Asset rundown after retirement: The importance of rate of return shocks

Eric French, Phil Doctor, and Olesya Baker

Introduction and summary

Do people run down their assets after retirement? This is an important question for a number of reasons. First, the elderly have a lot of wealth: Households with heads who are 65 years old and older have more than one-third of all U.S. household wealth. Given that the baby boomer cohort is approaching retirement age, this fraction will likely increase. Whether the baby boomers run down their wealth has important implications for all of us. Some have argued that when the boomers retire, they will run down their assets. They will wish to sell their assets, which will in turn drive down the price of assets. Poterba (2001) refers to this as the "asset market meltdown hypothesis." As Poterba points out, however, this depends critically upon how quickly the elderly actually run down their assets.

In this article, we provide evidence that households run down their assets after retirement. We track a group of elderly households over the 1996–2004 period, and find that assets for these households decline modestly over the sample period. However, the U.S. experienced a remarkable run-up in housing prices from 1996 through 2004. Thus, the fact that assets declined modestly does not mean that households *planned* to run down their assets modestly. Instead, it could be that households planned to run down their assets rapidly, but enjoyed high asset returns. Thus, using these measured asset profiles might give us a very misleading picture of what the baby boomers may do with their wealth. We find that, had there been no run-up in asset prices, assets would have declined substantially over the sample period.

Related literature and contributions of our article

The question of whether the elderly run down their assets has been debated at least since Modigliani and Ando (1957), in part because the answer to the question provides key insights as to why people save over the course of their lives.

There are two main reasons why the elderly maintain high levels of assets after retirement. First, the elderly presumably maintain assets to finance consumption after retirement. Furthermore, given that the elderly are presumably unsure of the age at which they will die and are unsure of the medical expenses they may incur after retirement, they must maintain additional assets to insure themselves against these risks. Second, the elderly may be slow to reduce their assets during retirement because they wish to bequeath some of their assets to their children, relatives, friends, or charities. Determining the extent of asset rundown during retirement is important for understanding whether these motivations are important.

Better understanding these savings motives will help us to better inform policymakers as to the likely effects of changing tax and transfer systems within the United States. For example, consider a policy issue where it is important to consider savings motives of individuals at the end of their lives: estate taxation. The estate tax is a tax on assets that remain after an individual dies and, for this reason, is sometimes called the "death tax." On July 7, 2001, President George W. Bush signed into law the Economic Growth and Tax Relief Reconciliation Act, which raised the estate tax exemption level and reduced the tax rate on estates starting in 2002. Before the Economic Growth and Tax Relief Reconciliation Act was passed, only estates valued over $675,000 were taxed. The exemption rose to $1,000,000 in 2002, then rose again to $1,500,000 in 2004, and is currently $2,000,000

Eric French is a senior economist and Phil Doctor and Olesya Baker are associate economists in the Economic Research Department at the Federal Reserve Bank of Chicago. *The authors thank Gene Amromin, Craig Furfine, Ellen Rissman, Richard Rosen, and Paul Smith for helpful comments.*

(because the exemption level is per person, this translates into $4,000,000 per couple). Given the current $2,000,000 exemption level, only 0.5 percent of all estates are subject to the estate tax, according to the Urban–Brookings Tax Policy Center. Under current law, the estate tax exemption level will rise to $3,500,000 in 2009, and the estate tax will be completely repealed in the year 2010 and will be reinstated in 2011. There are proposals to repeal the tax permanently, although these proposals have stalled in the U.S. Congress.

Whether or not repealing the estate tax increases or reduces gross domestic product (GDP) depends critically on the strength and type of the bequest motive. If individuals have no bequest motive, indicating they do not value the estate that they leave to their children, the estate tax will not affect the economic behavior of elderly households.[1] The alternative to taxes on assets left after death is a tax on assets while alive (income tax). In contrast to estate taxes, income taxes will likely reduce savings and work effort, which causes economic inefficiency, or "dead weight loss." It is likely that any loss of federal income due to a repeal of the estate taxes will force an increase in income taxes. Therefore, assuming that progressivity is a desirable feature in a tax system and distortions on work decisions and savings are undesirable, the repeal of the estate tax might be seen as undesirable; that is, the decrease in estate taxes reduces progressivity, while the increase in the income tax distorts work and savings decisions.

On the other hand, if parents have a strong desire to leave a bequest, then taxing estates may reduce national savings. This reduction may reduce the capital stock and thus wages. If bequest motives are important, then eliminating the estate tax may raise national wealth and income.

In our analysis, our conclusions differed dramatically depending on whether we used the simple life-cycle model or one that assumes a bequest motive. This indicates that understanding bequest motives is important to making policy decisions. An important first step for determining the strength of the bequest motive is to determine whether individuals decumulate, or run down, assets at the end of their lives. The absence of asset decumulation is potential evidence that bequest motives are important. The goal of this article is to provide new evidence on the extent to which households run down their assets near the end of the life cycle. Using data from *Asset and Health Dynamics Among the Oldest Old* (AHEAD)—a survey collected by scholars at the University of Michigan—we document asset growth at each age for members of different cohorts. This allows us to consider the quantitative importance of the asset decumulation puzzle.

Most recent research has found that assets decline with age. However, the estimated rate at which assets decline differs from study to study. These differences across studies arise because of both differences in data and methods to calculate assets at different ages (see Hurd, 1990, for a review, and Shorrocks, 1975, and Anderson, French, and Lam, 2004, for discussions of key methodological issues).

This article builds upon Anderson, French, and Lam (2004), who also investigate the importance of asset rundown by using AHEAD data. First, we use AHEAD data from 2002 and 2004, whereas Anderson, French, and Lam only used data to 2000. Second, we conduct a more comprehensive analysis of the rates of return faced by sample members.[2] Third, we show asset profiles, adjusted by rates of return on a year-by-year basis.

Asset rundown as predicted by the life-cycle model

In this section, we briefly describe the amount of asset rundown that we would expect to see if people behaved according to the life-cycle model. We calibrate a simple life-cycle model, as described in appendix 1. Individuals in the model make consumption and savings decisions depending on their current assets, their perceived income and medical expenses in the future, their expectation for how long they will live, and their decision to have a bequest motive or not.

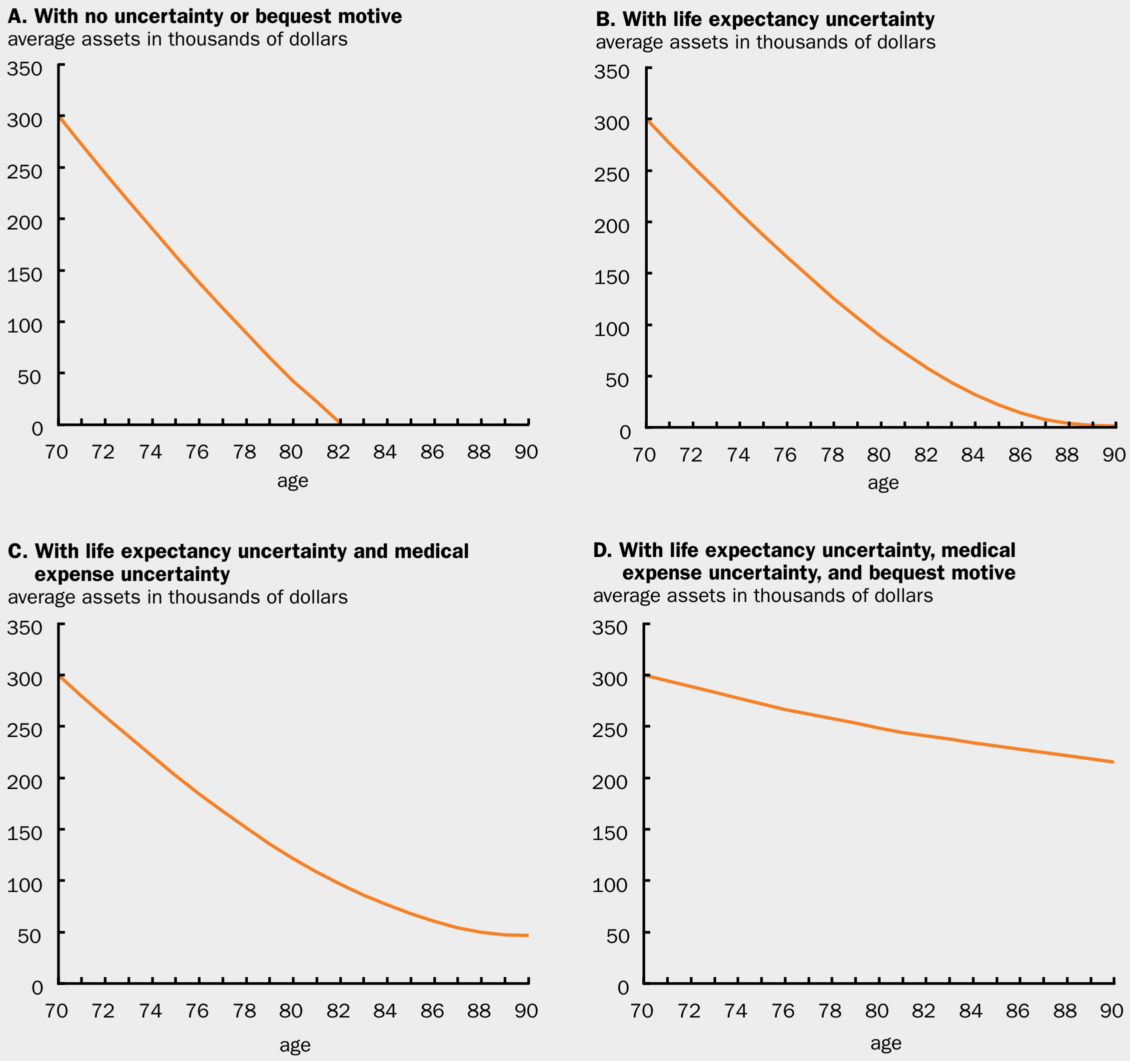
A model can help us to frame the questions we need to ask in order to understand why people build up their savings. A model that is calibrated to the data can also illuminate the likely causes of why individuals run down their assets so slowly. In this section, we provide evidence that uncertain life expectancy, uncertain medical expenses, and bequest motives are all potentially important savings incentives at the end of the life cycle.

We begin with the simplest version of the model and then move to more complex models. First, we present the case in which individuals face no medical expense risk, have no bequest motive, and are certain to live 12 years (to 82), which is the average life expectancy for a man aged 70. Panel A of figure 1 presents the asset profile implied by this model and highlights its key implication: Assets at age 82, the age of certain death, are equal to zero. This implication of the life-cycle model is at odds with the data, as we describe later.

Panel B of figure 1 presents the asset profile implied by a model augmented to include mortality risk. Life expectancy is still 12 years, but there exists the possibility of living much longer. Panel B shows that individuals run down their assets much more slowly

FIGURE 1

Asset profiles



Note: All dollar values are in 1998 dollars.
Source: Authors' calculations based on data from the *Asset and Health Dynamics Among the Oldest Old*.

when the model is augmented to account for uncertain life expectancy. Because individuals are risk averse, they do not wish to outlive their financial resources, a point made by Davies (1981). By holding assets until a very old age, they insure themselves against the risk of outliving their financial resources.[3] Nevertheless, the model still predicts that by age 95, assets are near zero. Conditional on being age 70, there is only a 4 percent chance of surviving to age 95. Moreover, mortality rates exceed 20 percent by age 95. Therefore, this model indicates that individuals are willing to bear the risk of low consumption at age 95 on the off chance that they survive to that age. However, as we show later, this does not fit what is actually observed; many people still hold considerable levels of assets, even at age 95. Therefore, it seems that uncertain life expectancy alone cannot explain the slow rate of asset decumulation we observe in the data.[4]

Panel C of figure 1 presents the asset profile implied by a model augmented to include medical expenses, as well as mortality risk. The risk of catastrophic out-of-pocket medical expenses also helps explain the absence of asset rundown. Even in the presence of social insurance (Medicare and Medicaid), households still face potentially substantial out-of-pocket medical expenses (for estimates, see De Nardi, French, and Jones, 2006; Brown and Finkelstein, 2004; French and Jones, 2004a; Palumbo, 1999; and Feenberg and Skinner, 1994). Moreover, nursing home expenses are potentially large and virtually uninsurable. French and Jones (2004a) find that in any given year, 1 percent of all households incur a medical expense shock that costs $44,000 over their lifetimes and 0.1 percent of all households incur a medical expense shock that costs $125,000 over their lifetimes. Because the medical expenses associated with health problems are persistent and the risk of incurring such expenses repeatedly could financially decimate a household, this could cause a household to keep a large amount of assets in order to buffer itself against the possibility of catastrophic medical expenses. Therefore, the risk of catastrophic medical expenses might generate precautionary savings on top of those accumulated against the risk of living a very long life. Panel C shows that individuals run down their assets much more slowly when faced with medical expense risk. Nevertheless, they still run down their assets much more quickly than we see in the data.

Lastly, panel D of figure 1 presents the asset profiles implied by a model augmented to include a bequest function, as well as medical expenses and mortality risk. Unsurprisingly, asset rundown at the end of the life cycle is even slower when we augment the model to include a bequest function. In short, uncertain life expectancy, uncertain medical expenses, and bequest motives all potentially play a part in asset rundown. Therefore, while a relatively slow rate of asset rundown is not necessarily *evidence* of a bequest motive, it is consistent with having a bequest motive.

Data

In order to estimate the extent of asset rundown, we use data from the *Asset and Health Dynamics Among the Oldest Old* data set. The AHEAD is a sample of noninstitutionalized individuals aged 70 or older. A total of 8,222 individuals in 6,047 households were interviewed for the AHEAD survey in late 1993/early 1994. These individuals were interviewed again in early 1996, 1998, 2000, 2002, and 2004.[5] The AHEAD data include a nationally representative core sample, as well as additional samples of blacks, Hispanics, and Florida residents.

The AHEAD has comprehensive asset measures for each time that sample members are interviewed. It has information on the value of housing and real estate, autos, liquid assets (which include money market accounts, savings accounts, and Treasury bills), individual retirement accounts (IRAs), Keogh plans, stocks, the value of a farm or business, mutual funds, bonds, and other assets and investment trusts. Our measure of wealth is the sum of all these assets, less mortgages and other debts. Following common practice (for example, Hurd, 1989, and Attanasio and Hoynes, 2000), we exclude pension and Social Security wealth. Because assets appear to be significantly underreported in the first wave, in 1993/1994 (see Rohwedder, Haider, and Hurd, 2004), we begin our analysis with data from the second wave, in 1996.

There are three important problems with our asset data. The first is that the wealthy tend to underreport their wealth in virtually all household surveys (Davies and Shorrocks, 2000). This leads us to understate asset levels at all ages. However, Juster, Smith, and Stafford (1999) show that the wealth distribution of the AHEAD matches up well with aggregate values for all but the richest 1 percent of households. A second important problem with our data is that it spans the years 1996–2004, a period in which there was a rapid rise in asset prices. This makes it difficult for us to distinguish between intended asset growth through active savings versus unintended asset growth through unexpectedly high returns. Tackling this issue is the goal of our article.

Our data also suffer from attrition—people leaving the sample over time—a problem common to all panel data sets. In the AHEAD, attrition is largely due to death: Reported deaths are confirmed using the National Death Index. However, in some cases, interviewers are unable to track down sample members as they move from house to house, and some individuals refuse to give follow-up interviews. If the people who are difficult to contact differ systematically from those we are able to keep track of, "nondeath" attrition could distort the composition of our sample. If, for example, it is more difficult to track down poor individuals, poor households will be dropped from the sample at greater rates than rich ones.

The third problem with the asset data is that it is not clear whether to include the amount held in trust accounts. The final wealth question asked of AHEAD respondents is whether they have a trust account. About 10 percent of all respondents have a trust account. In 2002, respondents were asked whether the value of the trust was included in their previously described assets (such as stocks and bonds). Only 6 percent of those with a trust (that is, slightly over 0.6 percent of the full sample) reported that the value of the trust was not already reported in the form of other assets. In other words, stock market wealth that is held in a trust account is usually reported as stock market wealth. Because we do not want to double count this wealth, we do not include the value of trusts in our measure of assets. This is an important difference between our article and Anderson, French, and Lam (2004).

Two additional problems arise from the fact that assets are a household-level variable rather than an individual-level variable. First, some of the households in our sample consist of two unmarried individuals. Because it is not clear how these respondents might answer the asset questions, we drop these households. Second, many sample members get married or divorced over the sample period. Therefore, changes in wealth over time reflect not only savings decisions (the object of interest in our article) but also household formation decisions. To counter this problem, we drop individuals who get married or divorced during the sample period. To sum up, we keep only those households that were either married or single living alone in the first wave and that changed household structure only because of death.[6]

Table 1 reports some descriptive statistics for our sample. We are left with 4,408 households alive in 1996 for the main analysis, of whom 2,304 have at least one surviving member in 2004. Mortality rates observed in the data are similar to average mortality rates for the United States, conditional on age (see Anderson, French, and Lam, 2004).

Table 1 shows average reported assets in each wave, by type of asset. Housing is the largest component of assets, although liquid assets (such as bonds) and stocks are also important components of households' portfolios. The numbers are expressed in 1998 real dollars.[7]

The run-up in asset prices

Table 1 shows that assets do not fall over the sample period, which is contrary to the predictions of the simple versions of the life-cycle model. However, one potential reason that assets did not fall is the run-up in asset prices. This section describes the run-up in asset prices. All asset prices described henceforth are deflated by the Personal Consumption Expenditure deflator.

Figure 2 shows growth in the stock market. Specifically, it shows the annual total return from both dividends and price growth on a broad portfolio of stocks (as measured by the Center for Research in Security Prices, or CRSP, at the University of Chicago's Graduate School of Business). The CRSP stock market index measures the growth of a portfolio of stocks that includes all stocks in the New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and National Association of Securities Dealers Automated Quotation (NASDAQ) indexes. It is a broader measure of stock prices than the Standard & Poor's (S&P) 500 or the Wilshire 5000 indexes, although the returns from the CRSP stock index and these other two indexes look similar. Figure 2 shows not only the annual return but also the average return over both the 1950–95 and 1996–2003 periods. Figure 2 shows not only that stocks grew at roughly the same rate over the 1996–2003 period as they did over the 1950–95 period. For example, the CRSP index grew at an average annual rate of 9.3 percent over the 1996–2003 period, compared with 9.7 percent over the 1950–95 period.

Figure 3 shows the total return from owning a home. The total return includes house price appreciation and the value of the service flow from housing (that is, the value of rent that homeowners need not pay), less maintenance costs and property taxes. Most of the variability in the series is from variability in housing price growth. For price growth rates between 1950 and 1971, data are from the price index for private residential investment divided by the price index

TABLE 1

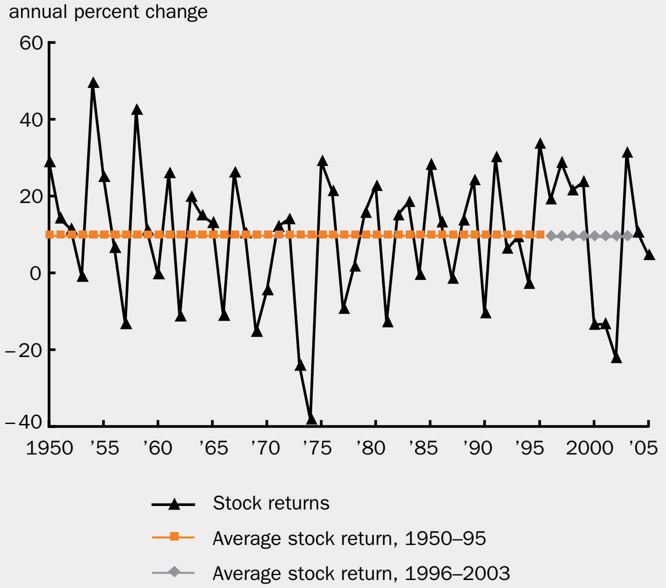
Household wealth, by asset type

	1996	1998	2000	2002	2004
Housing	85,179	87,858	92,875	96,301	106,296
Liquid assets	55,513	49,677	52,094	62,211	57,775
Stocks	54,664	55,785	56,298	48,457	53,456
Automobiles	5,356	5,997	5,562	5,222	4,767
Businesses	15,007	11,369	11,685	16,324	12,883
Individual retirement accounts	12,512	12,617	14,481	12,475	12,126
Other assets	3,951	5,448	4,798	3,983	5,813
Debt	3,862	4,195	3,811	4,128	4,884
Total assets	228,322	224,557	233,983	240,845	248,233
Observations	4,408	3,803	3,253	2,723	2,304

Notes: The value of estates are not included here. All dollar values are in 1998 dollars. Columns may not total because of rounding.
Source: Authors' calculations based on data from the *Asset and Health Dynamics Among the Oldest Old*.

FIGURE 2

Total return from stocks, 1950–2005



Source: Authors’ calculations based on data from the University of Chicago, Graduate School of Business, Center for Research in Security Prices.

for all personal consumption expenditures, as measured in the national income and product accounts (NIPAs). For housing price growth after 1971, data are the price series from the U.S. Office of Federal Housing Enterprise Oversight’s (OFHEO) Conventional Mortgage Home Price Index, which measures the price change for resold single-family homes. Because the OFHEO index measures the price of the same houses over time, the index accounts for the fact that the quality of houses may have changed over time. Details are provided in appendix 2.

The main reason for the variability in the return from housing is in the variability of house price appreciation. Figure 3 shows that housing prices grew much more rapidly over the 1996–2003 sample period than over the previous 45 years; the total return from housing was 8.0 percent over the 1996–2003 period, versus 4.7 percent over the 1950–95 period.

Figure 4 shows that the total return from bonds (the return includes coupon payments) with long maturities was 5.1 percent in the 1996–2003 period, versus 1.7 percent in the 1950–95 period. Appendix 3 provides details of the construction of figure 4. Figure 5 shows the return from short-term Treasury bills, which averaged 2.4 percent in the 1996–2003 period, versus 1.9 percent in the 1950–95 period. Thus, we can see that the rates of return on most assets were above average over the sample period. It is therefore likely that many households received unanticipated increases in wealth.

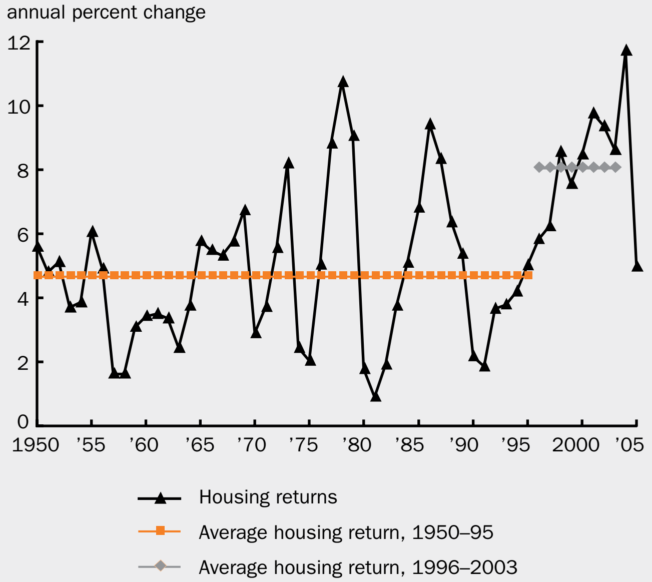
Household portfolios

Table 2 shows average portfolio shares in our AHEAD data.[8] It shows that in our AHEAD sample in 1996, 37 percent of household wealth was held in housing and another 27 percent of household wealth was held in stocks.[9] Much of the remainder of household wealth is held in assets that likely did not grow very much over the sample period, such as short-term bonds.

Table 2 also shows portfolio shares in the Federal Reserve Board’s *Flow of*

FIGURE 3

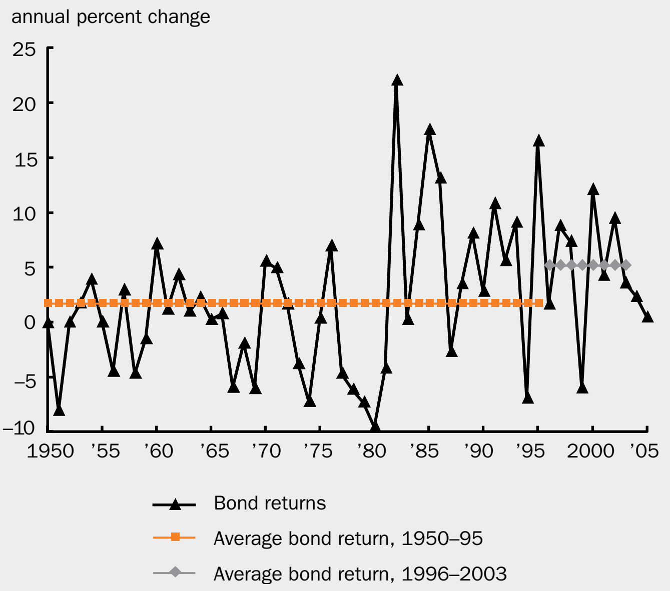
Total return from housing, 1950–2005



Note: See appendix 2 for further details.
Sources: Authors’ calculations based on data from the U.S. Bureau of Economic Analysis, national income and product accounts; U.S. Office of Federal Housing Enterprise Oversight, Conventional Mortgage Home Price Index; U.S. Bureau of Labor Statistics, Consumer Price Index, owners’ equivalent rent component; and Smith and Smith (2006).

FIGURE 4

Total return from bonds, 1950–2005



Note: See appendix 3 for further details.
Sources: Authors’ calculations based on data from Merrill Lynch; University of Chicago, Graduate School of Business, Center for Research in Security Prices; and Ibbotson Associates.

Funds Accounts of the United States. The flow of funds accounts are arguably the best measure of the wealth of the United States. Note that average shares in housing, liquid assets, and stocks are similar between the two data sets. However, there are differences between the shares in the AHEAD and the flow of funds accounts that are worth noting. Most importantly, AHEAD respondents have less business wealth and debt than the general population represented in the flow of funds accounts. The differences likely arise for two reasons. First, AHEAD respondents are old, and old people have less business wealth and debt than younger people. Second, the AHEAD oversamples the poor, who have very little business wealth.

Calculating rates of return

In this section, we describe our approach to estimating rates of return. The key equation to understanding the approach is the following:

1) $A(it+1) = (1 + r(it)(1 - \tau(it)))A(it) + S(it)$,

where $A(it+1)$ is individual i’s level of assets at time $t+1$, $A(it)$ is her level of assets at time t, $r(it)$ is her return on assets between t and $t+1$, $\tau(it)$ is the tax rate on capital, and $S(it)$ is her savings rate (that is, the difference between consumption and post-tax nonasset income).

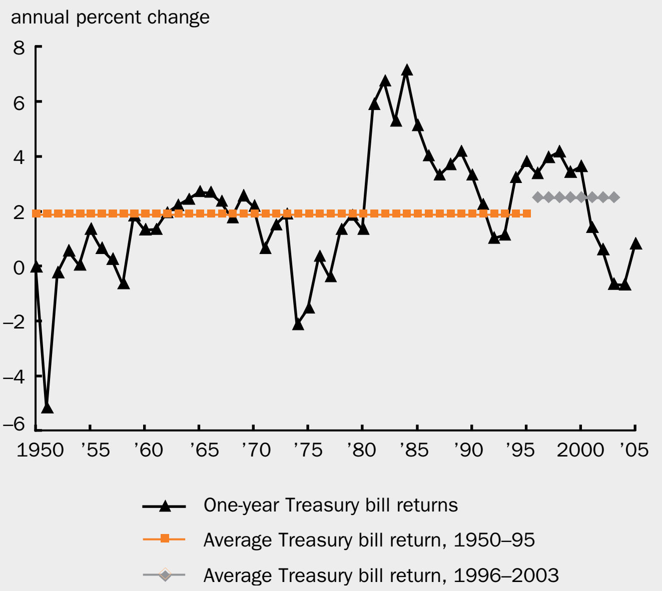
We take a weighted average of returns in different assets to infer the total return. Specifically, let there be K different types of assets, and suppose that in time t a quantity $A^1(it)$ is invested in asset 1, $A^2(it)$ is invested in asset 2, … , $A^K(it)$ is invested in asset K, and between time t and $t+1$, the various assets have returns of $r^1(t)$, $r^2(t)$, … , $r^K(t)$. Thus, we allow for heterogeneity in rates of return because different households have different portfolios. However, conditioning on the portfolio, we assume all individuals have the same return. We assume

2) $r(it) = [r^1(t)s^1(it) + \ldots + r^K(t)s^K(it)]$,

where $s^1(it) = A^1(it)/A(it)$, … , $s^K(it) = A^K(it)/A(it)$. We use the rate of return series shown in figures 2–5 and the

FIGURE 5

Total return from short-term Treasury bills, 1950–2005



Source: Authors’ calculations based on data from the Board of Governors of the Federal Reserve System, statistical release, No. H.15.

TABLE 2

Share of total assets, by various types of assets, 1996

	AHEAD	Flow of funds
Housing	0.37	0.36
Liquid assets	0.27	0.25
Stocks	0.27	0.30
Autos	0.02	0.11
Businesses	0.06	0.16
Other assets	0.02	0.01
Total debt	0.01	0.20

Notes: The shares are of gross assets, not net assets; that is, the debt of each asset type is not included. The *Asset and Health Dynamics Among the Oldest Old* (AHEAD) survey measures wealth in individual retirement accounts (IRAs), but not the composition of that wealth. We assume that 60 percent of IRA wealth is in stocks and 40 percent is in liquid assets.
Sources: Authors' calculations based on data from the *Asset and Health Dynamics Among the Oldest Old* and Board of Governors of the Federal Reserve System, *Flow of Funds Accounts of the United States*.

household-level wealth shares to calculate the household-level rates of return in equation 2.[10]

Figure 6 shows average returns using this method with the shares described in table 2.[11] It also shows average returns from an alternative method for which we use aggregate data. The close relationship between the two series gives us confidence in our methods. Regressing the first series upon the second yields an R-squared of 0.86.[12] Thus, we take this as evidence that both procedures provide reasonable estimates of year-specific returns.

To derive our alternative method, assume that everyone faces the same interest rate in year t, defined as $r(t)$. Define $A(t+1)$ as total assets in the U.S. economy at time $t+1$, $A(t)$ as total assets at time t, $S(t)$ as total savings at time t, and $\tau(t)$ as the average tax rate on capital. Assuming that the capital tax rate is uncorrelated with assets, we can rearrange equation 1 and solve for $r(t)$:

$$3)\quad r(it) = r(t) = (A(t+1) - A(t) - S(t)) / (A(t)\,(1 - \tau(t)))\,.$$

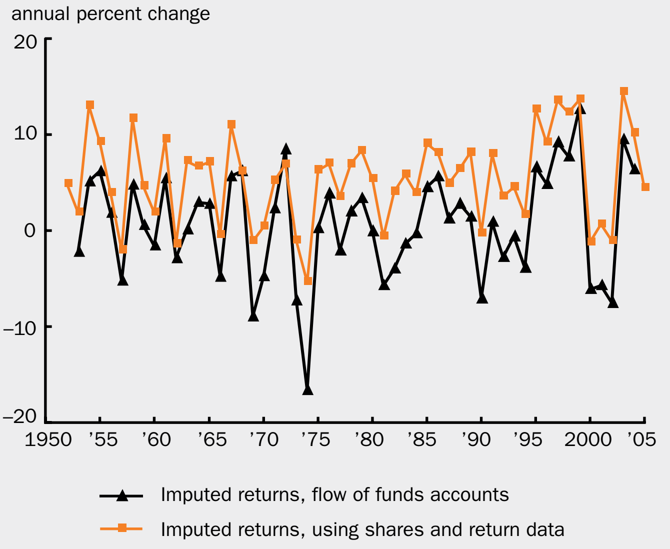
Thus, if we know $A(t+1)$, $A(t)$, $S(t)$, and $\tau(t)$, we can infer $r(t)$. In our analysis in the following section, we use data from the flow of funds accounts to infer $A(t+1)$, $A(t)$, and $S(t)$, and we assume $\tau(t) = 0.2$, which allows us to infer $r(t)$. Specifically, we take aggregate assets and savings (savings are measured as personal savings plus undistributed corporate profits) from the flow of funds accounts for the period 1950–2003.

Estimating expected and realized returns

In this article, we provide some evidence on what would have happened to asset changes if there had been no sharp run-up in asset prices. In order to do this, we need to place sharp restrictions on individual behavior. Here, our key maintained assumptions are twofold. Our first assumption is that asset prices over the 1996–2003 period were expected to be equal to the average asset price change in the 1950–95 period. Although there is some mixed evidence on whether it is possible to forecast asset returns (see Cochrane, 1997, for a review), we view this assumption as reasonable. Our second assumption is that there is no savings response to the run-up in asset prices. This second assumption is probably less plausible. It seems likely that as households became richer, they consumed some of their newfound wealth. Furthermore, there is strong empirical evidence that increases in wealth do lead to higher consumption (Dynan and Maki, 2001).

FIGURE 6

Aggregate return, 1952–2005



Note: Shares (weights) are from the *Asset and Health Dynamics Among the Oldest Old,* as described in table 2.
Sources: Authors' calculations based on data from the *Asset and Health Dynamics Among the Oldest Old*; Board of Governors of the Federal Reserve System, *Flow of Funds Accounts of the United States*; University of Chicago, Graduate School of Business, Center for Research in Security Prices; U.S. Bureau of Economic Analysis, national income and product accounts; U.S. Office of Federal Housing Enterprise Oversight, Conventional Mortgage Home Price Index; Merrill Lynch; Ibbotson Associates; and Board of Governors of the Federal Reserve System, statistical release, No. H.15.

It is likely that failure to account for an individual's consuming her newfound wealth will lead us to overstate the importance of rate of return shocks. The reason for this is straightforward. Both theory and evidence suggest that unexpected wealth gains today will be partly spent in the near future. If all unexpected wealth gains were spent immediately, then unexpected wealth gains would not affect the level of wealth, and we would not have to make any adjustments to account for asset return shocks. However, we assume that all of the unexpected wealth gains will be saved. Thus, our procedure "overadjusts" for wealth gains and helps put an upper bound on the importance of rate of return shocks on intended asset decumulation.

We generate cumulative returns under two scenarios: 1) given the realized returns over the 1996–2003 period, and 2) given the returns had they been at their historical average (based on the 1960–95 period). The difference will allow us to measure the size of the wealth shock for every year of our data. Although we have data back to 1950 for many series, we used data back only to 1960 because the data for 1950–59 are of lower quality. However, using data going back to 1950 produced similar results.

We assume that individual's expectations of future returns in the stock and housing markets comes from looking at historical returns. Specifically, we assume that an individual's expected return over the 1996–2003 period is merely the average return over the 1960–95 period for each asset. The difference between the historical return and our estimated return (weighted by its share of the household's portfolio) is our measure of the wealth shock in any given year. Specifically, we use the 1996 portfolio shares and rates of return over the 1960–95 period to infer wealth shocks over the 1996–2003 period.

Using the asset-specific returns listed previously, we generate cumulative asset returns using the following approach. As before, let asset type k have return $r^k(t)$ at time t. Then $1 + r^k(t)$ is the dollar value of assets priced \$1 at time t. Thus, if \$1 of asset k at time t were held until time T, then the asset would be worth $(1 + r^k(t))*(1 + r^k(t + 1))* \ldots *(1 + r^k(T - 1))$ at time T. Using this formula we can solve for a household's wealth for different times in the future. Using equation 1, we can write for each household

$$
\begin{aligned}
4)\quad A(it+1) &= (1 + r(it)(1 - \tau(it)))A(it) + S(it),\\
A(it+2) &= (1 + r(it+1)(1 - \tau(it+1)))A(it+1) + S(it+1)\\
&= (1 + r(it+1)(1 - \tau(it+1)))(1 + r(it)(1 - \tau(it)))A(t) + (1 + r(it+1)(1 - \tau(it+1)))S(it) + S(it+1),
\end{aligned}
$$

where $r(it)$ is defined in equation 2.

Now define $r^{*k}(t + j)$ as the time t expectation of time $t + j$ returns on asset k. Recall that we assume that this is the average historical return on asset k before time $t - 1$. Given this assumption, $r^{*k}(t + j) = r^{*k}(t + j + 1)$ for all $j > 0$. In practice, we use the 1960–95 sample periods to construct $r^{*k}(t + j)$ for the different K assets. Furthermore, we define $r^*(it) = s^1(it)\, r^{*1}(t) + s^2(it)\, r^{*2}(it) + \ldots + s^K(it)\, r^{*K}(t)$.

Analogous to equation 4, we can generate

$$
\begin{aligned}
5)\quad A^*(it+2) &= (1 + r^*(it+1)(1 - \tau(it+1)))A^*(it+1) + S(it+1)\\
&= (1 + r^*(it+1)(1 - \tau(it+1)))(1 + r^*(it)(1 - \tau(it)))A^*(t) + (1 + r^*(it+1)(1 - \tau(it+1)))S(it) + S(it+1),
\end{aligned}
$$

where $A^*(it)$ is the asset level we would have observed if asset returns were at their historical averages. We set $A^*(it) = A(it)$ for $t = 1996$ because this is our initial time period. We assume that $r^*(t + 2)S(it) = r(t + 2)S(it)$ in equation 5. Combining equations 4 and 5 yields

$$
\begin{aligned}
6)\quad A(it+2) - A^*(it+2) = &[(1 + r(it+1)(1 - \tau(it+1)))(1 + r(it)(1 - \tau(it))) - (1 + r^*(it+1)(1 - \tau(it+1)))\\
&(1 + r^*(it)(1 - \tau(it)))]\, A(t).
\end{aligned}
$$

By assumption, this is the unanticipated capital gain. The same approach can be used to calculate the difference between actual and expected returns at any arbitrary horizon.

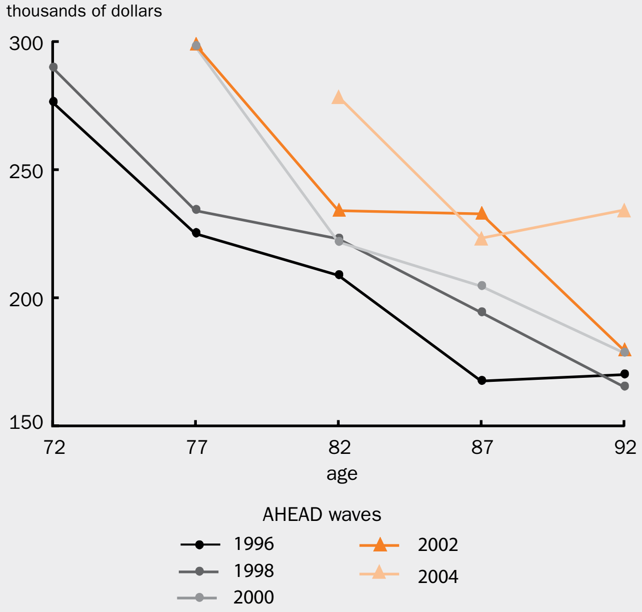
Life-cycle asset profiles in the cross section

Given that most studies use cross-sectional data to estimate the life-cycle profile of assets, we begin by repeating this exercise. By initially replicating the results of other studies, we can infer whether our results differ from previous results because we use different data or because we use different estimation techniques. Figure 7 shows mean household assets, by five-year age cohorts of the head of household (starting with age 70–74 and ending at age 90–94) from the 1996, 1998, 2000, 2002, and 2004 waves of the AHEAD. For 2000 and 2002, we have insufficient observations to infer assets for those aged 70–74, and in 2004 we have insufficient observations to infer assets for those aged 70–74 and 75–79.[13]

There are several things that we can note from figure 7. First, later cross sections show higher assets than earlier cross sections at each age. For example, for those aged 75–79, the 1996 cross section shows assets equal to \$225,000, the 1998 cross section shows assets equal to \$234,000, the 2000 cross section

FIGURE 7

Average assets, by age and AHEAD wave



Notes: AHEAD means *Asset and Health Dynamics Among the Oldest Old*. The average age of each cohort (aged 70–74, 75–79, 80–84, 85–89, and 90–94) in an AHEAD wave was used to plot this figure. For the 2000 and 2002 waves, there are insufficient observations to infer assets for those aged 70–74, and for the 2004 wave, there are insufficient observations to infer assets for those aged 70–74 and 75–79. All dollar values are in 1998 dollars.
Source: Authors' calculations based on data from the *Asset and Health Dynamics Among the Oldest Old*.

shows assets equal to $298,000, and the 2002 cross section shows assets equal to $299,000. Second, figure 7 shows that in each cross section, older heads of households have lower assets than younger ones. For instance, the 1996 asset profile shows average assets of $276,000 for those aged 70–74 and $170,000 for those aged 90–94. Asset profiles for other years also show lower assets at older ages.

Because the distribution of assets is skewed (that is, a small number of households have very high assets), mean assets can give a misleading depiction of the asset distribution at each age. Nevertheless, median and mean asset profiles have similar shapes. For example, in 1996, median assets were $117,000 for households aged 70–74 and only $44,000 for heads of households aged 90–94. These results suggest that assets do decline with age. Recall, however, that those aged 90–94 in a given year were born 20 years earlier than those aged 70–74 in the same year.

Because of a lack of panel data, cross-sectional data have often been used to infer life-cycle savings decisions. Until recently, panel data on wealth were not available, so most analyses of the life cycle were based on single cross sections by necessity (see Hurd, 1990, who mentions the rare exceptions). In the next section, we discuss some of the problems associated with using a cross-sectional profile to infer the evolution of wealth over the life cycle.

Estimation issues

We estimate life-cycle asset profiles of households. However, there are three main problems with the estimation of life-cycle asset profiles. Here, we discuss these problems, as well as our approach to dealing with them.

First, in cross-sectional data, we observe individuals who were born at different times (that is, older people were born in earlier years than younger people). Households from older cohorts have, on average, lower real lifetime earnings than households from younger cohorts. Thus, we would expect the asset levels of households in older cohorts to be lower than those of younger cohorts in any given year. Therefore, comparing older households with younger households in a particular year leads the econometrician to overstate assets when they are young and to understate assets when they are old. In other words, this will potentially lead the econometrician to infer that individuals run down their assets near the end of their lives when this is not actually the case. For example, over the 1950–2003 period, per capita income in the United States grew on average 1.7 percent per year. Therefore, two cohorts born 20 years apart tend to have lifetime incomes that are different by a factor of $1.017^{20} = 1.40$. In other words, members of the cohort who were aged 70–74 in 1996 are likely to have average lifetime incomes that are 40 percent higher than those of the cohort who were aged 90–94 in 1996.

A second econometric problem occurs because people with lower income and wealth tend to die at younger ages than those with higher income and wealth. Therefore, the average survivor in a cohort has higher assets than the average deceased member of the cohort. As a result, "mortality bias" leads the econometrician to overstate the average lifetime income of members of a cohort. This bias is more severe at older ages, when a greater share of the cohort members are dead. The econometrician is forced to treat the level of assets of surviving members (who, on average, have had higher assets) as indicative of the entire cohort, had all members survived. This leads the econometrician to increasingly overstate assets as individuals become older. Using AHEAD data, Anderson, French, and Lam (2004) show that the probability of death for 80-year-old men who are at the 80th percentile of the wealth distribution is 7.0 percent, whereas the probability of death for 80-year-old men whose wealth is at the 20th percentile of the wealth distribution is 10.1 percent. Using data from the U.S. Census Bureau's *Survey of Income and Program Participation*, Attanasio and Hoynes (2000) find even steeper wealth gradients.

We solve both of these problems by using panel data, which allow us to track the same households over time. Our profiles are estimated using the growth rate of assets for surviving households in different years. Because we are tracking the same households over time, we are obviously tracking members of the same cohort over time. Because we estimate growth rates for surviving households, our estimates do not suffer from mortality bias. In the next section, we detail these procedures.

While tracking the same households over time solves the two problems discussed previously, it also creates a problem. As we have pointed out before, asset growth of a household represents not only anticipated asset growth through saving but also unanticipated asset growth. It is precisely this problem that our methods in this article are designed to address.

Estimation methodology

Figure 8 presents estimates of the life-cycle asset profile for four different five-year birth cohorts, using both fixed effects (FE) and ordinary least squares (OLS). Anderson, French, and Lam (2004) describe some of the differences in the two methods.

Consider a set of individuals referenced by $i \in \{1, \ldots, I\}$ who were born on December 31, 1921 (in practice, we use five-year cohorts, this one having been born in 1919–23). We observe these individuals in 1996, 1998, 2000, 2002, and 2004. Therefore, we observe members of this cohort at age 74, 76, 78, 80, and 82. We denote their age by $a \in \{74, \ldots, 82\}$. Assets of a particular individual at a certain age, denoted A_{ia} are determined by the following function:

$$7) \quad A_{ia} = f_i + \beta(a) + u_{ia},$$

where f_i is the individual's fixed effect, which includes all age-invariant factors, u_{ia} is a residual, and $\beta(a)$ is a function of a. Note that for a given individual, assets can change only because of changes in age, or changes in u_{ia}. When using a fixed effects estimator, u_{ia} and $\beta(a)$ are uncorrelated by construction. As a result, we can obtain consistent estimates of $\beta(a)$ that are uncontaminated by individual heterogeneity.

We wish to estimate the function $\beta(a)$, which measures how assets change as individuals age. In the section titled "Asset rundown as predicted by the life-cycle model," the results indicate that understanding $\beta(a)$ will help us better understand savings motives after retirement. We estimate the function using a full set of dummy variables, that is,

$$8) \quad \beta(a) = \sum_{age \in \{76,78,80,82\}} \beta_{age} \times 1\{age = a\} + u_{ia},$$

where $1\{.\}$ represents an indicator function that is equal to 1 when the statement in parentheses is true and is 0 otherwise.[14]

The fixed effect f_i and the residual u_{ia} merit further discussion. The residual captures variation in wealth arising from short-term contingencies, such as medical expenses. It also captures the difference between the true level of assets and reported assets; that is, it is possibly a measurement error.

The fixed effect captures objects such as lifetime earnings. Individuals with high lifetime earnings likely have high wealth at every age. The fixed effect is potentially correlated with the probability of being observed at older ages because poor people (that is, those with a low value of f_i) die at younger ages. By using a fixed effects estimator, we can obtain consistent estimates of the β_{age} parameters. Our fixed effects estimator estimates equation 7 for every cohort.

We also estimate a variant of equation 7 using OLS. Specifically, we estimate

$$9) \quad A_{ia} = f + \beta(a) + u_{ia},$$

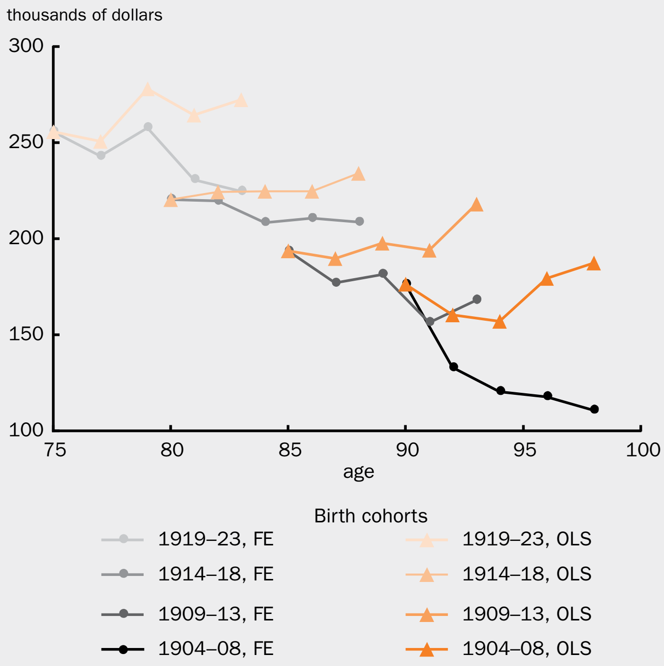
where $\beta(a)$ takes the functional form in equation 8. Note that f is common to everyone within the cohort, so that u_{ia} now includes higher asset levels coming from things such as lifetime wealth. Thus, u_{ia} is likely correlated with the probability of being observed at older ages, and thus estimates of the β_{age} parameters are inconsistent.

Life-cycle asset profiles

Figure 8 presents estimates of the life-cycle asset profile for four different five-year birth cohorts using both FE and OLS. The connected lines show how assets change over time for members of specific cohorts. These life-cycle profiles are for the cohorts born in 1919–23, 1914–18, 1909–13, and 1904–08 (or those

FIGURE 8

Wealth profiles: Ordinary least squares and fixed effects estimates



Notes: OLS means ordinary least squares. FE means fixed effects. The average age of each cohort in 1996, 1998, 2000, 2002, and 2004 was used to plot this figure. All dollar values are in 1998 dollars.

Source: Authors' calculations based on data from the *Asset and Health Dynamics Among the Oldest Old*.

aged 72–76, 77–81, 82–86, and 87–91 in 1996, respectively). Note that in 1996, mean household wealth was $256,000 for those aged 72–76, $220,000 for those aged 77–81, $194,000 for those aged 82–86, and $176,000 for those aged 87–91. In other words, wealth of the oldest cohort was 31 percent lower than wealth of the youngest cohort in 1996. One could argue that this is evidence of asset rundown within households. Recall, however, that households aged 87–91 in 1996 were born 15 years earlier than households aged 72–76 in 1996. If aggregate income grows 1.7 percent per year, then the lifetime income of the oldest cohort is 26 percent lower than that of the youngest cohort. Therefore, the fact that the 1996 wealth level is 31 percent lower for the cohort aged 87–91 relative to the cohort aged 72–76 is not necessarily evidence of a rundown in assets (although recall that mortality bias works in the opposite direction and indicates that the cross-sectional evidence may be consistent with a modest rundown). When tracking assets of households within a cohort, note that assets do not run down over the length of the panel when using an OLS estimator. For example, assets increase about 6 percent between 1996 and 2004 for the cohort born in 1919–23 (or aged 72–76 in 1996).

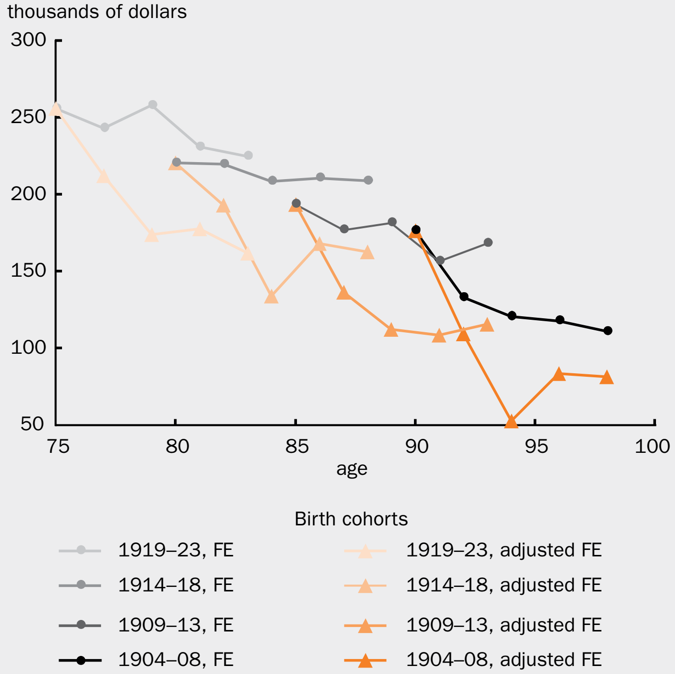
Next, consider the fixed effects profiles. Fixed effects profiles show less asset growth with age. For example, assets decline 12 percent between 1996 and 2004 for the cohort born in 1919–23. If no members of the sample left the survey because of death or other reasons, OLS would produce the same results as fixed effects. However, because sample members die, the two profiles are different, especially for the older cohorts with higher mortality rates. Because the fixed effects estimator estimates asset growth for the same households, it does not suffer from mortality bias.

The question remains, however, whether these run-ups in assets were anticipated. Because the sample period was 1996–2004 and the fixed effects profiles track asset growth over the sample period, the fixed effects profiles still suffer from mixing anticipated asset gains with unanticipated asset gains from the stock and housing markets, as mentioned previously. Figure 9 shows the fixed effects profiles, as well as the fixed effects profiles that adjust for the run-up in asset prices by using the methods described earlier. Specifically, the adjusted profiles show what would have happened to assets if there had been no run-up in asset prices and savings rates had been unchanged. The adjusted profiles indicate that, had there been no run-up in asset prices, there would have been steep declines in assets over the sample period. When adjusting for return shocks, assets decline 35 percent between 1996 and 2004 for the cohort born in 1919–23. Other cohorts also have large asset declines after adjusting for asset returns. Between 1996 and 2004, the adjusted fixed effects asset profiles decline 27 percent, 41 percent, and 51 percent for the cohorts born in 1914–18, 1909–13, and 1904–08, respectively. In short, asset profiles decline dramatically after adjusting for both mortality bias and rate of return shocks.

Table 3 summarizes our results. It shows several things. First, the OLS estimates indicate that assets rise between 1996 and 2004. Second, fixed effects estimates indicate that assets fall with age. Third, making adjustments for rate of return shocks indicates that individuals would likely have reduced their assets

FIGURE 9

Wealth profiles: Fixed effects and adjusted fixed effects estimates



Notes: FE means fixed effects. The adjustment accounts for the run-up in asset prices over the period 1996–2004. The average age of each cohort in 1996, 1998, 2000, 2002, and 2004 was used to plot this figure. All dollar values are in 1998 dollars.

Source: Authors' calculations based on data from the *Asset and Health Dynamics Among the Oldest Old*.

rapidly had there been no run-up in asset prices. Finally, older cohorts tend to have more rapid asset decumulation than younger cohorts.

The estimates in this article are similar to estimates in other studies that use panel data and account for mortality bias. Hurd (1990) summarizes the earlier literature on asset decumulation. For example, Hurd (1990) reports that over the 1969–79 period, wealth declined 13.9 percent among retirees when using data from the University of Michigan's *Retirement History Survey*. This is roughly similar to our fixed effects estimates where we did not control for the run-up in asset prices. Diamond and Hausman (1984), using data from the U.S. Bureau of Labor Statistics' *National Longitudinal Survey of Mature Men*, find that wealth declines 5 percent per year after retirement during the years 1966–76. There are several important differences between our article and these earlier studies. First, the earlier studies do not attempt to adjust for rate of return shocks. Second, these earlier studies measured asset changes during a time when households received negative return shocks. Finally, these earlier studies did not have much information on the decisions of households with heads aged 80 and older. Using data from the Federal Reserve Board's *Survey of Consumer Finances* for the years 1983–95, Poterba (2001) compares those aged 70–74 versus those aged 75 and older. He finds that those aged 75 and older have 18 percent less wealth than those aged 70–74. His estimates control for cohort effects, but not mortality bias or rate of return shocks. Using data from the *Survey of Consumer Finances*, Sabelhaus and Pence (1999) account for mortality bias and find somewhat sharper declines in assets.

Conclusion

A key implication of the life-cycle model is that assets are run down as individuals near death. This article presents new evidence on asset rundown at the end of the life cycle. We show that older individuals have lower assets than younger individuals when observing individuals at different ages at a single point in time. We also show that wealth declines modestly with age when tracking the same individuals as they age. Because we track households over the 1996–2004 period, we observe individuals in 1996 and the same individuals eight years later, in 2004. Although we can measure the asset growth of the exact same people, we do not know whether assets grew because

TABLE 3

Estimated wealth change by cohort and estimation technique, 1996–2004

Year of birth	Average age in 1996	Percent change, OLS	Percent change, FE	Percent change, adjusted FE
1919–23	74	0.06	–0.12	–0.35
1914–18	79	0.07	–0.05	–0.27
1909–13	84	0.13	–0.15	–0.41
1904–08	89	0.09	–0.37	–0.51

Notes: OLS means ordinary least squares. FE means fixed effects.

Source: Authors' calculations based on data from the *Asset and Health Dynamics Among the Oldest Old*.

of intentional savings decisions or because of the run-up in asset prices over this period. Using the methods described in this article to adjust for the run-up in asset prices, we find that assets fall rapidly with age. Thus, both methods indicate that assets fall substantially with age. Although assets decline with age, the simplest versions of the life-cycle model predict even faster asset decumulation. Instead, we also show that our results fit better with versions of the life-cycle model that are augmented to include life expectancy and medical expense uncertainty, as well as bequest motives.

NOTES

[1]However, it might affect the savings decisions of the children; see Gale and Perozek (2001). Gale and Perozek also point out that the presence of a bequest motive does not imply that the estate tax reduces national savings. Whether the estate tax raises or lowers national savings depends upon the type of bequest motive, as well as the decisions of children.

[2]Specifically, we do more to take into account rates of return from investments other than housing and stocks, such as bonds. Also, we investigate more aspects of the return to housing, such as the value of the service flow provided by housing. We also match our estimated returns in the flow of funds accounts to provide evidence on the quality of our estimated return procedures. Lastly, we exclude the value of trusts from our asset measure. This last point is described further in the data section.

[3]An alternative of self-insuring against the risk of long life is to purchase annuities. However, very few people purchase annuities, potentially because administrative costs and adverse selection make them very expensive.

[4]Survivor probabilities are from the U.S. life tables (Arias, 2006).

[5]We assume that the interviews happened on January 1 of each year; for example, for the 1996 wave, we assume the interviews were held on January 1, 1996. Different people were interviewed at different times of the year. In all waves, at least 75 percent of all AHEAD households were interviewed within a few months of the assumed interview date (for example, between November 1995 and March 1996 for the 1996 wave).

[6]We also drop AHEAD cases that overlap with the University of Michigan's *Health and Retirement Study*. Of 5,990 households in the AHEAD, we drop 353 households because of this criterion. We also drop 678 households that left the sample for reasons other than death. This leaves us with 4,959 households. We also drop the first wave, because the first wave's asset data are suspect. Because 549 households have all members die by 1996, we are left with 4,410 alive in 1996 for the main analysis, of whom 4,408 have useful asset information. Of those 4,408 households, 2,304 households had at least one member still alive in 2004 and 2,104 households had all members die by 2004.

[7]In order to be comparable to the rest of the literature, we do not include the value of the estate for those who die. See French, De Nardi, Jones, Baker, and Doctor (2006) for how including the value of the estate potentially affects estimates of asset rundown.

[8]This is calculated as $s^k(t) = \frac{\sum_{i=1}^{I} A^k(it)}{\sum_{i=1}^{I} A(it)}$, where k is the asset type and I is the number of individuals in the sample. An alternative approach is to calculate $s^k(t) = \sum_{i=1}^{I} s^k(it) = \sum_{i=1}^{I} \frac{A^k(it)}{A(it)}$. This alternative approach shows a greater share of the average household's portfolio in housing, liquid assets, and debt.

[9]Another 4 percent of wealth was in IRAs. Cheng and French (2000) find that 60 percent of all IRA wealth was held in stocks during our sample period, so it is likely that about 27 percent of household wealth was held in stocks directly or through IRAs.

[10]To derive equation 2, note that equation 1 can be rewritten as

$$\begin{aligned} A(it+1) &= [(1+r^1(t)(1-\tau(it)))A^1(t) + \ldots + (1+r^K(t)(1-\tau(it)))A^K(it)] \\ &\quad + S(it) \\ &= A(it) + [(r^1(t)(1-\tau(it)))A^1(it) + \ldots + (r^K(t)(1-\tau(it)))A^K(it)] \\ &\quad + S(it) \\ &= (1 + [r^1(t)s^1(it) + \ldots + r^K(t)s^K(it)]\,(1-\tau(it)))\,A(it) + S(it), \end{aligned}$$

which is equation 1, with equation 2 substituted for $r(it)$.

[11]We assume that the return on debt and autos is 3 percent. We assume that business wealth is split 15 percent and 85 percent between stocks and housing, respectively, which seemed to match growth in the flow of funds accounts better than any other combination of stocks and housing. Although it is difficult to know whether liquid assets, such as bonds, are short or long maturity in the flow of funds accounts, our best estimate was that 31 percent was in short-term financial instruments and the other 69 percent was in long-term instruments.

[12]However, the series derived using portfolio shares gives a higher average return (average of 5.8 percent) than the flow of funds accounts measure (average of 0.6 percent) over the sample period. The reason for the discrepancy is at least partly due to the flow of funds accounts' measure of savings. The flow of funds accounts' measure of income includes rent, dividends, and interest. Ideally, the savings measure would be free of rent, dividends, and interest, as they are part of the return from assets. Furthermore, the flow of funds accounts' consumption measure does not include the service flow from owner-occupied housing. Thus, the flow of funds accounts overstate our savings measure, and thus understate the return from assets. On the other hand, our return measures are not net of brokerage fees and administrative costs, so our method using shares may overstate the return households face.

[13]The reason for the lack of observations is that the core sample was age 70 and older in 1994, and thus age 76 and older by 2000.

[14]Because we have a fixed effect for each household, the age 74 coefficient is captured in the intercept term f_i; the age 74 wealth level is just the average fixed effect for individuals aged 74.

APPENDIX 1: A MATHEMATICAL REPRESENTATION OF THE LIFE-CYCLE MODEL

In order to fix ideas about the life-cycle model, we discuss a parameterized mathematical model of how individuals consume and save over their lives. In the figure 1 (p. 50), we show the implied consumption and wealth profiles for a given initial value of wealth and for income over the life cycle. Assume that there is no uncertainty about income, or medical expenses, although we will allow for uncertainty about age of death. The model is similar to that of Palumbo (1999), although it also allows for a bequest function, as in Hurd (1989).

Specifically, consider a household head seeking to maximize his expected lifetime utility at age t, $t = 70, 71, 72, \ldots$. Each period that he lives, the individual receives utility, U_t, from consumption, C_t. Furthermore, assume that his preferences are of the constant relative risk aversion form, so that $U_t = \frac{(C_t)^{1-\gamma}}{1-\gamma}$ and $U_t = \ln C_t$ if $\gamma = 1$. The parameter γ is called the coefficient of relative risk aversion. The greater the value of γ, the more risk averse the individual. Most estimates of γ are between 1 and 5. A value of γ equal to 1 implies that an individual would be indifferent to consuming \$14,140 this year or consuming a sum determined by the following lottery: with probability 1/2 consume \$10,000 this year and with probability 1/2 consume \$20,000. Note that this lottery has an expected payout of 1/2 × \$10,000 + 1/2 × \$20,000 = \$15,000. If the individual has γ equal to 5, an individual would be indifferent to consuming \$11,700 this year or consuming a sum determined by the lottery described here. In other words, the greater the value of γ, the greater the amount the individual is willing to pay to avoid the risk associated with a lottery.

When the individual dies, he values bequests of assets, A_t, according to a constant relative risk aversion bequest function $b(A_t) = \theta_B \frac{(C_t)^{1-\gamma}}{1-\gamma}$. The greater the value of θ_B, the stronger the bequest motive. We know very little about this parameter.

Let s_t denote the probability of being alive at age t, conditional on being alive at age $t-1$, and let $S(j,t) = \left(1/s_t \right) \prod_{k=t}^{j} s_k$ denote the probability of living to age $j \geq t$, conditional on being alive at age t. Let $T = 95$ denote the terminal period, so that $s_{T+1} = 0$.

We assume that preferences take the form

$$\text{A1)} \quad U(C_t) + E_t\left(\sum_{j=t+1}^{T+1} \beta^{j-t} S(j-1,t) \left[s_j U(C_j) + (1-s_j) b(A_j) \right] \right),$$

where E_t is an expectations operator and β is the time discount factor. The smaller the value of β, the more individuals discount the future relative to the present. Most estimates of β are between 0.95 and 1.

Furthermore, assume that individuals have the following asset accumulation equation:

$$\text{A2)} \quad A_{t+1} = (1 + r)(A_t + Y_t - m_t - C_t), \; A_{t+1} \geq 0,$$

where r is the interest rate, Y_t is income, and m_t is the medical expenses. Assets must always be nonnegative in all periods.[1] In this article, we present simulations from this model.

When presenting profiles implied by the model, we consider a value of γ equal to 3 and β equal to 0.95. Throughout the article, we will assume that assets in the bank receive a 4 percent rate of interest. Initial assets at age 70 are \$300,000 (which is close to the mean for our sample), and income at each age is \$20,000 (which is close to the mean in our sample).

[1]If the nonnegativity constraint on assets implies consumption below \$5,000 (which is a conservative estimate of the Supplemental Security Income, housing, and Medicaid benefits the elderly can receive), we set consumption equal to \$5,000. See French and Jones (2004b) for more on this.

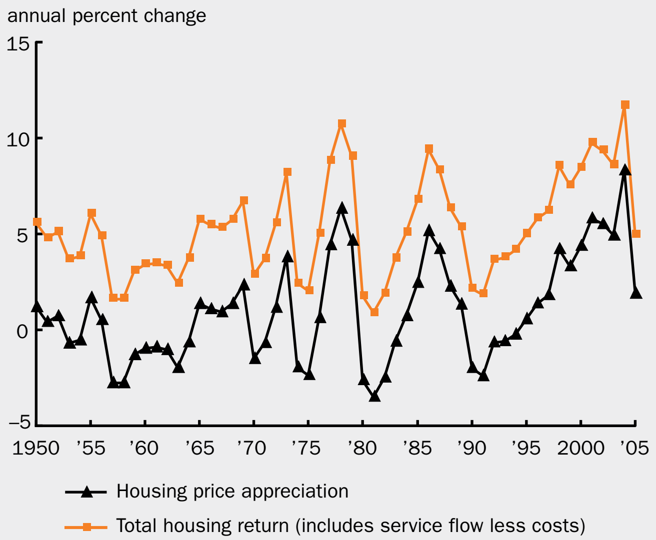
For price growth rates between 1950 and 1971, data are from the price index for private residential investment divided by the price index for all personal consumption expenditures, as measured in the NIPAs. For housing price growth after 1971, data are the price series from the Conventional Mortgage Home Price Index from the U.S. Office of Federal Housing Enterprise Oversight, which measures the price change for resold single-family homes. Because the OFHEO index measures the price of the same houses over time, the index accounts for the fact that the quality of houses may have changed over time.

We calculate the service flow from housing, less the costs, using the following approach. We begin by measuring the service flow from housing in 2005. Smith and Smith (2006) collected data in 2005 from ten metropolitan areas in the United States, and documented an average price of a house and the equivalent rental price for the same (or similar) property for each of those areas. They find that in 2005, the average annual rent on a house was 6 percent of its value. We made several assumptions about the annual costs associated with homeownership. In particular, we assumed that the total annual costs of owning a home were equal to 3 percent (1 percent for maintenance, 1 percent for taxes, and 1 percent for transaction fees, assuming that total transaction fees were 6 percent and owners sold the house after 6 years of residency). Thus, we infer that the annual service flow of housing, net of costs, was 3.05 percent of the average house price in 2005.

Unfortunately, we are aware of no time series of rents, less the costs, for housing. However, we have time series on *changes* in rents (from the Consumer Price Index, or CPI, owners' equivalent rent index, which began in 1982) and *changes* in home prices (from the OFHEO). The CPI owners' equivalent rent index is constructed from a survey that asks homeowners how much their homes would rent for if they were to rent them out. These two series are useful because they allow us to calculate growth in rents and housing, although they do not allow us to calculate the level of rents to house prices. Using these two series, we can calculate the relative inflation rates in the two series. We find the relative price of rents relative to housing (normalized to 1 in 2005) and multiply this by the 3.05 percent return in 2005. Using this series, we find that the return from the service flow from housing was 4.37 percent in 1982 and then fell to 3 percent in 2005. We assume the return from the service flow to housing was also 4.37 percent in all years before 1982. Figure A1 shows our values for both house price inflation and also for house price inflation plus the service flow from housing, less the costs.

FIGURE A1

Growth in housing prices and total return from housing, 1950–2005



Sources: Authors' calculations based on data from the U.S. Bureau of Economic Analysis, national income and product accounts; U.S. Office of Federal Housing Enterprise Oversight, Conventional Mortgage Home Price Index; U.S. Bureau of Labor Statistics, Consumer Price Index, owners' equivalent rent component; and Smith and Smith (2006).

APPENDIX 3: RETURN FROM LONG BONDS

We used two data sources to construct a series of annual long-term bond returns. Data for corporate, Treasury, and municipal securities are provided by Merrill Lynch and are available back to 1973, 1978, and 1989, respectively. For previous years, dating back to 1960, we also used data on long government bonds, corporate securities, and Treasury securities collected by the Center for Research in Security Prices and analyzed by Ibbotson Associates. The long bond indexes typically had a maturity of 15–20 years. We used weights from portfolio shares for heads of households aged 70 and older from the Federal Reserve Board's *Survey of Consumer Finances*.

REFERENCES

Anderson, Kate, Eric French, and Tina Lam, 2004, "You can't take it with you: Asset rundown at the end of the life cycle," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 28, No. 3, Third Quarter, pp. 40–54.

Arias, Elizabeth, 2006, "United States life tables, 2003," *National Vital Statistics Report*, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, Vol. 54, No. 14, available at www.cdc.gov/nchs/data/nvsr/nvsr54/nvsr54_14.pdf.

Attanasio, Orazio P., and Hilary Williamson Hoynes, 2000, "Differential mortality and wealth accumulation," *Journal of Human Resources*, Vol. 35, No. 1, Winter, pp. 1–29.

Brown, Jeffrey R., and Amy Finkelstein, 2004, "The interaction of public and private insurance: Medicaid and the long-term care insurance market," National Bureau of Economic Research, working paper, No. 10989, December.

Cheng, Ing-Haw, and Eric French, 2000, "The effect of the run-up in the stock market on labor supply," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 24, No. 4, Fourth Quarter, pp. 48–65.

Cochrane, John H., 1997, "Where is the market going? Uncertain facts and novel theories," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 21, No. 6, November/December, pp. 3–37.

Davies, James B., 1981, "Uncertain lifetime, consumption, and dissaving in retirement," *Journal of Political Economy*, Vol. 89, No. 3, June, pp. 561–577.

Davies, James B., and Anthony F. Shorrocks, 2000, "The distribution of wealth," in *Handbook of Income Distribution*, Vol. 1, A. B. Atkinson and F. Bourguignon (eds.), Amsterdam: Elsevier Science, chapter 11.

De Nardi, Mariacristina, Eric French, and John Bailey Jones, 2006, "Differential mortality, uncertain medical expenses, and the saving of elderly singles," Federal Reserve Bank of Chicago, working paper, No. WP-2005-13, revised March 2006.

Diamond, P. A., and J. A. Hausman, 1984, "Individual retirement and savings behavior," *Journal of Public Economics*, Vol. 23, No. 1/2, pp. 81–114.

Dynan, Karen E., and Dean M. Maki, 2001, "Does stock market wealth matter for consumption?," Board of Governors of the Federal Reserve System, Finance and Economics Discussion Series, discussion paper, No. 2001-23, May.

Feenberg, Daniel, and Jonathan Skinner, 1994, "The risk and duration of catastrophic health care expenditures," *Review of Economics and Statistics*, Vol. 76, No. 4, November, pp. 633–647.

French, Eric, Mariacristina De Nardi, John Bailey Jones, Olesya Baker, and Phil Doctor, 2006, "Right before the end: Asset decumulation at the end of life," *Economic Perspectives*, Federal Reserve Bank of Chicago, Vol. 30, No. 3, Third Quarter, pp. 2–13.

French, Eric, and John Bailey Jones, 2004a, "On the distribution and dynamics of health care costs," *Journal of Applied Econometrics*, Vol. 19, No. 6, pp. 705–721.

__________, 2004b, "The effects of health insurance and self-insurance on retirement behavior," Federal Reserve Bank of Chicago, working paper, No. WP-2001-19, revised March 2004.

Gale, William G., and Maria G. Perozek, 2001, "Do estate taxes reduce saving?," in *Rethinking Estate and Gift Taxation*, William G. Gale, James R. Hines Jr., and Joel Slemrod (eds.), Washington, DC: Brookings Institution Press, pp. 216–247.

Hurd, Michael D., 1990, "Research on the elderly: Economic status, retirement, and consumption and saving," *Journal of Economic Literature*, Vol. 28, No. 2, June, pp. 565–637.

__________, 1989, "Mortality risk and bequests," *Econometrica*, Vol. 57, No. 4. July, pp. 779–813.

Juster, F. Thomas, James P. Smith, and Frank Stafford, 1999, "The measurement and structure of household wealth," University of Michigan, manuscript.

Modigliani, Franco, and Albert Ando, 1957, "Tests of the life-cycle hypothesis of saving: Comments and suggestions," *Bulletin of the Oxford Institute of Statistics*, Vol. 19, May, pp. 99–124.

Palumbo, Michael G., 1999, "Uncertain medical expenses and precautionary saving near the end of the life cycle," *Review of Economic Studies*, Vol. 66, No. 2, April, pp. 395–421.

Poterba, James, 2001, "Demographic structure and asset returns," *Review of Economics and Statistics*, Vol. 83, No. 4, November, pp. 565–584.

Rohwedder, Susann, and Steven J. Haider, and Michael D. Hurd, 2004, "Increases in wealth among the elderly in the early 1990s: How much is due to survey design?," National Bureau of Economic Research, working paper, No. 10862, November.

Sabelhaus, John, and Karen Pence, 1999, "Household saving in the '90s: Evidence from cross-section wealth surveys," *Review of Income and Wealth,* Vol. 45, No. 4, December, pp. 435–453.

Shorrocks, Anthony F., 1975, "The age–wealth relationship: A cross-section and cohort analysis," *Review of Economics and Statistics*, Vol. 57, No. 2, May, pp. 155–163.

Smith, Margaret H., and Gary Smith, 2006, "Bubble, bubble, where's the housing bubble?," Brookings Panel on Economic Activity, Washington, DC, unpublished draft, March 30–31.

SAVE THE DATE

Tenth Annual International Banking Conference

Globalization and Systemic Risk

September 27–28, 2007
Federal Reserve Bank of Chicago

In conjunction with the International Monetary Fund, the Federal Reserve Bank of Chicago will hold its tenth annual International Banking Conference on September 27–28, 2007. This year's theme is Globalization and Systemic Risk and addresses the current landscape of cross-border banking activity, how systemic risk may be enhanced or contained by globalization, the potential sources of systemic risk (particularly banks, insurance companies, pension funds, hedge funds, and other capital market participants), regulatory efforts currently underway to address systemic concerns, and what policy alternatives need to be considered going forward. The two-day conference will feature keynote presentations by Frederic Mishkin, Governor, U.S. Federal Reserve Board, and John Lipsky, First Deputy Managing Director, International Monetary Fund.

Last year, the conference attracted over 170 participants from some 40 countries.

Additional information, including the agenda and conference and hotel registration information, will be posted at:

www.chicagofed.org/InternationalBankingConference

LOCATION:
Federal Reserve Bank of Chicago
230 South LaSalle Street
Chicago, IL 60604–1413

FOR SPECIFIC QUESTIONS, CONTACT:
Ms. Blanca Sepulveda
(312) 322-8340
Blanca.Sepulveda@chi.frb.org