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ABSTRACT

We examine the implications of persistent low real interest rates and wage growth rates on individuals nearing retirement. We begin by reviewing the concept of r star – the long-term real, safe interest rate that is neither expansionary nor contractionary – and presenting recent estimates suggesting that this value has declined. We then examine the implications of low returns and low wage growth for individuals currently aged 45 and 55. We find that low returns and low wage growth have substantial welfare effects, with compensating variations that are often in the hundreds of thousands of dollars. Low returns increase optimal Social Security claiming ages and the marginal benefit of working longer, while low wage growth decreases the marginal benefit of working longer. Low economy-wide wage growth has a much larger welfare effect than low individual wage growth due to wage indexation of the initial benefit and the progressivity of the Social Security benefit formula. When individual wage growth alone is low, wage indexation is unchanged, and the progressivity of the benefit formula provides insurance. When economy-wide wage growth is low, wage indexation is less generous and there is no insurance benefit from progressivity as average wages fall along with individual wages.

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I. Introduction

Real interest rates have remained persistently low despite an economic recovery that began in June 2009. Yields on 10- and 20-year Treasury Inflation Protected Securities (TIPS) have averaged less than 1 percent since the start of 2010.[1] The macroeconomics literature has attempted to explain this phenomenon via a concept called the natural rate of interest, or "r star." R star is the real, safe short-term interest rate that is neither expansionary nor contractionary and neutral with respect to inflation; it is important for those setting monetary policy as it indicates whether current real interest rates are expansionary or contractionary. The natural rate of interest is not directly observable but can be estimated by examining actual real short-term interest rates, the acceleration or deceleration of inflation, and the widening or narrowing of the difference between actual and estimated potential aggregate output (i.e. the output gap). Recent estimates of this parameter suggest that r star has declined considerably since 2000 and has been close to zero since 2008 (Laubach and Williams 2003; 2015). A related concept is the growth rate of potential output. The macroeconomic models used to estimate r star also suggest that the growth rate of potential output has fallen over the past 10 years. Persistently low economic growth translates into persistently low real wage growth.

These macroeconomic shifts have important implications for retirement planning and security. Two key inputs into any retirement plan are future rates of return on retirement assets and future wage growth rates. Estimates of r star are natural candidates for future, real safe rates of return and provide a more defensible basis for assumptions in a life cycle plan than current real interest rates. In this paper, we use a life cycle model to explore how shifts in r star and economy-wide real wage growth affect the retirement plans and well-being of individuals in their

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[1] See https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=realyieldAll

40s and 50s today. We find that low real interest rates increase optimal Social Security claiming ages. Low growth (characterized by both low interest rates and low real wage growth) reduces optimal saving rates close to retirement and reduces consumption in retirement. For any exogenous retirement age, it also increases the marginal benefit of working an additional year, suggesting that working longer is part of an optimal response to today's macroeconomic environment.

We further demonstrate that the low economy-wide rate of wage growth has a much stronger adverse effect on retirement well-being than low individual wage growth. Social Security benefits are calculated by applying a progressive benefit formula to the highest 35 years of earnings indexed for economy-wide wage growth. Specifically, earnings prior to age 60 are indexed by dividing by the economy-wide average wage during the year in which they were earned and multiplying by the economy-wide level of wages at age 60. (Earnings after age 60 count at their nominal value.) If individual wage growth is lower than expected, while economy-wide wage growth remains constant, average earnings fall but the indexation of earnings does not change, and the progressive benefit formula provides insurance by ensuring that Social Security benefits are affected less than proportionately. On the other hand, if low individual wage growth reflects low economy-wide wage growth, the individual's position relative to the economy-wide average wage does not change and there is no insurance benefit from the progressive formula. Moreover, wages are indexed to a lower benchmark, which exacerbates the impact of low wage growth on retirement income.

Our analysis is based on a standard life cycle model in which households save to smooth consumption over their lifetime (Friedman 1957; Modigliani 1966). Life cycle models have been used to study a range of retirement behavior. For example, Haan and Prowse (2014) and

Gustman and Steinmeier (2008; 2015) have examined the impact of changes in Social Security or pension claiming rules on consumption and retirement behavior. Most closely related to this paper is work by Horneoff, Maurer, and Mitchell (2018), who examine the impact of persistently low real asset returns on life cycle consumption and retirement behavior. Their model is calibrated to the U.S. economy and shows that low real returns cause individuals to save less in tax-preferred accounts and more in taxable accounts; overall, saving declines. In addition, individuals claim Social Security later. Brohnshtein, Scott, Shoven, and Slavov (2018) do not use a life cycle model but show that working 3-6 months longer, and delaying Social Security over that period, has the same impact on retirement living standards as saving an extra one percent of earnings over 30 years. The closer one is to retirement, and the lower are real asset returns, the greater the relative impact of working longer.

Relative to Horneoff, Maurer, and Mitchell (2018), the contribution of this paper is to explore the implications of low wage growth in conjunction with low interest rates. Low economy-wide wage growth has important implications for retirement given the way it interacts with the Social Security benefit formula. It has a far greater impact than low individual wage growth. In addition, we consider the optimal strategies for individuals who are approaching retirement (aged either 45 or 55) instead of just starting their careers, and we also provide an estimate of the welfare cost of low r star and wage growth. Relative to Brohnshtein, Scott, Shoven, and Slavov (2018), we formally show using a life cycle model that the marginal benefit of additional work increases in a low return environment. This impact is even larger when individuals follow the commonly observed behavior of claiming Social Security upon retirement (see Shoven, Slavov, and Wise 2018) rather than optimizing claiming age. Individuals who make retirement decisions by comparing the marginal benefit of additional work to the marginal cost of effort are likely to work longer.

Our work is also related to the large literature examining the tradeoffs involved in Social Security claiming and documenting the impact of recent low real interest rates on those tradeoffs (e.g., Meyer & Reichenstein, 2010; Munnell & Soto, 2005; Sass, Sun, & Webb, 2007, 2013; Coile, Diamond, Gruber, & Jousten, 2002; Mahaney & Carlson, 2007; Shoven & Slavov, 2014a,b; Kotlikoff, Moeller, and Solman, 2015). Most of these papers use straightforward expected present value calculations rather than life cycle models. The key findings of this literature are that delaying Social Security claiming, often to age 70, substantially increases the expected present value of benefits for important groups such as married primary earners. At historical interest rates, delay does not produce large gains for single men, those with higher than average mortality, or married secondary earners. But when real interest rates are close to zero, some degree of delay becomes actuarially advantageous for most people. Our findings here are consistent with this prior research and shows that low interest rates indeed delay optimal claiming in a life cycle framework with liquidity constraints.

This paper is organized as follows. Section II discusses the macroeconomics literature on r star and its implications for assumed real interest rates and wage growth in retirement planning. Section III presents our life cycle model and calibration. Section IV discusses our results. Section V compares the recommendations of the life cycle model in a low growth scenario with standard financial planning advice. Section VI concludes.

II. Implications of R Star

The natural rate of interest is the real interest rate that would prevail once the impact of temporary shocks to the economy have dissipated. It is the best forecast of what safe rates of return will be over the medium to long-run horizon. The literature that attempts to estimate r star is extensive and is reviewed in Taylor and Wieland (2016) and Laubach and Williams (2015). One of the most important models in this literature is laid out in Laubach and Williams (2003, 2015), who use a multivariate Kalman filtering technique to estimate both the natural rate of interest and the growth rate of potential output. The intuition behind the methodology is that if inflation and the estimated output gap are steady, then observed short-term real interest rates must approximate the natural rate. Such a situation, at least in terms of inflation, has been the case since the Great Recession. On the other hand, if inflation is accelerating as it did in the 1970s, then current interest rates are below the natural rate. If inflation is rapidly decelerating, as it did in the Volcker years, then the natural rate is below the current rate. Laubach and Williams utilize this approach to provide updated quarterly estimates of r star.

Figure 1 shows the Laubach and Williams point estimates of r star from 1980 through the first quarter of 2018. The figure shows that the natural rate fluctuated somewhat above 3 percent in the 1980s, dipped to 2 percent in the mid- 1990s, and recovered to about 3 percent in the 1999-2002 period. It then fell gradually from 2002 to 2008 (reaching about 2 percent), when it plummeted to roughly 0 percent. The natural real rate of interest has shown no sign of recovery since, with the most recent reading (Q1 2018) being close to 0 percent. These estimates are different from the current TIPS rates cited in the introduction to this paper. They are the center of the distribution of future real rates, assuming neutral monetary policy in the long-run.

The safe interest rate going forward is a key input into any lifecycle retirement plan. Certainly, investors can hope for higher investment returns than short-term federal government interest rates, but such returns can only be achieved by investing in risky portfolios. While the expected returns of risky portfolios will exceed r star, such portfolios also increase the likelihood of realizing less than r star. Figure 1 suggests that someone who made retirement plans in 2000 assuming that real safe short-term interest rates would remain around 3 percent should now reassess that assumption and substitute zero or one percent as the best forecast for real, safe interest rates going forward.

The Laubach-Williams approach also generates estimates for the trend rate of growth of real potential output for the U.S. economy. The relevance for retirement planning comes from the fact that average future wage growth is associated, via labor productivity, with the growth rate of the economy. Figure 2 shows the latest Laubach-Williams estimates for the trend rate of growth for potential output. It shows that the growth rate of potential output has fallen from the 3.2 to 3.4 percent range over the period 1980 to 2002, to closer to 2.4 percent for the past two years. The fall in growth rate of potential output was steepest during the Great Recession. Just as with the natural rate of interest, there is no sign of recovery in the rate of growth of potential output. A major contributor to the fall in the rate of growth of potential output is the decline in labor productivity growth, a phenomenon that has been extensively studied in the literature. Baily and Montalbano (2016) provide a review.

While the r star approach is not universally agreed upon, it has sufficient backing that it is worth considering its implications for retirement planning. The purpose of this paper is to determine the optimal response to taking down interest rate and wage growth assumptions mid-career.

III. Model

a. Setup

Consider an individual who starts working life at age $t = 20$ and can live up to age $t = 110$. The individual chooses consumption in each period, $c_t \in \mathbb{R}_{\geq 0}$, as well as an age at which to claim Social Security, t_c. Social Security full retirement age is denoted FRA. Retirement age, t_R, is exogenous; it is defined as first year with no earnings. We assume the earnings test effectively requires that $t_R \leq t_c$ if $t_c < FRA$. That is, individuals who are currently working may not claim before full retirement age.[2] The wage at time t is w_t and the risk-free real interest rate in period t is r_t. The real Social Security benefit received in each period $t \geq t_C$ is

$$b_t(t_C)= b_0(w_0, \dots., w_t) \prod_{k=63}^{t_C}(1 + z_k)$$

where z_k is the growth rate of benefits between period $k - 1$ and k and $b_0(w_0, \dots., w_t)$ is the benefit that would be payable at age 62 based on earnings history $(w_0, \dots., w_t)$. It is based on an application of the Social Security benefit formula to the earnings history at time t. For each year of delay between age 62 and benefit receipt, the benefit grows by z_k. Note that benefits are updated each period to reflect any earnings after claiming.

The probability of surviving to period t is S_t. Note that $S_{111} = 0$. That is, survival beyond 110 is impossible. We assume all assets are invested in actuarially fair annuities, and a \$1 annuity contract pays a gross return of $(1 + r_t^a)$ in period t if and only if the individual is still alive. Since S_t is the unconditional probability of surviving to period t, S_t/S_{t-1} is the probability of surviving to period t conditional on having survived to period $t - 1$. Annuity markets are competitive, so the expected gross payout for the annuity seller, $(1 + r_t^a)S_t/S_{t-1}$,

[2] The earnings test effectively forces individuals who work to delay some fraction (possibly 100 percent) of their benefits depending on the income they earn.

must equal $(1 + r_t)$. Therefore, the period t return on \$1 used to purchase annuities is $(1 + r_t^a) = (1 + r_t)S_{t-1}/S_t$.

We solve the model for individuals who are aged either 44 or 54 in 2019. Starting in this base year, t_0, the individual solves

$$\max_{t_C, c} \sum_{t=t_0}^{110} \left(\frac{1}{1+\rho}\right)^{t-t_0} u(c_t)$$

subject to

$$A_{t+1} = (A_t + y_t - c_t)(1 + r_{t+1}^a)$$

$$y_t = w_t I(t < t_R) + b_t(w_0, \dots, w_t) I(t \geq t_c)$$

$$A_{t_0} \text{ given}$$

$$A_t \geq 0 \; for \; all \; t$$

Here $c = (c_{t_0}, \dots, c_{110})$ is the consumption path, $u(c_t)$ is the utility derived from period t consumption[3], $I(\cdot)$ is an indicator function, A_t is assets carried into period t, and δ is the discount factor. The constraint $A_t \geq 0$ implies that borrowing is not allowed. The individual assumes a deterministic, constant future real interest rate, r, and deterministic future path of wages $(w_{t_0}, \dots, w_{t_R})$. Under the baseline, these future projections are in line with the average of past values for these variables (described in detail in the following section). Under alternative scenarios, we consider lowering the future real interest rate and wage growth and examining how these alter the solution to the model. The initial level of assets, A_{t_0}, is determined by solving the same model for a 20-year-old using a historical series of wages and interest rates (through 2018), combined with the baseline future projections. The 20-year-old is assumed to have perfect foresight over future wages and interest rates. (Even if this assumption is not literally true, this

[3] Unless otherwise noted, we analyze power utility with risk parameter equal to 3.

solution gives us a ballpark figure for initial assets for the age 44 or 54 problem.) We set A_{t_0} to optimal assets at either 44 or 54. Let $V\left(A_{t_0}; r, w, t_R\right)$ be the maximized value of this problem given projected real interest rate r, projected wages $w = (w_{t_0}, \dots, w_{t_R})$, and retirement age t_R.

Social Security benefits are based on the average of the highest 35 years of earnings, indexed for economy-wide wage growth though age 60. (Any additional years of earnings count at their nominal value.) This average, divided by 12 to convert to a monthly rate, is called average indexed monthly earnings (AIME). A progressive benefit formula is applied to AIME to obtain the primary insurance amount (PIA), or the monthly benefit payable at full retirement age. Under the progressive benefit formula, there are two thresholds, or "bend points," that are indexed to the economy-wide average wage. Individuals receive 90 percent of their AIME up to the first bend point ($895 in 2018), 32 percent of any AIME between the first and second bend points ($5,397 in 2018), and 15 percent of any additional AIME. The applicable bend points are taken from the year in which the individual turns 62. We allow earnings after claiming to affect the AIME (assuming they enter into the highest 35 years). Social Security benefits are adjusted based on claiming age. Individuals born in 1960 or later who claim at 62 receive 70 percent of their PIA, and that amount increases with each month of delay.[4] To simplify our calculations, however, we assume claims must take place on birthdates, which allows for 9 possible claiming ages.

Our model makes two important simplifying assumptions. First, there is no uncertainty. We assume that individuals have perfect foresight about the paths of r_t and w_t. The late-career shock to both series from a shift to a low-growth economy is completely unanticipated. A

[4] The adjustment for claims before full retirement age are given here https://www.ssa.gov/planners/retire/1960.html. Benefits delayed beyond full retirement age increase by 8 percent of PIA per year (prorated monthly).

realistic model would incorporate uncertainty period-to-period fluctuations in both series. However, modeling uncertainty about the key macroeconomic shift we consider – in r star and long-term real wage growth – is challenging. Thus, we treat these shifts as one-off surprises: they are completely unanticipated, and once they happen they are expected to be permanent. This simple deterministic model captures the basic intuition behind long-term shifts in interest rates and wage growth, and that is likely how many people approaching retirement today view the recent low-growth environment. Second, there is no labor supply decision or cost of effort. Rather, the individual works full time until an exogenous retirement date. We are still able to derive findings relating to career length by examining the increase in $V\left(A_{t_0}; r, w, t_R\right)$ when t_R increases by one year. This quantity is the marginal benefit from extending working life, which the individual can compare to the cost of effort in the additional year of work.

b. Parameter Choices

Mortality rates come from the cohort mortality tables underlying the intermediate scenario in the Social Security Administration's 2013 Trustee's Report. These mortality tables extend through age 120; however, survival probabilities beyond 110 are small, and we truncate the distribution at 110 by assuming a zero probability of survival to age 111 conditional on attaining age 110. We perform our analysis for stylized single males in the 1965 and 1975 birth cohorts, aged 54 and 44, respectively, in 2019. Full retirement age for both cohorts is 67. Workers are assumed to enter the labor force at age 20 and work full time until retirement. Our baseline retirement age is chosen as 65. However, we perform calculations for alternative retirement ages.

Social security COLAs are based on the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W). We model inflation using this index. From the year a worker turns age 20 through 2018, we use the historical average monthly CPI-W values for the third quarter to calculate a year-over-year inflation rate. For example, a worker born in 1965 (1975) experienced a 2.55% (2.16%) annual growth rate. From 2019 after, CPI-W is assumed to grow at a constant rate, i.e., the forecasted inflation rate. For the base case, we assume forecasted inflation grows at 2.5 percent, in line with the historical average for the 1965 cohort. All monetary amounts are expressed in 2018 dollars.

We construct an age-earnings profile based on the Center for Economic Policy Research's Uniform Current Population Survey (CPS) Extracts. We utilize the 2016 Outgoing Rotation Groups file, which includes the subset of monthly CPS respondents who are asked detailed questions about hours and earnings. This file contains a consistent hourly wage variable (rw_ot), the construction of which is detailed in Schmitt (2003). We multiply this hourly wage variable by 2,000 (roughly the number of hours in a full time working year) to get imputed full time annual earnings for each worker. We divide each worker's full time annual earnings by economy-wide full time annual earnings (i.e., the average value of this variable of all individuals in the dataset). We then calculate average relative annual earnings by age. Since this age-earnings profile is not smooth, particularly at older ages when the sample of workers is small, we smooth it by regressing age-specific average earnings on a 5^{th} order polynomial in age and using the predicted values for this estimation. This procedure gives us predicted full-time earnings at each age relative to economy-wide earnings. The relative age-earnings profile is shown in Figure 3. It suggests that most age-related wage growth occurs early in the average worker's career. At older ages, real earnings growth occurs primarily via economy-wide wage growth.

A worker's nominal wages from the year he turns age 20 through 2016 are modeled as the product of the age-earnings profile and the Social Security average wage index (AWI) for that year. In 2016 and prior, we use the AWI's historical record.[5] For the years 2017 and 2018, we estimate the AWI using the growth rate the worker experienced since starting work. For example, a worker born in 1965 (1975) experienced a 3.50% (3.30%) nominal annual growth rate. Going forward from 2019 through retirement, the worker's wages are the product of the age-earnings profile and a quantity we refer to as the Worker's Wage Index (WWI), which grows at a constant rate, g_{WWI}. Growth in the WWI represents growth in the worker's individual wage, holding age constant. Similarly, the AWI, which is used to compute AIME, is assumed to grow at a constant rate, g_{AWI}, from 2019 and after. Note that the WWI may differ from the AWI. The AWI affects all workers, whereas the WWI reflects a worker's individual expectations. For the base case, we assume that AWI and WWI are equal and grow at 3.5 percent, in line with historical growth for the 1965 cohort. The various low-growth scenarios reduce one or both assumed growth rates to 2.5 percent, the same value as assumed long-term inflation, making real wage growth zero.

IV. Results

a. Reevaluating Saving, Claiming, and Work Decisions

The baseline solution to the model when retirement age is fixed at 65 is shown in Figure 4. For the 1965 cohort, consumption is constant at $49,527, and assets reach a maximum of $404,649 at age 65. The optimal claiming age is 68. Because the liquidity constraint does not bind and actuarially fair annuities are available, the optimal claiming age reflects the age that

[5] This is available from SSA at https://www.ssa.gov/oact/cola/AWI.html

maximizes the expected net present value of Social Security wealth. This age depends only on Social Security rules, mortality, and the real interest rate. Results for the 1975 cohort are similar, with consumption constant at $53,972 and assets reaching a maximum of $445,842 at age 65. The optimal claiming age is again 68.

We consider several alternative scenarios.

1) 1 percent real interest rate
2) 1 percent real interest rate and real discount rate
3) AWI and WWI grow at 2.5 percent (same as inflation)
4) 1 percent real interest rate; AWI and WWI grow at 2.5 percent (same as inflation)
5) 1 percent real interest rate and real discount rate; AWI and WWI grow at 2.5 percent (same as inflation)

Figures 5-9 show the deviation from the baseline for consumption, income, and assets. The one percent real interest rate in scenario 1 increases the optimal claiming age to 70. However, it remains 68 in scenario 3 where the real interest rate remains at the baseline value of 3 percent. In the two scenarios where the interest rate falls but the discount rate remains at 3 percent (scenarios 1 and 4), the profile of consumption is altered in such a way that it falls over the lifetime. In scenario 1, consumption initially increases relative to the baseline but then falls. Thus, saving declines initially but then increases. In scenario 4, consumption declines initially and then continues to decline relative to the baseline. When both the real interest rate and the real discount rate decline in scenarios 2 and 5 (reflecting a shock to both preferences and asset returns), the consumption profile remains flat but lower relative to the baseline. A decline in economy-wide (and individual) wage growth, reflected in scenarios 3-5 reduce both income and consumption relative to the baseline.

We next explore the welfare effects of each of these changes by calculating their compensating variation. Recall that $V(A_{t_0}; r, w, t_R)$ is the maximized value of the life cycle problem at base age t_0 given projected real interest rate r and wages $w = (w_{t_0}, \dots, w_{t_R})$. The compensating variation for a change in r and w, to r' and w', is defined as Δ in the following equation:

$$V(A_{t_0}; r, w, t_R) = V(A_{t_0} + \Delta; r', w', t_R)$$

The first three columns of Table 1 indicates the compensating variation at age 55 (for the 1965 birth cohort) and 45 (for the 1975 birth cohort) of the shift from the baseline assumptions in alternative scenarios 1, 3, and 4 described above. (We do not calculate compensating variations for scenarios 2 and 5 because this concept is not well defined when there is a shock to preferences.) For comparison, initial assets for the 1965 cohort are $141,002 and initial assets for the 1975 birth cohort are $19,862. Relative to these initial assets, the compensating variations are large. For a retirement age of 65, the compensating variation for a reduction in the interest rate is more than two-thirds of initial assets for the older cohort almost 5 times initial assets for the younger cohort. The compensating variation for a reduction in real wage growth is around a third of initial assets for the older cohort and more than 6 times initial assets for the younger cohort. Comparing scenarios 1 and 3, a low interest rate has a greater cost to the 1965 birth cohort than low wage growth. However, the relationship is reversed for the 1975 birth cohort assuming a retirement age of 63 or older. This result makes intuitive sense, since the older cohort has less time remaining in the labor market and more initial assets; moreover, the time remaining in the labor market for either cohort is positively related to retirement age. A shock to wages and real interest rates (scenario 4) has a compensating variation that is greater than the sum of the compensating variations for each of the shocks individually.

Table 1 assumes that retirement date is fixed. To the extent that retirement date is adjustable, working longer can mitigate some of the welfare cost of low growth. Table 2 indicates the wealth equivalent of delaying retirement by an additional year for baseline retirement ages between 62 and 69, and under the alternative scenario with real interest rate r' and real wage vector w'. That is, it is Δ_R from the following equation:

$$V\left(A_{t_0}; r', w', t_R + 1\right) \;=\; V\left(A_{t_0} + \Delta; r', w', t_R\right)$$

It is the compensating variation of being forced to retired at time t_R instead of $t_R + 1$. Our model does not include a cost of effort. But without taking a stand on the functional form for cost of effort, we can state that low interest rates generally increase the benefit of working longer, while low growth rates reduce it. These results suggest that there is a stronger incentive to delay retirement in a low interest rate environment and a weaker incentive in a low wage growth environment.

Table 3 is identical to Table 2 except that the Social Security claiming age is constrained to be equal to the retirement age. Claiming upon retirement is a common behavior observed in the data (see Shoven, Slavov, and Wise 2018). Each cell in the table presents the compensating variation of being forced to both retire and claim at time t_R instead of $t_R + 1$. In this table, the marginal benefit of working longer incorporates any gains or losses from delaying Social Security. The values reported in this table are usually (though not always, due to nonlinearity in the actuarial adjustment) greater than the corresponding values in Table 2 for retirement (claiming) ages that are below the optimal claiming age. The values in Tables 2 and 3 are a direct measure of the value of working longer relative to saving more (having additional wealth).

b. Economy-Wide Wage Growth vs. Individual Wage Growth

The adjustments required in response to a reduction in economy-wide wage growth are substantially larger than the adjustments required in response to a reduction in individual wage growth. In addition to the five alternative scenarios considered above, we consider a sixth and final alternative scenario: reducing g_{WWI} to 2.5 percent (the rate of inflation) while g_{AWI} remains at 3.5 percent. Figure 10 illustrates the deviations of consumption, income, and assets from the baseline under the assumption that the retirement age is fixed at 65. The decline in consumption is smaller relative to scenario 3, which lowered both economy-wide growth (g_{AWI}) and individual wage growth (g_{WWI}) to 2.5 percent. Annual consumption for the 1965 (1975) birth cohort declines by only $1,770 ($4,455) in alternative scenario 6, compared to $2,407 ($5,329) in alternative scenario 3. The milder impact on consumption is reflected in the compensating variations, which are shown in the fourth column of Table 1. Depending on retirement age, the 1965 (1975) birth cohort's compensating variation for a shock to individual wage growth is between 61 and 83 percent (79 and 88 percent) of the compensating variation for a shock to economy-wide wage growth.

This large difference arises from the Social Security benefit formula, and there are two factors driving it. First, when there is a shock to individual wages but not economy-wide wages, there is no change to wage indexation relative to the baseline. That is, the individual's earnings history is indexed to the same economy-wide level. Second, the bend points do not change relative to the baseline, but the individual's AIME is lower relative to them. Thus, the progressivity of the benefit formula provides some insurance against the wage shock. Table 4 summarizes this contrast. The first column of the table shows each worker's AIME and PIA under the baseline; these amounts are expressed in nominal dollars in the year each worker turns 62. The next two columns show the same values under alternative scenarios 3 (low economy-wide and individual wage growth) and 6 (low individual wage growth only). For the 1965 cohort, a shock to economy-wide wages lowers PIA by 6.78 percent, while a shock to individual wages alone lowers PIA by only 1.37 percent. The contrast is even larger for the 1975 birth cohort, which has a longer time remaining in the labor market. The decline in PIA is 15.39 percent when economy-wide wage growth is low, compared to only 4.63 percent when individual wage growth is low.

V. Relationship to Financial Planning Advice

These life cycle model results stand in contrast to standard financial planning advice, which generally holds that lower interest rates require greater saving to meet income targets. The retirement planning process typically starts with retirement goals and ends with a plan for investing and saving. The process can be divided into three general steps. First, a goal for income in retirement is established. Typically, this goal is set as some fraction of preretirement income, e.g. 70% or 80%. The next step calculates the amount of assets needed at retirement to fund this spending goal. Finally, with an assumed rate of interest, a saving plan can be constructed to achieve the target asset level at retirement.

Consider how this planning process is impacted by a change in the real interest rate. First, if wage growth is assumed to be unchanged, the goal for retirement income is also unchanged. The amount of assets needed to fund this goal has unambiguously increased with a lower real rate assumption. Economists would generally look to prices of real annuities to estimate this cost increase. Given our framework, we estimate real annuity prices at age 65 for our stylized retiree as increasing from $15.09 per $1 of income when real rates are 3% to $18.57 per $1 of income when real rates are 1%. That represents a price increase of over 23%.

The baseline financial planning rule of thumb for spending down assets is the "4% rule." The 4% rule prescribes spending for a new retiree to equal 4% of initial retirement assets. Each subsequent year, spending is increased to keep pace with inflation. Based on an analysis of historical returns, investing the assets in a 50/50 bond/stock portfolio has been able to support the 4% rule spending profile (Bengen 1994). The 4% rule suggests $25 are needed for every $1 of retirement income. This is substantially higher than the annuity price for two reasons. First, the 4% rule approach does not benefit from mortality discounting, and in fact often leaves substantial assets to heirs. Second, the 4% rule approach invest in risky assets, and requires the payouts are feasible even under worst-observed market conditions.

However, the financial planning community has also recognized that lower interest rates should translate into lower retirement spending. Blanchett, Fink and Pfau (2013) consider the impact of lower interest rates on "safe portfolio withdrawal rates." The authors state that "This research also shows that a 2.5% real withdrawal rate will result in an estimated 30-year failure rate of 10 percent." If the 4% rule is replaced with the 2.5% rule, the price of $1 income in retirement has now skyrocketed to $40! That represents a 60% increase. They recognize this dramatic increase and suggest clients might want to consider annuity type products: "Few clients will be satisfied spending such a small amount in retirement. It is possible to boost optimal withdrawal rates by incorporating assets that provide a mortality credit and longevity protection."

Finally, lower interest rates mean workers need to save more to achieve any given accumulation goal. For instance, suppose the goal is to accumulate $100,000 after 10 years. With a 3% interest rate, $8,469 in annual saving is required. If interest rates fall to 1%, saving must increase to $9,463 to fund the $100,000 goal. That represents almost a 12% bump up in annual saving.

In contrast, with the life-cycle approach, a change in interest rates is essentially viewed as a change in prices. In this case, the price of later consumption has gone up relative to earlier consumption. Like all price changes, this leads to a wealth effect and a substitution effect. First consider the wealth effect. Since wages are significantly higher than Social Security income, our stylized workers save early so that they can spend more later. The wealth effect of an interest rate decrease should drive our agents to want to spend less in every period. How much less? To gain some intuition, consider a simple model where the goal is to spend equal amounts each year. For our economic agent born in 1965, we estimate they can spend $49,460 per year for life if interest rates are 3%. If interest rates decrease to 1%, the lifetime annual spending that can be supported from savings, wages and Social Security drop to $44,934, a 9% decline.

In addition to the wealth effect, there is also a substitution effect. Prices for late-life consumption significantly increase when interest rates decline. If interest rates change from 3% to 1%, the price of consumption at age 84 relative to consumption at age 54 has increased by over 80%! With this level of price change, we would expect substantial substitution away from late-life consumption. This is exactly what we observe in the life-cycle model. In the baseline case, our agent born in 1965 has arranged things so that their consumption is constant throughout their lifetime at a level of $49,460. As previously described, changing the interest rate to 1% would imply that this person's lifetime wealth would only support constant annual consumption at a level of 44,934. However, as we see in Table 5, this is not the chosen strategy. Instead, the person chooses an initial spending level of $49,526. This is substantially above the constant consumption solution, and in fact is even above the initial spending rate. For the first year, the substitution effect is larger than the wealth effect. If the person survives to their maximum age of 110, the plan is to reduce consumption to $34,346. Early consumption is costly relative to later consumption, so to shift consumption earlier in life, average consumption must fall. In this case, consumption falls to $41,482.

The life cycle model suggests two major differences from the planning approach. First, spending in retirement should not be held constant. Since dollars are needed to be shifted from working years to retirement years, a lower interest rate reduces wealth and should be generally pushing down spending in all years. Moreover, a lower interest rate significantly increases the relative price of consumption during retirement, which also pushes down optimal consumption in retirement. Saving levels is more ambiguous. The life-cycle model would strongly argue against massive increases in saving levels pre-retirement. In addition, there are some situations where initial saving levels would not increase at all. Since the price of current consumption is now relatively low, the substitution effect could outweigh the wealth effect and increase initial consumption thereby decreasing saving levels.

VI. Discussion and Conclusions

The main purpose of the paper has been to examine the consequences of mid-career workers lowering their assumptions regarding real interest rates, wage growth rates or both in the context of a standard life cycle model. We think that this circumstance is relevant to many mid-career Americans who may have chosen their initial assumptions in the 1990s. At that time, safe interest rates were approximately 3 percent. Not only have real interest rates been under 1 percent for a decade now, but one prominent model in the r star literature suggests that future real interest rates over the medium to long run will average between zero and one percent. So, there is good macroeconomic reasons why mid-career workers might be taking down their safe rate of return assumption within their life cycle plan. We investigate the consequences of reducing the real interest rate assumption from 3 percent to 1 percent.

The need to take down the future wage growth assumption could come from either macroeconomic factors (such as the slowdown in the growth rate of average labor productivity) or more microeconomic factors. Figure 3 shows that the average mid-career worker cannot expect real wage increases based on additional experience, unlike a much younger worker. Some mid-career workers undoubtedly have become more pessimistic about their future wage increases and there probably are more of them in a slower growing economy. We investigate two circumstances. The first is where future projected wage growth is reduced both for the individual and also for the economy as a whole. The second is where the newfound pessimism about wage growth applies only to the individual and not to economy-wide average wage growth.

We reach several conclusions. First, reducing the safe rate of return assumption for a mid-career worker is equivalent to a substantial hit to assets. The numbers were shown in Table 1. This wealth effect lowers optimal consumption both in retirement and for the rest of the working career. Second, for the cases where the rate of time preference is unchanged, future consumption becomes more expensive relative to current consumption with the lower real interest rate. This encourages a shift of consumption towards the present, leading to lower saving, at least initially. Third, the optimal age for single men to commence Social Security advances from 68 to 70, when the real safe interest rate changes from 3 to 1 percent. Fourth, the incentive to retire later is increased when interest rates are lower. Finally, all of this is contrary to standard financial advice which often is to save significantly more in the face of lower rates of return. This advice comes from an attempt to maintain the retirement standard of living.   But, maintaining a given standard of living in retirement is not optimal when one is poorer in a lifetime sense and when future consumption has become relatively more expensive.

When mid-career workers lower their assumption about future wage growth, it makes a big difference whether their more pessimistic outlook is for the economy as a whole or just for themselves. If they are only taking down their own outlook, then Social Security provides them with an element of insurance. If their final wage is now forecast to be 20 percent lower than previously, their Social Security benefits will fall far less than 20 percent. This cushions their loss in a compensating variation sense (comparing scenarios 6 and 3 in Table 1) and also cushions the fall in their optimat consumption path. On the other hand, Social Security offers no insurance against slower aggregate wage growth.   In that case, if one's final wage is reduced by 20 percent due to the aggregate slowdown in wage growth, projected Social Security benefits will also fall by roughly 20 percent.   The Social Security replacement rate of final wages will be approximately unchanged.

The consequences of a low return, low wage growth environment on mid-career workers are non-trivial as our compensating variation numbers indicate.   However, financial planners who advocate saving lots more in the face of these circumstances are not giving advice consistent with the optimal plan for a life cycle model of economics.

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Figure 1: Laubach and Williams Estimates of the Natural Real Interest Rate

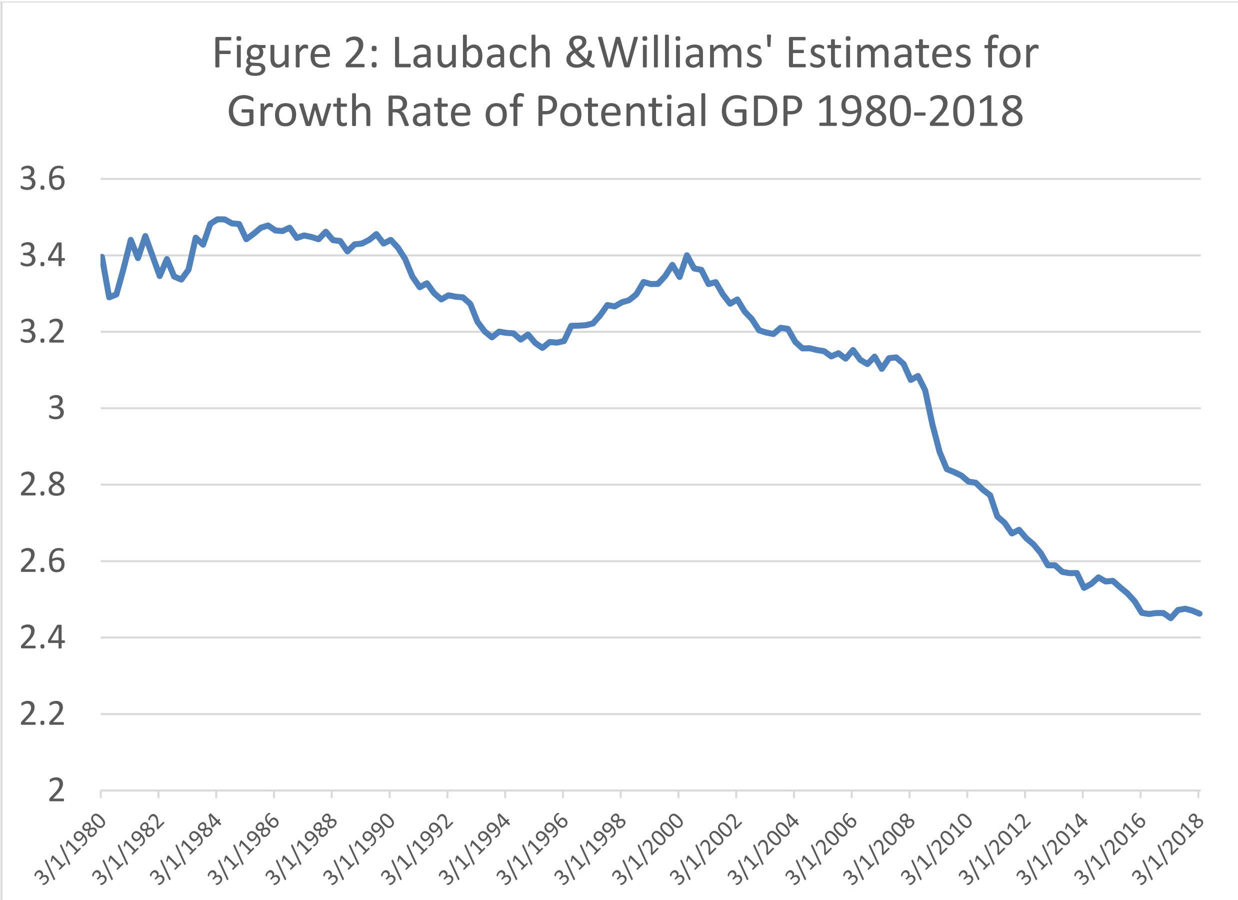
Figure 2: Laubach &Williams' Estimates for Growth Rate of Potential GDP 1980-2018
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Figure 3: Relative Full-Time Earnings by Age

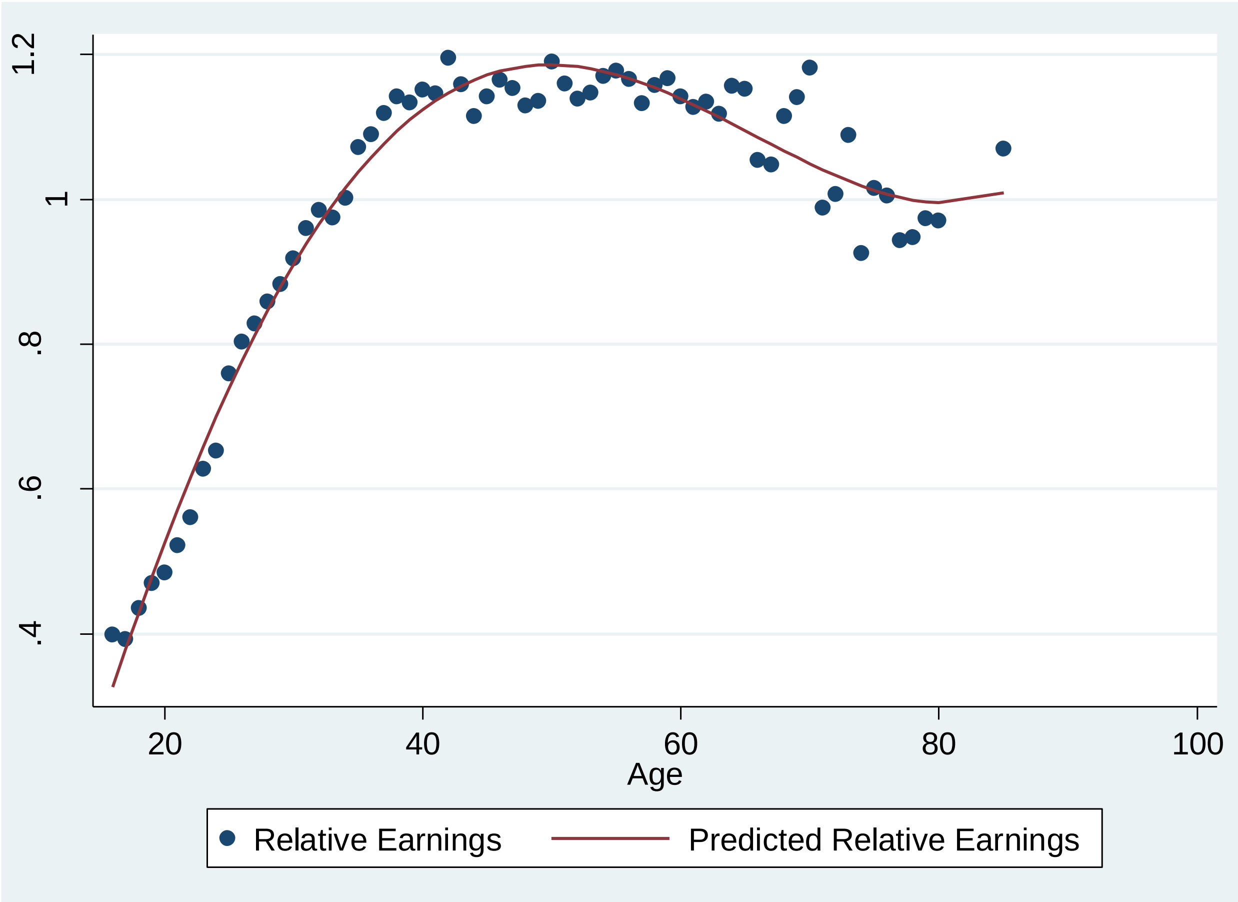

Figure 4: Baseline Paths of Consumption, Income, and Assets

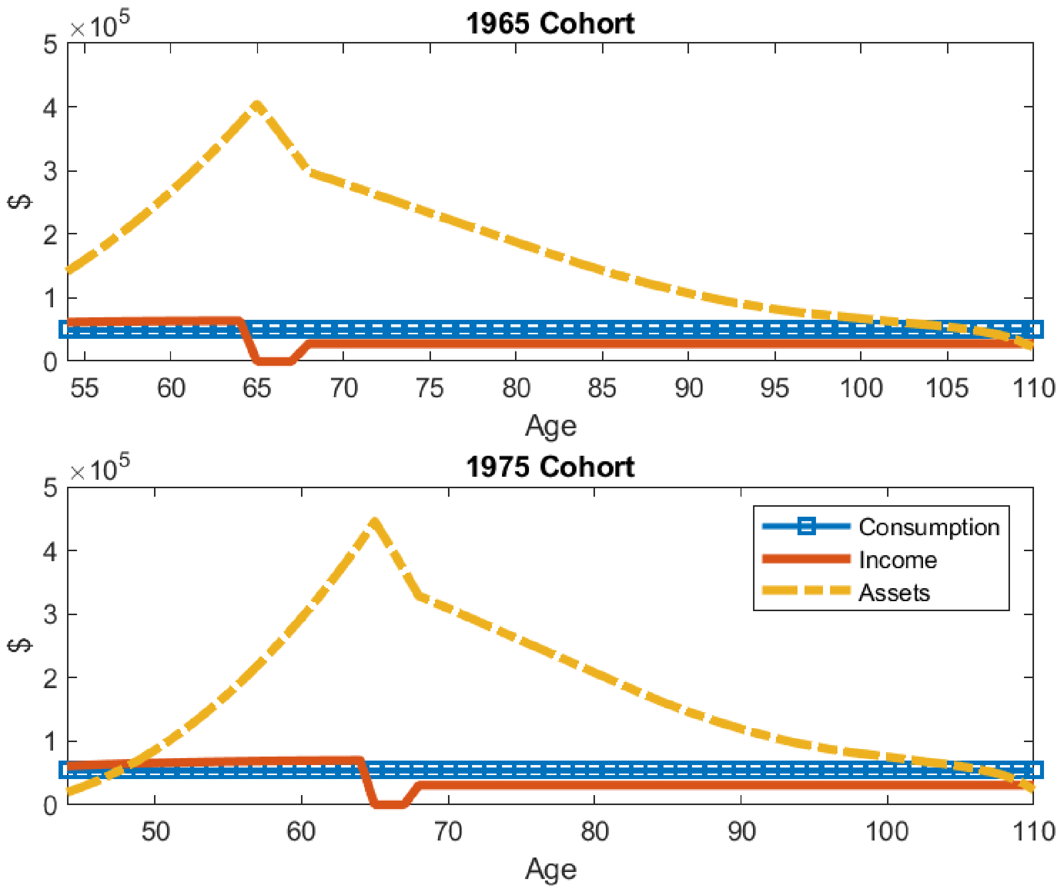

Figure 5: Change from Baseline Paths of Consumption, Income, and Assets (Scenario 1, r = 1%)

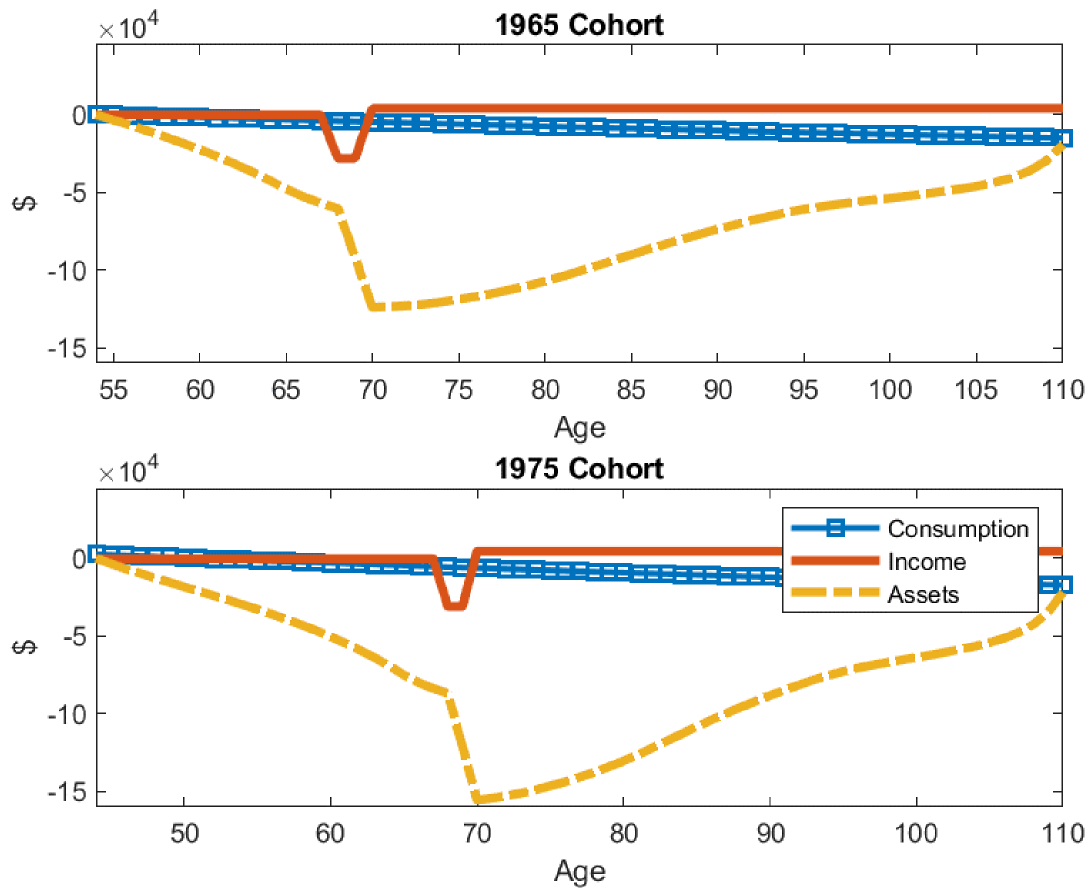

Figure 6: Change from Baseline Paths of Consumption, Income, and Assets (Scenario 2, r = 1%, $\rho = 1\%$)

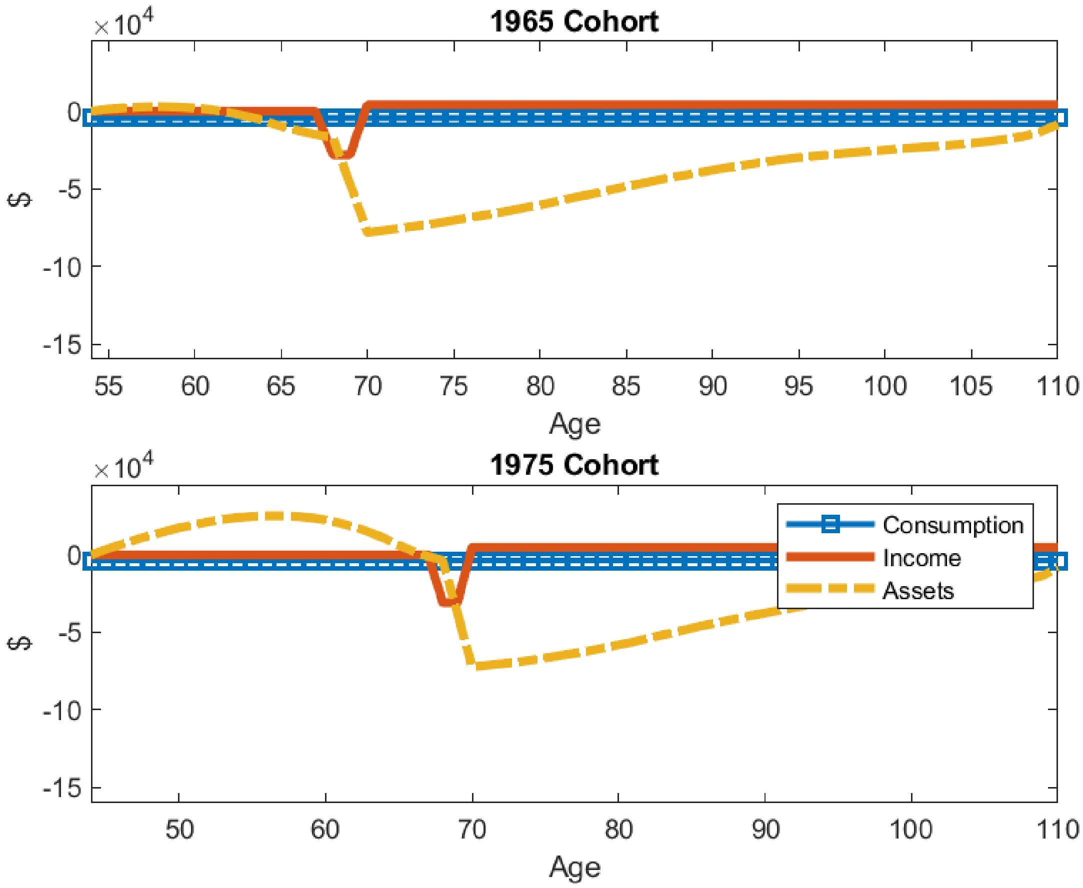

Figure 7: Change from Baseline Paths of Consumption, Income, and Assets (Scenario 3, $g_{AWI} = g_{WWI} = 2.5\%$)

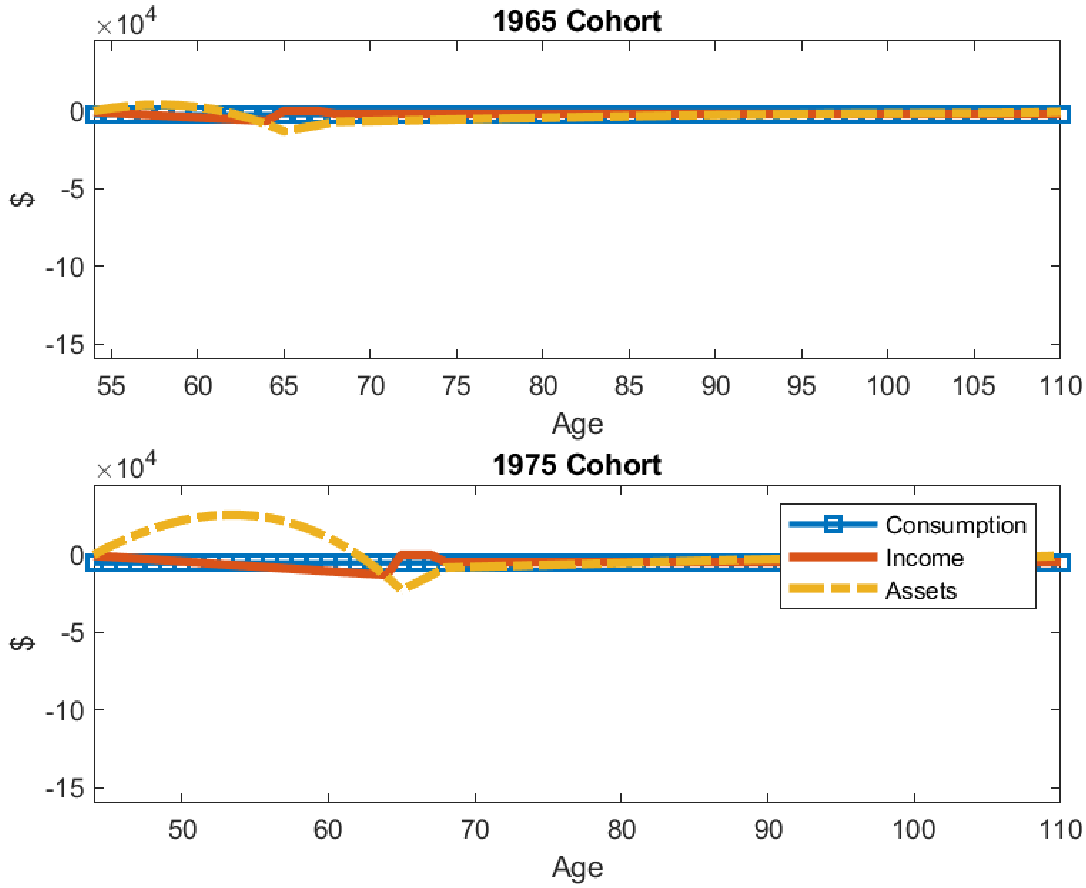

Figure 8: Change from Baseline Paths of Consumption, Income, and Assets (Scenario 4, r = 1%, $g_{AWI} = g_{WWI} = 2.5\%$)

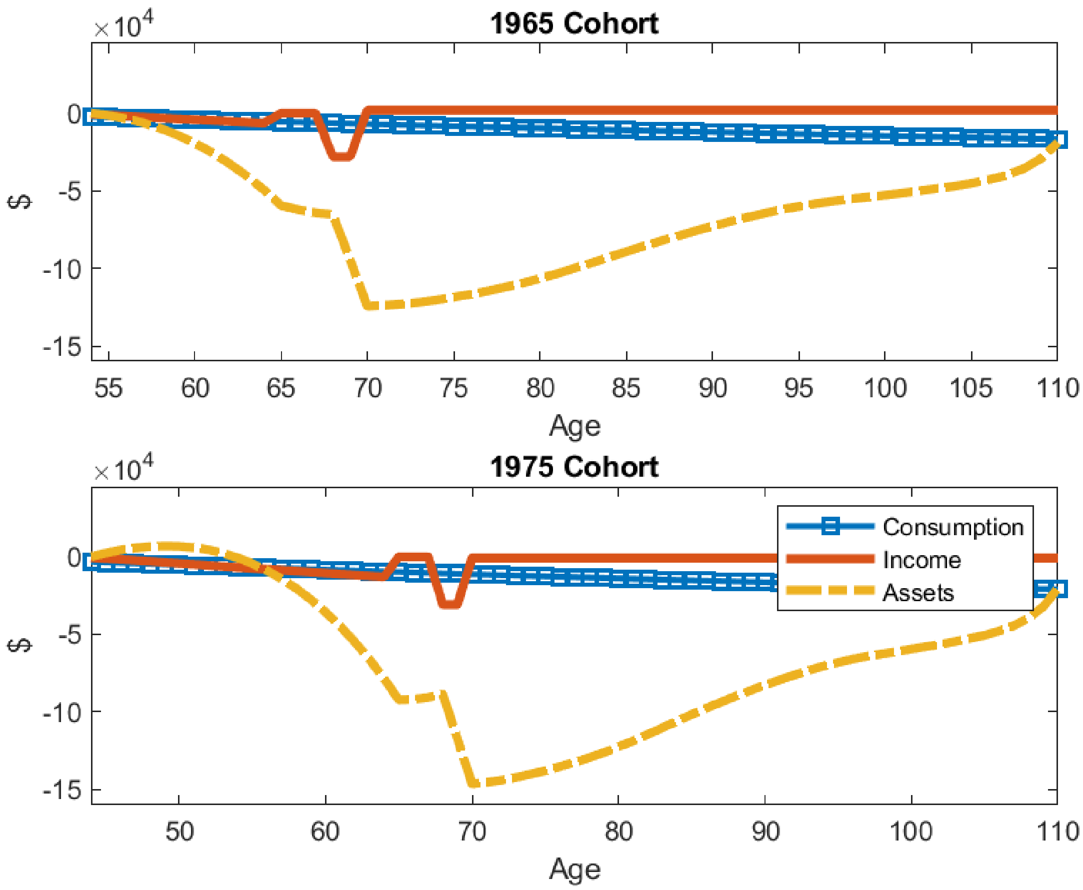

Figure 9: Change from Baseline Paths of Consumption, Income, and Assets (Scenario 5, r = 1%, $\rho = 1\%$ $g_{AWI} = g_{WWI} = 2.5\%$)

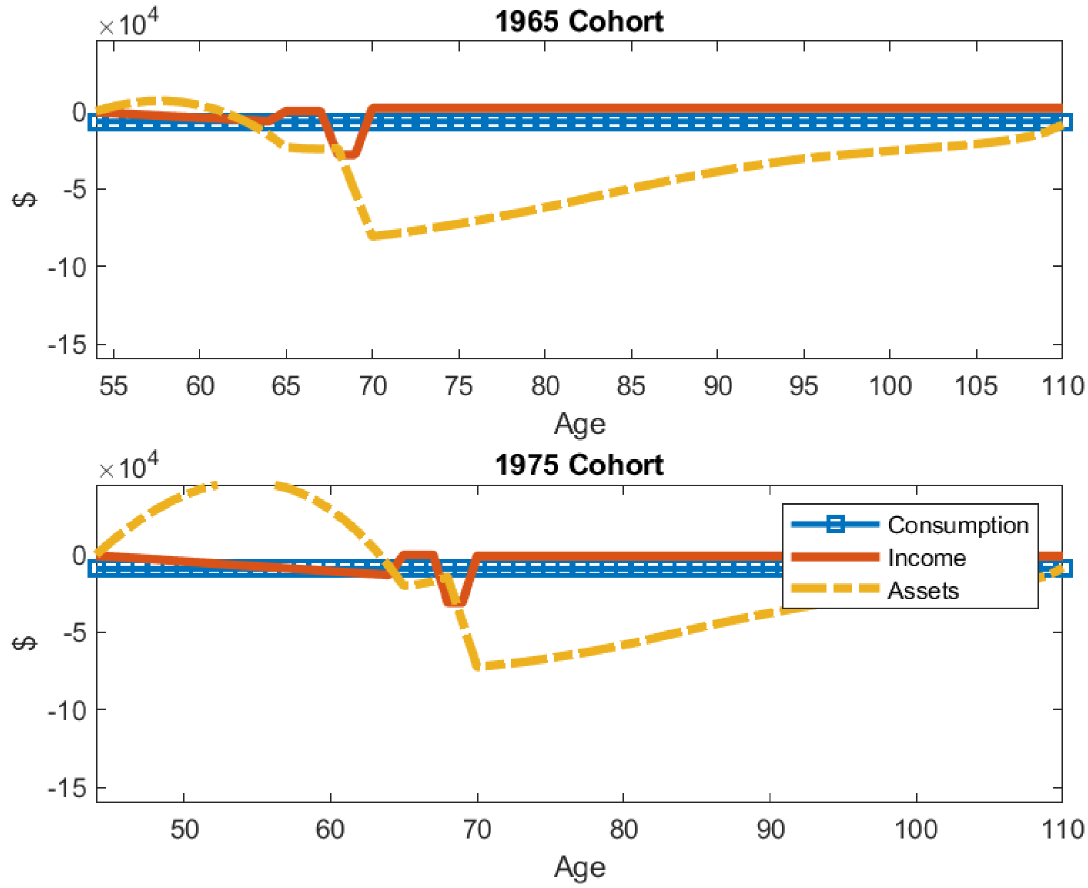

Figure 10: Change from Baseline Paths of Consumption, Income, and Assets (Scenario 6, g_{WWI} = 2.5%)

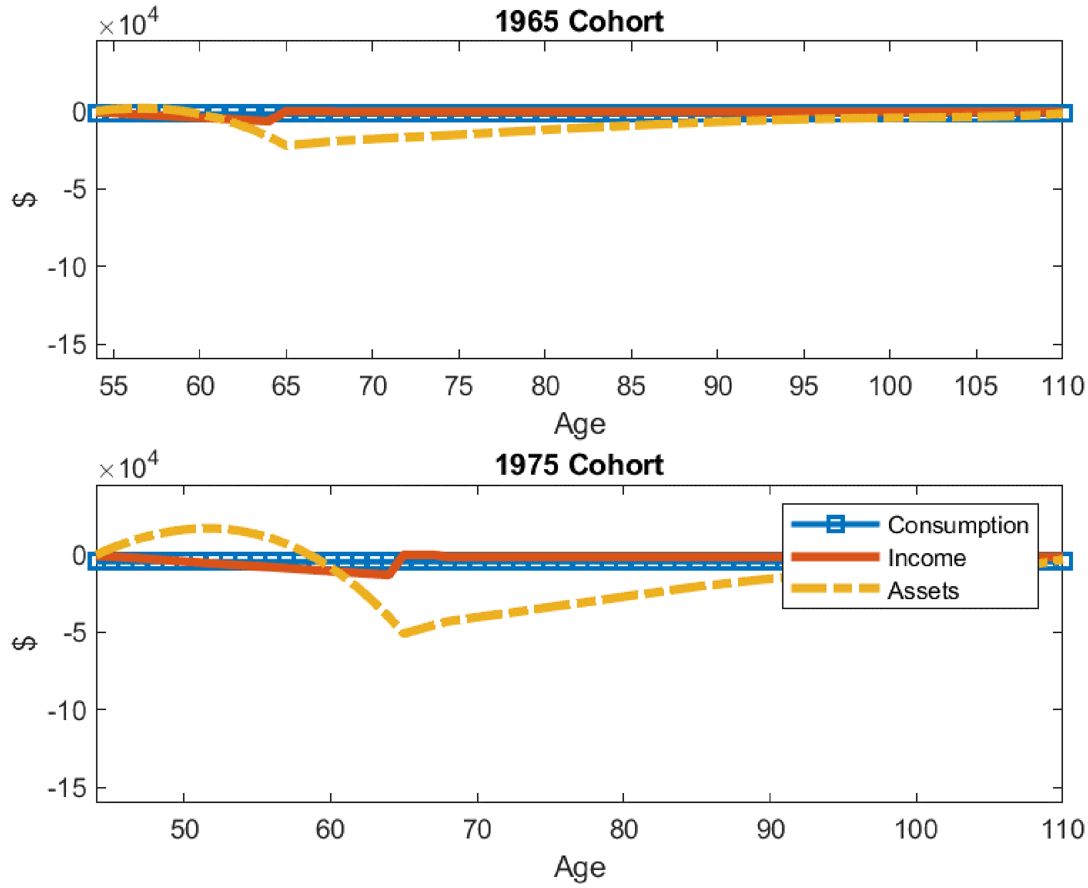

Table 1: Compensating Variation of Low Growth Economy

1965 Birth Cohort				
Retirement Age	Alternate Scenario 1: r = 1%	Alternate Scenario 3: g_AWI = g_WWI = 2.5%	Alternate Scenario 4: r = 1%, g_AWI = G_WWI = 2.5%	Alternate Scenario 6: g_WWI= 2.5%
62	$ 108,362	$ 32,606	$ 151,497	$ 19,813
63	$ 105,457	$ 36,789	$ 153,538	$ 24,150
64	$ 101,715	$ 41,229	$ 155,249	$ 28,821
65	$ 97,341	$ 45,972	$ 156,703	$ 33,796
66	$ 92,415	$ 50,988	$ 158,170	$ 39,042
67	$ 86,966	$ 56,168	$ 159,327	$ 44,531
68	$ 80,702	$ 61,562	$ 160,291	$ 50,156
69	$ 74,073	$ 67,103	$ 161,159	$ 55,983

1975 Birth Cohort				
Retirement Age	Alternate Scenario 1: r = 1%	Alternate Scenario 3: g_AWI = g_WWI = 2.5%	Alternate Scenario 4: r = 1%, g_AWI = G_WWI = 2.5%	Alternate Scenario 6: g_WWI= 2.5%
62	$ 114,199	$ 100,075	$ 258,064	$ 79,081
63	$ 108,284	$ 106,560	$ 261,520	$ 86,010
64	$ 101,999	$ 113,199	$ 265,031	$ 93,094
65	$ 95,437	$ 119,927	$ 268,589	$ 100,267
66	$ 88,502	$ 126,724	$ 271,998	$ 107,554
67	$ 80,853	$ 133,525	$ 275,043	$ 114,844
68	$ 72,850	$ 140,401	$ 277,983	$ 122,209
69	$ 64,549	$ 147,169	$ 280,925	$ 129,391

Baseline assumptions: r = 3% ρ = 3%, g_AWI = g_WWI = 3.5%, inflation = 2.5%
All figures are in 2018 dollars.

Table 2: Wealth Equivalent of Working an Additional Year

1965 Birth Cohort

Retirement Age	Baseline	Alternate Scenario 1: r = 1%	Alternate Scenario 2: r = 1%, rho = 1%	Alternate Scenario 3: g_AWI = g_WWI = 2.5%	Alternate Scenario 4: r = 1%, g_AWI = G_WWI = 2.5%	Alternate Scenario 5: r = 1%, rho = 1%, g_AWI = g_WWI = 2.5%	Alternate Scenario 6: g_WWI= 2.5%
62	$ 48,843	$ 57,945	$ 57,945	$ 44,660	$ 52,998	$ 52,998	$ 44,506
63	$ 47,110	$ 56,863	$ 56,863	$ 42,670	$ 51,410	$ 51,410	$ 42,438
64	$ 45,403	$ 55,861	$ 55,861	$ 40,660	$ 50,033	$ 50,033	$ 40,428
65	$ 43,796	$ 54,935	$ 54,935	$ 38,781	$ 48,543	$ 48,543	$ 38,550
66	$ 42,058	$ 53,759	$ 53,759	$ 36,877	$ 47,152	$ 47,152	$ 36,569
67	$ 40,498	$ 52,876	$ 52,876	$ 35,104	$ 45,649	$ 45,649	$ 34,873
68	$ 38,838	$ 51,751	$ 51,751	$ 33,297	$ 44,254	$ 44,254	$ 33,011
69	$ 37,143	$ 50,609	$ 50,609	$ 31,555	$ 42,868	$ 42,868	$ 31,290

1975 Birth Cohort

Retirement Age	Baseline	Alternate Scenario 1: r = 1%	Alternate Scenario 2: r = 1%, rho = 1%	Alternate Scenario 3: g_AWI = g_WWI = 2.5%	Alternate Scenario 4: r = 1%, g_AWI = G_WWI = 2.5%	Alternate Scenario 5: r = 1%, rho = 1%, g_AWI = g_WWI = 2.5%	Alternate Scenario 6: g_WWI= 2.5%
62	$ 38,466	$ 55,508	$ 55,508	$ 31,981	$ 46,137	$ 46,137	$ 31,536
63	$ 37,189	$ 54,638	$ 54,638	$ 30,549	$ 44,842	$ 44,842	$ 30,105
64	$ 35,884	$ 53,737	$ 53,737	$ 29,156	$ 43,617	$ 43,617	$ 28,711
65	$ 34,594	$ 52,803	$ 52,803	$ 27,797	$ 42,460	$ 42,460	$ 27,308
66	$ 33,319	$ 51,910	$ 51,910	$ 26,518	$ 41,216	$ 41,216	$ 26,028
67	$ 32,104	$ 50,909	$ 50,909	$ 25,228	$ 39,966	$ 39,966	$ 24,739
68	$ 30,769	$ 50,034	$ 50,034	$ 24,000	$ 38,791	$ 38,791	$ 23,587
69	$ 29,541	$ 47,757	$ 48,991	$ 22,696	$ 37,623	$ 37,623	$ 22,351

Baseline assumptions: r = 3%, ρ= 3%, g_AWI = g_WWI = 3.5%, i = 2.5%

All figures are in 2018 dollars.

Table 3: Wealth Equivalent of Working an Additional Year (Claim upon Retirement)

1965 Birth Cohort

Retirement Age	Baseline	Alternate Scenario 1: r = 1%	Alternate Scenario 2: r = 1%, rho = 1%	Alternate Scenario 3: g_AWI = g_WWI = 2.5%	Alternate Scenario 4: r = 1%, g_AWI = G_WWI = 2.5%	Alternate Scenario 5: r = 1%, rho = 1%, g_AWI = g_WWI = 2.5%	Alternate Scenario 6: g_WWI= 2.5%
62	$ 50,026	$ 63,589	$ 63,589	$ 45,856	$ 58,366	$ 58,366	$ 45,631
63	$ 46,992	$ 60,822	$ 60,822	$ 42,463	$ 55,037	$ 55,037	$ 42,403
64	$ 48,334	$ 64,596	$ 64,596	$ 43,417	$ 58,171	$ 58,171	$ 43,295
65	$ 45,004	$ 61,260	$ 61,260	$ 39,954	$ 54,559	$ 54,559	$ 39,686
66	$ 41,781	$ 57,928	$ 57,928	$ 36,554	$ 50,863	$ 50,863	$ 36,328
67	$ 41,444	$ 59,018	$ 59,018	$ 36,014	$ 51,529	$ 51,529	$ 35,818
68	$ 38,192	$ 55,428	$ 55,428	$ 32,695	$ 47,712	$ 47,712	$ 32,302
69	$ 34,923	$ 51,635	$ 51,635	$ 29,403	$ 43,749	$ 43,749	$ 29,048

1975 Birth Cohort

Retirement Age	Baseline	Alternate Scenario 1: r = 1%	Alternate Scenario 2: r = 1%, rho = 1%	Alternate Scenario 3: g_AWI = g_WWI = 2.5%	Alternate Scenario 4: r = 1%, g_AWI = G_WWI = 2.5%	Alternate Scenario 5: r = 1%, rho = 1%, g_AWI = g_WWI = 2.5%	Alternate Scenario 6: g_WWI= 2.5%
62	$ 39,625	$ 61,447	$ 61,447	$ 32,953	$ 51,167	$ 51,167	$ 32,668
63	$ 37,285	$ 58,874	$ 58,874	$ 30,675	$ 48,529	$ 48,529	$ 30,262
64	$ 38,510	$ 62,820	$ 62,820	$ 31,381	$ 51,319	$ 51,319	$ 31,184
65	$ 35,844	$ 59,541	$ 59,541	$ 28,893	$ 48,153	$ 48,153	$ 28,558
66	$ 33,319	$ 56,370	$ 56,370	$ 26,511	$ 45,029	$ 45,029	$ 26,055
67	$ 33,236	$ 57,784	$ 57,784	$ 26,146	$ 45,665	$ 45,665	$ 25,764
68	$ 30,594	$ 54,193	$ 54,193	$ 23,790	$ 42,378	$ 42,378	$ 23,334
69	$ 28,057	$ 49,408	$ 50,638	$ 21,464	$ 38,990	$ 38,990	$ 20,904

Baseline assumptions: r = 3%, ρ= 3%, g_AWI = g_WWI = 3.5%, i = 2.5%

All figures are in 2018 dollars.

Table 4: Impact of Individual vs. Economy-Wide Wage Shock on AIME and PIA

	Baseline	Alternate Scenario 3: g_AWI = g_WWI = 2.5%	Alternate Scenario 6: g_WWI= 2.5%
		1965 Birth Cohort	
AIME	$ 6,243	$ 5,815	$ 6,127
PIA	$ 2,705	$ 2,522	$ 2,668
PIA Change Relative to Baseline		-6.78%	-1.37%
		1975 Birth Cohort	
AIME	$ 8,772	$ 7,415	$ 8,222
PIA	$ 3,801	$ 3,216	$ 3,625
PIA Change Relative to Baseline		-15.39%	-4.63%

Note: AIME and PIA expressed in nominal dollars in year in which worker turns 62.

Table 5: Impact of Real Rate Decline on Saving Rate

1965 Birth Year		
	Base Case	Real Rate = 1%
Maximum Constant Spending Level	$49,528	$44,934
Age 54 consumption	$49,528	$49,822
Average consumption 54-110	$49,528	$41,730
Age 110 consumption	$49,528	$34,551

Baseline assumptions: r = 3% rho = 3%, g = historical average