)	$499.40	$478.75	−4.14
Mean predicted housing services (subsidized units)	$486.14	$465.54	−4.24
Difference-in-differences	0.10		
$N = 3521$ for unsubsidized units, 769 for subsidized units			
	1985–1997		
	1985 Average value	1997 Average value	% Change
Mean predicted housing services (unsubsidized units)	$486.15	$460.73	−5.23
Mean predicted housing services (subsidized units)	$461.59	$425.29	−7.89
Difference-in-differences	2.66***		
N=4337 for unsubsidized units, 813 for subsidized units			
	1997–2005		
	1997 Average value	2005 Average value	% Change
Mean predicted housing services (unsubsidized units)	$723.72	$721.11	−0.36
Mean predicted housing services (subsidized units)	$668.19	$668.94	0.11
Difference-in-differences	−0.47		

$N = 4607$ for unsubsidized units, 811 for subsidized units.
The difference-in-differences statistic is the difference between the change in the mean predicted quantity of housing services for unsubsidized units and the change in this mean for subsidized units.
*** indicates statistical significance at the 1% level.

Table 4
Change in the predicted quantity of housing services in central cities, one-regression specification.

	1985–2005		
	1985 Average value	2005 Average value	% Change
Mean predicted housing services (unsubsidized units)	$455.02	$444.75	−2.26
Mean predicted housing services (subsidized units)	$453.28	$440.36	−2.85
Difference-in-differences	0.59		
N = 1688 for unsubsidized units, 403 for subsidized units			
	1985–1997		
	1985 Average value	1997 Average value	% Change
Mean predicted housing services (unsubsidized units)	$443.63	$422.36	−4.79
Mean predicted housing services (subsidized units)	$427.72	$390.50	−8.70
Difference-in-differences	3.91***		
N = 2039 for unsubsidized units, 441 for subsidized units			
	1997–2005		
	1997 Average value	2005 Average value	% Change
Mean predicted housing services (unsubsidized units)	$647.93	$646.46	−0.23
Mean predicted housing services (subsidized units)	$609.99	$609.21	−0.13
Difference-in-differences	−0.10		

N = 4607 for unsubsidized units, 811 for subsidized units.
The difference-in-differences statistic is the difference between the change in the mean predicted quantity of housing services for unsubsidized units and the change in this mean for subsidized units.
*** indicates statistical significance at the 1% level.

Table 5
Change in the predicted quantity of housing services outside central cities, one-regression specification.

	1985–2005		
	1985 Average value	2005 Average value	% Change
Mean predicted housing services (unsubsidized units)	$522.25	$490.06	−6.16
Mean predicted housing services (subsidized units)	$513.13	$479.00	−6.65
Difference-in-differences	0.49		
N = 1833 for unsubsidized units, 366 for subsidized units			
	1985–1997		
	1985 Average value	1997 Average value	% Change
Mean predicted housing services (unsubsidized units)	$512.96	$483.21	−5.80
Mean predicted housing services (subsidized units)	$493.94	$455.60	−7.76
Difference-in-differences	1.96***		
N = 2298 for unsubsidized units, 372 for subsidized units			
	1997–2005		
	1997 Average value	2005 Average value	% Change
Mean predicted housing services (unsubsidized units)	$769.24	$764.34	−0.64
Mean predicted housing services (subsidized units)	$708.33	$709.16	0.12
Difference-in-differences	−0.76		

N = 2487 for unsubsidized units, 415 for subsidized units.
The difference-in-differences statistic is the difference between the change in the mean predicted quantity of housing services for unsubsidized units and the change in this mean for subsidized units.
*** indicates statistical significance at the 1% level.

5. Conclusion

This paper was designed to examine the depreciation rates of subsidized and unsubsidized rental housing units. None of the results strongly support the hypothesis that public and private project units depreciate in quality significantly more quickly than unsubsidized and voucher units, and some analyses suggest that unsubsidized units may actually depreciate relatively quickly. There are three possible explanations for these results. First, the modernization and rehabilitation programs available to owners and administrators of subsidized units offset the difference in incentives driving the result of the simplest theoretical analysis. Second, it is possible that the incentive effects described in Section 1 are quantitatively small. Finally, measurement error in the subsidy status variables in the American Housing Survey may obscure real differences between subsidized and unsubsidized units. More work in this area is needed. Replicating this analysis using data not subject to measurement error in subsidy status would be useful. Investigation into the operation of rehabilitation and modernization programs for public and private housing projects would also be of significant interest. Determining the relative costs of achieving a given depre-

Table 6
Change in the predicted quantity of housing services, two-regression specification.

	1985–2005		
	1985 Average value	2005 Average value	% Change
Mean predicted housing services (unsubsidized units)	$415.38	$402.93	−3.00
Mean predicted housing services (subsidized units)	$393.10	$399.58	1.65
Difference-in-differences	−4.65***		
N = 3521 for unsubsidized units, 769 for subsidized units			
	1985–1997		
	1985 Average value	1997 Average value	% Change
Mean predicted housing services (unsubsidized units)	$415.44	$395.57	−4.78
Mean predicted housing services (subsidized units)	$388.33	$367.41	−5.39
Difference-in-differences	0.604		
N = 4337 for unsubsidized units, 813 for subsidized units			
	1997–2005		
	1997 Average value	2005 Average value	% Change
Mean predicted housing services (unsubsidized units)	$617.67	$616.87	−0.13
Mean predicted housing services (subsidized units)	$556.74	$588.87	5.77
Difference-in-differences	−5.90***		

N = 4607 for unsubsidized units, 811 for subsidized units.
The difference-in-differences statistic is the difference between the change in the mean predicted quantity of housing services for unsubsidized units and the change in this mean for subsidized units.
*** indicates statistical significance at the 1% level.

ciation rate in the various types of subsidized housing is an important subject for future research.

Appendix A. AHS housing subsidy questions

This appendix describes the questions used to determine subsidy status in the preceding analysis. In the years 1985–1995, a rental housing unit is counted as subsidized if and only if its tenants answered in the affirmative to one of the following questions:

- Does the Federal government pay some of the cost of the unit?
- Does the State or local government pay some of the cost of the unit?
- Do (you/the people living here) have to report the household's income to someone every year so they can set the rent?
- Is the building owned by a public housing authority?

In the years 1997–2005, the following questions are used:

- Does the Federal, State, or local government pay some of the cost of the unit?
- As part of your rental agreement, do you need to answer questions about your income whenever your lease is up for renewal?
- Did a public housing authority, or some similar agency, give you a certificate or voucher to help pay the rent for this housing unit?
- Is the building owned by a public housing authority?

Each survey also contains questions about rent control and whether rent is adjusted as a result of a relationship with the unit's owner. Units for which rent is adjusted because of such a relationship are eliminated from the sample. Due to differences in the regulations governing rent controlled units across places and times, households that answer "yes" to the rent control question are eliminated from the sample. In the 1997–2005 data, any household that answers "yes" to one of the first two subsidy questions and "no" to the voucher and public project questions is assumed to be in a private housing project. In tables that differentiate between the types of housing assistance, the sum of the sample sizes for the three types is not equal to the total number of subsidized units because units that report different subsidy types over time are counted as subsidized but are not included in any of the specific subsidy categories.

Appendix B. Hedonic regression results

Specification (1), dependent variable *ln(RENT)*		
Variable	Coefficient Estimate	Standard error
Unit age 6–10 years	−0.082***	0.01
Unit age 11–15 years	−0.075***	0.02
Unit age 16–25 years	−0.119***	0.01
Unit age 26–35 years	−0.171***	0.01
Unit age 36–45 years	−0.181***	0.02
Unit age 46–55 years	−0.195***	0.02
Unit age 56–65 years	−0.219***	0.02
Unit age above 65 years	−0.229***	0.02
Climb for non-apartment building	−0.002	0.03
First floor of apartment building	−0.003	0.01
Climb for apartment building	−0.011	0.01

Appendix B (*continued*)

Specification (1), dependent variable *ln(RENT)*

Variable	Coefficient Estimate	Standard error
Elevator * Climb for apartment	0.025***	0.01
Persons per room	0.086***	0.01
No evidence of rodents	−0.002	0.01
Neighborhood crime bothersome	−0.008	0.01
Neighborhood crime N/A	−0.005	0.01
Business/institutions nearby	−0.013*	0.01
Single family townhouses nearby	0.022**	0.01
Heavy street traffic	0.013	0.01
Tenure length 1 year	−0.008	0.01
Tenure length 2 years	−0.022	0.01
Tenure length 3 years	−0.045**	0.01
Tenure length 4 years	−0.057***	0.02
Tenure length 5 years	−0.080***	0.02
Tenure length 6 years	−0.085***	0.02
Tenure length 7 years	−0.104***	0.02
Tenure length 8 years	−0.089***	0.02
Tenure length 9 years	−0.149***	0.03
Tenure length 10–14 years	−0.138***	0.02
Tenure length 15–19 years	−0.186***	0.02
Tenure length 20–39 years	−0.244***	0.02
Tenure length 40 or more years	−0.397***	0.05
Tenure length N/A	−0.560	0.37
1 bedroom	0.164***	0.02
2 bedrooms	0.304***	0.02
3 bedrooms	0.411***	0.02
4 bedrooms	0.458***	0.03
5 or more bedrooms	0.448***	0.04
1 bathroom	0.327***	0.03
2 bathrooms	0.433***	0.03
3 or more bathrooms	0.500***	0.04
1 half-bathroom	0.072***	0.01
2 or more half-bathrooms	0.086*	0.04
1 dining room	0.045***	0.01
2 or more dining rooms	−0.003	0.04
1 other room	0.061	0.21
2 other rooms	0.116	0.21
3 other rooms	0.199	0.21
4 other rooms	0.202	0.21
5 other rooms	0.163	0.22
6 or more other rooms	0.223	0.22
Unit lacks porch	−0.026***	0.01
Building has 2 units	−0.032**	0.01
Building has 3 units	−0.051**	0.02
Building has 4 units	−0.037*	0.01
Building has 5 units	−0.092***	0.02
Building has 6 units	−0.050**	0.02
Building has 7 units	−0.091**	0.03
Building has 8 units	−0.040*	0.02
Building has 9–17 units	−0.031*	0.02
Building has 18–26 units	−0.022	0.02
Building has 27–41 units	−0.000	0.02
Building has 42–56 units	0.024	0.03
Building has 57–70 units	0.085**	0.03

Appendix B (*continued*)

Specification (1), dependent variable *ln(RENT)*

Variable	Coefficient Estimate	Standard error
Building has more than 70 units	0.122***	0.02
Building has 2 floors	−0.011	0.01
Buildings has 3 floors	0.018	0.01
Building has 4 floors	0.058***	0.02
Building has 5 floors	0.068**	0.03
Building has 6 floors	0.057*	0.03
Building has 7 floors	−0.062	0.04
Building has more than 7 floors	−0.010	0.03
Unit lacks garage	−0.066	0.04
Garage N/A	−0.144*	0.07
Unit lacks refrigerator	−0.126**	0.04
Unit lacks garbage disposal	−0.064***	0.01
Unit lacks cookstove	0.097***	0.02
Unit lacks washer	0.018	0.01
Unit lacks dryer	−0.074***	0.01
Unit not connected to sewer	−0.023	0.01
No room air conditioners	−0.030***	0.01
No central air conditioning	−0.092***	0.01
No working fireplace	−0.080***	0.01
Roof's surface sags	0.002	0.02
Roof has holes	−0.004	0.03
Cracks in foundation	−0.024	0.02
Walls missing siding or bricks	−0.008	0.02
Roof missing shingles	0.002	0.02
Outside walls slanted	0.013	0.03
Windows broken	−0.013	0.02
All hallway lights work	0.035**	0.01
Only some hallway lights work	0.002	0.02
No hallway lights work	0.003	0.02
No light fixtures in hallway	0.001	0.03
Hallway light question unanswered	0.004	0.02
No broken stairs in common area	−0.029	0.02
No common stairs	−0.020	0.01
Broken stairs N/A	−0.000	0.03
No outside water leaks	−0.005	0.01
Outside water leaks N/A	−0.024	0.06
No inside water leaks	−0.006	0.01
Inside water leaks N/A	−0.001	0.06
No open cracks wider than a dime	0.023*	0.01
No holes in floor	0.036	0.02
No areas of paint peeling	0.013	0.01
Electrical wiring not concealed	−0.044*	0.02
No electrical wiring	0.016	0.22
Unit did no experience extended cold	−0.040	0.10
Unit cold N/A	−0.050	0.10
Main heating equipment did not break recently	−0.016	0.02
Main heating equipment not answered	0.012	0.10
Fuses did not blow recently	−0.022*	0.01

(*continued on next page*)

Appendix B (*continued*)

Specification (1), dependent variable *ln(RENT)*		
Variable	Coefficient Estimate	Standard error
Tenant did not know if fuses recently blew	−0.044	0.03
Fuses N/A	−0.099*	0.05
Mobile homes nearby	−0.083***	0.01
Parking lot nearby	0.007	0.01
Body of water nearby	0.050***	0.01
Open spaces nearby	0.016*	0.01
Single-family homes nearby	0.007	0.01
More than one abandoned building nearby	−0.047*	0.02
No abandoned buildings nearby	0.034	0.02
No other buildings nearby	0.006	0.03
Abandoned buildings not answered	0.033	0.03
Roads nearby need minor repairs	−0.024	0.01
Roads nearby do not need repairs	−0.008	0.01
No roads nearby	0.019	0.03
Road maintenance not answered	−0.060	0.04
Minor trash in nearby area	0.012	0.02
No trash in nearby area	0.047**	0.02
Trash N/A	−0.026	0.05
Litter in neighborhood bothersome	0.023	0.02
Poor services in neighborhood	−0.034	0.03
People in neighborhood are bothersome	−0.016	0.01
Neighborhood shopping unsatisfactory	−0.004	0.01
Neighborhood shopping N/A	0.043	0.03
Neighborhood elementary school unsatisfactory	0.010	0.02
Neighborhood elementary school N/A	0.040***	0.01
No offstreet parking	−0.014	0.01
Offstreet parking N/A	−0.002	0.04
Public transportation unsatisfactory	−0.016*	0.01
Public transportation N/A	−0.024	0.02
Gas heating	0.010	0.01
Fuel oil heating	0.024	0.01
Kerosene heating	−0.038	0.04
Other heating	−0.042	0.03
Steam or hot water heating system	0.018	0.01
Electric heat pump	0.029*	0.01
Built-in electric heating	−0.011	0.01
Floor, wall, or other pipeless furnace	0.016	0.01
Vented room heaters burning kerosene or gas	−0.073***	0.02
Unvented room heaters burning kerosene or gas	−0.131***	0.02
Portable electric heaters for main heating	−0.057*	0.03
Woodburning stove for main heating	−0.115***	0.03
Other heating equipment	0.014	0.03
No primary heating equipment	0.062	0.04
Constant	5.708***	0.23
N	18,245	
Adj. *R*-squared	0.623	

Regression also includes place × year dummy variables.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

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