DEMOGRAPHICS AND FINANCIAL ASSET PRICES IN THE MAJOR INDUSTRIAL ECONOMIES

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Abstract

This paper explores the relationship between demographics and aggregate financial asset prices in 7 OECD countries over the past 50 years. Unlike most extant work it adopts an international as well as US focus, and also includes non-demographic variables usually considered to influence asset prices in the econometric specification. Furthermore, we examine effects on bond yields as well as share prices. The results indicate a significant link between panel, international and US demographics on the one hand, and real stock prices and real bond yields on the other. Generally, an increase in the fraction of middle-aged people (aged 40-64) tends to boost real asset prices. A corollary is that a decline in this cohort in coming decades will tend to weaken them. More tentative results including estimated effects of the over-65 cohort in the US suggest a more severe downturn is possible, thus underlining the potential market risks associated with sole reliance on fully funded pension schemes.
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Introduction

The link between changing demographic structure and macroeconomic performance has been widely studied; see for example Turner et al (1998), Kohl and O'Brien (1998) and McMorrow and Roeger (2000). There is also an extensive literature of the impact of ageing on pension systems and public finance, see Dang et al (2001) for a recent example. US researchers have put a considerable focus on links of demographic trends to equity markets (see Poterba (2001) for a recent survey). However, there has been more limited systematic research into demographic effects on financial asset prices in an international context or on bond yields. Also most extant work looks purely at bivariate relationships between demographics and equity markets. Accordingly, in this paper we estimate effects of demographics on asset prices, not only in the US but also in Europe and Japan, country-by-country and aggregated, including standard non-demographic variables in the specification.

The structure of the paper is as follows: Section 1 briefly examines the historical evolution of the population structure in US, EU and Japan and factors underlying it. Section 2 presents a review of the theoretical and empirical literature on demographics and financial asset demands, including aspects of the life cycle hypothesis and household asset allocation. We examine predictions of these theories for when baby boomers retire, concentrating on risk aversion and the so-called "market meltdown" hypothesis. We also survey the more limited literature on international demographics and financial asset returns. Principally using data from 1950 to 1999, Section 3 tests empirically the relation between demographics and financial asset prices in a panel of 7 OECD countries, as well as in the US and internationally, including non-demographic variables in the specification. The conclusion summarises the main findings and notes limitations and areas for further research.

1 International demographics: past and future perspective

The major industrialised countries of Europe, Japan and the US have undergone dramatic demographic changes since the 1950's. Most of the seven countries witnessed an acceleration of population growth in the 1950s, followed by a decline during the late 1960s. Given that most people concerned are already alive, demographic projections tend to be reliable for several decades ahead. UN projections show all the seven countries are expected to experience a continued decline in population growth after 2002. After 2003 most European countries except the UK are expected to experience a declining population.

Fertility rates underlying population growth are shown in Table 1.1. They have declined to below 2 children per woman for all countries since 1980, except for the US in the 1990s. This is well below the replacement level needed to maintain a stable population without immigration. Forecasts[2] suggest that all seven countries would be below the replacement rate on average over 2000-10.

Separately, life expectancy has increased gradually since 1950. Table 1.2 shows, for example, that life expectancy for Japan has increased by 15 years in the last 50 years. Forecasts suggest that life expectancy at birth would rise a further 2 years in the current decade. There is a similar pattern for all 7 countries. Factors behind these patterns are better healthcare, medical advances, and improved living standards.

Table 1.3 shows the elderly dependency ratio, defined as the percentage of population over 65 years old as a ratio of the economically active population aged 15-64. Although longevity is also important, the patterns are largely a consequence of changes in fertility. The table shows that the demographic transition has been remarkably uniform so far, but will become less so after 2010. Japan had a lower dependency ratio of 10.3% in 1970 compared to the US and European countries, but this is rapidly increasing and would overtake other countries by 2010. Projections show that by 2050, dependency ratios for Japan and the European countries would be above 42%, with Spain reaching the highest level of 72%. This implies that less than two economically active people would be supporting one retiree, suggesting a massive shift in the age distribution towards the old. In contrast, the US ratio will be only 36% in 2050.

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[2] Demographic data in this chapter beyond 2000 are projections under the assumption of medium variant fertility and no immigration.

In the shorter term, the baby booms mean there will be a remarkable increase in the number of people having already reached middle age or reaching it in the near future. Chart 1 shows the projected effects of the baby boom generation on the age distribution of 40-64 years olds across Europe, Japan and the US, which shows the ratio of 40-64 years old to the adult population aged 20+. Europe and the US will have similar shifts in terms of increases in the proportion of those aged 40-64 in the coming decades. For the US, the ratio in 2009 will be 49%, followed by the UK and Germany in 2014 at 44% and 46% respectively. Japan had the highest percentage of the population within the age range in the 1990s, which peaked in 1993 at 46% due to an earlier baby boom. Later, Spain would have the highest proportion of those aged 40-64 peaking at 49% in 2022. It is interesting to note that the percentage of those aged 40–64 is not yet at its peak in countries other than Japan – and that the Japanese stock market has been sluggish throughout the 1990s as the share of 40-64s began to decline.

2. Theoretical and empirical background

In the light of the demographic data, this section aims to survey research on the theoretical and empirical link between demographic structures and financial asset prices.

2.1 Household life cycle consumption and savings behaviour

Theory suggesting a link between an individual's age, consumption and saving decisions originated with the permanent income hypothesis (Friedman 1957), and the later life cycle hypothesis (Modigliani and Brumberg (1954), and Ando and Modigliani (1963)). Both theories of optimal consumption imply consumption will be smoothed out through an individual's lifetime. Notably, the life cycle theory of consumption suggests that early in one's life, consumption may well exceed income as individuals may be making major purchases related to buying a new home, starting a family, and beginning a career. At this stage in life, individuals may borrow based on their expected labour income in the future (human wealth). In mid-life, these expenditures begin to level off while labour income increases. Individuals at this point will repay debts and start to save on a net basis for retirement in stocks, bonds, pension schemes, etc. At retirement, income normally decreases, and individuals may start to dis-save. This involves selling off some of their financial assets.

As regards empirical evidence, at a macroeconomic time series level, Disney (1996) noted that, consistent with the life cycle, savings rates tend to decline in countries where there are a larger number of retired people. The changes in savings lead to changes in demand for financial assets. Econometrically, a strong effect of demographics on private saving is found by many studies, with for example Masson et al (1995) finding the total dependency ratio to have a significant negative effect on private saving in a panel of both advanced and developing countries. Modigliani (1986) shows life-cycle savings follow a hump shaped pattern where an investor's asset holdings increase with age and decline after retirement. Goyal (2001), using aggregate stock market data, found that outflows from the equity market (defined as the difference between the value weighted stock market return (NYSE, AMEX and NASDAQ) including dividends and the percentage increase in stock market capitalisation) are related to a rise in the size of the cohort aged 65 and over, and inflows are linked to the size of the cohort aged 45-64.

As regards asset allocation by households over the life cycle, Bergantino (1998), looking at cross sections derived from the US Survey of Consumer Finances, found young households under 40 usually draw credit from the financial markets via taking out mortgages for buying houses, consistent with the life cycle. Bergantino showed that households aged 40–60 tend to provide credit to financial markets, via employer and personal pension accounts. Those households which are over the age of 60 tend to withdraw from the financial markets as a result of using accumulated assets to fund consumption at retirement. Mankiw and Weil (1989) found housing demand is high for those aged 25-40. Thus, their borrowings tend to exceed their purchases of financial assets.

While the life cycle hypothesis focuses on the overall household asset demand, empirical evidence also suggests household portfolio allocation across specific asset classes would vary with age, which could have implications for asset prices. On an individual household level, Yoo (1994b) found demand for risky assets, bonds and equities increases with age and decreases after individuals retire.

Bergantino (1998) showed that households with heads under the age of 35 generally have near zero ownership of bonds and stocks. However he finds a divergence in stock and bond holding of older households. Ownership of stocks for those over 55 tends to decrease more rapidly than for bonds. He attributes this to possible cohort effects and risk aversion.

Although such findings are consistent with the life cycle hypothesis on average, a study by Poterba (1998) suggests the life cycle hypothesis cannot be proven by focus on average cross-section based asset accumulation profiles. First, average figures are distorted by the wealthiest 10 percent of households who hold approximately 70 percent of financial assets. If equities are included, this will raise the number to 90 percent, see Poterba and Samwick (1995). Second, micro data typically omit social security wealth and wealth in defined benefit pension funds. Third, there is a problem in using cross-section data to evaluate the life cycle hypothesis or project asset demands, in the style of Yoo (1994b) and Bergantino (1998) since they mix age and cohort effects, as discussed by Poterba (2001). The associated problems can be described using equation (1) where A is individual asset holdings of age α at time t:

$$A_{at} = \alpha_a + \beta_t + \delta_{t-a} \tag{1}$$

If α_a is the age-specific asset demand at age a. β_t is the time-period-specific shift in asset demand and δ_{t-a} is the cohort-specific effort for asset demand for those born in the period t-a. ‘Cohorts’ are a linear combination of age and time. With panel or repeated cross-section data, it is possible to estimate two effects, but it is impossible to estimate all three effects. Poterba and Samwick (2001) estimated the effects of ageing using the US Survey of Consumer Finances data, allowing for this critique. They found the hump shape for net worth but not for net financial assets, which level off in old age. The levelling off of net financial assets could link to precautionary saving or a bequest motive (Hurd (1990), Bernheim (1991)). On the other hand, Poterba (1998) shows that equities decline in old age even if age and cohort effects are allowed for. Ameriks and Zeldes (2000), who also correct for age and cohort effects using data from the US pension fund TIAA-CREF noted a rapid increase in the proportion of household owning equities, from 33% in 1989 to 49% in 1998 as the baby boom generation increased in size. This is consistent with high equity holding by the high-saving middle age group. But they also note that half of Americans do not hold any wealth in the stock market.

2.2 Demographics and asset returns

Many authors, including Shiller (2000), have suggested that the rise in the US stock market during the 1990's was at least partly due to the post-war baby boom cohort who had entered into their prime earning years and begun saving for their retirement. This explanation can be formalized using a simple model presented in Poterba (2001),

$$p*K= N_y*s \tag{2}$$

whereby if individuals work for 2 periods, they work when young (Y), and retire when old (O). N_y *s is the demand for assets in any given period; cohorts work for one unit of good and production is normalised; the fixed supply of the durable good does not depreciate and (s) is the fixed savings rate out of labour incomes for young workers N_y. K is the fixed supply of durable assets. The relative price of assets in terms of one unit of the good is (p). Increases in the size of working cohorts will drive up asset prices, while a decrease of working cohorts will have the opposite effect. As the large cohort work through their life cycle, they will purchase assets at high prices and sell them at low prices. This framework leads to a low return earned on investments, although this may be muted by variations in the supply of the durable asset, or more so by changes in productivity. Also the saving ratio of young workers might be expected to vary with expectations of future asset returns rather than being fixed.

Among empirical studies, Bakshi and Chen (1994) estimated an Euler equation linking consumption to the returns on various assets, and found that a variable capturing the average age of the population had a positive effect on the equity premium, indicating declining risk tolerance with age. Yoo (1994b) related real returns on stocks, bonds and treasury bills to five demographic variables and found a higher fraction in the high-savings middle-aged group is linked to a lower real return on Treasury

Bills. Macunovitch (1997) included 12 demographic variables and fitted well the post-war real return on the US stock market. Erb et al (1997) found that there was a positive correlation between the population aged 25-45 and US real stock returns over 1970-95. The argument is that the middle aged hold more equity than other groups, owing to a riskier portfolio and a longer time horizon than the elderly but also more wealth to invest than the young.

Brooks (1998) looked at the determination of the level of equity prices in 14 OECD countries using the share of the 40-65 age group in the population as an independent variable, and found it to be significant for 11 countries. Bergantino (1998) studied house prices and stock prices in the US using age-specific asset demands derived as above from cross sectional data. There was found to be a clear relation between the level of age-specific asset demand and the level of stock prices, notably over multi-year horizons. Goyal (2001), concentrating on equity returns, found a relative increase in the fraction of middle-aged cohorts aged 45-64 leads to an increase in equity prices and also returns, given its impact on net payouts from the corporate sector.

On the other hand, Poterba (2001), after estimating a range of bivariate relations linking demographics to asset prices on US data, suggests that at a macro level, there is little evidence of a 'robust' historical relationship between demographic structure and financial asset returns. He critically reviewed the above studies and found many faults with the empirical model specifications, attributed to the limitation of statistical tests, poor data construction, lack of testing for unit roots (e.g. using the level of asset prices), "overfitting" with too many demographic variables, and few effective degrees of freedom (only one baby boom in the US). This prompts the question of whether demographic effects are significant enough to be detectable in historical data, which we investigate in this study.

One answer to the lack of degrees of freedom is to look at international data, as we do in this study. Erb et al. (1997) looked at 18 developed and 45 developing countries over 1970-95. They found that although demographics influenced regional prices of financial markets, no significant relationship existed between world average measures and expected returns. They argue this could be due to lack of market integration. Poterba (2001) was not surprised by the results. He argued there are only a small number of countries which have had a long history of established liquid and developed equity markets. Ownership of stocks is small for the majority of countries. Furthermore, there are difficulties in treating cross-sectional data of individual countries in the same way, due to the differences in the size of capital markets. Poterba looked at Canada and UK, and found no support for the relationship of demographics on asset returns, although for Canada, there was a significant positive relationship between long-term bond yields and the size of the age group 40-64. For the UK, this was not the case.

On the other hand, Brooks (1998) study showed the 40-64 age group for UK, Japan and US taken together is highly significant against real stock prices. Ang and Maddeloni (2003), in a recent contribution, offer transnational empirical evidence favouring the hypothesis that demographic variables - notably the change in the proportion of the population over 65 – predict excess returns on equity relative to the short term interest rate. An increase in the proportion of the population over 65 tends to reduce the risk premium, especially in countries with well-developed social security systems and less developed financial markets. This is the case both for long pooled samples since 1920 for the G-5 countries and for shorter samples covering the period since 1970 for 15 countries.

Other recent studies of the effects of shifts in demographic structure on equilibrium asset returns and/or asset prices have used calibrated intertemporal general equilibrium models, generally based on overlapping-generations models (OLG). These studies typically do not directly address the empirical question of whether the recent rise in US asset values can be linked to demographic structure, but look more closely at issues of whether demographic shifts can conceptually affect equilibrium asset prices and returns. The common thread to these studies does suggest a relationship between changing demographics and asset returns is plausible.

For example, Yoo (1994a) simulated a baby boom by using an overlapping generations model, where consumers live for 55 periods and work for the first 45 years. He found a negative relationship between the size of the middle aged group (45-54) and the low frequency returns on financial assets including: common and small corporate stocks, long corporate bonds, long government bonds, intermediate government bonds and T-bills. This is due to the age group which has the highest increment of wealth[3], having the largest impact on the supply of savings, resulting in a rise in prices and hence a fall of those asset returns ex ante. The rise in share prices is 33% with a fixed capital stock but is attenuated to 15% if capital is endogenous.

Consistent with Yoo (1994a), Brooks (1998) in his OLG model suggests ex ante real asset returns move positively with real interest rates and negatively with aggregate savings, thus real return on bonds and equities move inversely with the size of cohorts aged 40-64 relative to those over 65 years. This is because the real rate of interest rate will factor into the discounted future income streams. But as noted in terms of prices, real bond and stock prices are positively related to the size of the cohorts, given excess demand for securities and a relatively fixed supply of capital (see also Poterba 2001). Furthermore on a backward looking ex post basis as adopted by many empirical studies, looking at total return adding capital appreciation to dividend yield or bond yield, it is likely that asset prices and asset returns go in the same direction.

In another OLG study, Brooks (2000) focused on future switches between riskless and risky assets as individuals age, and found that the bond yield would rise from 4.5% to 4.8% as the baby boomers buy equity then fall to 4.1% as they retire. Abel (2000, 2001) allowed for a variation in the price of capital owing to adjustment costs and found that a baby boom would again impact on asset prices, even if bequests are allowed for. He notes that demographic structure can affect the ability of agents in an economy to share risk. Finally Ang and Maddaloni (2003) show how the population growth rate may affect the risk premium on equity in an OLG framework.

Overall, there is a broad consistency in econometric and OLG research, which suggests the potential existence of relationship between demographics and asset prices but also a number of pitfalls in identifying the effect empirically.

2.3 Construction of demographic structure and asset returns variables

[3] Changes in wealth are nearly $80,000 for this age group. Also, Bergantino (1998) found the maximum level of household income achieved is between the ages of 45-50 years old.

There are three broad approaches to the measurement of the demographic structure. One approach is to estimate the demand for assets based on a combination of the projected demographic trend and the expected household demand for financial assets. The approach of Bergantino (1998), and Yoo (1994b), involves the use of cross-sectional age-wealth profiles to construct asset demand profiles. These represent average asset holdings of individuals of different ages at a point in time. The data are combined with the age distribution of the US population to construct time series data. As noted, there are problems with this approach; Poterba (2001) argues this method distorts the evolution of asset demand in the changing population structures in terms of 'cohort effects', as discussed above.

In his own work (Poterba (2001), Poterba and Samwick (2001)), Poterba derives measures of projected asset returns which seek to correct for age and cohort effects. This of course requires detailed micro data as is available for the US but not for most other countries. Meanwhile, Goyal (2001) uses net outflows from stock markets in addition to financial asset returns. Ameriks and Zeldes (2000) show examples of age-wealth profiles over time where there are different underlying patterns of asset accumulation over the life cycle as a result of different combinations of cohort and time effects[4].

In a second approach, Bakshi and Chen (1994), and Erb et al. (1997) use the average age as a demographic variable. The latter argued that changes in average age would predict asset returns, as demographic fluctuations are persistent i.e. slowing moving and highly predictable. However, this approach although less complex, is not without its problems. Poterba (1998) argues it is not clear why average age as opposed to other demographic measures would capture the profile of lifetime asset accumulation. In a later study, Poterba (2001) argued that in developing countries, the use of average age largely captures changes in morbidity and mortality. In Yoo (1997)'s theoretical research, average age does not capture the age distribution; in the steady-state average age remains constant as the asset

[4] This is known as 'intergenerational effects', see Wang and Sherman (1997), another example of which was the baby boom generation born between 1897 and 1924 in the US which went through a major stock market crash in 1929 and the great depression. They held a different composition of financial assets relative to the next generation of cohorts.

price increases. Additionally, there are several periods where the average age and asset prices move in opposite directions.

Third, rather than the average age, most recent macroeconomic studies use aggregate age groups as a proportion of the total population. We follow this tradition. For example, Poterba (1998, 2000) and Brooks (1998) use the group aged 40–64 as one of their variables. A variable based on the size of the retired generation is used in studies by Goyal (2001), Yoo (1994a) and Ang and Maddeloni (2002). Yoo (1994b) and Macunovitch (1997) use a large number of share variables, prompting criticisms of "overfitting" by Poterba (2001). Whereas most studies focus on the level of the share of age groups, Goyal (2001) and Ang and Maddeloni (2002) maintain that changes are more relevant.

The most commonly used asset classes are corporate stocks, bonds and 3-month treasury bills. Authors tend to use real annual price or returns data adjusted for inflation, for example Goyal (2001), Brooks (1998), Bergantino (1998), Yoo (1994a, 1997), Erb et al. (1997), and Poterba (1998, 2001). Ang and Maddeloni (2002) evaluate the performance of the premium of total returns on equity over the short rate. In most cases, real returns are backward looking in empirical studies (i.e. ex post holding period returns or price changes), although OLG studies often highlight the relevance of forward looking measures. Besides the need to allow for inflation, use of annual real returns highlights the importance of using low frequency data when investigating the relationship between financial assets and demographics, which is likely to be more detectable over the long term given the volatility of short-term asset prices. Studies often note that when asset returns are smoothed, it increases the significance of the relationship. For instance, Bergantino (1998) notes over a five-year period, demographics can explain 38% of variation in bond price appreciation, in contrast to only 12% in annual data. Ang and Maddeloni (2002) also use overlapping observations (the equity premium up to 5 years ahead), correcting standard errors with the Hodrick (1992) procedure.

Poterba (2001) notes that most extant work, including his own, ignores a range of nondemographic variables[5] that may affect equilibrium asset returns and asset prices, and that the results of these may also have policy implications. We accordingly seek to include a range of such variables in our own work below, also taking seriously the issue of stationarity.

2.4 Baby boomers and retirement

So far we have discussed estimation of past relationships between demographics and asset returns, but another equally important and related question is what will happen to overall asset returns when the large baby boom cohorts retire. The arguments surrounding the 'asset meltdown hypothesis' theory as coined by Poterba (2001) relate to the situation where the retirement of baby boomers leads to a sell-off of large amounts of assets that have been accumulated during their prime working years. The sell-off of assets is used to support their retirement consumption.

Brooks (2000) argues that because there is a smaller generation of investors to sell their assets to, this would put downward pressure on asset prices. Also there will be excess demand for bonds and excess supply of equities in coming decades, with a marked decline in the returns on the retirement savings of baby boomers held in equities. Shieber and Shoven (1994) developed a similar argument suggesting that in the future, defined benefit pension systems will become net sellers, with the structure and pattern of flows from defined benefit pension plans means asset prices will be depressed. On the other hand, Poterba (1998) argues that the meltdown hypothesis is inconsistent with empirical survey data. Consumers decumulate assets at a less rapid rate than the life cycle suggests. This is because the life cycle model takes no account of the bequest motive and lifetime uncertainty. Hence, although asset demands have risen to fuel the recent boom, they will not fall in the future. However, Abel (2001) using a rational expectations model, which took account of the bequest motive, found stock prices are still expected to fall when baby boomers retire despite high projected asset demands owing to shifts in the supply of capital in response to changes in its price.

[5] One exception is Ang and Maddeloni (2003) who use growth in consumption and the term structure as supplementary variables to forecast the risk premium.

2.5 Factors weakening the link between demographics and asset prices

Researchers disagree on the rate at which assets are decumulated during retirement. This raises the issue of the bequest motive for savings. Studies such as Kotlikoff and Summers (1981) suggest bequests account for a large proportion of the capital stock owned by households. However, Hurd (1987) and Bergantino (1998)'s findings show little support for the bequest motive, arguing that the elderly save little for bequest purposes. Poterba (2001) suggests the relative importance of bequest motive is still an open question.

Second, the liberalisation of financial systems since the 1970's has given rise to rapid international integration of financial markets even in a large market such as the US. This could break any domestic link between demographic structure and financial asset prices and imply that only global demographics and asset prices are relevant. In this context, the "meltdown" highlighted above might be attenuated by the growing maturing and wealth of populations of emerging market economies such as China in the coming decades. Reisen (1998) points to both the offsetting patterns of saving and the diversification benefits arising from EMEs as helpful in ensuring adequate returns on OECD pension funds that invest in EMEs, not least in the light of the tendency for returns in OECD countries to fall in coming decades.

On the other hand, evidence from research of US equity markets by Brennan and Cao (1997) found investors have a strong 'home bias' towards holding domestic equity portfolios, despite advantages of the international diversification in equity markets. This implies markets are still segmented, because domestic investors possess cumulative advantages over foreign investors in terms of their domestic equity markets (see French and Poterba (1991) and Kang and Stulz (1994)). For bonds, Poterba (1998) suggests there are vast cross border flows, suggesting a weaker link from domestic asset prices to demographics. Moreover, correlations between stock markets have grown in recent years (Davis 2002).

Meanwhile, productivity changes as the population ages could offset declines in the return on equity owing to demand side factors, as suggested by Cutler et al (1990). Monetary policy may be expected to respond to high real interest rates by an appropriate loosening, which will help attenuate the peaks (Poterba 2001). Investor demand would be likely to switch in the light of relative returns, for example to buy high-yield bonds in the later years. Pension reform in Europe and Japan may boost the global demand for equities with a given demographic structure. Sufficient immigration from emerging markets could change the overall demographic pattern in OECD countries. Finally, Neuberger (1999) argues that the increase and subsequent decrease in flows will be balanced by rises and falls in equity issues, with little effect on prices and returns.

Finally, since financial markets tend to be efficient and forward looking, and because demographic changes are slow moving and predictable, the market meltdown could be forestalled with rational expectations. Yoo (1997) criticises existing empirical studies as they do not include forecasts based on expectations. Results may be biased as to the magnitude of demographic effects on asset prices and the turning points of the likely effect. This is illustrated in his work. A static expectations OLG model produced a rise in asset prices of 32% in the first 15 years whilst a 'perfect foresight' model produced a rise of only 19%. The retirement of baby boomers depresses asset prices sooner at 8 years earlier i.e. around 2002 rather than 2010 – indeed, quite close to the current bear market. Nevertheless, asset prices also deviate from the no baby boom path under the assumption of 'perfect foresight'[6].

The possible implications are further illustrated by Poterba (1998) who suggests that if capital goods lasted longer than one period and as demographic shifts are predictable as soon as the size of a birth cohort is revealed, a well-functioning asset market could price these capital goods so that their current market price would equal the expected present discounted value of future earnings. In this case, adjustment to asset prices will have taken place when the cohort became public information, i.e. when they were born in early 1960's, rather than when they reach middle age in the 1990's. Since these patterns were not observed it poses a challenge to rational expectations, and may justify the implicit

[6] Most recent research by Brooks (2000) and Abel (2001) sought to incorporate the role of rational expectations into their models, which still implies a boom and bust in asset prices.

adaptive expectations approach adopted in our regressions. It is reinforced by the success of equations estimated up to 1990 in forecasting to 1999, when demographic effects have been most discussed. Nevertheless we have to allow for the possibility that although agents were unaware of demographic effects over our sample, they will in the future be sensitised to them, thus weakening the forecasting power of our equations in the medium term.

3. Demographics and financial asset prices: an empirical investigation

Section 1 showed the past and future parallel shifts in age distribution in the US, Japan and Europe, while Section 2 noted that whereas work on US equity markets has been voluminous, there is more limited empirical research at a macro level within an international context, as well as on bond yields. Accordingly, this section empirically investigates the effects of demographic shifts on several financial asset prices in seven OECD countries and internationally. Our analysis provides estimates using the most recent data from 1950-1999[7] and on a wider range of countries than previous work with disaggregated demographic variables have covered.

Following Poterba's suggestion, we include non-demographic variables in the specification. We principally undertake panel estimation, as well as testing for effects in the US to ensure comparability with earlier work. But also we test for effects on aggregates of the seven countries (labelled "international"). This has generally accounted for a high proportion of world GDP and financial assets and hence can be seen as approximating "global" shifts. The weighting used was GDP weights, implicitly allowing for differing income and wealth levels. We also ran estimates with population weights, and found the results comparable[8].

As a preliminary, Table 3.1 shows unit root tests for the variables used in the bond and equity equations. Besides the individual country data, we include the international aggregates and the panel

[7] The most recent data used for empirical analysis is by Poterba (2001), in the US only, for the period 1926-1999. Most empirical studies relevant for the research use data prior to 1999 see Erb et al. (1997), Goyal (2001), Bergantino (1998), Brooks (1998), and Yoo (1994a).

[8] The international results test the superiority of aggregate data whereby the benefits in reducing residual variance from statistical averaging may offset any aggregation bias, as was observed in the case of Euro-Area wide monetary aggregates (Fagan and Henry 1998).

unit root tests (undertaken according to the method of Im et al (1997), to average out the individual ADF statistics)

In general, all the variables are stationary except the AGE65 cohort (which is unsurprising given the ageing of the population), while inflation, dividend yields and the HP filter on trend growth are also often borderline. In fact AGE65 is only on the borderline of stationarity in the US. Whereas the logic of non stationarity is to use differences of the relevant variables, Poterba (1998) argues that the use of differences of demographic shares is hard to base in rational expectations, since changes in the share of a given population group are not “news” once the cohort is born. Following this argument, in the current exercise, we consider it appropriate to estimate our main results in levels of population shares. Accordingly, and also to avoid the possibility of “overfitting”, we only use the stationary AGE20 and AGE40 cohorts in our main results. We test the US with AGE65 as a variant.

3.1 Specification for equities

Our aim is to provide appropriate specifications for share prices and bond yields within which to test for the separate effects of demographic variables. By this method we can ensure that our results are not subject to omitted variables bias.

A helpful way of considering equity price determination is in terms of the Gordon’s (1962) growth model (see Bodie et al 2000). This highlights expected dividend growth (g) as well as real long term interest rates (rr) and share price volatility as a proxy for the risk premium (pr) as key determinants of share valuations (V). Equation (3) shows that the value of a share depends on the dividend and the future price. The latter, as shown in equation (4) depends on future dividends suitably discounted. As shown in equation (5), if dividend growth, the long rate and the risk premium are expected to be constant, a series of discounted dividends can be simplified to an expression in dividend growth, the real long rate, the risk premium and the level of dividends:

$$V_o = (D_t(1+g) + P_{t+1})/1+(rr_{t+1}+pr_{t+1}) \qquad (3)$$

$$V_o = D_{t+1}/(1+ (rr_{t+1}+pr_{t+1})) + D_{t+2}/(1+(rr_{t+2}+pr_{t+2}))^2 + D_{t+3}/(1+(rr_{t+3}+pr_{t+3}))^3 \ldots.. \quad (4)$$

$$V_o = D_{t+1} / ((rr+pr) - g) \quad (5)$$

To implement this structure, data for the estimated real long term interest rate and share price volatility are directly available. However, there are ambiguities in the relation with inflation, which may affect the reaction to real long rates also. In theory, share prices should be determined in real terms and not affected by inflation. If real interest rates fall in inflationary periods, share prices could even be boosted. On the other hand, some theorists (Modigliani and Cohn 1989) have suggested that inflation could interact with taxation systems to reduce corporate profitability. This would be particularly the case when there is fiscal drag, with lack of appropriate indexation of tax bands. Lack of indexed allowances for stock relief was a particular problem in countries such as the UK in the 1970s, with firms being held to profit from the rise in value of their inventories, although the impact on profits was wholly offset by rising costs. Equally, inflation might be expected to increase uncertainty and hence the risk premium required for holding equities. Accordingly, since the long rate is defined as the nominal long rate less inflation, it may also be affected by inflation's negative effect on share prices.

As regards growth in dividends, since capital's share of GDP is bounded but not stationary, GDP growth itself gives a helpful proxy for dividend growth. The most relevant variable is trend growth, although cyclical influences are also likely to influence prices temporarily. We can allow for different responses to trend and cycle by estimating a Hodrick Prescott filter on GDP growth with a smoothing factor of 100[9] and deducting it from actual GDP growth. Thus, the trend itself is given by the smoothed estimates and the cyclical effect by the difference between actual GDP growth and the trend (a positive value thus indicates growth in excess of trend). An alternative measure of expected dividend growth is capital productivity, as argued in Davis and Madsen (2001).

The level of dividends is straightforwardly entered via the lagged dividend yield. Note that this also follows the extensive empirical literature that finds dividend ratios predict equity returns (see

[9] Note that we included IMF World Economic Outlook forecast data for 2002-5 in the HP filter estimation to avoid the estimate for 2001 being distorted by the end point problem.

Campbell and Shiller (1989), Fama and French (1988) and the survey in Cochrane (1997))[10]. Furthermore, it can be seen as a form of error-correction term also in that there may plausibly be a "normal" relation between share prices and dividends; a high dividend yield should make share price increases more likely if associated real dividends are regarded as sustainable.

Following this discussion, the basic regression models used to test the statistical significance of correlations between demographic structures and real stock prices takes the form of a regression of the difference of real share prices (Δ ln RSP) on trend GDP growth (DYHP), differences from trend (DDIFY), the real long rate (RLR), monthly average real share price volatility (VOL), and the lagged dividend yield (DIVY), with the demographic effects tested using the share of ages 20-39 and 40-64 in the total population (AGE20 and AGE40).

$$\Delta \ln RSP = \alpha + \beta_1 AGE20 + \beta_2 AGE40 + \beta_3 DYHP + \beta_4 DDIFY + \beta_5 RLR + \beta_6 VOL + \beta_7 DIVY(-1) \qquad (6)$$

Definitions are as set out in Table 3.1. Regressions use annual data and are for 1950-1999. The demographic variables in the specifications are similar to Yoo (1994a)'s model, with a similar rationale, that the age distribution indicates the demand for financial assets, which in turn drives asset prices and yields over and above other key variables. However, Yoo used different age groups and only estimated the relation between US demographics and financial asset prices. He did not use the range of additional determining variables employed here. He split the age groups evenly for population demographics and used 5 demographic variables. Demographic variables in our estimated equations are split into 2 age groups as a proportion of the total population based upon empirical research findings in sections 2.1 and 2.2 and results showing non-stationarity of the over-65s[11]. Obviously the end-points of each cohort are open to debate – in some countries activity may begin later than 20 and retirement is earlier than 65. Another issue is that labour force participation and

[10] Note that more recent work has cast doubt on some of the earlier confidence about the predictive power of dividend ratios (Goyal and Welch 2002).
[11] A variable based on the population of 65 and over is used in studies by Goyal (2001) and Yoo (1994a).

longevity have changed over the sample, which might affect savings behaviour, albeit potentially in offsetting ways.

The smaller number of demographic variables should avoid the problem of "overfitting" met by Yoo (1994a) and Macunovitch (1997). Poterba (1998, 2001) and Brooks (1998) also use the group aged 40–64 as one of their variables. It is not possible to use measures based on projected asset returns due to lack of survey data allowing breakdown of age and cohort effects for most countries. Also, it avoids a critique of such approaches, namely that the underlying survey data typically omit valuation of defined benefit pension assets and implicit responses to social security wealth.

3.2 Results for equities

Table 3.2 displays results from the estimation of the change in real stock prices using panel estimation for all 7 countries. In the specifications, we regressed country-specific demographic and dummy variables for fixed effects against real stock prices. The methodology was GLS, with fixed effects and cross section weights. Brooks (1998) adopted a similar approach, arguing that cross section weights allow for a global cycle in non-demographic fundamentals, providing more precise estimates of demographic variables. Standard errors are White heteroscedasticity consistent[12].

Looking at the panel results for all seven countries, the non-demographic specification is satisfactory with generally signs as expected. The trend in income has a strong positive effect on share price growth, as does the lagged dividend yield. The volatility and cyclical variables are not significant. What is more surprising is that the real interest rate has a positive sign. This is an indication that the negative inflation effect on share prices is greater than the negative effect of the long rate itself. The demographic variables are highly significant despite inclusion of these standard determinants and display a positive sign, which is consistent with empirical findings found in sections 2.1 & 2.2. The AGE20 variable has a smaller coefficient than AGE40, consistent with a lower effect given the lesser

[12] This is a partial attempt to correct for variances. Hence we are able to interpret the coefficients and undertake t-tests subject to there being no other forms of misspecification.

wealth of this age group, suggesting a relative increase in those aged 40–64 year leads to an increase in the annual percentage change in real stock prices. The Wald test indicates that exclusion of the AGE20 and AGE40 variables is not warranted.

Note that the second column in Table 3.2 shows that even without the US, the panel results remain robust. And indeed we now capture a significant cyclical effect on share prices. This suggests that the results are not purely dependent on the demographic effect in the US, but rather a wider global effect is being captured. Following these panel results, we undertook further tests to split out the country specific effects, as shown in Table 3.3. The two sets of results correspond to estimation with and without the US.

In the seven-country equations, 8 out of 14 coefficients on demographic variables are significant suggesting that it is not just a question of spillovers from the US. The US, France and Spain have a significant AGE20 and the US, Japan, Germany, France and Italy have AGE40 significant. It is interesting to note that apart from the US these are generally classed as "bank dominated countries" where equity prices would not be expected to be sensitive to domestic variables such as demographics[13]. The coefficients for these countries are also stable when the US is excluded.

Following the panel work, we went on to estimate OLS equations with a similar specification for the US and for the aggregate of the seven countries, where variables were weighted by annual GDP weights. We label the latter "international". The former allows comparison to be made with extant work cited above, while the latter gives a view of the global effects of ageing (given we have the majority of global wealth included in our seven countries). Results are shown in Table 3.4

Results for the US are consistent with the panel estimation. We find that the real long rate, the lagged dividend yield and also share price volatility are significant. However, unlike the panel the HP filter on GDP growth is not significant. In terms of demographics we have a significant positive coefficient for

[13] Ang and Maddeloni (2003) found sensitivity of equity risk premia to the change in the share of retired people in bank dominated countries with generous social security.

the AGE40 variable but not for AGE20. This result is in line with empirical studies by Yoo (1994a), Bergantino (1998), Poterba (1998, 2001) and Brooks (1998), allowing for different scaling of the dependent variable. Note that the US equation includes dummies for the years 1953 and 1957, with a value of -0.29 and a standard error of 0.09.

Similar results are found when we allow for full integration of international capital markets and regress international demographics against the international percentage change in real stock prices, with all variables GDP-weighted. Again the AGE40 variable is significant at the 95% level with correct signs. Note however that the AGE40 in the international sample is non-stationary, which lends less credence to this result than the US and panel work.

OLS estimation allows a much wider range of diagnostic statistics to be provided than for the panel. Most US studies do not provide detailed diagnostics so it is hard for us to evaluate whether we have superior results. In the table we provide the Lagrange multiplier test for second order serial correlation, the ARCH test for heteroskedasticity, the Jarque-Bera normality test, Ramsey's RESET test with three fitted terms, the forecast Chow test over the period 1990-99 and the ADF unit root test for stationary residuals. We also show the F-test for the significance of all variables jointly and a Wald test for exclusion of the AGE40 variable. For both the US and international data, we find that all the test are passed, with the exception of the RESET test for the US which is marginally significant at the 10% level. Meanwhile the Wald test shows that exclusion of the demographic variable would be unjustified. We contend that these results underpin the validity of the inference that demographics have a significant effect on share prices in an international as well as US arena. The Chow test is of particular interest, since it shows that a specification for the US and the international sample estimated solely up to 1990 can forecast the difficult period of the 1990s successfully. When the demographic variable is omitted the results for this test are much poorer.

Meanwhile, the R bar squared for equations in Table 3.4 shows demographic variables along with the other independent variables can explain 30-50% of the total variation in the dependent variables. Results produced by other studies found a lower R bar squared, for example, Yoo (1994a) found for large corporate, common, and small company stocks, the adjusted R squared is 15%, 0% and –7% respectively.

3.3 Specification for bonds

Turning to bonds, in our proposed specification the real long-term bond yield is partly derived from the expectations theory of the term structure (which applies strictly to the nominal long rate with zero inflation). As is well known, this suggests that the long-term interest rate is based on future expected short rates. If the future short rate exceeds the current one the term structure will be upward sloping. We use a change of the short rate to proxy monetary tightening, which if there is positive serial correlation in monetary decision making would lead to higher expected future rates. We also allow for some mean reversion in the term structure by including a lag of the term structure differential (long versus short rates). Since we are modelling the real long rate some additional variables are needed. We add the lag and acceleration of inflation to allow for possible deviations from the Fisher identity whereby the real (long or short) interest rate is normally constant but may be reduced in the short term by unexpected inflation. Finally we allow for cyclical and trend-growth effects on the real rate by including the HP filter of GDP growth and the difference of actual growth from this (i.e. a proxy for the output gap). These should capture effects of the demand for loanable funds, as well as potentially helping to forecast future interest rate changes. Note that the specification does not allow for changes in monetary policy regime, which is an issue discussed below for the US. Given that short rate data were only available from 1960, the estimation period is 1960-99.

$$RLR = \alpha + \beta_1 AGE20 + \beta_2 AGE40 + \beta_3 DSR + \beta_4 TS(-1) + \beta_5 \Delta \ln CPI(-1) + \beta_6 \Delta\Delta \ln CPI + \beta_7 DYHP + \beta_8 DDIFY \quad (7)$$

3.4 Results for bonds

As above, in the panel specifications, we regressed country-specific demographic and dummy variables for fixed effects against real bond yields. The methodology was GLS, with White standard errors and cross section weights. Basic results are shown in Table 3.5.

Variables are significant other than the output gap and the lagged term structure. Most signs are as expected, with for example a rise in the short rate boosting the real long rate, and high and accelerating inflation reducing the real long rate. Interestingly, lower trend growth tends to boost the real long rate. Both the demographic variables are significant at 5% and cannot be excluded by the Wald test. The younger age group tends to raise bond yields, consistent with heavy demand for mortgage borrowing. It is the 40-64 group that reduces yields, implicitly raising bond prices owing to heavy net demands for financial assets from this age group. In assessing the size of the coefficients it is worth noting that changes in one variable may accompany offsetting changes in another. Hence the implied changes in yields as the population ages may be relatively small. Meanwhile results excluding the US are very similar to those for the seven countries together.

Looking at the separate country coefficients in Table 3.6, it can be seen that the result is not at all driven solely by the US. Of the AGE20 coefficients, four are significant, namely the US, UK, France and Italy although Italy has a negative sign (this may link to the low level of mortgage financing in that country, see Byrne and Davis (2003)). All of the AGE40 coefficients are significant, although those for Italy and Spain have a negative sign. This may link again to housing finance, but could also be due to different patterns of ageing relative to global trends in real rates, and possibly omitted fiscal effects. In the estimate excluding the US, results are very similar, with the Japanese AGE20 coefficient also becoming significant.

We then went on to estimate results for the US and the International aggregate by OLS, shown in Table 3.7. Unlike the panel results, the term structure is significant with a negative sign, suggesting that a large differential of long rate over short rate leads to a diminution of the real long rate. For the US, both AGE20 and AGE40 are significant with expected signs, while in the international aggregate it is only the AGE40 which is significant. The R bar squared for all regressions is sizeable, suggesting explanatory variables can collectively explain 80-90% of total variation in the dependent variables. The SE of the regression is low and F tests show one cannot reject significance of the independent variables. As for equities, the estimated results for each equation pass all diagnostic tests, namely for autocorrelation, normality of residuals, heteroskedasticity, stability and forecasting ability over the 1990s. Note that we required some dummy variables for the early 1980s, with the variables being unable to fully capture the high level of real rates in that period.

3.6 Summary of principal results

The main empirical findings are as follows; we detect a significant relationship between panel, international and US age distributions and the change in panel, international and US real stock prices. This is especially true for those aged 40-64. Variables for equities were significant despite use of a specification with the key variables from the Gordon growth model, including separate terms in trend growth and the output gap and also a lagged dividend yield. Our evidence provides support for existing theoretical and empirical studies, mentioned in Section 2, while extending them outside the US to a panel of seven countries, a panel of six excluding the US, and an aggregate international grouping. Both US and global results for share prices show sound statistical properties, including ability to forecast over the 1990s. Meanwhile, results for bond yields also give evidence of a relationship between demographics and real bond yields for the panel, US and internationally, with the OLS results again having satisfactory statistical properties. This is despite inclusion of variables capturing the key macroeconomic determinants of long rates. When we allow separate coefficients in the panel, our analysis shows most coefficients for the demographic variables are highly significant when regressed on real stock price levels and real bond yields.

3.7 Variants and projections

In order to check the robustness of the results, we ran a number of variants on the basic equations (that is, the seven-country panel equation with fixed effects, the US OLS equation, and the international OLS equation). These were as follows:

(1) We estimated only up to 1990, in order to assess whether the results are driven by the 1990s when asset prices have risen along with demographic shifts.

(2) We estimated the equity price equations for ex post real returns including dividends and not only the rise in real share prices.

(3) We excluded the lagged dividend yield from the equity price equation, given it is at most borderline stationary in most countries.

(4) We sought to include the AGE65 cohort, while bearing in mind that only in the US is this variable is close to stationary over the sample.

(5) We replaced the trend income term with growth in capital productivity, which as argued in Davis and Madsen (2001) is a better proxy for dividend growth.

In Table 3.8, we do not provide full details on the variants but only the coefficients on the demographic variables and their standard errors.

Results for excluding the 1990s are more consistent for the panel than for the US and international regressions. In the panel all the coefficients remain significant at the 95% level for real returns on both bonds and equities. In the US results, there remains a strong AGE40 effect for equities but neither demographic coefficient is significant for bonds. All variables are insignificant in the international regressions except AGE40 for bonds. As regards replacing the change in equity prices with the total return, there remain strong demographic effects for the panel and US but again not for the international regression. Excluding the lagged dividend yield leaves the panel result unchanged, while the AGE20 variable is now significant for the US, while AGE40 remains significant for the international regression, albeit only at the 90% level. Replacing GDP growth with productivity retains a high level of significance for all the AGE40 variables, and for AGE20 in the panel.

Turning to the estimates including AGE65, it must be borne in mind that only for the US are the results statistically sound owing to non-stationarity of this variable elsewhere. That said, we find that there is no significant effect for equities in the US unless the dividend yield is excluded, in which case all of the demographic variables are significant at least at the 90% level. In the US bond equation, both AGE40 and AGE 65 are significant. AGE65 tends to put downward pressure on equity prices and upward pressure on bond yields, consistent with a low level of saving and some decumulation of existing assets by pensioners. As regards the panel and international results, in the panel we find a significant AGE65 with a positive sign for equities when the dividend yield is included, but an insignificant coefficient when it is excluded. The international equity equation with no dividend yield has a negative effect of AGE65 as in the US, at the 90% level. In the bond yield equations, no AGE65 effect is detectable for the international sample, while in the panel it has a negative sign.

The issue of whether the AGE65 effect is statistically supported is an important one for the market meltdown hypothesis (Section 2.4). We can assess this by using estimated coefficients from US equity equations in Table 3.4 and Table 3.8 variant 6 to project potential effects of changing demographics on US stock markets. We also use those from Table 3.7 and Table 3.8 variant 7 for US bond markets. UN median variant estimates of population are used as our source of demographic projections for the period 2000-2025. We assumed GDP growth and CPI inflation in the US is 3%.

As shown in Chart 2, our main results with AGE65 excluded do not indicate a substantial weakening of asset prices in coming decades. The share price rises sharply in the period up to 2010, then increases fall back while remaining above zero. The bond yield falls to remain around 2% up to 2025. On the other hand, Chart 3 shows that with AGE65 included, the equity price is set to decline from 2015 onwards, while the real interest rate rises to historic peaks only previously seen in the early 1980s.

Even if the Chart 3 projections were seen as plausible, there are a number of reasons why asset price declines might be attenuated, as discussed in Section 2.5, relating inter alia to bequests, demand from

Emerging Market Economies, productivity, monetary policy and expectations. Furthermore, we have assumed variables such as GDP and inflation are exogenous, which is unlikely to be the case.

Despite such caveats, the projections shown in Chart 3, especially if they were reproduced across the OECD, do identify potential pressures on asset prices that will have to be taken into account by policy makers. Moreover, some credence is given to the results here by projections from a Japanese equation up to 1990 including AGE65 (not illustrated), which show that population ageing in that country was projected to sharply weaken share prices in that country, even if GDP growth had remained strong. The slump in share prices in Japan in the 1990s may hence have been linked to demographics as well as other macroeconomic and financial factors.

Recall that since the 1980's, major OECD countries have been undergoing major pension reforms. The fundamental reasons for such reforms are the profound shifts in international demographic structures and aging of developed countries discussed in Section 1 in combination with the generosity of existing schemes. This implies a massive future debt burden, notably for Europe and Japan. The net present value of PAYG schemes' liabilities as a percentage of GDP given current trends in demographics and taxation is as much as 100% for France, Germany and Japan (Chand and Jaeger 1996). As a result there are calls for a move towards funded pension schemes. However, whilst there are benefits from funded pension schemes, see Davis (1995), the forecasts in Charts 2 and 3 highlight market risks associated with a move towards funding, notably through defined contribution funds.

Brooks (2000) argues that governments should take an insurance role to eliminate the 'cohort-specific risk' that comes from demographic changes by borrowing over time to stabilize the risk free return. It may also be prudent for a partial switch to funding to take place as in the case of the US, so that PAYG pensions are retained to provide a 'safety net' and to reduce the inherent market, and diversification risks associated with funding. Although PAYG pensions are subject to "political risk" that future generations will not be bound by past commitments, these are unlikely to be perfectly correlated with market risks.

5. Conclusion

In Section 1, we observed a persistent influence of baby boomers and increasing life expectancy on the overall past and future demographic landscape of major OECD countries. Against this background, in Section 2 we outlined the theoretical literature, which suggests a potential link between demographics and asset prices supported by past US empirical studies. In Section 3, we have sought to follow best practice given limitations of international data. The empirical results presented provide evidence that changes in panel, US and international demographics have had a significant impact on US and international stock prices and bond yields, even in the presence of standard additional independent variables. The international results are of interest given the logic of international financial integration. More tentative results including estimated effects of the over-65 cohort in the US suggest a more severe downturn is possible, thus underlining the potential market risks associated with sole reliance on fully funded pension schemes.

Further work could allow for fiscal deficits to have an impact on real bond yields. Real bond yields themselves could be specified differently from the traditional approximation of long rates less current inflation, although lack of inflation survey data for most countries limits such possibilities. Also our regression models fail to consider the role of rational expectations, which some studies have incorporated in their models in section 2.5. Further research could quantify such effects in a ‘calibrated’ asset market equilibrium model, or use an overlapping generations simulation model incorporating rational expectations. We have conducted much of our analysis in an international context and assumed stock markets are highly integrated; however, there is still the issue of the evolving extent of world capital market integration over the sample that can be allowed for in estimation. Use of GDP weights for global variables could be challenged, with an alternative being population. Attempts could be made to deal better with non-stationarity of the elderly cohort outside the US, for example in an error correction framework. In further work, modelling could be elaborated, possibly with real bond yields and share prices jointly determined in a VAR or VECM framework.

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Table 1. 1 - Total fertility rate - estimates and projections

Number of children per female	1950-60	1960-70	1970-80	1980-90	1990-2000	2000-10
Japan	2.4	2.0	1.9	1.7	1.5	1.4
UK	2.3	2.7	1.9	1.8	1.7	1.6
Italy	2.3	2.5	2.1	1.4	1.2	1.2
Spain	2.7	2.9	2.7	1.7	1.2	1.1
France	2.7	2.7	2.1	1.8	1.7	1.8
Germany	2.2	2.4	1.6	1.4	1.4	1.3
US	3.6	2.9	1.9	1.9	2.0	1.9

Source: United Nations (1998)

Table 1. 2 – Life expectancy at birth - estimates and projections

Years	1950-60	1960-70	1970-80	1980-90	1990-2000	2000-10
Japan	65.3	70.0	74.4	77.6	80.0	81.9
UK	69.8	71.1	72.4	74.5	76.8	78.6
Italy	67.2	70.4	72.9	75.4	77.8	79.0
Spain	65.8	70.9	73.6	76.2	77.8	79.0
France	68.1	71.3	73.0	75.4	77.8	79.4
Germany	68.3	70.6	71.8	74.3	76.7	78.5
US	69.3	70.2	72.4	74.7	76.1	78.0

Source: United Nations (1998)

Table 1.3 – Elderly dependency ratio estimates and projections

	1950	1970	1990	2000	2010	2030	2050
US	12.8	15.9	18.9	19.0	19.5	33.6	35.5
UK	16.0	20.6	24.1	24.6	25.9	38.3	42.2
Germany	14.5	21.7	21.7	23.6	29.6	43.3	48.7
France	17.3	20.7	21.3	24.1	25.3	38.7	44.2
Spain	11.1	15.7	20.7	24.5	27.0	42.3	72.0
Italy	12.6	16.9	22.3	26.4	31.4	49.1	65.7
Japan	8.3	10.3	17.2	25.0	33.8	46.0	58.4

Source: United Nations (1998)

Chart 1: 40-64 year olds as a percent of the adult population

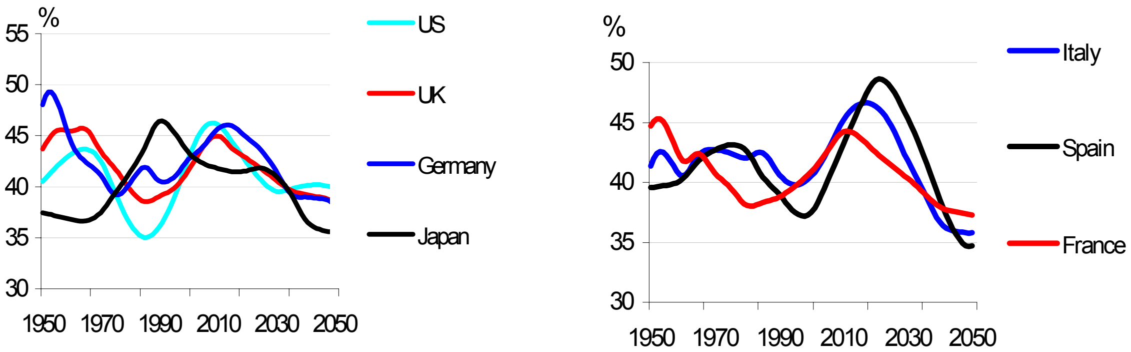


Table 3.1 Unit root tests (ADF)

	DDIFY	DYHP	DLCPI	DLRSP	RLR	VOL	DY
Germany	-7.1**	-1.0	-3.5**	-5.4**	-11.4**	-7.8**	-2.6*
France	-5.4**	-2.4	-2.7*	-5.2**	-3.8**	-3.4**	-1.9
Italy	-6.5**	0.0	-1.8	-4.6**	-2.8*	-4.8**	-2.2
Spain	-8.0**	-4.2**	-2.7*	-3.2**	-2.4	-4.0**	-1.9
Japan	-5.9**	-2.4	-2.0	-5.6**	-9.7**	-3.9**	-1.6
UK	-5.9**	-4.0**	-2.1	-5.9**	-3.1**	-4.0**	-3.1**
US	-5.9**	-4.0**	-3.0**	-5.6**	-3.0**	-6.5**	-1.6
Panel unit root	-6.4**	-2.6*	-2.5*	-5.1**	-5.2**	-4.9**	-2.1
International	-6.1**	-1.5	-2.1	-5.0**	-3.5**	-5.7**	-1.5
	AGE20	AGE40	AGE65	DSR	TS	DDLCPI	
Germany	-7.4**	-5.7**	-0.5	-6.5**	-3.9**	-8.4**	
France	-3.7**	-5.2**	-1.1	-3.8**	-3.1**	-6.0**	
Italy	-4.8**	1.5	-0.2	-5.1**	-3.2**	-6.8**	
Spain	-7.5**	3.2	0.5	-3.7**	-2.2	-5.8**	
Japan	-5.1**	-4.3**	-1.6	-4.8**	-4.8**	-6.4**	
UK	-4.6**	-5.0**	-1.1	-3.7**	-3.7**	-5.8**	
US	-22.5**	-7.9**	-2.5	-4.0**	-4.0**	-7.8**	
Panel unit root	-7.9**	-3.3**	-0.9	-3.5**	-3.6**	-6.7**	
International	-6.1**	-1.5	-2.1	-5.7**	-5.9**	-6.5**	

Key: DDIFY difference of log difference of real GDP from HP filter; DYHP trend growth derived from HP filter on log difference of real GDP; DY dividend yield; DLCPI log difference of CPI index; DLRSP log difference of real share prices, derived as nominal share index divided by CPI; RLR real bond yield, derived as nominal yield to maturity less current CPI inflation; VOL real equity price volatility, derived as variance of log of monthly change in share prices divided by CPI within each year; DY dividend yield; AGE20 population aged 20-39 as a percent of the total; AGE40 population aged 40-64 as a percent of the total; AGE65 population 65+ as a percent of the total, DSR is the first difference of the nominal short term interest rate, TS is the term structure (long rate less short rate) and DDLCPI is the acceleration of the CPI index (log second difference)[14]. Tests are run without trend. Critical values for a unit root, 95% -2.9, 90% -2.6 hence ** indicates stationarity at 95% and * and 90%.

[14] Data sources for share prices, GDP, CPI, short term money market rate: IMF Financial Statistics yearbooks (IFS). Bond yields: Shomera (1991) for the period 1952-1965 and IFS for the period 1966-2000. Demographic data: UN population database (1998). Data after 1998 are based on UN projections in the medium – fertility variant. For descriptive statistics see Appendix to Davis and Li (2003).

Table 3.2 – Panel estimation results for change in real share prices (1950-1999)

Dependent variable is log difference of real share prices. Estimation is by GLS, Fixed effects, Cross section weights, White heteroscedasticity adjusted standard errors.

Independent variables	Seven countries	Excluding US
AGE20	0.017 (0.0045)**	0.032 (0.0085)**
AGE40	0.031 (0.0069)**	0.034 (0.008)**
DYHP	2.75 (0.85)**	2.71 (0.8)**
DDIFY	0.703 (0.48)	1.43 (0.64)**
RLR	0.013 (0.0036)**	0.011 (0.0035)**
VOL	-0.306 (0.476)	-0.20 (0.7)
DY (-1)	0.033 (0.0083)**	0.036 (0.0075)**
Fixed effects		
US—C	-1.5	
UK—C	-1.6	-2.2
JP—C	-1.6	-2.1
DE—C	-1.7	-2.2
FR—C	-1.6	-2.2
IT—C	-1.6	-2.2
ES--C	-1.6	-2.2
R squared	0.158	0.16
SE of regression	0.21	0.22
Wald test for exclusion of AGE20 and AGE40	25.0 (0.0)**	21.1 (0.0)**
No of observations	350	300

* Indicates significant at 90% and ** at 95%. Standard errors in parenthesis.

Table 3.3 – Panel estimation results for change in real share prices (1950-1999) – country-specific demographic effects

Dependent variable is log difference of real share prices. Estimation is by GLS, Fixed effects, Cross section weights, White heteroscedasticity adjusted standard errors.

Independent variables	Coeff	SE	Coeff	SE
US--USAGE20	0.011	(0.0043)**		
UK--UKAGE20	0.025	(0.024)	0.029	(0.023)
JP--JPAGE20	0.0083	(0.020)	0.0074	(0.016)
DE--DEAGE20	0.013	(0.025)	0.013	(0.024)
FR--FRAGE20	0.044	(0.022)**	0.048	(0.024)**
IT--ITAGE20	0.029	(0.033)	0.035	(0.028)
ES--ESAGE20	0.058	(0.017)**	0.062	(0.017)**
US--USAGE40	0.065	(0.010)**		
UK--UKAGE40	0.0071	(0.023)	0.009	(0.024)
JP--JPAGE40	0.025	(0.013)*	0.025	(0.013)*
DE--DEAGE40	0.037	(0.019)**	0.039	(0.019)**
FR--FRAGE40	0.058	(0.020)**	0.061	(0.021)**
IT—ITAGE40	0.058	(0.031)*	0.06	(0.031)*
ES—ESAGE40	0.031	(0.030)	0.041	(0.038)

* Indicates significant at 90% and ** at 95%. Standard errors in parenthesis.

Table 3.4 Demographics and real stock prices for the US and international samples (1950-1999)

Independent variables	Log difference of US real stock prices	Log difference of international real stock prices
Constant	-2.97 (0.64)**	-1.78 (0.81)**
AGE20	-0.0024 (0.0098)	-0.018 (0.027)
AGE40	0.108 (0.02)**	0.076 (0.024)**
DYHP	-3.4 (6.5)	-1.44 (4.3)
DDIFY	-1.28 (0.97)	0.99 (1.7)
RLR	0.03 (0.009)**	0.02 (0.009)**
VOL	-1.19 (0.62)*	-1.19 (0.89)
DY (-1)	0.092 (0.026)**	0.086 (0.035)**
R^2	0.54	0.41
RSS	0.58	0.62
SE of regression	0.12	0.12
F-statistic (7,50)	6.0 (0.0)**	4.07 (0.0)**
Wald test for exclusion of AGE40	15.2 (0.0)**	9.6 (0.0)**
R-bar-squared	0.45	0.31
Serial correlation (2)	1.1 (0.36)	0.9 (0.4)
Normality	1.53 (0.28)	1.0 (0.6)
Heteroscedasticity	0.53 (0.47)	0.31 (0.58)
Stability (RESET)	2.4 (0.09)*	2.1 (0.11)
Stability (Chow forecast)	0.81 (0.62)	1.1 (0.41)
Unit root test	-5.9	-5.6

Note: Standard errors in parentheses, except for diagnostics where the P values are shown. * indicates significance at 90% and ** at 95%. Serial correlation test is the LM (2) test; normality is the Jarque Bera statistic; heteroskedasticity is ARCH (1); stability is the RESET (3) test and the Chow forecast test over 1990-99; unit root is the ADF.

Table 3.5 – Panel estimation results for real bond yields (1960-1999)

GLS, Fixed effects, Cross section weights, and White heteroscedasticity adjusted standard errors. * Indicates significant at 90% and ** at 95%. Standard errors in parenthesis.

Independent variables	Seven countries	Excluding US
AGE20	0.249 (0.045)**	0.157 (0.066)**
AGE40	-0.434 (0.074)**	-0.52 (0.086)**
DSR	0.181 (0.054)**	0.188 (0.057)**
TS(-1)	-0.083 (0.061)	-0.095 (0.066)
DLCPI(-1)	-64.4 (3.1)**	-66.0 (3.4)**
DDLCPI	-92.7 (4.7)**	-91.4 (4.8)**
DYHP	-65.5 (9.0)**	-75.0 (9.8)**
DDIFY	1.3 (5.7)	0.037 (6.3)
Fixed effects		
US—C	11.7	
UK—C	14.3	19.8
JP—C	12.7	18.7
DE—C	14.0	19.6
FR—C	13.3	18.7
IT—C	14.9	20.6
ES--C	13.3	18.8
R squared	0.84	0.85
SE of regression	1.8	1.9
Wald test for exclusion of AGE20 and AGE40	64.6 (0.0)**	43.8 (0.0)**
No of observations	273	234

Table 3.6 – Panel estimation results for real bond yields (1960-1999) – country-specific demographic effects

GLS, Fixed effects, Cross section weights, and White heteroscedasticity adjusted standard errors. * Indicates significant at 90% and ** at 95%. Standard errors in parenthesis.

Independent variables	Coeff	SE	Coeff	SE
US--USAGE20	0.424	(0.061)**		
UK--UKAGE20	-0.277	(0.135)**	-0.230	(0.137)**
JP--JPAGE20	-0.368	(0.232)	-0.396	(0.235)*
DE--DEAGE20	0.161	(0.171)	0.173	(0.173)
FR--FRAGE20	0.836	(0.130)**	0.830	(0.131)**
IT--ITAGE20	-1.012	(0.339)**	-0.979	(0.342)**
ES—ESAGE20	-0.051	(0.324)	-0.024	(0.325)
US--USAGE40	-0.374	(0.155)**		
UK--UKAGE40	-1.311	(0.188)**	-1.258	(0.192)**
JP—JPAGE40	-0.533	(0.172)**	-0.553	(0.174)**
DE--DEAGE40	-0.420	(0.142)**	-0.415	(0.144)**
FR--FRAGE40	-0.865	(0.193)**	-0.845	(0.198)**
IT—ITAGE40	0.690	(0.355)**	0.697	(0.356)**
ES—ESAGE40	2.078	(1.023)**	2.007	(1.024)**

Table 3.7 Demographics and real bond yields in the US and international samples (1960-1999)

Independent variables	**US real bond yields**	**International real bond yields**
Constant	12.3 (4.0)**	33.8 (22.6)
AGE20	0.266 (0.052)**	0.487 (0.29)
AGE40	-0.239 (0.084)**	-1.29 (0.4)**
DSR	0.628 (0.1)**	0.504 (0.14)**
TS(-1)	-0.73 (0.125)**	-0.72 (0.23)**
DLCPI(-1)	-109.1 (9.7)**	-116.4 (19.1)**
DDLCPI	-142.6 (10.0)**	-143.3 (15.9)**
DYHP	-197.3 (58.9)**	-99.3 (69.5)
DDIFY	-5.8 (6.4)	-8.67 (15.9)
R^2	0.98	0.96
RSS	4.9	9.1
SE of regression	0.4	0.58
F-statistic (12,39)	102.9 (0.0)**	53.9 (0.0)**
Wald test for exclusion of AGE20 and AGE40	16.2 (0.0)**	44.9 (0.0)**
R-bar-squared	0.97	0.94
Serial correlation (2)	1.8 (0.19)	0.93 (0.41)
Normality	0.045 (0.97)	0.91 (0.63)
Heteroscedasticity	0.06 (0.81)	2.3 (0.14)
Stability (RESET)	1.98 (0.14)	1.5 (0.25)
Stability (Chow forecast)	0.74 (0.67)	0.75 (0.67)
Unit root test	-3.7	-3.5

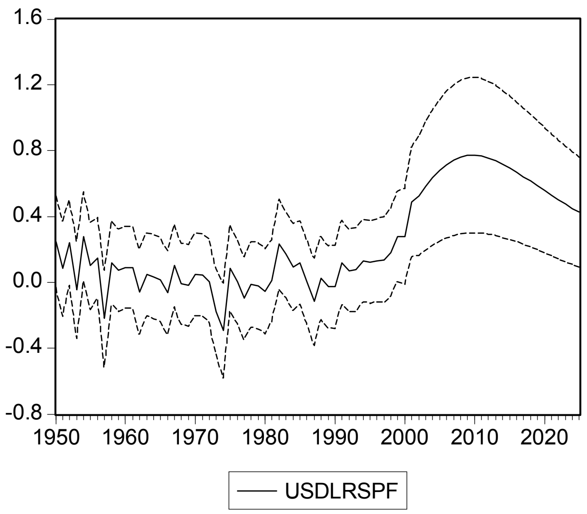
Notes: See Table 3.4. The US equation includes dummies for the years 1982, 1983, 1984 and 1985, while the international equation includes dummies for 1982 1984 and 1986

Table 3.8 – Variants – demographic effects only

Variant	Variable	Panel (fixed effects)	US (US demographics)	International (international demographics)
(1) 1950-90, equity prices	AGE20	0.011 (0.05)**	0.002 (0.015)	-0.006 0.035)
	AGE40	0.029 (0.008)**	0.127 (0.07)**	0.071 (0.066)
(2) 1960-90, bond yields	AGE20	0.286 (0.053)**	0.17 (0.16)	0.84 (0.6)
	AGE40	-0.39 (0.089)**	-0.53 (0.72)	-1.87 (0.66)**
(3) Real return on equity	AGE20	1.85 (0.5)**	-0.029 (1.02)	2.6 (1.96)
	AGE40	3.5 (0.089)**	11.4 (2.9)**	2.9 (1.9)
(4) Lagged dividend yield excluded	AGE20	0.013 (0.005)**	0.019 (0.009)**	0.018 (0.018)
	AGE40	0.014 (0.007)**	0.036 (0.021)*	0.031 (0.017)*
(5) Capital productivity growth replacing GDP growth	AGE20	0.014**	0.015	0.0
	AGE40	0.024**	0.085**	0.069**
(6) AGE65 included for equities	AGE20	0.029 (0.006)**	-0.027 (0.02)	-0.011 (0.029)
	AGE40	0.037 (0.009)**	0.10 (0.028)**	0.071 (0.036)**
	AGE65	0.016 (0.0097)	0.064 (0.046)	0.0098 (0.057)
(7) AGE65 included for equities without dividend yield	AGE20	0.012 (0.005)**	0.031 (0.011)**	0.072 (0.017)**
	AGE40	0.014 (0.007)**	0.076 (0.03)**	0.083 (0.035)**
	AGE65	0.001 (0.001)	-0.057 (0.057)*	-0.075 (0.045)*
(8) AGE65 included for bonds	AGE20	0.28 (0.04)**	-0.7 (0.43)	0.84 (0.71)
	AGE40	-0.43 (0.073)**	-2.35 (1.06)**	-1.86 (1.3)
	AGE65	-0.19 (0.08)**	1.72 (0.8)**	-0.02 (1.6)

Chart 2: Projected asset prices for equations excluding AGE65

Equities



Bonds

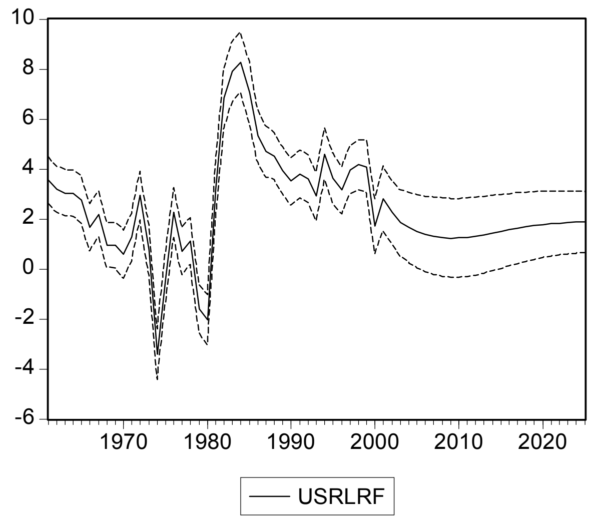
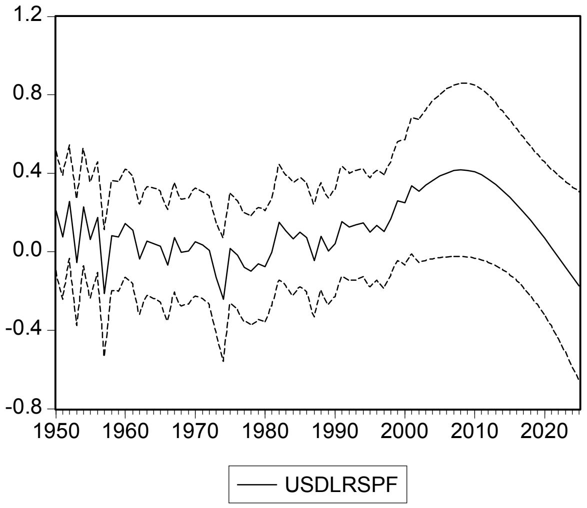


Chart 3: Projected asset prices for equations including AGE65

Equities



Bonds