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The *Review of Economics and Statistics* Lecture

We are pleased to announce the *Review of Economics and Statistics* Lecture, the first in a series of occasional invited lectures presented in person then published along with comments by discussants. The inaugural lecture was presented by Professor James M. Poterba of the MIT Department of Economics at Harvard University on March 20, 2000. His discussants were Professor Andrew B. Abel of the Wharton School at the University of Pennsylvania and Professor John Y. Campbell of the Harvard Economics Department. We have been doubly fortunate that Professor Abel's comments come in the form of a complete separate paper on the same topic as the lecture but with a different methodological approach and different conclusions. We are pleased to include this separate paper here as a complement to the lecture itself.

DEMOGRAPHIC STRUCTURE AND ASSET RETURNS

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Abstract—This paper investigates the association between population age structure, particularly the share of the population in the "prime saving years" (40 to 64), and the returns on stocks and bonds. The paper is motivated by recent claims that the aging of the "baby boom" cohort is a key factor in explaining the recent rise in asset values, and by predictions that asset prices will decline when this group reaches retirement age and begins to reduce its asset holdings. This paper begins by considering household age-asset accumulation profiles. Data from repeated cross sections of the Survey of Consumer Finances suggest that, whereas age-wealth profiles rise sharply when households are in their thirties and forties, they decline much more gradually when households are in their retirement years. When these data are used to generate "projected asset demands" based on the projected future age structure of the U.S. population, they do not show a sharp decline in asset demand between 2020 and 2050. The paper considers the historical relationship between demographic structure and real returns on Treasury bills, long-term government bonds, and corporate stock, using data from the United States, Canada, and the United Kingdom. Although theoretical models generally suggest that equilibrium returns on financial assets will vary in response to changes in population age structure, it is difficult to find robust evidence of such relationships in the time series data. This is partly due to the limited power of statistical tests based on the few "effective degrees of freedom" in the historical record of age structure and asset returns. These results suggest caution in projecting large future changes in asset values on the basis of shifting demographics. Although the projected asset demand does display some correlation with the price-dividend ratio on corporate stocks, this does not portend a sharp prospective decline in asset values, because the projected asset demand variable does not fall in future decades.

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I. Introduction

THE baby boom generation—those born in roughly the two decades following World War II—has had and will continue to have important effects on the U.S. economy. In its youth, this group placed high demands on infrastructure for education and other types of training. The entry of this large cohort into the labor market may have been associated with an increase in the aggregate unemployment rate. The baby boom cohort is now in its prime earning years, and it will begin to reach retirement age in just over a decade. Concern has now begun to focus on the preparations that this cohort has made for retirement, and on the burden that this cohort will place on government programs such as Social Security and Medicare.

How the aging of the baby boom will affect financial markets is an important issue for assessing whether this cohort is saving enough for retirement. Popular accounts, such as Passell (1996), Sterling and Waite (1998), and Dent (1998), sometimes suggest that the rise in U.S. stock prices during the 1990s was partly attributable to the growing demand for financial assets as baby boomers began to save for retirement. Demographic explanations for recent share price movements are typically accompanied by a warning about what may happen in the future, when the baby boomers reach retirement and begin to draw down their wealth. Siegel (1998) summarizes this argument when he writes, "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 the same argument in their analysis of the link between demographic structure and the pattern of inflows and outflows from defined benefit pension plans. While cautious, they nevertheless suggest that "when the pension system begins to be a net seller [of assets] . . . in the third decade of the next century . . . this could depress asset prices, particularly since the demographic structure of the United States does not differ that greatly from Japan and Europe . . ." (p. 25).

Although the potential link between demographic structure and asset returns is widely discussed, few systematic studies have explored the historical relationship among asset prices, population age structure, and asset returns. This paper presents new empirical evidence on these links. It focuses on the returns on Treasury bills, long-term government bonds, and corporate stock in the United States over the last three-quarters of a century, and it also presents some evidence from Canada and the United Kingdom. It considers how the level of asset prices, and the returns earned by investors have varied with shifting demographic structure.

The paper is divided into seven sections. Section II develops a stylized model indicating how demographic changes can affect rates of return on various assets, and it summarizes previous theoretical research on demographic structure and asset returns. Section III describes the age structure of asset holdings in the current U.S. economy. It considers the age pattern of net worth, net financial assets, and corporate stock holdings. This section also describes the historical and prospective age structure of the U.S. population. Section IV summarizes previous empirical research on the links between demographic structure and asset returns.

Section V presents the core empirical findings on the time series relationships between returns and population age structure. The results do not suggest any robust patterns linking demographic structure and asset returns. This finding for the United States is supported by the analysis of data from the United Kingdom and Canada. Section VI combines information from the age structure of asset demands, and from the changing age structure of the population over time, to create a "predicted asset demand" variable that can be related to both asset returns and the level of asset prices. This analysis yields some evidence that higher asset demand is associated with higher asset prices, as measured by the price-to-dividend ratio for common stocks.

Section VII investigates whether changing demographic structure affects returns through its impact on the risk tolerance of potential investors. This section presents survey evidence suggesting that households become more risk averse only at ages that are traditionally associated with retirement, and it raises questions about previous claims that age-related risk aversion affects aggregate returns.

A brief concluding section (VIII) considers several factors that might contribute to a weak relationship between asset returns and demographic structure in a single nation. It also suggests several directions for future empirical as well as theoretical work on the financial market consequences of population aging.

II. Theoretical Analysis of Population Age Structure and Asset Returns

Much of the interest in demographic change and asset markets stems from popular accounts of the rapid rise in U.S. share prices during the 1990s. Such accounts suggest that, as the baby boom cohort entered its prime earning years and began saving for retirement, their asset demand drove up asset prices. It is possible to formalize this logic in a simple model that highlights the many strong assumptions that are needed for this conclusion. Abel (2001) develops more-rigorous formulation and indicates when the general conclusion of rising asset prices is likely to hold.

Assume that individuals live for two periods, and that 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 any period 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) will satisfy

$$p{*}K = N_y{*}s. \tag{1}$$

An increase in the size of the working cohort will drive up asset prices, and the arrival of a small cohort of working age will lead to a decline in asset prices. In such a setting, as a large birth cohort works its way through the life cycle, it will purchase assets at high prices, and sell them at low prices, thereby earning a low return on investments.

The foregoing logic is simple, and it seems compelling in many popular accounts, but it neglects many important realities of asset pricing. First, it fixes the saving rate of young workers, rather than deriving it from an optimizing model with endogenous saving and rational, forward-looking behavior. Rational expectations pose an important challenge to those who argue that demographic factors account for the recent increase in asset values in economies like the United States. The fact that a growing share of the U.S. population would enter the prime saving years of 40 to 64 during the 1990s was predictable at least two decades ago. Forward-looking investors should have anticipated the rising demand for capital and bid up share prices and the prices of other durable assets before the baby boomers reached their saving years.

Second, the foregoing model does not allow for endogenous production of capital. In a more realistic setting, the price of capital goods would affect the growth of the capital stock. Abel (2001) shows that allowing for a supply curve for capital goods can affect the conclusions. His results illustrate that the precise impact of a demographic change is likely to be model specific, and that it is in particular sensitive to specific choices regarding the specification of demand and supply.

Third, the analysis does not consider how a changing age structure might affect other aspects of the economy, such as the rate of productivity growth or, more directly, the marginal product of capital. Cutler et al. (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.

Several recent studies have used intertemporal general equilibrium models, with varying degrees of richness along each of these dimensions, to study whether shifting age structures can significantly affect equilibrium asset returns and asset prices. These studies are not directed at the question of whether demographic factors can explain the recent run-up in U.S. asset values, but rather at issues involving lower-frequency movements in asset values, returns, and demographic structure. Such studies may be relevant for discussions of the potential returns available to the baby boom cohort over the next few decades. The most detailed studies—which include Yoo (1994a), Brooks (2000), and Abel (1999, 2001)—present simulation or analytic results suggesting that demographic change can affect equilibrium returns. These studies leave open the question of whether demographic effects are large enough to be detectable in historical data.

The various studies of equilibrium asset returns and population age structure adopt different modeling strategies, but they reach broadly similar conclusions. Yoo (1994a) calibrates a model in which overlapping generations of consumers live for 55 periods, working for the first 45, and he simulates a "baby boom." He finds that a rise in the birth rate, followed by a decline, first raises then lowers asset prices, but he also discovers that the effects are 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 to a height of roughly 35% above their level in the baseline case. This effect is attenuated, to a 15% increase in asset prices, in a production economy. In both settings, asset prices reach their peak approximately 35 years after the baby boom commences. In the endowment economy, equilibrium asset returns change by roughly 85 basis points per year relative to their values in the absence of a baby boom, whereas, in the production economy, the effect is roughly forty basis points per year.

Brooks (2000) also presents simulation evidence on the impact of a baby boom, but he develops a more stylized model in which consumers 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. Rapid population growth that persists for half a generation (two periods) and that is followed by below-average population growth affects the equilibrium level of both risky and riskless asset returns. The riskless return rises when the baby boom generation is young and working, and it falls by roughly the same amount when the large cohort reaches retirement age, because older households prefer riskless to risky assets. 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. The simulation results suggest that these effects are modest in size. A simulation designed to roughly approximate the postwar baby boom in the United States suggests that riskless returns rise from 4.5% per year, in the initial baseline, to 4.8% per year when the large population cohort is in its peak saving years. Risk-free returns subsequently fall to just over 4.1% when the large cohort reaches retirement. The model also yields intriguing predictions about the relative movements in riskless and risky rates, with a decline in the risk premium when the large birth cohort begins saving and a rise in this premium when it retires.

The third study of demographic change and asset values, Abel (1999), also uses an overlapping-generations model, but it develops analytical rather than simulation results on the impact of demographic change. Abel modifies Diamond's (1965) overlapping-generation neoclassical growth model to allow for random population growth and for adjustment costs in producing capital. The latter permits a shift in population growth to affect the equilibrium price of capital goods. The key analytical finding is that a baby boom drives up the price of capital, but that the price of capital subsequently reverts toward its long-run mean. Thus, the price of capital goods will rise when the baby boom cohort is in the labor force, and decline as this cohort reaches retirement age. The analytical results highlight the dependence of the asset price effect on the parameters of both the consumer's utility function and the production function that is associated with the production of capital goods.

Abel (2001) builds on this framework to explore how introducing a bequest motive would alter the basis analysis. A bequest motive could explain the empirical findings reported later in this paper on the slow decumulation of assets after households reach retirement age, although it is not the only possible explanation for such findings. For at least some specifications of the bequest motive, the slow draw-down of assets during retirement does not overturn the basic conclusion that a decline in the population growth rate in associated with a decline in the equilibrium price of capital. This implies that showing that households do not draw down their assets does not provide conclusive evidence against the view that a demographic shock like the baby boom could lead to an increase, and then a decline, in asset prices.

These studies confirm the basic insight that shocks to the rate of population growth can affect equilibrium asset returns in well-specified general equilibrium models. The simulation results from Yoo (1994a) and Brooks (2000) nevertheless suggest that the effects of plausible-sized demographic shocks may be relatively modest in magnitude. These findings motivate the empirical work on asset returns, asset prices, and demographic structure that comprises the balance of this paper.

III. Age Patterns in Asset Ownership

The theoretical analysis in each of the papers previously described, with the exception of Abel (2001), assumes that there are pronounced age patterns in the ownership of financial assets. This can take two forms: differences in the amount of wealth that households hold at different ages, and differences in the composition of wealth that households hold at different ages. In overlapping-generations models in which consumers are born, acquire assets, and then die, and in which consumers do not have bequest motives, assets are accumulated as the household ages and then they are decumulated before death. In practice, although there is little doubt that households accumulate assets early in life and through middle age, Hurd's (1990) summary suggests that there is less agreement on the rate at which assets are decumulated in retirement. Researchers also disagree on the reason for slow decumulation, in particular on the relative importance of bequest motives and precautionary saving demands in accounting for this pattern. Studying how asset profiles vary as households age provides evidence on how rapidly assets are likely to be sold off as the baby boom cohort ages.

A. Age-Wealth Profiles in the Survey of Consumer Finances

Many previous studies have computed age-wealth profiles, or age-saving profiles, and tested for evidence of stylized "life cycle" behavior. However, relatively few of these studies have focused on the high-net-worth households who account for the majority of net worth in the U.S. economy. Data on these households is provided by the repeated cross sections of the Survey of Consumer Finances (SCF). The SCF provides the most comprehensive information on asset ownership in the United States. The Federal Reserve Board commissioned the first "modern" SCF in 1983, and the survey has been conducted every three years since then. Kennickell, Starr-McLuer, and Sunden (1997) provide a detailed description of the SCF, along with summary tabulations from the most recent survey.

The Survey of Consumer Finances can be used to measure average levels of asset holdings for individuals in different age groups. The basic unit of observation in the survey is the household, and most households include several adult members. To construct age-specific asset profiles, I have allocated half of the assets held by married couples to each member of the couple. Thus, if a married couple in which the husband is 62 and the wife is 57 holds $250,000 in financial assets, this will translate into $125,000 held by a 62-year-old, and $125,000 held by a 57-year-old.

Many previous studies of age-wealth profiles, including those by Yoo (1994b) and Bergantino (1998), focus on cross-sectional age-wealth profiles. Such wealth profiles describe the average asset holdings of individuals of different ages at a point in time. Such data can be used to summarize the potential evolution of asset demand as the population age structure changes only under the assumption that the cohort effects for all of the age groups are identical. Shorrocks (1975) is one of the first studies to recognize the need to move beyond cross-sectional data in studying age-wealth profiles.

To illustrate the difficultly with cross-sectional age-wealth profiles, the asset holdings by individuals of age a at time period t, A_{at}, can in principle be decomposed as follows:

$$A_{at} = \alpha_a + \beta_t + \gamma_{t-a}, \tag{2}$$

where α_a is the age-specific asset demand at age a, β_t is the time-period-specific shift in asset demand, and γ_{t-a} is the cohort-specific asset demand effort for those who were born in period $t - a$. With a single cross-section of asset demands by age, it is not possible to separate any of these effects. With panel data or repeated cross sections, it is possible to estimate two of the three effects, but it is not possible to recover all three. Because birth cohort is a linear combination of age and time, there is a fundamental identification problem with recovering all three effects.

There are good reasons to expect both cohort effects and time effects in asset demands. For example, individuals who lived through the Great Depression may have lower levels of lifetime earnings, and correspondingly lower levels of net worth at all ages, than individuals who were born in more recent years. This could lead to cohort effects. Alternatively, a revaluation of assets, such as a sharp increase in asset values in the 1990s, may raise the wealth of all individuals in a given period. This would result in time effects. This makes it natural to compare cross-sectional age-wealth profiles with profiles estimated with some allowance for time or cohort effects.

Table 1 presents a cross-sectional age-wealth profile from the 1995 SCF. It reports average holdings of common stock, net financial assets, and net worth for individuals in different five-year age groups. Not surprisingly, there are important age-related differences in the levels of assets and in net worth. The table focuses on mean holdings, which are much higher than median holdings at all ages. Average holdings of net financial assets rise with an individual's age for those between their early thirties and those in their early sixties. There is a decline in the rate of increase in financial asset holdings for individuals at older ages, but there is no evident decline in net financial assets when one compares those above age 75 with those in somewhat younger age groups.

A similar pattern emerges with respect to both corporate stock and net worth. Older individuals exhibit larger asset holdings than do younger ones, but there is only a limited

TABLE 1.—CROSS-SECTIONAL ESTIMATES OF AGE-SPECIFIC ASSET DEMANDS, 1995 SURVEY OF CONSUMER FINANCES

Age of Individual	Common Stock Holdings	Net Financial Assets	Net Worth
15–19	$0	$1,610	$10,144
		(2,832)	(5,406)
20–24	384	−1,340	7,635
	(73)	(1,660)	(5,308)
25–29	3,073	4,322	19,798
	(510)	(1,339)	(2,984)
30–34	4,666	7,806	30,666
	(1,515)	(3,334)	(8,891)
35–39	7,438	13,692	53,767
	(4,399)	(8,019)	(12,171)
40–44	14,593	26,564	90,606
	(3,584)	(6,168)	(18,701)
45–49	21,762	42,442	131,932
	(4,554)	(9,915)	(26,660)
50–54	29,965	59,083	169,574
	(20,628)	(25,660)	(42,454)
55–59	38,319	65,781	186,505
	(17,943)	(27,798)	(54,645)
60–64	29,416	63,066	178,648
	(16,167)	(28,842)	(54,312)
65–69	29,219	82,538	189,068
	(16,605)	(37,538)	(65,026)
70–74	31,367	76,835	190,729
	(30,067)	(45,789)	(70,800)
75+	34,558	84,806	167,279
	(26,645)	(42,151)	(62,174)
All ages	18,272	38,351	106,399
	(3,407)	(5,475)	(9,612)

Common stock holding includes assets held through defined contribution pension accounts. 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. Standard errors are shown in parentheses.

downturn in average asset holdings at older ages. There is some downturn in holdings of corporate stock, where the age-specific ownership peaks between the age of 55 and 59 at $38,319, and declines by nearly $10,000 for those in the next two age categories. The imprecision of the age-specific asset holdings makes it difficult, however, to reject the null hypothesis that stock holdings is constant at ages above 55. Net worth (which includes financial assets as well as holdings of owner-occupied real estate, other real property, equity in unincorporated businesses, and assets held through defined-contribution pension plans) rises up to age 55, and then stays relatively constant for the remainder of an individual's lifetime.

The confounding effects of age and cohort make it difficult to interpret findings like those in table 1. If older cohorts have lower lifetime earnings than do younger cohorts, and if the accumulation of financial assets is correlated with lifetime earnings, then we could observe lower asset holdings at older ages even if households did not draw down assets in their old age. Alternatively, if older households had higher lifetime earnings on average than did their younger counterparts, or if older households had lived through a period of particularly favorable asset market returns, then it would be possible to observe a rising age-asset profile at all ages, even if older households did reduce their asset holdings as they aged.

Ameriks and Zeldes (2000) present simple examples of how a given age-wealth profile, and even 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. In light of the fundamental identification problem noted above, studies that move beyond cross-sectional comparisons of asset holdings at different ages must choose between a cohort-effects and a time-effects specification. Allowing for cohort effects offers the best chance of detecting a traditional hump-shaped, life cycle pattern of asset holdings in cross-sectional data like those in table 1. Because cohort effects allow for different wealth levels for households at different ages, they can reconcile a flat age-wealth cross-sectional profile with a declining cohort-specific pattern. Allowing for time effects, however, would not recover such a pattern because all cohorts are constrained to experience the same asset shock in each period.

To provide the best possible opportunity for evidence of prospective asset decumulation to emerge from the SCF data, I use repeated cross sections of the SCF from 1983, 1986, 1989, 1992, and 1995 to estimate age profiles of asset ownership, allowing for different lifetime asset levels for different birth cohorts. The empirical specification models A_{it}, the level of an asset stock (or of net worth) held by individuals in age group a in period t as

$$A_{it} = \Sigma\alpha_j{*}AGE_{ijt} + \Sigma\gamma_c{*}COHORT_{it} + \epsilon_{it}, \qquad (3)$$

where α_j denotes the age effect on asset ownership and γ_c denotes a birth-cohort-specific intercept term that captures the level of assets held by different birth cohorts. Both sets of parameters are estimated conditional on the assumption that there are no time effects on asset demand.

Assets in different years of the SCF are inflated or deflated to constant 1995 dollars using the Consumer Price Index. The equations are estimated by ordinary least squares, and the sample size varies across years of the SCF. There are 30,553 individuals in the combined SCF data files for these years, with 30,394 observations reporting all of the variables that are needed to estimate equation (3). Net financial assets are defined inclusive of assets in defined contribution pension accounts, and equity for 1983 includes an imputation of half of the assets in self-directed defined-contribution pension accounts.

The α_j coefficients in equation (3) can be used to predict how an individual's asset holdings will change as they age. Poterba and Samwick (2001) present detailed findings, using this method, for a range of different asset classes. Ameriks and Zeldes (2000) also analyze repeated cross sections of the SCF, along with a panel data set of TIAA-CREF participants, to study how the equity share of household portfolios change as households age.

Table 2 presents the estimates of the age effects, the $\{\alpha_i\}$ coefficients, from equation (3) for three asset categories,

TABLE 2.—AGE-SPECIFIC ASSET DEMANDS ESTIMATED ALLOWING FOR AGE AND COHORT EFFECTS, SURVEYS OF CONSUMER FINANCES, 1983–1995

Age of Individual	Common Stock Holdings	Net Financial Assets	Net Worth
15–19	$0	$2,285	$11,042
	(0)	(2,823)	(5,391)
20–24	470	2,170	13,656
	(134)	(2,939)	(6,337)
25–29	1,477	4,477	25,471
	(214)	(3,010)	(6,848)
30–34	3,391	9,402	37,706
	(367)	(3,126)	(6,648)
35–39	5,906	14,325	60,758
	(908)	(3,352)	(7,166)
40–44	10,795	20,236	86,808
	(1,175)	(4,789)	(7,939)
45–49	18,631	37,122	123,683
	(1,996)	(4,668)	(10,136)
50–54	23,913	57,396	151,981
	(2,805)	(6,634)	(15,641)
55–59	32,515	71,884	177,522
	(3,882)	(7,505)	(17,133)
60–64	31,004	80,931	189,134
	(4,857)	(8,757)	(19,670)
65–69	30,822	92,262	201,509
	(5,791)	(9,901)	(22,973)
70–74	28,219	92,366	173,796
	(7,186)	(11,707)	(25,961)
75+	24,722	92,239	144,316
	(7,482)	(12,091)	(27,026)

Estimates are based on regression models that relate real holdings of various assets by age cohorts in different survey years to a set of cohort "intercepts" and indicator variables for various age groups. Standard errors are shown in parentheses. See text for further discussion.

and table 3 shows the cohort-specific intercepts. The patterns in the age-effect coefficients in table 2 are quite similar to those of the cross-sectional wealth holding coefficients in table 1. The results suggest that allowing for cohort effects has a surprisingly small impact on the estimated age structure of asset holdings. Whereas holdings of common stock and total financial assets increase as individuals age, the decline in assets as individuals enter old age is again much less pronounced than the increase in asset holdings during middle age. For equities, for example, real holdings of common stock peak between the age of 55 and 59, at $32,515. They decline to $28,219 for those between the ages of 70 and 74, and further, to $24,722, for those over the age of 75.

For net financial assets, there is virtually no decline in old age, with peak holdings between the ages of 70 and 74, and, for net worth, the peak occurs between 65 and 69 with a notable decline at ages above 75. For household net worth (which may be the most relevant variable in determining the demand for assets), the point estimates of the age effects decline after age 65, but the standard errors are large enough to admit a relatively wide range of age-wealth profiles. The point estimate of the net worth level for individuals aged 75 and older is roughly one-quarter lower than that for households in their mid sixties. The large standard errors in table 2 are a reflection of the very large underlying dispersion of asset wealth, which makes it difficult to precisely estimate age patterns in asset holdings.

The limited decline in financial asset holdings as individuals age suggests that the rush to sell financial assets that underlies most predictions of "market meltdown" in 2020 or 2030 may be somewhat muted. The results in tables 1 and 2 do suggest that there are substantial increases in asset holdings as households move through their thirties and forties, which supports the view that the aging of the baby boom cohort during the last two decades could have raised the demand for financial assets.

The coefficient estimates in table 2 suggest that corporate stock as a share of net financial assets rises as individuals age, but that this share declines after individuals reach retirement age. The systematic growth in equity ownership during the last two decades, however, makes it particularly difficult to attribute this to a hump-shaped pattern of age effects for equity ownership. Ameriks and Zeldes (2000) show that, over the 1989–1995 period, when one fits a model that includes age and time effects, the pattern of estimated age effects is virtually flat. With age and cohort effects, however, there is an upward-sloping profile to age effects for the share of equity in the total portfolio. The age profile of equity shares may be particularly important for discussions of how population aging may affect the equity premium, but it may be less central for discussions of overall asset returns.

Table 3 presents the estimated cohort-specific intercepts from equation (3). There are surprisingly small differences across cohorts for net worth, equities, and net financial

TABLE 3.—COHORT-SPECIFIC INTERCEPTS FOR ASSET DEMANDS, SURVEYS OF CONSUMER FINANCES, 1983–1995

Birth Year Cohort for Individual	Common Stock Holdings	Net Financial Assets	Net Worth
1971–1975	$−102	$−2,673	$−4,317
	(136)	(2,991)	(6,333)
1970–1974	624	−881	−4,720
	(236)	(2,982)	(6,631)
1965–1969	−9	−1,220	−36
	(94)	(2,897)	(6,002)
1960–1964	−178	−703	−821
	(255)	(3,111)	(6,822)
1955–1959	−1,137	−3,671	−4,923
	(321)	(3,078)	(6,766)
1950–1954	−507	−5,512	8,425
	(1,335)	(3,891)	(7,523)
1945–1949	−2,394	−5,444	−1,250
	(1,250)	(4,292)	(8,342)
1940–1944	−2,087	−11,024	−3,230
	(2,767)	(5,414)	(11,829)
1935–1939	−8,917	−26,819	−15,385
	(3.057)	(7,314)	(17,616)
1930–1934	−2,771	−15,294	−3,741
	(4,730)	(8,478)	(19,196)
1925–1929	−6,984	−24,458	−19,281
	(5,351)	(9,312)	(20,572)
Before 1925	1,714	−21,686	−720
	(6593)	(10,756)	(25,601)
R^2	0.008	0.017	0.041

Estimates are based on regression models that relate real holdings of various assets by age cohorts in different survey years to a set of cohort "intercepts" and indicator variables for various age groups. Robust standard errors are shown in parentheses. Sample size is 30,394 observations. See text for further discussion.

TABLE 4.—HISTORICAL AND FORECAST VALUES FOR INDICATORS OF DEMOGRAPHIC STRUCTURE, 1920–2050

Year	Median Age	Average Age of Those 20+	Percentage of Population 40–64	(Population 40–64)/ Population 65+	(Population 40–64)/ Population 20+
1920	25.3	40.3	22.2	4.8	0.375
1930	26.5	41.2	24.1	4.4	0.392
1940	29.1	42.2	26.5	3.9	0.404
1950	30.2	43.5	27.0	3.3	0.409
1960	29.4	45.3	26.5	2.9	0.431
1970	27.9	45.2	26.3	2.7	0.423
1980	30.0	44.5	24.7	2.2	0.362
1990	32.8	45.1	25.7	2.1	0.361
2000	35.7	46.6	30.4	2.4	0.426
2010	35.7	46.6	30.4	2.4	0.456
2020	37.6	49.2	30.5	1.8	0.416
2030	38.5	50.5	28.0	1.4	0.382
2040	38.6	51.0	27.9	1.4	0.381
2050	38.1	51.1	27.6	1.4	0.379

Source: U.S. Census Bureau historical data and projections from CPS Reports P25–1130. Average age over twenty 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.

assets, and the standard errors associated with most of the cohort effects are large relative to the differences in the cohort-specific coefficients. For example, one cannot reject the null hypothesis that the age-specific net worth profile for individuals born between 1925 and 1929 is the same as that for individuals born between 1945 and 1949. The large dispersion in wealth at various ages is reflected in the low R^2 values for models like equation (3). The model has the greatest explanatory power with respect to net worth, and, even in that case, cohort and age effects explain less than 5% of the variation in real net worth.

The foregoing results suggest rapid growth in asset holdings during the early part of a household's working career. They suggest somewhat less rapid decumulation of assets in retirement, but they do indicate, particularly with respect to net worth, some decline. One recent study using SCF data, Sabelhaus and Pence (1998), finds somewhat greater dissaving after retirement than the estimates in table 2 suggest. This is in part due to different "mortality adjustments" for older households. Tables 1 and 2 report asset holdings for individuals, not households. At most ages, dividing household assets equally across adult members of the household is a natural way to generate an age-asset holding profile. For older individuals, however, mortality can have an important effect on the measured trajectory of asset holding, for at least three reasons.

First, mortality may be correlated with net worth. Attanasio and Hoynes (2000) find that high-income households have lower mortality rates than do their lower-net-worth counterparts. Those who survive to advanced ages may therefore be a selected group, biased toward a higher-net-worth part of the population. This is very likely to result in upward bias in the age-wealth profile.

Second, when one member of a married couple dies, the couple's assets typically flow to the surviving spouse. This can raise the net worth of the survivor relative to what it would have been when this individual's spouse was still alive. Because other research suggests that surviving spouses draw down their assets faster than do married couples, however, the net effect of this bias may be modest. Reestimating the age effects in table 2 with the wealth of each widow or widower divided by 2 lowered the level of the age-wealth profile, but it did not affect the proportionate decumulation at older ages.

Third, when an older person dies and leaves his or her assets to a group of heirs, this may affect the demand for assets, but the effects are complex. If the recipients of bequests continue to hold the assets, rather than using them to finance consumption, the death of the decedent may not have a pronounced effect on the desired stock of wealth. How long assets are held after the recipients of bequests receive them is an open issue. Holtz-Eakin, Joulfaian, and Rosen (1993) present some evidence that individuals who receive large inheritances are more likely to leave the labor force than are those with comparable pre-inheritance incomes who do not receive bequests. This provides some support for the notion that bequests are used to support higher levels of consumption. The absence of other data on consumption spending by bequest recipients, however, makes it difficult to address this issue quantitatively.

The calculations of age-wealth profiles in tables 1 and 2 omit defined-benefit pension assets. Schieber and Shoven's (1997) analysis of population aging and asset demand emphasizes the mechanical accumulation, and then decumulation, of assets that occurs as individuals age in a defined-benefit pension regime. 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. Such effects may be have been more important historically then they will be prospectively, at least in the United States, because current trends suggest an important shift away from defined-benefit and toward defined-contribution pension plans.

B. *Changing Demographic Patterns: Past and Future*

To translate the age-wealth profiles reported in tables 1 and 2 into measures of aggregate asset demand, one needs information on the demographic structure of the population. Table 4 presents summary statistics on various measures of the age structure of the U.S. population for every tenth year between 1920 and 2050. The historical data are drawn from Census Bureau *Population Reports P-25* publications, whereas the forecasts beginning in year 2000 are based on Census projections.

The data in table 4 show that, between 1970 and 2000, the median age of the U.S. population increased by nearly eight years. It is projected to increase by more than an additional two years between 2000 and 2050. The median age in 2000 is more than ten years greater than the median age was in 1900. The two periods of most rapid increase in median age during the last century were 1920–1940 and 1960–1990. The average age of the adult population rose by 4.2 years between 1930 and 1960. The median age rose by less. In the last three decades, the average age of adults has risen less than 1.5 years. The summary measure of population age structure shows both increases and decreases during the postwar period.

The fraction of the population in the asset-accumulating years, 40–64, is often cited as a key variable in discussions of asset demand and demographic structure. Table 4 shows that this fraction rose by roughly four percentage points, to 30.4%, between 1970 and 2000. Looking forward, this fraction is expected to decline by nearly three percentage points between 2000 and 2050. The population share in this age group exhibits substantial long-term and short-term variation. It was 19.4% in 1900, compared with 30.4% today, and it has changed by nearly five percentage points since 1990. It was 27% in 1950, 24.7% in 1980, and 25.7% in 1990.

Table 4 shows that there was a rapid change between 1950 and 2000 in the median age of the entire population, with a smaller change in the average age of those over the age of nineteen. In the next fifty years, however, the most dramatic change will be in the average age of those in the twenty-and-older age group. Today, the population between the ages of 40 and 64 is 2.3 times as large as the population over the age of 65. By 2050, this ratio, which is sometimes called the elderly dependency ratio, will have declined to 1.4. As a share of the adult population, those between the ages of 40 and 64 account for 42.6% of the population in 2000, up from 36.1% in 1990, but similar to the 42.3% value for 1990. The record of past experience is important because it suggests that the prospective demographic changes that the United States will experience in the next three decades are not outside the range of experience in the past century.

C. *Integrating Age-Specific Asset Demands with Changing Age Structure: Projected Asset Demand*

To illustrate the impact of population aging on the demand for financial assets, it is possible 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:

$$(PROJECTED\ ASSET\ DEMAND)_t = \Sigma\alpha_i{*}N_{it}, \qquad (4)$$

where α_i denotes the age-specific asset holdings from table 2, and N_{it} denotes the actual or projected number of individuals of age i in year t. Mankiw and Weil (1989) used a similar strategy to construct their measure of demography-affected housing demand, with estimates of age-specific housing demand based on Census data. Bergantino (1998) followed a similar approach in estimating demand for both housing and corporate stock based on a cross-sectional household wealth survey.

Table 5 reports the projected demand for common stock, financial assets, and net worth for each year between 1925 and 2050, based on the age-specific asset demand coefficients reported in table 2. (These are estimates that correct for cohort effects.) The table shows that projected asset demand rises over the four-decade period between 1980 and 2020. Projected asset holdings per capita reach a plateau after that date, reflecting the relatively flat profile of age-specific asset ownership between middle age and death. This finding contrasts with the "asset market meltdown" scenarios that predict a sharp decline in asset demand in the decades after 2020. Because there is only modest dissaving at older ages in table 2, the aging of the baby boom cohort does not result in a significant decline in asset demand.

The data in table 5 also show a modest decline in the projected per capita holdings of both common stock and net worth between 1960 and 1980. This reflects the growing importance of young households, with relatively small asset holdings, during this time period. Between 1925 and 1950, each of the three projected asset demand series display substantial increase.

Time series like those in table 5 can be used to study the historical relationship between demographic shifts and the returns on various financial assets. High values of projected asset demand should be associated with low required returns and high asset prices. Calculations like those that underlie the estimates in table 5 should be viewed with caution, however. Using a static age-wealth profile, like the estimates of the $\{\alpha_i\}$ parameters in table 2, does not allow for rational forward-looking consumers to adjust their saving and asset holdings in response to expected changes in asset returns. Of course, analyses that predict future asset prices on the basis of currently forecastable demographics assume a relatively stable relationship between asset demand and demographic structure.

TABLE 5.—PROJECTED ASSET DEMAND PER CAPITA, PERSONS AGED FIFTEEN AND GREATER

Year	Common Stock Holdings	Net Financial Assets	Net Worth	Year	Common Stock Holdings	Net Financial Assets	Net Worth
1925	10.359	26.120	74.790	1968	13.099	34.342	89.397
1926	10.419	26.275	75.121	1969	13.041	34.238	89.009
1927	10.476	26.433	75.433	1970	12.982	34.156	88.611
1928	10.487	26.533	75.492	1971	12.914	34.039	88.167
1929	10.583	26.742	76.059	1972	12.844	33.924	87.769
1930	10.652	26.942	76.451	1973	12.777	33.817	87.386
1931	10.750	27.204	76.969	1974	12.715	33.721	87.015
1932	10.846	27.457	77.474	1975	12.665	33.661	86.698
1933	10.937	27.701	77.957	1976	12.603	33.563	86.334
1934	11.022	27.931	78.411	1977	12.569	33.527	86.143
1935	11.100	28.150	78.833	1978	12.536	33.491	85.984
1936	11.171	28.353	79.219	1979	12.504	33.465	85.834
1937	11.236	28.547	79.580	1980	12.474	33.444	85.706
1938	11.308	28.760	79.988	1981	12.450	33.430	85.633
1939	11.366	28.938	80.313	1982	12.454	33.477	85.774
1940	11.423	29.107	80.631	1983	12.471	33.538	85.963
1941	11.505	29.334	81.099	1984	12.475	33.571	86.086
1942	11.600	29.593	81.623	1985	12.475	33.599	86.183
1943	11.683	29.831	82.116	1986	12.468	33.607	86.246
1944	11.765	30.059	82.592	1987	12.514	33.720	86.616
1945	11.892	30.411	83.328	1988	12.575	33.869	87.056
1946	12.013	30.749	84.029	1989	12.638	34.029	87.520
1947	12.121	31.061	84.654	1990	12.726	34.250	88.102
1948	12.229	31.369	85.278	1991	12.773	34.360	88.444
1949	12.351	31.714	85.975	1992	12.900	34.655	89.186
1950	12.457	32.031	86.608	1993	12.991	34.859	89.720
1951	12.584	32.384	87.328	1994	13.093	35.076	90.294
1952	12.704	32.724	88.024	1995	13.173	35.240	90.760
1953	12.817	33.053	88.676	1996	13.258	35.403	91.227
1954	12.929	33.387	89.313	1997	13.371	35.654	91.811
1955	13.039	33.710	89.927	1998	13.511	35.968	92.506
1956	13.125	33.968	90.403	1999	13.632	36.231	93.110
1957	13.192	34.184	90.769	2000	13.749	36.491	93.695
1958	13.222	34.299	90.884	2001	13.860	36.739	94.248
1959	13.275	34.479	91.130	2002	14.014	37.073	94.953
1960	13.332	34.665	91.405	2003	14.148	37.393	95.603
1961	13.378	34.820	91.606	2004	14.274	37.688	96.210
1962	13.319	34.709	91.165	2005	14.390	37.968	96.754
1963	13.288	34.652	90.887	2010	14.953	39.584	99.600
1964	13.260	34.614	90.627	2020	15.697	42.603	103.756
1965	13.231	34.575	90.368	2030	15.709	43.896	103.957
1966	13.188	34.502	90.041	2040	15.660	44.138	103.066
1967	13.146	34.428	89.726	2050	15.690	44.202	103.248

Each column reports the value of $\Sigma \alpha_i {}^* N_{it}$, where α_i denotes age-specific asset holdings (for five-year age groups) based on the cohort-corrected wealth accumulation models reported in table 2. N denotes the actual or projected number of individuals in a given age range in a given year. Tabulations apply to individuals aged fifteen and greater. Dollar amounts are in 1995 dollars. See text for further details.

IV. Previous Empirical Evidence on Asset Returns and Population Age Structure

Several previous studies have considered how changing demographic structure affects asset prices and asset returns. The best known is Mankiw and Weil's (1989) analysis of house prices and the age structure of the U.S. population. It shows that demand for owner-occupied housing rises sharply when households pass through ages between 25 and 40, and finds a strong time series correlation between a demographic housing demand variable and real house prices in the postwar period. The study forecast that the reduced housing demand that would result from the aging of the U.S. population in the decades after 1990 would lead to substantially lower house prices. The last decade has not witnessed the sharp decline in real prices that the study predicted, although it is difficult to interpret this experience as a clear refutation. Housing demand is increasing in household net worth, and the sharp increase in household net worth during the last decade has surely led to higher demand for housing than would otherwise have occurred.

A number of studies have specifically considered issues relating to the "asset market meltdown" scenario. The first systematic study of age structure and asset returns, by Bakshi and Chen (1994), includes a variable measuring the average age of the U.S. population in a standard Euler equation that relates the growth rate of consumption to either T-bill or stock returns. This specification is motivated by claims that risk tolerance declines as households age, as in Brooks' (1999) model described previously. The authors assume that the utility function of the representative consumer is given by

$$U(C_t, M_t) = C_t^{1-\gamma-\lambda^* M_t}/(1 - \gamma - \lambda^* M_t), \quad (5)$$

where M_t denotes the average age of the population, and C_t denotes aggregate per capita consumption. Allowing for nonzero values of λ improves the fit of the intertemporal Euler equation associated with equation (5), and the authors interpret this as evidence of age-dependent risk aversion. This finding implies that changes in population age structure would affect equilibrium asset returns.

Whereas Bakshi and Chen (1994) constrain demographic change to affect asset returns in a tightly parameterized way, a second study, Yoo (1994b), allows for a more flexible relationship. This study relates real returns on stocks, bonds, and Treasury bills to five explanatory variables corresponding to the share of the population in different age groups. Some of the empirical results presented later are similar, although they impose greater structure on the demographic variables to avoid "overfitting" with many slowly trending time series on population shares. Yoo focuses on the 1926–1988 period, and finds that a higher fraction of the population in the prime saving years is associated with a lower real return on Treasury bills. The results for other asset classes are less definitive, and large standard errors make it impossible to draw firm inferences about the link between demographic structure and returns on longer-maturity assets.

Two related studies focus on U.S. stock returns over a shorter time period. Macunovich (1997) follows a strategy similar to that of Yoo (1994b), although she includes an even richer set of demographic variables in regression equations that seek to explain the postwar fluctuation in the real return to the Dow Jones Industrial Average. She considers nearly a dozen population age share variables, and overfitting appears to be a substantial problem. Poterba (1998) shows that specifications like those used by Macunovich lead to implausible out-of-sample predictions for the real return on stocks, with both very large positive and very large negative returns. This suggests that the underlying regression models may be overfitting within-sample trends.

Erb, Harvey, and Viskanta (1997), in another study of the postwar U.S. experience, focus on the sample period 1970–1995 and finds a positive correlation between the fraction of the population between the ages of 25 and 45 and real stock returns. This contrasts with Yoo's (1994b) statistically insignificant, but negative, effect of the share for this population age group. They also show that there is a positive relationship in both developed and developing countries between stock returns and the change in the average age of a country's inhabitants. Although this finding suggests a possible link from demographic structure to asset returns, other interpretations are also possible. In many developing nations, 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.

Goyal (1999) explores the link between population age structure and the net cash outflows, defined as dividends plus net share repurchases, from the corporate sector. The study finds 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, and a decline in the equity premium. However, the study also considers the impact of prospective changes in population age structure, and concludes that they are likely to have at most a modest impact on asset returns.

Finally, two other studies, by Brooks (1998) and Bergantino (1998), focus on the link between demographic structure and the level of asset prices. Brooks relates the level of real equity prices for OECD nations to the ratio of the population aged 40–64 to that outside this age range. For eleven of fourteen 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. For some of the smaller nations in the sample (such as Denmark, Belgium, and the Netherlands), it is also unclear whether domestic demographic variables should have much impact on domestic share prices.

Bergantino's (1998) study extends Mankiw and Weil's (1989) research strategy. It studies house prices and stock returns in the United States, and estimates age-specific asset demands using cross-sectional data. The study then considers the effect of changes in the level of demographic demand on changes in house and share prices, and it finds a clear relationship between the level of age-specific asset demand and the level of stock prices. These effects are clearest in multiyear differences of prices, which tend to emphasize the low-frequency variation in the demographic demand variable. Bergantino interprets these findings as strong support for an important demographic demand effect on stock prices. He uses his model to calculate the share of postwar equity price movements that can be attributed to demographic factors, and to predict the future evolution of equity values. Given the size of demographic changes, he concludes that these changes have had and will have a large impact on stock price levels.

The balance of previous work seems to suggest that demographic factors are correlated with the level of asset prices, although each of the empirical specifications is open to some question. One of the generic difficulties that plagues all of these studies concerns effective sample size. This is a manifestation of a more general problem, discussed for example by Campbell, Lo, and MacKinlay (1996) and by Ferson, Sarkissian, and Simin (2000), of testing for low-frequency patterns in asset returns. Given the slowly evolving character of population age structure, even annual data may overstate the effective degrees of freedom associated with studies of demography and asset markets. There is one baby boom shock in the postwar U.S. demographic experience, and, as the baby boom cohort has approached age fifty,

TABLE 6.—DEMOGRAPHIC STRUCTURE AND REAL RETURNS ON STOCKS, BONDS, AND BILLS: ANNUAL REGRESSION ESTIMATES

Asset Return and Sample Period	Independent Variable Measuring Demographic Structure: Median Age	Average Age of Those 20+	Percentage of Population 40–64	(Population 40–64)/ Population 65+	(Population 40–64)/ Population 20+
1926–1999					
Treasury bills	−0.001	0.000	−1.303	−0.002	−0.392
	(0.002)	(0.004)	(0.350)	(0.006)	(0.187)
Long-term government bonds	0.004	−0.006	−1.732	0.000	−1.158
	(0.006)	(0.008)	(0.959)	(0.015)	(0.474)
Common stock	0.014	0.003	1.464	−0.001	−0.070
	(0.011)	(0.015)	(1.877)	(0.030)	(0.948)
1947–1999					
Treasury bills	0.004	0.021	−0.553	−0.040	−0.291
	(0.002)	(0.005)	(0.396)	(0.009)	(0.155)
Long-term government bonds	0.015	0.023	−1.180	−0.082	−1.131
	(0.007)	(0.020)	(1.336)	(0.032)	(0.510)
Common stock	0.023	0.027	2.851	−0.018	−0.045
	(0.011)	(0.030)	(2.016)	(0.052)	(0.816)
1926–1975					
Treasury bills	−0.021	−0.004	−2.573	0.015	−0.253
	(0.004)	(0.004)	(0.496)	(0.010)	(0.465)
Long-term government bonds	−0.023	−0.017	−3.111	0.046	−1.440
	(0.008)	(0.007)	(0.980)	(0.016)	(0.785)
Common stock	0.010	−0.008	−0.287	0.027	−0.034
	(0.026)	(0.020)	(3.073)	(0.050)	(2.313)

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

$$R_t = \alpha + \beta^*(DEMOGRAPHIC\ VARIABLE)_t + \epsilon_t.$$

Standard errors are shown in parentheses. Equations are estimated using annual data for the sample period indicated. Dickey-Fuller (1979) tests, allowing for an estimated mean, applied to the five explanatory variables for the 1926–1999 sample period yield t-statistics of 1.804, −2.356, −1.018, −5.271, and −0.572, respectively.

real stock market wealth has risen rapidly. This is consistent with the same variants of the demographic demand hypothesis. Whether fifty years of prices and returns on this experience represent one observation or fifty is, however, an open question.

Against the background of these prior studies, the current paper presents a battery of new empirical findings. First, it examines the U.S. time series on asset returns and relates real returns on stocks, bonds, and bills to a broader range of demographic variables than do previous studies. It also explores the sensitivity of the empirical findings to different data subsamples, and presents related evidence for Canada and the United Kingdom. Second, it considers the relationship between the level of stock prices, measured by the price-to-dividend ratio, and various measures of demographic structure. Third, it uses the projected asset demand variable described previously to explore how demographic demand is related to asset returns. Finally, this study revisits Bakshi and Chen's (1994) estimates of how the representative consumer's coefficient of relative risk aversion depends on demographic variables, using both survey data on household preferences with respect to risk as well as aggregate time series data.

V. New Evidence on Population Age Structure and Asset Returns

The theoretical models discussed previously do not offer clear guidance on which measure of population age structure should affect asset prices and asset returns. Rather than trying to make an arbitrary choice among such variables, this section presents empirical results that exploit a range of different potential measures of demographic structure. Each measure is included in a bivariate regression in which an asset return is the dependent variable.

A. *Evidence for the United States*

This section considers the relationship between real returns on three assets—Treasury bills, long-term government bonds, and large corporate stocks (as measured by the return on the S&P index)—and several measures of population age structure. Real returns are computed by subtracting actual inflation rates for each year (based on 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 1926–1999, for which Ibbotson Associates (2000) provides reliable and comparable data on returns. For each of the three asset classes, I consider the link between demography and asset returns for the postwar period (1947–1999) as well as for the 1926–1975 sample. Considering several different asset categories provides information on returns on both relatively low-volatility assets (Treasury bills) and more-risky assets. It also has the potential to provide information on how demographic factors affect the equity risk premium. Considering several different assets also allows for the possibility that age-related patterns in the demand for particular assets (such as equities) lead to more-pronounced demographic effects for some assets than for others, and thus to movements in the risk premium for some assets.

Table 6 presents the estimated δ_j coefficients from regres-

TABLE 7.—UNIT ROOT TEST STATISTICS FOR RESIDUALS FROM MODELS RELATING RETURNS TO DEMOGRAPHIC VARIABLES, 1926–1999

	Independent Variable Measuring Demographic Structure				
Asset Return and Sample Period	Median Age	Average Age of Those 20+	Percentage of Population 40–64	(Population 40–64)/ Population 65+	(Population 40–64)/ Population 20+
Treasury bills	−3.805	−3.824	−3.973	−3.846	−3.932
Long-term government bonds	−7.981	−7.927	−8.150	−7.890	−8.490
Common stock	−8.613	−8.380	−8.469	−8.373	−8.372

Each entry reports the value of the Dickey-Fuller (1979) test statistic, allowing for an unknown mean, applied to the residuals corresponding to the regression equations in the first panel of table 6. The critical (95%) value for these test statistics is −2.91, based on tables in Fuller (1976).

sion models of the form:

$$R_{i,t} = \kappa + \delta_j{}^*Z_{j,t} + \epsilon_{i,t}, \quad (6)$$

where $R_{i,t}$ denotes the real return on asset i in year t, and $Z_{j,t}$ denotes the value of one of the demographic summary statistics described previously.

At best, the results provide limited support for a link between asset returns and demographic structure. For common stocks, only one of the fifteen estimated coefficients—that on median age for the 1947–1999 period—is statistically significantly different from zero, and the associated coefficient estimate suggests that increasing the median age raises equity returns. There is some evidence in the fixed income markets, and particularly the Treasury bill market, for a link between population age structure and asset returns. This result is consistent with the findings of Yoo (1994b). The variable measuring the fraction of the population between the ages of 40 and 64 has the greatest explanatory power in the equations for Treasury bill and long-term government bond returns, although the coefficients vary as we alter the sample period. The results are not very sensitive to whether this population age group is compared to the total population or the population over the age of nineteen. In most cases, the estimated coefficients are negative, suggesting that an increase in the fraction of the population in the key asset-accumulating years reduces required returns and thereby lowers observed returns. The finding that other measures of demographic structure do not appear to covary with real returns should nevertheless be borne in mind to avoid the risk of overinterpreting the findings for the population share aged 40–64.

Although the point estimates of how the population age share between 40 and 64 is correlated with short-term real rates and bond returns are consistent with the theoretical models discussed previously, the estimated effects are large and may be viewed as implausible. The percentage of the population between the ages of 40 and 64 rose by nearly 0.05 (five percentage points) between 1975 and 2000. The point estimates of the δ_j coefficient for the full sample (−1.30 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 seem larger than actual experience with respect to changes in real interest rates. They are also much larger than the modest predictions from the simulation models developed by Brooks (2000) and Yoo (1994a). The very large values of these predicted effects raise the possibility that the demographic variables are capturing other omitted variables, rather than the relationship between notional asset demand and equilibrium returns.

The large predicted effects of demographic changes are also difficult to explain in light of what appear to be relatively high real interest rates at the end of the sample period. The average realized short-term real interest rate in the United States, defined as the nominal short-term rate minus the actual inflation rate, was 1.3% in the five years centered on 1980, and 1.9% in the five years centered on 1995. In the United Kingdom, where the term structure of indexed bond yields permits direct observation of real interest rates, the ten-year real interest rate averaged less than 3% in 1982 and 1983, the first years when indexed bonds were traded, and between 3% and 4% in the mid-1980s. This real rate averaged more than 4% during the early 1990s, and there has been some decline in the late 1990s. In the United States, inflation-indexed bonds have been available for only several years, but long-term real yields of more than 4% are high by historical standards. These observations do not support the notion that real interest rates are low, at least by historical standards, even though we currently observe a large age cohort in its prime working years.

The problem of drawing inferences regarding how low-frequency demographic variation affects asset returns is illustrated by the results for different subsamples. When the estimation sample begins in 1947, the resulting point estimates of the effect of the 40–64 population share on bill and bond returns are substantially smaller than the estimates for the longer sample period. For the 1926–1975 sample period, the estimated effects are larger than those for the full sample. For some of the other demographic variables (which do not have statistically significant effects for the long sample period), the signs of the coefficient estimates also change when the sample changes.

Econometric analyses like those reported in table 6 must be viewed with caution, because the explanatory variables evolve slowly. Dickey-Fuller (1979) test statistics (including a constant term) for the presence of a unit root in the five demographic time series reject the null hypothesis of a unit root in only one case, that of the population aged 40–64 relative to the population aged 65 and older. When the explanatory variables have unit roots, the "spurious regres-

TABLE 8.—"LONG-HORIZON" EVIDENCE ON DEMOGRAPHIC STRUCTURE AND REAL RETURNS ON STOCKS, BONDS, AND BILLS, 1926–1995

	Independent Variable Measuring Demographic Structure				
Asset Return	Median Age	Average Age of Those 20+	Percent of Population 40–64	(Population 40–64)/ Population 65+	(Population 40–64)/ Population 20+
Treasury bills	−0.002	−0.001	−2.187	−0.001	−0.441
	(0.005)	(0.006)	(0.579)	(0.011)	(0.330)
Long-term government bonds	0.007	−0.008	−2.576	0.001	−1.291
	(0.009)	(0.011)	(1.428)	(0.021)	(0.551)
Common stock	0.007	−0.008	0.023	0.013	−0.221
	(0.009)	(0.012)	(1.717)	(0.022)	(0.706)

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

$R_t = \alpha + \beta^*(DEMOGRAPHIC\ VARIABLE)_t + \epsilon_t$.

The equations are estimated using data for five-year nonoverlapping intervals from the period 1926–1995. There are a total of fourteen nonoverlapping observations. Standard errors are shown in parentheses. For the "level" specification, the dependent and independent variables are five-year averages of the underlying annual variables. For the demographic change specifications, the independent variables are the average annual change over the five-year measurement interval.

sion problem" described by Granger and Newbold (1974) may result in incorrect statistical inferences.

To evaluate the potential importance of this problem, the residuals from the estimating equations that underlie the coefficients in table 6 were tested for the presence of a unit root. This is a variant of a test suggested by Engle and Granger (1987). If the null hypothesis of a unit root in the residuals cannot be rejected using Dickey-Fuller types tests, then the underlying regression model may be misspecified.

Table 7 reports the Dickey-Fuller test statistics for the residuals from the fifteen regression models reported in the first panel of table 6. These are the models that use data from the full 1926–1999 sample period. The t-statistics that are shown reject the null hypothesis of a unit root for each of the specifications; the critical values are approximately −2.91 for the 5% tail, and −3.20 for the 2.5% tail. The estimated t-values in table 7 are all substantially smaller than these critical values.

The results in table 6, supported by the specification tests of table 7, suggest several conclusions. First, to the extent that there is a correlation between population age structure and returns on assets in the United States, the effect is most pronounced for Treasury bills. This may in part reflect the greater volatility of returns in other asset markets, which makes it more difficult to detect the impact of demographic change or other factors. Nevertheless, the real returns on corporate stocks for the last 75 years do not display a clear link with population age structure. Second, the demographic effect appears to be much larger in the prewar period than in the postwar period. Studying the impact of the postwar baby boom cohort on asset markets does not provide 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.

Given the low-frequency variation in population age structure, annual returns may introduce substantial noise to any relationship with demographic structure. I therefore constructed five-year returns for nonoverlapping five-year periods between 1926 and 1995. (When one additional year of data, for 2000, becomes available, it will be possible to add another five-year return.) Such multiperiod returns will tend to emphasize the low-frequency variation in asset returns. Table 8 presents the results of estimating models like those in table 6 with these nonoverlapping return observations. The results are quite similar to those in table 6. There is once again evidence of a negative correlation between the percentage of the population between the ages of 40 and 64 and the real return on T-bills and long-term government bonds. There is still no evidence of an impact of population age structure on real equity returns. There is also no evidence that the other demographic variables, such as the median age of the population or the average age of the adult population, are correlated with any of the asset return measures. The point estimates of the coefficients on the percentage aged 40–64 variable are even larger with the long-period returns than with annual returns. This means that the concerns raised above about the large predicted effects of demographic change arise with even more force for these estimates.

The analysis so far has studied the relationship between returns and demographic structure, which is the approach of most of the previous empirical studies. However, theoretical models such as Abel (1999) suggest that, when a large age cohort begins to purchase assets for retirement, this should bid up the price of capital. This would suggest that the level of stock market values should be high at such a time, on the grounds that stock prices reflect the purchase price of existing capital assets. This issue can be tested by studying the relationship between stock prices, normalized for example by corporate dividends, and the demographic variables considered in table 6. Both Brooks (1998) and Bergantino (1998) pursue empirical strategies motivated by these insights. The end-of-year level of the price-to-dividend ratio on the S&P 500, available on a Web site maintained by Robert Shiller, provides the dependent variable for these calculations.

Table 9 reports the results of regression equations of the form

$$(P/D)_t = \kappa + \delta_{j,t}^* Z_{j,t} + \epsilon_{j,t}, \tag{7}$$

TABLE 9.—DEMOGRAPHIC STRUCTURE AND PRICE-DIVIDEND RATIOS, ANNUAL REGRESSION ESTIMATES

	Independent Variable Measuring Demographic Structure				
Asset Return and Sample Period	Median Age	Average Age of Those 20+	Percentage of Population 40–64	(Population 40–64)/ Population 65+	(Population 40–64)/ Population 20+
Coefficient estimates, 1926–1999	3.302	4.969	532.284	−6.885	68.641
	(0.524)	(0.739)	(96.929)	(1.628)	(57.557)
Coefficient estimates, 1946–1999	3.613	13.216	719.114	−9.384	75.771
	(0.715)	(1.447)	(123.211)	(3.787)	(62.052)
Coefficient estimates, 1926–1975	−0.578	2.879	48.225	−6.196	312.952
	(0.786)	(0.472)	(94.172)	(1.245)	(54.889)
Dickey-Fuller test for residuals, 1926–1999	−0.456	0.262	−0.492	1.175	1.610
Coefficient estimates, differenced model, 1926–1999	0.625	10.244	644.998	49.888	148.922
	(3.270)	(6.378)	(273.614)	(17.692)	(167.271)

Each equation in rows one through three presents the results of estimating an equation of the form

$(P/D)_t = \alpha + \beta^*(DEMOGRAPHIC\ VARIABLE)_t + \epsilon_t.$

Standard errors are shown in parentheses. Equations are estimated using annual data for the sample period indicated. The entries in the fourth row are Dickey-Fuller t-test statistics, with an unknown mean, applied to the residuals from the regression models in the first row. The estimates in the last row correspond to a regression model of the form

$\Delta(P/D)_t = \alpha' + \beta'^*\Delta(DEMOGRAPHIC\ VARIABLE)_t + \epsilon_t'.$

where Z_t denotes various demographic variables. The results suggest that several demographic variables do exhibit a strong association with the price-dividend (P/D) ratio. In the first row of table 9, the null hypothesis of no relationship between the demographic variable and the price-dividend ratio is rejected for all five demographic measures. The estimated coefficients are sometimes inconsistent across specifications, however. In the third column, an increase in the share of the population between ages 40 and 64 has a positive effect on the P/D ratio, whereas, in the fourth column, an increase in this population age group relative to those over the age of 65 has a negative effect. The estimates in the next two rows fit the same regression models, equation (7), for different subsamples. The coefficient estimates vary substantially in most cases as the sample period changes. In spite of these concerns, the point estimates in the first three rows of table 9 suggest the possibility of large potential effects of demographic changes on asset prices.

Regression models like those that underlie the estimates in the first three rows of table 9 are more subject to the "spurious regression" problem than the equations in table 6, because the P/D ratio is a more slowly evolving time series than the return measures that were the dependent variables in table 6. To address the possibility of spurious regression findings, the fourth row of table 9 reports Dickey-Fuller test statistics that test the null hypothesis of a unit root in the residuals from the equations reported in the first row. It is not possible to reject the null hypothesis of a unit root in any case. This suggests that the underlying regression equations may be misspecified.

In light of this finding, the last row of table 9 reports coefficient estimates for the full sample period from a differenced version of equation (7):

$$\Delta(P/D)_t = \kappa' + \delta_j'^*\Delta Z_{j,t} + \epsilon_{j,t}'. \tag{7'}$$

In this case, the coefficient estimates for the demographic variables (δ_j') are statistically significantly different from zero in only two of the five equations. These correspond to the cases in which the independent variable is the percentage of the population between the ages of 40 and 64, and the population aged 40–64 as a share of the population aged 65 and above. In these cases, however, the point estimates of the coefficients seem implausibly large. Consider the increase of 0.05 in the percentage of the population aged 40 to 64 that took place between 1980 and 2000. The coefficient estimate in the third column of the last row in table 9 suggests that this demographic shift would be associated with an increase of more than thirty in the price-dividend ratio.

The results in table 9 suggest two conclusions. First, regressions relating the price-dividend ratio to demographic variables may be subject to spurious regression bias. The coefficients from these models are sensitive to differencing and to altering the sample period of estimation. Second, however, there is some evidence, even from differenced models that address the spurious regression problem, that the price-dividend ratio is higher when a larger share of the population is between the ages of 40 and 64. The point estimates of these effects are implausibly large, but more plausible ranges may fall within the 95% confidence interval for the coefficients. This finding provides more support than any of the earlier findings for the possibility that demographics are related to asset prices.

B. *Evidence for Canada and the United Kingdom*

In an effort to overcome the problem of "only one baby boom" in the United States, I also estimated equations like equation (6) with data from two other nations with well-developed capital markets: the United Kingdom and Canada. The desire to obtain greater demographic variation also motivates Brooks' (1998) focus on stock price levels in the OECD nations, and Erb, Harvey, and Viskanta's (1997) focus on demographics and stock returns in a broad sample of countries. Given the widely disparate sizes of the capital

TABLE 10.–PERCENTAGE OF THE POPULATION AGED 40–64 AND ASSET RETURNS, CANADA AND UNITED KINGDOM

Asset Category	Canada	United Kingdom
Treasury bills (50–97 Canada, 50–96 U.K.)	0.766	−0.333
	(0.234)	(0.334)
Long-term government bonds (50–97 Canada, 50–96 U.K.)	0.893	−0.164
	(0.206)	(0.274)
Corporate stock (61–97 Canada, 61–96 U.K.)	0.903	−2.174
	(1.588)	(3.048)

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

$R_t = \alpha + \beta = (\textit{Population Share 40–64})_t + \epsilon_t.$

Standard errors are shown in parentheses. See text for further discussion.

markets (and especially the equity markets) in different nations, however, it can be difficult to evaluate the results from cross-sectional studies that treat all countries in the same way. Rather than following this strategy, I apply the one-country time series approach to these two other nations.

I focus on equity market returns for the period 1961–1997 in Canada, and 1961–1996 in the United Kingdom. Data on equity market returns for these samples are computed from information provided by Morgan Stanley–Capital International. Returns are measured in local currency for both nations. Data on Treasury bill returns, on returns to holding long-term bonds, and on the Consumer Price Index in each country were drawn from the IMF database. Returns on fixed-income instruments were available for the period since 1950, so the sample for Canada is 1950–1997, whereas that for the United Kingdom is 1950–1996. Demographic data were tabulated from various issues of the *United Nations Demographic Yearbook,* updated as necessary using data from the U.S. Census International Database, and the United Kingdom *Annual Abstract of Statistics.*

Table 10 presents regression results relating the population share between the ages of 40 and 64 and various real return measures for each of these countries. The results do not match those for the United States, and they further weaken the claim that demographic structure and asset returns exhibit systematic linkages. In Canada, the share of the population between the ages of 40 and 64 exhibits a positive correlation with all three real return measures. The effect is statistically significantly different from zero for both long-term government bonds and Treasury bills. (In the United States, the coefficients were negative and statistically significantly different from zero.) For the United Kingdom, the point estimates of the coefficients for the real bill and real bond returns are negative, but the coefficient estimates are not statistically significantly different from zero in either case. There is no evidence for either country of a strong relationship between real stock returns and the share of the population between the ages of 40 and 64. Other results, not reported here, confirm the generally weak relationship between other measures of demographic structure and real asset returns in Canada and the United Kingdom.

VI. Demography-Based "Projected Asset Demand," Asset Returns, and Asset Prices

The empirical results in the last section consider the links between population age structure, asset returns, and asset levels, but they do not utilize the detailed information on the age-wealth profile that emerges from the analysis of the Surveys of Consumer Finances. To do so, I also analyzed how asset returns and asset prices are related to the projected asset demand variable that was defined in equation (4). Because this variable combines information on the age-specific evolution of asset holdings with information on the age structure of the population in various years, it offers a more formal link between household-level data on the wealth-age profiles and the aggregate analysis of asset demand.

Table 11 reports the results of estimating regression models in which the real returns on bills, bonds, and stocks are related to the level of the projected asset demand variable. The table reports two different sets of estimates, corresponding to the 1926–1999 and postwar (1946–1999) sample periods. The pre-1975 sample is excluded on the grounds that the age-specific asset holding data, which are drawn from household surveys in the 1980s and 1990s, are less likely to apply to that sample period. The results are all based on the age-specific asset profiles that were estimated with cohort effects, and they consider separately the predictive power of the age-specific patterns of corporate stock ownership, net financial asset ownership, and net worth.

The results suggest very limited linkage between any of the projected demand variables and the realized patterns of asset returns. This is particularly true for the full sample estimates. Only three of the estimated coefficients—those relating the T-bill return to the three projected demand variables for the postwar period—are statistically significantly different from zero. The coefficients for T-bills for the longer sample period are not statistically distinguishable from zero. The net demand for financial assets at various

TABLE 11.—PROJECTED ASSET DEMAND AND ASSET RETURNS

Asset Return	Common Stocks	Net Financial Assets	Net Worth
1926–1999			
Treasury bills	−0.004	−0.001	−0.001
	(0.006)	(0.002)	(0.001)
Long-term government bonds	−0.018	−0.004	−0.003
	(0.014)	(0.004)	(0.003)
Corporate stock	0.010	0.002	0.003
	(0.027)	(0.009)	(0.005)
1946–1999			
Treasury bills	0.031	0.017	0.005
	(0.012)	(0.004)	(0.002)
Long-term government bonds	0.013	0.021	0.003
	(0.041)	(0.014)	(0.007)
Corporate stock	0.094	0.030	0.019
	(0.062)	(0.021)	(0.010)

Each entry reports the regression coefficient, and standard error (in parentheses), from a regression with the real asset return as the dependent variable, and the indicated demographic demand variable as the independent variable. See text for further discussion. Dickey-Fuller tests applied to the explanatory variables for the 1926–1999 period yield t-statistics of −3.49, −4.16, and −2.97 for projected common stock holdings, projected net financial assets, and projected net worth, respectively.

TABLE 12.—UNIT ROOT TEST STATISTICS FOR RESIDUALS FROM PROJECTED ASSET DEMAND AND ASSET RETURN MODELS, 1926–1999

Asset Return	Common Stocks	Net Financial Assets	Net Worth
Treasury bills	−3.801	−3.810	−3.801
Long-tern government bonds	−8.022	−7.938	−7.997
Corporate stock	−8.392	−8.385	−8.411

Each entry reports the value of the Dickey-Fuller (1979) test statistic, allowing for an unknown mean, applied to the residuals corresponding to the regression equations in the first panel of table 11. The critical (95%) value for these test statistics is −2.91, based on table in Fuller (1976).

ages should provide important information on the aggregate demand for financial assets as the population ages. The weak empirical findings in table 11 cast doubt on whether the coefficients on the 40–64 age share in the earlier tables reflect age-specified asset demand effects or other factors.

To inform the possibility of spurious regressions in the regressions that include the projected asset demand variables, table 12 presents Dickey-Fuller test statistics similar to those in table 7, but now for the full-sample regression models in table 11. In all nine cases (three return measures related to three possible asset demand measures), the null hypothesis of a unit root in the residuals from the regression model can be rejected.

It is also possible to use the projected demographic demand for assets to explore whether projected wealth holdings are related to the level of stock prices. This exercise is similar to the empirical analysis using various measures of population age structure that was described in equation (7). Table 13 presents the results of regressing the price-to-dividend ratio on projected asset demand. The full-sample findings, as well as those from the postwar subsample, suggest that an increase in projected asset demand is associated with an increase in the price-dividend ratio. This finding is robust to the choice between projected asset demand measured using age-specific net worth, net financial assets, or common stocks. As in some of the earlier specifications, the results again appear quite sensitive to the choice between the full sample and the most recent subsample, with the coefficient estimates doubling or tripling as a result of this sample change.

As with some of the earlier estimates, however, the coefficients imply larger demographic effects than theoretical analyses of demography and asset prices suggest. Consider, for example, the estimates of the link between projected net worth and the price-dividend ratio for the full sample period. The estimated coefficient of 1.435 implies that the change in projected net worth between 1980 and 2000, (93.7 − 85.7 = 8), could have raised the price-dividend ratio by 11.2. This seems like a large change in the price-dividend ratio to ascribe to a single factor, but it does suggest that the change in desired wealth holdings associated with demographic changes in the last two decades may explain some of the variation in price-dividend ratios.

The equations reported in the first two rows of table 13, like those in table 9, may be misspecified. To address this question, the third row of table 13 reports Dickey-Fuller test statistics for the presence of unit roots in the residuals from the regression models estimated for the full sample period. The null hypothesis of a unit root is not rejected in any case. As in the previous set of regression models for P/D ratios, I difference the underlying specification, and reestimate a model linking changes in the price-dividend ratio to changes in the projected asset demand variable. The results are shown in the penultimate row of table 13. The statistical significance of the coefficient estimates declines when the variables are differenced, although the point estimates continue to suggest a positive effect of projected asset demand on the P/D ratio. For the projected demand for common stock variable, the coefficient estimate is statistically distinguishable from zero at the 90%, but not the 95%, confidence level. The last row of table 13 shows that applying the Dickey-Fuller test to the residuals from the differenced models clearly rejects the null hypothesis of a unit root in this specification. The results in table 13 broadly confirm the findings of Bergantino (1998) and Brooks (1998). They illustrate that it is possible to find statistical support for a link between demographic structure and asset prices.

The results in table 13 raise an important question about why projected asset demand measures are correlated with the price-to-dividend ratio while simple measures of demographic structure, such as the population share between the ages of 40 and 64, are not. A key difference between the projected asset demand variables that constitute the explanatory variables in table 13, 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. Thus, the variables that seem to track at least the level of equity prices do not distinguish between prime-age workers and older individuals. This observation has important implications for evaluating the "asset market

TABLE 13.—PROJECTED ASSET DEMAND AND PRICE-DIVIDEND RATIOS

Sample Period	Common Stocks	Net Financial Assets	Net Worth
Coefficient estimates, 1926–1999	7.830	2.507	1.453
	(1.402)	(0.436)	(0.249)
Coefficient estimates, 1947–1995	24.506	9.338	4.088
	(3.487)	(1.058)	(0.579)
Dickey-Fuller test statistics, 1926–1999	0.586	0.577	0.484
Coefficient estimates from differenced model, 1926–1999	17.104	6.036	2.640
	(9.247)	(4.024)	(1.587)
Dickey-Fuller test statistics, differenced model, 1926–1999	−9.540	−9.419	−9.474

Each entry in the first two rows presents the results of estimating an equation of the form

$$(P/D)_t = \alpha + \beta^*(PROJECTED\ ASSET\ DEMAND)_t + \epsilon_t.$$

Standard errors are shown in parentheses. Equations are estimated using annual data for the sample period indicated. The entries in the third row are Dickey-Fuller t-test statistics, with an unknown mean, applied to the residuals from the regression models in the first row. The estimates in the penultimate row correspond to a regression model of the form

$$\Delta(P/D)_t = \alpha' + \beta'^*\Delta(PROJECTED\ ASSET\ DEMAND)_t + \epsilon_t'$$

and the entries in the final row are Dickey-Fuller test statistics for the residuals from this equation.

TABLE 14.—AGE-SPECIFIC PATTERNS OF RISK TOLERANCE, 1995 SURVEY OF CONSUMER FINANCES

Age of Household Head	"Take Substantial Risk to Earn Substantial Reward"	"Take Above-Average Risk for Above-Average Reward"	"Take Average Risks for Average Returns"	"Not Willing to Take Any Financial Risks"
Population That Holds Stocks or Equity Mutual Funds				
<25	3.9%	34.5%	41.9%	19.7%
25–34	9.8%	34.2%	45.5%	10.6%
35–44	5.6%	26.4%	54.2%	13.8%
45–54	4.8%	24.8%	58.6%	11.8%
55–64	1.7%	22.2%	62.1%	14.0%
65–74	4.1%	12.8%	56.7%	26.4%
75–84	3.2%	7.0%	33.2%	56.6%
>85	0.0%	12.4%	33.1%	54.5%
ALL	5.0%	23.2%	52.7%	19.1%
Entire Population				
<25	6.3%	14.0%	39.8%	39.9%
25–34	4.3%	20.3%	38.4%	37.0%
35–44	4.5%	17.0%	42.5%	36.0%
45–54	3.8%	14.5%	42.0%	39.8%
55–64	2.2%	10.7%	38.1%	49.0%
65–74	2.0%	5.9%	29.1%	62.9%
75–84	1.2%	3.1%	23.5%	72.1%
>85	0.0%	5.0%	14.8%	80.3%
ALL	3.5%	13.6%	37.3%	45.6%

Source: Author's tabulations using the 1995 Survey of Consumer Finances.

meltdown" hypothesis. Because projected asset demand does not decline in the period between 2020 and 2050, as table 5 illustrates, the empirical results in table 13 do not imply that asset values will fall when the baby boom cohort reaches retirement age. This is the implication of these results, even though they are consistent with demographic changes such as those in the last two decades affecting asset values.

VII. Demographic Structure and Risk Aversion of the Representative Consumer

The foregoing results raise questions about whether there is a robust relationship between population age structure and asset returns. They also beg the question of whether by imposing still further structure on the empirical analysis, it might be possible to obtain more definitive results. One previous study that imposed substantial structure on the problem of how demographic change might affect asset demands, the study by Bakshi and Chen (1994), did find statistically significant effects of the average age of the population older than nineteen in an Euler equation setting. This section revisits their findings.

Data from the Survey of Consumer Finances can be used to test the maintained hypothesis that age is related to risk tolerance. SCF survey respondents are asked whether they are prepared to accept "substantial risk in pursuit of substantially above-average returns," "above average risk in return for above-average returns," "average risk for average returns," or virtually no risk in pursuit of higher investment returns. Table 14 shows the resulting breakdown of responses, tabulated by the age of the head of the household responding to the SCF. The table is divided into two parts: the first shows the responses of the self-selected subset of individuals who hold corporate stock, and the second shows the responses for the entire population. Not surprisingly, the investors who hold some stocks are more prepared to take risk than are their nonequity-investing counterparts. There are also substantial differences between the fraction of households headed by individuals who are younger than 65, and the fraction headed by individuals older than 65, that are willing to take some risk in return for higher average returns.

The data in table 14 do not suggest any clear age patterns in risk tolerance at younger ages. This is consistent with the results of Barsky et al. (1997) based on survey questions in the Health and Retirement Survey. Their analysis suggests that risk tolerance is greatest at older and young ages, with the most risk-averse group in middle age. The findings in table 14, as well as similar findings in other studies, suggest that simple summary measures like the average age in the adult population may not fully capture the link between demographic structure and risk tolerance. In contrast to the data on age-specific asset holdings, which do not draw a strong distinction between prime-age workers and retirees, the data in table 12 on risk aversion do suggest differences between these groups.

The foregoing discussion of previous literature noted that Bakshi and Chen (1994) assume that the utility function of the representative investor is given by

$$U(C_t, M_t) = C_t^{1-\gamma-\lambda^* M_t}/(1 - \gamma - \lambda^* M_t), \tag{8}$$

where M_t denotes the average age of the population, and C_t denotes aggregate per capita consumption. They use the average age of the adult population over the age of nineteen as their focal variable in studying how age structure affects asset returns.

If preferences are given by equation (8), then the standard intertemporal Euler equation generalizes to

TABLE 15.—SENSITIVITY OF EULER EQUATION RESULTS TO ALTERNATIVE DEMOGRAPHIC SUMMARY VARIABLES

	Return = T-Bill Rate		Return = Return on S&P 500	
Demographic Summary Measure	γ	λ	γ	λ
Average age of persons over 19	−3.89	0.11	−10.99	0.34
	(1.67)	(0.04)	(8.60)	(0.19)
Percentage of population 40–64	0.02	2.95	0.39	12.57
	(0.49)	(1.52)	(2.61)	(8.38)
Percentage of population aged 55+	2.87	−7.94	8.62	−18.08
	(0.96)	(3.32)	(4.57)	(15.91)

Coefficient estimates from NLIV estimation of equation (10) in the text. Sample period 1959–1994, with real per capita consumption of nondurables as the consumption measure. Standard errors are shown in parentheses. See text for further discussion of specification and the set of instrumental variables.

$$E_t[(C_{t+1}/C_t)^{-\gamma-\lambda^*M_t}(1 + r_t)] = 1. \tag{9}$$

Thus, Bakshi and Chen (1994) argue, testing the null hypothesis that $\lambda = 0$ provides a parametric test of whether or not age factors affect the equilibrium determination of asset returns.

Choosing this parametric approach to testing for demographic effects on asset pricing—rather than the approach in earlier sections that is not constrained by functional form—has potential pitfalls. Say the particular functional form for the Euler equation turns out to be invalid. This might be because some households face liquidity constraints, because aggregation across households fails or because of other factors. In these cases, the age variable may have some explanatory power in tracking the movements of consumption growth and asset returns, but this may not reflect an age structure effect on risk tolerance and hence asset returns. Bakshi and Chen (1994) estimate equation (8) for the 1945–1990 period and find that λ is positive and statistically significantly different from zero. For a range of other sample periods, including 1926–1990 and 1900–1945, they cannot reject the null hypothesis that $\lambda = 0$.

Table 15 presents estimates of both γ and λ from the equation

$$E_t[(C_{t+1}/C_t)^{-\gamma-\lambda^*Z_{j,t}}(1 + r_t)] = 1, \tag{10}$$

where $Z_{j,t}$ is one of the demographic variables considered in the previous sections. This includes the average age of the adult population, the variable considered by Bakshi and Chen (1994), as well as the population share between the ages of 40 and 64.

The equations are estimated for the sample period 1959–1994. These equations are based on data on personal consumption expenditures in the National Incomes and Product Accounts. The consumption measure is nondurable consumption, which avoids problems of durability that may contaminate the Euler equation specification. The equations are estimated by nonlinear instrumental variables, with the second and third lags of real per capita consumption and the real return, as well as a constant, a time trend, and the contemporaneous, first, and second lag of the applicable demographic variable, as instruments.

The results in Table 15 confirm the findings reported by Bakshi and Chen (1994). When population age structure is measured using the average age of the adult population, the estimate of λ is positive and statistically significantly different from zero. This is particularly evident when the Treasury bill return is used as the rate of return variable in the Euler equation, but it is also true when the stock market return is used. These estimates suggest that, as the population becomes older, the relative risk aversion of the representative consumer increases.

The results from other specifications that include alternative demographic variables are not as encouraging with respect to the age-dependent risk-aversion interpretation. When the demography variable (Z) is the population share between the ages of 40 and 64, there is again evidence of increasing risk aversion as this age group expands. This is consistent with some of the findings of Barsky et al. (1997) but not with the evidence from the risk-aversion questions in the Survey of Consumer Finances that suggested that this age group was not more risk averse than were other age groups. The evidence from including the fraction of the population over the age of 55 is even more discouraging for the age-dependent risk-aversion view. The SCF data suggest that there is a clear increase in the risk aversion of older households, relative to their younger counterparts, yet the coefficient estimate (λ) on this demographic variable is negative and statistically significant for Treasury bills, and negative (but not significant) for stocks. These results suggest that risk aversion of the representative consumer declines as the fraction of the population over the age of 55 increases. This finding is not consistent with the model that Bakshi and Chen (1994) use to motivate their analysis, and it contrasts with evidence from household surveys that ask about risk preferences.

VII. Conclusion

The empirical results in this paper suggest that it is difficult to find a robust relationship between asset returns on stocks, bonds, or bills, and the age structure of the U.S. population over the last seventy years. The correlations that do emerge are stronger between Treasury bill returns, and long-term government bond returns, and demographic variables, than between stock returns and these demographic variables. Most measures of demographic structure, however, do not show a statistically significant correlation with asset returns. These findings stand in contrast to the results of general equilibrium models for asset returns, which suggest a clear link between age structure and returns. One possible interpretation of these findings is that, even though changes in age structure do affect asset demand, these effects are simply too small to be detected among the other shocks to asset markets.

The empirical findings do provide some evidence that the level of asset prices, measured as the price of corporate equities relative to corporate dividends, is related to demographic structure. The evidence is strongest when age-specific asset demands are used to construct time-varying projected asset demands at different dates, and when these projected asset demands are then related to price-dividend ratios. There is substantial variation in the estimated effect of projected asset demand on asset prices as the estimation sample varies, but, for both postwar and longer sample periods, there is some evidence of a link between demographic structure and the price-dividend ratio.

Neither the findings on returns, nor the findings on the level of asset prices, are consistent with the view that asset returns will decline sharply when the baby boom cohort reaches retirement age. Most of the empirical results suggest very little relationship between population age structure and asset returns. Moreover, the variable that does appear to be related to share price levels (the projected asset demand variable) is not projected to decline when the baby boomers reach retirement, because asset decumulation in retirement takes place much more gradually than asset accumulation during working years. The results suggesting at best a weak link between population age structure and price-dividend ratios indicate that future work is needed to isolate and empirically measure the channels through which demographic changes may affect asset prices.

Any attempt to assess the future link between asset returns and demographic structure must also consider the potentially important role of integrated world capital markets. Such markets make the link between population age structure in any nation, and the asset market returns in that nation, substantially weaker than such a link would be in a closed economy. For textbook "small open economies," required returns are exogenous, and they are determined in world, not domestic, capital markets. For such nations, if demography affects returns at all, it is global demographic structure that should matter. Shifts in the demographic structure of a single nation would affect the amount of capital owned by that country's residents, but not the return earned on such capital.

The degree to which world capital markets are integrated, and hence the importance of this modeling assumption, remains an open question. Feldstein and Horioka (1980), Frankel (1991), and Taylor (1996) document substantial correlation between national saving and national investment rates. These relationships make the effect of a change in a country's domestic saving rate and desired asset holdings on the equilibrium return on its capital stock an open issue. With respect to risky assets, particularly corporate equity, the evidence on capital market integration is even less clear. Despite large cross-border gross investment flows, there is still a substantial home bias in equity ownership. French and Poterba (1991) present evidence showing that more than 90% of the equity assets of investors in the United States and Japan are held in their domestic equity markets.

Prospectively, the integration of capital markets in currently emerging economies with those of currently established economies may be an important factor determining the demand for financial assets. Siegel (1998) succinctly presents the issue when he writes, "The developing world emerges as the answer to the age mismatch of the industrialized economies. If their progress continues, they will sell goods to the baby boomers and thereby acquire the buying power to purchase their assets" (p. 41).

The empirical findings reported here suggest several directions for future work. One is expanding the current analysis to consider asset accumulation in defined-benefit pension plans and in funded government Social Security systems. The projected asset demand variable includes only those assets that individuals purchase directly or hold through defined-contribution pension plans; it excludes accumulations on their behalf in defined-benefit plans. These accumulations are a substantial share of total household asset holdings, and they display a somewhat mechanical accumulation and decumulation profile as a result of population aging. Miles (1999) presents calculations for the United Kingdom and for Europe that suggest the potential importance of including pension saving in calculating age-wealth profiles.

A second issue, which may be too subtle to study with existing data, concerns the timing of any asset market reactions to demographic shocks. The "news" about demography is revealed when cohorts are born, not when they reach their prime saving years. Yet multiperiod, overlapping-generations models suggest that the equilibrium path of asset prices, and not just the initial level of such prices, is affected by demographic shocks. Detailing the structure of the asset market response to a demographic shock, and then testing for the presence of such effects in actual data, would represent an important improvement on the reduced-form regression strategies used in the current paper.

Finally, the current analysis has ignored a wide range of nondemographic factors that may affect equilibrium real returns and asset prices. Monetary policy is an obvious 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. This raises a whole host of questions about other control variables that might be included in regression specifications like those reported in the current paper. These questions have implications for the design of empirical tests, and they might lead to the addition of variables other than demographic factors in the real return models. These issues also raise important questions about optimal policy, and how the monetary authority (let alone the fiscal policymakers) should react to changing demographic structure.

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