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Understanding the Impact of the Low Interest Rate Environment on Retirement Security in the United States

A Review of Academic and Practitioner Research

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Understanding the Impact of the Low Interest Rate Environment on Retirement Security in the United States

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Executive summary

After decades of declines in real and nominal interest rates, intensified by the Great Recession, COVID-19, and monetary policy responses, the United States has been and may continue to be in a protracted period of low interest rates. Persistent low interest rates could affect the retirement security of Americans profoundly through direct impacts on investment returns and through impacts on the capacities of governments and the private sector to finance Social Security, pension funds, and other retirement savings mechanisms.

This report examines academic and practitioner research on these topics critically, with an eye toward drawing common themes and conclusions, while reconciling and explaining discrepancies.

We have divided research into three broad topics:

- Studies of interest rates: What caused the decline, and will it persist?
- Studies of how persistent low interest rates could affect the retirement security of individuals, and
- Studies of how persistent low interest rates could affect pension funds, insurance companies, asset management firms, and Social Security

STUDIES OF INTEREST RATES: WHAT CAUSED THE DECLINE, AND WILL IT PERSIST?

Real and nominal interest rates have been declining for decades. The declines were largely unanticipated by economic forecasters and were a global phenomenon. This has important implications for retirement security. First, if past retirement plans and saving decisions were based on expectations that interest rates and asset returns would be higher than they are now, savers may not have accumulated enough wealth to support planned retirement spending. Second, the worldwide decline in real interest rates makes it difficult, or impractically expensive, for savers to offset the impact of the decline by holding a globally diversified portfolio of interest-bearing assets.

Several studies examined the historical decline from the related perspectives of how factors driving economic growth affect interest rates, and how factors affecting desired savings and investment affect interest rates.

Slowing economic growth caused by slowing productivity growth and by slowing labor force growth as a result of population aging has put downward pressure on interest rates by increasing the supply of loanable funds and reducing the demand for investment. In addition, several factors directly affecting desired savings have placed downward pressure on interest rates, including shifting demographics, rising inequality, and an emerging-market savings glut. Factors directly affecting interest rates through desired investment, including a reduction in the price of capital goods relative to labor and other inputs, lower public sector investment, and a rise in the spread between risk-free rates and rates of return on capital from the early 1990s through the early 2010s also have put downward pressure on rates.

Studies do not reach a consensus on how much of the interest rate decline is attributable to each factor but generally agree that the above factors have been at work.

While there is still debate among economists, a consensus has been forming that the low interest rate environment will be persistent. This can be seen in econometric forecasts from professional forecasters, and in projections implied by financial markets. Despite the general agreement, specific projections of long-run equilibrium interest rates vary across studies and are subject to great uncertainty.

STUDIES OF HOW PERSISTENT LOW INTEREST RATES COULD AFFECT THE RETIREMENT SECURITY OF INDIVIDUALS

The main sources of income and resources for U.S. residents age 65 or older are Social Security, income from earnings, pension income, income from financial assets, and real estate. The extent to which older individuals rely on these sources varies greatly by income range. Social Security is the largest income source by far for older individuals with below-median income and remains quite important for those between the median and the 75th percentile. Income from earnings is the most important source for individuals in the top quartile and is relatively important for the next quartile. Income from assets constitutes about 10 percent of total income for those above median income but plays a small role for those below the median.

The potential impact of sustained low interest rates differs by type of income and therefore also differs by income group. Interest rates do not play a direct role in the calculation of Social Security benefits but could affect the ability or willingness of the federal government to pay full benefits, an issue we discuss in the next section. Income from work may not be directly affected by low interest rates but increased work is one possible behavioral response to lower interest rates. Payments from defined contribution plans and other investment accounts will be affected by how persistent low interest rates affect asset returns and risk.

Several quantitative studies have examined the potential impact of persistent low interest rates. The estimated impact differs across studies, ranging from minimal to moderate depending on assumptions about asset accumulation and the treatment of home equity as a source of retirement income.

One study estimated that low interest rates would have very little impact on income replacement rates upon retirement. However, this study assumed that people would (1) accumulate as much wealth in their working years, relative to their income, as previous generations had accumulated in higher interest-rate environments, presumably by saving more or by earning higher returns, and (2) borrow more through reverse mortgages when rates are lower, with no impact on overall financial well-being. (Munnell et al. 2013). By contrast, another study concluded that persistent low interest rates would have a larger negative impact on retirement security. (VanDerhei 2013). This latter study assumed that households would maintain their current saving pattern, which means a lower expected wealth-to-income ratio under the low-rate environment, and also that reverse mortgages are not available (or are not a free resource). The assumptions of VanDerhei (2013) lead to a more pessimistic outcome than those of Munnell et al. (2013).

The studies we reviewed also found that the impact of persistent low interest rates differs across income and age groups. Although low-income households generally have worse retirement security compared to high-income households, they will face much less impact from the low interest rate environment because Social Security accounts for the majority of their retirement income and they have lower financial assets, and thus less risk of reduced investment income as a result of lower investment returns. (This assumes that Social Security payments are not at risk as a result of low interest rates.) Younger generations face a greater challenge in achieving retirement security in the low interest rate environment than older generations because they face a lower expected return on their retirement savings and longer expected retirement periods. Younger generations also face more favorable borrowing terms (e.g. lower rates for mortgages and auto loans) in low interest rate environments, but the studies we reviewed did not evaluate the extent to which lower borrowing costs can mitigate retirement security challenges (aside from the assumption of increased reverse mortgage borrowing in Munnell et al. (2013)).

Studies also illustrated the important roles that behavioral responses, such as increasing savings rates and delaying retirement, can play in improving retirement security in a low return environment. The studies we reviewed suggest that most wage earners can achieve a reasonable replacement rate in a moderate low-return environment if they save between 10 and 15 percent of their income, start saving early, and save consistently throughout their careers (Blanchett, et al. (2018) and Byrne and Reilly (2018)). Although these savings rates are much higher than the savings rates required to achieve the same replacement rate under historical returns (usually in single digits), they can still

be considered in a reasonable range. Studies also have shown that delaying retirement can be a very powerful tool for buffering the impact of low interest rates on retirement adequacy due to the resulting higher expected asset accumulation, higher Social Security benefits, and a shortened expected period of retirement.

Studies using life-cycle models can shed light on how households might change their saving, retirement, work, and investment behavior jointly in response to a low interest rate environment with the goal of maximizing lifetime welfare. Using a life-cycle model calibrated to U.S. data, the simulation in Horneff and Maurer (2018) concludes that households would accumulate less wealth, retire later, and work more in a low-return scenario, and that people with more education would alter their behavior more than people with less education.

STUDIES OF HOW PERSISTENT LOW INTEREST RATES COULD AFFECT PENSION FUNDS, INSURANCE COMPANIES, ASSET MANAGEMENT FIRMS, AND SOCIAL SECURITY

The potential impacts of a persistent low interest rate environment on institutions that provide retirement income and implications for retirement security are summarized in the table below.

POTENTIAL IMPACT OF PERSISTENT LOW INTEREST RATES ON INSTITUTIONS AND IMPLICATIONS FOR RETIREMENT SECURITY

	Assets/ obligations ($ trillion)	Direct impacts of low interest rates	Indirect consequences	Implications for retirement security
Public defined benefit plans	$8.6	Public DB plans have lowered their discount rates only slightly in response to the low interest rate environment, largely due to the unique regulatory environment for public pension plans in the U.S. Low returns will cause challenges in meeting existing pension obligations.	To maintain the high discount rates (assumed returns) public DB plans have increased allocation to equity-like asset classes, leading to greater investment risk. Higher contributions will be required if lower-then-expected returns cause underfunding. More and more public DB plans choose to cut benefits for new members, share risk with plan members, and introduce DB-DC hybrid plans.	In the short to medium term, the impact of low interest rates through public DB plans is expected to be limited because the finances of public DB plans are backed by tax revenue and the benefits are usually statutorily protected. In the long term, pension reforms will generally make public DB plans less generous for future employees and make plan participants bear more risk.
Corporate defined benefit plans	$3.4	The reported liabilities increase because discount rates are tied to market interest rates. Low returns will cause challenges in meeting existing pension obligations.	Reaching for yield and risk taking is discouraged by relatively strict funding requirements and the concern of accounting expense volatility; the allocations to equity have decreased after 2006. Low interest rates may accelerate the transition from DB to DC.	In the short to medium term, impact of low interest rates through corporate DB plans is expected to be limited because the strict regulations on corporate DB plans reduces the likelihood of insolvency and the benefits are protected by the Pension Benefit Guaranty Corporation (PBGC). In the long term, the availability of secure retirement income will be reduced as more corporate plans transition from DB to DC.
Life insurance companies	$2.6 (annuity)	Currently, the declining interest rates only affect the reported liabilities of new policies. A new FASB guidance (effective after 2023) will make discount rates and liabilities more sensitive to interest rate changes. Low returns will cause challenges in meeting existing obligations for annuities and products with guaranteed returns	The incentive for reaching for yield is limited by capital requirements, while evidence exists for reaching for yield within risk-categories of bond investments. Markets for annuities and life insurance products with guaranteed returns are likely to shrink. The overall profitability will be reduced because of lower interest income.	In the short to medium term, impact of low interest rates through life insurers is expected to be limited because the strict capital requirements for insurers reduces the likelihood of insolvency and the shares of annuity and life insurance products in total retirement savings are small. In the long term, the availability of secure retirement income will be reduced if the markets for annuity and guaranteed-return insurance products shrink.
Retirement savings in defined-contribution plans and asset management firms	$15.8 (DC and IRA savings)	Investment returns will become lower. The aggregate size of the impact will depend on the fund's investment options and the extent to which the equity part of the portfolio also suffers from a low-interest-rate environment.	Asset-management firms may seek to improve the risk-return profiles of their portfolios by increasing exposure to illiquid assets, increasing the use of leverage, taking long-short positions, exploiting "investment styles". (These proposed approaches are not common and are subject skepticism)	Lower investment returns will eventually translate into lower retirement income that can be drawn from DC and other personal retirement savings, unless employees and employers contribute more, or take on more risk in their investment portfolio.
Social Security	Considerably greater than $35.2	Lower interest income for Social Security Trust fund		The finances of Social Security are dominated by demographic trends and tax and benefit policies. As the Social Security trust fund shrinks in size, the low interest rates are not expected to have a substantial impact on Social Security.

Defined benefit funds and life insurance companies will face the challenge of meeting their existing obligations of guaranteed benefits with lower expected returns in the prolonged low-interest-rate environment. Public pension funds, corporate pension funds and insurance companies face different regulatory environments and respond to the low-rate environment differently. Public pension funds have the largest exposure to risky assets, partly due to their unique regulatory environment. These institutions face pressure to improve investment returns, often by investing in riskier assets. In the research literature and much of the practitioner literature, this often is referred to as a "search for yield." The term is a slight misnomer because institutions may take on risk to seeking higher capital gains, higher dividends, or other forms of asset return that might not technically be termed "yield." In this report we depart from the practice of several researchers and use the term "search for return" for this behavior rather than "search for yield". According to one paper, these behaviors are more moderate among corporate pension funds and insurers for which risk-taking is discouraged by the regulatory environment.

Although challenges exist, the impacts of low interest rates on retirement security through defined benefit plans and life insurers are expected by researchers and analysts to be limited in the short to medium term. The funding of public defined benefit plans is backed by tax revenue and the benefits are usually statutorily protected. Private sector pension plans in the U.S. face more stringent rules about underfunding, which discourage excessive risk-taking and reduce the risk of insolvency. Moreover, private pension benefits are protected by the Pension Benefit Guaranty Corporation (PBGC). Life insurance companies also face strict regulations that limit risks they may take and thereby limit the risk of insolvency.

One implication of the research we reviewed is that if the low interest rate environment persists into the long run, defined benefit pension funds and life insurers may have no choice but to reduce the guaranteed benefits for new workers and clients. As a result, secure retirement income will become increasingly less available to retirees in the future.

For defined contribution savers, reduced portfolio returns in the low-interest-rate environment will eventually translate into lower retirement income from defined contribution savings, unless they contribute more or take on more risk in their investment portfolio.

Interest rates will have very limited impact on Social Security through the direct mechanism of lower returns on trust fund assets because the trust funds are expected to shrink in size and interest income will become increasingly small. Rather, the main driving forces for Social Security finances over the longer term are demographics and tax policies. To the extent lower interest rates affect economic growth, this could affect tax revenue available for Social Security, but the direct interest-rate impact will be minimal.

1 Motivation and introduction

After decades of declines in real and nominal interest rates, intensified by the Great Recession and COVID-19, and monetary policy responses, the United States has been and may continue to be in a protracted period of low interest rates. The decline of long-term rates is a global phenomenon that was largely unanticipated.

This could affect the retirement security of Americans profoundly, through impacts on investment returns, on the capacities of governments and the private sector to finance Social Security, pension funds, and other retirement savings mechanisms, and on the economy more broadly.

Research by academics and practitioners can shed light on the implications of the prolonged low-interest-rate environment, but research to date has been complicated and mixed. The research has not yet been synthesized in a cohesive, analytical, comparative manner. Our objective in this report is to provide a careful review that clarifies the likely impacts and helps explain why different studies reach seemingly different conclusions.

Researchers, practitioners, and the media use the term "interest rate" to refer to different kinds of rates. One important distinction is between nominal interest rates and real interest rates, which are nominal rates adjusted for actual or expected inflation. Economists make a second distinction, between observable interest rates, which among other things reflect transitory factors such as business cycle conditions and changes in monetary policy, and an unobservable "neutral" interest rate that reflects longer run fundamental factors that affect investment and savings decisions and would prevail if the economy were at full employment with stable inflation and neutral monetary policy (neither contractionary nor expansionary). Economists also refer to this rate as the natural rate or the long-run equilibrium rate.[1] [2] Much of the research we discuss on causes of the decline in interest rates and whether it will persist examines underlying forces affecting the long-run equilibrium rate, which is the primary driver of economic decisions that will affect retirement security. In addition, the forces driving the long-run equilibrium rate will drive observed interest rates over the long run, even if other forces affect short run cyclical swings in observed rates.[3] In this report, when referring to interest rates we use "long run" to mean an interest rate in long run equilibrium, and we use "long term" to refer to an interest rate on a security with longer-term duration, such as a 30-year bond.

We cover three major topics in this literature review, in the following order.

1. Studies of whether the low interest rate environment will persist
2. Studies of how persistent low interest rates could affect the retirement security of *individuals*
3. Studies of how persistent low interest rates could affect *institutions*: pension funds, insurance companies, asset management firms, and Social Security

2 Studies of interest rates: What caused the decline, and will it persist?

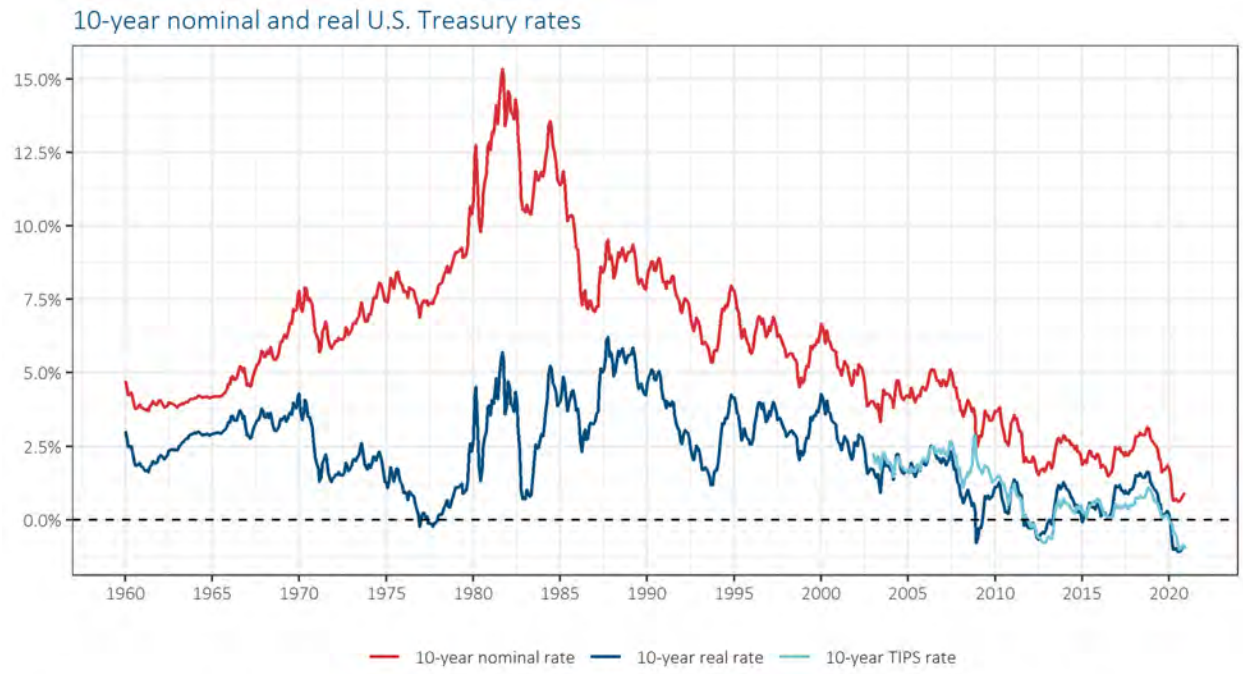
In this section we summarize and synthesize important studies that examine the driving forces underlying the decline in interest rates and discuss the possible future path of interest rates.

2.1 THE DOWNWARD TREND IN INTEREST RATES SINCE THE 1980S

Both nominal and real rates have declined substantially in the past 40 years (Figure 1).[4]

Figure 1

NOMINAL AND REAL INTEREST RATES HAVE BEEN DECLINING FOR 40 YEARS



Note: 10-year real rates are proxied by 10-year nominal treasury rates minus average annual CPI inflation rates of the past five years.
Source: Board of Governors of the Federal Reserve System; U.S. Bureau of Labor Statistics

Declining interest rates are a global phenomenon that was largely unanticipated by economic forecasters. For example, the Council of Economic Advisors (2015) showed that in the 1990s and 2000s rates declined in the U.S., Canada, the U.K., the Euro area, Korea and Japan. They also showed that the Blue Chip "consensus" forecasts of 10-year Treasury rates published in the mid-1990s through 2015 consistently were too high: forecasters did not anticipate that rates would stay so low for so long has important implications for retirement security. First, if past retirement plans and saving decisions were based on expectations that interest rates and asset returns would be higher than they are now, savers may not have accumulated enough wealth to support planned retirement spending. Second, the worldwide decline in real interest rates makes it difficult, if not impossible, to hedge interest rate risk by holding a globally diversified portfolio of interest-bearing assets.

2.2 WHAT CAUSED THE DECLINE IN INTEREST RATES?

Several studies have examined the driving forces underlying the decline in interest rates in the past 40 years. These studies examine fundamental forces that drive interest rates over the long run under the assumption of neutral monetary policy. We focus primarily on the following studies, using short names (see the bibliography for full citations):

- Council of Economic Advisors (CEA) (2015): Long-Term Interest Rates: A Survey
- Rachel and Smith (2015): Secular Drivers of the Global Real Interest Rate
- IMF (2014a): Perspectives on Global Real Interest Rates

We review two frameworks for understanding the commonly discussed driving forces of long run equilibrium real interest rates. The structure of the following analysis generally follows Rachel and Smith (2015) and Council of Economic Advisors (2015) (referred to as CEA (2015) hereafter). Framework 1 focuses on the connection between economic growth and interest rates, and Framework 2 looks at how shifts in saving and investment preferences affect interest rates. The two frameworks are not independent of each other but discussing them separately will help clarify the pathways through which major underlying factors affect interest rates.

2.2.1 FRAMEWORK 1: ECONOMIC GROWTH AND INTEREST RATES

Slowing economic growth is a commonly cited factor behind the decline in real interest rates. How is economic growth connected with real interest rates? Productivity growth and labor force growth are two major components of long-run economic growth, both of which can affect equilibrium interest rates.

Slowing productivity growth can put downward pressure on interest rates through its impact on savings behavior of households and on investment behavior of firms. Lower prospective productivity growth would cause households to lower their expected future income, because income and wages depend heavily on productivity. Facing lower expected future income, households may reduce current consumption and increase savings to boost their potential consumption in retirement, smoothing their consumption between working years and retirement years. The additional savings would increase the supply of loanable funds, creating downward pressure on interest rates. Slower expected productivity growth is also associated with fewer profitable investment opportunities for firms, which decreases the demand for investment and creates downward pressure on interest rates.

Global productivity growth has been slowing over the past 30 years and the U.S is no exception. A broad measure of business sector productivity growth in the U.S. was only 1.25 percent from 2006 to 2015 and 0.5 percent from 2011 to 2015, compared to an average of over 2 percent per year from 1976 to 2005 (Fischer 2016).

Economists differ on the outlook for productivity growth, with pessimistic and optimistic views. Gordon (2012, 2014) argues that long-term structural factors, including the slowing pace of educational attainment, rising inequality, and an increase in public debt will hold back future productivity growth in the U.S. Syverson (2013), Mokyr (2014), Brynjolfsson and McAfee (2014) take a more optimistic view, arguing that productivity growth will eventually pick up, albeit unevenly across the economy, largely as a result of digital technologies.

As an increasing share of the population enters retirement, labor force growth will slow, putting downward pressure on U.S. economic growth. Aaronson et al. (2014) estimates that future labor growth will be reduced by about 0.25 percent by the effect of population aging.

2.2.2 FRAMEWORK 2: SHIFTS IN DESIRED DEMAND FOR INVESTMENTS AND SUPPLY OF SAVINGS

The equilibrium long-run real interest rate equates desired savings and desired investment for any given prospect of long-run economic growth. Rachel and Smith (2015) shows that aggregate global savings and investment as a share of GDP have been relatively stable over the past 30 years as real interest rates declined. This implies that the decline in interest rates was caused by a combination of an increase in desired savings and a decrease in desired investment at any given interest rate.[5]

2.2.2.1 Desired savings

Three factors affecting desired savings in the past 30 years have been widely discussed in the literature: shifting demographics, the rising level of inequality, and the global savings glut.

Shifting demographics. Savings rates vary through an individual's lifetime. The path of income is generally hump-shaped (lower income in early years, higher income in prime working years, and lower income in retirement) but consumption is more stable over the life cycle: individuals of working age tend to have higher savings rates than younger individuals and older individuals. A higher share of working-age people in the population leads to a higher desired aggregate savings rate, putting downward pressure on interest rates, all else equal. The share of working-age people in the global population has risen from about 50 percent in 1970s to about 60 percent in 2010s (Rachel and Smith 2015), driven by factors such as baby-boomers entering the workforce and the fall in the proportion of young dependents.[6]

Rising inequality. Higher-income individuals tend to save a larger proportion of their income than lower-income individuals do. Rising income inequality will lead to a higher desired aggregate savings rate and lower interest rates, all else equal.

Global savings glut. Bernanke (2005) discussed two major international forces that represented shifts in desired savings, particularly in emerging markets. First, many Asian governments have greatly increased their foreign exchange reserve as a precautionary measure after the Asian financial crisis in 1998. Second, oil producing countries have seen large increases in their savings due to the periods of high oil prices. These forces have increased the global supply of savings and placed downward pressure on global interest rates. Bernanke (2015) suggests a mixed outlook for the emerging-market savings glut, depending upon the country, while the IMF forecast (IMF 2014a) suggests the emerging-market savings glut will unwind very gradually in the near future.

2.2.2.2 Desired investment

Three major trends have affected interest rates through their impact on desired investment: a decline in the price of capital goods relative to other business inputs such as labor, lower public sector investment, and a rise in risk-premia between risk-free rates and returns on capital.

A fall in the relative price of capital goods. The relative price of capital goods has declined by about 30 percent in the past 40 years (Eichengreen 2015). The drop in the relative price of capital can affect total investment in two opposing ways: cheaper capital lowers the costs of investment projects reducing investment as a share of nominal GDP, while low costs encourage firms to increase real investment. Economic theory suggests that the net effect depends on the extent to which firms will substitute capital for labor in response to the declining relative price of capital. Empirical research suggests that capital investments are relatively inelastic with respect to the relative price of capital (IMF 2014a; Thwaites 2015), meaning the fall in the relative price of capital goods will lead to smaller nominal amount of investment at any given interest rate, pushing the equilibrium interest rate downward.

Lower public sector investment. According to IMF (2014b), public investment as a share of global GDP has been declining since the 1980s, resulting in about a 1 percentage point decrease in the global investment-to-GDP ratio between 1980 and 2007.[7] Although public investment in emerging economies picked up significantly after the Great Recession, the declining trend of public investment in advanced economies has continued. Rachel and Smith (2015) deemed the decline of public sector investment to be a secular trend but believe it has placed and will place relatively little downward pressure on real interest rates.

Rise in spread between risk-free rate and the cost of capital. Our discussion has focused on risk-free interest rates in long-run equilibrium. However, business investment decisions depend upon the expected rate of return on capital, which reflects the risk of these investments and is related to the risk-free rate through a spread, or risk premium.

Changes in this spread can affect the relationship between risk-free interest rates and desired investment. All else equal, if the required spread increases by 1 percentage point, then the risk-free rate will need to decrease by 1 percentage point to retain the same level of return on capital and thus maintain the same level of desired investment.[8] (In the long run, all else is not equal: a lower risk-free rate would lead to lower desired savings, placing

upward pressure on the risk-free rate that would offset some of this impact.) Based on a weighted measure of global return on capital constructed by IMF (2014a), the global spread between risk-free rates and returns on capital increased by about 1 percent from the early 1990s through the early 2010s, placing downward pressure on equilibrium interest rates.[9] Rachel and Smith (2015) showed that U.S. markets shared the same upward trend in the spread over a similar time period.

2.3 WILL THE LOW INTEREST RATE ENVIRONMENT PERSIST?

The future path of the long-run equilibrium interest rate depends on how the underlying driving forces discussed in the previous section change over time. We summarize and compare studies that use quantitative methods to evaluate these major underlying factors and project the future trend of the equilibrium interest rate. We also review projections of interest rates provided by prominent economic forecasters and implied by financial markets.

2.3.1 QUANTITATIVE STUDIES OF LONG-RUN EQUILIBRIUM INTEREST RATES AND UNDERLYING FACTORS

We review three prominent quantitative studies that cover major factors underlying interest rates and summarize the key results and conclusions in Table 1. The studies generally concluded that major factors causing the decline are likely to persist for the foreseeable future.

Eggertsson et al. (2019) formalize and quantify the "secular stagnation" hypothesis for the low interest rate environment - a hypothesis driven by the idea that the decline may be driven by long-run persistent forces rather than by shorter-run cyclical forces - by constructing a series of overlapping generation models that decomposed the contribution of various factors. (Overlapping generation models can capture the changing behavior of consumers and other economic actors over different phases of their lives, and often are used to examine the dynamics of the macroeconomy over time.) In addition to factors we have discussed above, the models in this paper include government and consumer debt, which tend to push interest rates upward and offset the effects of other secular factors. This study focuses on domestic factors within the U.S. and does not discuss the impact of a global savings glut. Their model suggests the economy may be at a point in which real interest rates need, on average, to be negative to achieve full employment, although policy changes such as a higher inflation target, higher debt relative to GDP, or more generous Social Security benefits could avert this.

In a speech at the Economic Club of New York, Federal Reserve Board vice-chair Stanley Fischer examined the relative importance of contributing factors to low interest rates using alternative-scenario simulations from the US/FRB model, one of the main econometric tools used by the Federal Reserve Board (Fischer 2016). This study estimated the effect of each factor in isolation, as shown in Table 1; because the effects can overlap, we cannot simply add the numbers together to arrive at combined impacts. He concluded that slower U.S. economic growth driven by lower productivity growth and slowing workforce growth was the largest contributor to the decline in interest rates, followed by changing demographics (in isolation), lower investment, and slowing foreign growth. He concludes that many of these factors are likely to persist, meaning that a low-interest-rate environment is likely to persist. However, he also analyzed future policy and behavioral scenarios that could lead to higher interest rates. The scenarios examined include 1) an increase in business-sector investment equal to 1 percent of GDP which caused a 0.3 percent increase in the equilibrium rate, 2) an increase in government spending of 1 percent of GDP (+0.5%), and 3) a tax cut of 1 percent GDP (+0.4%). Thus, he concluded that macroeconomic policies to increase investment or add fiscal stimulus could partly offset forces causing low interest rates to persist.

Rachel and Smith (2015) take a global perspective and provide a comprehensive review of how underlying factors affect interest rates. Rather than running simulations with macroeconomic or econometric models, the authors try to quantify the impact of different factors on interest rates by drawing upon results and estimates from existing literature. Their study employs the framework of the Ramsey model to analyze the relationship between economic growth and interest rates and uses the framework of desired saving and investment to examine how shifts in saving

and investment preferences affect the equilibrium interest rate. (The Ramsey model is one of several frameworks economists use to study the dynamics of economic growth. It involves some simplifying assumptions but produces useful insights.) They assessed the relative importance of the underlying factors by reviewing and synthesizing existing estimates of model parameters and findings regarding determinants of investment and saving preferences.

Rachel and Smith's analysis indicates that slowing economic growth and demographic change can explain the bulk of the decline in real interest rates since the 1980s. They conclude that these underlying factors likely will persist and therefore real interest rates are likely to remain historically low in the foreseeable future, although there is great uncertainty around future trends in the underlying factors.

The first study in Table 1, Eggertsson et al. (2019), estimates much bigger effects for some factors than the other studies. The most prominent difference between it and the other two studies is that it includes government debt in the model, which Eggertsson et al. (2019) estimated to have a very large positive impact on interest rates (+2.11%), requiring, as a technical matter, larger estimates of negative effects for other factors in order to explain the full decline.

Still, that is not a fully satisfying explanation. It can be difficult to determine why estimates differ across studies because they use different analytic and modeling approaches. Differences in methods and results contribute to the great uncertainty in estimates of the long run equilibrium rate and how it is related to underlying factors.

Table 1

COMPARISON OF STUDIES ON WHETHER THE LOW INTEREST RATE ENVIRONMENT WILL PERSIST

		Estimates of the importance of underlying factors					
	Real interest rate change to explain	Slowing economic growth	Demographic change	Weak investment demand	Global saving glut	Other factors	Prospective analysis and projections
Eggertsson et al. (2019)	**4.02%** decrease from 1970 to 2015	**Total: -2.42%** Slower productivity growth: -1.90% Changes in the labor share: -0.52%	**Total: -3.77%** Reduction in fertility: -1.84% Reduction in mortality: - 1.92%	**Total: -0.44%** Fall in relative price of investment goods: -0.44%	Not analyzed	**Total: +2.24%** Increase in government debt: +2.11%; Variation in consumer debt capacity: +0.13%.	While this trend may reverse itself, if current projections for fertility and productivity hold, the natural rate of interest will be low or negative for the foreseeable future. A key determinant of whether interest rates are likely to increase is whether the rate of productivity growth returns to its long-run rate of 2%.
Fischer (2016)	No target Effects of underlying factors are estimated in isolation and are not additive	**-1.20%**	**-0.75%**	**-0.60%**		Slow growth in other countries: **-0.3%**	A variety of factors have been holding down interest rates and may continue to do so for some time. But economic policy can help offset the forces driving down longer-run equilibrium interest rates (higher private investment, higher gov't spending, tax cut).
Rachel and Smith (2015)	**4.5%** decrease in **global rates** since late 1980	**Total: -1%** Slower productivity growth in developed economies: -0.75% Weaker labor supply: -0.25%	**-0.90%**	**Total: -1.4%** Fall in relative price of capital goods: -0.5% Weak public investment: -0.2% Rising risk premium: -0.7%	**-0.25%**	**Total: -0.45%** Higher inequality within countries: -0.45%	The global neutral rate will remain low, perhaps settling at or slightly below 1% in the medium- to long-term. Underlying factors that may drag further: decline in global growth; falling relative price of capital; rising inequality. Underlying factors that may reverse in the future: demographic trend.

2.3.2 PROJECTIONS BY PROMINENT ECONOMIC FORECASTERS AND BY FINANCIAL MARKETS

Two kinds of forecasts suggest that the low interest rate environment will persist for an extended period – those from prominent economic forecasters and those from financial markets. Error! Not a valid bookmark self-reference. summarizes long-term forecasts of interest rates by government agencies, financial firms, and forecasts implied by financial markets as reported in CEA (2015). We focus on forecasts of 10-year Treasury rates to facilitate comparison across forecasts.

- The Federal Open Market Committee (FOMC): The FOMC provides long-run projections of the federal funds rate by Federal Reserve Board members and Federal Reserve Bank presidents. The projected nominal 10-year Treasury rate is constructed by adding an assumed term premium of 1 percent (CEA, 2015) to the median long-run projection of the federal funds rate. We have updated the FOMC numbers to incorporate forecasts prepared in early 2019.
- Congressional Budget Office (CBO): The projection is drawn from the Outlook for the Budget and the Economy 2019. We have updated the CBO numbers to incorporate forecasts prepared in early 2019.
- Blue Chip Economic Indicators: Blue Chip Economic Indicators collects forecasts for major economic variables by more than 50 leading private-sector economists. The median 10-year projection of the 10-year Treasury rate made in 2015 is presented in the table. We have not updated these estimates because we do not have access to proprietary Blue Chip forecasts.
- Forward TIPS and Treasury rates: Forward rates reflect the expected future rates of the bond market participants and other factors such as term premia to account for risk aversion. As such, they are imperfect indicators of what markets expect about future rates but can provide insight. The table presents the 10-year forward rates for 10-year TIPS and 10-year Treasury reported in CEA (2015) based on the market data in 2015. To the extent that the forward rate includes a substantial term premium, market expectations of future Treasury rates at the time of CEA's 2015 paper would have been lower than the shown forward rate. This buttresses the point that markets expected low rates to persist.

The column to focus on in Error! Not a valid bookmark self-reference. is the rightmost column, which gives an estimated forecast of the real 10-year Treasury rate approximately 10 years after the date of the forecast.[10]

There are two ways to gain insight from Error! Not a valid bookmark self-reference.. First, we can compare the forecasted rates to longer-run historical rates. The forecasted 10-year ahead real rates range from 1 percent to 2.4 percent, which are generally below the real rates of the 1980s and 1990s. Second, we can compare the forecasted rates to real rates at the time of the forecasts, which were near zero. Thus, the econometric forecasts and forward market forecasts of real rates suggest a rise over a decade of about 1 to 2.5 percent, with rates remaining below the rates of the 1980s and 1990s (with the caveat above about term premia embedded in forward rates).

Table 2
ECONOMIC AND MARKET FORECASTS OF 10-YEAR-AHEAD RATES

	Projection horizon and base year	Projected 10-year Treasury rate	
		Projected nominal rate	Real rate assuming 2% inflation
FOMC-based	Longer-run from 2019	3.5%*	1.5%
CBO	10-year from 2019	3.8%	1.8%
Blue Chip	10-year from 2015	4.4%	2.4%
Forward TIPS as reported in CEA (2015)	10-year from 2015	-	1.0%
Forward Treasury as reported in CEA (2015)	10-year from 2015	3.1%	1.1%

* Based on the projected federal funds rate of 2.5% and an assumed term premium of 1%.

2.3.3 UNCERTAINTY ABOUT FUTURE LONG-RUN EQUILIBRIUM INTEREST RATES

Forecasts of long-run interest rates have multiple layers of uncertainty. First, it can be difficult to estimate true real interest rates (Laubach and Williams 2003; 2016; Hamilton et al. 2016). Second, long-run trends in underlying factors driving interest rates and their relationships with interest rates are uncertain. Finally, financial markets may overreact to the current environment.

2.3.4 THE IMPACT OF COVID-19 PANDEMIC

The impact of the COVID-19 pandemic on the long-run equilibrium interest rate depends on how the pandemic will affect the underlying driving forces of interest rates discussed above. Economic theories suggest that pandemics can put downward pressure on interest rates through reduced investment opportunities and increased preference to save. There is emerging literature on the possible impact of COVID-19 on the long-run equilibrium interest rate. Jordà et al. (2020), for example, examined the long-term economic consequences of previous severe pandemics and found that pandemics can have long-lasting effects on interest rates: real interest rates decline by nearly 1.5 percent for about 20 years and it takes an additional 20 years for the equilibrium rate to recover. The authors also point out that the impact of COVID-19 on interest rates may be lower than the estimate based on historical events due to at least three factors: (1) deaths caused by COVID-19 relative to the total population could be smaller due to improved medical and public health measures, (2) the health consequence of COVID-19 is disproportionally greater for the elderly, who are less likely to be in the labor force, and (3) massive stimulative fiscal policies in response to COVID-19 will lead to further increases in government debt, which will place upward pressure on interest rates.

2.4 SECTION CONCLUSIONS

The decline in interest rates was not anticipated by forecasters and has been a global phenomenon with nominal and real interest rates in almost all major economies declining over the past four decades. A consensus has been

forming among economists that the low interest rate environment will be persistent, although interest rates may rise moderately as the effects of some short-run factors fade away.

Projections of long-run equilibrium interest rates vary across studies, largely due to differences in analytic approaches and in assessment of the relative importance of underlying factors. Despite the consensus on the likely persistence of the low interest rate environment, these forecasts are subject to great uncertainty.

3 Studies of how persistent low-interest rates could affect the retirement security of individuals

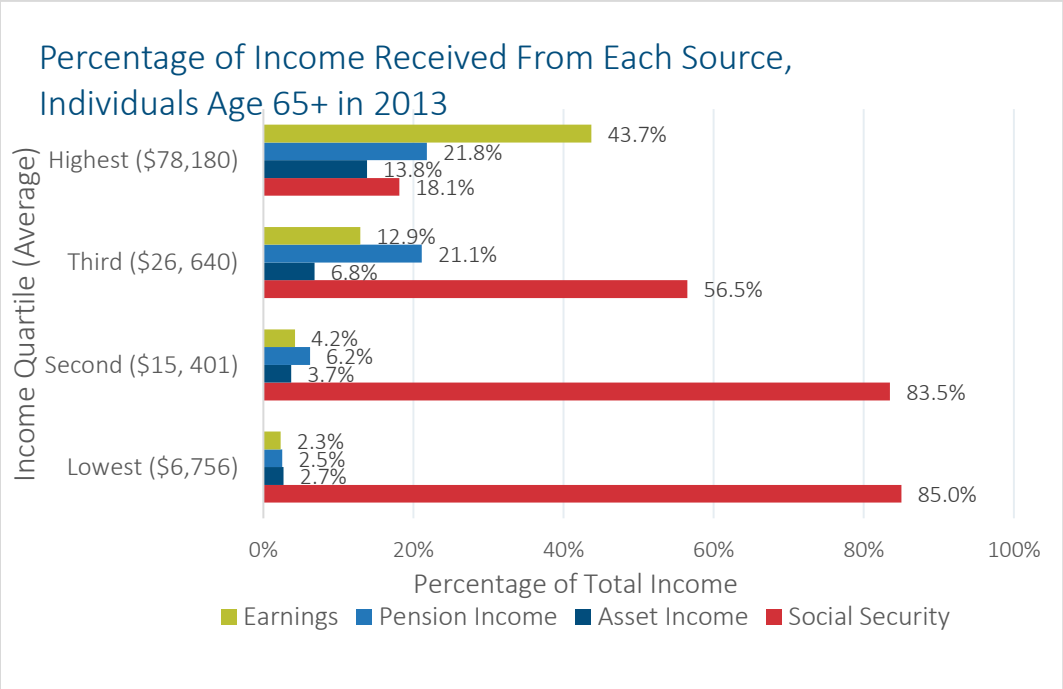
We summarize and compare prominent studies that examine the potential impact of the low interest rate environment on the retirement security of individuals. To facilitate comparison across studies, we first provide an overview of how different sources of retirement income are affected by the low interest rate environment and review important considerations in evaluating retirement security.

3.1 SOURCES OF RETIREMENT INCOME AND HOW THEY ARE AFFECTED BY LOW INTEREST RATES

The main sources of income and resources for U.S. residents age 65 or older are Social Security, income from earnings, pension income, income from financial assets, and real estate. The extent to which older individuals rely on these sources varies greatly by income range. Figure 2 reproduces data from Poterba (2014), which collapses several categories.[11] It shows that Social Security is the largest income source by far for older individuals with below-median income and remains quite important for those between the median and the 75th percentile. Income from earnings is the most important source for individuals in the top quartile and is relatively important for the next quartile. Income from assets constitutes about 10 percent of total income for those above median income but plays a small role for those below the median.

Figure 2

SOCIAL SECURITY IS AN IMPORTANT INCOME SOURCE FOR THREE-QUARTERS OF OLDER AMERICANS



Source: Table 6 in Poterba (2014), based on March 2013 Current Population

In this section we describe the major sources of retirement income. Section 4 will examine the impact of low interest rates on institutions that provide retirement income, through effects on the market value and cash-flow-generating capability of the assets underlying this income.

Social Security is the most-important source of retirement income for the majority of Americans aged 65 or older, and for about a quarter of the older population it accounts for more than 90 percent of income (Dushi et al. 2017). (Different studies examine different subgroups of the older population and use slightly different data sources, so this is not directly comparable to the figure above.) Social Security benefits are based upon lifetime earnings, calculated in a progressive manner so that benefits as a share of pre-retirement earnings (known as "replacement rates") are greater for lower-earning individuals than for higher-earning individuals. Interest rates do not play a direct role in the calculation of benefits but could affect the ability or willingness of the federal government to pay full Social Security benefits, examined later in this report.

The extent to which older people have earnings – i.e., income from work – may be surprising. However, in recent decades labor participation rates among the older population have risen, in part reflecting rising longevity (Poterba 2014).[12]

Payments from defined benefit pensions and annuities generally represent a secure regular source of retirement income backed by the underlying financial assets. When interest rates fall, annuity contracts become more expensive: the same amount will buy lower annuity payouts. The cost of buying the same amount of annuity income has doubled in the past 30 years because of improved longevity and the decline in interest rates. Defined benefit pension and annuity providers may change policies in response to the low interest rate environment to maintain sustainability. An important reason for this is that the current low interest rate environment was largely unexpected, as discussed in section 2. The impact of lower interest rates on institutions is discussed in section 4.

Payments from defined contribution plans, such as 401(k), individual retirement arrangements (IRAs) and similar accounts depend upon the assets in those accounts. The plans are invested in financial assets such as direct investments in bonds and equities and indirect investments through vehicles such as mutual funds and ETFs.

The market values of existing bonds are inversely related to interest rates. Therefore, the current low interest rate environment implies a risk of market-value loss of fixed-income assets if interest rates rise. If low interest rates persist, new bond issues will bear lower interest rates.

Changes in long-run interest rates can affect stock returns through many channels. Over the long run, stock returns reflect the risk-free return plus a risk premium (the anticipated return to risk taking). With lower interest rates, stock returns will be lower unless the risk premium rises. Professional forecasters generally expect low future returns to equity, compared to historical experience.[13] Factors underlying the low-interest rate environment can also affect stock returns indirectly. The anticipated slow productivity growth underlying the low interest rate environment is also a headwind for long-run stock returns: slow productivity growth may lead to lower expected and actual profit growth and in turn cause slower appreciation of market values and slower growth of dividends.

Real estate may play an increasingly important role in retirement security. Housing assets are a more significant form of wealth than financial assets for most households, and mortgages are largely paid-off for individuals close to retirement age. Reverse mortgages are an important tool that can convert housing equity into cash income in retirement and can provide some hedge against declining interest rates: the proportion of home value that can be borrowed through a reverse mortgage is inversely related to the nominal interest rate. As we show below, assumptions about how real estate is used as a source of retirement income can greatly affect the estimated impact of low interest rates on retirement adequacy.

3.2 IMPORTANT CONSIDERATIONS IN EVALUATING RETIREMENT SECURITY

We review three important considerations in evaluating retirement security: (1) different population subgroups, such as age cohorts and income groups, face different situations in terms of retirement planning and preparation, (2) individuals and families may have behavioral responses to shifts in the economic environment that can mitigate

the impact on retirement security, and (3) retirement security can be measured using different methods, each of which has advantages and disadvantages.

3.2.1 DIFFERENCES ACROSS POPULATION SUBGROUPS

Age cohorts. Younger cohorts face greater challenges preparing for retirement than older cohorts. First, younger generations have longer expected lifespans. In the low interest rate environment, the younger generation will need to save for a longer expected retirement period with a lower expected return. Second, defined benefit retirement plans are much less common for the younger cohorts than for Baby Boomers. They will need to rely more upon their own investments and associated investment risk. If they want the secure annual income that defined benefit plans provide, they can purchase annuities, but annuity plans are more expensive to purchase for young people now than they were for Baby Boomers due to increased longevity and lower expected returns - it is nearly twice as expensive to buy a given annuity now as it was 30 years ago.[14] Furthermore, annuity income is more sensitive to changes in interest rates when expected lifespans are longer than when they were shorter. On the other hand, the challenges described above may be mitigated by the lower borrowing costs younger cohorts face in a low interest rate environment.[15] Income groups. The impact of the persistent low interest rate environment differs across income groups. Low-income households are generally affected by persistent low interest rates to a lesser extent than high-income households because a larger share of their retirement income is from Social Security and they generally have lower financial assets. Also, the longer life expectancy of high earners makes their retirement income more sensitive to changes in expected asset returns (Olshansky et al. 2012).

It generally is easier for high-income individuals to mitigate the impact of low interest rates through behavioral changes without making major lifestyle changes: because consumption expenditures of higher-income individuals is a smaller share of income than it is for lower-income individuals, particularly for necessities: it may be easier to add to savings by scaling back consumption of non-necessities rather than by cutting back on necessities or working longer.[16]

Higher income households are also more likely to own more housing that can be converted into retirement income.

3.2.2 BEHAVIORAL FACTORS

Individuals and families may choose to improve their retirement security through changes in savings behavior, housing consumption, and retirement timing in response to shifts in the economic environment, particularly interest rates. These behavioral responses vary across population groups: Low income groups are less likely to own real estate, have less room to increase their savings rate, and may have less flexibility over when to retire.

3.2.3 MEASURING RETIREMENT SECURITY[17]

Three common methods of measuring retirement security are replacement ratios, success or failure rates, and wealth ratios. Each has advantages and disadvantages for measuring retirement security.

Replacement ratios calculate post-retirement income as a percentage of a measure of pre-retirement income and compare this to a target percentage that is deemed to be “adequate.”

- Advantages: The primary advantages of replacement ratios for analysis of retirement income adequacy are that they are easily explained, can be compared over time, and may be used for individuals, groups of individuals or the entire retiree population.

- Disadvantages: However, there is no universally agreed-upon definition or consensus on what constitutes an adequate replacement ratio or on how to adjust for differences in individual circumstances.

Success or failure rates based on personalized planning forecasts, where failure might be defined (for example) of having insufficient funds to meet planned expenditures in some future period.

- Advantages: Adequacy estimates can be individualized for households with a personalized forecast of needs and resources; can incorporate personalized post-retirement risks.

- Disadvantages: Requires substantial individual information. It is an all or nothing measure (success or failure), generally most appropriate in stochastic analysis, in which the probability of success or failure can be estimated.

Wealth ratios calculate wealth relative to the present value of future expenditures after subtracting guaranteed lifetime income such as Social Security.

- Advantages: Wealth ratios can measure retirement adequacy for the entire retirement period, rather than just at the beginning of retirement, and can be adapted to individual circumstances.

- Disadvantages: They are less practical than other measures because measuring wealth and future expenditures requires substantially more information on household finances and expected lifetime expenditure patterns. In addition, results are very sensitive to the choice of discount rate in the calculation of present value of future spending.

None of the studies we examine in detail below uses a wealth-ratio approach.

3.3 STUDIES OF THE IMPACT OF LOW INTEREST RATES ON RETIREMENT SECURITY

We reviewed two types of studies that examined the impact of the low interest rate environment on retirement adequacy. The first type of study examined the question, "How will individuals' retirement security be affected by persistent low interest rates, given current patterns of saving and retirement behavior?" Examples of this type of study include Finke et al. (2013), Munnell et al. (2013), and VanDerhei (2013). The second type of study examined the question, "To achieve retirement adequacy in a low interest rate environment, how should individuals adjust their retirement and saving behavior?" Examples of this type of study include Blanchett et al. (2018) and Byrne and Reilly (2018).

We also reviewed studies that provide empirical evidence on behavioral responses to the low interest rate environment and that propose behavioral changes that can mitigate the impact.

We examine key elements of these studies below. A section appendix includes more-detailed summaries and comparison tables for these studies.

3.3.1 HOW WILL INDIVIDUALS' RETIREMENT SECURITY BE AFFECTED BY PERSISTENT LOW INTEREST RATES, GIVEN CURRENT PATTERNS OF SAVING AND RETIREMENT BEHAVIOR?

The three major studies we reviewed on this topic have reached seemingly different conclusions, which we discuss below.

Finke et al. (2013) used a stochastic model to examine scenarios in which safe intermediate bonds had real returns ranging from 2.6 percent to -1.4 percent, a range of 4 percentage points, and found a large impact from sustained low interest rates: the probability that a 50-50 stocks-bonds portfolio would fail to provide sustainable income at a 4 percent annual withdrawal rate would increase from 6 percent in the baseline interest rate scenario to 33 percent in the low-rate scenario and further to 57 percent in the negative-rate scenario, a range of about 51 percentage points. Put differently, they estimated that a 4 percent withdrawal rate would be sustainable 94 percent of the time

in the baseline scenario, 67 percent of the time in the low-rate scenario, and 43 percent of the time in the negative-rate scenario. These numbers are used as indicators of retirement adequacy or sustainability in Table 3.

VanDerhei (2013) examined the same scenarios stochastically and reached seemingly more optimistic conclusions, estimating that the low-rate scenario would lead to about a 15-percentage-point drop in "retirement readiness" (compared to the 27 percentage-point increase in the savings failure rate in Finke et al. (2013)). The retirement readiness measure in VanDerhei (2013) is an estimate of the percentage of the population that will be at risk of not having retirement income adequate to cover average expenses and uninsured health care costs (including long-term-care costs) during retirement years. For example, in the high-rate scenario, "Early Boomers" would have retirement income sufficient to cover their expenses in 55 percent of simulations, but in the low-rate scenario they would have adequate income in only 40 percent of simulations. The results for "Late Boomers" and "Generation X" were similar to those for "Early Boomers".

The minus 1.4 percent scenario may strike some as unduly low, but it is an inflation-adjusted rate and is consistent with positive but very low nominal rates. It was based on 10-year Treasury Inflation Protected Securities (TIPS) rates at the start of 2013, when the papers were written.

Munnell et al. (2013) examined scenarios in which real interest rates also ranged by 4 percentage points, using a deterministic model applied to households in the Federal Reserve Board's Survey of Consumer Finances. They found that their National Retirement Risk Index, which measures the share of working-age households who are "at risk" of being unable to maintain their pre-retirement standard of living in retirement, was only 3 percentage points higher in the low-rate scenario than in the high-rate scenario, rising from 51 percent to 54 percent. They concluded that higher interest rates would do very little to improve retirement security.

Table 3 summarizes the interest rate scenarios and results for these studies.

Table 3

COMPARISON OF RESULTS FOR THE OVERALL IMPACT OF PERSISTENT LOW INTEREST RATES ON MEASURES OF RETIREMENT ADEQUACY

	Interest rate scenarios (real rates)				Measures of retirement adequacy as defined in the study in different scenarios			
	High	Baseline/ Medium	Low	Very Low	High	Baseline/ Medium	Low	Very Low
Finke et al. (2013)	-	2.6%	0%	-1.4%	-	94%	67%	43%
VanDerhei (2013)*	-	2.6%	0%	-1.4%	-	55%	45%	40%
Munnell et al. (2013)	4%	2.2%	0%	-	49%	47%	46%	

* For early boomers, results for late boomers and Generation X are similar.

Please refer to Table 4 for the definition of retirement income adequacy or sustainability used in Table 3.

3.3.1.1 Differences across studies

How can we reconcile the seemingly different findings of these studies?

Table 4 summarizes differences in important aspects of the studies.

Table 4
SUMMARY OF KEY DIFFERENCES BETWEEN FINKE ET AL. (2013), VANDERHEI (2013) AND MUNNELL ET AL. (2013)

	Measure of retirement adequacy	Sources of retirement income modeled	How interest rates affect retirement income	Does the mode include stochastic elements?
Finke et al. (2013)	Probability of retirement savings not being depleted in 30 years	DC assets (50/50 stock-bond portfolio for results in Table 3)	Investment return in retirement years	Stochastic asset values
VanDerhei (2013)	Probability that retirement income can cover retirement expenses	Social Security DB and annuity DC / Tax deferred savings Housing equity	Investment return in both working and retirement years	Stochastic asset values Stochastic catastrophic retirement/health care expenses
Munnell et al. (2013)	Percentage of households achieving target replacement rate (maintain the safe level of consumption after retirement)	Social Security DB and annuity DC / Tax deferred savings Housing equity	Annuity payout from financial assets Reverse mortgage (inversely related to nominal interest rate)	Deterministic projections

As the table shows, Finke et al. (2013) only includes income from defined contribution assets and thus is relevant primarily for households that will rely primarily on this income source in retirement – typically upper-income households. By contrast, VanDerhei (2013) and Munnell et al. (2013) also include income from Social Security, defined benefit plans, annuities, and the value of housing equity, and take into account the potential for catastrophic retirement health care expenses. Thus, these latter studies are relevant for a much broader swath of the U.S. population. Note that the baseline rate of retirement adequacy or retirement income is much higher in Finke et al. (2013) compared to the other two studies (94 percent compared to 55 percent and 47 percent), which can be largely explained by the difference in their measures. Finke et al. (2013) examines whether a 4 percent withdrawal rate can be sustained without depleting retirement savings. Thus, a withdrawal rate is considered safe as long as assets are available, even if they provide only a minimal standard of living. By contrast, the other studies examine retirement adequacy by comparing retirement income to expense (VanDerhei 2013) and comparing the replacement rate to a target (Munnell et al. 2013).

The VanDerhei (2013) and Munnell et al. (2013) results demonstrate that the potential impact of low interest rates on retirement security is much smaller once retirement income from Social Security, defined benefit plans, and housing equity are taken into account in addition to income from financial assets, given that income from financial assets is extraordinarily interest-rate sensitive.

Two factors may explain the minimal impact of low interest rates found in Munnell et al. (2013) compared to VanDerhei (2013).

First, Munnell et al. (2013) assume that real estate equity held by households can be converted to retirement income through a reverse mortgage. The proportion of real estate value that a household is allowed to borrow is inversely related to the expected borrowing rate, allowing real estate to serve as a partial hedging tool against the low interest rate environment.[18]

Munnell et al. (2013) examined this issue by estimating the separate impacts of (1) lower annuity income resulting from lower interest rates, holding reverse mortgage borrowing constant, and (2) higher annuity income resulting from higher reverse mortgage borrowing allowed by lower rates. They found that about half of the reduction in the retirement security measure caused by moving from the baseline scenario to the zero-interest-rate scenario, holding borrowing constant, is offset by the increased retirement security resulting from higher reverse mortgage proceeds to annuitize. (They found a 2.7 percent increase in their retirement risk index holding reverse mortgage borrowing constant, but only a 1.4 percent increase if they assume that households will take advantage of the opportunity to borrow more.) This implicitly treats additional reverse mortgage borrowing as a free resource even though it reduces the amount that might be available to heirs in an estate.

In comparison, VanDerhei (2013) assumes that the value of housing equity will be converted to retirement savings in the form of a lump-sum distribution once individual defined contribution accounts are depleted, and interest rates have no impact on the amount of housing equity available as a resource in retirement.

The second factor is that Munnell et al. (2013) assume that interest rates and associated investment returns do not affect asset accumulation during household members' working lives. In their simulation model, the projected value of financial assets and housing equity upon retirement is based on the relationship between the wealth-income ratio and age, which they find to be stable over time based upon analysis of the Survey of Consumer Finances (SCF) data from 1983 to 2010. It does not seem safe to us to project the stable wealth-income ratio observed in the past 30 years into the future. If households maintain their current savings rates, they may end up with lower wealth-income ratios at retirement if the low return environment persists. By using a constant wealth-income ratio, the simulation implicitly assumes that households will save more during working years in response to the low return environment to achieve the same expected level of wealth at retirement. The impact of increasing savings rate on retirement readiness will be further discussed below.

3.3.1.2 Impacts on population subgroups

VanDerhei (2013) and Munnell, Webb, and Fraenkel (2013) also examined the impact of low interest rates by population subgroups and both have identified greater impacts on younger cohorts and higher income groups. VanDerhei (2013) found that an important factor influencing the impact of low interest rates on retirement readiness of Generation X is the number of future years of potential savings in a DC plan: those with longer periods ahead in a low interest environment are less likely to achieve retirement adequacy than those with fewer low-interest-rate years ahead. They also found that low interest rates have almost no impact on the retirement readiness for households in the lowest income quartile. Munnell et al. (2013) also shows higher impacts for younger cohorts and high earners, but the difference is small.

3.3.2 TO WHAT EXTENT CAN THE IMPACT OF LOW INTEREST RATES ON RETIREMENT SECURITY BE MITIGATED BY BEHAVIORAL CHANGES?

Studies have illustrated the important roles that behavioral responses, such as increasing savings rates and delaying retirement, can play in improving retirement security in a low return environment. The studies we reviewed suggest that most wage earners can achieve a reasonable replacement rate in a moderate low return environment if they save between 10 and 15 percent of their income, start saving early, and save consistently throughout their careers.[19] Although these savings rates are much higher than the savings rates required to achieve the same replacement rate under historical returns (usually in single digits), they can still be considered in a reasonable range. Studies also have shown that delaying retirement can be a very powerful tool for buffering the impact of low interest rates on retirement adequacy.

Blanchett et al. (2018) estimated the required savings rates for individuals and households to fund a consumption level that smooths consumption immediately after retirement at age 65 and then follows a declining path of retirement spending. The authors found that the optimal savings rates would need to rise by at least two-thirds for

most Americans given persistent low returns. The required savings rate for a 25-year old low-income individual ($25,000 annual income) under its low return scenario is 11.3 percent, compared to the required savings rate of 6.8 percent under the high return scenario based on historical returns, an increase of 66 percent. The percentage increase in the required savings rate under low returns rises for individuals for higher incomes. An individual earning $150,000 a year will need to save about 80 percent more to fully smooth her consumption after retirement in the low return scenario compared to the high return scenario (8.81 percent to 15.9 percent). Even greater increases would be required of people with higher incomes. Presumably this occurs because high earners are more reliant on income from invested assets than are lower earners. Blanchett et al. (2018) used an average real bond return of 2 percent in their low return scenario, which is similar to the medium interest rate scenarios simulated in the three papers discussed in section 3.3. If the 0 percent or negative rates are applied, the required savings rates calculated by their model would be even higher.

Byrne and Reilly (2018) calculated the required savings rates to achieve a 70 percent replacement rate including Social Security for individuals starting to save for retirement from age 25. For a target retirement age of 65, they found the required savings rates for low income groups and high-income groups are 7 percent and 15 percent respectively in their low return scenario, which is broadly consistent with the required savings rates in Blanchett et al. (2018) for similar income groups. However, the results from these two papers cannot be compared in a meaningful way as Byrne and Reilly (2018) did not provide details of their return scenarios and did not calculate the required savings rates in their high return scenario based on historical returns.

Table 5 shows how different interest rate scenarios affect the required savings rate under these two papers.

Table 5

COMPARING RESULTS FOR THE REQUIRED SAVINGS RATE TO ACHIEVE A TARGET

		Required saving rate for a 25-year-old to achieve target replacement rate defined in the study (Retirement age = 65)			Target Replacement Rate (including Social Security)
		High return	Medium return	Low return	
Blanchett et al. (2018)	Low income individual ($25,000)	6.8%	9.0%	11.3%	100%
	High income individual ($150,000)	8.8%	12.1%	15.9%	
Byrne and Reilly (2018)	Low income individual		7%		70%
	High income individual ($127,000)		15%		

Notes:

1. Return scenarios in Blanchett et al. (2018): the average bond return starts at 2% and rises to 4% in the medium scenario, the average real bond return stays at around 2% in the low return scenarios; the bond returns in the high return scenarios are based on historical real bond returns.
2. Return scenarios in Byrne and Reilly (2018): Realized historical returns are applied to older individuals; returns based on forecasted future returns (SSGA's Investment Solution Group) are applied to younger individuals.

3. The 100% replacement rate in Blanchett et al. (2018) is based on the statement in the paper that "the model assumes that the individual seeks to maintain his or her level of after-tax pay during retirement, compared to his or her after-tax income immediately before retirement." The 100% rate is on the after-tax basis. The before-tax replacement rate would be lower than 100% because tax rates will generally become lower after retirement. The model also allows for a 20% probability that the retirees will outlive their savings when determining the required saving rates.
4. It is not clear if the 70% target replacement rate in Byrne and Reilly (2018) is calculated based on final earnings immediately preceding retirement or on the wage-indexed average of life-time earnings usually used in the calculation of Social Security replacement rates.

An important common finding of these two papers is that delaying retirement can be a very powerful tool for buffering the impact of low interest rates on retirement adequacy due to the resulting higher expected asset accumulation, higher Social Security benefits, and a shorter expected period of retirement.

Blanchett et al. (2018) found that for most mid- or low-earning households the impact of the low return scenario can be offset (more than offset for low-earners) by delaying retirement from age 65 to 70. For a couple earning $100,000 annually and starting to save at age 35, postponing retirement from age 65 to age 70 would reduce the required savings rate in the low return environment from 16.8 percent to 9.1 percent, which is even slightly lower than the required savings rate of 10.7 percent for retiring at age 65 assuming the higher historical returns. Byrne and Reilly (2018) demonstrated the power of delaying retirement for improving retirement readiness for those who start saving late in their career. For an individual who starts saving at age 45 and plans to retire at age 65, the expected replacement rate is only 55 percent even assuming a very high savings rate of 20 percent. Delaying retirement to age 70 will allow the individual to achieve a higher replacement rate of about 66 percent with a lower savings rate of 10 percent and increasing the savings rate to 15 percent will further push the expected replacement rate up over 70 percent. Because these “late starters” have a shorter time to accumulate savings, the effects on them of delaying retirement largely come from the increased Social Security benefits.

3.3.3 OTHER STUDIES ON BEHAVIORAL CHANGES IN RESPONSE TO LOW INTEREST RATES

We reviewed additional studies that examine behavioral changes by individuals and households in response to persistent low interest rates or explore actions that can potentially mitigate the impact of low interest rates on retirement security.

3.3.3.1 Life-cycle model for work, retirement, saving, and investing behavior

Horneff and Maurer (2018) examined how persistent low returns will reshape work, retirement, saving, and investment behavior of older persons and how the changes differ across population subgroups using a dynamic theoretical life-cycle model calibrated to U.S. data. They simulate the changes in behavior given a low interest rate of 0 percent in real terms and compare the results with a baseline scenario with a 2 percent real interest rate. The simulation results suggest that with lower interest rates, people accumulate less wealth throughout their life cycle, particularly in the tax-qualified accounts, claim Social Security benefits later, and work more. People close to retirement (55-64 age group) would accumulate about 22 percent less wealth in their 401(k) account on average in the low interest rate scenario compared to the baseline. People tend to delay claiming Social Security by about 1 year and increase weekly hours of work by about 5 percent in response to the low interest rate environment. They also found that the changes in behavior are generally more prominent among well-educated individuals compared to the less-educated individuals.

To the extent the simulation of Horneff and Maurer (2018) is consistent with people’s real-world behavior, their results can shed light on the plausibility of the assumptions and results of other studies examining the impact of low interest rates on retirement security. The simulation predicts that people will earn more labor income by working longer hours and accumulating less wealth in the low interest rate environment, suggesting a lower wealth-to-income ratio when interest rate is low. This result does not support the assumption of fixed wealth-to-income ratios by age used in Munnell et al. (2013). In other words, if people accumulate lower assets in the face of lower interest rates, then the conclusions in Munnell et al. (2013), which assume that they do not, may be too optimistic.

In addition, the life-cycle model used in Horneff and Maurer (2018) assumes that individuals make work, retirement, and saving decisions jointly to maximize their lifetime welfare, providing a good framework to evaluate the welfare implications of the suggested behavioral changes in response to low interest rates, such as increasing savings rates and working more. Their simulation result of lower wealth accumulation in the low interest rate scenario may imply that the reduction in investment earnings caused by the lower returns is so much that it would require very big increases in savings rates and work time to fully offset the effect. Under their modeling framework, saving more and working more reduce total welfare by reducing consumption and leisure time, other things being equal; thus, welfare-maximizing individuals would accept less asset accumulation to avoid steep increases in savings rates and work time. Unfortunately, changes in savings rates are not reported in Horneff and Maurer (2018), preventing further comparison with other studies.

3.3.3.2 Empirical evidence from data after the Great Recession

Fichtner and Seligman (2018) investigate the impacts of the severe asset shock during the Great Recession and the subsequent low interest rate environment on saving, wealth, and asset allocation using Health and Retirement Study (HRS) data from 1992 to 2014. They found the impacts differ across wealth subgroups. Households in the top 10 percent wealth group saw strong increases in their total assets, more than recovering their losses. This group also held higher allocations to stock and mutual funds, and it has increased its proportional allocation overtime. The lowest 25 percent wealth group appears to have relied on home equity to finance their retirement. At the bottom 10 percent of the wealth distribution, home equity drawdowns were nearly complete.

As the "low interest rate period" defined in this paper is 2008 to 2014 which is a relatively short period, their results mainly reflect the impact of the severe asset shock of the Great Recession, rather than the persistent low rate environment. The paper found faster asset recovery and increases in stock holdings for rich households. But the paper's suggestion of considering "wealth management strategies targeting increases in equities" to "add value in a persistent low return environment" should be taken with caution because a large part of the strong performance of the stock market in the post-recession period can be attributed to extremely loose monetary policy. The paper's analysis of the impact on home equity shows that in extreme market conditions disadvantaged households may deplete their home equity very quickly, weakening their ability to tap into home equity as a long-term source of retirement income.

3.3.3.3 Boosting returns through more sophisticated investment strategies

Several analysts, primarily from capital management firms, have argued that some investors may be able to boost returns without increasing risk through more sophisticated portfolio construction strategies.[20] This is a goal of investors whether interest rates are low or high. Even if successful the proposed strategies would be relevant only to a small segment of retirement savers willing to engage in leverage and shorting. Increasing expected return without increasing risk is appropriately subject to skepticism despite the rising popularity of some techniques in the asset management industry. For example, Malkiel (2014) argues that the outperformance of "smart beta" funds can be attributed to taking more risk, or to favorable market conditions when the funds were established, rather than from exploiting an enduring way of boosting returns.

3.4 SECTION CONCLUSIONS

The estimated impact of persistent low interest rates on retirement security differs across studies, ranging from being minimal to moderate depending on assumptions about asset accumulation and the treatment of home equity as a source of retirement income. Low interest rates would have very little impact on replacement rates upon retirement if (1) the wealth-to-income ratio observed in the past 30 years can be maintained in the low-rate environment (that is, if people increase savings or asset returns during their working years), and (2) reverse mortgage borrowing can be increased as a result of lower interest rates with no impact on overall financial well-being, as assumed in Munnell et al. (2013). But if households maintain their current saving pattern, which means a lower expected wealth-to-income ratio under the low-rate environment, and if reverse mortgages are not available

(or are not a free resource), as assumed in VanDerhei (2013), persistent low interest rates would have a larger negative impact on retirement security.

The studies we reviewed also found that the impact of persistent low interest rates differs across income and age groups. Although low-income households generally have worse retirement security compared to high-income households, they will face much less impact from the low interest rate environment because Social Security accounts for the majority of their retirement income and they have lower financial assets, and thus less risk of reduced investment income as a result of lower investment returns. (This assumes that Social Security payments are not at risk as a result of low interest rates, an issue we discuss in the next section.) Younger generations face a greater challenge in achieving retirement security in the low interest rate environment than older generations because they face a lower expected return on their retirement savings and longer expected retirement periods.

Studies also illustrated the important roles that increasing savings rates and delaying retirement can play in improving retirement security in a low return environment. The studies we reviewed suggest that most wage earners can achieve a reasonable replacement rate in a moderate low-return environment with an annual savings rate between 10 percent and 15 percent if they start saving early and save consistently throughout their careers. Although these savings rates are much higher than the savings rates required to achieve the same replacement rate under historical returns (usually in single digits), they can still be considered in a reasonable range. Studies also have shown that delaying retirement can be a very powerful tool for buffering the impact of low interest rates on retirement adequacy due to the resulting higher expected asset accumulation, higher Social Security benefits, and a shortened expected period of retirement.

Studies using life-cycle models can shed light on how households might change their saving, retirement, work, and investment behavior jointly in response to a low interest rate environment with the goal of maximizing lifetime welfare. Using a life-cycle model calibrated to U.S. data, the simulation in Horneff and Maurer (2018) concludes that households would accumulate less wealth, retire later, and work more in a low-return scenario, and that people with more education would alter their behavior more than people with less education.

4 Studies of how persistent low interest rates could affect pension funds, insurance companies, asset management firms, and Social Security

We summarize and synthesize important studies that examine how the persistent low interest rate environment could affect institutions that provide retirement income and how this could affect retirement security.

We discuss the following types of institutions, categorized based on the nature of their liabilities and assets and the different regulatory environments they face.

1. **Defined benefit (DB) pension plans.** Liabilities generally are future income streams that may be wholly or partially guaranteed. Pension contributions are invested in diverse assets. An important consideration in investment decisions is (or should be) ensuring that the cash flow generated by assets can cover benefit obligations when they come due, through asset-liability management (ALM).
2. **Life insurance companies providing annuities.** As with defined benefit pension plans, liabilities generally are guaranteed minimum yield or future income streams. Insurance premiums are invested in assets dominated by bonds, mortgages, and real estate.[21] An important consideration in investment decisions is (or should be) ensuring that the cash flow generated by assets can cover benefit obligations when they come due, through asset-liability management (ALM). Compared to DB pension plans, particularly public plans, the liabilities of life insurance companies are generally better matched with their assets as a result of ALM practice.
3. **Defined contribution (DC) plans and asset management firms.** Retirement income that can be derived from defined contribution plans and the investments they make through asset managers is determined by market returns on plan assets. Participants in defined contribution plans and clients of asset management firms bear the investment risk; thus, the plans and firms generally are not directly subject to asset-liability management concerns although it is a concern to the asset owners.
4. **Social Security.** The obligations of Social Security consist of inflation-indexed benefits that are defined in law. Under current law benefits may be delayed or reduced when trust funds are depleted and incoming tax revenue is insufficient to pay full amounts. Furthermore, the benefits defined in law can be changed, so Social Security benefits do not have the constitutional or contractual protection that pension promises generally have, but Social Security benefits have strong political protection – the law cannot easily be changed. The benefit promises are backed by payroll tax revenue and by assets of the Social Security trust funds. The payroll tax is a function of tax policy, growth of labor income, and demographic trends. The trust funds are required by law to be invested in special issue Treasury bonds that earn market interest rates.

As we discussed in section 2, Social Security is the largest source of retirement income. Similarly, it constitutes the largest institutional retirement obligation, although this is largely a political rather than legal obligation. We are not aware of data that allow perfect comparison of Social Security to the other obligations, but multiple reported estimates indicate that Social Security obligations are far greater than other retirement obligations discussed in this report.[22]

Table 6 shows major non-Social Security retirement assets and obligations at the end of 2018. For defined benefit plans we use obligations, rather than assets, because obligations are most important from the perspective of beneficiaries (assuming the obligations will be paid).[23] Defined benefit plans and assets owned by individuals, including defined contribution plans and IRA savings, each account for about 46 percent of non-Social Security retirement obligations, and are far larger than life insurance annuities.[24]

Table 6

DEFINED BENEFIT PLANS AND RETIREMENT ACCOUNTS OWNED BY INDIVIDUALS EACH ACCOUNT FOR 46 PERCENT OF NON-SOCIAL SECURITY OBLIGATIONS

Major types of retirement assets or obligations in 2018

	Assets (for non-DB) or obligations (for DB) ($ Billion)	Percentage (%)
Annuities at life insurance companies	**$ 2,646**	**7.8**
Defined benefit (DB) plans	**$ 15,524**	**45.7**
Private sector	3,443	10.1
State & local government employees	8,634	25.4
Federal government employees	3,447	10.1
Retirement accounts owned by individuals	**$ 15,824**	**46.5**
Defined contribution (DC) plans	*7,018*	*20.6*
Private sector	5,975	17.6
State & local government employees	473	1.4
Federal government employees	570	1.7
Individual Retirement accounts (IRA)	*8,806*	*25.9*
Total	**$ 33,994**	**100.0**

Source: Federal Reserve Financial Accounts of the United States (2019), Tables L.117, L.118, L.119, L.120.

Note: DB plan obligations are based on estimates produced by Bureau of Economic Analysis (BEA) using standardized assumptions and discount rates and differ from actuarial liabilities produced by pension plans for funding or reporting purposes.

4.1 DEFINED BENEFIT PENSION FUNDS

Defined benefit pension plans provide bond-like guarantees largely not tied to market interest rates and investment returns. Thus, like bonds, when interest rates fall these liabilities rise in value, although this rise is not always fully or immediately reflected in financial statements.

We discuss the impact of low interest rates on defined benefit pension funds from three perspectives. First, the interest rate usually is a key element in determining the discount rate used in calculations of *reported* pension obligations and changes in discount rates will directly affect financial statements of these institutions, although the speed and extent of this depends upon accounting standards that vary by type of sector. Second, persistent low

interest rates and associated low asset returns, for funds that do not match assets to liabilities, will pose great challenges for defined benefit pension funds to meet obligations established under more favorable interest rate conditions. Third, some defined benefit pension plans or their sponsors may have little choice but to cut benefits or raise contributions substantially if the low-interest-rate environment persists in the long run.

Private sector defined benefit pension funds and public defined benefit pension funds in the U.S. face distinct regulatory environments that create different incentives for how they will respond to the low interest rate environment.

4.1.1 THE REGULATORY ENVIRONMENT AND THE IMPACT OF FALLING INTEREST RATES THROUGH DISCOUNT RATES

In general, the reported liabilities of defined benefit pension plans are calculated as the discounted values of future benefit payouts. To the extent that the discount rate used in the liability valuation is linked to interest rates, a decline in long-term interest rates would cause reported pension and insurance liabilities to rise along with the increase in true (economic) liabilities.

Liabilities of defined benefit pension plans often have longer durations than their assets, particularly in the public sector.[25] As a result, when interest rates fall, if the discount rate is adjusted accordingly, pension liabilities will rise more than portfolio values rise, leading to a larger funding gap. If the lower interest rates persist, pension funds will have to reinvest their assets at lower returns before the obligations backed by these assets come due.

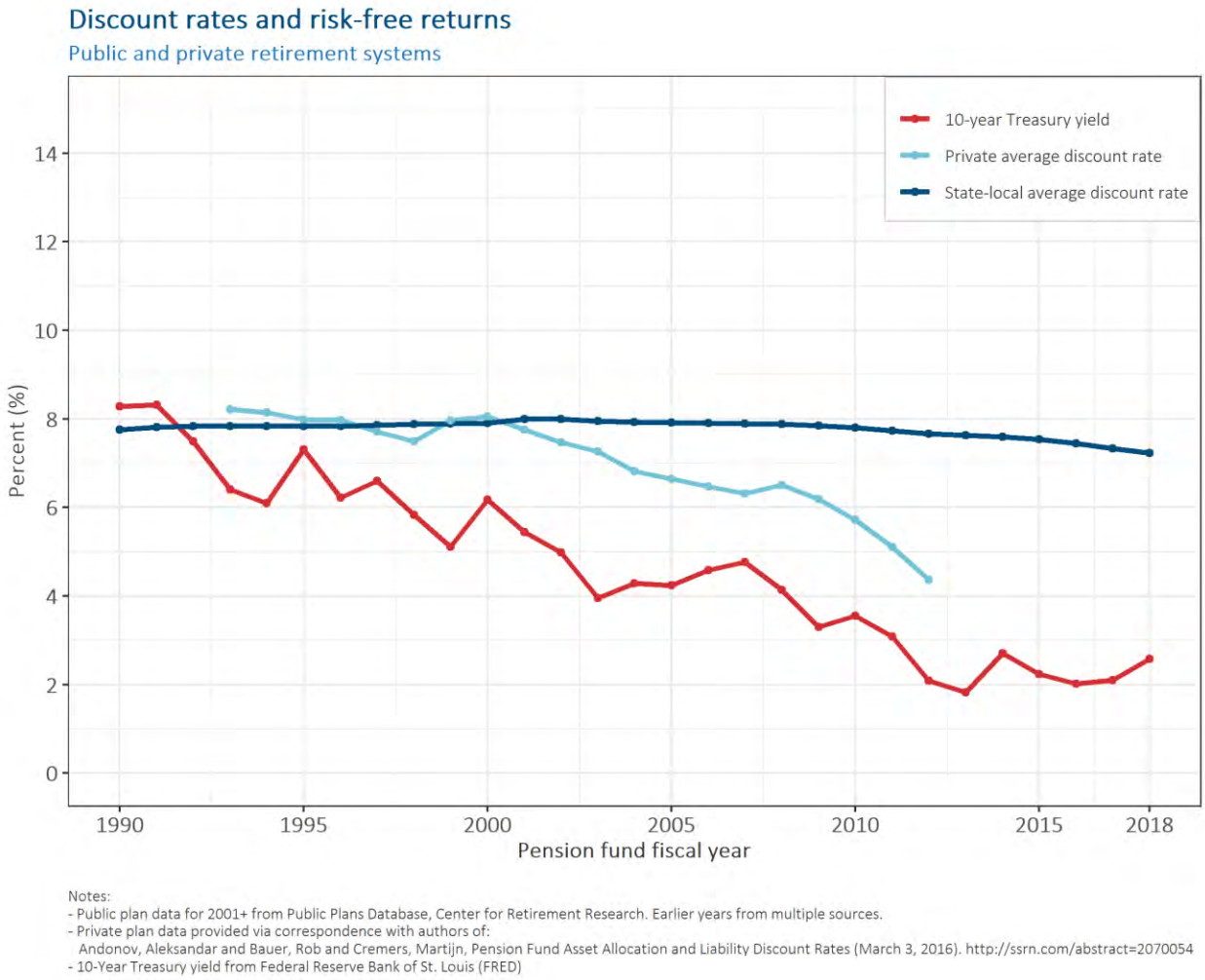
With lower discount rates, the reported liabilities of defined benefit pension plans will become more sensitive to changes in future cash flows (higher expected payments due to improvements in mortality, for example) because cash flows far in the future are less heavily discounted.

Below we review the rules and regulations for public and corporate pension plans that determine to what extent and how quickly the impact of low interest rates will be recognized in reported liabilities through changes in discount rates.

4.1.1.1 Public pension plans

Governmental Accounting Standards Board (GASB) standards generally require public pension plans to value their liabilities for financial reporting purposes using discount rates equal to earnings assumptions the plans select based upon the plan's own portfolio. The discount rates used by public pension plans have largely fallen slightly within the range of 7 to 8 percent during the last three decades while market interest rates have declined substantially. (Compare the dark blue line and red line in Figure 3.)

Figure 3
DISCOUNT RATES AND INTEREST RATES



Notes:
- Public plan data for 2001+ from Public Plans Database, Center for Retirement Research. Earlier years from multiple sources.
- Private plan data provided via correspondence with authors of:
  Andonov, Aleksandar and Bauer, Rob and Cremers, Martijn, Pension Fund Asset Allocation and Liability Discount Rates (March 3, 2016). http://ssrn.com/abstract=2070054
- 10-Year Treasury yield from Federal Reserve Bank of St. Louis (FRED)

Researchers have argued that public plans' assumed returns have not followed risk-free returns downward in part because pension fund boards and sponsors prefer high discount rates, which keep the reported actuarial value of pension liabilities and actuarially determined contributions lower, all else equal. (See Andonov et al. (2017), for example.) The decline in risk-free rates created difficult choices for public pension funds. Before 1990, 10-year Treasuries were above 8 percent and public pension funds could achieve their assumptions by taking very little risk. As interest rates declined, public pension funds could have chosen to reduce their return assumptions, but most public pension funds reduced assumptions only slightly; lowering the assumption significantly would have led to large increases in actuarially determined contributions, causing potential stress for the sponsoring governments. Instead, public pension funds have chosen to maintain high discount rates and justify them by investing in riskier asset classes, discussed further in the next section.

4.1.1.2 Private pension plans

U.S. private sector pension plans value their liabilities using two separate processes, one for financial reporting purposes and one for funding purposes. The discount rates used in these two valuation processes are distinct and governed by different rules and regulations, but currently they are both tied to long-term bond rates.

The liability discount rates for financial reporting purposes are governed by standards set by the Financial Accounting Standards Board (FASB). Single-employer corporate pension plans in the U.S. are required to set the rates based upon a current high-quality corporate bond rate linked to market rates.[26,27] The liability valuations conducted with this rate are used to determine pension liabilities reported on the sponsoring firms' balance sheets, which rise as the discount rate declines.

The discount rates for funding purposes, which are used to determine the minimum pension contributions plan sponsors are required to make, are regulated by the Employee Retirement Income Security Act (ERISA), the Pension Protection Act (PPA) of 2006, and related federal legislation. Single-employer plans currently use rates for funding purposes that are established by the IRS, within these legislative requirements, related to a blend of long-term investment grade corporate bonds. Previously key funding rates had been tied to a 2-year average of market rates on high quality bonds, but Congress subsequently manipulated funding rates by allowing a 25-year average. This slowed and muted the impact of market interest-rate declines, providing contribution relief to private plan sponsors. Rising liabilities caused by the drop in discount rates puts downward pressure on the plan funded ratio and potentially triggers additional contribution requirements to the plan mandated by PPA. Private plan rates for funding purposes are lower than rates chosen by public plans (Figure 3).

4.1.2 CHALLENGES IN MEETING EXISTING OBLIGATIONS

The persistent low interest rate environment poses challenges for defined benefit pension funds because, as IMF (2017) put it, "[t]he large existing stock of liabilities [implicitly] offering guaranteed returns creates cash flow obligations over the medium term that are difficult to meet through investment income given lower interest rates and flatter yield curves." ["implicitly" added by report authors] To meet existing defined-benefit obligations pension plans face three options: (1) reduce existing obligations and liabilities, (2) replenish assets by increasing contributions, and (3) seek higher investment earnings.

4.1.2.1 Reducing pension obligations

It generally is difficult to reduce *accrued* pension liabilities because they usually are contractually or statutorily protected. It can be difficult to alter current benefit provisions as well.

Private sector pension plans generally are governed by ERISA but public sector plans are not. Under ERISA, private employers may not reduce accrued liabilities but may reduce the rate at which future benefits are earned. In addition, employers may terminate or freeze plans in several ways.[28] For example, a plan may be closed to new entrants while allowing existing members to continue to accrue benefits, or a plan may stop benefit accruals for existing members as well but allow benefits to increase with the growth in their wages, or it may close the plan to new entrants and stop all accruals for new service of existing members as well. Terminating plans has become commonplace in the private sector and has contributed to the decline over the last four decades in the use of defined benefit plans in the private sector.[29]

Protections for public pensions tend to be much stronger than those for private sector pensions but they vary widely, depending upon the state, type of benefit, and other factors (Monahan 2015). All states may adopt lower pensions for new workers than for existing workers, but that does nothing to reduce existing obligations. Whereas under ERISA private firms can reduce pension accruals for new service of existing workers, many states cannot do this under their laws (Monahan 2011). For public pension plans, cost-of-living-adjustments (COLAs) are not always protected by constitutions explicitly. In some plans, COLAs are indexed to the plan's funded status and/or investment returns, providing a way to slow the liability growth when a plan is poorly funded, or investment returns are lower than expected. But the cost reduction effects of contingent COLA policies in most plans are generally moderate (Boyd et al. 2019). Closing plans to new employees is legally possible in the public sector but has been extremely rare, with Alaska and Michigan two notable exceptions. Many public pension beneficiaries are voters and

have strong advocates in the political process, contributing to the challenge of reducing benefits or closing plans in the public sector.

The difficult legal and political environment for public pensions helps to explain why governments have tended to raise taxes, cut services, reduce pension benefits for new workers, and delay contributions rather than cut existing obligations and are likely to continue to respond in this fashion except when pressure is inexorable. By contrast, private firms have found it more practical to freeze defined benefit plans and enroll workers in defined contribution plans in response to low interest rates and other factors.

4.1.2.2 Increasing contributions

Under common actuarial funding rules, actuarially determined contributions of plan sponsors increase when expected market returns decline, regardless of whether the lower expected return is reflected in their reported liabilities through a lower discount rate.[30]

In the private sector, sponsors generally are required to pay these higher contributions under applicable funding rules. Corporate defined benefit plans are required to pay mandatory additional contributions on top of regular amortization costs if their funded ratios fall below certain thresholds.

In the public sector, it is more complicated. State governments may impose payment requirements on local governments by statute; some do and some do not. State governments and local governments each may impose requirements on themselves by law; and may override, evade, or avoid the payment laws they make for themselves. The extent to which governments pay actuarially determined contributions varies greatly and appears to depend on political culture as well as laws. Because public sector pensions have strong legal protections, underpaying actuarially determined contributions generally means postponing costs to the future rather than avoiding those costs in the long run. For public defined benefit pension plans, rising pension costs will pose fiscal pressure on the sponsoring governments and potentially crowd out spending on other public services.

4.1.2.3 Seeking higher investment returns

The pressure to meet legacy obligations in the prolonged low interest rate environment creates incentives for defined benefit pension funds to seek higher investment returns by increasing their exposure to riskier asset classes. The elevated investment risk resulting from reaching for higher returns can lead to higher solvency risk for these institutions and potentially greater systemic risk for the financial system. The extent and the form of this behavior differs between public and private pension funds reflecting the different regulatory environments they face. IMF (2017) concluded that "reaching for yield" (their term) has been moderate in corporate pension plans (and also insurance companies), while it has been encouraged for public pension plans in the U.S. by their unique regulatory and accounting environment, and lax rules compared to other sectors.

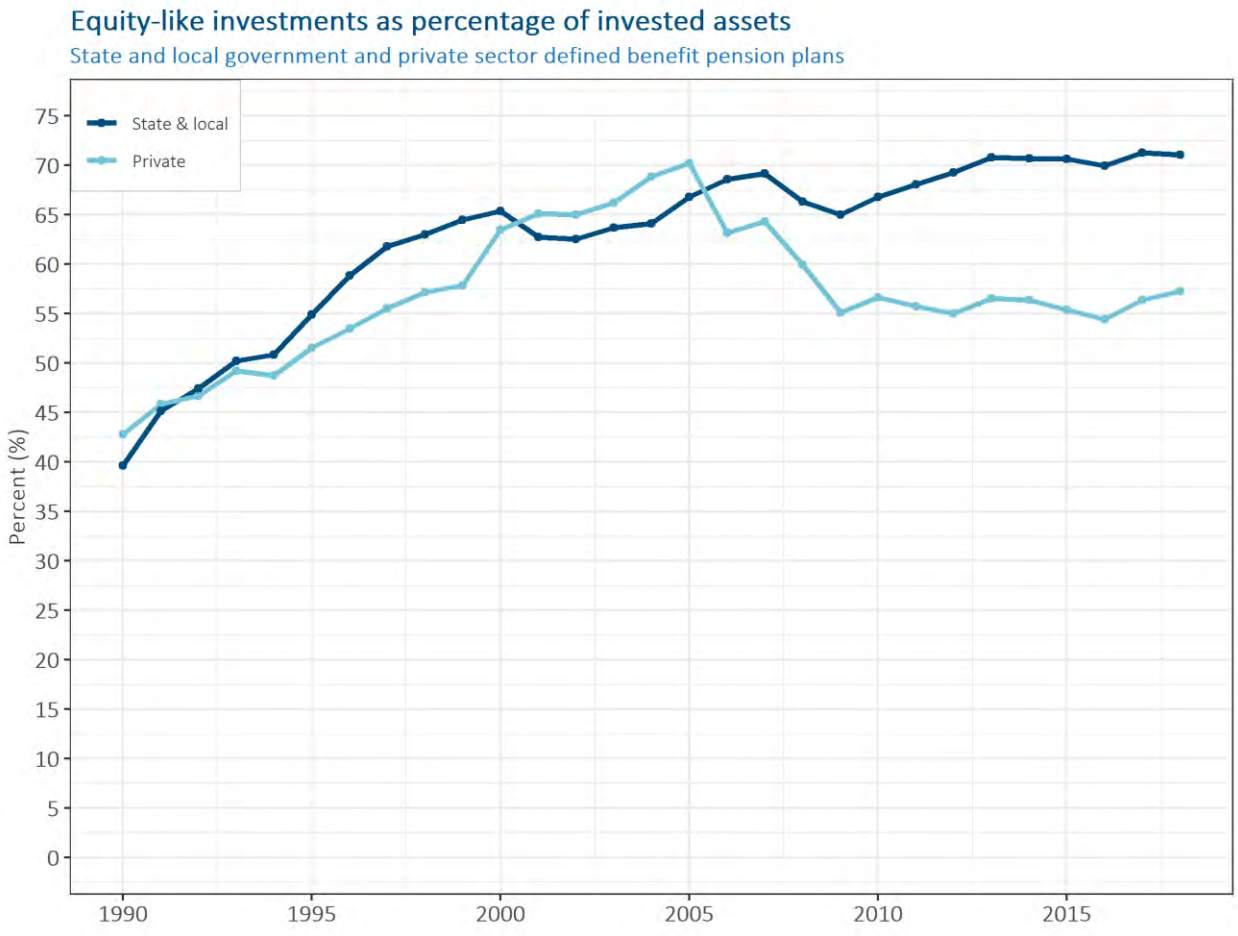
4.1.2.3.1 Public pension plans

As shown in Figure 3, the investment return assumptions (discount rates) of public pension plans have been "sticky" over the past 30 years while market interest rates have declined substantially. Public pension funds appear to have increased their allocation to riskier assets with higher expected returns to keep expected portfolio investment returns consistent with the assumed returns. In a study of public pension funds in the U.S., Boubaker et al. (2017) found that "a lower interest rate environment and the use of unconventional monetary policy measures [such as quantitative easing in the Great Recession] prompted pension funds to change their strategic asset allocation from safe to riskier investments."

Public pension plans in the U.S. now invest nearly two-thirds of their assets in equity-like investments, up from one-quarter in the 1970s and about 40 percent in 1990. While public plans once were more conservative investors than private defined benefit plans, they now have a much greater share of their assets invested in equity-like investments (including alternative investments such as private equity, hedge funds, and financial derivatives) than do private

plans (Figure 4).[31] According to IMF (2017), plans with weak funding held about 25 percent of their assets in alternative investments in 2011, up from almost zero in 2001.

Figure 4
PUBLIC PENSION FUNDS HAVE INCREASED THEIR EQUITY-LIKE INVESTMENTS



Source: Authors' analysis of Z.1 Financial Accounts of the United States, Federal Reserve Board, Tables L.118.b, L.120.b, and L.122

Empirical studies have found that the impacts of low interest rates on risk-taking behavior are more pronounced for poorly funded plans, which tend to have stronger incentive to invest in riskier assets in the hope of closing their funding gaps. Lu et al. (2019) examined whether U.S. public pension funds reach for return by taking more investment risk in a low interest rate environment and found evidence that funds take more risk in response to underfunding and low interest rates on safe assets. The effects of low interest rates on risk-taking are especially pronounced for funds that are more underfunded or are affiliated with states and municipalities with weaker public finances. They estimated that up to one-third of the funds' total risk was related to underfunding and low interest rates at the end of our sample period of 2002 to 2016. Andonov et al. (2017), although not focused on the impact of interest rates, found that U.S. public pension funds with a higher level of underfunding as well as funds with more politicians and elected plan participants serving on the board take more risk and use higher discount rates.

The direct impact of the elevated risk-taking by public pension on the retirement security of plan members will be limited as public pension benefits usually enjoy statutory or constitutional protection. However, holding excessive

risky assets will result in greater volatility in required government pension contributions and funded status (Biggs 2014; Farrell and Shoag 2016; Boyd and Yin 2017; Lu et al. 2019), increasing the likelihood of severe underfunding and large increases in pension contributions. Increases in underfunding and in government contributions could erode political support for public pensions, trigger lower benefits for future plan members and, where legally and politically practical, cuts in benefits for existing members.

4.1.2.3.2 Private pension plans

Compared to public pension plans, private sector pension plans in the U.S. face more stringent rules about underfunding, which discourage excessive risk-taking and reaching-for-return behaviors that can lead to greater volatility in asset values.[32] Sponsors of corporate pension plans are required to make contributions in addition to the actuarially determined amount if the plans are consistently underfunded.[33] Risky investment strategies may lead to greater volatility in a plan's funded ratio and make the requirement for additional contributions more likely to be triggered. In addition, PPA of 2006 shortened the amortization period for unfunded liabilities, making required contributions more sensitive to the volatility of portfolio returns. As Figure 4 shows, U.S. private defined benefit pension plans chose to significantly reduce the share of equity-like assets after 2006 in response to the rules introduced in PPA (including but not limited to shorter amortization periods).

4.1.3 LONG-TERM IMPACT ON PENSION ARRANGEMENTS

Over the long term, many defined benefit pension plans may have little choice but to try to reduce benefits to plan participants if low interest rates persist, although laws – and litigation – may determine which beneficiaries are most at risk. As discussed earlier, public pension cuts for existing participants, other than in COLAs, are rarely allowed, and virtually all will be challenged. Governments may continue to reduce defined benefits for new workers.

For defined benefit pension plans, the combination of demographic changes and prolonged low interest rates will put downward pressure on benefit levels. Benefit cuts below a certain level will make defined benefit pensions less competitive than defined contribution plans, which offer better portability that is attractive to younger employees who value labor mobility. The transition from defined benefit plans to defined contribution plans in the private sector is already very far along in the U.S. (IMF 2017). In the public sector, the transition to defined contribution plans is unlikely to occur for existing workers as defined benefit arrangements are statutorily or constitutionally protected, but they may become more common for new workers. However, the large asset losses during the two recessions in the 2000s and the slow recovery of funded status in the past 10 years have triggered reforms in many public sector defined benefit pension systems, which include reducing benefits for new employees, introducing risk-sharing between employer and plan members, and establishing DB-DC hybrid plans. Pension reforms may become more common under the pressure of the prolonged low-return environment.

4.2 LIFE INSURANCE COMPANIES

Life insurance companies offer annuities and other products with savings elements. However, the value of these obligations is less than 10 percent of defined benefit pension obligations (Table 6), so the risk to retirement security is far less even before considering differences in regulatory arrangements that appear to further reduce the risk.

The interest rate is a key element in determining the discount rate used in calculations of insurance reserves. Changes in discount rates will directly affect insurers' financial statements. U.S. insurance companies follow FASB (Financial Accounting Standards Board) guidance in choosing discount rates. Currently, life insurers can discount liabilities for future benefits using investment yields expected when policies were established and do not update them when market rates change. Therefore, declining interest rates would only affect liabilities on new policies, and the impacts would vary across companies depending on the extent to which market interest rates were incorporated into their investment yield assumptions. FASB has published new guidance, expected to become effective after 2023 but with earlier adoption allowed, that ties discount rates used by insurers more closely to

market interest rates, making liabilities of annuity and life insurance contracts more sensitive to interest rate changes.[34]

Persistent low interest rates and associated low asset returns for institutions that do not match assets to liabilities will pose great challenges for life insurance companies to meet obligations established under more favorable interest rate conditions. As a practical matter, life insurance companies cannot reduce benefits under existing policies, which are contractually protected. Benefits offered in new contracts will be – and already are – lower than benefits offered when rates were higher. IMF (2017) observes that life insurers have engaged in liability management operations. For instance, they have lowered rates on legacy products where possible, curtailed interest-sensitive products, sought to renegotiate terms, and sold blocks of business to private equity funds. But the limits of most of these measures have already been reached.

As with defined benefit plans, interest rate reductions increase liabilities that are difficult or impossible to reduce, and so create incentives to take risk to increase yields and thereby the assets available to pay liabilities. The risk insurance companies can take is limited by regulations that require them to hold capital minimums based on the risk profile of their portfolios.[35] However, in their paper "Reaching for Yield in the Bond Market" Becker and Ivashina (2012) found evidence that insurance companies seek higher returns in choosing their bond investments within risk categories. In a related article (Becker and Ivashina, 2013), the authors do not conclude whether reaching for higher returns was aggravated by the decline of long-run interest rates but state that "reaching for yield may be back with a vengeance" in the current low-interest-rate environment.[36] Although there may be risk-taking within categories, IMF (2017) concluded that "search for yield in the insurance sector so far has been moderate" in contrast to U.S. public pension plans.

The market for annuities and life insurance products with guaranteed returns is likely to shrink in the persistent low interest rate environment, while insurers may seek to expand into so-called "unit-linked" products where investors bear the investment risk (IMF 2017). In addition, Antolin, Schich, and Yermo (2011) note that protracted low interest rates can also reduce the overall profitability of insurance companies to the extent that profitability is driven by interest income. In this situation, insurance companies will have to depend more on their core business activities, including underwriting, premium income, claims experience, and lapse rates, than before for profitability. If low interest rates coincide with a period of low economic growth, insurance companies will face additional pressure as premium growth is linked to economic growth.

4.3 DEFINED CONTRIBUTION PLANS AND ASSET MANAGEMENT FIRMS

The retirement income that can be derived from defined contribution savings and other personal saving vehicles is directly tied to asset returns and investment risks borne by savers. Asset management firms hold a large portion of personal retirement savings through mutual funds, IRAs, and similar vehicles, in addition to holding pension and insurance assets. The way they react to the low interest rate environment will affect the risk-return profiles of the assets under management and potentially the stability of the financial system, which would in turn affect the retirement security of individuals and families (IMF (2017).

Investment returns of defined contribution plans are directly affected by low interest rates. When interest rates initially drop, defined contribution fixed-return funds experience gains in their bond holdings, with the amount of gain depending on the duration of assets and the slope of the yield curve.[37] If low interest rates persist, future returns may be lower; the longer-run net impact will depend on the extent to which the equity part of the portfolio also suffers from a low-interest-rate environment. Over the long-term, lower investment returns will translate into lower retirement income that can be drawn from defined contribution savings, unless employees and employers contribute more, or take on more risk in their investment portfolios.

We reviewed studies that discuss how asset management firms in general (not limited to those providing DC investment options) may react to the prolonged low interest rates environment. Beer and Gnan (2015) discussed potential reactions by asset management firms. First, fund managers may attempt to improve risk-return profiles of their portfolios through efforts such as harvesting market and alternative risk premiums, exploiting past empirical patterns supporting certain "investment styles" or combinations thereof, and taking long and short positions that may allow them to better manage the risk of a sudden bond yield reversal. All investors have incentives to maximize return for a given level of risk, so this incentive is not new. We are unaware of research concluding that firms will newly discover ways to increase returns without increasing risks in ways that will not be competed away. Second, in the face of the competition to meet demanding customer expectations in the low-return environment, fund managers may resort to searching for higher return on behalf of their clients thereby taking more risk. Third, searching for return may also prompt investment in illiquid assets, although according to the authors the extent of this is limited by mandates on asset managers.

4.4 SOCIAL SECURITY

Social Security benefits are financed primarily on a pay-as-you-go basis rather than with actuarial funding. Payroll taxes account for nearly 90 percent of receipts in the Social Security trust funds, with interest on trust fund assets and taxation of benefits accounting for virtually all of the remainder. Social Security benefit payments exceed payroll tax revenue due to an aging population and the trust funds will need to supplement taxes by drawing down assets accumulated from prior surpluses. Once trust fund assets are depleted, current law requires that the total Social Security benefits paid must not exceed the payroll taxes received. Under current projections the trust fund assets will be depleted by around 2035, after which taxes will be sufficient to pay only about 80 percent of benefits. By 2093, tax income will only cover 75 percent of the benefits (OASDI Board of Trustees 2019). Social Security is not sustainable over a longer period unless taxes are raised, benefits are cut, or both.[38]

Social Security is affected by interest rates through the yield earned on the special Treasury bonds issued to the trust funds. The nominal effective interest rate on the special Treasury bonds, which reflects the overall yield of the special issues across different maturities and issue years, have followed the same declining trend as other Treasury bond yields, falling from the peak of 11.6 percent in 1984 to 2.9 percent in 2018. As a result, interest rate declines to date have led to lower investment income and lower trust fund assets than would have been obtained in a higher interest rate environment.

The effective yields will continue to fall as the special issues with higher interest rates acquired in earlier years mature over time and are rolled over to new special issues with lower interest rates. However, the impact of future changes in interest rates on Social Security will be limited because the trust funds are projected to shrink in size, few new issues will be purchased, and interest income will become increasingly small. The OASDI Board of Trustees (2019) conducted sensitivity analysis using long-run real interest rates on Treasury bonds newly issued to the trust funds of 2 percent, 2.5 percent and 3 percent and found moderate impact of these interest rates. For example, the projected 75-year actuarial balance is -2.97 percent of taxable payroll with a 2 percent real interest rate, compared to -2.60 percent with a 3 percent real interest rate, and the projected year of the depletion of the fund (2035) does not vary across their interest rate scenarios.

Note that the real interest rates used in the analysis in OASDI Board of Trustees (2019) are quite high compared to the current real effective yield (0.3 percent real interest rate based on the 2.6 percent CPI assumption) and the projected long-run real rate of 1 to 2 percent under the model-based and market-based methods described in section 3. This reflects the long-term perspective (generally 75 years) of the Social Security Administration and their assumption that interest rates will gradually return to the long-term historical level. OASDI Board of Trustees (2019) does not examine scenarios with lower real interest rates, which could be more relevant for the next 10 to 30 years, but given the limited impact of interest rates found in the sensitivity analysis, few new bond purchases expected,

and expected declining trust fund balances, using lower real interest rates may not greatly change the current projection results.

In sum, current Social Security benefits are not sustainable in the long run without policy changes, but interest rates have little direct impact on this conclusion. Simulation analysis suggests that the low interest rate environment will not have a substantial negative impact on Social Security and that the sustainability of Social Security will not benefit greatly from potential future increases in interest rates.

4.5 SECTION CONCLUSIONS

The impacts of a persistent low interest rate environment on different types of institutions that provide retirement income and the implications for retirement security, according to the papers reviewed above, are summarized in this section.

Table 7

LOW INTEREST RATES, INSTITUTIONS, AND RETIREMENT INCOME AND RETIREMENT SECURITY

	Assets/ obligations ($ trillion)	Direct impacts of low interest rates	Indirect consequences	Implications for retirement security
Public defined benefit plans	$8.6	Public DB plans have lowered their discount rates only slightly in response to the low interest rate environment, largely due to the unique regulatory environment for public pension plans in the U.S. Low returns will cause challenges in meeting existing pension obligations.	To maintain the high discount rates (assumed returns) public DB plans have increased allocation to equity-like asset classes, leading to greater investment risk. Higher contributions will be required if lower-then-expected returns cause underfunding. More and more public DB plans choose to cut benefits for new members, share risk with plan members, and introduce DB-DC hybrid plans.	In the short to medium term, the impact of low interest rates through public DB plans is expected to be limited because the finances of public DB plans are backed by tax revenue and the benefits are usually statutorily protected. In the long term, pension reforms will generally make public DB plans less generous for future employees and make plan participants bear more risk.
Corporate defined benefit plans	$3.4	The reported liabilities increase because discount rates are tied to market interest rates. Low returns will cause challenges in meeting existing pension obligations.	Reaching for yield and risk taking is discouraged by relatively strict funding requirements and the concern of accounting expense volatility; the allocations to equity have decreased after 2006. Low interest rates may accelerate the transition from DB to DC.	In the short to medium term, impact of low interest rates through corporate DB plans is expected to be limited because the strict regulations on corporate DB plans reduces the likelihood of insolvency and the benefits are protected by the Pension Benefit Guaranty Corporation (PBGC). In the long term, the availability of secure retirement income will be reduced as more corporate plans transition from DB to DC.
Life insurance companies	$2.6 (annuity)	Currently, the declining interest rates only affect the reported liabilities of new policies. A new FASB guidance (effective after 2023) will make discount rates and liabilities more sensitive to interest rate changes. Low returns will cause challenges in meeting existing obligations for annuities and products with guaranteed returns	The incentive for reaching for yield is limited by capital requirements, while evidence exists for reaching for yield within risk-categories of bond investments. Markets for annuities and life insurance products with guaranteed returns are likely to shrink. The overall profitability will be reduced because of lower interest income.	In the short to medium term, impact of low interest rates through life insurers is expected to be limited because the strict capital requirements for insurers reduces the likelihood of insolvency and the shares of annuity and life insurance products in total retirement savings are small. In the long term, the availability of secure retirement income will be reduced if the markets for annuity and guaranteed-return insurance products shrink.
Retirement savings in defined-contribution plans and asset management firms	$15.8 (DC and IRA savings)	Investment returns will become lower. The aggregate size of the impact will depend on the fund's investment options and the extent to which the equity part of the portfolio also suffers from a low-interest-rate environment.	Asset-management firms may seek to improve the risk-return profiles of their portfolios by increasing exposure to illiquid assets, increasing the use of leverage, taking long-short positions, exploiting "investment styles". (These proposed approaches are not common and are subject skepticism)	Lower investment returns will eventually translate into lower retirement income that can be drawn from DC and other personal retirement savings, unless employees and employers contribute more, or take on more risk in their investment portfolio.
Social Security	Considerably greater than $35.2	Lower interest income for Social Security Trust fund		The finances of Social Security are dominated by demographic trends and tax and benefit policies. As the Social Security trust fund shrinks in size, the low interest rates are not expected to have a substantial impact on Social Security.

Defined benefit funds and life insurance companies will face the challenge of meeting their existing obligations of guaranteed benefits with lower expected returns in the prolonged low-interest-rate environment. Public pension funds, corporate pension funds and insurance companies face very different regulatory environments and will respond to the low rate environment differently. Public pension funds have the largest exposure to risky assets, partly due to the unique regulatory environment they face. Search-for-return behaviors are more moderate among corporate pension funds and insurers for which risk-taking are more heavily discouraged or penalized.

Although challenges exist, the impacts of low interest rates on retirement security through defined benefit plans and life insurers are expected to be limited in the short to medium term. The funding of public defined benefit plans is backed by tax revenue and the benefits are usually statutorily protected. Private sector pension plans in the U.S. face more stringent rules about underfunding, which discourage excessive risk-taking and reduce the risk of insolvency. Moreover, private pension benefits are protected by the Pension Benefit Guaranty Corporation (PBGC). Life insurance companies also face strict regulations that limit risks they may take and thereby the risk of insolvency.

If the low interest rate environment persists in the long run, many public sector defined benefit pension funds may try to reduce guaranteed benefits for new workers. As a result, secure retirement income will become increasingly less available to retirees in the future, although this will differ by sector.

For defined contribution savers, the reduced portfolio returns in the low-interest-rate environment will eventually translate into lower retirement income from defined contribution savings, unless they contribute more or take on more risk in their investment portfolio.

Asset management firms may seek to improve the risk-return profiles of their clients' portfolios in the low-return world through various measures, including increasing exposure to illiquid assets, increasing the use of leverage, taking long-short positions, and exploiting "investment styles".

The main driving forces for the future trend of the finances of Social Security are demographics and tax policies. Interest rates will have very limited impact on Social Security because the trust funds are expected to shrink in size and interest income will become increasingly small.

5 Conclusions

The decline in interest rates is a result of many factors including a slowdown in economic growth driven by slowing productivity growth and slowing workforce growth, as well as factors directly affecting the desire for savings and investment and savings. Most recent studies suggest the long-term equilibrium interest rate is likely to stay at an historically low level for an extended period, although great uncertainty remains.

The estimated impact of persistent low interest rates on retirement security is likely to be negative but the magnitude differs across studies, driven substantially by underlying assumptions. A study estimating an especially small negative impact (Munnell et al. 2013) implicitly assumed that people will be able to accumulate as much pre-retirement wealth, relative to their income, as they could when interest rates were higher, and assumed that households would borrow more against their homes through reverse mortgages than they would when interest rates are high.

By contrast, a study that found a relatively large negative impact, VanDerhei (2013), assumed (1) wealth accumulation during working years would be lower when interest rates are lower, and (2) the share of home equity used to fund retirement expenses would not be higher when interest rates are lower. These two important assumptions appear to be the main drivers of the very different conclusions.

The adverse effects of persistent low interest rates will depend on the structure of retirement income sources, will differ across population subgroups, and can be partially mitigated by behavioral changes such as increased saving and delayed retirement, albeit with potentially negative implications for the lifetime welfare of individuals.

The low interest rate environment also can affect retirement security through its impact on institutions. Social Security is the largest source of retirement income, but the direct impacts of low-interest rates on its capacity to make payments is likely to be minimal; it faces far larger concerns related to changing demographics and its overall fiscal structure. Other institutions face greater risks and concerns. Low interest rates could have a large impact on defined benefit pension funds and annuity providers. The overall direct effect on these institutions depends on the duration of assets and liabilities and asset allocation. A search for return would lead to greater exposure to investment risks for these institutions, and researchers have concluded this already has happened in the case of public pension plans.

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Notes

[1] This rate is sometimes called the r* or r-star. Although it is affected by long-run factors, estimates of the neutral rate generally are for a short term (short duration) rate, in part because it is used to help guide monetary policymakers in the setting of monetary policy.

[2] For accessible discussions of the neutral rate, see Williams (2003) and Ng and Wessel (2018).

[3] While the long-run equilibrium rate is unobservable, economists estimate it using observable data.

[4] Newell and Pizer (2003) argue that the trend of declining real interest rates goes back much further than 1876.

[5] Economists often represent desired savings as a rising curve with interest rates on the vertical axis and savings on the horizontal axis where, all else equal, people will save more when interest rates are higher. Economists represent desired investment as a falling curve where, all else equal, firms will invest less when interest rates are higher. In an equilibrium the two curves will intersect at one interest rate, and savings (funds available for investment) equal investment (amount invested). If the "all else" changes the curves can shift: savings or investment desired at any given interest rate will be different than before. The Rachel and Smith (2015) analysis suggests that the savings curve shifted to the right (more desired savings at any interest rate) and the investment curve shifted to the left (less desired investment at any given interest rate) - with these shifts, the equilibrium interest rate could fall but savings and investment could remain approximately as they were before.

[6] The share of old-age dependents has risen during the same time period due to the increase in longevity, but its impact is more than offset by the decline of the share of young dependents caused by the fall in birth rates.

[7] In the U.S., public investment as a share GDP has been trending downward for decades, primarily driven by the decline of federal government investment. Its impact on the federal government deficit is more than offset by factors such as the expansion of entitlement programs, tax cuts, and increases in stimulus spending and decreases in tax revenue after recessions. In isolation, declining public sector investment places downward pressure on interest rates.

[8] Imagine a downward-sloped curve that describes the desired level of investment at any given risk-free interest rate, with the horizontal axis representing investment level and vertical axis representing the interest rate. If the spread between the risk-free rate and return on capital increases by 1 percentage point, the risk-free rate will need to decrease by 1 percentage point to maintain the same level of desired investment, pushing the entire curve downward by 1 percentage point. In the framework of desired saving and investment for interest rates, a downward shift in the investment curve pushes the equilibrium interest rate down.

[9] As there is no single empirical measure of the spread between risk-free interest rate and rate of return on capital, IMF (2014a) constructs a weighted measure of three measures: (1) bank credit spreads (the difference between bank deposit and lending rates); (2) fixed income spreads (the difference between

yields on corporate and government bonds), and (3) Equity market spreads (earning yields minus government bond yield).

[10] Where forecasts were available only in nominal terms, we subtracted an assumed inflation rate of 2 percent from the nominal rate to obtain the estimated real rate.

[11] The figure includes income from employer-provided defined contribution plans in the pensions category. Income from real estate is included in the assets category. Recent research suggests that the Current Population Survey, the primary data source used to measure retirement income, understates retirement income, particularly from defined benefit pensions and retirement account withdrawals. No simple adjustment is available and the pension and asset income categories in the figure may be underestimated. See (Bee and Mitchell 2017).

[12] The labor force participation rate for the elderly aged 65 and above has increased substantially from the postwar low in the 1980s, for example rising for men aged 65-69 from 26 percent in 1990 to 36.5 percent in 2010. It is difficult to determine whether the rising labor force participation rate reflects increased desire to work at older ages, holding financial status constant (for example because of falling disability rates), or is a reaction to changes in retirement income due to changes in the pension system, adverse financial shocks, or other factors. It is most likely a combination. The most substantial change over this period was the growth in the importance of earnings for individuals in the upper half of the income distribution. The relative importance of other income sources for elderly individuals has been relatively stable over time. In 1988 (the earliest year for comparable data from the March Current Population Survey) only 11.5 percent of age 65+ individuals in the top quartile of the income distribution reported any earnings; in 2013, the analogous value was 51.3 percent.

[13] See, for example: Benz, Christine, “Experts Forecast Long-Term Stock and Bond Returns: 2020 Edition”, Morningstar, January 16, 2020.

[14] Based on a comparison by the authors of historical annuity payouts and current payouts. Historical annuity sources include James M. Poterba, 1997. "The History of Annuities in the United States," NBER Working Papers 6001, National Bureau of Economic Research, Inc. (see p.2). Current payouts are based upon annuity calculators (see, for example, https://www.schwab.com/annuities/fixed-income-annuity-calculator).

[15] Younger generations also have advantages that are not directly related to the low interest rate environment, such as extended period of low inflation, low investment fees, and more investment opportunities made possible by the latest development of financial technology.

[16] “About 30 percent of males in the lowest income quintile are still in full-time employment at 60, compared with almost 80 percent in the highest income quintile” (Gorodnichenko et al. 2013).

[17] This section is based heavily on (Bajtelsmit and Rappaport 2018).

[18] For example, under Federal Housing Administration guidelines, a 62-year old faces a borrowing limit of 52.4 percent of property value when the expected nominal interest rate is 3 percent, but only 31.2 percent when the expected rate is 7 percent. See sheet “General Table - 62 to 99” of https://www.hud.gov/sites/dfiles/SFH/documents/PLF_on_after_10_2_17.xls. In other words, the borrowing limit is 68 percent higher at an expected rate of 3 percent than at an expected rate of 7 percent.

[19] Leakage and career breaks can affect retirement saving greatly (Munnell and Webb 2015).

[20] Ilmanen and Rauseo (2018) explore how 401(k) savers can achieve retirement security at the current savings rate (9%) by adopting more advanced portfolio construction strategies involving non-market-cap weighting, leveraging, and shorting without increasing investment risk. The authors estimate that the traditional long-only DC portfolios can only reach an expected real return of about 3.5 percent under the low interest rate environment, which is below the 5 percent real return required, based on their calculation, to achieve a 75 percent target replacement rate at today's typical 9 percent savings rate among DC savers. The authors also estimate that the required savings rate to achieve a target replacement rate of 75 percent with 3.5 percent real return is about 15 percent, which is broadly consistent with the results of Blanchett et al (2018).

With the goal of achieving a 5 percent real return without increasing expected volatility, the authors discuss three investment strategies that are not commonly used in traditional DC portfolios: 1) allocating to traditional asset classes (stocks, bonds) beyond market capitalization-weighted exposure, which is also known as "smart beta", 2) more fully realizing the benefits of diversification by incorporating moderate leverage, and 3) instead of holding a long-only portfolio, constructing a long/short portfolio across a diversified set of asset classes engineered to be market-neutral and resilient across a range of macroeconomic environments. Under the capital market assumptions used in the paper, an optimized portfolio involving these three strategies can boost the expected real return to 5 percent compared to the 3.4 percent expected return of a traditional 60/40 stocks/bonds portfolio, while maintaining the same expected volatility.

While the strategies discussed in Ilmanen and Rauseo (2018) may look appealing to 401(k) savers seeking excess returns in a low interest rate world, as the authors pointed out they may not be for everyone because of individual investors' inability or unwillingness to incorporate leverage and shorting.

[21] S&P Global Ratings. "A Look At U.S. Life Insurers' $4.5 Trillion Investment Portfolios Amid COVID-19," September 16, 2020. https://www.spglobal.com/ratings/en/research/articles/200916-a-look-at-u-s-life-insurers-4-5-trillion-investment-portfolios-amid-covid-19-11640241.

[22] Alternative estimates of open and closed-group Social Security obligations reported in OASDI Board of Trustees (2019) all are much larger than other retirement security obligations discussed in this report.

[23] The total obligation of defined benefit pension plans and annuities is $18.2 trillion, while only 57 percent ($8.8 trillion) of it was funded by assets. Based on the obligations in the Federal Reserve Flow of Fund Accounts, the Private sector DB plans are 84 percent funded, state and local government employee DB pension plans are 48 percent funded, and the Federal government employee DB pension plans are 52 percent funded. Note these funded ratios may differ from those reported by pension plans, for which different actuarial methods, assumptions, and discount rates are used in the calculation of obligations.

[24] The table includes major obligations, but it is not exhaustive. Other retirement savings include life insurance policies with saving elements and non-tax-favored savings accounts. In 2012, annuity reserves accounted for about 60 percent of total life insurance policy reserves. Whole life and universal life insurance products also have saving elements and can be bought for retirement saving purposes. Their combined size is about half that of annuities.

[25] In recent decades, an increasing number of corporate DB pension plans have adopted "liability driven investing" (LDI), an investment approach that aims to match the cash flows of pension liabilities and assets when making asset-allocation decisions. However, one restriction on perfectly matching durations of pension liabilities and assets is that the durations of pension liabilities are generally longer than the durations of balanced fixed-income portfolios available in financial markets. As many corporate pension

plans in the U.S. are closed to new members and the durations of their liabilities will shorten over time, it will become more practical for them to implement LDI. But duration-matching can still be difficult for open DB pension plans (most U.S. public pension plans are open).

[26] See ASC 715-30-35-43 through ASC 715-30-35-46, at https://asc.fasb.org/section&trid=2235091#d3e14239-114931. Also see "Financial Reporting Considerations Related to Pension and Other Postretirement Benefits" (Deloitte 2015). FASB also sets standards for an expected return on plan assets that enters into pension expense for financial reporting, but it is not used for funding purposes.

[27] Compared to U.S. plans, corporate pension plans in many other developed countries tend to use lower discount rates for the calculation of pension obligations due to different regulation environments and practices. According to a global survey of accounting assumptions for defined benefit pension plans in 2019, the average discount rate of U.S. corporate pension plans was 4.3%, while the average discount rates for plans in Canada, Netherlands, and the United Kingdom were 3.63%, 1.89%, and 2.74% respectively.

[28] See Levine and Golumbic (2017).

[29] See "Private Pension Plan Bulletin Historical Tables and Graphs 1975-2017" (Employee Benefits Security Administration 2019).

[30] If a defined benefit pension plan lowers its discount rate for funding purposes in response to the low return environment, its actuarial liability will rise immediately and the plan sponsor will be expected to make up the resulting unfunded liability, usually through an amortization process. If the plan maintains a discount rate that is higher than the actual long-term expected return, then actual returns will fall short on average and create consistent actuarial losses which will be gradually reflected in the amortization costs.

[31] There is a debate on how the investment risks of alternative asset classes compare to traditional asset classes such as public equity and bonds. The studies we reviewed tend to group alternative investments and stock as "equity-like" asset classes and treat them the same way in terms of risk. Some alternative investments, such as private equity, have much greater liquidity risk than traditional investments, which is not extensively discussed by the literature. We appreciate comments from the Project Oversight Group on this issue.

[32] Although the strict regulations on corporate pensions suppress the reaching-for-return behavior, the regulations may also create incentives for corporate pension plans to avoid heavy penalties by taking more risk. Addoum et al. (2010) found that, in the face of mandatory contributions when the funded ratio falls below certain thresholds, corporate pension plans alter their asset allocations and increase their risk-taking to avoid mandatory contributions. They also found that plan sponsors increase their assumed rates of return on plan assets when subject to pension-related costs.

[33] PPA of 2006 provides that a plan will be deemed "at-risk" if the plan is unable to pass either of two tests: (1) funded ratio is less than 70 percent with a set of very conservative actuarial assumptions, and (2) funded ratio is less than 80% under standard actuarial assumptions. If a plan has been in at-risk status for at least two of the last four years, the plan sponsor will be required to make additional contributions.

[34] The guidance standardizes discount rates for long-duration insurance contracts to an upper-medium grade corporate bond yield that reflects the duration of the liability and requires the discount rates to be updated each reporting date (PwC 2019). The guidance was issued in 2018 and FASB has deferred its effective dates. The most recent effective dates are fiscal years beginning after December 15, 2022 for public companies and fiscal years beginning after December 15, 2024, with an option of early adoption.

(see “FASB Accounting Standards Updates – Effective Dates” https://www.fasb.org/jsp/FASB/Page/SectionPage&cid=1218220137102)

[35] U.S. insurers are subject to risk-based capital (RBC) requirements, under which non-Treasury securities are assigned to one of six risk categories with capital requirements increasing with risk level. The authors found that insurance companies systematically buy the riskiest bonds in the low-risk categories to reach for yield while maintaining lower capital requirements.

[36] Becker and Ivashina (2012) found that insurance companies systematically buy the riskiest bonds in the low-risk categories in order to reach for yield while maintaining lower capital requirements. They also show in a related article, Becker and Ivashina (2013), that prior to the Great Recession insurance companies held 72 percent of all the issuances of the safest quartile of investment-grade bonds, but 88 percent of the riskiest quartile of those bonds. The study did not conclude whether the “reaching-for-yield” behavior (their terminology) of insurance companies was aggravated by the decline of long-run interest rates, as their data only covers 2004 to 2010 but they state that the high yields in fixed-income markets before the 2000s “made it relatively easy for institutions to get high yields”, while “reaching for yield may be back with a vengeance” in the current low-interest-rate environment.

[37] For defined contribution fund holders close to retirement, the gain in asset value is likely to be offset by lower annuity values they will get as a result of lower interest rates (Antolin et al. 2011). This is a lesser concern in the U.S. because annuity purchase is very uncommon for U.S. DC plan participants.

[38] OASDI Board of Trustees (2019) estimates that to ensure full solvency throughout the next 75 years, (1) the payroll tax will need to be increased immediately and permanently by 2.7 percentage points to 15.1 percent; (2) scheduled benefits will need to be reduced immediately and permanently by 17 percent for all current and future beneficiaries, or by about 20 percent for future beneficiaries only; or (3) some combination of these approaches.

Bibliography

Aaronson, Stephanie, Tomaz Cajner, Bruce Fallick, Felix Galbis-Reig, Christopher Smith, and William Wascher. 2014. "Labor Force Participation: Recent Developments and Future Prospects." *Brookings Papers on Economic Activity (Fall)*, 197–255. https://www.brookings.edu/wp-content/uploads/2016/07/Fall2014BPEA_Aaronson_et_al.pdf.

Addoum, Jawad M., Jules H. van Binsbergen, and Michael W. Brandt. 2010. "Asset Allocation and Managerial Assumptions in Corporate Pension Plans." *Working Paper*. https://doi.org/10.2139/ssrn.1710902.

Andonov, Aleksandar, Rob M.M.J. Bauer, and K.J. Martijn Cremers. 2017. "Pension Fund Asset Allocation and Liability Discount Rates." *The Review of Financial Studies* 30 (8): 2555–95. https://doi.org/10.1093/rfs/hhx020.

Antolin, Pablo, Sebastian Schich, and Juan Yermo. 2011. "The Economic Impact of Protracted Low Interest Rates on Pension Funds and Insurance Companies." *OECD Journal: Financial Market Trends* 2011 (1): 237–56. http://www.oecd-ilibrary.org/finance-and-investment/the-economic-impact-of-protracted-low-interest-rates-on-pension-funds-and-insurance-companies_fmt-2011-5kg55qw0m56l.

Bajtelsmit, Vickie, and Anna Rappaport. 2018. "Retirement Adequacy in the United States: Should We Be Concerned?" Society of Actuaries. https://www.soa.org/research-reports/2018/retire-adequacy-us-concern/.

Becker, Bo, and Victoria Ivashina. 2012. "Reaching for Yield in the Bond Market." Working Paper.

———. 2013. "Reaching for Yield in Hot Credit Markets." *VoxEU.Org* (blog). May 3, 2013. https://voxeu.org/article/measuring-reach-yield.

Bee, Charles Adam, and Joshua Mitchell. 2017. "Do Older Americans Have More Income Than We Think?" *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3015870.

Beer, Christian, and Ernest Gnan. 2015. "Implications of Ultra-Low Interest Rates for Financial Institutions' Asset Liability Management–a Policy-Oriented Overview." *Monetary Policy & the Economy, Oesterreichische Nationalbank (Austrian Central Bank)*, no. 2: 52–76. https://ideas.repec.org/a/onb/oenbmp/y2015i2b3.html.

Bernanke, Ben. 2005. "The Global Saving Glut and the U.S. Current Account Deficit." Richmond, VA: The Sandridge Lecture, Virginia Association of Economists. https://www.federalreserve.gov/boarddocs/speeches/2005/200503102/.

———. 2015. "Why Are Interest Rates so Low, Part 3: The Global Savings Glut." *Brookings* (blog). April 1, 2015. https://www.brookings.edu/blog/ben-bernanke/2015/04/01/why-are-interest-rates-so-low-part-3-the-global-savings-glut/.

Biggs, Andrew G. 2014. "The Public Pension Quadrilemma: The Intersection of Investment Risk and Contribution Risk." *The Journal of Retirement*.

Blanchett, David, Michael Finke, and Wade Pfau. 2018. "Low Returns and Optimal Retirement Savings." In *How Persistent Low Returns Will Shape Saving and Retirement*, edited by Olivia S. Mitchell, Robert Clark, and Raimond Maurer. http://www.oxfordscholarship.com/view/10.1093/oso/9780198827443.001.0001/oso-9780198827443-chapter-3.

Boubaker, Sabri, Dimitrios Gounopoulos, Duc Khuong Nguyen, and Nikos Paltalidis. 2017. "Assessing the Effects of Unconventional Monetary Policy and Low Interest Rates on Pension Fund Risk Incentives." *Journal of Banking & Finance* 77 (Supplement C): 35–52. https://doi.org/10.1016/j.jbankfin.2016.12.007.

Boyd, Donald, Gang Chen, and Yimeng Yin. 2019. “Public Pension Risk-Sharing Mechanisms and Their Potential Impacts.” 53. Hutchins Center Working Paper. Brookings Institution.

Boyd, Donald, and Yimeng Yin. 2017. “How Public Pension Plan Investment Risk Affects Funding and Contribution Risk.” Rockefeller Institute of Government.

Brynjolfsson, Erik, and Andrew McAfee. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*. The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. New York, NY, US: W. W. Norton & Company.

Byrne, Alistair, and Catherine Reilly. 2018. “Investing for Retirement in a Low Returns Environment: Making the Right Decisions to Make the Money Last.” In *How Persistent Low Returns Will Shape Saving and Retirement*, edited by Olivia S. Mitchell, Robert Clark, and Raimond Maurer. Oxford University Press. https://www.oxfordscholarship.com/view/10.1093/oso/9780198827443.001.0001/oso-9780198827443-chapter-5.

Council of Economic Advisors. 2015. “Long-Term Interest Rates: A Survey.” Council of Economic Advisors. https://obamawhitehouse.archives.gov/sites/default/files/docs/interest_rate_report_final.pdf.

Deloitte. 2015. “Financial Reporting Considerations Related to Pension and Other Postretirement Benefits.” Financial Reporting Alert 15. Deloitte.

Dushi, Irena, Howard M. Iams, and Brad Trenkamp. 2017. “The Importance of Social Security Benefits to the Income of the Aged Population.” *Social Security Bulletin* 77 (2): 28.

Eggertsson, Gauti B., Neil R. Mehrotra, and Jacob A. Robbins. 2019. “A Model of Secular Stagnation: Theory and Quantitative Evaluation.” *American Economic Journal: Macroeconomics* 11 (1). https://doi.org/10.1257/mac.20170367.

Eichengreen, Barry. 2015. “Secular Stagnation: The Long View.” Working Paper 20836. NBER Working Paper Series. National Bureau of Economic Research. https://www.nber.org/papers/w20836.pdf.

Employee Benefits Security Administration. 2019. “Private Pension Plan Bulletin Historical Tables and Graphs 1975-2017.” Employee Benefits Security Administration, United States Department of Labor.

Farrell, James, and Daniel Shoag. 2016. “Simulating Public Pension Funding Stress with Realistic Shocks.” Working Paper.

Fichtner, Jason J., and Jason S. Seligman. 2018. “Retirement Saving and Decumulation in a Persistent Low-Return Environment.” In *How Persistent Low Returns Will Shape Saving and Retirement*, edited by Olivia S. Mitchell, Robert Clark, and Raimond Maurer. Vol. 1. Oxford University Press. http://www.oxfordscholarship.com/view/10.1093/oso/9780198827443.001.0001/oso-9780198827443-chapter-9.

Finke, Michael, Wade D. Pfau, and David M. Blanchett. 2013. “The 4 Percent Rule Is Not Safe in a Low-Yield World.” *Journal of Financial Planning* 26 (6): 46–55. https://www.onefpa.org/journal/Pages/The%204%20Percent%20Rule%20Is%20Not%20Safe%20in%20a%20Low-Yield%20World.aspx.

Fischer, Stanley. 2016. “Why Are Interest Rates So Low? Causes and Implications. Remarks by Stanley Fischer, Vice Chairman, Board of Governors of the Federal Reserve System.” Presented at the Economic Club of New York, October 17. https://www.federalreserve.gov/newsevents/speech/fischer20161017a.htm.

Gordon, Robert J. 2012. “Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds.” *NBER Working Paper 18315*, August. https://doi.org/10.3386/w18315.

———. 2014. “The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections.” *NBER Working Paper No. 19895*, February. https://doi.org/10.3386/w19895.

Gorodnichenko, Yuriy, Jae Song, and Dmitriy Stolyarov. 2013. “Macroeconomic Determinants of Retirement Timing.” Working Paper 19638. National Bureau of Economic Research. https://doi.org/10.3386/w19638.

Hamilton, James D., Ethan S. Harris, Jan Hatzius, and Kenneth D. West. 2016. “The Equilibrium Real Funds Rate: Past, Present, and Future.” *IMF Economic Review* 64 (4): 660–707.

Horneff, Vanya, and Raimond Maurer. 2018. “How Persistent Low Expected Returns Alter Optimal Life Cycle Saving, Investment, and Retirement Behavior.” In *How Persistent Low Returns Will Shape Saving and Retirement*, edited by Olivia S. Mitchell, Robert Clark, and Raimond Maurer. Oxford University Press. https://www.oxfordscholarship.com/view/10.1093/oso/9780198827443.001.0001/oso-9780198827443-chapter-8.

Ilmanen, Antti, and Matthew Rauseo. 2018. “Intelligent Risk Taking: How to Secure Retirement in a Low Expected Return World.” In *How Persistent Low Returns Will Shape Saving and Retirement*, 29. Oxford University Press.

IMF. 2014a. “Perspectives on Global Real Interest Rates.” In *IMF World Economic Outlook*. http://www.imf.org/external/Pubs/ft/weo/2014/01/pdf/c3.pdf.

———. 2014b. “Chapter 3. Is It Time for an Infrastructure Push? The Macroeconomic Effects of Public Investment.” In . Internat. Monetary Fund. https://www.elibrary.imf.org/view/IMF081/21398-9781498331555/21398-9781498331555/ch3.xml.

———. 2017. “Low Growth, Low Interest Rates, and Financial Intermediation (Chapter 2).” In *Global Financial Stability Report: Getting the Policy Mix Right*. International Monetary Fund. https://www.imf.org/~/media/Files/Publications/GFSR/2017/April/ch2.ashx.

Jordà, Òscar, Sanjay R. Singh, University of California, Davis, Alan M. Taylor, and University of California, Davis. 2020. “Longer-Run Economic Consequences of Pandemics.” *Federal Reserve Bank of San Francisco, Working Paper Series*, March, 01–16. https://doi.org/10.24148/wp2020-09.

Laubach, Thomas, and John C. Williams. 2003. “Measuring the Natural Rate of Interest.” *The Review of Economics and Statistics* 85 (4): 1063–70. https://www.jstor.org/stable/3211826.

———. 2016. “Measuring the Natural Rate of Interest Redux.” *Business Economics* 51 (2): 57–67.

Levine, David N., and Lars C. Golumbic. 2017. “Freezing Defined Benefit Pension Plans – The Process & Post-Freeze Issues.” Groom Law Group. https://www.groom.com/wp-content/uploads/2017/09/33_FreezeArticle-PostPPA-Final.pdf.

Lu, Lina, Matthew Pritsker, Andrei Zlate, Ken Anadu, and James Bohn. 2019. “Reach for Yield by U.S. Public Pension Funds.” *Federal Reserve Bank of Boston* Working Paper SRA 19-02 (July). https://doi.org/10.17016/FEDS.2019.048.

Malkiel, Burton G. 2014. “Is Smart Beta Really Smart?” *The Journal of Portfolio Management* 40 (5): 127–34. https://doi.org/10.3905/jpm.2014.40.5.127.

Michael Ng and David Wessel. 2018. “The Hutchins Center Explains: The Neutral Rate of Interest.” October 22, 2018. https://www.brookings.edu/blog/up-front/2018/10/22/the-hutchins-center-explains-the-neutral-rate-of-interest/.

Mokyr, Joel. 2014. “The Next Age of Invention.” *City Journal*, 2014. https://cpb-us-e1.wpmucdn.com/sites.northwestern.edu/dist/3/1222/files/2016/06/The-Next-Age-of-Invention-Technologys-future-is-brighter-than-pessimists-allow-24f8u5v.pdf.

Monahan, Amy B. 2011. “Statutes as Contracts-The California Rule and Its Impact on Public Pension Reform.” *Iowa L. Rev.* 97: 1029. http://heinonlinebackup.com/hol-cgi-bin/get_pdf.cgi?handle=hein.journals/ilr97&section=36.

———. 2015. “State Fiscal Constitutions and the Law and Politics of Public Pensions.” *University of Illinois Law Review*, 117. http://heinonlinebackup.com/hol-cgi-bin/get_pdf.cgi?handle=hein.journals/unilllr2015&section=7.

Munnell, Alicia H., and Anthony Webb. 2015. “The Impact of Leakages from 401(k)s and IRAs.” CRR WP 2015-2. Center for Retirement Research at Boston College. https://crr.bc.edu/wp-content/uploads/2015/02/wp_2015-2.pdf.

Munnell, Alicia H., Anthony Webb, and Rebecca Cannon Fraenkel. 2013. “The Impact of Interest Rates on the National Retirement Risk Index.” 13–9. Center for Retirement Research at Boston College. http://boots.bc.edu/islandora/object/bc-ir:103846/datastream/PDF/download/citation.pdf.

Newell, Richard G., and William A. Pizer. 2003. “Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations?” *Journal of Environmental Economics and Management* 46 (1): 52–71. https://doi.org/10.1016/S0095-0696(02)00031-1.

OASDI Board of Trustees. 2019. “The 2019 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds.” The Board of Trustees, Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds.

Olshansky, S. Jay, Toni Antonucci, Lisa Berkman, Robert H. Binstock, Axel Boersch-Supan, John T. Cacioppo, Bruce A. Carnes, et al. 2012. “Differences In Life Expectancy Due To Race And Educational Differences Are Widening, And Many May Not Catch Up.” *Health Affairs* 31 (8): 1803–13. https://doi.org/10.1377/hlthaff.2011.0746.

Poterba, James. 2014. “Retirement Security in an Aging Society.” w19930. Cambridge, MA: National Bureau of Economic Research. https://doi.org/10.3386/w19930.

PwC. 2019. “Detailing the New Accounting for Long-Duration Contracts of Insurers (Modifed as of May 16, 2019).” In Depth： A Look at Current Financial Reporting Issues. National Professional Services Group. https://www.pwc.com/us/en/cfodirect/assets/pdf/in-depth/us-2018-20-long-duration-contracts-asu-2018-12.pdf.

Rachel, Lukasz, and Thomas Smith. 2015. “Secular Drivers of the Global Real Interest Rate.” Bank of England Staff Working Paper 571. https://www.bankofengland.co.uk/working-paper/2015/secular-drivers-of-the-global-real-interest-rate.

Syverson, Chad. 2013. “Will History Repeat Itself? Comments on ‘Is the Information Technology Revolution Over?’” *International Productivity Monitor* 25: 37–40. https://ideas.repec.org/a/sls/ipmsls/v25y20134.html.

Thwaites, Gregory. 2015. “Why Are Real Interest Rates so Low? Secular Stagnation and the Relative Price of Investment Goods.” *Working Paper*. https://doi.org/10.2139/ssrn.2687998.

VanDerhei, Jack. 2013. “What a Sustained Low-Yield Rate Environment Means for Retirement Income Adequacy: Results from the 2013 EBRI Retirement Security Projection Model.” Vol. 34, no. 6. Employee Benefit Research Institute Notes. https://www.ebri.org/docs/default-source/ebri-notes/ebri_notes_06_june-13_intrts_accs.pdf?sfvrsn=472e362f_0.

Williams, John C. 2003. “The Natural Rate of Interest.” 2003–32. FRBSF Economic Letter. Federal Reserve Bank of San Francisco. https://www.frbsf.org/economic-research/files/el2003-32.pdf.

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