9 Elderly Health, Housing, and Mobility

Jonathan S. Feinstein

9.1 Introduction

The growing population of elderly persons in the United States poses many challenges for American society and policymakers; some of the most important challenges involve providing appropriate housing for the elderly who suffer from health-related disabilities.

Elderly persons are vulnerable to a wide spectrum of disabilities, of differing degrees of severity, creating a need for many different kinds of elderly housing and home services, extending from the demand for homes with particular architectural features, like wheelchair access, through the need for home health care and basic community services, to requirements of severely disabled individuals for intensive nursing home care. During the past few decades the need for these many kinds of housing has been widely recognized, and the growth in alternative elderly housing arrangements holds out the promise of a world in which each elderly person is matched to his or her "ideal" kind of housing, and, when the person's health status changes, he or she moves into a new preferred housing state.

Although this vision is appealing, it ignores a number of important issues, especially the role of mobility costs and economic factors in elderly housing decisions. Previous research supports the view that most elderly persons who have lived in their dwelling for an extended period of time prefer not to move, if possible; see for example Feinstein and McFadden (1989), Venti and Wise (1989), and Sheiner and Weil (1992), all of whom document the fact that mobility rates are very low among the elderly. In part the unwillingness of elderly persons to move derives from the emotional attachment they feel to their

Jonathan S. Feinstein is associate professor of economics at the Yale School of Management and a research associate of the National Bureau of Economic Research.

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homes (see Danigelis and Fengler 1991), and in part it derives from the very high costs that moving imposes on the elderly, including psychological, health-related, and financial costs (see Golant 1984). The elderly often seem more willing to endure the daily hardships and inconveniences caused by the mismatch between their impaired functional skills and those demanded by their living environment, than to bear the high cost of moving. The fact that an elderly person may not wish to move as her health deteriorates significantly complicates the simple vision that imagines perfectly matching housing to health status, and suggests that attachment behavior and mobility costs must be included in any policy analysis that seeks to evaluate the attractiveness and likely utilization of alternative housing options.

In addition, housing of almost any kind is expensive to own or to rent, and many kinds of home-related health services, notably nursing care, are also extremely costly. Hence elderly housing decisions invariably depend upon the prices of the various housing options, expected changes in those prices, and household wealth, and we are linked to decisions about consumption and desired bequests, themselves complex topics that have been widely investigated (see the survey by Hurd [1990]). Again, comprehensive analyses of elderly housing must consider the effect of prices, and the link between housing decisions and other economic decisions made by elderly households.

My purpose in this paper is to investigate the relationship between elderly health and elderly housing decisions, and, in particular, to examine the effect of mobility costs and economic factors on this relationship. To explore these issues, I construct a conventional dynamic economic model, draw upon published sources to parameterize the model, and then present the results of computer simulations that I have used to characterize the model's implications. I actually construct two models, the first simpler and designed to illustrate the main ways in which health and housing interact, and the second extending the first to incorporate economic factors.

The two models share a number of features that are central to my investigation. Both follow an elderly person from age 65 through age 90, determining the individual's mobility decision and housing choice at each age, as a function of sex, health status, and previous year's housing state. Both also employ particular parameterizations of morbidity and mortality transition probabilities, based on published sources, which specify an individual's future health status, as a function of age, sex, and current health. Finally, in modeling health and housing states, both models consider a world in which an elderly person can fall into one of three health states, good health, moderate disability, or poor health, and must choose to live in one of three housing states: conventional (nonelderly specific) housing; transitional housing, which is meant to include a variety of housing options, including retirement communities, life care (see Feinstein and Keating 1992 for a discussion), and shared living; or institutional housing, including nursing homes and hospices.

Within this general context the first model focuses on two issues. First, it

introduces a simple utility function that assumes that an individual's utility is highest when his residence type "matches" his health status, and lower when the two are mismatched; according to this specification a moderately disabled individual is happiest living in transitional housing, and earns lower utility in either conventional housing or an institution, while a person in good health prefers conventional housing, and a person in poor health does best in an institution. Second, this first model considers several kinds of mobility costs, including a separation or attachment cost, a direct but temporary utility cost, and a health cost.

The analysis of the first model confirms that when there are no mobility costs an individual will always move in response to changes in his health status (into his new preferred housing state), and that moving costs reduce mobility, with higher costs reducing mobility to a greater extent. More interestingly, the analysis highlights the importance of transitional housing. I find that for most parameterizations individuals who fall into moderate disability choose to move into transitional housing. In contrast, individuals who fall into poor health often choose not to move into an institution, even in versions of the model with relatively low mobility costs, and especially at younger ages. When combined, as they are in many of the simulations, these two patterns result in transitional housing playing the role of an "absorbing state," so that once an elderly person moves into such housing she stays there for the rest of her life. As a related finding, a mobility pattern rarely observed is one in which an elderly person skips over transitional housing, choosing not to move from conventional housing into transitional housing when first becoming moderately disabled, and then moving directly into an institution when she falls into poor health.

The second model extends the first to place greater emphasis on household wealth and bequest, to incorporate housing prices, and, most importantly, to model the individual's consumption decision each period jointly with his housing decision. The simulation results for this model generally confirm the findings for the first model, particularly the importance of transitional housing. The results also illustrate the link between consumption, savings, spend down of assets, and housing choices; for example, elderly with very low wealth are predicted to follow a "bankruptcy" strategy in which they consume their remaining wealth, then move into an institution where they become a ward of the state. Generally, both the first and second model seem able to predict realistic mobility patterns, offering support for the augmented economic model of elderly decision making that I develop.

The remainder of the paper is organized as follows. The section 9.2 describes the first model, including the parameterizations of the health transition matrices and other key variables. Section 9.3 presents the simulation results for the first model. Section 9.4 describes the second model, and section 9.5 presents the simulation results for this model. Finally, section 9.6 offers some concluding comments, and an appendix discusses the procedure used to construct the transition matrices.

9.2 Initial Model: Specification and Parameterization

In this section I present an initial, relatively simple model of elderly health and mobility. This first model assumes that an elderly person's utility in any year depends only on the match between housing type and health in that year, and on whether the person has moved in the current or previous year. Lifetime utility is assumed to be equal to the sum of discounted annual utilities, plus a bequest. Since it is focused almost entirely on the relationship between health and housing, the model is well suited to an investigation of the relationship between changes in health status and both housing mobility and housing characteristics, as I hope to show in section 9.3, where I review the results of simulating the model. However, the model cannot address how elderly health status and mobility costs affect and are affected by financial incentives and economic decisions, because it includes only a very limited role for household wealth (restricting its impact to the bequest), and does not incorporate any role for annuity income, housing prices, or consumption decisions. The second model, presented in section 9.4, extends the model of this section to include these various factors.

In presenting the model, I first define the various health states, health transition probabilities, and housing states used in the analysis. Next I describe utility, and two kinds of mobility costs, direct utility costs of moving and indirect health costs. Finally I consider the elderly person's decision-making process in more detail, outlining the dynamic programming method of analysis I have used to determine the mobility patterns implied by the model. Since I analyze the model via computer simulations, I must parameterize several different functions and distributions that appear in the model, including health transition probabilities, mortality profiles, and utility. The parameterizations I have chosen are described together with the model, and presented in several tables, with the appendix providing greater details about the sources and methods used to construct these tables. For completeness and to provide greater understanding of how sensitive the model's solution is to changes in parameterization, separate parameterizations are specified for men and women.

I end this brief introduction to the model with two notes. First, most aspects of the model, including the parameterizations, are carried over to the model presented in section 9.4. Second, throughout the paper the analysis is couched in terms of a single elderly person (a one-person household), either male or female; the extension to an elderly couple, possibly living with or as dependents, is important but is left to future work.

9.2.1 Health and Housing States

Consider a 65-year-old man or woman, who lives alone but is assumed to have heirs who will inherit any remaining wealth, including housing wealth, when he or she dies. The man or woman is assumed to be in good health, and to own his or her home.

Beginning at age 66, and for each year thereafter, the individual faces a risk of deteriorating health or death. To formalize this risk and the different levels of ill health associated with it, I assume that in each year for which she remains alive the individual finds herself in one of three health states: "good health," "moderately disabled health," or "poor health." I define good, moderately disabled, and poor health in terms of limitations of activities of daily living (ADLs) and instrumental activities of daily living (IADLs), so as to conform with standard gerontologic terminology. Thus "good health" means that the individual has essentially no limitations of daily life, that is, zero ADLs and zero to two IADLs. A person in "moderately disabled health" suffers from several IADLs and perhaps one or two ADLs. Such an individual is likely to endure minor or moderate inconveniences in a traditional family home, particularly if there are stairs or other encumbrances, and may benefit from living in an environment of congregate or shared housing, a suitable retirement community, or simply a well-designed apartment with ready access to transportation, shopping, and other activities (see Altman, Lawton, and Wohlwill 1984 for a fuller discussion). Someone in "poor health" possesses significant limitations, including several ADL limitations and numerous IADL limitations. Thus "poor health" is, as defined, approximately equivalent to the condition of patients who would benefit from consideration for, are resident in, or are about to be admitted to a long-term care facility such as a nursing home. The fact that these definitions mesh with standard gerontologic terminology is critical for my analysis, because the published data I have relied upon to parameterize the model describes health status almost exclusively in terms of ADL and IADL limitations.

An individual of given health status at age t will, at age $t + 1$, either be in one of the three health states described above or be dead. Further, as will become clear later in this section, the elderly person's decision whether to move at age t, and where to move, depends on his expectation of what his health is likely to be like at age $t + 1$ and subsequent ages. Thus a central feature of the model is the parameterization of the transition probabilities that describe the movement from health states at age t to states at age $t + 1$. Tables 9.1 and 9.2 depict these transition probabilities. Table 9.1 lists, for each age t and separately for men and women, the nine numbers contained in the three-by-three transition matrix that governs transitions from each health state at age t to each of the three living states at age $t + 1$; as the table makes clear, these probabilities are different at each age. Table 9.2 describes the mortality risk at age $t + 1$, as a function of health at age t, again separately for men and women.

The health transition probabilities depicted in tables 9.1 and 9.2 apply only to the case in which the individual does not move at age t, or moves but suffers no increased risk of ill health or death as a consequence. Later in this section I will describe how the numbers in tables 9.1 and 9.2 are altered, in models in which mobility is assumed to increase the risk of ill health and death, if an elderly man or woman chooses to move at age t.

The appendix provides details about the construction of tables 9.1 and 9.2.

Table 9.1 **Probability of a Transition from One Health State to Another, by Age and Sex, Base Case**

	From Good Health to			From Moderately Disabled to			From Poor Health to		
Age	Good	Moderate	Poor	Good	Moderate	Poor	Good	Moderate	Poor
				A. Men					
65	.9180	.0510	.0158	.0730	.8500	.0395	.0000	.4600	.0500
66	.9110	.0550	.0158	.0700	.8465	.0395	.0000	.4600	.0500
67	.9032	.0600	.0158	.0680	.8425	.0395	.0000	.4600	.0500
68	.8952	.0650	.0158	.0650	.8375	.0395	.0000	.4600	.0500
69	.8855	.0700	.0175	.0630	.8270	.0450	.0000	.4600	.0500
70	.8780	.0750	.0190	.0610	.8240	.0480	.0000	.4500	.0500
71	.8698	.0800	.0202	.0590	.8185	.0505	.0000	.4500	.0500
72	.8618	.0840	.0202	.0570	.8105	.0505	.0000	.4500	.0500
73	.8538	.0880	.0202	.0550	.8035	.0505	.0000	.4500	.0500
74	.8465	.0900	.0215	.0540	.7940	.0520	.0000	.4500	.0500
75	.8400	.0950	.0230	.0530	.7895	.0575	.0000	.4000	.0500
76	.8332	.1000	.0248	.0500	.7860	.0620	.0000	.4000	.0500
77	.8191	.1100	.0269	.0450	.7838	.0672	.0000	.4000	.0500
78	.8048	.1200	.0292	.0400	.7810	.0730	.0000	.4000	.0500
79	.7884	.1300	.0316	.0350	.7810	.0758	.0000	.4000	.0500
80	.7725	.1400	.0345	.0300	.7789	.0811	.0000	.4000	.0500
81	.7561	.1500	.0379	.0250	.7758	.0872	.0000	.4000	.0500
82	.7380	.1600	.0420	.0200	.7676	.0924	.0000	.3900	.0500
83	.7198	.1700	.0472	.0160	.7636	.0944	.0000	.3700	.0500
84	.7025	.1800	.0525	.0120	.7630	.0950	.0000	.3600	.0400
85	.6798	.1900	.0602	.0110	.7570	.1020	.0000	.3600	.0400
86	.6518	.2000	.0682	.0100	.7510	.1090	.0000	.3400	.0400
87	.6285	.2050	.0765	.0100	.7350	.1150	.0000	.3400	.0400
88	.6095	.2100	.0855	.0100	.7170	.1280	.0000	.3300	.0400
89	.5875	.2150	.0975	.0100	.6940	.1460	.0000	.3000	.0400
90	.5635	.2200	.1125	.0100	.6730	.1570	.0000	.2800	.0400
				B. Women					
65	.9224	.0600	.0158	.1000	.8535	.0395	.0000	.4750	.0550
66	.9159	.0650	.0158	.0900	.8575	.0395	.0000	.4750	.0550
67	.9092	.0700	.0158	.0800	.8605	.0395	.0000	.4750	.0550
68	.9074	.0700	.0158	.0800	.8533	.0395	.0000	.4750	.0550
69	.8967	.0770	.0175	.0750	.8462	.0438	.0000	.4600	.0500
70	.8880	.0830	.0202	.0700	.8445	.0505	.0000	.4500	.0460
71	.8808	.0900	.0202	.0650	.8485	.0505	.0000	.4340	.0460
72	.8728	.0970	.0202	.0580	.8515	.0505	.0000	.4340	.0460
73	.8628	.1050	.0202	.0500	.8575	.0505	.0000	.4340	.0460
74	.8505	.1130	.0215	.0420	.8592	.0538	.0000	.4340	.0460
75	.8385	.1220	.0230	.0350	.8595	.0575	.0000	.4250	.0450
76	.8272	.1300	.0248	.0300	.8580	.0620	.0000	.4150	.0450
77	.8161	.1380	.0269	.0260	.8584	.0646	.0000	.4150	.0450
78	.8028	.1460	.0292	.0220	.8544	.0686	.0000	.4150	.0450
79	.7894	.1540	.0316	.0190	.8483	.0727	.0000	.4150	.0450
80	.7735	.1620	.0345	.0160	.8431	.0759	.0000	.4080	.0420
81	.7591	.1700	.0379	.0130	.8415	.0795	.0000	.3990	.0410
82	.7430	.1780	.0420	.0100	.8390	.0840	.0000	.3900	.0400

Table 9.1 (continued)

	From Good Health to			From Moderately Disabled to			From Poor Health to		
Age	Good	Moderate	Poor	Good	Moderate	Poor	Good	Moderate	Poor
83	.7258	.1860	.0472	.0070	.8343	.0897	.0000	.3810	.0390
84	.7085	.1940	.0525	.0050	.8305	.0945	.0000	.3720	.0380
85	.6918	.2020	.0602	.0030	.8247	.1023	.0000	.3630	.0370
86	.6718	.2120	.0682	.0010	.8179	.1091	.0000	.3540	.0360
87	.6505	.2220	.0765	.0000	.8112	.1148	.0000	.3440	.0360
88	.6305	.2320	.0855	.0000	.7977	.1283	.0000	.3440	.0360
89	.6085	.2420	.0975	.0000	.7787	.1463	.0000	.3340	.0360
90	.5805	.2520	.1125	.0000	.7655	.1575	.0000	.3240	.0360

Table 9.2 **Probability of Death in the Next Year as a Function of Current Health State, by Age and Sex, Base Case**

	Men				Women		
Age	Good Health	Moderately Disabled	Poor Health	Age	Good Health	Moderately Disabled	Poor Health
65	.0150	.0370	.4900	65	.0018	.0070	.4700
66	.0180	.0440	.4900	66	.0033	.0130	.4700
67	.0210	.0500	.4900	67	.0050	.0200	4700
68	.0240	.0580	.4900	68	.0068	.0272	.4700
69	.0270	.0650	.4900	69	.0088	.0350	.4850
70	.0280	.0670	.5000	70	.0088	.0350	.5040
71	.0300	.0720	.5000	71	.0090	.0360	.5200
72	.0340	.0820	.5000	72	.0100	.0400	.5200
73	.0380	.0910	.5000	73	.0120	.0420	.5200
74	.0420	.1000	.5000	74	.0150	.0450	.5200
75	.0420	.1000	.5500	75	.0165	.0480	.5300
76	.0420	.1020	.5500	76	.0180	.0500	.5400
77	.0440	.1040	.5500	77	.0190	.0510	.5400
78	.0460	.1060	.5500	78	.0220	.0550	.5400
79	.0500	.1080	.5500	79	.0250	.0600	.5400
80	.0530	.1100	.5500	80	.0300	.0650	.5500
81	.0560	.1120	.5500	81	.0330	.0660	.5600
82	.0600	.1200	.5600	82	.0370	.0670	.5700
83	.0630	.1260	.5800	83	.0410	.0690	.5800
84	.0650	.1300	.6000	84	.0450	.0700	.5900
85	.0700	.1300	.6000	85	.0460	.0700	.6000
86	.0800	.1300	.6200	86	.0480	.0720	.6100
87	.0900	.1400	.6200	87	.0510	.0740	.6200
88	.0950	.1450	.6300	88	.0520	.0740	.6200
89	.1000	.1500	.6600	89	.0520	.0750	.6300
90	.1040	.1600	.6800	90	.0550	.0770	.6400

Here I restrict myself to several brief comments about the tables. I have relied primarily on two sets of sources in constructing the tables. One source is the series of papers published by Manton and his coauthors, which present data from the National Long-Term Care Survey (see especially Manton 1988; see also Liu, Manton, and Liu 1990); these papers provide considerable information on the transitions between good health, moderate disability, and death. The other source is the tables presented in Feinstein and Keating (1992), which are derived from the National Nursing Home Survey and several econometric analyses of nursing home admissions and discharge data; these tables provide information about the transition into and out of what I have called poor health. The numbers in these two sources do not always agree; when they do not, the numbers in tables 9.1 and 9.2 generally represent a compromise between them. In addition, the probabilities in the tables reflect smoothing, which was used to guarantee certain monotonicity properties over time, for example, that the probability a man in good health at age t remains in good health at age $t + 1$ falls smoothly as t rises. One limitation of the tables is that the numbers contained in them refer to a representative or "base case" elderly man or woman; in reality, of course, elderly men, and elderly women, differ substantially from one another in their actual morbidity and mortality experiences, and these individual differences are not captured by the tables.

Just as a person finds herself in one of three health states in each year, she also occupies one of three kinds of housing. One kind of housing is denoted "conventional"; this housing, of which a good example is a detached single-family dwelling, is best suited to individuals in good health, and poses modest difficulties for individuals in moderately disabled health, and severe difficulties for individuals in poor health. The second kind of housing is denoted "transitional," and may be thought of as catering to the moderately disabled elderly person; included in this group are congregate and other kinds of shared housing, retirement communities in which services are provided by management or are otherwise readily accessible, and other kinds of independent housing—generally apartments and flats—located near transportation, shops, and other services. Finally, the third kind of housing is "institutional care," including nursing homes, hospices, and other kinds of intensive-care facilities.

In introducing three housing states I am positing a slightly richer housing state space than has been used in most previous studies in the economics of aging, which have either focused exclusively on what I have called conventional housing, or have considered the dichotomous choice between conventional housing and institutional care. I am thus taking one step toward the direction of incorporating into analytic model building the vast swath of "transitional housing" available to the elderly. In fact, I am greatly simplifying the actual diversity of housing types available to elderly persons, since I have consolidated many different kinds of housing into the single category "transitional"; nonetheless, as the analysis to follow will demonstrate, even this

simple extension of the standard approach yields considerable insight into elderly mobility patterns.

In each period the elderly person chooses whether to remain in the previous housing state, or to move to a new housing state. I discuss this decision-making process further below.

9.2.2 Utility and Bequest

The health and housing states described above are linked by a utility function that specifies that utility in a given year depends upon the match between health and housing. The idea behind this formulation is that each health state has associated with it an ideal housing situation that provides the optimal mixture of support and amenities. Thus good health is most enjoyable if an elderly person lives in conventional housing, with the many amenities that conventional homes afford, including privacy, space, and aesthetic value. In contrast, moderately disabled health is most successfully accommodated in transitional housing, in which an elderly person finds support that makes daily living easier and simpler, while maintaining a reasonable amount of freedom and independence. Finally, poor health is tolerated best if the elderly person resides in a long-term care facility.

The utility function formalizes the idea of an optimal match between health and housing by letting utility in a given year depend upon both health and housing state. For a given health state, utility is highest if a person resides in the home that matches that health state, as described above, and is reduced if the person resides in some other kind of home. Table 9.3 depicts the utility values used as benchmarks for most of the simulations reported later in the paper. Utility is set to 1.0 if a person is healthy and resides in a conventional home. Utility falls to 0.9 if the person is healthy but lives in transitional housing, and falls to 0.5 if the person is healthy but lives in an institution or equivalent. Similarly, if a person is in moderately disabled health, utility attains its highest level, 0.7, if he lives in transitional housing, and falls to 0.4 if he lives in conventional housing or institutional housing. Finally, utility is 0.4 if a person in poor health lives in an institution, and falls to 0.1 and 0.2, respectively, if that person lives in conventional or transitional housing. Note that utility is assessed at the end of the period, so that, if a person moves, his utility in the year in question corresponds to the match between his health and his final housing state.

The diagonal entries of the utility matrix correspond to the highest utility that can be achieved in each health state. The first diagonal element, 1.0, is a normalization, but the remaining two diagonal entries reflect the degree to which utility falls as health deteriorates, even when a person resides in an optimal living environment. The value 0.7 was chosen to reflect evidence on health-dependent utilities presented by Torrance (1986) and Viscusi and Evans (1990) and the collection of articles in Walker and Rosser (1993). Torrance

Table 9.3 Utility as a Function of Health and Housing, Base Case Parameterization

Health	Housing: Conventional	Housing: Transitional	Housing: Institutional
Good	1.0	0.9	0.5
Moderately disabled	0.4	0.7	0.4
Poor	0.1	0.2	0.4

discusses in some detail the methodologic underpinnings of using a quality adjusted life year (QALY) index to measure the disutility of ill health, and provides estimates suggesting that a year spent in moderate ill health has a QALY-equivalent of about .7 of that of a year spent in good health. Viscusi and Evans estimate health-dependent utility functions, and find that the marginal utility of a given level of income is approximately .7 or .8 as large in states of moderate ill health as in states of good health; assuming a simple multiplicative form for utility (as I do in the model specified in section 9.4) and that other forms of consumption remain constant, generates the implication that a year spent in moderate ill health is worth .7 or .8 of a year spent in good health. The edited edition by Walker and Rosser contains descriptions of several of the most well-known indices used to measure quality of life.

The value 0.4 was chosen based on consideration of various sources that

describe the reductions in quality of life that accompany various kinds of disabilities; see the collection of papers in Walker and Rosser (1993) and Birren et al. (1991) for further discussion of the various indices used to assess the impact of disability.

The off-diagonal elements in the utility matrix indicate the reduction in utility an elderly person experiences when she does not reside in the housing state that matches her health status. Since there is little direct evidence available that might help determine these values, I have tried to pick reasonable values. I have also explored the sensitivity of my results to variations in the most important of these off-diagonal elements, which turns out to be element (2, 1), which describes the utility accruing to a moderately disabled person who lives in a conventional home. This particular element is important for several reasons. First, it describes the most common nonoptimal match: when an elderly person enters the model at age 65 in good health and living in conventional housing, the health transition that he is most likely to experience in subsequent years is to moderate disability, in which case, if he chooses not to move, his utility is given by element (2, 1). Second, the model allows considerable discretion in the choice of this value, particularly as compared with the range of feasible values for the off-diagonal elements corresponding to the case of poor health. Thus utility for an individual whose health status is moderately disabled can rise as high as 0.7 if he chooses to live in transitional housing, leaving considerable latitude in the choice of how far utility falls if the individual instead lives in a different kind of housing; in contrast, for an individual in poor health, the highest utility he can achieve is 0.4 (realized if the individual resides in an institution), a rather small number that leaves less latitude in the choice of how far utility falls in nonoptimal housing states.

Element (2, 1) of utility is set at 0.4 in the base case, a reduction of approximately 43% from the peak utility of 0.7 attainable in the health state of moderate disability. One can argue that this is too steep a reduction; hence in the simulations I have explored alternative values of this parameter, specifically 0.5 (28% reduction), 0.6 (15% reduction), and 0.63 (10% reduction).

Lifetime utility is the discounted sum of annual utilities, discounted at a rate of either .9 or .95 in the simulations.[1]

In addition to accruing utility in each year of life, an elderly person gains utility upon death in the form of a bequest left to her heirs. Following Feinstein and Keating (1992), I assume that total lifetime utility is an additively separable function of the sum of discounted annual utilities and a bequest function that takes the form

$$B(W) = [\beta(W - ec)]^{\alpha},$$

1. This is in fact a rather large discount rate, meaning that in this model the elderly place a high value on the future. Note, however, that mortality risk is explicitly included in the model, so this reflects true discounting, with no correction for the risk of death.

where W is end-of-life wealth, ec are end-of-life health costs, and β and α are parameters; the bequest is discounted at the same rate as annual utility. I assume that the elderly person possesses wealth W_0 at age 65; for the simulations I report in section 9.3, W_0 is set at $500,000, while in the later simulations of the model presented in section 9.4, W_0 is chosen to be $250,000. In the model of this section, in which wealth plays only a small role, I assume that wealth then shrinks by a fixed proportion θ each year the individual remains alive, an assumption that is meant to represent a very crude form of asset spend down, and I set θ to 0.9. Following Scitovsky (1988), HC is set equal to $20,000, independent of age or sex.[2] Finally, β is set equal to .00002 and α is set equal to 0.5; at these values, a bequest of $1,000,000 is worth approximately 4.5 years of healthy life lived in conventional housing, and a bequest of $100,000 is worth approximately 1.5 years of healthy life.

9.2.3 Mobility Costs

For the model developed in this section, I consider three kinds of mobility costs. The first kind is a temporary utility cost, whereby an individual's utility in a particular year is lowered by a fixed amount if he has moved during the year or, in some specifications, if he has moved during either the current or previous year. The second kind is a health cost, which increases the probability that an individual will either suffer a deterioration in health status or death in the year(s) following a move. Finally, the third kind of mobility cost is a separation cost, meant to capture the emotional loss experienced when a person moves away from a home in which she has lived for a prolonged period. I apply the concept of separation cost by assuming that at age 65 an individual occupies a dwelling she has lived in for a long time, and that, upon her first move away from this home, she suffers a fixed utility loss that continues for all the remaining years of her life.

Most of the evidence about these three kinds of mobility costs is anecdotal, and cannot be used to determine the specific magnitude of each cost.[3] In the case of the temporary utility and separation costs, I have avoided choosing a single numerical value for the costs, preferring instead to simulate the model over a relatively wide range of alternative values. The specification of health costs is more complex, however, and is less amenable to alternative parameterizations; to capture some of the potential variability in these costs I have considered both the case in which they last one year and the case in which they last two years. Below I describe my parameterization of each of the three kinds of costs in greater detail.

Consider first temporary utility costs of moving. I consider two distinct patterns for these costs. The flat cost pattern assumes that the utility cost is the same across all health states. For this pattern I simulate the model under the alternative cost values 0, 0.1, 0.2, 0.3, and 0.4. Note that these five values cover a wide range; in particular, when the disutility of moving costs 0.4 units, the magnitude of the transaction cost is at lest 40%—its value when an individual in poor health moves to conventional housing—and as much as 100%—when an individual in poor health moves to institutional housing.[4] The other pattern assumes costs that are proportional to the utility of the best housing state available to a person of given health status. These cost structures are 0.1 0.08 0.04, 0.2 0.16 0.08, 0.3 0.24 0.12, and 0.4 0.32 0.16, where, for each triplet, the first number refers to the disutility suffered by a person in good health, the second to the disutility suffered by a moderately disabled person, and the third to the disutility suffered by someone in poor health. For both kinds of cost patterns, I consider separately and simulate separately models in which these direct utility costs last for one year (the year in which the move is made) or two years.

The health costs associated with mobility possess a more complex structure than the corresponding temporary utility and separation costs. In particular, the impact of a move on an individual's risk of falling into worsened health or death is likely to depend upon the individual's age, sex, and initial health status. To formalize the relationship between mobility and health, I define a set of multipliers that multiply the baseline morbidity and mortality transition probabilities set forth in tables 9.1 and 9.2, leading to a new pair of tables, 9.4 and 9.5, which apply to individuals who have moved. As the numbers in tables 9.4 and 9.5 indicate, the effect of the multipliers is to raise the probability of a transition into worsened health and death, and to lower the probability of a transition to improved health. The multipliers vary in size; in general they are smaller the larger is the baseline probability they multiply, and are somewhat larger for persons whose initial health status is moderately disabled or poor, since the available evidence suggests that mobility is more deleterious for such persons. I determined the multipliers by first choosing values for ages 65 and 90, and then using a linear interpolation scheme and a small amount of smoothing to determine the value of the multipliers that apply between these ages.[5]

2. Scitovsky shows that end-of-life health costs vary only slightly with age and sex of the deceased.

3. Some interesting quantitative evidence on the direct, transient utility costs of moving has been assembled by Venti and Wise (1990), in the context of estimates of mobility based on the Retirement History Survey. They assume that the transaction costs of moving are proportionate to utility (they assume a multiplicative, or log-linear, form for utility), and allow the magnitude of these costs to depend on initial health status. Venti and Wise then infer the magnitude of these costs by estimating a model of mobility; as mobility is very low in their data, they infer a quite large value for transaction costs, as much as 50% of one-year utility; they also find that costs (as a proportion of utility) are larger when an individual is in worse health. However, Venti and Wise do not specify any sort of morbidity or mortality tables, and do not allow for the possibility that a move may affect morbidity or mortality. In addition, they do not explicitly posit a utility function that depends on both housing and health, and do not fit an optimizing dynamic model of the kind I develop in this paper.

4. When the transaction cost is this high, the results never exhibit a mobility pattern in which a person in poor health moves to transitional housing, in which case total utility would have been negative.

5. Subject to a monotonicity constraint that says that, for example, the probability of death is nondecreasing with age.

Table 9.4 Probability of Transition from One Health State to Another, by Age and Sex, Effect of Mobility—Modified Case

	From Good Health to			From Moderately Disabled to			From Poor Health to		
Age	Good	Moderate	Poor	Good	Moderate	Poor	Good	Moderate	Poor
				A. Men					
65	.8056	.1020	.0474	.0365	.7722	.0988	.0000	.2150	.0500
66	.7911	.1089	.0468	.0364	.7582	.0972	.0000	.2150	.0500
67	.7749	.1176	.0461	.0364	.7470	.0956	.0000	.2150	.0500
68	.7593	.1261	.0455	.0364	.7315	.0940	.0000	.2150	.0500
69	.7392	.1344	.0497	.0364	.7062	.1053	.0000	.2150	.0500
70	.7259	.1425	.0532	.0364	.6991	.1104	.0000	.2150	.0500
71	.7110	.1504	.0558	.0364	.6867	.1141	.0000	.2150	.0500
72	.6963	.1562	.0549	.0364	.6694	.1121	.0000	.2150	.0500
73	.6821	.1619	.0541	.0363	.6552	.1101	.0000	.2150	.0500
74	.6686	.1638	.0568	.0363	.6384	.1113	.0000	.2150	.0500
75	.6583	.1710	.0598	.0363	.6289	.1208	.0000	.1910	.0500
76	.6476	.1780	.0635	.0360	.6223	.1277	.0000	.1910	.0500
77	.6277	.1936	.0678	.0333	.6170	.1357	.0000	.1910	.0500
78	.6047	.2088	.0724	.0304	.6111	.1445	.0000	.1910	.0500
79	.5773	.2236	.0771	.0273	.6116	.1471	.0000	.1910	.0500
80	.5520	.2380	.0828	.0240	.6079	.1541	.0000	.1910	.0500
81	.5264	.2520	.0894	.0205	.6033	.1622	.0000	.1910	.0500
82	.4978	.2656	.0974	.0168	.5966	.1682	.0000	.1910	.0500
83	.4699	.2788	.1076	.0138	.5939	.1680	.0000	.1910	.0500
84	.4452	.2916	.1176	.0106	.5979	.1653	.0000	.1968	.0400
85	.4096	.3040	.1324	.0099	.5905	.1734	.0000	.1968	.0400
86	.3639	.3160	.1473	.0092	.5837	.1809	.0000	.1862	.0400
87	.3272	.3198	.1622	.0092	.5777	.1863	.0000	.1862	.0400
88	.3012	.3234	.1778	.0092	.5595	.2022	.0000	.1862	.0400
89	.2703	.3268	.1989	.0092	.5350	.2248	.0000	.1601	.0400
90	.2370	.3300	.2250	.0092	.5153	.2355	.0000	.1440	.0400
				B. Women					
65	.8254	.1200	.0474	.0500	.8303	.0988	.0000	.2400	.0550
66	.8116	.1287	.0468	.0468	.8176	.0972	.0000	.2400	.0550
67	.7975	.1372	.0461	.0432	.8028	.0956	.0000	.2400	.0550
68	.7931	.1358	.0455	.0432	.7845	.0940	.0000	.2400	.0550
69	.7701	.1478	.0497	.0432	.7549	.1025	.0000	.2450	.0500
70	.7534	.1577	.0566	.0420	.7424	.1162	.0000	.2282	.0460
71	.7427	.1692	.0558	.0403	.7462	.1141	.0000	.2114	.0460
72	.7302	.1804	.0549	.0371	.7420	.1121	.0000	.2114	.0460
73	.7123	.1932	.0541	.0330	.7444	.1101	.0000	.2114	.0460
74	.6884	.2057	.0568	.0286	.7375	.1151	.0000	.2114	.0460
75	.6678	.2196	.0598	.0245	.7300	.1208	.0000	.2124	.0450
76	.6490	.2314	.0635	.0216	.7227	.1277	.0000	.2124	.0450
77	.6316	.2429	.0678	.0192	.7217	.1305	.0000	.2124	.0450
78	.6084	.2540	.0724	.0167	.7111	.1358	.0000	.2124	.0450
79	.5860	.2649	.0771	.0148	.6977	.1410	.0000	.2124	.0450
80	.5578	.2754	.0828	.0128	.6870	.1442	.0000	.2154	.0420
81	.5352	.2856	.0894	.0107	.6855	.1479	.0000	.2164	.0410
82	.5094	.2955	.0974	.0084	.6827	.1529	.0000	.2174	.0400

Table 9.4 (continued)

	From Good Health to			From Moderately Disabled to			From Poor Health to		
Age	Good	Moderate	Poor	Good	Moderate	Poor	Good	Moderate	Poor
83	.4824	.3050	.1076	.0060	.6770	.1597	.0000	.2163	.0390
84	.4565	.3143	.1176	.0044	.6738	.1644	.0000	.2115	.0380
85	.4328	.3232	.1324	.0027	.6661	.1739	.0000	.2070	.0370
86	.4061	.3350	.1473	.0009	.6607	.1811	.0000	.2027	.0360
87	.3773	.3463	.1622	.0000	.6567	.1860	.0000	.1977	.0360
88	.3506	.3573	.1778	.0000	.6400	.2027	.0000	.1977	.0360
89	.3190	.3678	.1989	.0000	.6174	.2253	.0000	.1977	.0360
90	.2828	.3780	.2250	.0000	.6064	.2362	.0000	.1960	.0360

Table 9.5 Probability of Death in the Next Year as a Function of Current Health State, by Age and Sex, Effect of Mobility—Modified Case

	Men				Women		
Age	Good Health	Moderately Disabled	Poor Health	Age	Good Health	Moderately Disabled	Poor Health
65	.0450	.0925	.7350	65	.0072	.0210	.7050
66	.0533	.1082	.7350	66	.0129	.0385	.7050
67	.0613	.1210	.7350	67	.0192	.0584	7050
68	.0691	.1380	.7350	68	.0256	.0783	.7050
69	.0767	.1521	.7350	69	.0324	.0994	.7050
70	.0784	.1541	.7350	70	.0324	.0994	.7258
71	.0828	.1627	.7350	71	.0324	.0994	.7426
72	.0925	.1820	.7350	72	.0344	.1088	.7426
73	.1018	.1984	.7350	73	.0403	.1126	.7426
74	.1109	.2140	.7350	74	.0492	.1188	.7426
75	.1109	.2140	.7590	75	.0528	.1248	.7426
76	.1109	.2140	.7590	76	.0562	.1280	.7426
77	.1109	.2140	.7590	77	.0578	.1285	.7426
78	.1141	.2140	.7590	78	.0651	.1364	.7426
79	.1220	.2140	.7590	79	.0720	.1464	.7426
80	.1272	.2140	.7590	80	.0840	.1560	.7426
81	.1322	.2140	.7590	81	.0898	.1560	.7426
82	.1392	.2184	.7590	82	.0977	.1560	.7426
83	.1436	.2243	.7590	83	.1050	.1573	.7447
84	.1456	.2262	.7632	84	.1116	.1573	.7505
85	.1540	.2262	.7632	85	.1116	.1573	.7560
86	.1728	.2262	.7738	86	.1116	.1573	.7613
87	.1908	.2268	.7738	87	.1142	.1573	.7663
88	.1976	.2291	.7738	88	.1142	.1573	.7663
89	.2040	.2310	.7999	89	.1142	.1573	7663
90	.2080	.2400	.8160	90	.1142	.1573	.7680

As an example of how the multipliers were determined, consider males in good health. The multipliers chosen for age 65 multiply the probability of a transition to moderate disability by 2.0 (raising it from .051 to .102), the probability of a transition to poor health by 3.0 (raised from .0158 to .0474), and the probability of death by 3.0 (raised from .015 to .045); the probability of remaining in good health in the transition from age 65 to 66 is then set to be the residual probability, one minus the sum of the other three revised transition probabilities. At age 90, the three multipliers fall in value to 1.5, 2.0, and 2.0, so that the probability of a transition to moderate disability rises from .22 to .33, that for a transition to poor health rises from .1125 to .225, and that for death rises from .104 to .208. Between ages 65 and 90, a linear interpolation scheme smoothly adjusts each multiplier from its value at age 65 to its value at age 90, subject to the monotonicity requirement that each probability (other than that of remaining in good health) be nondecreasing with age. In the simulation, I consider both the case in which the mortality and morbidity costs of moving last only a single year, and the case in which these costs last two years.

Finally, consider separation costs. This cost refers to the psychic disutility that an elderly person experiences when she is uprooted from a home she has lived in for an extended period. The tremendous pain that accompanies such a move is widely recognized in the gerontologic literature. For example, in *No Place Like Home* (1991), Danigelis and Fengler write: "Home has many attractions for the elderly homeowner. The sense of history and family tradition as expressed through memories and possessions; the feeling of familiarity and resulting security from a long tenancy in this residence; privacy, and above all the sense of mastery and control over environment all combine to make home an attractive place to live out one's life" (9). They go on to cite a number of studies that have used surveys and interviews to verify the importance of attachment to home among the elderly.

The separation cost can be modeled as follows. First, assume that at age 65 the elderly person lives in the "family home." If the elderly person leaves the home, he or she suffers a fixed disutility, *which persists for an extended period*, as much as the rest of his or her life, in sharp contrast to the relatively brief costs associated with leaving more temporary abodes. Further, once the elderly person leaves the family home, this fixed cost begins, and it continues, regardless of later mobility patterns. I specify the alternative values 0, 0.1, 0.2, and 0.3 for this cost.

9.2.4 Decisions and Method of Analysis

In the model developed above, in each period the elderly person chooses whether to remain in his current residence, or to move to one of the two alternative housing states available to him; if he does choose to move, he incurs any mobility costs included in the model. The individual's decision-making process must take into account not only the positive utility earned and possible mobility costs incurred in the current period, but the impact of his decision on his future expected utility. To model this decision-making procedure and determine the elderly person's optimal choice, I employ standard dynamic programming techniques.

Let i denote the individual's current housing state, let j denote his current health state, let k_1 and k_2 denote the two alternative housing states, and let h_1, h_2, and h_3 denote the three health states in the model. Further, define $U(r, s)$ to be current utility when an individual of health status r occupies housing state s, let $x(r)$ denote the utility or separation costs of moving (which may or may not depend on health status r), let $q_0(r, z; t)$ denote the baseline probability of a transition from health state r in period t to health state z in period $t + 1$, and let $q_m(r, z; t)$ denote the probability of a transition from r to z when the individual is experiencing a health cost related to moving. Finally, let $V(r, z; t)$ denote the value function, defined below.

Consider now the case in which the utility and health costs of moving last only one year, and there are no separation costs of moving. An individual who finds himself in health state j and housing state i at the start of period t has the following total expected utility if he chooses not to move:

$$U(j, i) + \delta \sum_{z=1,2,3} q_0(j, z; t)V(z, i; t + 1)\ \delta\left[1 - \sum_{z=1,2,3} q_0(j, z; t)\right]B(W_t - ec_t),$$

where δ is the discount factor, $B()$ is the bequest function, defined earlier, and W_t and ec_t are wealth and end-of-life costs in year t, also both defined earlier. If the individual moves to housing state k_l, his total expected utility is

$$U(j, k_l) - x(j) + \delta \sum_{z=1,2,3} q_m(j, z; t)V(z, k_l; t + 1)$$
$$+ \delta\left[1 - \sum_{z=1,2,3} q_m(j, z; t)\right]B(W_t - ec_t).$$

The individual compares these expressions across his three options, choosing that option with highest total expected utility; this maximal expected utility is then denoted $V(j, i; t)$.

To solve for the elderly person's optimal decision each period, I have followed conventional methods and worked backward, beginning at age 90. For each year I have analyzed each possible combination of health and housing states that an individual might possess at the beginning of the period—nine total states in this model—and, for each initial combination, have determined the optimal decision.

For the most part, the procedure I have just outlined is quite straightforward. There is one subtlety, however, that arises whenever mobility costs last for two years. In that case one must distinguish two different value functions for each health and housing combination i and j: one value function, denoted $V_1(i, j; t)$ refers to the value of being in states i and j in t when one has moved in the previous period and must incur further mobility costs this period, regardless of whether or not one moves again; while the other, denoted $V_0(i, j; t)$, refers to the value of being in states i and j in t and not having moved in the previous period. The above expressions for total expected utility then become

$$U(j, i) + \delta \sum_{z=1,2,3} q_0(j, z; t)V_0(z, i; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_0(j, z; t)\right]B(W_t - ec_t)$$

and

$$U(j, k_l) - x(j) + \delta \sum_{z=1,2,3} q_m(j, z; t)V_1(z, k_l; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_m(j, z; t)\right]B(W_t - ec_t)$$

in the case in which the elderly person did not move last period, with the optimal expected utility generating $V_0(j, i; t)$; when the elderly person did move last period, the second expression remains the same, but the first becomes

$$U(j, i) - x(j) + \delta \sum_{z=1,2,3} q_m(j, z; t)V_0(z, i; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_m(j, z; t)\right]B(W_t - ec_t),$$

and the optimal expected utility is denoted $V_1(j, i; t)$.

The expressions for total expected utility are slightly different for the separation cost model. Consider this model for the case in which there are both separation costs and a one-year health cost of moving. If the individual has never left his age-65 home, his utility from remaining there is

$$U(j, i) + \delta \sum_{z=1,2,3} q_0(j, z; t)V_0(z, i; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_0(j, z; t)\right]B(W_t - ec_t),$$

where V_0 refers to the value function when he resides in his age-65 home and has never moved in the past. If has never left his age-65 home but contemplates moving, his utility is

$$U(j, k_l) - x + \delta \sum_{z=1,2,3} q_m(j, z; t)V_1(z, k_l; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_m(j, z; t)\right]B(W_t - ec_t),$$

where x is the separation cost and V_1 refers to the value function if he has moved. Finally, if he lives elsewhere than in his age-65 home, his utility is

$$U(j, i) - x + \delta \sum_{z=1,2,3} q_0(j, z; t)V_1(z, i; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_0(j, z; t)\right]B(W_t - ec_t)$$

if he chooses not to move, and

$$U(j, k_l) - x + \delta \sum_{z=1,2,3} q_m(j, z; t)V_1(z, k_l; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_m(j, z; t)\right]B(W_t - ec_t)$$

if he chooses to move.

9.3 Simulation Results for the First Model

In this section I summarize the results of an extensive set of simulations of the model presented in section 9.2. The most interesting aspect of this model is its predictions of how mobility patterns and housing choices are likely to vary in response to variations in the magnitude of mobility costs. In order to properly gauge this response pattern, I have considered a wide range of mobility cost parameters in the simulations. Further, since these mobility patterns and housing choices are my main interest, I focus most of my discussion on these issues, and say very little about either the calculation of utility or the predicted value functions.

In interpreting the simulation results, it is useful to define a benchmark against which to measure the extent of mobility predicted by any particular parameterization of the model. For this purpose note that, according to the model, when all mobility costs are zero an elderly person will move each time she experiences a change in health status, generating what may conveniently be called the complete mobility pattern. In much of the discussion below, I will present results in terms of the ways in which a particular mobility pattern deviates from the complete mobility pattern.

Figure 9.1 presents some descriptive results from simulating the model with no mobility costs. This figure, and all subsequent figures, forecasts the life history of an elderly person who enters the model at age 65 in good health and living in conventional housing. Figure 9.1a depicts the probability of a move, as a function of age; specifically, the panel shows, for both men and women, the conditional probability, given that the individual is alive in a particular year, that the individual will move, with the probability assessed based on a population that is in good health and conventional housing at age 65, and that experiences health transitions according to the probabilities in tables 9.1 and 9.2. Note that the probability of a move increases sharply with age. This increase is due to two factors: first, as individuals age, those in good health are more likely to experience a deterioration in health status; and second, at older ages a larger fraction of the population is likely to suffer from some degree of disability, and therefore be relatively more likely than those in good health to experience a change in health status. In interpreting this and subsequent figures, note that an individual may well move more than once; thus the predicted probability of a move in later years is an average of three terms, each term representing the product of the probability of residing in one of the three possible housing states at the beginning of the year multiplied by the probability of a move, conditional on beginning the period in that housing state. The average annual mobility rate implied by the figure is 14%, well above the true mobility rate among the elderly, which is closer to 7%, according to figures presented in Feinstein and McFadden (1989).

Figure 9.1b illustrates the probability that the elderly person will live in conventional, transitional, or institutional housing, again as a function of age

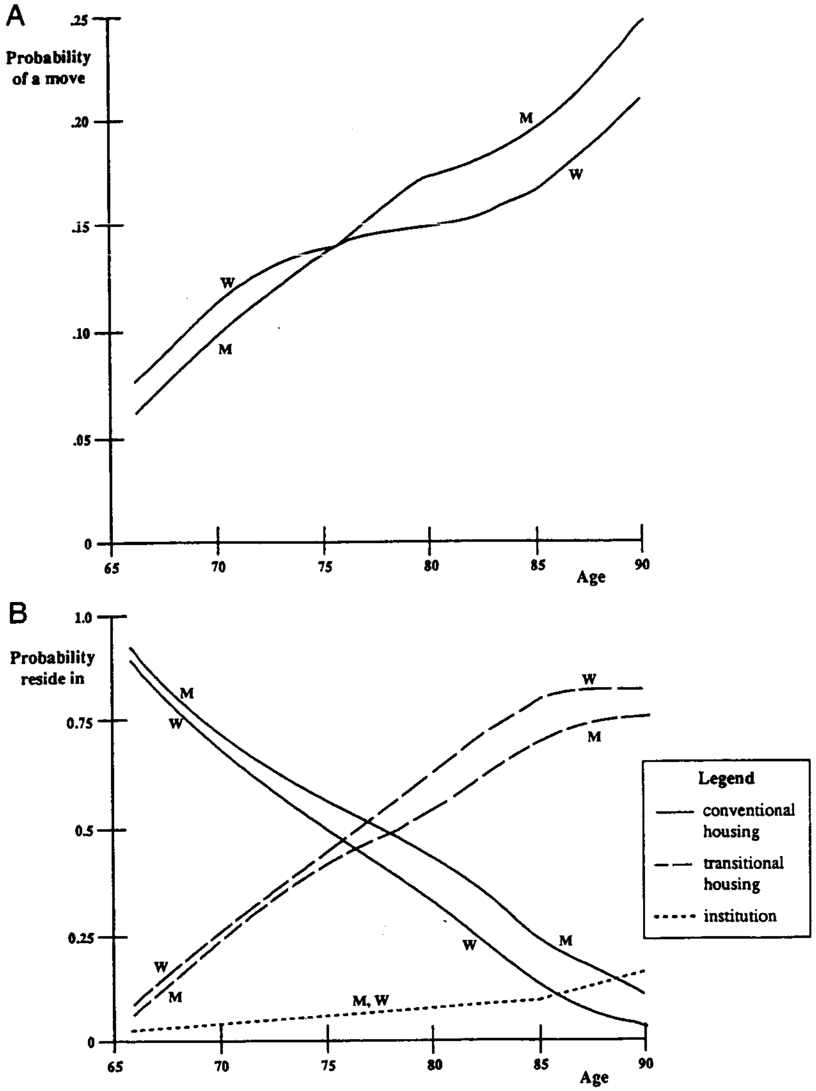

Fig. 9.1 Simulation results, first model, no mobility costs. *a,* mobility; *b,* residence.

and separately for men and women. Notice that the probability of living in transitional housing rises sharply with age, reflecting the fact that most of those alive at later ages belong to the moderately disabled health category; the probability of residing in an institution rises more slowly, increasing from approximately 1% at younger ages to approximately 15% by age 90.

I first discuss the results of simulating models in which there is both a temporary utility cost of moving and a health cost, then go on to discuss results from models in which there is both a separation cost and a health cost, and conclude by examining the sensitivity of some of my results to variations in the off-diagonal utility element (2, 1), a particularly crucial parameter that was mentioned earlier and that measures the extent to which utility falls when a moderately disabled person lives in conventional housing.

Consider first the class of models in which there is both a temporary utility cost and a health cost of moving. Figure 9.2 provides some descriptive results for a particular model in this class, the one for which the utility cost of moving is set at 0.4 and lasts for two years, and the health cost also lasts for two years; this particular model contains the highest level of mobility costs of any I have examined in this class, and hence offers a particularly striking and informative comparison with the zero-mobility-cost model discussed above, for which comparable results are depicted in figure 9.1.

Figure 9.2a reveals that mobility is substantially lower in this case than in the zero-mobility-cost case. In particular, for both men and women mobility is comparable to the zero-cost case at young ages, but does not rise smoothly with age; instead, for women mobility gradually falls, only to rise sharply during the last few years of life, while for men, after increasing for a few years, mobility plummets to zero (at age 72), then rapidly increases from zero at age 77, only to fall thereafter. Figure 9.2b depicts, for each age, the fraction of the population living in conventional, transitional, and institutional housing. As in figure 9.1b, the proportion of individuals living in conventional housing falls with age, while the proportion living in transitional housing rises. The most significant difference between this graph and the corresponding graph in figure 9.1 is that in this case the proportion of individuals residing in institutional housing is zero at all ages.

A detailed examination of the simulation results produces the following explanations for these patterns. At younger ages, for both men and women, individuals who fall into moderate disability always choose to move immediately into transitional housing. However, beginning at age 74, continuing until age 78, and then beginning again at age 87, men who fall into moderate disability and live in conventional housing choose not to move; this fact explains both the deep trough in the male mobility pattern between ages 74 and 77 and the sharp spike at age 78 (due to a queue), as well as the decline in male mobility at later ages. At all ages individuals who fall into poor health choose not to move into an institution, and individuals who live in transitional housing and recover to good health choose not to move back into conventional housing; these facts explain why mobility is lower overall in this case than in the zero-cost case, and contributes toward an understanding of why mobility rates do not increase with age. Finally, for women mobility decreases between ages 85 and 87 as those in moderate disability choose not to move into conventional housing, only to rise sharply during the last few years of life when moves into transitional housing resume.

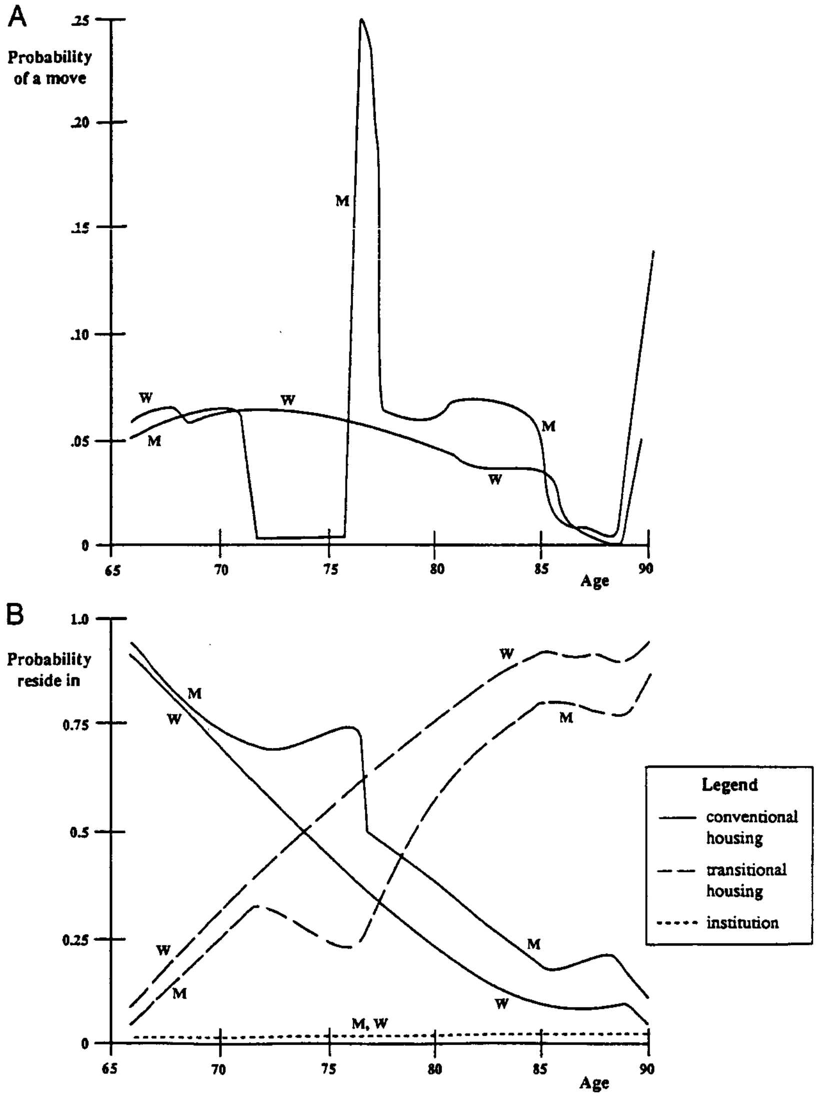

Fig. 9.2 Simulation results, first model, mobility costs: two-year utility cost of 0.4 plus two-year health cost. *a,* mobility; *b,* residence.

Although results from models in which the utility cost and health costs of moving last only one year, or in which the utility cost if less than 0.4, differ in some respects from the model discussed above, the results from all models in this class share certain qualitative features. Overall, the simulation results for this class indicate that mobility is less common as mobility costs increase, as

expected. Nonetheless, the results also show that mobility costs must be quite substantial in order to significantly reduce mobility. To see this, consider again the model discussed at length above. In this model mobility is in fact considerably lower than in the zero-mobility-cost model depicted in figure 9.1; in particular, average mobility has fallen from approximately 14% a year to approximately 5%, a value that is reasonably consistent with empirical evidence. However, this model incorporates very substantial mobility costs: the direct utility costs are 40% of the highest attainable one-year utility, are considerably more than 40% for those in worse health, and last over two years, while the indirect health costs last over two years and are, by any measure, steep. Apparently, mobility costs must be this high in order to produce realistic mobility patterns.

Beyond the simple finding that mobility falls with increasing costs, the simulation results suggest several other conclusions. One conclusion is that individuals who fall into poor health often are unwilling to bear the relatively high transaction costs of moving (relative to utility) to an institution, and often choose to remain in current housing. Interestingly, the results suggest that individuals who fall into poor health are most likely to move at more advanced ages, presumably in part because they are then less likely to experience an improvement in health in the future, and therefore can expect to benefit less from staying where they are. A second conclusion is that persons whose health improves from moderately disabled or poor to good are often unwilling to move back into conventional housing, especially at advanced ages, presumably because they are likely to lapse back into poor health in the near future. Thus reverse flows are discouraged by mobility costs. A third result is that, for many sets of simulations, transaction costs affect mobility more at older ages than at younger ages, in the sense that mobility patterns vary more with variations in transaction costs at these ages (this result is well illustrated by a comparison of figures 9.1a and 9.2a).

Perhaps the most striking mobility pattern concerns individuals who fall into the health category *moderately disabled.* Throughout nearly all of the simulation results such individuals, whether they were previously in good or poor health, choose to move (immediately) into transitional housing upon falling into moderate disability. In contrast, in models for which the transaction costs of moving are high, individuals do not always move into institutional housing if they fall into poor health, and do not always move back into conventional housing if their health improves from poor or moderately disabled to good. The combination of these two patterns results, in many circumstances, in transitional housing being a predeath absorbing state: once an individual moves into this kind of housing, he or she may never leave, even when his or her health status changes.

The fact that individuals move into transitional housing so often has several important implications. First, this finding highlights the importance of including such a housing state in empirical models of aging and housing choice—reducing housing to the two states "conventional" and "institutional" precludes exactly those mobility patterns that economic theory, as developed in this paper, predicts will occur most frequently in an elderly population. Second, from the viewpoint of elderly housing policy, this finding suggests that transitional housing could play an important role in improving elderly well-being, particularly in a world in which mobility is costly.

On examination, the finding that individuals choose to move into transitional housing so readily can be explained as due in part to the fact that in this intermediate housing state the elderly can choose not to move again should their health either deteriorate further or improve, without suffering a huge disutility as a consequence (support for this hypothesis comes from the fact that the elderly do not always move when they fall into poor health or when their health improves from moderately disabled to good). This rationale would not be uncovered by static or nonoptimizing models, but is highlighted by the dynamic programming approach taken in this paper.

It is interesting to note that, according to the simulation results, the movement into an institution tends to be reduced relatively more by mobility costs than does the movement into transitional housing. Specifically, the results suggest that it is often the case that an individual will move into transitional housing upon a deterioration from good to moderately disabled health, and then choose not to move into an institution when his health deteriorates further to poor; whereas the opposite mobility pattern, in which the individual chooses not to move from conventional into transitional housing when his health first deteriorates from good to moderately disabled, but then moves directly from conventional housing into an institution when his health deteriorates further to poor, *is never observed.*

With one exception, it is never the case that an individual who chooses to move decides not to move into the housing state that matches his current health status. This one exception occurs when a person who was previously in poor health recovers to good health (this transition has probability zero in the simulations and therefore is not directly relevant; but the mobility pattern described still has inherent interest). In this situation, and for certain parameter values, the person moves into transitional housing, a result that again highlights the importance of the dynamic programming approach (since this would never occur in a one-period static model).

Now consider the class of models in which there is both a permanent separation cost incurred when an individual leaves his "family home" (his home as of age 65), as well as a one-year health cost incurred following all moves. Figure 9.3 describes the model in this class for which the separation cost is 0.2. Figure 9.3a shows that for both men and women there is no mobility until age 71, at which age there is a very large mobility spike, followed by an initially steep and progressively more gradual decline in mobility at later ages. This mobility pattern is not difficult to understand, in the light of the nature of the mobility costs individuals face. Young elderly are unwilling to leave their age-65 home, since doing so results in a permanent cost. Eventually, in this case at age 71, the benefits of moving outweigh the costs for those in moderate

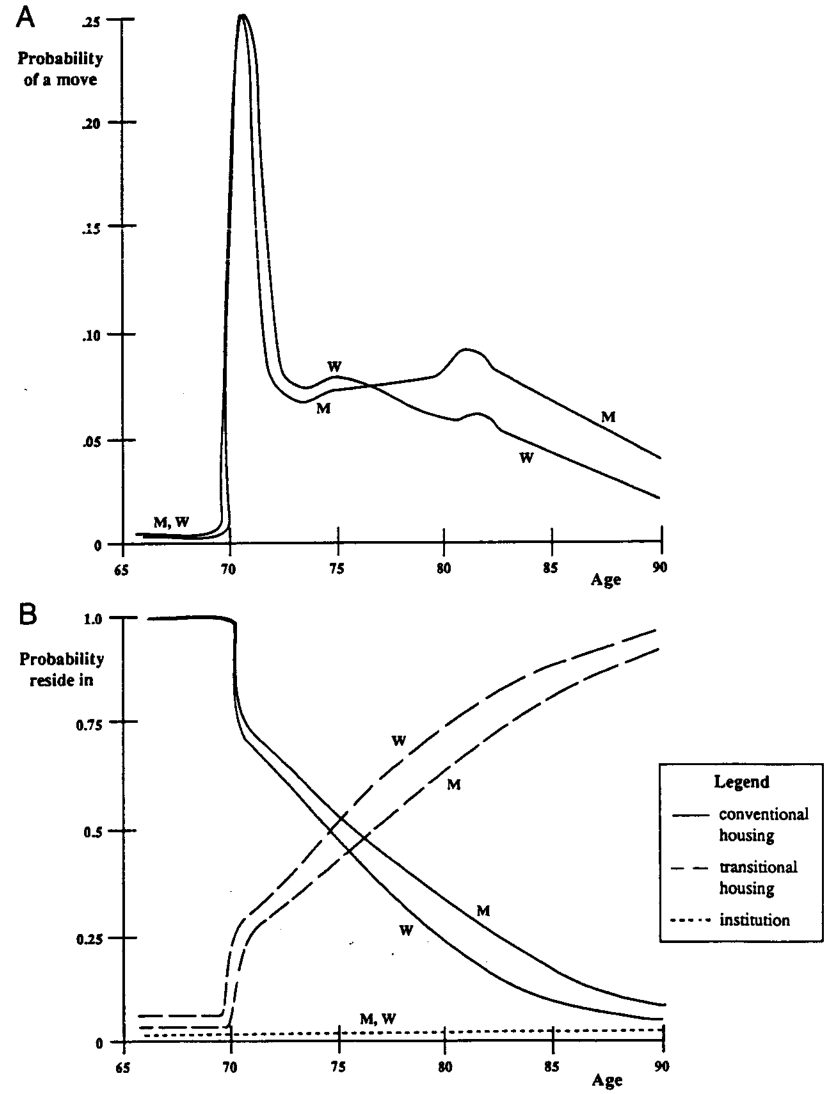

Fig. 9.3 Simulation results, first model, mobility costs: sepration cost of 0.2 plus one-year health cost. *a*, mobility; *b*, residence.

disability or poor health, and the large number in these health states do move—hence the spike at this age. In subsequent years the elderly continue to move from conventional housing into transitional housing when their health deteriorates from good to moderately disabled; but since fewer and fewer persons live in conventional housing and possess good health, this flow contributes less to overall mobility. Meanwhile, at all ages individuals who fall into poor health choose not to move into an institution. Together, these two phenomena explain the gradual decline in mobility at older ages. Figure 9.3b depicts the fraction of residents in each of the three housing states, at each age, and is fully consistent with the discussion above.

The fact that the separation-cost model predicts a somewhat different mobility pattern than the temporary-utility-cost model suggests that the relative importance empirically of these two kinds of mobility-cost models could perhaps be determined with appropriate data.

One striking qualitative feature shared by nearly all the results reviewed above is the finding that individuals who fall into moderately disabled health often move into transitional housing. While this result holds true both for individuals previously in poor health and institutionalized as well as for individuals previously in good health and living in conventional housing, it is far more common for an elderly person to deteriorate from good health to moderate disability than to recover from poor health to moderate disability. Since the sequence of events in which an elderly person deteriorates from good to moderately disabled health is so common, and the simulation results predict that the move into transitional housing that accompanies this health transition is relatively likely, this particular mobility decision seems worthy of further investigation; in particular, we may ask how variations in the utility benefits of occupying transitional housing (as opposed to conventional housing) affect the willingness of elderly people to move in this situation.

Recall that the utility parameterization sets the utility associated with moderate disability and transitional housing to 0.7, and the utility associated with moderate disability and conventional housing to 0.4. I have explored how an increase in this second parameter affects the willingness of elderly persons to move when they fall into moderate disability. I note that, whenever this parameter is small enough that a moderately disabled person living in conventional housing always wishes to move, the parameter has no impact (that is, within this range varying this parameter has no effect on the model's solution). I have found that when the parameter is raised to 0.5, the elderly continue to move in this health state.

When the parameter is raised to 0.6, at which point the disutility associated with remaining in conventional housing is approximately 15% (from the level of 0.7 achieved when the elderly person moves to transitional housing), whether or not the elderly move depends on the transaction costs of moving. In particular, when the health cost of moving lasts one year and the utility cost is at or below 0.1 and lasts for one year, individuals always move; when the utility cost is between 0.1 and 0.2, individuals sometimes do and sometimes do not move, depending on their age and sex; and when the cost is 0.25 and above, no one moves.

Now consider what happens when the off-diagonal utility element is raised from 0.6 to 0.63, so that the disutility associated with not moving into transitional housing is only 10%. Again, assume health costs of moving that last one year. When the utility cost of moving is zero, mobility is still not assured: among men, a move takes place only for those 81 or older; among women, a move is made for those aged 65 to 69, and 71 on. When the utility cost is raised to 0.07 for one year, itself 10% of the maximal utility in the moderately disabled health state, mobility falls further: men never move; women move beginning at age 74. When the utility cost is raised to 0.1, women move only between ages 78 and 83 (men never move); finally, when the cost is 0.15 and above, no one ever moves in this situation.

I conclude that, if the disutility of "mismatched" housing is 15% or more, then even when there are substantial costs associated with moving (one-year health costs plus moderate utility costs), the elderly will, according to the model, move into transitional housing.

9.4 Second Model

In this section I extend the model developed in section 9.2 to include a role for housing prices, a financial transaction cost on the sale of a home, interest rates, mortgage rates, annuity income, and an explicit consumption decision made each period jointly with the housing decision already described.

The most important extension of the first model modifies the definition of utility to include consumption, and computes the elderly individual's optimal consumption choice each period jointly with her housing decision. Recall that in the first model utility depends primarily on the quality of the match between housing and health, according to the function $U(j, i)$, where j is the individual's health state and i her housing state. The new utility function specifies utility to be equal to $\log[c(t)]U(j, i)$, where $c(t)$ is consumption in period t, measured in dollars spent. When the individual moves and incurs utility or separation costs x, utility is defined to be $\log[c(t)][U(j, i) - x]$. Note that according to this specification the marginal utility of consumption depends on both health status and the match between housing and health. Thus the marginal utility is highest for an individual in good health residing in conventional housing, and lower for individuals in worse health, or living in ill-suited housing. When there are utility costs of moving, the marginal utility of consumption also falls following a move. In contrast to the logarithmic form for consumption, I have also explored the implications of using an alternative linear specification, in which utility is equal to $c(t)[U(j, i)]$; in section 9.5 I briefly discuss the results of simulating models based on this alternative specification.

I modify the bequest function so as to preserve the value of the bequest relative to the utility associated with a year of healthy life. In particular, I multiply the earlier function by seven, so that the bequest is now defined to be

$$B(W) = 7.0[\beta(W - ec)]^{\alpha}.$$

Comparing the modified bequest function to the modified utility function reveals that a $1 million bequest is now worth approximately three years of good health to an individual living in a conventional home and spending approximately $20,000 annually on consumption.

Total utility continues to be equal to the expected value of the sum of the discounted annual utilities plus the discounted value of the bequest.

Consider now the modifications introduced by including housing prices in the model. Denote these prices as $p_1(t)$, $p_2(t)$, and $p_3(t)$, where $p_1(t)$ and $p_2(t)$ refer to the price of, respectively, a conventional and a transitional home in year t, and $p_3(t)$ refers to the cost charged for spending year t in an institution. For the simulations I set $p_1(65)$ equal to $200,000, somewhat above the median price for a detached single-family dwelling in the United States, $p_2(65)$ equal to $150,000, on the supposition that transitional housing, of which prime examples are retirement condominiums and townhomes, will typically be somewhat smaller and less expensive than conventional housing, and $p_3(65)$ equal to $25,000, which is approximately the average cost of one year in a private nursing home facility in the United States at the present time. Then I define $p_i(t) = p_i(65)(1 + \pi_i)^{t-65}$, where the π_i are rates of appreciation (or depreciation) for the three kinds of housing.

To determine explicit values for the π_i, I turn to several recent publications. Mankiw and Weil (1989) and Poterba (1991) discuss possible rates of real appreciation (or depreciation) for conventional homes over the next several decades, and argue that homes will either appreciate a small amount or depreciate. Based on their discussion, I set π_1 equal to .01, reflecting a 1% annual real appreciation. Elderly housing prices are likely to fare at least as well as conventional housing prices in the decades ahead, as the number of elderly grows; hence I also set π_2 equal to .01. To explore the sensitivity of my results to alternative rates of appreciation and depreciation, I have run a number of additional simulations, discussed in the next section, in which I experiment with smaller values for π_1 and larger values for π_2. Based on evidence presented by Maple, Donham, and Cowan (1992), I assume that the price of one year in an institution will rise at a real rate of 2% per year, so that $\pi_3 = .02$. In a number of additional simulations I assume, as an alternative, that $\pi_3 = .04$, reflecting a 4% annual rate of increase in the price of institutional care. I have not incorporated price uncertainty into the model, for reasons of computational complexity.

The calculation of household wealth is considerably more complicated in the new, extended model than in the original model. I will therefore describe this calculation in some detail, first defining a number of key variables, and then outlining the steps required to compute wealth in each period, for each possible housing state.

Define r to be the real rate of interest earned on savings, and define r_m to be the real interest rate assessed on mortgages when individuals purchase a home whose value exceeds their current wealth;[6] in the simulations I assume that r equals .02 and r_m equals .04. Next define $A(t)$ to be the amount of real annuity income an individual earns at the start of each period in which he is alive; I assume that $A(t) = A_0(1 + r)^{t-65}$, where A_0 is the value of the annuity at age 65, set to $18,000 in the simulations. In keeping with the earlier model, define W_0 to be total wealth as of age 65, and define W_t to be total wealth in year t. For the simulations I assume that W_0 equals $250,000, of which $200,000 is equity in the elderly person's home (which is assumed to be a conventional home on which no debt is owed), and the remainder is savings; these numbers are consistent with the findings of Feinstein and McFadden (1989), Venti and Wise (1990), and Ai et al. (1990) that the vast majority of all elderly wealth resides in homeownership. Finally, I assume that there is a financial transaction cost incurred whenever an elderly person sells a home of either the conventional or transitional type, assessed at 6% of the value of the home at the time of the sale.

Suppose now that household wealth is W_t at the beginning of year t. To calculate W_{t+1}, household wealth at the beginning of the following year, it is useful to distinguish the case in which the elderly person lives in conventional or transitional housing from the case in which she lives in an institution. Suppose first that the household lives in either conventional or transitional housing at the start of year t, denoted in what follows as housing state i. Two cases then arise: either total wealth exceeds the value of the home, in which case the household has additional savings; or total wealth falls short of the value of the home, in which case the household has a mortgage. If the household does not move in year t, then, in the first case, its wealth at the start of year $t + 1$ is equal to

$$p_i(t + 1) + (W_t - p_i(t) + A(t) - c(t))(1 + r),$$

where it is implicitly assumed that $c(t)$ is chosen to be less than $W_t + A(t) - p_i(t)$, disposable income.[7] In the second case, defining $y = (p_i(t) - W(t))/(p_i(t))$ to be the fraction of the home not owned by the household (so that $1 - y$ is the fraction that is owned), household wealth is

$$(1 - y)p_i(t + 1) - yp_i(t)r_m + (A(t) - c(t))(1 + r)$$

if the household consumes less than its annuity income, and

$$(1 - y)p_i(t + 1) - yp_i(t)r_m - (c(t) - A(t))(1 + r_m)$$

6. In the simulations I impose the restriction that a household is not allowed to move into a house if its total wealth falls below 25% of the house's price, an assumption that serves to eliminate the possibility of a household increasing its debt to very high levels, and is consistent with most mortgage-lending rules.

7. This and the other implicit assumptions made in the following few paragraphs are all part of all the optimal solutions found via the computer simulations.

if the household consumes more than its annuity income, where the first term refers to the percentage of capital gains captured by the household, the second to the mortgage payment, and the third to either the net savings or net debt created by the difference between annuity income and consumption.[8] If the household does move in year t, the calculation is similar, but slightly more complex. If the household moves to either conventional or transitional housing, denoted housing state k in what follows, it pays a transaction cost d equal to the value of the home being sold, so that $d = .06p_i(t)$. Thus total proceeds for the sale of the home are $S = (1 - y)p_i(t) - d$, where $y = 0$ if there is no mortgage on the initial home (it is implicitly assumed that S is positive). Now let $\hat{W}$ denote the household's total wealth immediately following sale of the home; $\hat{W}$ is equal to $S + A(t) + W_t - p_i(t)$ if the household's initial wealth exceeded $p_i(t)$, and $S + A(t)$ if not. Again, we must distinguish the case in which the household's total wealth $\hat{W}$ exceeds the price $p_k(t)$ of the new home from the case in which it does not. When $\hat{W}$ does exceed the purchase price, the household's wealth in year $t + 1$, W_{t+1}, is given by

$$p_k(t + 1) + (\hat{W} - p_k(t) - c(t))(1 + r),$$

while, when $\hat{W}$ falls short of the purchase price, W_{t+1} is given by

$$\frac{\hat{W}}{p_k(t)} p_k(t + 1) - (p_k(t) - \hat{W} - c(t))(1 + r_m).$$

If the elderly person moves into an institution, the calculation of $\hat{W}$ above is identical. If $\hat{W}$ exceeds $p_3(t)$, the price of institutional care, household wealth in year $t + 1$ is simply calculated to be

$$(\hat{W} - p_3(t) - c(t))(1 + r),$$

where $c(t)$ is constrained to be no more than $\hat{W} - p_3(t)$. If $\hat{W}$ falls short of $p_3(t)$, then $c(t)$ is set equal to zero (in the simulations, set to a very small finite value) and W_{t+1} is also set equal to zero.

Finally, let us consider the case in which the elderly person lives in an institution at the start of year t. I assume that an individual, for whom the sum of his wealth plus annuity income falls short of the price of institutional care, remains in the institution as a ward of the state, an assumption that is consistent with spend-down rules prevalent in most states. In this situation $c(t)$ is set to zero, wealth in year $t + 1$ is also zero, and the individual is not allowed to move. If the individual's wealth exceeds the cost of institutional care, then, if she chooses not to move, her wealth at the start of year $t + 1$ is given by the maximum of zero and

$$(W_t - p_3(t) + A(t) - c(t))(1 + r),$$

8. I am assuming that the household cannot refinance its mortgage, and that it simply pays the interest due on its loan, based on the home's current price, $r_m y p_i(t)$, each period.

where $c(t)$ is constrained to be no larger than $W_t - p_3(t) + A(t)$. If she moves to housing state k, then, if her total wealth, $W_t + A(t)$, exceeds the cost of the home, her wealth in $t + 1$ is given by

$$p_k(t + 1) + (W_t + A(t) - p_k(t) - c(t))(1 + r),$$

if $c(t) < W_t + A(t) - p_k(t)$, and

$$p_k(t + 1) - (c(t) - W_t - A(t) + p_k(t))(1 + r_m),$$

if $c(t) > W_t + A(t) - p_k(t)$, while if her wealth is less than the cost of the new home her wealth is given by

$$\frac{W_t + A(t)}{p_k(t)} p_k(t + 1) - (c(t) + p_k(t) - W_t)(1 + r_m).$$

To conclude my discussion of the model of this section, I will outline how the method used to analyze the earlier model must be extended to compute individuals' optimal consumption and housing decisions in the revised model.

As for the earlier model, let i denote the individual's current housing state, let j denote his current health state, let k_1 and k_2 denote the two alternative housing states, and let h_1, h_2, and h_3 denote the three health states in the model. In the revised model the value function V depends not only on health and housing, but also on wealth, and is denoted $V(W, r, z; t)$, where W is the household's wealth at the start of period t.

In the extended model the individual chooses both where to live and the level of consumption in each period. To determine the optimal housing choice and level of consumption, it is convenient to break the problem into two steps. In the first step each housing alternative is considered in turn, and for each alternative the optimal level of consumption is computed, assuming that alternative were to be chosen. Thus we define three interim value functions, one for each housing alternative, as follows:

$$R_i = \max_{c(t)} \log[c(t)]U(j, i) + \delta \sum_{z=1,2,3} q_0(j, z; t)V(W_{t+1}, z, i; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_0(j, z; t)\right]B(W_{t+1} - ec_t)$$

$$R_{k_l} = \max_{c(t)} \log[c(t)][U(j, k_l) - x] + \delta \sum_{z=1,2,3} q_m(j, z; t)V(W_{t+1}, z, k_l; t + 1) + \delta\left[1 - \sum_{z=1,2,3} q_m(j, z; t)\right]B(W_{t+1} - ec_t),$$

where $l = 1, 2$; W_{t+1} is wealth at the start of period $t + 1$, which depends upon $c(t)$ and must be computed separately (and in general will be different) for each of the three housing states according to the procedure described above; and x is the utility cost of moving, as before. In the second step a comparison is made among the three values R_i, R_{k_1}, and R_{k_2}, and the largest of these three is chosen; consumption is then equal to the value that was found to maximize the above expression for the appropriate R function.

The extension of this calculation to the case in which mobility costs last more than one year, and to the case in which there is a separation cost, is straightforward and is not presented here.

9.5 Simulation Results for the Second Model

In this section I present results obtained from simulating several different versions of the extended model of elderly housing and consumption. I first present results for a version of the model in which there are no mobility costs apart from a financial transaction cost. Then I turn to results for specifications of the model in which there are mobility costs, beginning with a model in which there are both temporary utility costs and health costs, and then discussing a specification in which there are both permanent separation costs and health costs. Finally, I explore the sensitivity of my findings to modifications in my parameterizations of the bequest function, the utility function, and the rate of appreciation of future housing prices. Throughout, I contrast the results for the extended model to the comparable results for the simpler model of elderly housing decisions analyzed in section 9.3.

As my detailed review of the results will show, the results for the extended model tend to corroborate the earlier findings for the first, simpler model of mobility. In particular, mobility is significantly affected by mobility costs, the pattern of mobility (with age) is different depending on whether there are temporary utility costs or a permanent separation cost of moving, and transitional housing emerges as an important modeling construct, housing a large proportion of the population, especially at older ages, and, in some versions of the model, serving as a predeath absorbing state.

Figure 9.4 presents a set of simulation results for the version of the extended model in which the only mobility cost is the 6% financial charge on the sale of a conventional or transitional home. In this figure, and figures 9.5 and 9.6, the graphs refer to the projected experience of an elderly person, who as of age 65 is in good health, lives in a conventional home that he or she owns and that is worth \$200,000, and possesses an additional \$50,000 in liquid assets. Figure 9.4a depicts the average probability of a move, at each age, separately for men and women. For both sexes mobility is approximately 6% at age 65, rises steadily to its peak in the early 80s, at which point it is 15% for women and 17% for men, and then falls sharply. Figure 9.4b depicts the fraction of individuals living in conventional, transitional, and institutional housing, again as a function of age. As expected, the fraction living in conventional housing falls steadily over time, from near 100% to near 0%, the fraction living in transitional housing rises steadily, from near 0% to near 100%, and the fraction living in institutions rises slowly, from near 0% at age 65 to slightly less than 10% in the late 80s (before falling at age 90). Finally, figure 9.4c depicts the

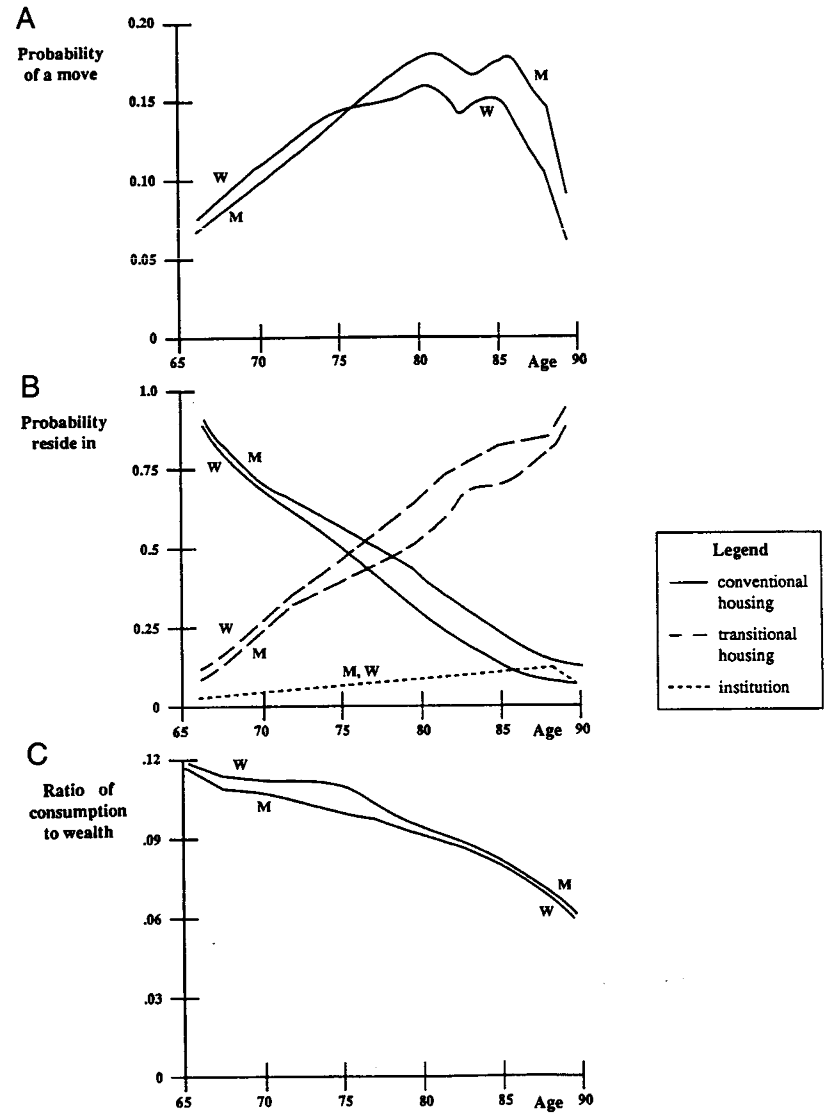

Fig. 9.4 Simulation results, second model, only mobility cost: financial transaction cost. ***a,*** **mobility;** ***b,*** **residence;** ***c,*** **ratio of consumption to wealth.**

average ratio of consumption to wealth among those living at each age, again separately for men and women. According to the graph, for both men and women the proportion of wealth consumed is near 12% at age 65, and falls slowly with age, to approximately 6% at age 90; women exhibit slightly larger consumption ratios than men at younger ages, and ratios essentially identical to those of men at older ages.

Figures 9.4a and b are directly comparable to figures 9.1a and b, which depict the corresponding graphs for the zero-mobility-cost specification of the first model of elderly housing, considered in sections 9.2 and 9.3. The only substantial difference between the two models is that in the earlier model mobility rises monotonically with age, whereas in the model of this section mobility first rises, but then falls at very old ages.

To gain greater insight into the shapes of the graphs depicted in figure 9.4, consider several facts that emerge from a detailed examination of the simulation results for the model. First, as in the earlier zero-mobility-cost model, the elderly nearly always move into their optimal housing state immediately following a change in health status. Thus the financial transaction cost does not by itself discourage mobility; further, the elderly do not choose to move out of conventional housing in order to invest more of their assets in savings, so as to earn a higher rate of return (2% versus 1% on housing) on their wealth. The one situation in which the elderly do not always choose to move into their preferred housing state is when they possess very low wealth; in this case they often choose not to move and, when they do move, at times follow what may be called a "bankruptcy" strategy in which they intentionally move to an institution, exhaust all of their wealth, and become a ward of the state.

A second set of facts concerns the consumption decisions of the elderly. At most ages and for most housing and health states, consumption is only slightly more than annuity income. The primary reason consumption is maintained at this modest level is to protect the size of the bequest, which exerts a substantial impact on total utility. In fact, the importance of the bequest helps explain why the ratio of consumption to wealth falls at very old ages: at these ages death is imminent (recall that in the model all individuals die by age 91), and individuals would rather hoard their wealth for the bequest than spend it on consumption. A contributing factor in this explanation is that many individuals suffer from either moderate disabilities or poor health at these older ages, and therefore benefit less from consumption (recall that utility is the log of consumption multiplied by a function that depends on health and housing). A last reason why consumption is maintained at modest levels is to hoard resources that may be needed either to pay the financial transaction cost associated with selling a conventional or transitional home, or to pay the cost of institutional care.

The simulation results also provide information about the relationship between wealth, mobility, and housing. Consider the results for men. At age 68, average wealth among the living is $229,000, $21,000 below wealth at age 65. At this age, among those who move average wealth is $227,000, among those

living in conventional housing average wealth is $229,000, and among those living in transitional housing average wealth is $234,000. At age 80, average wealth has fallen slightly to $213,000. At age 80, average wealth is $209,000 among those who move, $207,000 among those living in conventional housing, and $217,000 among those living in transitional housing. Note that average wealth is highest for those living in transitional housing; at least in part this result is due to the fact that for these individuals the marginal utility of consumption is lower than for those in (good health and living in) conventional housing. Results are similar for women and are not reported here.

Now consider a version of the extended model in which there are both two-year temporary utility costs of moving and two-year health costs, in addition to the financial transaction costs. I assess the health costs at the same level as in the earlier models. When the utility costs are set at a value of 0.4, comparable to those used to generate the results presented in figure 9.2 and discussed at length in section 9.3, the simulation results indicate that there is *no mobility*. Apparently, the combination of substantial health, financial, and utility costs is sufficient to discourage all mobility. When the utility costs are reduced to 0.2, there is mobility, and it is this specification that I will discuss in detail.

Figure 9.5 presents results from the simulation of the model with two-year utility costs of moving set at the value 0.2 (plus two-year health costs and financial costs of moving). Interestingly, the mobility pattern predicted by this model, shown in figure 9.5a, is very close to that predicted by the corresponding earlier model with utility costs of 0.4, depicted in figure 9.2a. In both models the mobility of men is approximately 6% from age 65 to early 70s, then plunges to zero, soars to a height of 25% for a single year, then falls sharply back to under 10% the next year, followed by a gradual descent, and then a sharp increase at age 90. Clearly, this complex pattern is not an artifact induced by a peculiarity of specification, but is robust to alternative modeling structures. For women, mobility is much smoother over time, remaining at approximately 6% from age 65 to age 80, and then falling smoothly, rising sharply at age 90. Figure 9.5b illustrates the fraction of individuals residing in conventional, transitional, and institutional housing, as a function of age, and is again very similar to figure 9.2b. Finally, figure 9.5c depicts the average ratio of consumption to wealth, separately for men and women, as a function of age. As in figure 9.4c the ratio falls with age, and the ratio is somewhat higher for women, especially at younger ages.

A detailed examination of the simulation shows that the only move that the elderly consistently make is from conventional housing to transitional housing, undertaken when their health deteriorates from good to moderately disabled. They *never* move into an institution, except occasionally at very low wealth levels when they adopt the bankruptcy strategy alluded to earlier. Further, they never move back from transitional housing to conventional housing when their health improves. Thus, as in the earlier models with mobility costs, transitional housing turns out to be a predeath absorbing state. The conclusion is that the

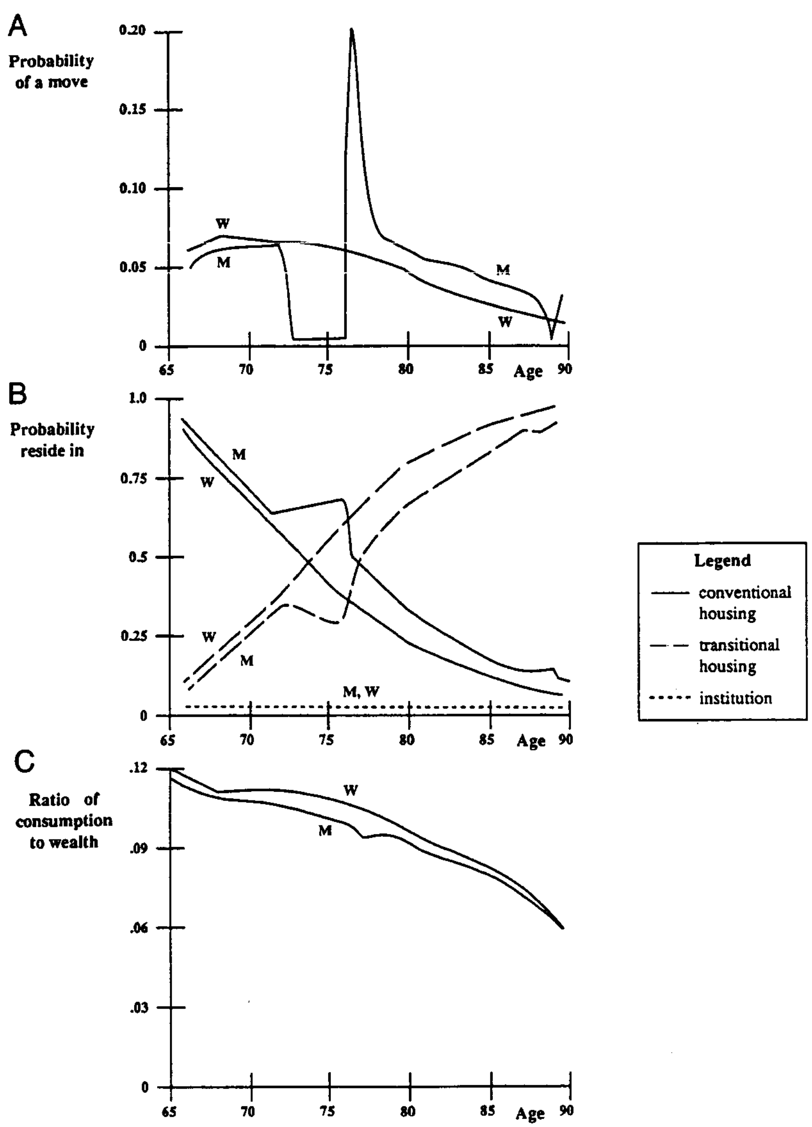

Fig. 9.5 Simulation results, second model, mobility costs: financial, two-year utility cost of 0.2, and two-year health cost. *a*, mobility; *b*, residence; *c*, ratio of consumption to wealth.

basic importance of transitional housing is preserved when the original model is extended to include a far richer specification of economic variables and decisions.

The finding that the ratio of consumption to wealth is slightly higher for women than for men, true in both of the two models just considered, seems to be due to the fact that men are relatively more likely to die, and therefore more likely to leave a bequest in the near future. Since the value of the bequest is quite high and, in particular, the marginal value of additional dollars preserved for the bequest is high relative to the marginal value of extra dollars of consumption (evaluated at the relevant baseline values indicated by the simulations), men have greater incentive to hoard their wealth.[9]

The extended model with separation and health costs of moving is depicted in figure 9.6; for this figure, the model was simulated with a separation cost of 0.2 and a one-year health cost of moving, the same specification used to generate the comparable results for the earlier model for which results are depicted in figure 9.3. As figure 9.6a shows, men do not move at all until past age 80; they then experience a sharp spike in mobility, which lasts for several years and is due to the unleashing of mobility among those in mismatched housing, followed by a decline to modest mobility levels in the last years of life. For women, mobility first begins at age 77, is followed by a very sharp one-year spike in mobility, and then gradually declines to modest levels. These mobility patterns are quite similar to those depicted in figure 9.3a, except that mobility begins at later ages in the model depicted in figure 9.6. Figure 9.6b depicts the fraction of individuals living in the various housing states, and is again quite similar to figure 9.3b. Finally, figure 9.6c denotes the average ratio of consumption to wealth; as with the earlier graphs of this ratio in figures 9.4 and 9.5, the ratio falls smoothly with age, in this case beginning just above 12% and falling to approximately 6%, with the ratio higher for women than for men at all ages.

9.6 Concluding Comments

The analysis of elderly mobility presented in this paper has generated a number of interesting insights. Most importantly, I have found that the economic model of mobility can predict realistic levels of mobility, when enriched to include a variety of mobility costs. In addition, my analysis indicates the importance of transitional housing, which is predicted to become an absorbing state for the elderly in many situations.

I believe the analysis could be fruitfully extended in several directions.

9. A simple calculation shows that the marginal utility associated with an additional $1,000 invested in the bequest, when its baseline value is $200,000, is nearly ten times higher than the marginal utility associated with consuming the extra $1,000, when the baseline level of consumption is $20,000. In part this difference is due to the absolute worth of the bequest; but it is also due to the fact that the bequest is a square-root function, whereas consumption is logarithmic, and hence relatively flatter at high dollar values.

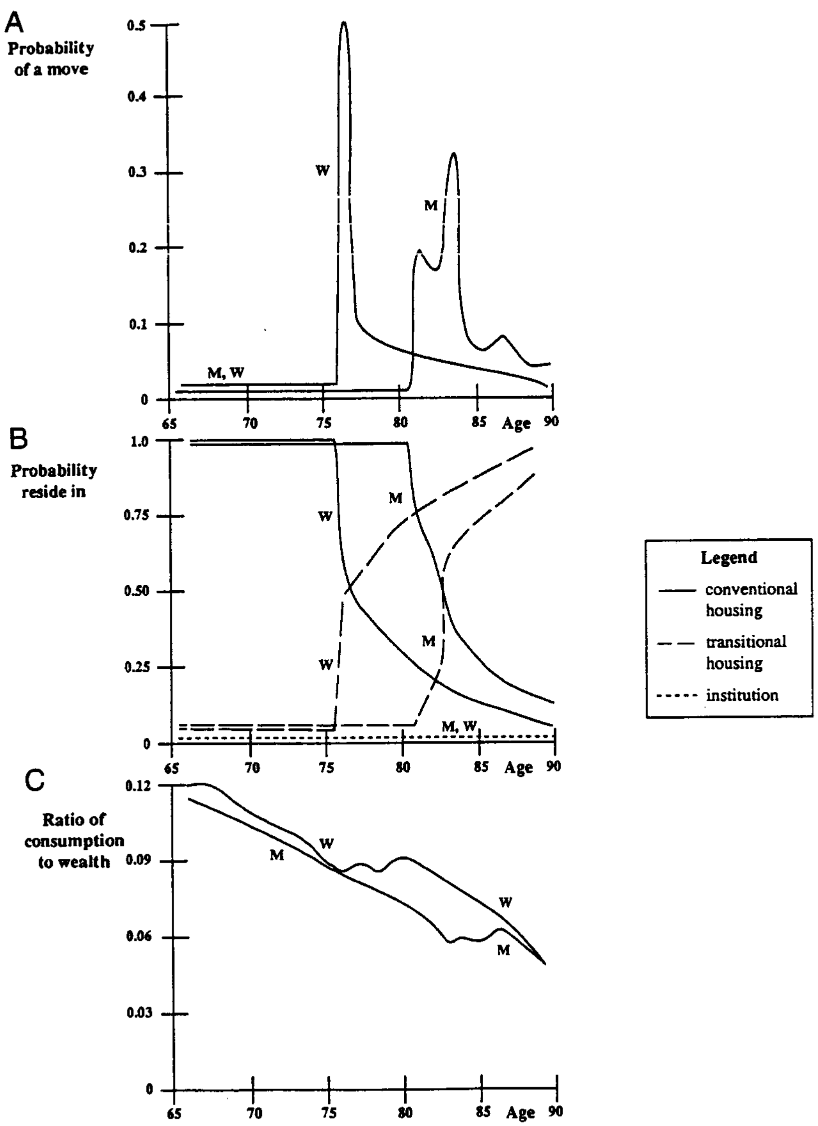

Fig. 9.6 Simulation results, second model, mobility costs: financial, separation cost of 0.2, and one-year health cost. *a,* mobility; *b,* residence; *c,* ratio of consumption to wealth.

Rather than specifying only three housing states, it would be more realistic to consider a larger number. One way to do this would be to define a bundle of housing attributes, including architectural design variables, location variables, and health services variables. Then each particular bundle of attributes might be considered to be a viable housing alternative. If prices were attached to each attribute (or small bundle of attributes), such a model would fit naturally into the framework developed in section 9.4.

A second important extension would incorporate uncertainty over future housing prices. Finally, a third extension would refine the definition of health states, perhaps by considering several "representative" patterns of aging. For each such pattern, a specific health transition matrix could be specified. In addition, each pattern could be associated with its own health-housing matching utility function, based on the relationship between the health scenario and specific housing attributes.

Appendix

In this appendix I describe the sources used and steps taken to construct tables 9.1 and 9.2. The two primary sources for these tables are Manton (1988) and Feinstein and Keating (1992). In table 4 of his 1988 paper Manton presents estimates of two-year transition probabilities based on data from the 1982 and 1984 National Long-Term Care Survey. Manton considers the following 1982 groups: no disability; IADL only; 1 to 2 ADLs, 3 to 4 ADLs; 5 to 6 ADLs; and institutionalized (there are also nonrespondents). Since I am specifying a model with only three health states, I have combined certain of Manton's categories; in particular, I have considered Manton's first group, "not disabled," to be equivalent to my category "good health"; his categories "IADLs," "1 to 2 ADLs," "3 to 4 ADLs," and "5 to 6 ADLs," summed, to be equivalent to my category "moderately disabled health"; and his "institutionalized" category to be equivalent to my category of the same name. For the 1984 data Manton forms the same categories, plus one additional category, "deceased" (again, there is a small problem with nonrespondents).

I have needed to make two main modifications to Manton's data. First, his data refers to transitions over a two-year period, whereas I require one-year transition probabilities. Second, his numbers clearly sharply understate the probability that an individual will be admitted to an institution at some point between 1982 and 1984, since it records institutionalization only at a single 1984 date; related to this is the fact that his numbers greatly overstate the probability of death when in "good" or "moderately disabled" health, since they do not capture a common sequence in which an elderly person enters an institution for a short stay before dying. To resolve these two issues I have drawn on tables in Feinstein and Keating.

I use Manton's numbers, unmodified, to compute

Probability(good health in $t + 1$ | moderately disabled in t)

and

Probability(moderately disabled health in $t + 1$ | good health in t)

separately for men and women, for each of the five-year age averages Manton reports (65–69, 70–74, 75–79, 80–84, 85–). I also impose the assumption that

Probability(good health in $t + 1$ | poor health in t) = 0

for all ages for both men and women. I use Feinstein and Keating, table 1, directly for

Probability(poor health in $t + 1$ | good health in t)

(this probability is assumed to be equivalent to the probability of nursing home entry as reported in that table; in that sense, it is probably something of an underestimate). I also rely on certain multipliers reported in Feinstein and Keating to set

Probability(poor health in $t + 1$ | moderately disabled health in t).

For younger ages I set this value to 2.5 times the probability assessed for those in good health in year t; at older ages I reduce this figure to 1.5 times the probability assessed for those in good health in year t.

I use table 4 of Feinstein and Keating (based on data from the National Nursing Home Survey), which reports detailed statistics on nursing home duration and discharge status, to determine

Probability(moderately disabled health in $t + 1$ | poor health in t).

Note that, whereas Feinstein and Keating present a discrete hazard model in which length of stay varies from as little as fourteen days to as much as seven years, for the purposes of this paper I have simplified their numbers to a simple one-year probability; the probability that a person continues in poor health in $t + 1$, denoted

Probability(poor health in $t + 1$ | poor health in t),

is taken from their numbers. But in the construction I am using in this paper, nursing home duration is assumed to follow a Markov process; empirical results reported by Garber and MaCurdy (1989) suggest that this is incorrect, and that there is some duration dependence. I also use the Feinstein and Keating numbers to assess

Probability(death in year $t + 1$ | poor health in t).

The most complex calculation I have performed in constructing tables 9.1 and 9.2 involves determining

Probability(death in year $t + 1$ | good health in t)

and

Probability(death in year $t + 1$ | moderately disabled health in t),

neither of which can be drawn directly from Manton's work, for reasons I discussed above. To estimate these probabilities, I have modified Manton's numbers by subtracting from each of the death probabilities he reports for these two health groups an estimate of the probability that an individual of that health level first entered an institution (poor health in my model) and then died. The probability of death, given institutionalization, is set as follows: .5, men aged 65 to 74; .46, men aged 75 to 84; .48, men aged 85 to 90; .5, women aged 65 to 74; .54, women aged 75 to 84; and .62, women aged 85 to 90. Since Manton's sample shrinks with age, I have deduced this rate of shrinkage and, assuming constant proportionate reduction in sample size each year, determined age weights. This step is necessary because, as shown in Feinstein and Keating's table 1, the probability of nursing home entry varies with age. The shrinkage numbers are .88 per year for men aged 65 to 74 (no shrinkage); .88 per year, men aged 75 to 90; .94 per year, women aged 65 to 74; .91 per year, women aged 75 to 84; .85 per year, women aged 85 to 90. For a shrinkage parameter μ, for initial state i (good or moderately disabled), and for probability of death conditional on institutionalization of δ, I then computed

$$P(\text{death} \mid i) = \text{Manton\#} - \delta \frac{\sum_{i=\text{ages}} P(\text{poor health in } t + 1 \text{ or } t + 2 \mid i)\mu^{(i-1)}}{\sum_{i=\text{ages}} \mu^{(i-1)}}.$$

For future reference, I will refer to this computed probability as λ_i.

Ultimately I wished to compare my estimate of these death probabilities based on Manton's table with the corresponding numbers in Feinstein and Keating. However, Feinstein and Keating, using data from National Life Tables, do not divide the population into good health and moderately disabled health (they simply use noninstitutionalized versus institutionalized—a division that is commonplace since separate death statistics are generally commonly available only for nursing home patients, who are assumed, in my model, to be in poor health). I have formed a weighted (by population) average of my modified Manton probabilities for the two health classes, good and moderately disabled, for each age and sex class, and compared these to the Feinstein and Keating numbers. For the most part the two different estimates are close, though not identical. I have generally chosen a number midway between the two, and used that as my estimate of

Probability(death in $t + 1$ | good or moderately disabled in t).

This gives me a scaling factor for the Feinstein and Keating numbers, which are 1.17, men aged 65 to 74; 1.08, men aged 75 to 84; 1.06, men aged 85 to

90; 1.7, women aged 65 to 74; 1.1, women aged 75 to 90. For reference below, I will denote the scaled Feinstein and Keating values as *FKMOD*. The number for women age 65 to 74 is so high because the probability of death, when in good or moderately disabled health, is very low for this group, so that small errors in either set of numbers generate large proportionate differences.

Having determined an estimate of

$$\text{Probability(death in } t+1 \mid \text{good or moderately disabled in } t),$$

I then decompose this into separate estimates of the probabilities for those in good health as opposed to those who are moderately disabled. I do this in several steps. First, since Manton's figures suggest that the relative size of these two classes varies with age, I have determined weights that reflect these relative percentages; the weights, denoted w_1 and w_2 (they sum to one) are chosen to vary with age so as to smoothly interpolate between the average ratios within each age group. Second, I use my original modified estimates from Manton's numbers of Probability(death | good health) (λ_1) and Probability(death | moderately disabled) (λ_2) to assess the relative chances of death in each class,

$$\frac{\lambda_1}{\lambda_2} = \alpha,$$

and solve the following equation for λ_1:

$$w_1\lambda_1 + w_2\alpha\lambda_2 = FKMOD$$

for each age and sex class. I then have values for each of λ_1 and λ_2. As a final step I smooth these probabilities over ages, so that they are nondecreasing.

References

Ai, Chunrong, Jonathan Feinstein, Daniel McFadden, and Henry Pollakowski. 1990. The Dynamics of Housing Demand by the Elderly: User Cost Effects. In *Issues in the Economics of Aging,* ed. David Wise, 33–82. Chicago: University of Chicago Press.

Altman, Irwin, M. Powell Lawton, and Joachim Wohlwill. 1984. *Elderly People and the Environment.* New York: Plenum Press.

Birren, James E., et al., eds. 1991. *The Concept and Measurement of Quality of Life in the Frail Elderly.* San Diego: Academic Press.

Danigelis, Nicholas, and Alfred Fengler. 1991. *No Place Like Home.* New York: Columbia University Press.

Feinstein, Jonathan S., and Edward G. Keating. 1992. An Economic Analysis of Life Care. NBER Working Paper no. 4155. Cambridge, MA: National Bureau of Economic Research.

Feinstein, Jonathan S., and Daniel McFadden. 1989. The Dynamics of Housing Demand by the Elderly: Wealth, Cash Flow, and Demographic Effects. In *The Economics of Aging,* ed. David Wise, 55–86. Chicago: University of Chicago Press.

Garber, Alan, and Thomas MaCurdy. 1989. Predicting Nursing Home Utilization among the High-Risk Elderly. NBER Working Paper no. 2843. Cambridge, MA: National Bureau of Economic Research.

Golant, Stephen M. 1984. *A Place to Grow Old.* New York: Columbia University Press.

Hurd, Michael D. 1990. Research on the Elderly: Economic Status, Retirement, and Consumption and Saving. *Journal of Economic Literature* 28:565–637.

Liu, Korbin, Kenneth Manton, and Barbara Marzetta Liu. 1990. Morbidity, Disability, and Long-Term Care of the Elderly: Implications for Insurance Financing. *Milbank Quarterly* 68 (3): 445–92.

Mankiw, Gregory N., and David N. Weil. 1989. The Baby Boom, the Baby Bust, and the Housing Market. *Regional Science and Urban Economics* 19:235–58.

Manton, Kenneth. 1988. A Longitudinal Study of Functional Change and Mortality in the United States. *Journal of Gerontology* 43 (5): S153–61.

Maple, Brenda T., Carolyn S. Donham, and Cathy A. Cowan. 1992. Health Care Indicators. *Health Care Financing Review* 13 (3): 173–99.

Poterba, James M. 1991. House Price Dynamics: The Role of Tax Policy and Demography. *Brookings Papers on Economic Activity* 143–203.

Scitovsky, Anne. 1988. Medical Care in the Last Twelve Months of Life: The Relation between Age, Functional Status, and Medical Care Expenditures. *Milbank Quarterly* 66 (4): 640–60.

Sheiner, Louise M., and David N. Weil. 1992. The Housing Wealth of the Aged. NBER Working Paper no. 4115. Cambridge, MA: National Bureau of Economic Research, July.

Torrance, George W. 1986. Measurement of Health State Utilities for Economic Appraisal. *Journal of Health Economics* 5 (1): 1–30.

Venti, Steve, and David Wise. 1989. Aging, Moving, and Housing Wealth. In *The Economics of Aging,* ed. David Wise, 9–48. Chicago: University of Chicago Press.

———. 1990. But They Don't Want to Reduce Housing Equity. In *Issues in the Economics of Aging,* ed. David Wise, 13–29. Chicago: University of Chicago Press.

Viscusi, W. Kip, and William Evans. 1990. Utility Functions That Depend on Health Status: Estimates and Economic Implications. *American Economic Review* 80 (3): 353–74.

Walker, Stuart R., and Rachel M. Rosser, eds. 1993. *Quality of Life Assessment: Key Issues in the 1990s.* Dordrecht, the Netherlands: Kluwer.

Comment Daniel L. McFadden

In an ideal world without transactions costs, a household would adjust living arrangements instantaneously to provide the best possible environment, given the health status of its members. In the real world with substantial out-of-pocket and psychic costs of moving, there are substantive questions about the optimality of behavior, and the efficacy of policies that promote arrangements such as conjugate living and life care. Questions of particular interest are whether households are rational in anticipating future declines in health status

Daniel L. McFadden is professor of economics at the University of California at Berkeley and a research associate of the National Bureau of Economic Research.