The Impact of Population Aging on Financial Markets

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The United States and many other developed nations are in the midst of a demographic transition. By 2030, the fraction of the U.S. population over the age of 65 will be greater than the current fraction in Florida. This demographic transition will have profound social and economic implications. Its impact on government fiscal balance has received widespread and growing attention. The substantial rise in the ratio of retired workers to those in the labor force during the next three decades will place substantial strains on public pension and health insurance programs. Some combination of higher taxes, reduced program benefits, and protracted government deficits is a likely consequence. In many other developed nations, the fiscal prospect is even more daunting than it is in the United States. More generally, as Arnott and Casscells (2004) and others have observed, the transition to an economy with many more aged dependents relative to the active workforce will require many adjustments in both the private and the public sector.

Population aging will affect government fiscal balances, but it is also likely to affect financial markets through other channels. Some argue that demographic changes, notably the entry of the baby boom cohort into their traditional high-saving years, contributed to the rise in stock prices during the 1990s. They extend this argument to suggest that when the baby boom cohort reaches retirement, many households will try to sell financial assets to support retirement consumption, thereby driving down asset values. Such selling pressure could reduce the long-term rate of return earned by baby boom investors on their retirement saving. Siegel (1998, p.41) describes this concern:

> The words "Sell? Sell to whom?" might haunt the baby boomers in the next century. Who are the buyers of the trillions of dollars of boomer assets? The [baby boomer generation] … threatens to drown in financial assets. The consequences could be disastrous not only for the boomers' retirement but also for the economic health of the entire population.

Schieber and Shoven (1997) develop this argument with regard to defined benefit pension funds: Net flows into these funds will shift from positive to negative as the population ages. In addition to affecting the market-wide pattern of asset returns, aging populations may also change the composition of financial products demanded by the household sector.

The paper examines the potential impact of population aging on asset returns, the valuation of financial assets, and the demand for various financial products and services. It does not consider the implications of demographic shifts for government budgets or fiscal balance, and it sidesteps the important issues that surround the differential aging of different nations and the resulting international capital flows.

The paper is divided into seven sections. The first provides a brief review of the demographic changes that will confront the United States and other developed nations during the next half-century. It summarizes the projected evolution of the share of the population between the ages of 40 and 64, and over the age of 65. Section two develops a conceptual framework for analyzing how an aging population, triggered by falling birth rates and rising life expectancy in old age, affects the demand for financial assets. A number of studies have modeled the impact of a "baby bust" on financial markets. This section describes the key features of the various models and it highlights the modeling assumptions that affect the results. While these models suggest that demography should affect equilibrium asset returns, they do not offer precise guidance on the empirical magnitude of such effects. This makes the analysis of historical relationships, and cross-country patterns, essential. The third section reviews previous empirical research on the relationship between demographic structure and asset returns.

The next three sections present new empirical evidence on the links between population aging and financial markets. Section four describes the age-specific pattern of asset holdings that emerges from the 2001 Survey of Consumer Finances and outlines the challenges that arise in estimating how population aging will alter aggregate asset demand. The fifth section presents new findings on the historical correlation between various measures of population age structure, asset returns on bonds and stocks, and the level of asset prices. As in the previous literature, the empirical findings are mixed. The most robust finding is a positive correlation between the share of the population in the prime working years and the level of stock prices, as measured by the price-dividend ratio. Even where statistically significant historical relationships emerge, however, there are often questions about the plausibility of the findings. In some cases the historical patterns, if extrapolated for the next three decades, suggest unreasonably large changes in asset prices. This raises the important possibility that demographic variables proxy for other omitted factors that may determine asset prices. Minor changes in the econometric specification also appear to lead to substantial changes in the empirical results in many cases.

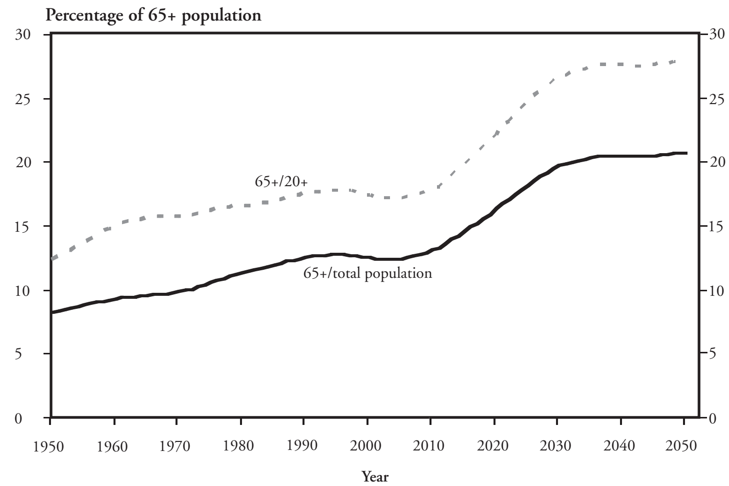
Section six moves beyond the analysis of aggregate financial market effects and explores the potential effect of population aging on the demand for particular categories of financial assets. Products such as annuities and long-term care insurance, which are demanded by households late in the life cycle, are likely to account for a growing share of financial market activity. Population aging may increase demand for products that facilitate the preservation or the draw-down of wealth, rather than the accumulation of assets. A critical question in making quantitative projections about future asset demands is whether the age-specific pattern of asset ownership is stable over time. A brief conclusion outlines some of the unresolved issues that are likely to play an important role in determining the long-run effect of population aging on financial markets.

The demographic transition in the United States and other nations 1

Between 2000 and 2030, the U.S. Census Bureau projects that the fraction of the U.S. population over the age of 65 will grow from 17 to 27 percent of the population over the age of 20. Chart 1 shows the historical and projected percentage over age 65 in the total U.S. population and in the adult (age 20+) population. Chart 2 presents analogous information on the population between the ages of 40 and 64. Table 1 reports the data that underlie these figures, as well as additional information on the coming demographic shift. The table shows that the median age of the U.S. population is projected to rise by 3.6 years over the next four decades. This reflects an ongoing trend; the median age in the U.S. rose by 7.5 years between 1970 and 2000.

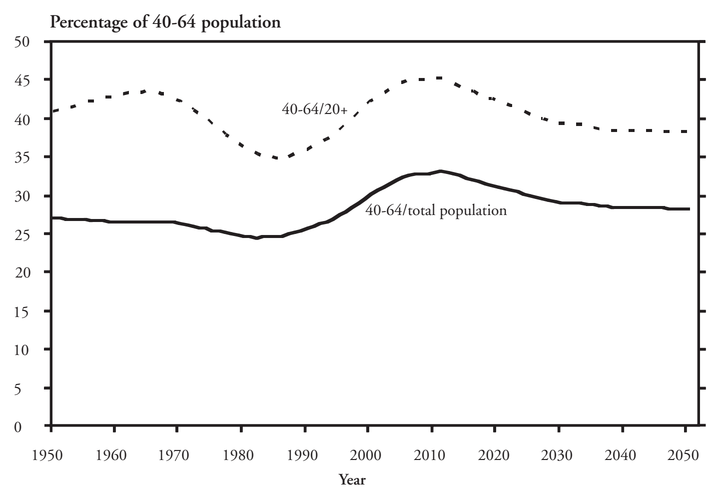
Many discussions of the prospective impact of demographic change on financial markets emphasize the changing share of the population in the "asset accumulating years," ages 40-64. Chart 3 explains the basis for this attention. During the last 50 years, the real level of stock prices, as measured by the real value of the Standard and Poor's 500, has moved in tandem with the fraction of the adult population in this age group. The relationship holds for long time periods, although there are high-frequency movements in stock prices that are not related to demographics. The pattern in this chart is reflected in the econometric results presented.

Chart 1
Percentage of 65+ Population Among Total Population and Among 20+ Population, 1950-2050



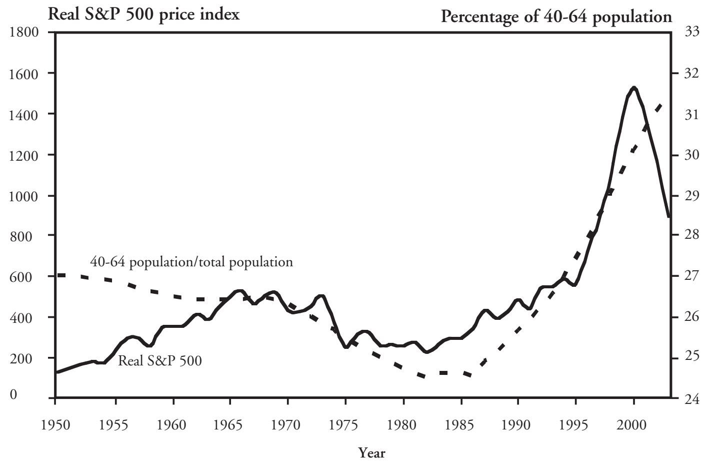
Source: Calculated from the U.S. Census Data

Chart 2
Percentage of 40-64 Population Among Total Population and Among 20+ Population, 1950-2050



Source: Calculated from the U.S. Census Data

Chart 3
Real S&P500 Price Index and Percentage of 40-64 Population Among Total Population, 1950-2003



Source: Population data are calculated from the U.S. Census Data
Real S&P 500 price index data are from Robert Shiller's website
http://www.econ.yale.edu/-shiller/data.htm

Whether this pattern reflects a causal link between demographic variation and the value of the stock market remains an open question.

The third column in Table 1 shows the predicted changes in the share of the population between the ages of 40 and 64, and places these changes in historical perspective. This percentage rose by roughly four percentage points, to 30.1, between 1970 and 2000. It is projected to rise to 33.1 percent in 2010, and then to drop nearly five percentage points to 28.3 percent by 2040. The predicted change during the next half-century is not substantially outside the range of historical experience. What *is* different, however, is the growing share of older individuals relative to children in the dependent population.

The penultimate column of Table 1 tracks the share of the over-20 population in the key asset accumulating years of 40-64. Individuals in this age group accounted for 42.2 percent of the adult population in 2000, an increase of six percentage points from just a decade earlier. This age group is projected to account for more than 45 percent of the adult population in 2010, but to decline to 38.3

Table 1
Historical and Forecast Values for Indicators of Demographic Structure, 1920-2050

Year	Median age	Average age of those 20+	Percent of pop. 40-64	Percent of pop. 65 and over	(Population 40-64) /population 20+	(Population > 65) /population 20+
1920	25.3	40.3	22.2	4.63	0.375	0.078
1930	26.5	41.2	24.1	5.45	0.392	0.089
1940	29.1	42.2	26.5	6.84	0.404	0.104
1950	30.2	43.5	27.0	8.14	0.409	0.123
1960	29.4	45.3	26.5	9.23	0.431	0.150
1970	27.9	45.2	26.3	9.81	0.423	0.157
1980	30.0	44.5	24.7	11.29	0.362	0.166
1990	32.8	45.3	25.7	12.52	0.361	0.176
2000	35.4	46.7	30.1	12.43	0.422	0.174
2010	37.4	48.3	33.1	13.03	0.455	0.178
2020	38.1	49.6	31.4	16.27	0.424	0.221
2030	38.9	50.9	28.7	19.65	0.389	0.266
2040	39.0	51.5	28.3	20.42	0.384	0.276
2050	38.8	52.5	28.3	20.65	0.383	0.279

Source: U.S. Census Bureau historical data and projections from CPS Reports P25-1130. Average age over 20 computed using the midpoint in five-year age intervals as the average age for all persons in that interval, and assuming that the average age for persons 85 and older is 90.

percent of the adult population by 2050. The historical record shows other periods of substantial variation in this ratio. In 1960, 43 percent of the adult population was between the ages of 40 and 64. The median age of the over-20 population in 1960 was 45.3 years. In 2000, it was 46.7, and it is projected to rise to 52.5 years by 2050.

Populations can grow older for three non-exclusive reasons: a decline in the birth rate, a decline in the mortality rate at old ages, or a decline in the number of young immigrants. The projected changes in the age structure of the U.S. population are due to a combination of falling fertility and rising old-age longevity. The birth rate in the United States declined from 3.03 in 1950, to 2.43 in 1970, to slightly greater than 2.0 today. At the same time, life expectancy for men at age 65 has increased from 12.8 years in 1950, to 15 years in 1990, to 16 years today. For women, the increase over the last half-century has been even larger, from 15.1 years in 1950 to 19 years today. When a population ages because the existing old live longer, it is challenged to transfer resources to individuals who did not expect to outlive their savings but did so because of mortality improvements. When a decline in birth rates is the predominant source of population aging, there is more time to prepare for the older population.

Demographic projections are more reliable than many types of long-term economic forecasts, because predicting the future number of individuals of a given age depends largely on the current number of younger individuals and the mortality rate over the prediction interval. It is nevertheless important to recognize two sources of potential uncertainty in these forecasts. The first is potential changes in either birth rates or mortality rates during the forecast period. The forecasts developed by the U.S. Census Bureau and the Social Security Administration do not project widely varying birth rates in the future, although there has been wide variation in the U.S. birth rate during the last half-century. They also embody future improvements in mortality at a relatively constant rate. It is possible that new diseases or major medical innovations could have a dramatic effect on the future course of mortality rates. There is an active debate within the demography literature on the likelihood of substantial improvements in the historical rate of mortality reduction.

The second source of uncertainty in demographic forecasts is immigration. If the United States were to substantially expand the number of immigrants who were allowed to enter the country over the next three decades, the rate of population aging would be slower than the data in Table 1 suggest. This is because the average age of immigrants is lower than the average age in the existing population. One open question about immigrants is whether they will decide to return to their home country when they retire. Such emigration could magnify the impact of immigration in offsetting the aging of the U.S. population.

The demographic shift facing the United States over the next few decades is matched, and in many cases exceeded, by the demographic changes in other nations. The decline in the U.S. birth rate during the last three decades has been smaller, and population aging in the United States is less dramatic, than that in many other nations. The pattern of aging in other developed nations is important for analyzing how financial markets in the United States will respond to an aging society. When only one nation experiences a demographic transition, international capital flows can blunt the impact on financial markets and on real activity. This moderating effect does not operate when many nations experience a demographic transition together. Bryant (2004) and Helliwell (2004) explore how differential rates of population aging in different nations may affect international capital flows.

Table 2 shows the evolution of the aged dependency ratio, the ratio of the number of individuals over the age of 65 to the number between the ages of 20 and 64, for a sample of developed nations. It also reports the total dependency ratio, which is the number of individuals over 65 or under 20 divided by the population aged 20-64. The table illustrates the relative speeds of the demographic transitions in different nations. In Italy, for example, where the birth rate has fallen to well below replacement in the last decade, the aged dependency ratio is projected to rise from 29 percent to 51 percent between 2000 and

Table 2
Dependency Ratios in Developed Nations, 2000 and 2030

	Aged dependency ratio: population 65+/population 20-64	
	2000	2030
United States	0.208	0.365
Canada	0.205	0.411
Germany	0.263	0.498
Italy	0.290	0.506
United Kingdom	0.267	0.440
Japan	0.276	0.560
	Total dependency ratio: (population < 20 or > 65)/population 20-64	
	2000	2030
United States	0.695	0.808
Canada	0.624	0.796
Germany	0.601	0.799
Italy	0.604	0.771
United Kingdom	0.693	0.809
Japan	0.607	0.864

Source: World Economic Forum Pension Readiness Initiative (2004)

2030. The corresponding change in Japan is nearly as large: 28 percent to 56 percent. By comparison, the changes in the United Kingdom and Canada are closer to those in the United States, which experiences an increase in the aged dependency ratio from 21 to 37 percent.

Conceptual analysis of age structure, asset prices, and asset returns 2

A variety of economic models suggest a link between demographic structure and asset values. The challenge is to move beyond the simple intuition that "demography matters" and to develop insight on the potential magnitude of demographic effects, while also understanding the factors that are likely to magnify or attenuate the impact of demographic influences on asset prices.

A very simple overlapping-generations model, sketched in Poterba (2001), offers a starting point for understanding why demographic shocks may affect asset prices and asset returns. The model assumes that individuals live for two periods. They work when young (y) and retire when old (o). Normalize their production while working to one unit of a numeraire good, and assume that there is also a durable capital good that does not depreciate and that is in fixed supply. If the saving rate out of labor income is fixed at s for young workers, then demand for assets in a period when there are N_y workers will be N_y*s. With a fixed supply of durable assets (K), the relative price of these assets in terms of the numeraire good (p) must satisfy p*K = N_y*s. A "baby boom," which increases the size of the young worker cohort, drives up asset prices so that the fixed physical supply of capital can meet the greater demand for financial asset holding. If a large birth cohort is followed by a small one, asset prices will increase and then decline. The return on investments by the large birth cohort will be low, since this cohort will purchase assets at high prices. A small cohort, in contrast, will earn a high return.

Key assumptions in modeling demography and asset prices

This simple model neglects many important realities of asset pricing. Four of the most important omissions are the following:

(i) Fixed saving rate for young workers. A more sophisticated analysis would allow workers to vary their saving rates in response to expectations about future rates of return. This requires an optimizing model of household behavior in which households choose how much to consume when they are working. If changing age structure affects the prices of financial assets, the associated changes in rates of return may affect saving decisions. If the saving rate of workers in a large cohort is lower than that for workers in a small cohort, the resulting demand for capital will be smaller and the price of capital will be bid up by less than the simple model suggests.

(ii) Fixed supply of capital. Fixing the supply of capital amplifies the impact of shocks to asset demand. In a more realistic setting, the price of capital goods will affect the growth of the capital stock. Abel (2001) and Lim and Weil (2003) show that allowing for a supply curve for capital goods can have an important impact on the link

from demography to asset prices. If the capital stock can be varied without any adjustment costs, then capital will always be priced at its reproduction cost, and demographic changes will not have *any* effect on the price of financial assets that represent claims on physical capital. In practice, there are likely to be costs to adjusting the capital stock, which admits the possibility of a link between demography and asset prices.

(iii) Closed economy without international capital flows. When the supply of capital in a single economy must equal the contemporaneous demand for that capital, the price of capital goods will vary more than when international capital flows allow for a more elastic supply of capital. With fully integrated global capital markets, asset prices and rates of return will depend only on global demographic forces to the extent that they affect the supply of saving. The large gross flows of financial capital across borders make the closed-economy assumption untenable, but perfect capital market integration also seems inconsistent with the empirical evidence. While the strong correlation between a country's investment rate and its saving rate, documented by Feldstein and Horioka (1980), appears to have weakened over time, it has not vanished. Obstfeld and Rogoff (2001) and Taylor (2002) offer recent overviews of the evidence on international capital market integration. Prospectively, the integration of capital markets in currently emerging economies with those of developed nations may be an important factor determining the link between domestic population age structure in developed nations and the demand for financial assets.

(iv) Other economic effects of population aging. The foregoing analysis does not consider how changing age structure may affect nonfinancial aspects of the economy, such as the rate of productivity growth, which play a central role in determining asset values and rates of return. Cutler, and others (1990) suggest that links between age structure and the rate of productivity improvement, if they exist, can swamp many other channels linking demographic change to equilibrium factor returns. Bosworth, Bryant, and Burtless (2004)

summarize existing evidence on how worker productivity varies over the lifecycle, and discuss a number of other channels through which a demographic shock may influence economic activity. Miles (1999), Börsch-Supan (2004), and others describe many channels other than the asset accumulation issues that are the focus of this paper through which population aging may affect aggregate economic activity.

Overview of previous models

A number of research studies have explored the effect of population aging on asset markets in stylized models that try to incorporate a more realistic description of saving behavior and asset price determination. The analysis is set in a closed economy and focuses only on how aging will affect the supply of saving. The models relax the stylized assumption of a fixed saving rate, and replace it with an overlapping-generations environment in which consumers live for many periods and formulate rational life-cycle plans. Some models also allow for a variable supply of capital, with adjustment costs.

Abel (2001, 2003) presents analytical results based on an overlapping generation model with a variable supply of capital. He shows that a stylized "baby boom," in which the birth rate rises and then falls, reduces the rate of return relative to what it would be in a steady state economy with a stable birth rate. Those born into a "baby boom cohort" therefore face less attractive capital market opportunities than those born at other times. Abel (2001) also explores the sensitivity of findings about demography-linked changes in asset prices to alternative models of saving behavior, and in particular the impact of allowing individuals to have a bequest motive. The basic results that emerge in models without a bequest motive can also obtain in models with a bequest motive, but the findings are sensitive to the specification of the bequest motive.

Several other studies have used calibrated versions of a numerical intertemporal general equilibrium model to study how changing cohort size affects asset prices and asset returns. Three examples of such models, in chronological order, are Yoo (1994a), Brooks (2002), and Geanakoplos, Magill, and Quinzii (2004). All of these models suggest that a demographic transition affects capital market returns, although the magnitude of the effect varies across models.

Yoo (1994a) calibrates a model in which overlapping generations of consumers live for 55 periods and work for 45. He finds that a rise in the birth rate, followed by a decline, first raises then lowers asset prices. While this broad pattern is consistent with the claim that the baby boom cohort may face lower financial market returns over their lifetime, the effects appear to be quite sensitive to whether or not capital is in variable supply. With a fixed supply of durable assets, asset prices in the "baby boom economy" rise nearly 35 percent above their level in the baseline case. This effect is attenuated, to a 15 percent increase in asset prices, when capital is in variable supply. In the case of variable asset supply, the return on capital varies by 40 basis points in a simulation of a "baby boom" that is loosely calibrated to resemble that in the United States during the last four decades.

Brooks (2002) also presents simulation evidence in an overlapping generations economy. Unlike Yoo's (1994a) specification in which individuals live for 55 years, he assumes that individuals live for four periods. His model incorporates both risky and riskless assets, however, so it is possible to explore how demographic shocks affect the risk premium. The model is calibrated so that older individuals prefer to hold less risky assets. Rapid population growth that persists for half a generation and that is followed by below-average population growth affects the equilibrium level of both risky and riskless asset returns. Equilibrium returns on the risky asset change by roughly half as much as the riskless return, so the equilibrium equity risk premium declines in the early stage of the "baby boom," and then increases when the large cohort is old. Brooks' (2002) simulation of a rise and then decline in the birth rate that is calibrated to mimic recent U.S. history suggests that riskless returns change by about 30 basis points as a result of the demographic shift, while asset prices vary by less than 7 percent as a result of this demographic shock.

Geanakoplos, Magill, and Quinzii (hereafter GMQ) (2004) develop an even more elaborate overlapping generations model in which they incorporate a number of factors, such as realistic age-income patterns, that improve the model's similarity to the postwar U.S. economy. They also explore the sensitivity of their findings to allowing for Social Security, bequests, and a range of other factors. Their core findings suggest that demographic shocks like those experienced in the postwar United States could generate substantial swings in asset values, but that actual peak-to-trough movements in the stock market are two to three times greater than the demographic analysis can explain. The GMQ results suggest larger effects of demography on asset values than either of the previous studies. They also offer insight on the comovement of riskless returns, the risk premium, and the value of claims on risky assets. The analysis is based on a closed economy model, so international capital flows might moderate the effects.

One common feature of the simulation models described above is their assumption that agents have perfect foresight about demographic shocks. This implies that when a demographic shift such as a decline in the birth rate occurs, it affects asset markets immediately. The long resulting lead times associated with demographic shocks mitigate the impact of these shocks on asset prices, because any potential adjustments such as changes in the capital stock can take place in advance.

The forward-looking character of asset markets casts substantial doubt on claims that asset prices will fall sharply when baby boomers begin to retire. If such a decline were expected, then traders could profit by short-selling in advance of the price change, and long-term investors would benefit from shifting portfolios to short-maturity riskless assets before the price decline. Through this mechanism, prices would decline *before* the actual retirement of the baby boom cohort. If investors are forward-looking and recognize today how demographic structure will evolve, the potential future price decline should already be incorporated into prices. Whether capital market participants are in fact so far-sighted is an important factor in determining the current and future impact of demographic change on asset markets. An intriguing recent study by Della Vigna and Pollett (2003) raises some questions about whether capital market participants are fully forward-looking. It suggests that changes in demographic factors more than six years into the future do not have large effects on asset prices, while nearer-term effects do matter.

The simulation models described above suggest that large demographic shocks have the potential to influence asset prices and asset returns, although the precise magnitude of these effects is not clear. In most settings, a plausibly-calibrated shock that resembles the baby boom in the United States appears to have a modest impact on asset returns. The results are sensitive to a number of modeling assumptions and choices about parameters, however, which motivates the analysis of historical data on asset returns, asset prices, and demographic structure. The next section provides a brief review of the empirical literature that has explored these issues. Unfortunately, the empirical work does not resolve many of the outstanding questions, so the guidance offered by theoretical models must play an important part in evaluating the likely effects of demographic change.

Existing empirical work on demographic structure and asset returns 3

Nearly a dozen studies have investigated the correlation between demographic structure and the prices of or returns on financial assets. Most of the research has analyzed time series data for the United States, but several studies have also explored the patterns in other nations. The results are mixed, with some studies finding what appear to be large effects of demographic structure, while other studies fail to reject the null hypothesis that population age structure and returns or asset prices are unrelated. The differences in the findings in the various studies can be attributed to differences in the econometric specification and in sample period. This section offers a brief review of the empirical literature, starting with the research on the United

States and then describing the studies on other nations. It highlights the limited amount of data that can be brought to bear to study demographic effects on asset markets.

To provide some perspective on the increasing sophistication of the empirical literature that considers how demography affects asset returns, I will describe a number of notable studies in chronological order. I begin with studies that focus on the relationship between asset returns and demographic variables, and then consider studies that focus on other variables.

The first study of population age structure and financial market returns, by Bakshi and Chen (1994), began from the presumption that older individuals are more risk averse than younger ones. A rise in the average age of the population would therefore be associated with an increase in aggregate risk aversion. All else equal, this would increase the required risk premium in financial markets. This study found that the fit of an empirical Euler equation for the intertemporal variation in aggregate consumption could be improved if the parameter describing aggregate risk aversion varied with the average age of the U.S. population. The results imply that a demographic transition like that expected over the next three decades could have a substantial effect on asset returns. This analysis, however, is conditional on a host of maintained assumptions about consumer preferences, the absence of constraints on consumption behavior, and the age profile of risk aversion. In addition, Poterba (2001) notes that survey evidence on household risk tolerance offers only limited support for the assumption that risk aversion rises with age.

Yoo (1994b) and Macunovich (1997) allow for a more flexible relationship between population age structure and asset returns. Yoo (1994b) finds that a higher fraction of the population in the prime saving years is associated with a lower real return on Treasury bills. Large standard errors make it impossible to draw firm inferences about the link between demographic structure and returns on longer-maturity assets. Even for Treasury bills, however, the results are quantitatively small. Macunovich (1997) uses a richer set of demographic variables to explain the postwar fluctuations in the real return on the Dow Jones Industrial Average. Her specification risks overfitting the variation in the data sample. The out-of-sample predictions from her models are unstable and they often imply effects that are several times larger than those in the simulation models discussed in the last section.

Bergantino (1998) follows a more sophisticated strategy, based on Mankiw and Weil's (1989) analysis of demographic factors in housing markets, to analyze how demography and asset markets interact. He uses cross-sectional data from the Survey of Consumer Finances to estimate age-specific demands for corporate stock and owner-occupied real estate, and combines these estimates with data on the changing age composition of the population to create measures of aggregate demand for both corporate equity and housing. He finds a positive association between his measure of asset demand and the level of stock prices, particularly when he focuses on low-frequency variation in demographic demand, and he concludes that demographic changes can explain a substantial share of the postwar fluctuations in equity prices. His results imply that the demographic changes that are projected for the next three decades could have a sizable effect on asset values, provided past patterns continue to hold.

Poterba (2001) builds on the earlier studies and re-examines the relationship between several measures of demographic structure and real returns on Treasury bills, government bonds, and corporate stock. The study emphasizes the limited number of effective degrees of freedom in time series studies of returns and demographic change. Since there is only one baby boom in the United States, it may be misleading to suggest that there are many years of data on demographics and asset market returns. It may be more accurate to view the existing data as the result of one realization of time-varying birth rates. Poterba's (2001) econometric results provide very limited support for a link between asset market returns and demographic variables. There is weak evidence linking population age structure to real returns on Treasury bills, as in Yoo (1994b), but no other clear patterns. There is some support for a link between price-dividend ratios and demographic variables. This result is similar to, although not as strong as, the finding in Bergantino (1998). Updated estimates of the core econometric models in Poterba (2001) are presented later in this paper.

GMQ (2004) present empirical evidence consistent with their simulation analysis. Their results suggest that the real level of share prices, measured by the S&P 500 index, is related to the ratio of middle-aged to young individuals in the population. This "MY ratio" is defined as the number of 40-49 year olds divided by the number of 20-29 year olds. The results suggest a statistically significant link between "MY" and real stock returns, with a change like that projected for the 2000-2050 period resulting in roughly 60 basis point decline in annual real returns.

While most studies of demographics and financial markets have analyzed data on asset returns, Goyal (2003) investigates whether age structure affects the demand for cash payouts from the corporate sector. This study suggests that an increase in the fraction of the population in the retirement years is associated with an increase in net payouts from the corporate sector, defined as cash dividends plus net share repurchases, as well as a decline in the equity premium. Although the results are statistically significant, the study also considers prospective changes in population age structure and concludes that such changes are likely to have at most a modest impact on asset returns.

In addition to the foregoing studies that focus on the United States, a number of studies have now used data from nations to explore related issues. Erb, Harvey, and Viskanta (1997) focus on the 1970-1995 period for a sample of developed and developing countries. They find a positive relationship in both developed and developing countries between stock returns and the change in the average age of a country's inhabitants. Taken at face value, the results would seem to suggest that an aging population is associated with rising stock values.

The interpretation of this finding is especially difficult, however, because of the many sources of variation in population age structure across nations. In many developing nations, for example, average age may proxy for changes in underlying economic conditions that reduce morbidity and mortality. It is not clear whether such demographic changes should be viewed as the driving force behind asset market movements, or whether they in turn reflect other factors at work in developing nations. Ang and Maddaloni (2003) also explore the correlation between the equity risk premium and population age structure in a number of developed nations. The study finds that country-by-country results differ substantially, and concludes that patterns that are observed in the U.S. time series often fail to generalize to other nations. When the data for many nations is pooled, however, there is some evidence of a decline in the risk premium in nations with rapidly rising retired populations.

Brooks (1998) also exploits cross-country variation by relating the level of real equity prices to a demographic structure variable. This variable equals the ratio of the population aged 40-64 to the population older or younger than this group. For 11 of 14 countries in the sample, there is a positive relationship between this demographic variable and the real stock price. A key question in evaluating these results is how to normalize share prices to account for differences in debt and other forms of leverage that differ across nations. Using domestic demographic data to study domestic returns in small nations may also face empirical difficulties. In countries with a substantial share of foreign investors in their equity markets, such as Denmark, Belgium, and the Netherlands, it is unclear whether *domestic* demographic variables should have much impact on asset returns and asset values.

Davis and Li (2003) focus on a smaller sample of seven countries with substantial equity markets. They find a statistically significant effect of the share of the population between the ages of 40 and 64 on the level of real stock prices and on real bond prices. Their study moves beyond most of the previous work in including control variables for non-demographic factors that may affect asset prices, such as the rate of economic growth, the inflation rate, and the recent volatility of the equity market. The findings are robust to the inclusion of these control variables. Developing tests for the impact of demographic variables on asset markets, with more extensive controls for other factors, is likely to be an important direction for future research.

GMQ (2004) also report some international evidence on the association between the "MY" ratio and real stock returns. They study France, Germany, Japan, and the United Kingdom, and find mixed results. For France and Japan there appears to be a link between the MY ratio and the real price of corporate equities, but the relationship does not emerge in the other nations.

The studies described above broadly suggest that demographic factors are correlated with the level of asset prices, although each empirical specification is open to some question. The findings are sensitive to changes in variable definitions and modeling assumptions. The search for robust relationships between returns and demographic variables is therefore ongoing. The next two sections present new empirical evidence on this issue.

Age patterns in asset ownership in the United States 4

In the multi-period lifecycle models that underlie the overlapping generations models described above, household financial asset holdings evolve predictably over the life course. Households accumulate while working and draw down assets in retirement. This is the pattern suggested by the celebrated lifecycle model of Modigliani and Brumberg (1954). A decades-long empirical debate about lifecycle saving effects, however, raises questions about the quantitative importance of lifecycle patterns. Data on consumption patterns among older households and on transfers across generations often suggest little, if any, wealth decumulation in post-retirement years. Kotlikoff (1988), Hurd (1990), and Browning and Lussardi (1996) offer summaries of much of this research. Modigliani (1988) defends of the importance of lifecycle considerations. While much of the empirical research has focused on the behavior of households in the United States, wealth accumulation patterns in other nations also raise questions about the extent of lifecycle behavior at older ages. Börsch-Supan, Reil-Held, and Schnabel (2003) find evidence of positive financial saving among elderly households in Germany. Other studies in Börsch-Supan (2003) present evidence on saving patterns by age in other nations. A balanced reading of the empirical evidence to date suggests that decumulation in retirement is slower than simple lifecycle models would suggest, although it may be possible to reconcile the observed patterns with expanded lifecycle models that recognize other factors that may influence saving behavior.

Expanded life-cycle models focus on the precautionary desire to hold wealth as insurance against health care costs or other late-life expenses, as potential explanations for the substantial wealth holdings at older ages. Alternatives to the lifecycle formulation emphasize bequest motives as a motivation for saving decisions. While the choice between alternative modeling approaches may be very important for analyzing how policy interventions may affect saving decisions, the alternative models lead to similar predictions with regard to financial market effects. If elderly households draw down their assets more slowly than the stylized lifecycle model suggests, then the pressure on asset prices that such models suggest will be attenuated.

This section presents data on age-specific asset holdings in the 2001 Survey of Consumer Finances (SCF), and it explains the limitations of such data for analyzing prospective changes in asset demand as a result of demographic change. The SCF provides the most comprehensive information on asset ownership in the United States. Aizcorbe, Kennickell, and Moore (2003) provide a detailed description of the 2001 SCF, along with information on the composition and concentration of household wealth in 2001. SCF data can be used to calculate average asset holdings for families headed by individuals of different ages. Table 3 presents information on mean and median net financial assets and net worth for the 2001 SCF. Net worth is a broader asset concept than net financial assets. It equals net financial assets plus holdings of both owner-occupied and investment real estate, less mortgage debt, along with vehicles, business equity, and miscellaneous other assets.

Table 3 presents both age-specific means and medians for net worth and net financial assets. At every age, the mean is several times greater than the median, reflecting the very substantial dispersion in private wealth holdings. Net financial assets are more dispersed than net worth. For households in their early 60s, mean net financial wealth is eight times greater than median net financial wealth. The substantial dispersion of asset holdings leads to standard errors of the means that are large enough to make it difficult to reject most hypotheses about the slope of the age-wealth profile at advanced ages. The substantial dispersion also implies that studies of how demographic change may affect asset demand should pay close attention to the lifecycle patterns of high net worth households, which account for a very large share of aggregate financial asset holdings.

Table 3 suggests that average holdings of net financial assets and average net worth rise with the age of the family head until roughly age 60. Neither net worth nor net financial assets increase after age 60, but given the imprecision of the estimated age-specific means, it is not possible to reject the null hypothesis that the averages are constant beyond age 60. For net financial assets there is virtually no decline in old age, while for net worth the mean for families headed by someone over the age of 75 is below that for younger families, although the standard error is large. The point estimate of the net worth level for individuals aged 75+ is roughly one quarter lower than that for households in their mid-60s. Large standard errors notwithstanding, the point estimates of the age-specific means in Table 3, which suggest a limited decline in financial asset holdings as families age, suggests caution in concluding that there will be a rush to sell financial assets when baby boomers reach their late 60s and early 70s.

Table 3
Age-Specific Asset Holdings, 2001 Survey of Consumer Finances

Age of household head	Net financial assets		Net worth	
	Mean	Median	Mean	Median
20-24	26,330 (22,642)	-340	44,075 (29,812)	3,300
25-29	11,649 (5,103)	50	52,282 (10,098)	11,895
30-34	32,806 (10,968)	940	88,514 (14,177)	20,500
35-39	46,504 (9,065)	6,300	122,712 (22,512)	37,000
40-44	75,099 (12,506)	13,540	204,488 (24,905)	68,711
45-49	99,240 (17,412)	14,000	240,273 (29,736)	74,301
50-54	181,181 (33,148)	30,130	369,670 (57,750)	103,700
55-59	210,908 (31,985)	33,450	455,729 (64,088)	134,130
60-64	207,848 (35,873)	24,000	421,902 (75,681)	109,700
65-69	156,288 (60,076)	28,525	346,338 (75,828)	119,790
70-74	205,077 (52,811)	32,800	409,932 (103,782)	133,840
75 & up	174,308 (8,237)	27,835	310,900 (68,733)	114,000
All ages	110,185 (8,237)	9,850	240,755 (14,285)	59,635

Note: Net financial assets subtracts consumer and investment debt from gross financial assets. Net worth is the sum of net financial assets, the gross value of owner-occupied housing, and holdings of other assets such as investment real estate, less the value of housing mortgage debt. All entries are measured in 2001 dollars. Standard errors are shown below the means.

Data from earlier waves of the SCF have been analyzed in previous research on decumulation behavior. One of the most careful studies, by Sabelhaus and Pence (1999), suggests more evidence of asset draw-down in old age than Table 3. The difference between the results in that study, and those in Table 3, is partly due to the use of different years of SCF data, but more importantly due to corrections that Sabelhaus and Pence (1999) make for age-related mortality differences. Wealth and mortality are inversely related, so that the sample of families that survive to extreme old age is likely to be a wealthier group than the general population at an earlier age. Sabelhaus and Pence (1999) develop a statistical technique that compensates for the resulting upward bias in the age-wealth profile, and not surprisingly they conclude that decumulation occurs at a higher rate than Table 3 suggests.

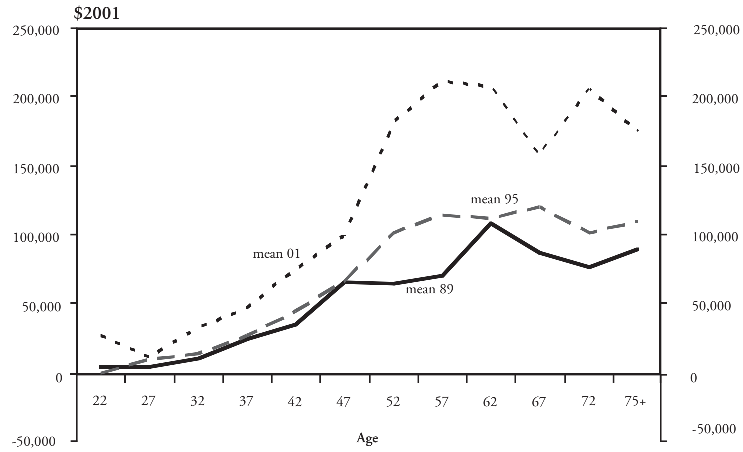
Table 3 presents cross-sectional age-wealth profiles from a single survey. Prior research on wealth accumulation emphasizes, however, that cross-sectional patterns may not describe the trajectory that a given cohort will follow as it ages. The asset holdings by an individual of age a in time period t can be decomposed into an age effect, a time-period specific effect, and a cohort effect for those who were born in period t - a. The age effect captures the effect of the "point in the lifecycle" on wealth holdings. It is the component that analyses of demographic change and asset markets seek to identify. The time effect recognizes the impact of the particular moment at which the survey is taken. After several years of favorable stock market returns, for example, average wealth at all ages will be higher than after several years of stock market decline. The cohort effect reflects life-long effects of date-of-birth. For example, individuals born prior to the Great Depression may have a greater desire to save than those born later, reflecting their greater experience with economic hardship and the loss of financial wealth. They also may have a smaller endowment of human capital as a result of their difficult early experiences in the labor market. Cross-sectional wealth profiles, such as those in Table 3, Yoo (1994b), and Bergantino (1998), are only informative under the assumption that there are no cohort effects.

With a single cross-sectional data set, it is not possible to separate age, cohort, and time effects. With panel data or repeated cross-sections, it is possible to estimate two, but not all three, of these effects. This is because the cohort effect is a linear combination of the age and time effects. This fundamental identification problem raises an important challenge for studying how population aging will affect asset demand. Two examples illustrate the difficulties. First, if older cohorts have lower lifetime earnings than younger cohorts, and if the accumulation of financial assets is correlated with lifetime earnings, then one might observe lower wealth levels for those at advanced ages than for younger households. This would not be the result of decumulation, however. Second, if the asset market returns over the lifetime of one cohort were more favorable than those over the lifetime of another cohort, the wealth at any age of the first cohort might be higher than that of the second, even if the share of income saved at all ages was the same for the two. Ameriks and Zeldes (2000) show how a given set of age-wealth profiles over time can be consistent with very different underlying patterns of asset accumulation over the life-cycle as a result of different combinations of time and cohort effects.

If cohort and time effects play an important role in determining the observed pattern of asset holdings at different ages, one would expect to see significant differences over time in the cross-sectional age-wealth profiles. Charts 4 and 5 present these profiles from the 1989, 1995, and 2001 Surveys of Consumer Finances. Chart 4 reports mean net financial assets, while Chart 5 reports medians for each age group. The charts show a level difference in mean financial assets, with 2001 greater than either 1995 or 1989 at all ages. Gale and Pence (2004) investigate the source of the increase in age-specific wealth, and find that changing household characteristics, such as higher rates of college completion, can explain a substantial part of the disparity. The shape of the age-net financial assets profile is nevertheless reasonably stable across the three different survey years.

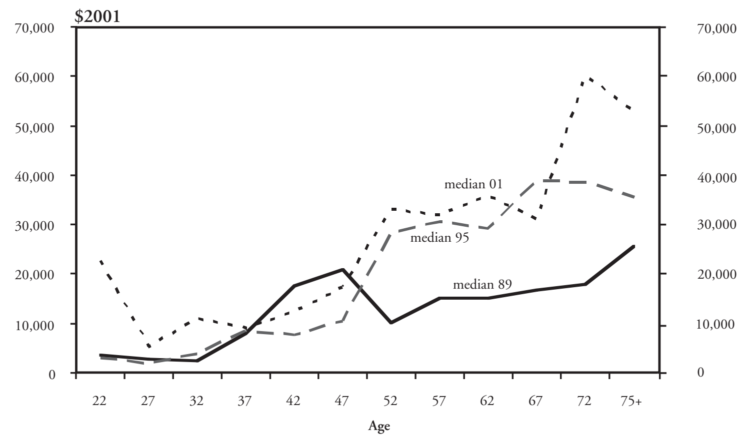
Poterba (2001) uses repeated cross-sections of the Survey of Consumer Finances (SCF) from 1983, 1986, 1989, 1992, and 1995

Chart 4
Mean Net Financial Assets by Age of Household Head, 1989-2001



Source: Calculated from Survey of Consumer Finances 1989, 1995 and 2001
Note: We used CPI to perform inflation adjustment.

Chart 5
Median Net Financial Assets by Age of Household Head, 1989-2001



Source: Calculated from Survey of Consumer Finances 1989, 1995 and 2001
Note: We used CPI to perform inflation adjustment.

to estimate age profiles of asset ownership allowing for different lifetime asset levels for different birth cohorts. The analysis assumes that there are no time effects. The estimates suggest that allowing for cohort effects has a surprisingly small impact on the estimated age structure of asset holdings. The resulting estimates of age-specific asset demand can be used to construct a measure of projected asset holdings per capita in each year, based on the age-specific structure of asset demands in a given year. This measure is defined by $\sum /_i {}^* N_{it}$ where $/_i$ denotes the age-specific asset holdings and N_{it} denotes the actual or projected number of individuals of age i in year t. It rises modestly over the four decade period between 1980 and 2020, but is not projected to decline very much after 2020 because the underlying age-specific patterns of asset holding do not show a sharp decline at older ages.

One important limitation of estimates of wealth decumulation based on household survey data is that they focus on financial assets held directly by households. They omit assets held through defined benefit pension plans, which while declining in importance, still represent a substantial share of the financial market. Schieber and Shoven (1997) point out that the mechanical draw-down of defined benefit pension assets in the years after the baby boom cohort reaches retirement will put downward pressure on asset prices. In most cases, the value of the assets that are accumulated in defined benefit plans peaks at the date when an individual retires. As benefits are paid out, the actuarial present value of the remaining payouts declines, and the assets needed to provide these benefits decline. This implies that there is a substantial force of accumulation and then decumulation as a large birth cohort ages. While a growing share of retirement assets are held in defined contribution rather than defined benefit pension plans, existing defined benefit plans still hold substantial pools of assets and the draw-down of these assets will diminish future asset demand, just as the simple models of lifecycle accumulation suggest.

Although cross-sectional age profiles for financial assets have well-known limitations, they can provide a starting point for analyzing how changing age structure in the population may affect the composition of asset ownership. Table 4 presents tabulations based on the 1989 and the 2001 Surveys of Consumer Finances. There are two panels, one for net financial assets and another for net worth. The first row in each panel shows the fraction either net financial assets or net worth held by families headed by someone between the ages of 20-39, 40-64, and over 65. In 1989, for example, over-65 families held 35 percent of net financial assets. The second row shows the *predicted* 2001 holdings, by age group, assuming that the 1989 age-specific pattern was unchanged, but allowing the population mix to change. The share of net financial assets held by those over the age of 65 was predicted to drop from 35 to 32.4 percent. The *actual* 2001 holdings of the over-65 group were 31.1 percent of net financial assets, so the 1989 cross-section over-predicted the actual 2001 holdings of the elderly.

The last two rows in each panel show the projections for 2020 and 2040, based on Census Bureau population projections and the 2001 cross-sectional pattern. The projections show a substantial increase in the share of assets held by the over-65 groups in both categories. For net financial assets, holdings of the over-65 group are predicted to rise to 44.3 percent, from 31.1 percent, by 2040. The increase for net worth is similar, from 29.4 percent in 2001 to 42.3 percent in 2040. These statistics offer insight on the changing demographics of the market for financial services. They suggest that the elderly will become more important, while households headed by someone under the age of 39 will become much less important, as the financial services market evolves between now and 2040.

New evidence on population age structure and asset returns 5

This section presents new empirical results on the relationship between various measures of demographic structure and asset returns and the level of asset prices in the United States. The analysis focuses on annual real returns on three assets—Treasury bills, long-term government bonds, and large corporate stocks. Stock returns are measured by the return on the S&P 500 index. The explanatory vari-

Table 4
Past and Predicted Shares of Assets Held by Households of Different Ages, Survey of Consumer Finances 1989 and 2001

	Age of household head		
	20-39	**40-64**	**Over 65**
Financial net assets			
1989 actual	13.1 (29.9)	51.9 (101.0)	35.0 (82.0)
2001 predicted from 1989	10.6 (25.5)	57.0 (104.8)	32.4 (76.1)
2001 actual	10.9 (16.0)	58.1 (71.7)	31.1 (36.2)
2020 predicted from 2001	9.0 (12.9)	54.2 (65.8)	36.9 (42.1)
2040 predicted from 2001	8.2 (11.8)	47.5 (56.7)	44.3 (49.6)
Net worth			
1989 actual	15.2 (34.1)	55.2 (106.6)	29.6 (69.2)
2001 predicted from 1989	12.2 (29.1)	60.4 (110.4)	27.4 (64.1)
2001 actual	12.0 (17.3)	58.6 (72.2)	29.4 (34.1)
2020 predicted from 2001	9.9 (14.1)	55.1 (66.6)	35.0 (39.9)
2040 predicted from 2001	9.1 (12.8)	48.5 (57.7)	42.3 (47.2)

Source: Author's calculations using cross-sectional age/net worth coefficients for household data from 1989 and 2001 SCF, along with estimates of the probability of household headship conditional on an individual being of a given age. These conditional probabilities estimated from the SCF were combined with census projections on the future distribution of population by age to project future asset holdings.

ables consist of several measures of population age structure, as well as other control variables that might affect the level of asset prices. There are four demographic variables: the share of the total population between ages 40 and 64, the share of the total population over age 65, the share of the adult population between the ages of 40 and 64, and the share of the adult population over the age of 65. Some regression specifications include both the share of the population in middle age and the share over the age of 65. Real returns are computed by subtracting each year's inflation rate, computed as the year-end to year-end change in the Consumer Price Index, from the pretax nominal return on each asset. The analysis focuses on the period 1926-2003, for which Ibbotson Associates (2004) provides reliable and comparable data on returns. For each of the three asset classes, the analysis explores the link between demography and asset returns for the full sample period as well as for the postwar (1947-2003) sample. Studying several different asset categories provides information on returns on both relatively low-volatility assets and more risky assets.

Evidence on asset returns

Table 5 presents regression coefficients from equations that relate each asset return measure to the demographic variables. There are six sub-panels in the table, two for each of the three asset classes. In each case there is one sub-panel for the 1926-2003 sample and one for the 1947-2003 sample. The results do not suggest important correlations between asset returns and demographic structure. There is weak evidence that in the fixed-income markets, and particularly the Treasury bill market, population age structure is correlated with asset returns. The variable measuring the fraction of the population between the ages of 40 and 64 displays a statistically significant coefficient in the Treasury bill regressions for the full sample period. This coefficient on this variable is statistically insignificantly different from zero in the postwar sample, and none of the other demographic variables have a statistically significant effect on asset returns.

Table 5
Demographic Structure and Real Returns on Financial Assets

1926-2003 sample, real returns on Treasury bills						
Population share 40-64	-1.392 (0.357)		-1.530 (0.362)			
Population share 65+		0.136 (0.205)	0.318 (0.190)			
Population 40-64/ population 20+				-0.398 (0.817)		-0.392 (0.196)
Population 65+/ population 20+					0.106 (0.157)	0.017 (0.160)
Adj. R-squared	0.163	-0.008	0.184	0.046	-0.008	0.033
1947-2003 sample, real returns on Treasury bills						
Population share 40-64	-0.632 (0.410)		-0.311 (0.372)			
Population share 65+		1.050 (0.249)	1.003 (0.256)			
Population 40-64/ population 20+				-0.298 (0.155)		0.077 (0.158)
Population 65+/ population 20+					1.053 (0.213)	1.120 (0.255)
Adj. R-pquared	0.025	0.240	0.236	0.049	0.306	0.296
1926-2003 sample, real return on government bonds						
Population share 40-64	-1.847 (0.983)		-2.049 (1.011)			
Population share 65+		0.221 (0.527)	0.466 (0.529)			
Population 40-64/ population 20+				-1.165 (0.474)		-1.261 (0.495)
Population 65+/ population 20+					0.002 (0.403)	-0.283 (0.404)
Adj. R-squared	0.034	-0.011	0.030	0.065	-0.014	0.058

Note: Each equation presents the results of estimating an equation of the form

R_t = / + € (demographic variable)$_t$ + ©$_t$.

Some equations include two demographic variables. Standard errors are shown in parentheses. Equations are estimated using annual data for the sample period indicated.

Table 5 (cont.)

1947-2003 sample, real returns on government bonds						
Population share 40-64	-1.331 (1.388)		-0.585 (1.356)			
Population share 65+		2.424 (0.903)	2.335 (0.933)			
Population 40-64/ population 20+				-1.142 (0.510)		-0.697 (0.602)
Population 65+/ population 20+					1.935 (0.820)	1.327 (0.971)
Adj. R-squared	-0.002	0.105	0.091	0.070	0.079	0.085
1926-2003 sample, real returns on common stocks						
Population share 40-64	1.425 (1.928)		1.368 (1.993)			
Population share 65+		0.294 (1.013)	0.131 (1.044)			
Population 40-64/ population 20+				-0.113 (0.949)		-0.102 (0.994)
Population 65+/ population 20+					0.058 (0.774)	0.035 (0.811)
Adj. R-squared	-0.006	-0.013	-0.020	-0.014	-0.014	-0.028
1947-2003 sample, real returns on common stocks						
Population share 40-64	2.880 (2.100)		3.428 (2.146)			
Population share 65+		1.197 (1.462)	1.716 (1.477)			
Population 40-64/ population 20+				-0.090 (0.816)		0.155 (0.977)
Population 65+/ population 20+					0.596 (1.314)	0.731 (1.577)
Adj. R-squared	0.016	-0.006	0.023	-0.019	-0.015	-0.035

Note: Each equation presents the results of estimating an equation of the form

$$R_t = \alpha + \beta\,(\text{demographic variable})_t + \varepsilon_t.$$

Some equations include two demographic variables. Standard errors are shown in parentheses. Equations are estimated using annual data for the sample period indicated.

For the full sample period, the coefficient of -1.39 from a regression of real Treasury bill returns on the population share aged 40-64 implies implausibly large changes in the real return on Treasury bills. Between 2000 and 2040, Table 1 showed that the population share aged 40-64 is projected to rise by 1.8 percentage points. Multiplying this amount by the coefficient -1.39 in the first column of Table 5 suggests a decline of 240 basis points in real Treasury bill yields between 2000 and 2040. Effects this large seem particularly unlikely because the population share aged 40-64 rose by more than five percentage points between 1975 and 2000, without any analogous movement in the real return on Treasury bills. The coefficient estimates for the full sample, -1.39 on real bill yields and -1.73 on real bond yields, imply that a demographic change of this magnitude would reduce real bill yields by 650 basis points and real bond yields by 900 basis points. These effects are much larger than the modest predictions from the simulation models discussed above.

The coefficients on the demographic variables in Table 5 may be affected by omitted variable bias, with other factors that are slowly varying influences on asset prices reflected in the estimated effects. A key limitation of virtually all of the previous empirical analysis on demography and asset returns is that it does not embed the analysis in a broader model of equilibrium asset return determination. As such, the equations lack control variables that might reduce the omitted variable problem.

The results for bond returns are similar to those for Treasury bill returns. For stocks, however, the results are somewhat different. None of the coefficient estimates are statistically significantly different from zero. Moreover, the coefficient estimates suggest that increasing the share of the total population or of the adult population in the 40-64 age category *raises* equity returns. This is inconsistent with the simulation models previously described in which expansion of the number of middle-aged workers raised demand for assets and reduced the prospective rate of return.

One potential concern with time series regressions like those in Table 5 is that there may be unit roots in the explanatory variables, since they are slowly-varying demographic time series. Poterba (2001) uses the tests proposed by Engle and Granger (1987) to test for unit roots in the residuals from equations similar to those reported in Table 5. The results reject the null hypothesis of a unit root.

Several conclusions emerge from the empirical results. First, the most substantial correlation between demographic factors and population age structure obtains for Treasury bills. One explanation for this may be that real returns on bills are less volatile than other return series, so it is less difficult to detect the impact of a slowly changing variable such as the demographic share in different age groups on these returns than on other time series. Nevertheless, there is no evidence that the real returns on corporate stocks for the last 75 years have been correlated with population age structure. Second, the demographic effect appears to be much larger in the pre-war period than in the postwar period. Studying the impact of the postwar baby boom cohort on asset markets does not provide any strong evidence of a link between demography and returns, even in the Treasury bill market. Finally, many measures of population age structure exhibit very little correlation with asset returns, so one must be careful in interpreting a finding that *some* demographic variable is correlated with returns. There is a danger of data-mining, in that the few statistically significant relationships may become the starting point for future research studies. This may lead to a spurious appearance of broad support for the link risk that the few specifications that yield statistically significant relationships become the standard workhorses for academic research, which then exaggerates the effective degree of correlation.

Evidence on asset price levels

In simple theoretical models such as those discussed above, when a large age cohort begins to purchase assets for retirement, it bids up asset prices. This implies both a positive return when this occurs and a positive association between the level of asset prices and the demographic demand variable. To test whether such a relationship emerges in the data, Table 6 presents regression models that relate a measure of the price level for common stocks, proxied by the price-dividend ratio for the S&P 500, to various demographic variables. Similar results emerge if the price-earnings ratio is used instead of the price-dividend ratio. The dependent variable is the price-to-dividend ratio on the S&P500 at the end of the year.

Empirical analysis of asset prices is clearly related to analysis of asset returns. If a change in the demographic structure of the population resulted in a higher level of asset prices, one could look for a relationship between population age structure and the level of asset prices, or between changes in population age structure and the return to asset holders.

The results in Table 6 provide some evidence of a link between population age structure and the level of asset prices. The first panel shows results in which demographic variables are the only explanatory variables. In the first column, the population share between the ages of 40 and 64 has a positive correlation with the P/D ratio, and the estimated regression coefficient is statistically significantly different from zero. The population share over age 65, the regressor in the second column, also shows a positive coefficient, although the magnitude is about half that of the population share between the ages of 40 and 64. This pattern remains in the third column, when both demographic variables are included. In the last three columns of the first panel, the demographic variables are scaled relative to the adult population. The coefficients on the share of the adult population between the ages of 40 and 64 and on the share over 65 remain statistically significantly different from zero, but now the relative magnitude of the coefficients reverses. The effect of an older population is greater than that of a middle-aged population.

The second panel in Table 6 adds control variables for the rate of economic growth and the real interest rate into the basic specification

Table 6
Demographic Structure and the Price-Dividend Ratio on Common Stocks

1926-2003 sample, level estimates						
Population share 40-64	667.54 (79.46)		536.81 (74.00)			
Population share 65+		375.56 (60.18)	248.55 (49.63)			
Population 40-64/ population 20+				146.12 (67.43)		220.02 (53.86)
Population 65+/ population 20+					275.66 (47.96)	311.35 (44.53)
Adj. R-squared	0.475	0.330	0.601	0.046	0.294	0.415
1926-2003 sample, estimated in differences						
Population share 40-64	772.38 (69.80)		652.80 (68.35)			
Population share 65+		363.94 (60.61)	193.67 (44.42)			
Population 40-64/ population 20+				190.34 (67.86)		256.79 (53.49)
Population 65+/ population 20+					266.95 (48.14)	303.19 (42.92)
Growth rate	28.84 (30.71)	29.23 (41.06)	23.63 (27.57)	44.48 (47.53)	30.86 (42.08)	30.93 (36.93)
Real interest rate	206.59 (36.95)	71.25 (48.34)	171.48 (34.10)	148.94 (57.34)	77.16 (49.46)	127.06 (44.64)
Adj. R-squared	0.626	0.332	0.699	0.101	0.298	0.459

Note: Each equation presents the results of estimating an equation of the form

(P/D)$_t$ = ⁄ + €*(demographic variable)$_t$ + Z_t + ©$_t$

where Z_t denotes control variables such as the real interest rate or the three-year average of the GDP growth rate. When the equation is estimated in differences, the specification still includes a constant term. Some equations include more than one demographic variable. Standard errors are shown in parentheses. Equations are estimated using annual data for the sample period indicated.

Table 6 (cont.)

1926-2003 sample, estimated in differences						
Population share 40-64	326.29 (296.33)		62.91 (371.38)			
Population share 65+		-1722.17 (1068.86)	-1583.53 (1351.85)			
Population 40-64/ population 20+				256.33 (171.97)		246.70 (174.64)
Population 65+/ population 20+					-384.83 (646.39)	-257.91 (648.34)
Adj. R-squared	-0.017	0.002	-0.011	-0.003	-0.028	-0.015
1947-2003 sample, level estimates						
Population share 40-64	780.21 (91.39)		737.46 (61.69)			
Population share 65+		554.87 (111.87)	495.21 (59.72)			
Population 40-64/ population 20+				148.38 (72.42)		348.50 (53.88)
Population 65+/ population 20+					489.56 (104.04)	741.53 (88.19)
Adj. R-squared	0.558	0.293	0.800	0.053	0.271	0.578

Note: Each equation presents the results of estimating an equation of the form

$(P/D)_t$ = ⁄ + €*(demographic variable)$_t$ + Z_t + ©$_t$

where Z_t denotes control variables such as the real interest rate or the three-year average of the GDP growth rate. When the equation is estimated in differences, the specification still includes a constant term. Some equations include more than one demographic variable. Standard errors are shown in parentheses. Equations are estimated using annual data for the sample period indicated.

Table 6 (cont.)

1947-2003 Sample, differenced estimates						
Population share 40-64	819.32 (70.33)		762.70 (60.57)			
Population share 65+		601.59 (161.37)	396.23 (83.15)			
Population 40-64/ population 20+				275.09 (69.72)		377.96 (55.44)
Population 65+/ population 20+					533.53 (158.73)	776.97 (122.28)
Growth Rate	-52.19 (68.50)	92.93 (122.44)	53.25 (61.94)	-227.45 (120.03)	15.93 (119.44)	-163.19 (91.84)
Real interest rate	279.02 (48.65)	-56.75 (114.31)	78.88 (58.75)	394.33 (88.84)	-43.49 (118.88)	33.01 (88.30)
Adj. R-squared	0.740	0.274	0.815	0.292	0.245	0.590
1947-2003 Sample, differenced estimates						
Population share 40-64	497.38 (322.21)		118.95 (552.60)			
Population share 65+		-2060.32 (1171.91)	-1707.15 (2022.40)			
Population 40-64/ population 20+				302.53 (177.25)		289.64 (180.10)
Population 65+/ population 20+					-504.76 (679.57)	-357.84 (675.99)
Adj. R-squared	-0.004	0.008	-0.010	0.005	-0.038	-0.008

Note: Each equation presents the results of estimating an equation of the form

(P/D)$_t$ = ⁄ + €*(demographic variable)$_t$ + Z_t + ©

where Z_t denotes control variables such as the real interest rate or the three-year average of the GDP growth rate. When the equation is estimated in differences, the specification still includes a constant term. Some equations include more than one demographic variable. Standard errors are shown in parentheses. Equations are estimated using annual data for the sample period indicated.

for the price-dividend ratio. Adding these control variables does not change the basic conclusions. The economic growth rate is measured as a three-year moving average of the growth in real GDP, and the real interest rate is the difference between the nominal interest rate on 20-year Treasury bonds and the three-year moving average CPI inflation rate. The coefficient on the growth rate is positive, which is consistent with the view that this growth rate proxies for the future growth of dividends, but it is statistically insignificantly different from zero. The real interest rate is also always positive; this is inconsistent with simple valuation theory.

The unit root problems alluded to previously are likely to be less important for the equations in Table 5 than for those in Table 6. The dependent variable in the former table, the real return, is nearly white noise, while the dependent variable in the latter table, the price-dividend ratio, is highly persistent. To address the econometric difficulties that might arise from regressors and dependent variables that are close to a random walk, the third panel of Table 6 reports coefficient estimates from a regression model in which the *change* in the price-dividend ratio is regressed on the *change* in the demographic measures from the earlier panels. In this case, the coefficient estimates for the demographic variables are no longer statistically significantly different from zero, and when a measure of the elderly population is included, the coefficient estimate is negative rather than positive in the level specification. These results raise important doubts about the robustness of the findings in the upper panels of Table 6. The three lower panels of Table 6 present similar regression equations estimated for the 1947-2003 sample period. The results are broadly similar to those for the full sample period, and the results are again dependent both on the choice of the denominator for normalization, the adult population or the total population, and on whether the equation is estimated in differences or in levels.

The results in Table 6 suggest two conclusions. First, it is possible to use regression analysis to estimate large effects of demographic factors on the level of asset prices. While the point estimates of these

Table 7
Age-Specific Probability of Asset or Liability Ownership, 2001 Survey of Consumer Finances

Age of household head	Common stock and stock mutual funds (percent)	Bonds and bond mutual funds (percent)	Mortgage, conditional on owning home (percent)	Owner occupied home (percent)	Annuity (percent)
20-24	30.3	11.0	85.3	14.9	0.2
25-29	47.8	18.0	82.7	41.3	1.1
30-34	56.6	24.7	94.5	54.9	1.8
35-39	52.7	23.0	88.7	61.6	1.1
40-44	58.4	36.1	84.9	72.9	2.1
45-49	54.7	26.0	79.6	75.4	1.8
50-54	55.5	32.3	74.2	77.3	6.3
55-59	57.1	23.5	58.9	83.3	8.4
60-64	49.8	19.8	49.1	83.2	10.0
65-69	35.6	10.8	42.7	80.1	7.4
70-74	32.3	7.4	30.4	85.6	9.5
75 & up	31.0	10.0	11.5	76.0	8.0

Note: Entries for common stock and stock mutual funds, and for bonds and bond mutual funds, include assets held through defined contribution pension accounts as well as in traditional taxable accounts.

effects are implausibly large, more plausible values usually fall within the 95 percent confidence interval for the coefficients. Thus, there is more support for a link between demography and asset markets when we study the level of asset prices than when we study returns. Second, however, the results of this price level analysis may be subject to "spurious regression bias" because the dependent and explanatory variables are all slowly trending time series. The coefficients from these models are sensitive to differencing and to altering the sample period of estimation. The statistical significance of the results from differenced models is much lower than that from models estimated in levels, thus casting doubt on the findings.

In addition to testing for a link between demographic variables and asset returns, Poterba (2001) also estimates regression models that relate the price-dividend ratio to the level of projected asset demand based on age-specific asset demands derived from the Survey of Consumer Finances. The results suggest that projected asset demand measures are more strongly correlated with the price-to-dividend ratio than are simple measures of demographic structure. A key difference between the projected asset demand variables that constitute the explanatory variables in Table 7 and the simpler measures of demographic structure that were in earlier tables, is that the projected asset demand variables place roughly equal weight on retired individuals and prime-age workers. This is because the age-wealth profiles do not show substantial decline in old age. The demographic variables that seem to perform most successfully in tracking the level of equity prices do not distinguish between prime-age workers and older individuals. This may be why GMQ (2004) find that the ratio of middle-aged individuals to young individuals, the "MY ratio," has substantial explanatory power for the level of asset values.

6 Population age structure and the composition of financial assets

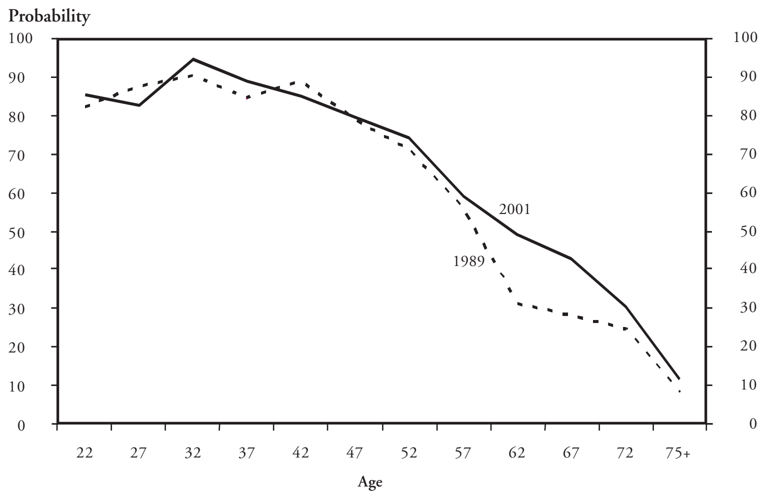
The foregoing analysis emphasizes the potential effects of population aging on the demand for financial assets in aggregate and the associated effects on financial market returns. A distinct question concerns the impact of these shifts on the types of financial assets, and financial services more generally, that households will demand. The aging of populations will shift emphasis from the accumulation of financial assets to the preservation of wealth and, for some households, the decumulation of wealth and the provision of insurance against late-life financial risks. This section presents a brief introduction to differences in age-specific probabilities of owning various asset categories, and then addresses changes that may be associated with population aging.

A natural starting point for analyzing how population aging will affect the demand for various assets is the current age-ownership profile for these assets. Table 7 shows the percentage of households headed by individuals of various ages who have various types of financial assets. The underlying data are drawn from the Survey of Consumer Finances (SCF). The table shows that in 2001, the probability of stock ownership, either directly or through a retirement plan, was greater than 50 percent for households headed by someone between the ages of 30 and 59, and that it declined slightly for those in the early 60s and then by a somewhat greater amount at older ages. At all ages, the share of households owning bonds is lower than the share owning corporate stock. Bonds display the same age profile as stocks, however with a decline in ownership probabilities at older ages.

It is tempting to extrapolate the age-ownership profiles in Table 7 and to conclude that an aging population will find fewer households holding stocks or bonds, either directly or through mutual funds. This is a perilous conclusion in light of the difficult problems associated with age, time, and cohort effects, as described previously. In the case of stock ownership, for example, there are good reasons to expect that the age-specific ownership rate at older ages will rise over time. As more households reach retirement age with assets in defined-contribution pension plans, such as 401(k) plans, there will be more elderly households with self-directed assets. Thus, it seems likely that future equity and bond ownership rates at older ages will exceed the current rates. It is possible that the current and growing popularity of "lifecycle" funds in retirement accounts, which move the participant's assets from equities to bonds as the participant ages, may lead to some automatic portfolio reallocation for retirement plan investors.

Time-varying age-specific patterns of asset or liability ownership can be illustrated by reference to the home mortgage market. The third column of Table 7 shows the probability that a family that owns a home has a home mortgage. In 2001, there was a clear decline in mortgage probabilities from nearly 60 percent for those in the 55-59 age group to 30 percent for those in the 70-74 age group. This pattern, extrapolated forward, would suggest that as the population ages, there will be less demand for home mortgages. While this conclusion is likely to be broadly accurate, the imprecision of any possible forecast is illustrated by Chart 6. It shows the age-specific probabilities of mortgage indebtedness in the 1989 and 2001 SCFs. The figure shows that the two curves track each other closely at younger ages and through middle age, but then diverge around age

Chart 6
Probability of Mortgage Indebtedness for Homeowner Households of Different Ages, 1989 and 2001



Source: Calculated from Survey of Consumer Finances 1989 and 2001

60. The probability of holding a mortgage was substantially higher for those in their 60s in 2001 than it was in 1989, presumably as a consequence of higher rates of refinancing during the 1990s than the 1980s. Thus, even over periods of a decade, there can be significant changes in age-specific wealth and asset profiles.

The problem of time-varying asset ownership probabilities is an important one and it needs to be recognized in any projection of future financial asset and liability holdings. It may nevertheless be of some interest to calibrate the changes in some aspects of financial asset demand that would be associated with changes in population age structure under the assumption that age-specific ownership patterns from 2001 persist into the future. Table 8 presents information on the fraction of owners of various assets who will fall into different age categories in 2020 and 2040 under this assumption. The table shows that in 2001, families headed by someone over the age of 65 accounted for 20.4 percent of all corporate stock investors. In 2040, the 2001 pattern suggests that 31.4 percent of all stockholders

Table 8
Percentage of Asset or Liability Holders in Various Age Categories, 2001 and Future Years

	Age of household head		
	20-39	40-64	65+
Common stock and stock mutual funds			
2001 actual	29.99 (41.31)	49.66 (59.83)	20.35 (23.07)
2020 predicted from 2001	25.87 (35.09)	48.77 (57.59)	25.36 (28.09)
2040 predicted from 2001	24.55 (32.84)	44.05 (51.07)	31.40 (34.07)
Bonds and bond mutual funds			
2001 actual	14.02 (19.65)	55.71 (67.73)	30.27 (34.61)
2020 predicted from 2001	11.57 (16.01)	52.34 (62.57)	36.08 (40.47)
2040 predicted from 2001	10.67 (14.59)	45.93 (54.04)	43.41 (47.83)
Mortgages			
2001 actual	33.91 (47.77)	57.12 (70.88)	8.97 (10.55)
2020 predicted from 2001	30.30 (42.12)	58.12 (70.84)	11.58 (13.35)
2040 predicted from 2001	30.08 (41.18)	54.92 (65.65)	15.00 (16.93)
Annuities			
2001 actual	11.31 (16.06)	51.78 (62.92)	36.91 (41.99)
2020 predicted from 2001	9.15 (12.87)	47.71 (57.15)	43.14 (48.28)
2040 predicted from 2001	8.26 (11.51)	40.96 (48.55)	50.78 (56.15)

Source: Author's calculations based on age-specific asset ownership probabilities estimated from the 2001 SCF. Projections are based on census population data combined with age-specific probabilities. Values in parentheses are standard errors for share of owners in the 2001 entries, and standard errors of prediction for the 2020 and 2040 values.

Table 9
Percentage of Assets or Liabilities of Various Types Held by Households in Various Age Categories, 2001 and Future Years

	Age of household head		
	20-39	40-64	65+
Common stock and stock mutual funds			
2001 actual	10.50 (17.57)	54.66 (70.61)	34.83 (41.99)
2020 predicted from 2001	8.54 (14.15)	50.58 (64.32)	40.89 (48.42)
2040 predicted from 2001	7.75 (12.76)	43.75 (54.95)	48.49 (56.60)
Bonds and bond mutual funds			
2001 actual	6.36 (21.70)	58.89 (89.31)	34.75 (49.48)
2020 predicted from 2001	5.14 (17.50)	54.25 (80.88)	40.61 (56.72)
2040 predicted from 2001	4.68 (15.90)	47.04 (69.21)	48.28 (66.42)
Mortgages			
2001 actual	34.87 (49.52)	59.10 (74.11)	6.04 (7.39)
2020 predicted from 2001	31.45 (44.14)	60.68 (74.93)	7.87 (9.48)
2040 predicted from 2001	31.61 (43.77)	58.07 (70.45)	10.32 (12.21)
Annuities			
2001 actual	5.24 (10.85)	44.35 (57.05)	50.40 (58.81)
2020 predicted from 2001	4.08 (8.41)	39.28 (50.05)	56.64 (65.31)
2040 predicted from 2001	3.54 (7.28)	32.41 (41.16)	64.06 (73.60)

Source: Author's calculations based on age-specific asset ownership probabilities estimated from the 2001 SCF. Projections are based on census population data combined with age-specific probabilities. Values in parentheses are standard errors for share of owners in the 2001 entries, and standard errors of prediction for the 2020 and 2040 values.

will be in families headed by someone over 65. Moreover, as the calculations in Table 9 show, which focus on the share of the asset owned by various age groups, the over-65 group is projected to hold 48.5 percent of all corporate stock. Thus, almost half of all corporate stock in 2040 would be projected to be held by families over the age of 65, up from roughly one-third today. The ownership pattern for bonds, presented in the second panel of Tables 8 and 9, is similar and also suggests a growing importance of older investors in the future.

The third panel of Tables 8 and 9 focuses on changing patterns of mortgage demand. Even though there are substantial demographic shifts, the aggregate ownership patterns for mortgages do not shift as much as the patterns for bond and stock ownership. This is due to the small amount of mortgage indebtedness at present for the older households that have mortgages. Whether this pattern will change in the future, and higher levels of reverse-annuity borrowing with emerge, remains an open question.

The last sub-panel in Tables 8 and 9 considers the changing pattern of demand for annuity products. Most of the demand for annuities occurs at older ages, so the shifting age distribution does increase the share of annuitants, and the fraction of annuities, held by those over the age of 65. The bottom row of Table 9 show, that in 2040, families headed by someone over the age of 65 are projected to hold 64 percent of all annuity contracts, up from 50 percent in 2001.

Annuities provide a useful illustration of how the aging population will affect the demand for financial services. The percentage of households with an annuity contract rises with age, from only 2 percent for households in their 40s to nearly 10 percent for those in their 70s. As the population ages, it seems very likely that there will be increased demand for products like annuities that provide an income stream in old age and that also offer some insurance against the financial risks that arise at advanced ages. In the case of annuities, they offer insurance against outliving one's financial resources. Mitchell and others (1999) and Mitchell (2002) discuss the role of annuity markets in providing insurance, and the potential for selection effects to influence the attractiveness of this market for prospective buyers.

Long-term care insurance is another example of a product that provides insurance against late-life financial risks. In the retirement saving market, attention will shift from the focus on how to accumulate balances for retirement, to concern about how to move these balances to annuities, structured payout programs, and other withdrawal arrangement. Public policy debates about retirement saving, which have concentrated on issues such as contribution limits for retirement plans, may shift to minimum distribution requirements and related issues concerning payouts.

Annuities offer one mechanism for households that have accumulated financial assets to draw down their resources, but there are other mechanisms that are also likely to witness increased demand. Reverse annuity mortgages may attract increasing attention as households seek to draw down their housing equity without moving. Cash dividend payouts are another device that older investors may use to draw down their wealth accumulation. Just as Goyal (2004) documents changing patterns of net cash inflows and outflows from the corporate sector as a function of population age structure, there may be growing demand for cash dividends as the population ages. Households with corporate stock portfolios also have other devices for translating their portfolios into cash, notably partial liquidation of their stock holdings. There may be growing demand for products that combine cash payouts with insurance of various types, such as long-term care insurance products that are paired with annuities, thereby providing life income if the buyer remains healthy and a nursing home benefit if the buyer is not well.

Conclusion 7

The correlation between asset returns on stocks, bonds, or bills, and the age structure of the U.S. population over the last 70 years, is weak. The results are more favorable to the demographic hypothesis when the level of asset prices, as measured by the price-dividend ratio for the S&P500, is the dependent variable. None of the empirical findings provide a strong and convincing measure of the amount by which asset prices will change as the population of the United States and other developed nations ages.

The weak empirical findings stand in contrast to the results of most theoretical models that consider how demographic shifts will affect asset prices and asset returns. In most models, there are clear effects in predictable directions, with a baby boom driving up asset values and driving down returns for those in the large birth cohort. The simulation evidence from these models usually suggests a modest impact on asset values and returns, but it is nevertheless important to recognize that there is a strong theoretical presumption for these effects. Given the limited amount of time series data on returns and demographic variation, and the difficulty of controlling for all of the other factors that may affect asset values and asset returns, the theoretical models should be accorded substantial weight in evaluating the potential impact of demographic shifts.

A critical issue for policymakers concerns with demographic change and asset markets is how policy variables may be brought to bear to offset any impact of changing population age structure. For example, if the monetary authority can affect the real interest rate on Treasury bills and long-term government bonds through its policy actions, then postulating a link between population age structure and equilibrium returns must make an implicit assumption about how the monetary authority would respond to changing age structure. The reaction of fiscal policy to population aging attracts much greater attention than the reaction of monetary policy, largely because the fiscal policy effects of population aging have been discussed more widely than the consequences for asset markets.

Many studies have documented the fundamental impact that an aging population will have, in most developed nations, on the government's share of GDP and the fiscal deficit. Kotlikoff and Burns (2004) offer an overview of the issues facing the United States. The

World Economic Forum Pension Initiative (2004) offers an introduction to related issues in other nations. The impact of demographic change on long-run fiscal balance depends critically on the future path of government transfer policy. In many nations, current policies are not sustainable, so some reform is inevitable. Will current commitments to deliver retiree health insurance be honored, or will they be modified? Will public pension programs in the United States and in Europe be modified so that future benefit obligations are more consistent with tax inflows? These questions of political economy are central to understanding how the demographic transition will affect population age structure and, in turn, how the changing pattern of fiscal balances will affect financial markets. The patterns of wealth decumulation in old age, which feature prominently in any discussion of how changing population age structure will affect financial markets, are likely to be very sensitive to the evolution of government transfer policy with regard to retired households.

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