ŁUKASZ RACHEL
Bank of England
LAWRENCE H. SUMMERS
Harvard University

On Secular Stagnation in the Industrialized World

ABSTRACT We argue that the economy of the industrialized world, taken as a whole, is currently—and for the foreseeable future will remain—highly prone to secular stagnation. But for extraordinary fiscal policies, real interest rates would have fallen much more and be far below their current slightly negative level, current and prospective inflation would be further short of the 2 percent target levels, and past and future economic recoveries would be even more sluggish. We start by arguing that, contrary to current practice, neutral real interest rates are best estimated for the bloc of all industrial economies, given capital mobility between them and the relatively limited fluctuations in their aggregated current account. We show, using standard econometric procedures and looking at direct market indicators of prospective real rates, that neutral real interest rates have declined by at least 300 basis points over the last generation. We argue that these secular movements are in larger part a reflection of changes in saving and investment propensities rather than the safety and liquidity properties of Treasury instruments. We highlight the observation that, ceteris paribus, levels of government debt, the extent of pay-as-you-go old-age pensions, and the insurance value of government health

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care programs have all operated to raise neutral real rates. Using estimates drawn from the literature—as well as two general equilibrium models emphasizing, respectively, life-cycle heterogeneity and individual uncertainty—we suggest that the "private sector neutral real rate" may have declined by as much as 700 basis points since the 1970s. The extent of the substantial shifts in private saving and investment propensities over time has been obscured by the impact of this decline in real rates. Our diagnosis necessitates radical revisions in the conventional wisdom about monetary policy frameworks, the role of fiscal policy in macroeconomic stabilization, and the appropriate level of budget deficits, as well as social insurance and regulatory policies. To that end, much more of creative economic research is required on the causes, consequences, and policy implications of the pervasive private sector excess saving problem.

Long after the 2008 financial crisis, real interest rates in the economies of the industrialized world remain very low by recent historical standards, central banks' balance sheets are inflated, government debt and deficit levels are high, and yet nominal GDP growth remains too low for the achievement of 2 percent inflation targets. This has led to a revival of interest in the secular stagnation hypothesis, according to which a chronic tendency of private investment to be insufficient to absorb private saving leads, in the absence of extraordinary policies, to extremely low interest rates, inflation that is lower than desirable, and sluggish economic growth.

Much of the discussion has focused on movements in what has come to be called "*R*-star" (R^*)—Knut Wicksell's (1898) neutral or natural interest rate, at which investment fully absorbs saving at full employment. Estimating the level and change in the neutral real interest rate has become a cottage industry, and the neutral real interest rates have come to play a prominent role in policy discussions.

Policymakers have taken notice of significant movements in the apparent neutral real rate. Federal Reserve chairman Jerome Powell's recent remark that the nominal federal funds rate—at the time, set at between 2 and 2.25 percent—was "just below the broad range of estimates of the level that would be neutral for the economy" puts the level of the real neutral rate in the United States at about 0.5 percent (Powell 2018). In Japan, which has been faced with very low neutral rates for a long time, the central bank has engaged in aggressive monetary easing, including directly targeting long-term interest rates (Kuroda 2016). Similarly, European policymakers have highlighted the equilibrium rate of interest as the key policy variable (Constâncio 2016; Draghi 2016), while the recent paper from the European Central Bank (ECB 2018, 5) concluded that "most of our estimates of R^* for the euro area have been negative regardless of the type of model used."

Our main contribution in this paper is to recognize that the neutral real interest rate is not a deep structural feature of an economy but instead reflects both how it is embedded in the global economy and how fiscal policy is set. The neutral interest rate for an individual open economy will depend on its current account position, which in turn depends on its real exchange rate, which is itself a function of current and prospective real interest rates. It is therefore hard to interpret estimates of the neutral interest rate for a single open economy. We therefore estimate the neutral real rate for the industrial economies taken in the aggregate. We show that our aggregate can to a good approximation be thought of as a closed economy. Our estimates suggest that the advanced economies' neutral real rate has declined by over 300 basis points since 1980 and is now in the neighborhood of zero.

We emphasize that this significant decline would have been substantially greater except for the buildup of government deficits and debt over the last generation and the increasing generosity of social insurance programs, particularly increases in old-age pensions. Although the uncertainties inherent in any calculation are enormous, we estimate that, with constant fiscal and social insurance policies, neutral real interest rates would have declined by about 700 basis points and would now be very substantially negative. Equivalently, our estimate is that, with constant real interest rates, the gap between private saving and private investment rates in the industrialized world has widened by over 10 percent of GDP.

Our findings raise the possibility that the industrialized world as a whole will increasingly in the years ahead face the challenges that Japan has faced over the last decade. The emergence of a large gap between private saving and private investment at normal interest rates is the essence of secular stagnation. We believe that it has profound implications for macroeconomics, pointing to the need for a "new Keynesian economics" that bears a substantial resemblance to the old Keynesian economics of the 1950s and 1960s. It suggests the need for substantial revisions in the conventional wisdom regarding monetary policy based on inflation targeting, the role of fiscal policy in macroeconomic stabilization, and the appropriate level of budget deficits and possibly social insurance and regulatory policies.

We make two methodological choices in this paper. First, we show that the current account balance of the advanced economies, taken as a whole, has been small and stable over the past four decades; and, given this, we argue that it is preferable to view the advanced economies as a fully integrated bloc—a departure from the literature that tends to focus on individual countries when estimating neutral real rates. Second, we show that the dominant force driving the downward trend in real rates is common to a wide range of asset classes with differing characteristics. This explains the focus in the paper on forces driving the balance of desired saving and investment, as opposed to those that relate to the liquidity or safety attributes of any particular asset class.

To set the scene, we present the results from the econometric exercise estimating R^* for the industrialized world as a whole, which are that the advanced economies' neutral rate—which we call AE R^* for brevity—has declined by about 300 basis points over the past half century. This large decline in the relative price of consumption today versus consumption tomorrow has meant that the observed saving and investment ratios remained broadly stable. In other words, the large decline in R^* had been a symptom of the excess saving problem, and has masked the underlying shifts in desired saving and investment propensities. To illustrate the magnitude of this problem, we calculate a counterfactual gap between saving and investment propensities under the hypothetical scenario of a constant interest rate. Our calculations suggest that, if interest rates had not declined, the excess saving gap in the advanced economies taken together would be very large—likely, north of 10 percent of GDP. In the remainder of the paper, we study the various factors that underlie this phenomenon.

Our main contribution is the analysis of public policies and their impact on R^*. We show that all the available evidence points to a sizable positive influence: that the secular trends in public policies in the industrialized world have helped to reduce the excess saving problem.

Policies may affect the interest rate through a range of channels. We review these mechanisms, focusing on the role of government borrowing, which is the main focus of both theoretical and empirical literatures in macroeconomics. We then survey the existing empirical estimates of the impact of government debt on interest rates. Simple calculations using observed estimates of the impact of deficits on interest rates suggest that the increase from 18 percent to 68 percent in the public debt-to-GDP ratio of the advanced economies should, ceteris paribus, have raised real rates by between 1.5 and 2 percentage points over the last four decades. A similar calculation based on the existing empirical literature on the link between Social Security and private saving suggests that the increase of about 3 percentage points in Social Security spending to GDP may have increased interest rates by a further 50–100 basis points.[1] Increasing old-age health expenditures likely have had a further positive impact. This analysis leads to the conclusion that the fall in real long-term interest rate observed in the data masks an even more dramatic decline in the equilibrium "private sector" real rate.

To build further understanding of the mechanisms involved and to cross-check the magnitudes of these effects, we study these phenomena in a dynamic general equilibrium framework. We construct two tractable models, each one designed to capture different channels through which policies play out in equilibrium.

Building on the work of Mark Gertler (1999), the first model captures life-cycle behavior, with workers saving for retirement and retirees decumulating their wealth. Ricardian equivalence—the proposition that government borrowing decisions are neutral in equilibrium—does not hold in our model, making the effects of a range of government policies on real rates nontrivial. Specifically, after a change in government finances, there is some Ricardian offset, but unlike in the representative agent model, this offset is incomplete. We simulate the model with the profiles of government debt, government spending, Social Security, and old-age health care expenditures that match the experience of developed economies over the past 40 years. These simulations suggest that shifts in these policies have pushed equilibrium real rates up by about 3 percentage points between the early 1970s and today.[2]

Our second model focuses on individual risks and precautionary behavior, channels that are absent from the life-cycle model. When people cannot fully insure against future uncertainty surrounding their individual income, they value holding financial assets such as government debt for the purposes of self-insurance. This demand for assets is, in part, satisfied by governments issuing debt; and the more debt that is issued, the lower is its price and the higher is the interest rate. Our numerical explorations suggest that the increase in the supply of government bonds has pushed interest rates up by about 40–70 basis points through this channel.[3] Overall, then, we find that public policies may have pushed interest rates up by about 3.5–4.0 percentage points.[4]

1. For descriptions of the calculations that yield these numbers, see the end of section IV.

2. This number is derived from 3.6 – 0.4 = 3.2, rounded to 3, in the incomplete markets model shown in table 7 below.

3. This range reflects the second and third columns of table 7 below.

4. This refers to the italicized 3.6 in the middle column of table 7 below.

In the final section of the paper, we validate our models by using them to quantify the impact of some of the private sector forces that the existing literature suggested have been important in driving the decline in the neutral real interest rates. Specifically, we show that the estimates of the impact of the decline in expected future growth, the demographic shifts, and the rise in income inequality on neutral real rates are well within the ranges of estimates found by other researchers. This lends credibility to the core contribution of our paper, namely, the quantification of the boost that the public sector gave to neutral real rates in the advanced economies.

The remainder of this paper is structured as follows. Section I discusses two methodological issues underlying our analysis. Section II contains the results of the estimation of the long-term equilibrium real interest rate for the advanced economies. Section III starts with a discussion of the channels through which government policy influences the equilibrium rate; it then summarizes the results from the existing empirical literature that estimates the size of these effects; and finally, it uses these elasticities to calculate several back-of-the-envelope measures of how policies have affected AE R^*. In section IV, we set up the two general equilibrium models and use them to study the impact of government policies. Section V validates the models by using them to assess the impact of secular demographic changes, the slowdown in technology, and the rise in inequality. Section VI concludes.

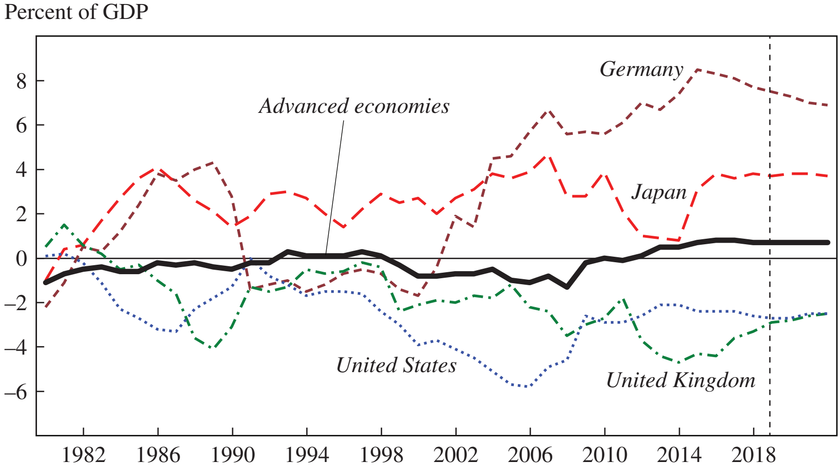
I. Understanding Neutral Real Interest Rates

We begin with a discussion of two methodological choices that permeate the analysis in this paper and where our approach differs from that of some other studies. The first is our treatment of the advanced economies as a bloc rather than focusing on individual countries. The second is our view that the decline in neutral real interest rates can be understood through the balance between desired saving and investment. This view leads us to focus on the macroeconomic forces affecting a broad range of returns, rather than on factors driving spreads or premia on particular financial instruments, and to deemphasize the importance of "safe asset shortage" theories for understanding the broad low frequency movements in interest rates.

I.A. The Advanced Economies as a Bloc

Our analysis assumes that the advanced economies bloc is fully integrated. In practice, we use aggregated data for all the developed countries (that is, the members of the Organization for Economic Cooperation and

Figure 1. The Aggregated Current Account of the Advanced Economies Bloc, and of Selected Individual Economies, 1980–2022[a]



Source: International Monetary Fund data.

a. The heavy solid line shows the current account for the advanced economies as defined by the International Monetary Fund.

Development, the OECD, whenever data are available), "as if" the bloc were a single economic entity. We treat this bloc as a large, closed economy with perfect internal capital mobility.

The perfect internal capital mobility assumption is justified by very large gross and substantial net capital flows between developed economies, strong commonality in trends in long-term real rates observed in the data, and high correlations in the performance of stock markets (Claessens and Kose 2017).

The assumption that the industrial economies as a whole can be treated as a closed economy is justified by the observation that their aggregate current account balance has fluctuated by less than 1.5 percent of GDP over the last 40 years (figure 1). Note also that the recent trend has been upward, suggesting that international capital flows have if anything operated to raise interest rates over time.

More importantly, our approach avoids the erroneous assumption implicit in much of the country-level analysis that the economies under consideration are closed. Current account balances for individual economies are large and variable; they are endogenous outcomes of the saving and investment propensities within each economy relative to the global average. For example, a country that runs a chronic trade surplus will be found to have a neutral real rate at a level where domestic demand is short of potential output, and the reverse will be true for a country running a chronic trade deficit. External balances should therefore be taken into account in such country-level analyses. We instead posit that the developed economies, taken together, experience structural excess saving, reflected in the trend decline in real interest rates without a discernible trend in their current account. At this level of aggregation, the country-level differences wash out, and econometric and theoretical analyses based on a closed-economy assumption are more credible.

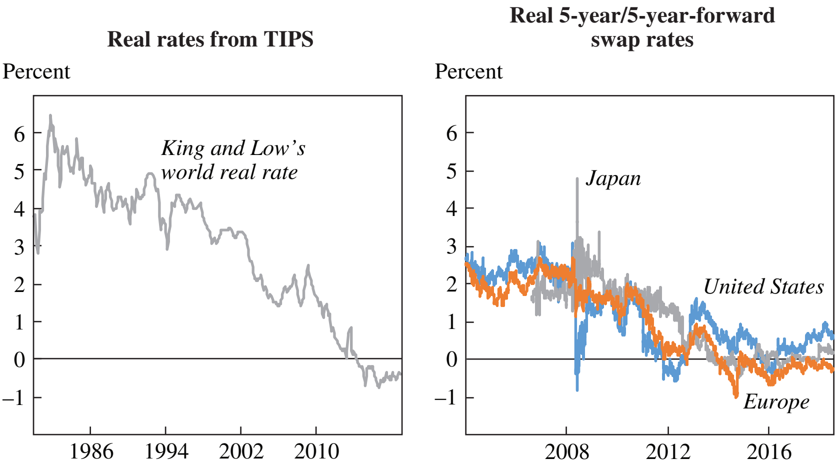
I.B. Excess of Desired Saving over Investment, and the Role of the Safety and Liquidity Premium

We carry out our analysis on the basis of the premise that, for analyzing long-term trend movements in neutral real rates, it is appropriate to focus on factors relating to saving and investment propensities rather than issues of liquidity or risk. Consequently, our analysis abstracts from aggregate uncertainty and differing levels of liquidity of various assets.

Several facts support our approach. First, the decline in rates on highly liquid securities tracks declines in yields on relatively illiquid government-indexed bonds and real swaps (figure 2), suggesting that the liquidity characteristics of government bonds play only a secondary role. Second, even in the United States, there has been little trend movement in spreads between Treasury securities and corporate securities in given rating classes, and though the pickup in equity risk premia has been somewhat more pronounced, it is nonetheless small relative to the decline in real interest rates over the decades (the left panel of figure 3). In any case, it is not clear whether one should interpret any changes in spreads as driven by changes in risk preferences or rather a result of changes in how risky the underlying assets are perceived to be. For instance, the recent global financial crisis has likely led to a reassessment of what it means that an asset is rated AAA, whereas the dot-com bubble appears to have had a lasting impact on the pricing of equities.

To get a sense of the relative importance of the trend decline in real returns versus changes in the dispersion between them, we summarize the patterns in the U.S. data using principal components analysis (PCA), which is a statistical procedure that summarizes the information in the correlated data series with a smaller set of mutually uncorrelated variables. The components are ordered in such a way that the first explains the highest share of variance in the data. The PCA thus offers a way of quantitatively distinguishing between the excess saving story, which drives the common

Figure 2. Real Interest Rates Estimated from Inflation-Linked Bonds and Forward Swaps, 1980–2022[a]



Sources: DataStream; Federal Reserve Bank of Saint Louis; Bloomberg; King and Low (2014).

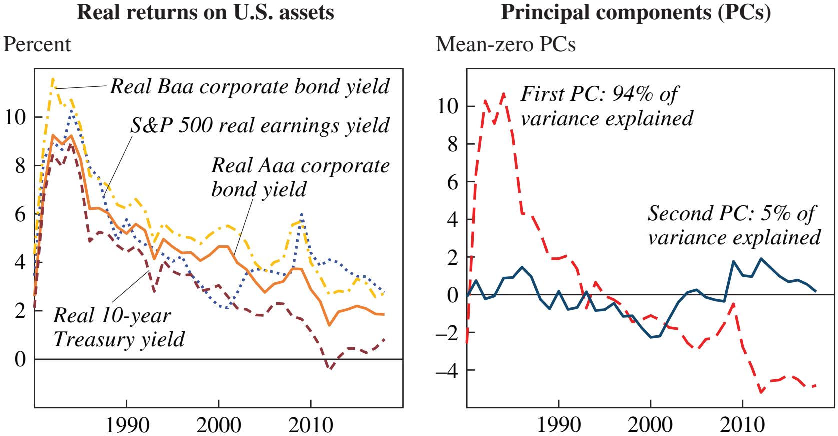
a. TIPS = Treasury Inflation-Protected Securities. The world real rate is calculated using the methodology of King and Low (2014): it is the average of interest rates on inflation-protected government debt securities across the Group of Seven, excluding Italy. Data are from DataStream and from an unbalanced panel. In particular, the figure relies on the U.K. inflation-indexed gilts in the early part of the sample. The U.S. TIPS yield is the yield on a constant maturity, 10-year Treasury Inflation-Indexed Security, retrieved from the FRED database of the Federal Reserve Bank of Saint Louis (code DFII10). Swaps data are from Bloomberg.

trend across all real rates, and the safety and liquidity story, which drives the dispersion between them.

When we perform this PCA on the set of U.S. real yields that span government debt, corporate bond and equity markets, we obtain results that are telling: the first principal component, which picks up the downward trend visible in all returns, explains 94 percent of the total variance in the underlying series (the right panel of figure 3). The second principal component, which appears to be related to the increase in the "convenience yield," explains only 5 percent. The very large share of total variance in the data accounted for by the common downward trend supports our focus in this paper.

This focus is also consistent with the finance literature that investigates the decline in neutral real interest rates in the presence of term and liquidity premia (Christensen and Rudebusch 2019; D'Amico, Kim, and Wei 2018). The "safe asset" literature finds a somewhat larger role for the convenience yield; but even there, the magnitudes are generally rather small relative

Figure 3. Real Returns in the United States: Data and Principal Components, 1980–2022[a]



Sources: FRED database of the Federal Reserve Bank of Saint Louis; Robert Shiller; authors' calculations.

a. The 10-year Treasury real yield post-2004 is the yield on 10-Year Treasury, Inflation-Indexed Security (code: DFII10). Before 2004, it is the nominal yield (GS10) minus inflation expectations measure from the Michigan survey (code: MICH). The real corporate yields are nominal yields (codes: Aaa, Baa), minus inflation expectations from Treasury Inflation-Protected Securities (post-2004) or from the Michigan survey (pre-2004). The real earnings yield is the inverse of the cyclically adjusted, total return price real earnings ratio from Robert Shiller (http://www.econ.yale.edu/~shiller/data.htm).

to the large trend decline in real rates. For example, using very different approaches, Marco Del Negro and others (2018) and Rachel and Thomas Smith (2017) concluded that the rise in the spread between risky and risk-free rates accounted for about 70 basis points of the decline in risk-free rates. This is less than a quarter of the overall decline in real neutral rates since 1980.

In summary, much of the available evidence points to a common underlying decline in real interest rates across different financial assets. This suggests that saving and investment propensities and how they have changed over time are the dominant underlying drivers of such a trend.

II. Estimating the Advanced Economies' Equilibrium Real Interest Rate

In this section, we estimate the natural rate of interest for the advanced economies, adopting what is perhaps the most celebrated applied empirical model designed for this purpose, which was originally developed by

Thomas Laubach and John Williams (2003) (hereafter, the Laubach-Williams model) and has recently been reapplied internationally by Kathryn Holston, Laubach, and Williams (2017b). Conceptually, this approach draws on two strands of the literature. By following Wicksell's (1898) definition of the natural rate as the rate consistent with stable inflation and output remaining at an equilibrium ("potential") level, it is well aligned with modern monetary theory, as presented by Carl Walsh (1998), Michael Woodford (2003), and Galí (2008). This literature is primarily concerned with fluctuations at the business-cycle frequency, where shocks move the economy around a stable steady state. In addition to these business-cycle shocks, the framework employed here is flexible enough to capture secular forces that affect the steady state.

II.A. A Sketch of the Model and the Estimation Procedure

Our approach to estimating the Laubach-Williams model is deliberately off the shelf: we use exactly the same procedures as the recent papers in that literature. Out contribution is solely to perform this exercise on the bloc of advanced economies as a whole. As such, we do not take a stance on the performance of the model, although we discuss some of the issues below.

The philosophy of the Laubach-Williams method is that the natural rate of interest is an endogenous object determined in general equilibrium, and as such it will depend on a host of socioeconomic forces, such as trends in preferences, technology, demography, and policies and policy frameworks. It is impossible to know and measure all the relevant factors. At the same time, a robust prediction of most workhorse macroeconomic models is that the natural rate should vary together with the economy's expected future trend growth rate.[5] To reflect the dependence on growth and on a range of possibly unknown other factors, the Laubach-Williams model assumes that the natural rate, denoted r_t^*, depends on the estimated trend growth rate of potential output g_t and a time-varying unobserved component z_t that captures the effects of other unspecified influences:

$$r_t^* = g_t + z_t. \tag{1}$$

The model further assumes that both the growth rate g_t and the unobserved component z_t are random walk processes:

$$g_t = g_{t-1} + \epsilon_{g,t} \qquad \epsilon_g \sim N\left(0, \sigma_g^2\right) \text{ and} \tag{2}$$

5. We discuss the rationale for this link in some detail in section IV.

$$z_t = z_{t-1} + \epsilon_{z,t} \qquad \epsilon_z \sim N(0, \sigma_z^2). \tag{3}$$

The model specification also admits shocks to the level of potential output. Denoting by y_t^* the natural logarithm of potential output at time t,

$$y_t^* = y_{t-1}^* + g_{t-1} + \epsilon_{y^*,t} \qquad \epsilon_{y^*} \sim N(0, \sigma_{y^*}^2). \tag{4}$$

In short, the Laubach-Williams model views the natural rate as the sum of two independent random walks. To achieve identification, Laubach and Williams add two further equations to the model. First, they specify a simple reduced-form equation relating output gap to its own lags, a moving average of the lagged real funds rate gap, and a serially uncorrelated error:

$$y_t = y_t^* + a_1(y_{t-1} - y_{t-1}^*) + a_2(y_{t-2} - y_{t-2}^*) + \frac{a_r}{2}\sum_{j=1}^{2}(r_{t-j} - r_{t-j}^*) + \epsilon_{y,t} \tag{5}$$

$$\epsilon_y \sim N(0, \sigma_y^2).$$

The key in this estimated investment-saving relation is the a_r coefficient, which we expect to be negative. Second, Laubach and Williams add the reduced-form Phillips curve to the model, linking current inflation, π_t, to lagged inflation and the output gap:

$$\pi_t = b_\pi \pi_{t-1} + (1 - b_\pi)\pi_{t+2,4} + b_y(y_{t-1} - y_{t-1}^*) + \epsilon_{\pi,t} \tag{6}$$

$$\epsilon_\pi \sim N(0, \sigma_\pi^2),$$

where the standard theory would suggest that coefficient b_y is positive.

The system presented above can be written in a state-space form, and the Kalman Filter can be used to estimate the unobservable states. To estimate the model, we use data for the advanced economies as a bloc. The data comprise the log of quarterly real GDP, core inflation, and long-term interest rates over the period 1971:Q1–2017:Q4 for the aggregated sample of OECD countries. The interest rate series is the average of long-term nominal interest rates across an unbalanced panel of 36 OECD economies.[6] To calculate real rates, we subtract from nominal rates a simple measure of expected inflation, constructed as the moving average of past core inflation

6. The results are robust to using weighted average or median of the interest rates across countries. Given the strong co-movement, these interest rate series are close to each other.

Table 1. State-Space Model Parameter Estimates

*Parameter point estimates (*t *statistics in parentheses)*							
a_1	a_2	a_r	b_π	b_y	σ_y	σ_g	σ_z
1.71	–0.79	–0.04	0.90	0.09	0.25	1.03	0.31
(21.65)	(10.28)	(2.3)	(17.78)	(2.06)	(5.30)	(29.63)	(9.38)

Average standard errors around the estimates		
y^*	r^*	g
1.19	3.12	0.16

Source: Authors' calculations.

rates, in line with the work of Holston, Laubach, and Williams (2017b). See online appendix A for further details on the data and the estimation procedure.[7]

II.B. Results

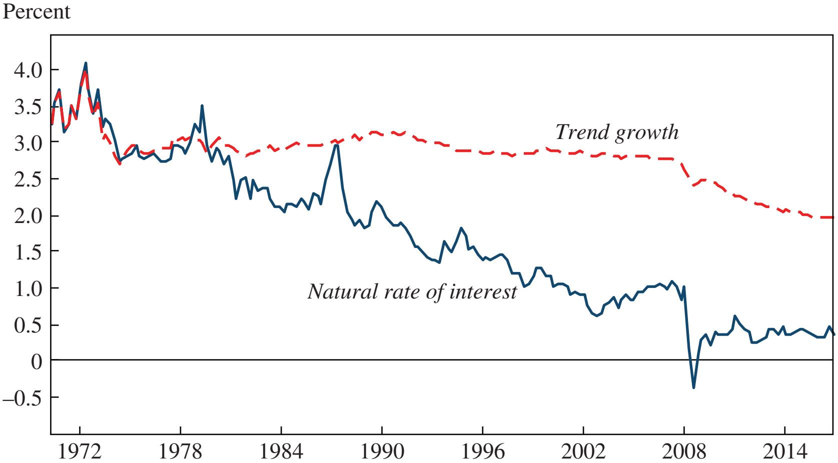
Table 1 shows the coefficients of the estimated model. The point estimates are all significantly different from zero and have expected signs. In particular, a positive interest rate gap reduces the output gap, while a positive output gap raises inflation. Table 1 also shows the standard errors around the estimated trends, which are large, especially those around the estimates of the equilibrium real rate. These wide standard error bands are not specific to our results—indeed, they are a norm in the literature. For instance, Holston, Laubach, and Williams (2017b) report similarly large errors for individual economies. These errors are, to an extent, an artifact of the long sample, as they reflect the cumulative uncertainty of the underlying drivers of equilibrium rates. Nonetheless, these large error bands should act as a reminder of the high uncertainty surrounding the econometric estimates of equilibrium interest rates.

Figure 4 contains the key results. According to our estimates, AE R^* declined steadily from the 1980s onward, and fell sharply during the 2008 global financial crisis.[8] It then stabilized at low levels (0.5 percent). The estimated growth rate of potential output was broadly stable up until the crisis, and declined during the crisis by about 1 percentage point. Thus,

7. The online appendixes for this and all other papers in this volume may be found at the *Brookings Papers* web page, www.brookings.edu/bpea, under "Past BPEA Editions."

8. Estimates for the first decade should be taken with a grain of salt, because the model is less accurate during the first few years of the sample when the initial conditions play a larger role.

Figure 4. Changes in AE R^* and Trend Growth, 1971–2016



Source: Authors' calculations.

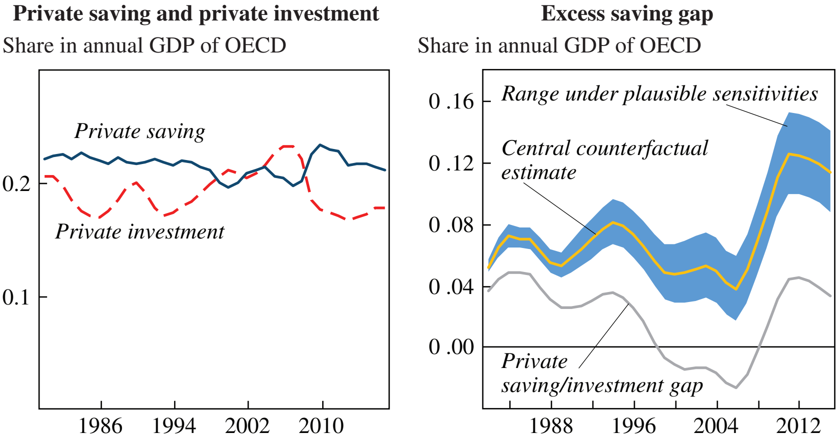
the model suggests that the bulk of the decline in real interest rates is due to factors other than trend GDP growth. This is consistent with the literature that finds only a loose connection between actual GDP growth and interest rates in the historical data (Hamilton and others 2016).

These results corroborate other existing findings in the literature. In particular, Holston, Laubach, and Williams (2017b) estimated declines in real rates for the United States, Canada, the euro area, and the United Kingdom of about 2.3 percentage points between 1990 and 2017; for comparison, the decline over this period for the advanced economies as a whole that we estimate here is about 2 percentage points.

Overall, despite high uncertainty surrounding the point estimates of these trends, we interpret the results of this exercise as broadly in line with the country-level findings in the literature. Indeed, given the high level of aggregation, we find it encouraging that the estimated unobservables do well at picking up the main events, such as the global financial crisis, during which our estimate of AE R^* declines very sharply.

Perhaps more significantly, our estimates of the decline in the neutral real rate track the evolution of 10-year real yields depicted in figure 2. This both provides further corroboration of our estimates and suggests a market judgment that real rates are likely to remain low for the foreseeable future.

Figure 5. Private Saving and Private Investment in Advanced Economies: The Level and Gap, 1980–2014/16[a]



Sources: International Monetary Fund; Organization for Economic Cooperation and Development; authors' calculations.

a. The left panel of this figure shows purchasing power parity–weighted gross private saving and gross private fixed-capital formation across the following countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, South Korea, Latvia, Lithuania, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The figure on the right shows the result of a simple counterfactual exercise where we calculate the private saving/investment gap under a scenario of no decline in the long-term interest rate since the 1980s. The swath contains the counterfactual for values of responsiveness of saving/investment ratios to interest rates between 2 and 4, and the central counterfactual estimate assumes the sensitivity of 3.

II.C. The Fall in AE R* *and the Excess Saving Problem*

The decline in the neutral real rate of this magnitude is a symptom of deep, fundamental changes that have taken place in the developed economies over the last half century. A useful way to think about these trends is through the lens of desired saving and investment, with the desire to save running ahead of the desire to invest. However, illustrating the fundamental change in this space is not straightforward, because the large fall in the intertemporal price—the interest rate—meant that the *observed* saving and investment ratios remained broadly stable throughout this period. The left panel of figure 5 shows the realized purchasing power parity–weighted private saving and investment ratios in the OECD, in proportion to the aggregate GDP of the OECD. The saving ratio is almost completely stable, and though there is some movement in the ratio of private investment to GDP, there certainly is no strong trend.

To assess the magnitude of the forces that operated under the surface in terms of excess saving over investment, one needs to perform a counterfactual analysis. Here we present a simple but telling attempt. Specifically, we calculate the counterfactual difference between private sector saving and investment—the counterfactual private sector saving/investment gap—under an assumption of no decrease in the interest rate since the 1980s. To construct such a counterfactual, we need an estimate of the strength of the link between desired saving and investment and the interest rate. We rely on the estimates reported in empirical literature,[9] which suggests that the elasticity of desired saving is in the region of 0.3 to 0.7 and the elasticity of desired investment is about –0.5 to –0.7. With average saving- and investment-to-GDP ratios at about 20 percent, elasticities of this magnitude suggest that a decline of 1 percentage point in the real interest rate is associated with a widening of the saving/investment gap of between 2 and 4 percentage points, with the central view of the sensitivity of about 3.[10] Given the uncertainties, we report the counterfactual gap under this range of sensitivities.

The main message from these simple calculations is striking: absent the cushioning decline of the interest rate, the excess saving gap would have been very large: the right panel of figure 5 indicates that it would have been between 9 and 14 percentage points.

Motivated by the size of these movements, we now turn to the discussion and analysis of the forces behind them. Our contribution is the focus on the role that public policies have played over this period.

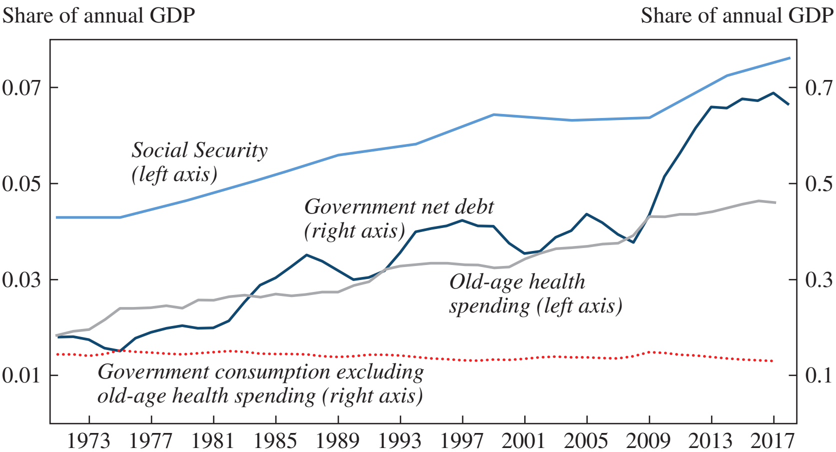
III. Government Policy and the Equilibrium Interest Rate

Over the past several decades, government policy in the developed world has shifted significantly in at least four respects (figure 6). First, government debt has risen, from about 20 percent of GDP to about 70 percent (government consumption—excluding health care—remained relatively stable). Second, old-age payments administered through the Social Security and health care systems have gone up, respectively, from about 4 percent

9. See Rachel and Smith (2015) for a review.

10. The central estimate given in the right panel of figure 5 errs on the side of caution, assuming the sensitivities at the lower end of these ranges. When interest rates are 5 percent, a decline of 1 percentage point in the interest rate constitutes a 20 percent decline. Given an elasticity of 0.3 of saving and –0.5 of investment, this is associated with a change in desired saving of 6 percent and investment of 10 percent, which add up to about 3 percent of GDP when these ratios are about 20 percent of GDP.

Figure 6. The Advanced Economies' Government Policy Ratios (in Proportion to GDP), 1971–2017[a]



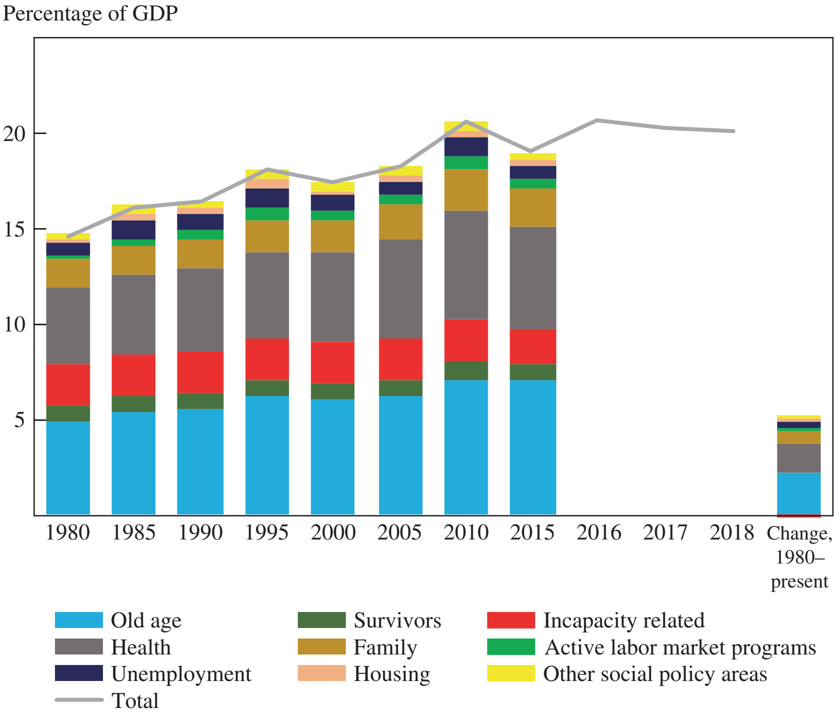
Source: OECD data.

a. This figure shows OECD aggregates in proportion to total GDP. The government net debt line measures general government net financial liabilities, from the *OECD Economic Outlook Database*. It includes the net government debt held by the public, and also other net liabilities of the government. For example, in the United States in 2017, net financial liabilities as reported by the OECD were 80 percent of GDP, while net debt held by the public was 75 percent of GDP. Government consumption figures represent general government final consumption expenditures, adjusted by subtracting old-age health spending (note that this series excludes the Social Security transfers by default). Old-age health spending is calculated as the aggregate health spending on those age 65 and above. The overall health spending figures are from OECD / World Health Organization statistics on sources of funding for health care. They include health care financed directly by the government and from compulsory schemes. The old-age share is then calculated under the assumption that 60 percent of total health spending is directed at the older demographic groups, which is consistent with the evidence available for a handful of OECD countries.

to about 7 percent, and from about 2 percent to about 5 percent of GDP, accounting for the lion's share of the increase in total social spending (figure 7). Third, significant changes have taken place in tax policies. The effective corporate tax rates in the high-income economies have fallen, from about 32 percent at the turn of the century to 24 percent more recently.[11] Wealth taxes, which were operational in 12 OECD countries in 1990, remain in place only in 4 countries today (OECD 2018). And, as documented by Thomas Piketty and Emmanuel Saez (2007), the overall progressivity of the tax system has decreased in some jurisdictions—notably, in the United States and the United Kingdom.

11. For the details, see OECD (2019).

Figure 7. Public Social Spending in the OECD Countries, 1980–2018[a]



Source: OECD Social Expenditure Database (SOCX).
a. The data for 2016–18 are preliminary and the breakdown by function is not yet available.

These shifts are likely to have had a profound impact on the economy in general, and on the equilibrium rate of interest in particular. Specifically, all these shifts—perhaps with the exception of tax changes—are likely to have pushed interest rates higher over the past 30 years. In this and the next section, we turn to the analysis of the impact of these policy shifts on the natural rate, with the ultimate goal to inform the counterfactual "pure" R^* that would prevail without government intervention.

We focus on government debt, Social Security, and health care spending, leaving the formal analysis of the impact of tax changes for future research. We find that shifts in government policy have likely pushed equilibrium rates of interest up by a significant amount over the period in question. As a rough rule of thumb for the magnitudes involved, our analysis suggests that the tripling of the government debt over the past half century has raised rates by 1.5 percentage points, while the expansion of social spending of about 5 percent of GDP has added a further 2.5 percentage points.[12] Although the precise magnitudes of these multipliers are subject to substantial model and statistical uncertainty, the qualitative conclusion is clear: If public policy had not responded, the advanced world's equilibrium rate would likely be deeply negative.[13]

III.A. A Brief Review of the Theoretical Arguments

We begin by reviewing the effects of government policy on the equilibrium interest rate, focusing on government borrowing, given that this has been the main subject of the large body of literature in macroeconomics on which we can draw.[14]

In the canonical neoclassical model with complete markets and infinitely lived agents, Ricardian Equivalence holds, and neither the deficit nor the debt is relevant, because the representative household can fully offset the changes to the government's borrowing policy through its saving decisions. Thus, independent shocks to government borrowing alone have no effect on the equilibrium interest rate. The neoclassical model instead emphasizes the link between the stock of capital and the interest rate: in equilibrium $r = f'(k) - \delta$.[15] Thus, government policies affect the interest rate only to the extent that they have an impact on the stock of private capital.

However, in the micro-founded modern macroeconomic models that depart from the representative agent and complete markets assumptions, Ricardian Equivalence does not hold, and government transfer policies affect the equilibrium allocations through several distinct channels.

12. This rounds the numbers in table 7 below. The 1.5 refers to the sum of the second column, second and third rows (1.2, but rounded to 1.5 here). The 2.5 rounds the sum of the fifth and sixth rows of the second column (1.2 + 1.1).

13. A corollary of this link between government debt and interest rates is that a higher value of public debt, compared with market expectations, is likely to raise the natural interest rate. For an analysis of this argument, see Kocherlakota (2015).

14. In our work, we do not explicitly model the impact of quantitative easing (QE) policies. One kind of QE encompasses policies that swap risky assets for safe assets and includes the Federal Reserve's initial round of QE (QE1) in the United States or the Long-Term Refinancing Operation (LTRO) in the euro zone. Such a policy may raise the short-run rate (Caballero and Farhi 2018), whereas we focus on the long-run rate. Another kind is a policy whereby the central bank issues reserves to buy risk-free debt. Such a policy is primarily a maturity transformation of government debt, rather than a change in the total availability of investable assets.

15. On the balanced growth path, the level of effective capital stock adjusts such that the interest rate simultaneously satisfies the balanced growth version of the representative household's Euler Equation: $r = \frac{1}{IES} \cdot g + \theta$, where *IES* is the intertemporal elasticity of substitution and θ is the rate of time preference.

First, the intertemporal transfers—that is, *redistribution across time*—matters if peoples' planning horizons are finite. This could be because of finite lives coupled with a less-than-perfect bequest motive, as in the seminal models of Peter Diamond (1965) and Olivier Blanchard (1985), or perhaps due to the time-dependent preferences and myopic behavior pioneered by David Laibson (1997). The reason is intuitive: with finite planning horizon, agents currently alive expect to shoulder only a part of the financing burden that comes with today's transfer; the rest is to be serviced by future generations. Such transfers thus affect agents' wealth and their consumption and saving plans.

Second, *transfers across agents* can affect aggregate consumption and saving (and hence the interest rate) if agents have different marginal propensities to consume (MPCs). Differences in MPCs could arise because of several distinct features of the economic environment. They could be a result of uninsurable risks and binding borrowing constraints, as in the works of Rao Aiyagari (1993), Aiyagari and Ellen McGrattan (1998), and the model of Hyunseung Oh and Ricardo Reis (2012). They could emerge because some agents have little to no liquid wealth, preventing them from adjusting their consumption, as in the paper by Greg Kaplan, Giovanni Violante, and Justin Weidner (2014). Another reason may be the life cycle: the propensity to consume may differ between workers and retirees, as shown by Gertler (1999); or it may vary with age, as shown by Etienne Gagnon, Benjamin Johannsen, and David Lopez-Salido (2016) and by Gauti Eggertsson, Neil Mehrotra, and Jacob Robbins (2019). Heterogeneous MPCs and distortionary taxes deliver this result in the savers-spenders model of N. Gregory Mankiw (2000).[16] In all these models, government transfers from a low-MPC agent to a high-MPC agent will boost the aggregate desire to consume and lower desired saving, thereby raising the interest rate.

The third way in which government policy affects interest rates is what may be called a *precautionary saving channel*. One facet of this channel is that government policies can directly reduce the risks faced by the agents. The mechanism is close to the one analyzed by Eric Engen and Jonathan Gruber (2001). Under imperfect insurance, agents who face idiosyncratic risks—for example, those related to health or unemployment—attempt to

16. In the savers-spenders model of Mankiw (2000), if taxes are levied lump-sum, a deficit-financed transfer that permanently increases the level of debt does not affect the stock of capital or the interest rate in the long run. The reason is that the interest rate is pinned down by the savers, who are infinitely lived and Ricardian.

self-insure through saving. This precautionary saving motive acts to push the interest rate below the rate that would prevail in a complete market economy (where all risks are insurable and thus do not affect the agents' behavior). Government policies such as social insurance will affect the importance of precautionary saving: a stronger social safety net or higher unemployment and disability benefits curtail the associated risks, curbing the desire to save. Conversely, the lack of social insurance means that agents need to rely on their own resources when experiencing hardship, making personal saving a priority. However, as illustrated in figure 7, the overall size of the social safety net across the OECD has changed little over the period in question. We do not attempt to model it here, but leave it as an important direction to be explored in future research.

The other facet of the precautionary saving channel—and the one we focus on in this paper—works through the provision of assets that agents use to insure themselves against shocks. This mechanism is at the heart of the work of Aiyagari and McGrattan (1998), and it has recently been discussed in the context of secular stagnation by Ricardo Caballero, Emmanuel Farhi, and Pierre-Olivier Gourinchas (2016) and by Caballero and Farhi (2018). The intuition we have in mind is simple: a rise in government debt raises the overall supply of assets in the economy, which, all else being equal, pushes interest rates up. Indeed, there is evidence in the data that government debt constitutes a nontrivial proportion of the total investable financial assets in the developed world, so that this channel can have a quantitative bite. The estimates of the share of government bonds in total financial assets range from one-third in the United States to two-thirds in Japan (Kay 2015).

In summary, macroeconomic theory developed over the past couple of decades has enriched the basic model of Frank Ramsey and Robert Barro (see Barro 1974), with several channels that make government policy a relevant determinant of the long-term interest rate. We now turn to the empirical evidence that has been accumulated in parallel to these theoretical advances.

III.B. Empirical Evidence on the Link between Government Debt and Long-Term Interest Rates

The main challenge when estimating the effect of government borrowing on interest rates is the large number of potentially confounding factors, which may make simple regressions of interest rates on debt spurious and uninformative. For example, deficits will tend to expand when the economy weakens, which is also the time when interest rates tend to fall.

This means that the simple regression coefficients are likely to be biased downward.

We shall not attempt a full-blown empirical assessment in this paper, and instead present a summary of the empirical estimates in the literature. For an interested reader, online appendix B illustrates several challenges in estimating the causal relationship between equilibrium interest rates and government debt through a simple empirical exercise for the United States, Canada, the euro area, and the United Kingdom. These challenges include the presence of international capital flows and of endogenous responsiveness of policy to an excess of private saving over private investment, both of which are likely to attenuate the individual-country estimates of the impact of deficits on interest rates. Instead, we present the estimates from a broad body of literature that attempted to deal with these and other confounding factors in finding the link between government finances and real rates.

Several key studies in the empirical literature have focused on the United States. In a chapter in the *Handbook of Macroeconomics* at the turn of the century, Douglas Elmendorf and Mankiw (1999) reviewed the theoretical and empirical literature on the Ricardian Equivalence proposition, and they concluded that, though the studies that attempted to estimate the impact of government finances on interest rates cannot reject the null hypothesis of zero impact, they suffer from lack of statistical power.[17] More recent work appears to be more conclusive. In their literature review, William Gale and Peter Orszag (2003) conclude that the effect of government deficit on real rates is positive and economically significant: an increase of 1 percentage point in the deficit-to-GDP ratio tends to raise interest rates by about 50–100 basis points. And the two most authoritative contributions on the topic suggest estimates that are significant, albeit somewhat smaller. Laubach (2009) studies how forward rates on government securities react to news in the fiscal forecasts of the Congressional Budget Office. The identifying assumption in his work is that long-term rates and forecasts are not contaminated by current events and shocks at the business cycle frequency. According to his estimates, a rise in the

17. They write of the literature that tends to find close to zero effect of government deficit on rates: “Our view is that this literature . . . is ultimately not very informative. . . . Plosser (1987) and Evans (1987) generally cannot reject the hypothesis that government spending, budget deficits, and monetary policy each have no effect on interest rates. Plosser (1987) also reports that expected inflation has no significant effect on nominal interest rates. These findings suggest that this framework has little power to measure the true effects of policy” (Elmendorf and Mankiw 1999, 1658).

government deficit of 1 percentage point of GDP raises interest rates by about 20–30 basis points; an equal increase in the debt-GDP ratio results in a rise of about 3–4 basis points. He asserts that these flow- and stock-multipliers are broadly consistent, because of the autocorrelation of the deficits observed in the data.[18] Another important contribution to this literature is that by Engen and Glenn Hubbard (2004), who consider a host of specifications linking interest rates or changes in interest rates to government debt or to the deficit, both contemporaneously and in a forward-looking setting. Their results suggest that a rise of 1 percentage point in government debt to GDP pushes interest rates up by about 3 basis points, broadly in line with Laubach's findings.[19]

Further evidence is available for the advanced economies beyond the United States. In an international setting, Anne-Marie Brook (2003) documents that the range of estimates of the effect of an increase of 1 percentage point increase in the government debt-to-GDP ratio on interest rates is 1–6 basis points, with the corresponding range for an increase of 1 percentage point in deficits in the region of 20–40 basis points. In an important study of the euro area, Riccardo Faini (2006) finds that a rise of 1 percentage point in deficits at the euro area level raises long-term rates by about 40 basis points, close to—and if anything, higher than—the U.S. multipliers. Considering an even wider panel of 19 OECD economies spanning the years 1971–2004, Noriaki Kinoshita (2006) finds that the effect of a rise of 1 percentage point in the government debt-to-GDP ratio is to raise interest rates by 4–5 basis points.

A complementary way to assess the size of these effects is to consider simulations from large-scale models used for quantitative analyses in policy institutions. Because these models are carefully estimated using real-world data, they should be able to provide a steer as to the size of the effects. A well-known example is the FRB/US model, which is used and maintained by researchers at the Federal Reserve Board (Laforte and Roberts 2014). In a recent speech, Stanley Fischer (2016) uses this model to estimate the impact of a persistent increase in the deficit on real rates, and finds that an increase of 1 percentage point in the deficit raises the equilibrium rate by between 40 and 50 basis points, depending on whether

18. Specifically, he estimates the autocorrelation of 0.83, implying that the 1 percentage point rise in the deficit should have $1/1 - 0.83 = 6$ times the effect of a 1 percentage point rise in debt—broadly in line with what he finds.

19. The results vary across different specifications, highlighting that the precise econometric details matter for the conclusions of this line of empirical research.

Table 2. The Impact of Government Borrowing on the Interest Rate: A Summary of the Literature

Study	*Country or region*	*Impact of 1 percentage point increase in deficit-GDP ratio (basis points)*	*Impact of 1 percentage point increase in debt-GDP ratio (basis points)*
Gale and Orszag (2002)	United States	50–100	—
Laubach (2009)	United States	20–30	3–4
Engen and Hubbard (2004)	United States	18	3
FRB/US model	United States	40–50	—
Faini (2006)	Euro area	40	—
Brook (2003)	Advanced economies	20–40	1–6
Kinoshita (2006)	19 OECD economies	—	4–5
Average		*38*	*3.5*

Sources: The studies listed in the first column; information on the FRB/US model can be found at https://www.federalreserve.gov/econres/us-models-about.htm.

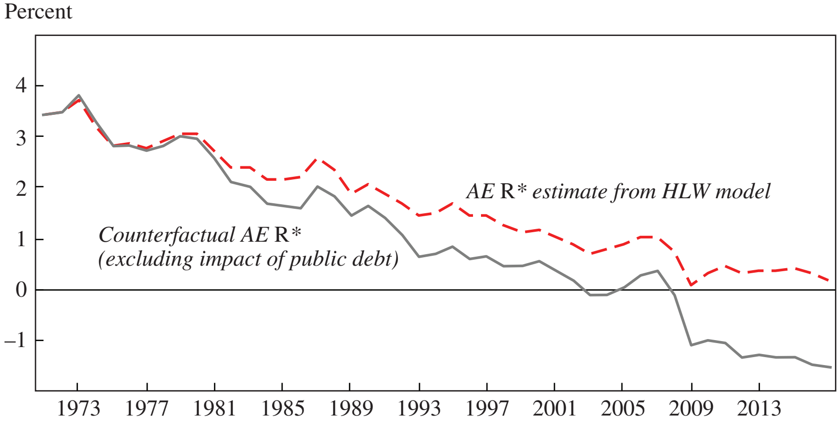
the deficit increased because of a tax cut (smaller effect) or a rise in government spending (larger effect). These figures are thus slightly larger than the empirical estimates cited above.

In summary, the estimates in the literature paint a fairly consistent picture: a rise of 1 percentage point in the deficit tends to raise interest rates by about 40 basis points; while a rise of 1 percentage point in the debt-GDP ratio results in an increase of about 3.5 basis points (table 2). We suspect this figure is an underestimate of the impact of an exogenous increase in budget deficits on real rates because fiscal expectations are measured with error, because any one country can import capital and so attenuate rate increases when budget deficits increase, and because there will be a tendency—as fiscal policy is used to stabilize the economy—for periods of low neutral real rates to coincide with periods of expansionary fiscal policy.

III.C. The Historical Impact of Government Borrowing on R^*

The elasticities identified in the empirical research combined with the historical path of government borrowing give simple back-of-the-envelope estimates of the historical influence of fiscal policy on real interest rates. Over the past 40 years, the increase in government debt in the OECD has likely pushed interest rates higher, perhaps by as much as 2 percentage points. The measure of R^* that excludes the impact of public debt has hovered around zero since the early 2000s, and remains negative at the moment (figure 8).

Figure 8. The Advanced Economies' R^*, Adjusted for the Impact of Government Debt, 1971–2017[a]



Source: Authors' calculations.

a. HLW = the model of Holston, Laubach, and Williams (2017a). This figure shows the estimated equilibrium real interest rate in the advanced economies, and an adjusted measure that subtracts the impact of government borrowing using the average elasticities reported in table 2.

III.D. The Link between Social Security and R^*

Social Security constitutes both an intertemporal and a between-group transfer. To be able to calculate by how much changes in Social Security have had an impact on the neutral real rate, we need the estimates of the impact of Social Security on individual saving, and also the differences in the MPCs of the groups funding and receiving the Social Security transfer.

A large body of literature has analyzed the first of these.[20] Several researchers relied on aggregate time series within a country. An example is the study by Martin Feldstein (1974), who finds a significant offset in the region of 30–50 percent of private saving to Social Security changes in the United States. However, other studies in this literature argued that the effects may be smaller and are highly uncertain. The second approach, based on micro data in the cross section of individuals, estimates a private sector offset of between 0 and 50 percent (Feldstein and Pellechio 1979). The cross-country studies find little to no effect (Barro and MacDonald 1979). More recent papers focus on pension system reforms to sharpen

20. See CBO (1998) for a review.

identification, and find significant responses to private saving (Attanasio and Brugiavini 2003; Attanasio and Rohwedder 2003). Overall, the literature is consistent with private saving reacting to the changes in Social Security, with elasticities between –0.3 and –0.4 representing the central tendency among a wide range of available estimates.

The impact of the between-group transfer depends on the differences in MPCs across the two groups: taxpayers and retirees. The traditional life-cycle logic suggests that retirees have a higher MPC relative to working-age individuals, although the evidence on the quantification of these differences is scarce. Christopher Carroll and others (2017) suggest that the difference could be in the region of 0.3.

Under these assumptions, the increase in Social Security of about 3 percentage points of GDP that we observed (figure 6) would have led to a decrease in desired saving of about 1 percentage point through the intertemporal channel and another 1 percentage point through the across-groups redistribution.[21] Based on the multipliers used in the calculations underlying figure 5, the overall decrease of 2 percentage points in desired private saving may have led to a rise in R^* of between 50 and 100 basis points. And the rise in old-age health care spending would have added further upward pressure on real rates.

To sum up, simple calculations suggest a very substantial upward impact of public policies on R^* over the past half century. To develop further intuition and to consider other mechanisms through which public policy may have affected the interest rate, we now turn to a complementary approach: a general equilibrium modeling framework.

IV. Government Policy and R^*: A Model-Based Approach

In subsection III.A, we outlined various channels through which government debt may affect the equilibrium real interest rate; our goal in this section is to illustrate their quantitative importance within a general equilibrium framework. We want our approach to be simple and transparent, providing a credible complement and a cross-check to the empirical analysis given above. To achieve these goals, we build two general equilibrium models: one capturing the finiteness of life and life-cycle heterogeneity, and another that focuses on precautionary behavior.

21. Both figures are obtained by multiplying the change in Social Security of 3 percentage points by 0.3.

IV.A. Two General Equilibrium Models

The first model, which builds closely on Gertler (1999), highlights life-cycle heterogeneity. In this economy, ex-ante identical individuals are at different points in their lives; some are working, and some have already retired. This drives the differences in their consumption and saving behavior. The framework is similar to that of Blanchard (1985) and Menahem Yaari (1965)—individuals face thr constant probability of death, and so their horizons are finite—but, in addition to their model, workers retire and finance consumption with saving until death.

The second model is a Bewley–Huggett–Aiyagari economy with incomplete markets and uninsurable income risk at the level of an individual household. A similar model was considered by Aiyagari and McGrattan (1998), who also studied the role of government debt in equilibrium allocation in the presence of idiosyncratic risk. The main differences between ours and their approach are that (1) we calibrate the risk component of the income process to deliver a realistic dose of uncertainty, which implies that distributions of income and assets in the model broadly match distributions observed in developed economies such as the United States;[22] and (2) we cast the model in continuous time, taking full advantage of the recent analytical and computational discoveries in macroeconomics.

Here, we sketch the main workings of the two models and develop the intuition; a more detailed description of the models is available in online appendix C for the life-cycle model and online appendix D for the incomplete market model.

IV.B. A Model of Finite Lives and Life-Cycle Heterogeneity

With respect to demographics and preferences, there are two stages of life: work and retirement, with exogenous transition probabilities. That is, each worker faces a given probability of retirement $1 - \omega$, and, once a retiree, a given probability of death $1 - \gamma$. Population grows at a gross rate $1 + n$.

There is no aggregate risk; the only sources of uncertainty facing an individual are the risk of retirement while a worker (associated with a loss of labor income) and the risk of death while a retiree. Left unchecked, these sources of risk would affect agents' behavior. This would make aggregation problematic, and, more important, it would be unrealistic: the timing

22. We match the degree of income inequality in the data, but fall short of matching the extreme degree of wealth inequality observed in the real world. We discuss the standard and well-known reasons why this is so below.

of retirement is, for the most part, known. To deal with this unrealistic feature, we assume that there are perfect annuity markets for the retirees (neutralizing the influence of the risk of death on their behavior), and that workers' preferences have a certainty equivalence property (such that the *risk* of retirement does not affect workers' behavior in equilibrium).[23] These two assumptions are both realistic and convenient, in that they allow for the derivation of the aggregate consumption function, as we illustrate momentarily.

Specifically, we assume that agents have recursive Epstein–Zin preferences, which are defined as follows:

$$V_t^z = \left[(C_t)^\rho + \beta^z \mathbb{E}_t\{V_{t+1}|z\}^\rho\right]^{1/\rho}, \tag{7}$$

where C_t denotes consumption, V_t^z and β^z stand for the agent's $z \in \{w, r\}$ value function and the discount factor respectively, and $\sigma = \dfrac{1}{1-\rho}$ is the intertemporal elasticity of substitution.

Retirees and workers differ in two crucial respects. First, they have different discount factors. Because of the positive probability of death facing any retiree, his or her discount factor is the time preference parameter β multiplied by the probability of surviving into the next period:

$$\beta^w = \beta \tag{8}$$

and

$$\beta^r = \beta \cdot \gamma. \tag{9}$$

Second, the expectation of the value function next period differs between a worker and a retiree. In particular, a worker takes into account the possibility of retiring, so that his or her expectation of the value function in the next period is a probability-weighted sum of the values in the two states:

$$E_t\{V_{t+1}|w\} = \omega V_{t+1}^w + (1-\omega)V_{t+1}^r, \tag{10}$$

23. In particular, workers are assumed to have recursive Epstein and Zin (1991) preferences that generate certainty equivalent decision rules in the presence of income risk.

while the expectation of the value function of a retiree is simply given by

$$E_t\{V_{t+1}|r\} = V^r_{t+1}. \tag{11}$$

We now outline the problems of the two types of agents.

RETIREES Retirees consume out of saving and Social Security payments. Each period, some retirees die. We make the assumption—which is standard in the literature—that those who survive receive the proportional share of the proceeds. This means that the effective return faced by individual retirees is R_t/γ, higher than the ongoing interest rate R_t.[24]

Because the probability of death is independent of age and the government does not discriminate across retirees in its Social Security transfer policy, each retiree (irrespective of age) solves an identical problem, which is:

$$V^r_t = \max_{C^r_t}\left[(C^r_t)^\rho + \beta\gamma\mathbb{E}_t\{V^r_{t+1}\}^\rho\right]^{1/\rho}, \tag{12}$$

subject to the flow budget constraint

$$A^r_{t+1} = (R_t/\gamma)A^r_t - C^r_t + E^r_t, \tag{13}$$

where A^r_t stands for a retiree's assets, C^r_t are his or her consumption expenditures, and E^r_t is the Social Security and health care cost transfer.[25]

WORKERS Individuals are born workers and have no assets at the start of life. They consume out of asset wealth and their labor income net of taxes. Because of the demographic structure (in particular, the assumption that the probability of retirement is independent of age[26]), a worker's problem is effectively the same no matter the age. Each worker solves:

$$V^w_t = \max_{C^w_t}\left\{(C^w_t)^\rho + \beta\left[\omega V^w_{t+1} + (1-\omega)V^r_{t+1}\right]^\rho\right\}^{1/\rho} \tag{14}$$

subject to

24. For retirees *as a group*, wealth accumulates at the interest rate R_t, as the higher individual return cancels out with some retirees dying.

25. Our modeling of health care provision is very simple—we treat old-age health care cost as a lump-sum transfer, subsumed in the variable E.

26. Of course this is an unrealistic assumption. But as explained above, the effect of this assumption on workers' behavior is neutralized through the structure of preferences that exhibit a certainty equivalence property. The role of this assumption is thus only to simplify the model and achieve aggregation, with little cost to the economics.

$$A^w_{t+1} = R_t A^w_t + W_t - T_t - C^w_t, \tag{15}$$

where T_t are lump-sum taxes levied by the government.[27]

FIRMS The supply side of the model is extremely simple. Market are competitive. Production is carried out by firms employing capital and labor. The aggregate production function is

$$Y_t = K^{\alpha}_t (X_t N_t)^{1-\alpha}, \tag{16}$$

where N_t is the number of workers in the economy. There is exogenous technological progress and population growth—that is, $X_{t+1} = (1 + x)X_t$ and $N_{t+1} = (1 + n)N_t$. Perfect competition in factor markets means that the wage and the rental rate are equated to the marginal products of the factors: $W_t = \alpha \frac{Y_t}{N_t}$ and $R_t = (1 - \alpha)\frac{Y_t}{K_t} + (1 - \delta)$. Capital evolves according to the standard law of motion: $K_{t+1} = Y_t - C_t - G_t + (1 - \delta) K_t$.

GOVERNMENT The government consumes G_t each period, and pays retirees a total of E_t in Social Security and health care benefits. To finance its expenditures, the government levies a lump sum tax T_t on the workers. It can also issue one-period government bonds B_{t+1}. The government flow budget constraint is

$$B_{t+1} + T_t = R_t B_t + G_t + E_t. \tag{17}$$

Iterating forward gives the intertemporal budget constraint of the government:

$$R_t B_t = \sum_{v=0}^{\infty} \frac{T_{t+v}}{\prod_{z=1}^{v} R_{t+z}} - \sum_{v=0}^{\infty} \frac{G_{t+v}}{\prod_{z=1}^{v} R_{t+z}} - \sum_{v=0}^{\infty} \frac{E_{t+v}}{\prod_{z=1}^{v} R_{t+z}}. \tag{18}$$

27. There are two key channels through which life-cycle considerations affect workers' behavior. First, a worker takes into account the fact that, with probability $1 - \omega$, he or she becomes a retiree. This means that, relative to the representative agent case, he or she discounts the future stream of wages by more; effectively, this is the *saving-for-retirement* effect. Mechanically, a larger discount rate reduces the value of human wealth in the consumption function, thus leading to lower consumption and higher saving. Second, a worker discounts the future stream of wealth more because he or she anticipates that inevitably there will come a time when he or she becomes a retiree, facing the sad truth that life is finite. With finite life, wealth can be smoothed out across fewer periods, so its marginal utility value is lower. This effect shows up as a higher effective discount rate applied to future wealth.

That is, the difference between the present discounted value of government revenue and spending must be exactly equal to the current value of the outstanding debt.

Government policy is exogenous. In particular, it is characterized by the four ratios, $\bar{g}_t$, $\bar{b}_t$, $\bar{e}_t$, $\bar{h}_t$ of, respectively, government consumption, debt, Social Security, and health care spending to GDP:

$$G_t = \bar{g}_t Y_t \tag{19}$$

$$B_t = \bar{b}_t Y_t \tag{20}$$

$$E_t = \left(\bar{e}_t + \bar{h}_t\right) Y_t. \tag{21}$$

Given the paths of G_t, E_t, and B_t, taxes adjust to satisfy the intertemporal budget constraint.

EQUILIBRIUM In this economy, markets are competitive and agents take prices as given. Formally, a competitive equilibrium is a sequence of quantities and prices such that (1) households maximize utility subject to their budget constraints; (2) firms maximize profits subject to their technology constraints; (3) the government chooses a path for taxes, compatible with intertemporal solvency, to finance debt, spending, and transfers; and (4) all markets clear.

Online appendix C contains the details of the derivation of the equilibrium conditions of the model. The individual policy functions within the two groups—workers and retirees—aggregate up nicely. Aggregating the two consumption levels, we derive the aggregate consumption function:

$$C_t = C_t^w + C_t^r = \pi_t \left\{ (1 - \lambda_t) R_t A_t + H_t + S_t^w + \epsilon_t \left(\lambda_t R_t A_t + S_t^r \right) \right\}. \tag{22}$$

In this consumption function, π_t denotes each worker's MPC out of wealth, and $\pi_t \epsilon_t$ is the MPC of each retiree. These MPCs multiply the total wealth of each group of consumers—with a slight abuse of notation, A_t now denotes aggregate financial wealth, H_t is aggregate human wealth (the net present value of future wages), and S_t stands for the aggregate value of Social Security and health care payments. Compared with a standard model, the only additional state variable is the share of wealth held by retirees, λ_t, which fully captures the heterogeneity in the economy.

Table 3. Calibration of the Model

Parameter	*Description*	*Calibration*
Preferences and technology		
β	Discount factor	0.98
σ	Intertemporal elasticity of substitution	0.5
α	Capital share	0.33
δ	Depreciation rate	0.1
x	Rate of technological change	1.51%
Demographics		
n	Gross population growth rate	1.35%
$\frac{1}{1-\omega}$	Average length of working life (years)	47.6
$\frac{1}{1-\gamma}$	Average length of retirement (years)	10.5
Government ratios		
$\overline{b}$	Government debt to GDP	0.18
$\overline{g}$	Government consumption to GDP	0.14
$\overline{e}$	Social Security spending to GDP	0.04
$\overline{h}$	Old-age health care spending to GDP	0.02

Source: Authors' calculations.

The total supply of assets is the sum of capital stock K_t and government debt B_t, so that the equilibrium requires

$$A_t = A_t^w + A_t^r = K_t + B_t, \tag{23}$$

that is, households asset demand equals the asset supply.

CALIBRATION AND THE INITIAL STEADY STATE OF THE LIFE-CYCLE MODEL Despite the richness of the economics, the model is parsimonious and relatively straightforward to calibrate. We set the preferences and technology parameters at the standard values in the macroeconomic literature (table 3). The growth rate of technological change, the demographics parameters, and the government policy ratios are all calibrated to match the data in the advanced economies in 1970.

Because there are population growth and technological progress in this economy, the steady state equilibrium takes the form of a balanced growth path, where all variables grow at a constant gross rate equal to $(1 + n)(1 + x)$. We can characterize the equilibrium by expressing all variables as ratios in units of effective labor (defining, for any variable $Z_t, z_t \equiv \frac{Z_t}{X_t N_t}$).

Table 4. The 1970s Steady State[a]

Variable	*Description*	*Value*
ψ	Ratio of retirees to workers	0.19
R	Real gross interest rate	1.045
ϵ	Ratio of retirees' to workers' MPCs	2.01
π_w	Workers' MPC	0.06
π_r	Retirees' MPC	0.13
λ	Share of retirees' wealth in total wealth	0.17
y	Output	1.50
Ratios (in proportion to output)		
c	Consumption	0.57
c_r	Consumption of retirees	0.11
c_w	Consumption of workers	0.45
a	Assets	2.42
a_r	Assets of retirees	0.40
a_w	Assets of workers	2.03
h	Human capital	4.23
i	Investment	0.27
k	Capital	2.25
τ	Taxes	0.21
s	Social Security wealth of the retirees	0.50
s_w	Social Security wealth of the workers	0.91

Source: Authors' calculations.
a. MPC = marginal propensity to consume.

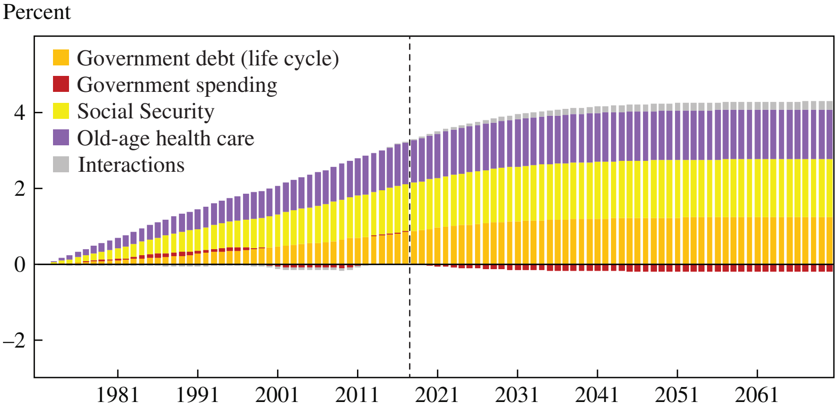
Table 4 shows the key variables along the initial (early-1970s) balanced growth path. The interest rate is 4.5 percent.[28] As we pointed out above, the key feature of this economy is the heterogeneity in MPCs between workers and retirees. Indeed, the endogenous MPC of retirees is over twice that of the workers. The additional state variable λ—the ratio of retirees' wealth in total wealth—takes a plausible value of 17 percent. Ratios of aggregate consumption, investment, capital, and assets to output also match the stylized facts from the data well.

THE SIMULATION EXERCISE We now explore how the model economy reacts to changes in government policy. We study four policy levers: government debt, government spending, old-age Social Security, and health care transfers.

We carry out the following experiment. Starting the economy in the initial 1970s steady state, we feed the model with the policy profiles depicted in figure 6. Once announced, the profile of these shifts is fully

28. With a growth rate of 2.9 percent a year, the economy is dynamically efficient.

Figure 9. The Simulated Impact of Government Policies on the Equilibrium Real Interest Rate in the Life-Cycle Model, 1971–2071[a]



Source: Authors' calculations.

a. This figure shows how the equilibrium real interest rate adjusts to the exogenously given paths of government debt, spending, and old-age Social Security transfers depicted in figure 6. The 2017 values given in figure 6 are assumed to be the new steady state values.

anticipated by the agents. Beyond the current date, we assume that future policy ratios remain constant at their 2017 values.[29] We then compute the transition path toward this new steady state.

Our focus is on the response of the interest rate to these policy shifts. Figure 9 contains the main result of this section: the total response of the interest rate to the policy changes discussed above. This response is quantitatively large; according to the model, government policies have pushed up on the equilibrium interest rate by about 3.2 percentage points over the past 50 years. Moreover, the model suggests that further upward pressure is to be expected as the economy settles at the new steady state. All the policies except government spending—which did not change much—play an important role. The final set of bars in figure 9, labeled "interactions," is the additional effect on the interest rate from the (nonlinear) synergies between the three different policies.[30]

29. This is a conservative assumption, as one may reasonably expect the upward drift in both debt and Social Security spending to continue, at least for some time.

30. More precisely, the interaction effect exists because the final steady state is a nonlinear system of equations. These nonlinearities make the overall effect of several exogenous changes different, in general, from the sum of the parts.

IV.C. A Model of Precautionary Saving

We now turn to the model of precautionary behavior, which is a continuous-time version of the Aiyagari and McGrattan (1998) economy. The population consists of a large number of infinitely lived individuals of measure 1. Every individual is ex-ante identical, but people face shocks to their income that they cannot fully insure against: markets are incomplete. As a result of this idiosyncratic risk, individuals experience different income histories and thus accumulate different levels of wealth. All the risk is at the individual level; for simplicity, we abstract from aggregate uncertainty.

Our goal here is to quantitatively assess the influence government debt has on precautionary behavior. In other words, how different is the prevailing interest rate when the government debt-to-GDP ratio is 18 percent versus when it is 68 percent?[31]

A BRIEF OUTLINE OF THE MODEL An individual chooses consumption and asset holdings to maximize his or her expected utility, subject to the flow budget constraint, the consumption nonnegativity constraint, the borrowing constraint, and a realization of the idiosyncratic income shock:

$$\max_{\{c_t\}_{t>0}} \mathbb{E}_0 \int_0^{\infty} e^{-\rho t} \frac{c_t^{1-\sigma}}{1-\sigma} dt \tag{24}$$

subject to

$$\dot{a}_t = (1-\tau) w_t e_t + (1-\tau) r_t a_t - c_t$$

$$c_t \geq 0$$

$$a_t \geq \underline{a}$$

$$e_t \in \{z_1, \ldots, z_n\},$$

31. Our model is highly stylized and abstracts from important features present in more advanced and larger models in the literature. We view our model here as an early attempt to quantify the precautionary saving channel of government debt. Richer features may usefully be incorporated in future attempts to answer this question. For analysis of saving rates across the distribution, see Straub (2017) and Fagereng and others (2019). For evidence on the differential rates of return, see Fagereng and others (2016). For models with multiple assets or a more careful analysis of the constraint—both of which contribute to a better match to the empirical distribution around the borrowing constraint, see Kaplan, Violante, and Weidner (2014); Kaplan, Moll, and Violante (2018); and Achdou and others (2017). For the state-of-the-art calibration of the income process, see Guvenen and others (2015). We conjecture that a richer model with some of the above features would likely predict larger effects of government policy.

where c_t is individual consumption, a_t are individual asset holdings (and $\dot{a}_t$ denotes the time derivative, that is, saving), r_t is the real (net) interest rate, w_t is the wage, and e_t is the idiosyncratic shock to a household's productivity. The household cannot insure against this idiosyncratic uncertainty. The government levies a proportional tax rate τ on both labor and capital income.[32]

The supply side is identical to that in the previous model: the production function is Cobb–Douglas, and there is perfect competition in all markets. The government issues bonds and collects taxes to finance its consumption and transfers. The government budget constraint is

$$\dot{B}_t = G_t + r_t B_t - \tau(w_t + rA_t), \tag{25}$$

which says that the change in government debt is equal to the government funding gap: government consumption G_t plus interest payments $r_t B_t$ minus the tax revenue.

Online appendix D presents the definition and solution of the equilibrium of this economy.

PARAMETERIZATION We choose the values of the parameters in the precautionary saving model to match the typical values in the literature and to be broadly consistent with the life-cycle model given above (table 3). We set the capital share at 0.33, the rate of time preference at 0.04, the depreciation rate at 10 percent, and the intertemporal elasticity of substitution at 0.50.

We next calibrate the income process. Intuitively, the size and persistence of income shocks will determine the strength of the precautionary saving motive, the degree of inequality, and the proportion of households close to or at the borrowing constraint. These outcomes will in turn determine the potency of government financing policy. In the real world, individual income varies over time for a host of reasons. We do not model these causes here. Instead, we make sure that the income process in our model reflects these uncertainties. Specifically, we follow Ana Castañeda, Javier Díaz-Giménez, and José-Víctor Ríos-Rull (2003) and Christopher Winter (2016), and we thus calibrate the income process

32. The assumption of a proportional tax rate is natural in a model with income and wealth heterogeneity. With lump-sum taxation, the poorest households would find themselves unable to pay the tax bill. Note that even though the tax is proportional it does not distort the labor supply decisions because the labor supply is inelastic.

to match aggregate income inequality in the OECD. There are four productivity and income states:

$$e \in \{0.20, 0.55, 0.80, 5.43\}. \tag{26}$$

The corresponding matrix of Poisson intensities is

$$P = \begin{pmatrix} 0.07^{-} & 0.04 & 0.02 & 0.001 \\ 0.03 & 0.13^{-} & 0.01 & 0.001 \\ 0.001 & 0.08 & 0.09^{-} & 0.011 \\ 0.1 & 0.02 & 0.06 & 0.17^{-} \end{pmatrix}, \tag{27}$$

where the values on the main diagonal marked with superscript $^{-}$ indicate the intensity of leaving the current state.

Given this income process, the distributional outcomes in the equilibrium of our model are broadly in line with those observed in the data: the income Gini coefficient is 0.32, close to the OECD average, and the income process is highly persistent.[33]

RESULTS We now compare the two stationary equilibria of the model, one with the government debt-GDP ratio set at 18 percent, and another at 68 percent, to see what the impact of such a higher pool of assets is on the interest rate. Because a larger amount of assets allows households to better insure against individual uncertainty, we expect the interest rate to be higher when government debt is high. The simulation results confirm this intuition: the increase in the public debt-GDP ratio observed in the data implies a real interest rate that is 66 basis points higher in equilibrium (table 5). Though not insignificant, such an increase is smaller than the other channels we identified above.

IV.D. Summary and Discussion

To summarize this section, our analysis underscores the importance of secular public policy shifts in accounting for changes in the equilibrium interest rate. The natural corollary of our findings is that government

33. Castañeda, Díaz-Giménez, and Ríos-Rull (2003) compare the across-the-income-distribution mobility statistics implied by their model with those observed in the data and conclude that the simple model does reasonably well in capturing the persistence moments.

Table 5. Equilibria in the Precautionary Saving Model

Aspect of model	*Low-debt equilibrium*	*High-debt equilibrium*
Government debt to GDP	0.18	0.68
Government consumption to GDP	0.14	0.14
Average tax rate	0.35	0.36
Real interest rate	4.50	5.16
Private capital to GDP	2.56	2.40
Income Gini coefficient	0.32	0.32
Fraction of individuals at the constraint	0.09	0.09

Source: Authors' calculations.

intra- and intertemporal transfer policy is, in principle, an effective tool that can affect equilibrium interest rates in the economy. Similar policy implications have been discussed previously by Narayana Kocherlakota (2015) and Caballero and Farhi (2018).

One objection to our analysis might be that economic agents—consumers, investors, firms, and the like—may in fact be more Ricardian than we currently assume. Our response to this is threefold. First, in section II we presented a broad range of empirical evidence that is inconsistent with the Ricardian Equivalence proposition. Second, in our framework, Ricardian Equivalence does not hold despite fully rational expectations and no information asymmetries; indeed, it would be irrational to be Ricardian in the economy we describe. Third, and relatedly, the assumptions that lead to rejection of Ricardian Equivalence are rather natural—first, people retire; second, people die; third, some people are credit constrained; and fourth, some people face risks they find hard to insure. All these considerations make us comfortable with our assumptions that the Ricardian offset is imperfect.

At this point, it is also useful to highlight that wide uncertainty bands surround our point estimates, including those coming out of the models discussed above. Like all theory models, these tools are built upon a set of uncertain assumptions, and as such are only rough approximations of reality—this is especially true for models as minimalistic and transparent as ours. Even abstracting from model misspecification, there is a wide range of plausible parameter values with which to calibrate these models. A different combination of parameters will produce quantitatively different results. We come back to the robustness of our analysis in online appendix E. Having said that, the combination of a range of empirical studies together with directional guidance from the theory suggest that there are strong reasons to conclude that the government policies we have

Table 6. Demographic Transition in the Advanced Economies, 1970–2030

Year	*Growth of 20+ population*	*Retirement age*	*Years working*	*Years in retirement*
1970	1.4	67.6	47.6	10.5
1975	1.3	66.6	46.6	12.3
1980	1.2	66.1	46.1	13.4
1985	1.1	65.1	45.1	15.0
1990	0.9	64.7	44.7	16.1
1995	0.8	63.8	43.8	17.5
2000	0.7	63.6	43.6	18.6
2005	0.8	64.1	44.1	18.9
2010	0.7	64.8	44.8	18.8
2015	0.4	65.5	45.5	18.7
Projection:				
2020	0.2	66.1	46.1	18.6
2025	0.2	66.8	46.8	18.4
2030	0.2	67.5	47.5	18.3

Sources: United Nations data; OECD data.

scrutinized here have put significant upward pressure on the safe neutral real rate over the past several decades.

V. Validating the Models by Assessing the Underlying Weakness in R^*

Our simulation analysis concluded that the major shifts in governments' policies over the past 50 years facilitated a significant transfer of resources from low-MPC to high-MPC individuals and allowed households to better self-insure against idiosyncratic shocks. All else being equal, added together these shifts would have pushed interest rates in the advanced world up by about 3.6 percentage points. But of course all else was not equal. In this section, we validate our models by showing that, when used to assess the impact of some of the private sector forces that have been highlighted by the literature, these models produce the quantitative effects that are plausible and in line with the existing findings. Specifically, our framework can readily be used to quantify the impact of the demographic transition, the decline in expected trend productivity growth, and the rise in income inequality on the long-term interest rate.

Table 6 documents the major demographic transition that has been under way in the advanced economies for the past 50 years. Population growth in the developed economies has fallen rapidly in past decades, from about 1.4 percent a year in the 1970s to less than 0.4 percent today. This trend is expected to continue; in fact, the latest UN projections suggest that population in the advanced economies will start shrinking in about 2050. As population growth has decelerated, life expectancy has gone up significantly, and retirement ages have not kept up. As a result, the average length of retirement is nearly twice what it was in the 1970s. This positive development carries significant implications for life-cycle budgeting and thus for the balance of desired saving and investment.

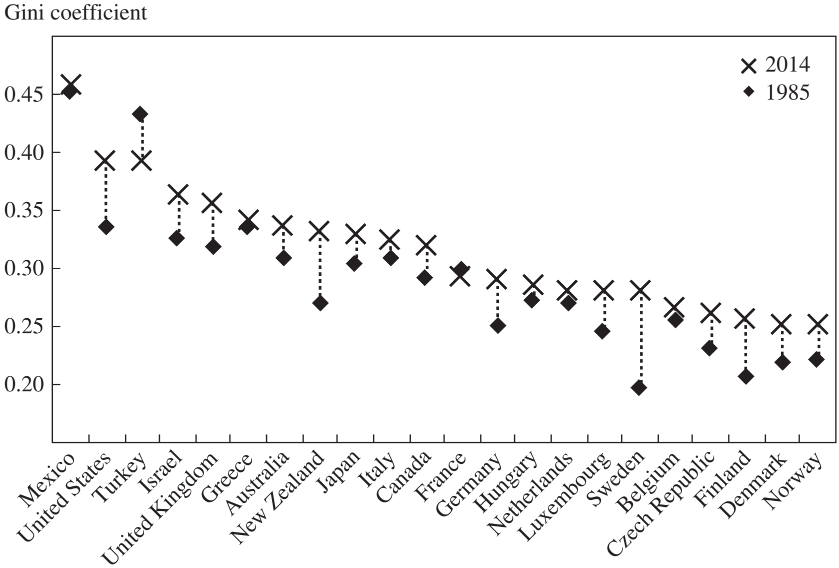
The slowdown in the pace of expected long-run growth has similar implications. Our modeling framework inherits the property shared by essentially all dynamic macroeconomic models, namely, that the long-run equilibrium interest rate is linked to expected future consumption growth. This relationship—the Euler Equation, or the dynamic investment–saving curve—is the result of the intertemporal optimization of households, which choose how much to consume today versus tomorrow (hence determining the growth rate of their consumption) based on the interest rate. In general equilibrium, the expectations of future consumption growth in the long run coincide with the expectations of total factor productivity (TFP) growth. Hence the theory suggests that real rates and expected productivity growth ought to be linked.[34]

This prediction of the theory is, however, more tenuous in practice. In an early contribution to this topic, Carroll and Summers (1991) established that, across countries, consumption growth and income growth are tightly linked and follow each other, and that households with more steeply rising income profiles tend to save more, not less. These findings—which are inconsistent with the standard permanent-income hypothesis and the life-cycle model—have been rationalized in the literature with buffer-stock models of saving (whereby households face uncertain income process, similarly to our second model) and introducing consumption habits in household preferences.[35] Although our models attenuate the link between

34. In a representative agent, infinite-horizon economy, the Euler Equation takes a particularly straightforward form, whereby the long-run consumption growth rate and the interest rate are linked linearly, with the coefficient equal to the intertemporal elasticity of substitution. Within our framework, that link is still there, although it is attenuated by finite horizons and borrowing constraints: intuitively, the interest rate is relatively "less important" in driving consumption growth, as other factors (such as the possibility of death or credit constraints) come into play. This implies that a given change in the expectations of future consumption growth—say, driven by news about TFP—will require a *larger* response of the interest rate to restore equilibrium.

35. See Deaton (1991); Carroll (1997); and Carroll, Overland, and Weil (2000)—and the literature that followed.

Figure 10. The Gini Coefficient of Disposable Household Income across the OECD, 1985 and 2014[a]



Source: OECD Database on Household Income Distribution and Poverty.
a. This figure shows the Gini coefficient of disposable income, adjusted for household size.

interest rates and consumption choices in line with these findings, nonetheless we urge a significant degree of caution when interpreting the results on the link between TFP and R^*. Our preferred interpretation is that the low interest rates today are chiefly a symptom of a demand-side problem. We return to this issue in the final section of the paper, where we discuss policy implications.

These caveats notwithstanding, numerous studies—for instance, that by Gustavo Adler and others (2017)—reach the conclusion that trend growth rates of both productivity and of TFP have declined significantly in the advanced economies—first in the early 1980s, when TFP growth halved from about 2 to 1 percent a year; and then again in the mid-2000s. Also, the macroeconomic models we use do suggest that such deterioration should have dragged on neutral real interest rates.

The third trend we quantify is the rise in income inequality, which has increased in the United States and many other advanced economies (figure 10). Our second model is well suited to give us an estimate of this shift on the real rate of interest. To trace out the effects of rising inequality in this model, we recalibrate the income process in such a way as to match the increase in income Gini coefficient in the OECD since the 1970s. Our calculations implicitly assume that ex-post inequality is driven by larger variance of individual income shocks, which constitutes a source of additional uncertainty for individual workers. An alternative view is that the increase in inequality is a consequence of shifts being more tightly linked to heterogeneity across households that is known ex-ante. The distinction is important because only the former kind of shift would lead to an increase in precautionary behavior. Because it is predictable, the latter shift is not associated with heightened risk. There is a long-standing debate about the merits of the two formulations in the literature.[36] The recent work by Fatih Guvenen and others (2015) has established the large departures of log-normality in the individual income changes; in particular, earnings changes display strong negative skewness and extremely high kurtosis. Important for our interpretation is their finding that large shocks at the top of the income distribution tend to be very persistent. We view these results as supportive of the gist of our exercise, which interprets the increased disparity between the poor and the rich as going hand in hand with an increase in ex-ante uncertainty. Given the lack of a clear consensus in the literature, it is possible that we overestimate the impact of inequality on real rates in this exercise. In any case, there likely are other powerful ways in which higher inequality has acted to depress rates, which we miss from our framework (and which we discuss momentarily).

To validate our models and to explore the implications of these trends for the equilibrium real interest rate, we perform this exercise: In the life-cycle model, we calibrate the changes in demographic transition probabilities, ω and λ, to match the trends depicted in the final two columns of table 6. We then feed in the series for population and TFP growth rates to match the evidence in the first column of table 6 and as given by Adler and others (2017). We use the United Nations' demographic projections to inform the path of demographics out to 2050, and we assume that the terminal 2050 values are the steady state. We do not have a strong prior as to the path for future TFP growth, and we are well aware of the wide range of existing and plausible views. Aiming for a scenario that reflects the mode of these expectations, we assume that the TFP growth rate picks up from around

36. Classic references include Lillard and Weiss (1979), MaCurdy (1982), and Guvenen (2009).

zero in the latest available data to 0.7 percent in the long run.[37] This pickup in TFP growth is broadly in line with the Congressional Budget Office's assumption for the pickup of TFP growth in the United States (CBO 2019).

In the precautionary saving model, we recalibrate the income process,[38] and we compare the steady states of the economy under the two calibrations.[39]

To reiterate, within each of the two models, we feed in the (model-specific) set of shocks all at the same time, thereby providing—within each model—an internally consistent laboratory to study this wide range of heterogeneous trends. What we miss are the potential interactions across the two models. We assume that the comparable calibration across the two frameworks makes the results comparable, and that simply adding the estimates of the impact on R^* over the transition across the models results in a consistent picture. But ultimately, only the framework for analysis of all the forces that we consider—and perhaps further ones—in a single unifying setting would provide a definitive answer to these doubts. This avenue of inquiry is left for future research.

Table 7 and figure 11 summarize the key results of this exercise. First, in section II we estimated that the neutral real rate declined by over 3 percentage points between 1970 and 2017. In sections III and IV, we argued that public policies have pushed rates up. Our models suggest that, together, the policies we have considered have pushed rates up by nearly 4 percentage points to date. This suggests that the private sector R^* may have declined by about 7 percentage points. The private sector forces we consider add up to a drag of 5.5 percentage points, leaving over 1 percentage point of the decline in private sector R^* unaccounted for. These results are in line with previous papers that have attempted the quantification of the different forces at play (Eggertsson, Mehrotra, and Robbins 2019; Carvalho, Ferrero, and Nechio 2016; Gagnon, Johannsen, and Lopez-Salido 2016). This makes us confident that the large quantitative effect of government policies

37. There is very large uncertainty around any long-term forecast of the TFP growth rate. In particular, research has shown that current-decade growth of productivity holds little information as to the growth in the following decade. Perhaps naturally, the commentators are split on the prospects for innovation and productivity. See, for example, Brynjolfsson and McAfee (2014) and Gordon (2016) for two perspectives from the opposite ends of a spectrum.

38. In particular, we change the income received in the highest income state. This is motivated by the fact that the increase in income inequality has been concentrated at the very top of the distribution, as documented by Piketty (2014) and others.

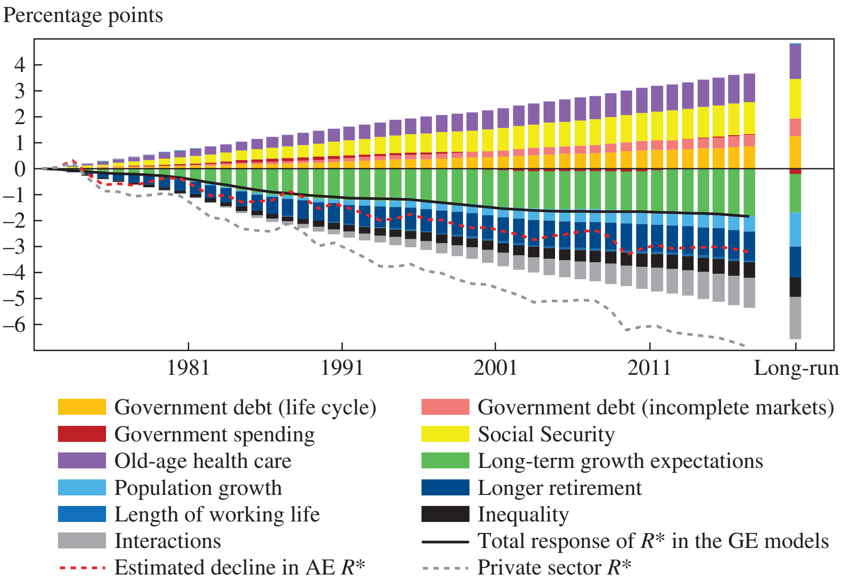
39. We obtain the dynamic path by assuming that the effect builds steadily, including over the next decade. Our treatment of the dynamics is thus crude. We leave the analysis of the dynamic adjustment path for future work.

Table 7. Decomposition of the Decline in the Neutral Real Interest Rate in the Advanced Economies[a]

Aspect of decomposition	*1970–2008*	*1970–2017*	*1970–2070*
Estimated decline in AE R^* (section II)	–2.7	–3.2	
Public policies			
Government debt (life cycle)	0.6	0.8	1.2
Government debt (incomplete markets)	0.3	0.4	0.7
Government spending	–0.1	0.0	–0.2
Social Security	1.0	1.2	1.5
Old-age health care	0.9	1.1	1.3
Total impact of public policies	*2.8*	*3.6*	*4.5*
Implied decline in private sector R^*	–5.4	–6.9	
Selected private sector forces			
TFP growth	–1.5	–1.8	–1.5
Population growth	–0.5	–0.6	–1.3
Longer retirement	–1.0	–1.1	–1.2
Length of working life	–0.1	–0.1	0.0
Inequality	–0.6	–0.7	–0.9
Interactions	–0.8	–1.1	–1.6
Total private sector forces	–4.4	–5.5	–6.5

Source: Authors' calculations.
a. TFP = total factor productivity. All values are in percentage points.

Figure 11. Changes in the Equilibrium Real Interest Rate as a Result of Policy, Demographic, and Technological Shifts, 1971–2022



Source: Authors' calculations.

that we estimated are credible and not just a result of model-specific assumptions or calibration.

Unsurprisingly, the forces that we consider in this exercise cannot account for the full extent of the decline in equilibrium rates, with over 1 percentage point left unexplained in our preferred calibration. Our models miss some of the secular forces that likely pushed neutral rates lower over the past 40 years. One omission is the increasing concentration and the associated increase in market power of firms in the United States and other advanced countries (Farhi and Gourio 2018). Another force is driven by the finding that propensities to save are higher for those with high permanent income (Carroll 2000; Dynan, Skinner, and Zeldes 2004). In light of these findings, our simulations likely understate the full impact of the increase in permanent income inequality. Using a model that captures this mechanism, Ludwig Straub (2017) estimates that the rise in inequality may have pushed down on the real equilibrium interest rate in the U.S. by about 1 percentage point through this channel. The decline in the price of capital goods may have contributed to lower investment propensities, further decreasing the neutral real rate (Sajedi and Thwaites 2016). Finally, changes in the tax code—particularly the decline in overall tax progressivity in some jurisdictions—may have been a public sector force that depressed interest rates. We leave more detailed investigation of these forces for future research.

VI. Conclusion

We draw three main conclusions from the analysis in this paper. First, the neutral real rate for the industrial world has trended downward for the last generation, and this is best understood in terms of changes in private sector saving and investment propensities. In the face of neutral real rate estimates, past trends in indexed bond yields, and measures of real swap yields, this conclusion seems inescapable. It is also noteworthy that current real rates appear to be quite well predicted by prefinancial crisis trends. We believe that these trends are best analyzed in terms of changes in saving and investment propensities or equivalently in terms of trends in desired wealth holdings by consumers and desired capital accumulation by producers. Although factors involving liquidity, scarcity, and risk no doubt bear on levels of real interest rates, we find it highly implausible that they are the main factor accounting for the trend movements. The movements are too large and too pervasive across assets and the fluctuations in spreads are too small and lacking in the trend for these factors to account for the observed trends in the data.

Second, the neutral real rate would have declined substantially more over the last generation but for increases in government debt and expansions in social insurance programs. Both straightforward extrapolations of existing rules of thumb regarding debt and deficit effects on interest rates and calculations using workhorse general equilibrium models suggest that fiscal policies have operated to raise real interest rates by several hundred basis points over the last generation. Though this conclusion is dependent on our rejection of Ricardian Equivalence, we see nothing that leads us to believe that increased government debt automatically calls for increased saving or that pay-as-you-go Social Security programs alter bequests for most families. The specific magnitudes are very uncertain, but open economy aspects and the possibility suggested by our analysis—that budget deficits emerge in response to excesses of private saving over private investment—lead us to think that we are more likely to understate than overstate the extent of fiscal support for real interest rates in recent years.

Third, the implication of our analysis that but for major increases in deficits, debt, and social insurance neutral real rates in the industrial world would be significantly negative by as much as several hundred basis points suggests substantial grounds for concern over secular stagnation. From the perspective of our analysis, the private economy is prone to being caught in an underemployment equilibrium if real interest rates cannot fall far below zero. Where full employment has been achieved in recent years, it has either been through large budget deficits, as in the United States or Japan, or through large trade surpluses, as in Germany. It is worth considering that in the United States during the period before the financial crisis, negative real short-term interest rates, a huge housing bubble, erosion of credit standards, and expansionary fiscal policy were only sufficient to achieve moderate growth. Adequate growth in Europe was only maintained through what in retrospect appears to have been clearly unsustainable lending to the countries on the so-called periphery.

What does our analysis say about stabilization policy? Most obviously, it says that traditional levels of interest rates combined with balanced budgets or even stable debt-GDP ratios are a prescription for recession. If policymakers wish to avoid output being demand constrained, they must do some combination of accepting high and rising deficits and government debt levels, living with real interest rates very close to zero or negative, and finding structural policies that promote investment or reduce saving.

Blanchard (2019) makes the argument that traditional views about fiscal policy likely reflect excessive concern about debt when real interest rates are very low and are likely to remain low for a long time to come. The sustainability of a given level of deficit or debt is greater when interest rates are low than when they are high. Nonetheless, it has to be acknowledged that the U.S. economy appears to be slowing to below potential growth despite projected primary deficits that will lead even on very favorable interest rate assumptions to steadily growing debt-to-GDP ratios that will ultimately set historical records. There is no guarantee that deficits sufficient to maintain positive neutral real rates will be associated with sustainable debt trajectories. Indeed, the Japanese experience suggests that this may not be the case.

Another possibility is the use of monetary policies that induce significantly negative real rates. This might be achieved through setting negative nominal rates, raising or adjusting inflation targets (for example, through targeting the average rate of inflation and thus "making up" for the past errors), or using unconventional monetary policies such as quantitative easing to achieve the equivalent of reductions in real rates. These approaches raise three issues. First, given that historically rates have been reduced by 500 basis points or more to mitigate recessions in industrial countries, there is the question of whether enough room can be generated to stabilize the economy when the next downturn hits. Second, there are questions about whether, starting at very low rates, further rate reductions are actually stimulative. Eggertsson and others (2019) suggest that negative nominal rates actually may interfere with financial intermediation. Third, there is a range of concerns about the possible toxic effects of low rates—including suggestions that they make bubbles and overleveraging more likely as they encourage risk taking, and that they may lead to a misallocation of capital by reducing loan payment levels and required rates of return, reinforcing monopoly power, benefiting the old at the expense of the young, and making the funding of insurance and pension obligations more difficult.

A final possibility is structural measures that reduce saving or promote investment. Clearly, regulatory policies that encourage investment without sacrificing vital social objectives are desirable. The extent to which these are available is very much open to question. Investment incentives will also operate to raise demand. Policies that reduce the need for retirement saving, such as strengthening Social Security, or that improve social insurance, will increase aggregate demand even if operated on a balanced budget basis. So will policies that redistribute income from those with lower to those with higher propensities to consume.

It is tempting to suggest that any measure that increases productivity growth will operate to raise neutral real rates as consumers seek to spend more out of higher expected future incomes and firms increase their investment demand. Effects of this kind are indeed suggested by our formal model. We are not sure of their validity in practice. As Carroll and Summers (1991) point out, growth accelerations internationally have typically been associated with declining rather than increasing real rates, and there is not much evidence that consumers are that forward looking, especially if the reforms are associated with transitional costs and heightened short-term uncertainties. Moreover, in policy discussions, central bankers usually cite stronger productivity as an antidote to inflation and therefore as a reason not to raise rates. Short-term productivity gains that reduce costs and inflation may act to elevate realized interest rates above the neutral rate, further worsening the demand imbalance.

All this suggests that if secular stagnation is avoided in the years ahead, it will not be because it is somehow impossible in a free market economy, but instead because of policy choices. Our conclusions thus underscore the urgent priority for governments to find new, sustainable ways of promoting investment to absorb the large supply of private saving and to devise novel long-term strategies to rekindle private demand.

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References

Achdou, Yves, Jiequn Han, Jean-Michel Lasry, Pierre-Louis Lions, and Benjamin Moll. 2017. "Income and Wealth Distribution in Macroeconomics: A Continuous-Time Approach." NBER Working Paper 23732. Cambridge, Mass.: National Bureau of Economic Research. https://www.nber.org/papers/w23732.

Adler, Gustavo, Romain Duval, Davide Furceri, Sinem Kiliç Çelik, Ksenia Koloskova, and Marcos Poplawski-Ribeiro. 2017. "Gone with the Headwinds: Global Productivity." IMF Staff Discussion DN/17/04. Washington: International Monetary Fund. https://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2017/04/03/Gone-with-the-Headwinds-Global-Productivity-44758.

Aiyagari, S. Rao. 1993. "Uninsured Idiosyncratic Risk and Aggregate Saving." *Quarterly Journal of Economics* 109, no. 3: 659–84.

Aiyagari, S. Rao, and Ellen R. McGrattan. 1998. "The Optimum Quantity of Debt." *Journal of Monetary Economics* 42, no. 3: 447–69.

Attanasio, Orazio P., and Agar Brugiavini. 2003. "Social Security and Households' Saving." *Quarterly Journal of Economics* 118, no. 3: 1075–1119.

Attanasio, Orazio P., and Susann Rohwedder. 2003. "Pension Wealth and Household Saving: Evidence from Pension Reforms in the United Kingdom." *American Economic Review* 93, no. 5: 1499–1521.

Barro, Robert J. 1974. "Are Government Bonds Net Wealth?" *Journal of Political Economy* 82, no. 6: 1095–1117.

Barro, Robert J., and Glenn M. MacDonald. 1979. "Social Security and Consumer Spending in an International Cross Section." *Journal of Public Economics* 11, no. 3: 275–89.

Blanchard, Olivier. 1985. "Debt, Deficits, and Finite Horizons." *Journal of Political Economy* 93, no. 2: 223–47.

———. 2019. "Public Debt and Low Interest Rates." *American Economic Review* 109, no. 4: 1197–1229.

Brook, Anne-Marie. 2003. "Recent and Prospective Trends in Real Long-Term Interest Rates." Working Paper 367. Paris: Organization for Economic Cooperation and Development, https://doi.org/10.1787/514820262776.

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

Caballero, Ricardo J., and Emmanuel Farhi. 2018. "The Safety Trap." *Review of Economic Studies* 85, no. 1: 223–74.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2016. "Safe Asset Scarcity and Aggregate Demand." *American Economic Review* 106, no. 5: 513–18.

Carroll, Christopher D. 1997. "Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis." *Quarterly Journal of Economics* 112 , no. 1: 1–55.

———. 2000. "Why Do the Rich Save So Much?" In *Does Atlas Shrug? The Economic Consequences of Taxing the Rich*, edited by Joel B. Slemrod. Cambridge, Mass.: Harvard University Press.

Carroll, Christopher D., Jody Overland, and David N. Weil. 2000. "Saving and Growth with Habit Formation." *American Economic Review* 90, no. 3: 341–55.

Carroll, Christopher, Jiri Slacalek, Kiichi Tokuoka, and Matthew N. White. 2017. "The Distribution of Wealth and the Marginal Propensity to Consume." *Quantitative Economics* 8 , no. 3: 977–1020.

Carroll, Christopher D., and Lawrence H. Summers. 1991. "Consumption Growth Parallels Income Growth: Some New Evidence." In *National Saving and Economic Performance*, edited by B. Douglas Bernheim and John B. Shoven. Chicago: University of Chicago Press.

Carvalho, Carlos, Andrea Ferrero, and Fernanda Nechio. 2016. "Demographics and Real Interest Rates: Inspecting the Mechanism." *European Economic Review* 88: 208–26.

Castañeda, Ana, Javier Díaz-Giménez, and José-Víctor Ríos-Rull. 2003. "Accounting for the U.S. Earnings and Wealth Inequality." *Journal of Political Economy* 111, no. 4: 818–57.

CBO (Congressional Budget Office). 1998. *Social Security and Private Saving: A Review of the Empirical Evidence*. Washington: CBO. https://www.cbo.gov/sites/default/files/105th-congress-1997-1998/reports/ssprisav.pdf.

———. 2019. *The Budget and Economic Outlook: 2019 to 2029–January 2019*. Washington: CBO. https://www.cbo.gov/system/files/2019-03/54918-Outlook-3.pdf.

Christensen, Jens H. E., and Glenn D. Rudebusch. 2019. "A New Normal for Interest Rates? Evidence from Inflation-Indexed Debt." *Review of Economics and Statistics*, forthcoming.

Claessens, Stijn, and M. Ayhan Kose. 2017. "Asset Prices and Macroeconomic Outcomes: A Survey." Working Paper 8259. Washington: World Bank. http://documents.worldbank.org/curated/en/599841511879164538/Asset-prices-and-macroeconomic-outcomes-a-survey.

Constâncio, Vítor. 2016. "The Challenge of Low Real Interest Rates for Monetary Policy." Lecture given at Macroeconomics Symposium at Utrecht School of Economics, Utrecht, June 15. https://www.ecb.europa.eu/press/key/date/2016/html/sp160615.en.html.

D'Amico, Stefania, Don H. Kim, and Min Wei. 2018. "Tips from TIPS: The Informational Content of Treasury Inflation-Protected Security Prices." *Journal of Financial and Quantitative Analysis* 53, no. 1: 395–436.

Deaton, Angus. 1991. "Saving and Liquidity Constraints." *Econometrica* 59, no. 5: 1221–48.

Del Negro, Marco, Domenico Giannone, Marc P. Giannoni, and Andrea Tambalotti. 2018. "Global Trends in Interest Rates." Staff Report 866. New York: Federal Reserve Bank of New York. https://www.newyorkfed.org/medialibrary/media/research/staff_reports/sr866.pdf.

Diamond, Peter A. 1965. "National Debt in a Neoclassical Growth Model." *American Economic Review* 55, no. 5, pt. 1: 1126–50.

Draghi, Mario. 2016. "The International Dimension of Monetary Policy." Speech given at ECB Forum on Central Banking, Sintra, June 28. https://www.ecb.europa.eu/press/key/date/2016/html/sp160628.en.html.

Dynan, Karen E., Jonathan Skinner, and Stephen P. Zeldes. 2004. "Do the Rich Save More?" *Journal of Political Economy* 112, no. 2: 397–444.

ECB (European Central Bank). 2018. "The Natural Rate of Interest: Estimates, Drivers, and Challenges to Monetary Policy." Edited by Claus Brand, Marcin Bielecki, and Adrian Penalver. Occasional Paper 217. Frankfurt: European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op217.en.pdf.

Eggertsson, Gauti B., Ragnar E. Juelsrud, Lawrence H. Summers, and Ella Getz Wold. 2019. "Negative Nominal Interest Rates and the Bank Lending Channel." NBER Working Paper 25416. Cambridge, Mass.: National Bureau of Economic Research. https://www.nber.org/papers/w25416.

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, no. 1: 1–48.

Elmendorf, Douglas W., and N. Gregory Mankiw. 1999. "Government Debt." In *Handbook of Macroeconomics*, edited by John B. Taylor and Michael Woodford. Amsterdam: North-Holland.

Engen, Eric M., and Jonathan Gruber. 2001. "Unemployment Insurance and Precautionary Saving." *Journal of Monetary Economics* 47, no. 3: 545–79.

Engen, Eric M., and R. Glenn Hubbard. 2004. "Federal Government Debts and Interest Rates." In *NBER Macroeconomics Annual*, edited by Mark Gertler and Kenneth Rogoff. Cambridge, Mass.: MIT Press.

Epstein, Larry G., and Stanely E. Zin. 1991. "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: An Empirical Analysis." *Journal of Political Economy* 99, no. 2: 263–86.

Evans, Paul. 1987. "Interest Rates and Expected Future Budget Deficits in the United States." *Journal of Political Economy* 95: 34–58.

Fagereng, Andreas, Luigi Guiso, Davide Malacrino, and Luigi Pistaferri. 2016. "Heterogeneity and Persistence in Returns to Wealth." NBER Working Paper 22822. Cambridge, Mass.: National Bureau of Economic Research. https://www.nber.org/papers/w22822.

Fagereng, Andreas, Martin Holm, Benjamin Moll, and Gisle Natvik. 2019. "Saving Behavior across the Wealth Distribution." Working paper. http://www.princeton.edu/~moll/SBWD.pdf.

Faini, Riccardo. 2006. "Fiscal Policy and Interest Rates in Europe." *Economic Policy* 21, no. 47: 444–89.

Farhi, Emmanuel, and François Gourio. 2018. "Accounting for Macro-Finance Trends: Market Power, Intangibles, and Risk Premia." *Brookings Papers on Economic Activity*, Fall, 147–223.

Feldstein, Martin. 1974. "Social Security, Induced Retirement, and Aggregate Capital Accumulation." *Journal of Political Economy* 82, no. 5: 905–26.

Feldstein, Martin, and Anthony Pellechio. 1979. 'Social Security and Household Wealth Accumulation: New Microeconometric Evidence." *Review of Economics and Statistics* 61, no. 3: 361–68.

Fischer, Stanley. 2016. "Why Are Interest Rates So Low? Causes and Implications." Speech given at Economic Club of New York, New York, October 17. https://www.federalreserve.gov/newsevents/speech/fischer20161017a.htm.

Gagnon, Etienne, Benjamin K. Johannsen, and David Lopez-Salido. 2016. "Understanding the New Normal: The Role of Demographics." Working Paper 2016-080. Washington: Federal Reserve Board of Governors. http://dx.doi.org/10.17016/FEDS.2016.080.

Gale, William G., and Peter R. Orszag. 2003. "The Economic Effects of Long-Term Fiscal Discipline." Working Paper 8. Washington: Urban-Brookings Tax Policy Center. https://www.urban.org/sites/default/files/publication/58901/310669-The-Economic-Effects-of-Long-Term-Fiscal-Discipline.pdf.

Galí, Jordi. 2008. *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications*. Princeton, N.J.: Princeton University Press.

Gertler, Mark. 1999. "Government Debt and Social Security in a Life-Cycle Economy." Carnegie-Rochester Conference Series on Public Policy 50: 61–110.

Gordon, Robert J. 2016. "Perspectives on the Rise and Fall of American Growth." *American Economic Review* 106, no. 5: 72–76.

Guvenen, Fatih. 2009. "An Empirical Investigation of Labor Income Processes." *Review of Economic Dynamics* 12, no. 1: 58–79.

Guvenen, Fatih, Fatih Karahan, Serdar Ozkan, and Jae Song. 2015. "What Do Data on Millions of U.S. Workers Reveal About Life-Cycle Earnings Risk?" NBER Working Paper 20913. Cambridge, Mass.: National Bureau of Economic Research. https://www.nber.org/papers/w20913.

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, no. 4: 660–707.

Holston, Kathryn, Thomas Laubach, and John C. Williams. 2017a. "Documentation of *R* Code and Data for Measuring the Natural Rate of Interest: International Trends are Determinants." https://usermanual.wiki/Pdf/HLWCodeGuide.843689289.pdf.

———. 2017b. "Measuring the Natural Rate of Interest: International Trends and Determinants." *Journal of International Economics* 108, no. S1: S59–S75.

Kaplan, Greg, Benjamin Moll, and Giovanni L. Violante. 2018. "Monetary Policy According to HANK." *American Economic Review* 108, no. 3: 697–743.

Kaplan, Greg, Giovanni L. Violante,, and Justin Weidner. 2014. "The Wealthy Hand-to-Mouth." *Brookings Papers on Economic Activity*, Spring, 77–138.

Kay, John. 2015. *Other People's Money: Masters of the Universe or Servants of the People?* London: Profile Books.

King, M., and D. Low. 2014. "Measuring the 'World' Real Interest Rate." NBER Working Paper 19887. Cambridge, Mass.: National Bureau of Economic Research. http://www.nber.org/papers/w19887.pdf.

Kinoshita, Noriaki. 2006. “Government Debt and Long-Term Interest Rates.” IMF Working Paper WP/06/63. Washington: International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Government-Debt-and-Long-Term-Interest-Rates-18866.

Kocherlakota, Narayana. 2015. “Public Debt and the Long-Run Neutral Real Interest Rate.” Speech given at Bank of Korea Conference, Seoul, August 19. https://www.minneapolisfed.org/news-and-events/presidents-speeches/public-debt-and-the-long-run-neutral-real-interest-rate.

Kuroda, Haruhiko. 2016. “The Battle against Deflation: The Evolution of Monetary Policy and Japan’s Experience.” Speech given at Columbia University, New York, April 13. https://www.boj.or.jp/en/announcements/press/koen_2016/data/ko160414a1.pdf.

Laforte, Jean-Philippe, and John Roberts. 2014. “November 2014 Update of the FRB/US Model.” *FEDS Notes*. https://doi.org/10.17016/2380-7172.0036.

Laibson, David. 1997. “Golden Eggs and Hyperbolic Discounting.” *Quarterly Journal of Economics* 112, no. 2: 443–77.

Laubach, Thomas. 2009. “New Evidence on the Interest Rate Effects of Budget Deficits and Debt.” *Journal of the European Economic Association* 7, no. 4: 858–85.

Laubach, Thomas, and John C. Williams. 2003. “Measuring the Natural Rate of Interest.” *Review of Economics and Statistics* 85, no. 4: 1063–70.

Lillard, Lee A., and Yoram Weiss. 1979. “Components of Variation in Panel Earnings Data: American Scientists 1960–70.” *Econometrica* 47, no. 2: 437–54.

MaCurdy, Thomas E. 1982. “The Use of Time Series Processes to Model the Error Structure of Earnings in a Longitudinal Data Analysis.” *Journal of Econometrics* 18, no. 1: 83–114.

Mankiw, N. Gregory. 2000. “The Savers-Spenders Theory of Fiscal Policy.” *American Economic Review* 90, no. 2: 120–25.

OECD (Organization for Economic Cooperation and Development). 2018. *OECD Tax Policy Studies: The Role and Design of Net Wealth Taxes*. OECD Tax Policy Study 26. Paris: OECD Publishing. https://www.oecd.org/ctp/the-role-and-design-of-net-wealth-taxes-in-the-oecd-9789264290303-en.htm.

———. 2019. “OECD Tax Database.” http://www.oecd.org/tax/tax-policy/tax-database/.

Oh, Hyunseung, and Ricardo Reis. 2012. “Targeted Transfers and the Fiscal Response to the Great Recession.” *Journal of Monetary Economics* 59: S50–S64.

Piketty, Thomas. 2014. *Capital in the Twenty-First Century*. Cambridge, Mass.: Belknap Press.

Piketty, Thomas, and Emmanuel Saez. 2007. “How Progressive Is the U.S. Federal Tax System? A Historical and International Perspective.” *Journal of Economic Perspectives* 21, no. 1: 3–24.

Plosser, Charles I. 1987. “Fiscal Policy and the Term Structure.” *Journal of Monetary Economics* 20: 343–67.

Powell, Jerome H. 2018. "The Federal Reserve's Framework for Monitoring Financial Stability." Speech given at Economic Club of New York, New York, November 28. https://www.federalreserve.gov/newsevents/speech/powell20181128a.htm.

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

———. 2017. "Are Low Real Interest Rates Here to Stay?" *International Journal of Central Banking* 13, no. 3: 1–42.

Sajedi, Rana, and Gregory Thwaites. 2016. "Why Are Real Interest Rates So Low? The Role of the Relative Price of Investment Goods." *IMF Economic Review* 64, no. 4: 635–59.

Straub, Ludwig. 2017. "Consumption, Saving, and the Distribution of Permanent Income." Working paper, Harvard University. https://scholar.harvard.edu/straub/publications/consumption-savings-and-distribution-permanent-income.

Walsh, Carl E. 1998. *Monetary Theory and Policy*. Cambridge, Mass.: MIT Press.

Wicksell, Knut. 1898. *Interest and Prices*. New York: Sentry Press.

Winter, Christopher. 2016. "The Impact of Government Debt on the Long-Run Natural Real Interest Rate: A Quantitative Evaluation." *Journal of Applied Economics Letters* 24, no. 20: 1429–34.

Woodford, Michael. 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton, N.J.: Princeton University Press.

Yaari, Menahem E. 1965. "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer." *Review of Economic Studies* 32, no. 2: 137–50.

Comments and Discussion

COMMENT BY

GAUTI B. EGGERTSSON Let me start with an overview of how this paper fits in the modern literature on the liquidity trap—that is, the literature on the zero lower bound (ZLB). I find it useful to separate this into three generations of models. The first-generation models considered the ZLB as being due to some temporary exogenous forces, such as preference shocks. Papers in this vein include two published in this journal: one by Paul Krugman (1998), and my paper with Michael Woodford (2003). The second-generation models instead study the nature of the underlying shocks. Examples include papers by Eggertsson and Krugman (2012) and by Veronica Guerrieri and Guido Lorenzoni (2018). A common culprit for a ZLB episode in the second-generation models is a disturbance in the financial sector, such as a household debt deleveraging shock or shocks to bank balance sheets. A key lesson that emerged from this literature was that most of the proposed shocks predicted a temporary reduction in the natural rate of interest that then recovers—for example, once households put their debt on a more sustainable level or banks clean up their balance sheets. At that point, the ZLB is no longer a constraint on policy and things return to normal. A common theme in the first- and second-generation models is that the central bank can have a big effect on outcomes by managing expectations about how it will conduct interest rate policy once the natural rate of interest has recovered. This has been usually termed "the forward guidance of central banks." It is a very powerful force in these models to limit output contractions.

The third-generation ZLB models emerged after a speech by one of the authors of this paper, Lawrence Summers, at the International Monetary Fund in 2013. The context of his speech was that in 2013, the world's recovery from the financial crisis of 2008 was still anemic, even if, by most accounts, households and bank balance sheets had been put on a more sustainable basis. Despite this normalization, markets projected the interest rate to remain low for a long time, and most people were disappointed by the slow recovery of output from the crisis. Summers (2013a, 2013b) suggested that perhaps the fall in the natural rate of interest was not just a temporary reaction to the financial crisis but instead a permanent drop—in contrast to the explicit or implicit prediction of the first- and second-generation ZLB models. If correct, this insight had broad and far-ranging implications for both modeling and economic policy. For one thing, forward guidance about interest rate policy once the natural rate normalizes is of limited help if there is no prospect of this normalization on the horizon. Overall, this perspective tends to shift the focus away from monetary policy as the major remedy for recessions and tilts the balance more toward fiscal activism, a prescription that has yet to make a serious mark on how actual policy is conducted today, but one that is well aligned with earlier Keynesian thinking.

For the idea of a permanent reduction in the natural rate of interest, Summers used the term "the secular stagnation hypothesis," an expression that originates in Alvyn Hansen's 1938 presidential speech to the American Economic Association (Hansen 1939). At the time of that speech, the United States was experiencing the second phase of the Great Depression. Hansen suggested that the United States might permanently experience sluggish demand, due to a slowdown in population growth and a lack of investment opportunities. Hansen's dire predictions, of course, turned out to be widely off the mark. The baby boom that followed World War II drastically changed the country's population dynamics, and there was a boom in all sorts of innovations. In the postwar prosperity that followed, too much inflation and high interest rates were the worry of the day, not deflation and low interest rates, which are at center stage in the secular stagnation literature. Summers suggested that perhaps Hansen might just have uttered his dire predictions 75 years too early.

Right after Summers's speech, the literature quickly started to formalize these ideas in the modern modeling context.[1] The current paper by Rachel

1. To my knowledge, the paper by Eggertsson and Mehrotra (2014) was the first one to formalize the idea in the modern dynamic stochastic general equilibrium model, using a small-scale overlapping-generations model. Eggertsson, Mehrotra, and Robbins (2019), in addition, considered a quantitative, large-scale overlapping-generations model. In those models, there can be a permanent decline in the natural rate due to a slowdown in population growth, a rise in life expectancy, a rise in productivity, a rise in inequality, and a fall in the relative price of investment. Caballero and Farhi (2018), however, show that a reduction in safe assets supply can also trigger a persistent fall in the natural rate of interest. Eggertsson and others (2016), conversely, consider the open economy dimension of these ideas.

and Summers synthesizes this literature, and extends it in several directions, putting special emphasis on how government policies may have counteracted the fall in the natural rate of interest—for example, by increases in government debt and in pay-as-you-go Social Security. Both policies tend to raise rather than reduce the natural rate of interest. Here, I highlight a few key results of the paper, do some nitpicking, and conclude by highlighting some unresolved questions that have to do with optimal policy responses to secular stagnation.

KEY RESULTS One major result in Rachel and Summers's paper is an empirical estimate of the natural rate of interest in the industrialized economies, suggesting that it has declined by about 300 basis point since 1980, leaving it today in the neighborhood of zero. The authors do a nice extension of a well-known method by Thomas Laubach and John Williams (2003) by considering the industrialized economies as a single bloc. Then they study how much government debt and Social Security have offset downward pressure on interest rates from private sector imbalances. Their results suggest that if government debt had not increased from about 20 to 70 percent of GDP, then the real interest rate would have declined even further, by about 100 basis points, while the increase in Social Security spending led to an additional offset by about 50–100 basis points. The authors thus leave us with the dire prediction that if it had not been for these government policies, then the natural rate today would be at –2 to –3 percent. In this case, today the ZLB would presumably be a severely binding constraint across all advanced economies. This is a very interesting result that goes against the conventional wisdom. An incredible amount of ink has been spilled about the looming crisis due to "unfunded" Social Security entitlement; and, similarly, there is a great deal of alarm over a supposed fiscal crisis that is around the corner due to the rise in government debt over the past decades. Contrary to this view, Rachel and Summers's paper suggests that had it not been for these developments, the industrialized world would currently be mired in a much deeper deflationary crisis than what we already see today in Japan and the euro zone. One takeaway from the empirical estimate that the authors choose not to highlight may seem to be that if low natural interest rates remain a problem in the future, then all the government has to do is to increase government debt and/or pay-as-you-go Social Security spending. As I again discuss at the end of this comment, the solution to secular stagnation may not be that simple.

Although these results are purely empirical, or are imputed using existing studies, the authors go beyond this empirical work, taking the paper from being only interesting to being excellent. We are also presented with two interesting structural models—one with overlapping generations that is ideal for studying the effect of age dynamics, and the other with agents confronted with uninsurable risk, a model ideal for studying inequality. They use these models to account for the empirical finding just highlighted, and in the process they are able to decompose the key drivers of the decline in the natural interest rate. The main conclusion is that, using 1970 as a benchmark (see Rachel and Summers's table 7), the natural rate of interest has dropped by about 320 basis points since then, with the private sector accounting for a drop of 690 basis points and the public sector offsetting this by 360 basis points. The largest individual component contributing to the fall in the natural rate is a fall in total factor productivity and population and working age dynamics (retirement, life expectancy, length of working lift, and the like). Inequality also plays a nontrivial role, accounting for a drop of about 100 basis points. The role of government policy also is roughly in line with the empirical estimates.

THE BIG PICTURE Overall, I interpret the findings, especially the results from the structural models, in a similar way as the findings in a recent paper I wrote jointly with Neil Mehrotra and Jacob Robbins (2019). Like Rachel and Summers, we also find that a model with an overlapping generation structure—although very different in the details of how the age pyramid is modeled—can account for a substantial drop in the real interest rate, from about 3 percent to modestly negative natural rates today in the context of a U.S. calibration.[2] The way I interpreted our finding was that the fall in the real interest rate observed in the data *can* be accounted for by age dynamics and a productivity slowdown and other slow-moving forces. I use the word "can" advisedly because I think that our model—and the same applies to that of Rachel and Summers—leaves enough free parameters so that the results are quite sensitive to assumptions. One could also tell stories consistent with the fact that the fall observed in natural rates is only temporary and due to the global financial crisis and its aftermath, so that they will ultimately rise to a more "normal" level (even if this sort of story becomes increasingly implausible the longer time elapses from the financial crisis and the longer the market seem to predict a low real interest rate). An important next step in the literature is to identify more clearly what elements of the structural models would lead us to one conclusion relative to the other.

This is not a criticism of Rachel and Summers's paper, however. What I think these results show quite conclusively is that a permanent fall in the

2. We have an 80-generation, medium-scale dynamic stochastic general equilibrium model in the tradition of Auerbach and Kotlikoff (1987).

natural rate *is a very plausible scenario that we ought to take seriously,* even if I think it is a bit too early to assign precise probability weights on the secular stagnation scenario relative to others. But the fact that the secular stagnation scenario is very much a plausible possibility should be considered a major result. A few years ago, very few people took seriously the idea that the ZLB would ever become an issue in the United States. They turned out to be very wrong. Today, similarly, I think far too few people have taken seriously the possibility that the ZLB will be a permanent feature of the landscape of stabilization policy in the coming years. Rachel and Summers's paper suggests that studying this uncomfortable possibility should be a first-order priority for macroeconomics. In this respect, their paper should be a wakeup call.

COMMENTS AND CONCERNS I would be remiss as a commenter if I did not do some nitpicking. One of the more interesting experiments the authors undertake is to consider the effect that the increase in inequality has had on the natural interest rate. Inequality rises due to the increase in the variance of the income process of infinitely lived agents that live in the model. The rise in income uncertainty, in turn, increases the precautionary savings of the agents, so they will increase their demand for savings to insure against future negative income shocks. This increase in savings puts downward pressure on the interest rate.

It is not obvious to me that the rise in income inequality we see in the United States has much connection with a rise in idiosyncratic income shocks that people need to insure against. Loosely speaking, it seems instead that the "rich are getting richer and the poor are getting poorer" and that there actually is a decline in mobility "between rich and poor"—that is, if you are born rich, you die rich. Thus, it is not clear that the rise in income inequality is tied to idiosyncratic income risk, for reasons discussed in footnote 3 below; or, in any event, this would need to be established empirically.[3]

3. To be more concrete: Imagine that that there are two types in the model, low type (poor) and high type (rich), and that this generates income inequality. Imagine, now, that there is no transition between types—that is, the poor always stay poor and the rich always stay rich—but allow for some idiosyncratic risk for year type (both rich and poor get sick, and so on). Now if you increase the income of the high types at the expense of the low type without affecting idiosyncratic uncertainty within a group, it is not obvious to me that this has any effect on the interest rate (to see this, you can shut down the idiosyncratic income risk, in which case there is no effect of increasing inequality on interest rates, as both types perfectly smooth consumption and the interest rate is given by the inverse of the discount factor). In the model of Rachel and Summers's paper—where agents are identical, except that they draw idiosyncratic income shocks—income inequality always must lead to an increase in uninsurable income risk, in contrast to the example discussed above.

My impression is that this sort of criticism applies to most of the literature that uses these types of models, and Rachel and Summers discuss this point at some length in their paper. In any event, to the extent that one is considering an infinitely lived household that is constantly drawing new income shocks, my guess is that the motive for precautionary savings is exaggerated. It will be interesting to see future research that merges the life-cycle model the authors present and the model with idiosyncratic risk, where one might be able to get at these issues inside a structural model.

Having said this, I do not think that the authors are necessarily exaggerating the effect of income inequality on the real interest rate. There is a body of literature that emphasizes that the "rich save more" for reasons independent of precautionary motives (see, for example, Dynan, Skinner, and Zeldes 2004). If this is correct, this might work toward an even stronger effect of inequality on the real interest rate than is documented here.

UNRESOLVED QUESTIONS AND POLICY ISSUES I think that one of the goals of this paper is to make the case that a permanent fall in the natural rate of interest is very much a plausible possibility. I think Rachel and Summers's paper succeeds on that score. A major question this finding then raises is what can be done about it.

When the first-generation ZLB models were developed, there was a tendency among academics to minimize the challenge imposed by these models on monetary authorities, with papers being written with titles such as "Japanese Monetary Policy: A Case of Self-Induced Paralysis?" (Bernanke 2000) and "A Foolproof Way Out of Escaping from a Liquidity Trap" (Svensson 2001). The perception was that the problem posed by the ZLB was easily solved. After all, central banks could just print money. For example, Kenneth Rogoff commented in this journal on Krugman's 1998 paper—which arguably launched the first generation of ZLB models, I think reflecting a relatively broad professional consensus—that "no one should seriously believe that the BOJ would face any significant technical problems in inflating if it puts its mind to the matter, liquidity trap or no. For example, one can feel quite confident that if the BOJ were to issue a 25 percent increase in the current supply and use it to buy back 4 percent of government nominal debt, inflationary expectations would rise." Since then, of course, the Bank of Japan has not increased its money supply by only 25 percent. Relative to 1998, it has almost increased the monetary base 10 times over. And this without inflation budging!

The reaction to the secular stagnation hypothesis by the economics profession has, in my experience, been somewhat similar and could be summarized similarly to how people reacted to the first-generation ZLB models: “It didn’t happen, it will not happen, it cannot happen.” And as for secular stagnation, if permanently low interest rates were ever truly a problem, some argue, why would the government simply not increase its debt until the interest rate rises? Is that not an obvious free lunch?

A comparative static that my colleagues and I recently presented puts an interesting perspective on this argument (Eggertsson, Mehrotra, and Robbins 2019). In this paper, we show that in a calibrated model of the U.S. economy, the ratio of debt to GDP would need to increase by over 215 percent of GDP for the interest rate to rise from –1.5 percent to 1 percent. If that sort of increase in the debt is needed in the real world, the question becomes: Could other forces, outside the model, start to play a role that could change the conclusion?

This is a question studied in a recent paper by Vaishali Garga (2019). Garga considers the plausible scenario—likely to be relevant in the real world—that even if the economy finds itself in secular stagnation of the type considered in Rachel and Summers’s paper, the public will (for good reasons) put some probability on the fact that the secular stagnation hypothesis will turn out to be incorrect and that the economy will instead transition at some future date into a “normal” state where interest rates are positive again. Her point is that if the debt is high enough, then this reversal to normality must trigger a fiscal crisis with associated tax increases and entitlement cuts. The mere expectation of this scenario, in turn, can then undo the positive effect that increasing the government’s debt has on the interest rate during secular stagnation. Higher debt during secular stagnation, in other words, can trigger people to save for the possibility of a fiscal crisis state and possible cuts in their Social Security. Theoretically, she shows that for a positive probability of a reversal of this kind, there will always be a tipping point for government debt, above which increasing debt will lead to a further decline in the natural rate of interest rather than an increase. Though this tipping point surely exists in theory, the question is how high it is empirically. Garga then shows evidence suggesting that in the case of Japan, this force might be quite strong—perhaps even strong enough so that the tipping point would be reached. All this is to say that simply increasing government debt may not be the silver bullet to solve the problem of secular stagnation.

This paper by Rachel and Summers, and the others on which it builds, have in my view conclusively shown that secular stagnation is a plausible scenario. It thus seems all the more urgent to begin doing more research on how this problem can be solved.

REFERENCES FOR THE EGGERTSSON COMMENT

Auerbach, Alan J., and Laurence J. Kotlikoff. 1987. *Dynamic Fiscal Policy*. Cambridge: University Press Cambridge.

Bernanke, Ben S. 2000. "Japanese Monetary Policy: A Case of Self-Induced Paralysis?" In *Japan's Financial Crisis and Its Parallels to the U.S. Experience*, edited by Ryoichi Mikitani and Adam S. Posen. Washington: Petersen Institute for International Economics.

Caballero, Ricardo J., and Emmanuel Farhi. 2018. "The Safety Trap." *Review of Economic Studies* 85, no. 1: 223–74.

Dynan, K., J. Skinner, and S. Zeldes. 2004. "Do the Rich Save More?" *Journal of Political Economy* 112, no. 2: 397–444.

Eggertsson, Gauti B., and Paul Krugman. 2012. "Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach." *Quarterly Journal of Economics* 127, no. 3: 1469–1513.

Eggertsson, Gauti B., and Neil R. Mehrotra. 2014. "A Model of Secular Stagnation." NBER Working Paper 20574. Cambridge, Mass.: National Bureau of Economic Research.

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, no. 1: 1–48.

Eggertsson, Gauti B., Neil R. Mehrotra, Sanjay R. Singh, and Lawrence H. Summers. 2016. "A Contagious Malady? Open Economy Dimensions of Secular Stagnation." *IMF Economic Review* 64, no. 4: 581–634.

Eggertsson, Gauti B., and Michael Woodford. 2003. "The Zero Bound on Interest Rates and Optimal Monetary Policy." *Brookings Papers on Economic Activity* 34, no. 1: 139–234.

Garga, Vaishali, 2019. "Fiscal Expansion in a Secular Stagnation: What If It Isn't Secular?" Working paper. https://www.vaishaligarga.com/research.

Guerrieri, Veronica, and Guido Lorenzoni. 2017. "Credit Crises, Precautionary Savings, and the Liquidity Trap." *Quarterly Journal of Economics* 132, no. 3: 1427–67.

Hansen, Alvin. 1939. "Economic Progress and Declining Population Growth." *American Economic Review* 29, no. 1: 1–15.

Krugman, Paul R. 1998. "It's Baaack: Japan's Slump and the Return of the Liquidity Trap." *Brookings Papers on Economic Activity* 29, no. 2: 137–205.

Laubach, Thomas, and John C. Williams. 2003. "Measuring the Natural Rate of Interest." *Review of Economics and Statistics* 85, no. 4: 1063–70.

Summers, Lawrence H. 2013a. "Speech given at IMF Fourteenth Annual Research Conference in Honor of Stanley Fischer," Washington, November 8. http://larrysummers.com/imf-fourteenth-annual-research-conference-in-honor-of-stanley-fischer/.

———. 2013b. "Why Stagnation Might Prove to Be the New Normal." *Financial Times*, December 15. http://larrysummers.com/commentary/financial-times-columns/why-stagnation-might-prove-to-be-the-new-normal/.

Svensson, Lars E. O. 2001. "The Zero Bound in an Open Economy: A Foolproof Way of Escaping from a Liquidity Trap." *Monetary and Economic Studies* 19, no. S1: 277–312.

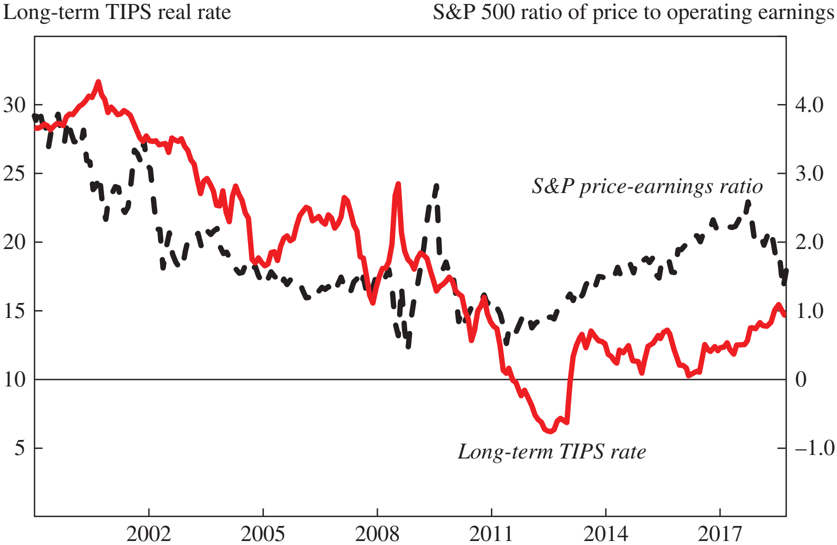
COMMENT BY

ARVIND KRISHNAMURTHY Over the past 30 years, real interest rates in the developed world have fallen by about 3 percent. The core of Rachel and Summers's paper is in their figure 11, which decomposes the drop in the real rate to various economic mechanisms. The remarkable lesson from the paper's analysis, which is evident in the figure, is that there are strong two-way forces at work in determining interest rates. For example, changes in demographics have by themselves led to a fall in interest rates of nearly 3 percent. However, the large rise in government debt has led to an offsetting rise in interest rates of about 1.5 percent. The paper goes through more economic mechanisms, and the broad lesson is that the net of these individually large economic mechanisms has led to a fall in observed real rates of about 3 percent.

The paper comes to these conclusions through the lens of two calibrated models: life-cycle and precautionary savings. The first is a life-cycle model where demographics and savings for retirement determine interest rates. The second model is a Bewley model with idiosyncratic income risk and an insurance channel for determining interest rates. Rachel and Summers's figure 11 is derived from running various experiments within these calibrated models.

In this comment, I argue that a nontrivial portion of the fall in interest rates is due to a decline in the rate of return on safe assets, not all assets. This point is a theme of the recent literature on safe assets. See, in particular, the work of Ricardo Caballero and his coauthors (Caballero, Farhi, and Gourinchas 2008; Caballero and Krishnamurthy 2009). Rachel and Summers acknowledge this point in their paper, but argue that it is a second-order effect. The models they write down are ones where their considered economic channels move the rates of return on all assets equally and not the rates of return particularly on safe assets. I argue the case that the fall in safe rates is not a second-order issue; and to make this point, I offer a set of "maximal" computations tracing the fall in safe rates. I acknowledge at the outset that my computations are subject to considerable uncertainty, but it

Figure 1. S&P 500 Ratio of Price to Operating Earnings and Long-Term TIPS Real Rate, 1999–2018[a]



Sources: Federal Reserve; Bloomberg; author's computations.
a. S&P = Standard & Poor's; TIPS = Treasury Inflation-Protected Securities.

should be clear that for the issue at hand, the authors' computations are also subject to considerable uncertainty.

STOCK MARKET VALUATIONS My figure 1 plots movements in the long-term yield on Treasury Inflation-Protected Securities (TIPS) (the solid line) from 1999 to 2018 as well as the ratio of price to operating earnings for all companies in the Standard & Poor's (S&P) 500 index (the dashed line). The U.S. Treasury first issued TIPS in 1999, which is the start of the sample, and the yield represented corresponds to the longest TIPS bond issued at that time (a 30-year security). In 2003, the Treasury moved to regularly issuing a 10-year TIPS, and that is the yield that is tracked from 2003 onward.

My figure 1 illustrates the sizable fall in real interest rates studied by Rachel and Summers's paper. I ask whether this fall is equally reflected in the discount rate pricing equities. To answer this question, I use the Gordon growth formula:

$$P_t = \sum_{s=t}^{\infty} \frac{\phi E_t (1+g)^{s-t}}{(1+r+ERP)^{s-t}}, \tag{1}$$

where P_t is stock price, E_t is earnings, ϕ is the payout ratio, g is earnings growth, r is the real rate on the safe asset (that is, the TIPS yields), and *ERP* is the equity risk premium, so that $r + ERP$ is the discount rate applied to risky corporate earnings. Rewriting this expression, we have the price-to-earnings ratio:

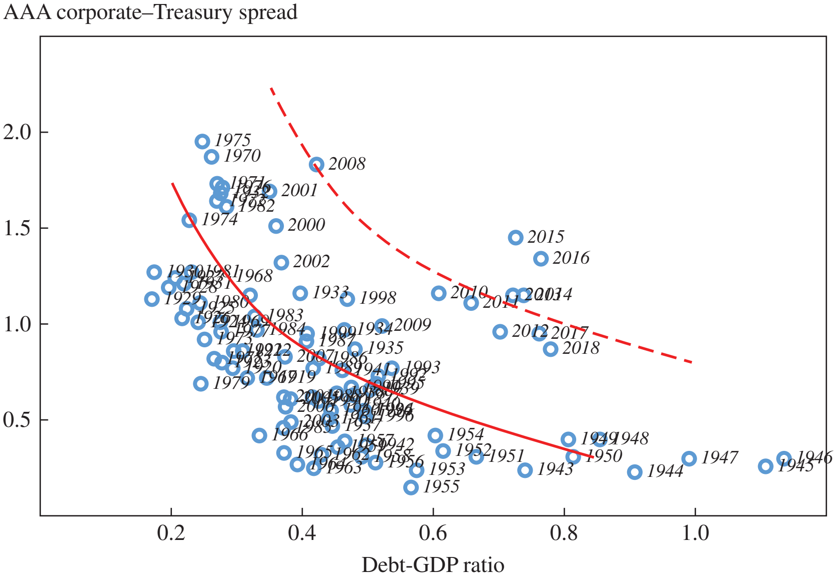
$$\frac{P_t}{E_t} = \frac{\phi}{r + ERP - g}. \tag{2}$$

We can use this formula to imply the movements in the ERP over the period represented in my figure 1. I compute that the average price/earnings ratio from 1999 to the 2007 precrisis sample is 21.0, and the average interest rate on TIPS is 3 percent. I use a value of g of 3.5 percent, corresponding to precrisis GDP growth, and matching estimates from Rachel and Summers's paper. I also use a payout ratio of 20 percent, but this number does not matter for the main conclusions. Using these calibrations, I solve for the implied ERP, which equals 4.3 percent (to match the 21.0 price/earnings ratio).

Similarly, I compute the ERP for the 2009–18 postcrisis sample. In this sample, the price/earnings ratio averages 17.6, and the TIPS rate averages 0.4 percent. I use a value of 2 percent for g, corresponding to postcrisis GDP growth rates. I keep the payout ratio the same, at 20 percent. The ERP required to match the price/earnings valuation is 6.1 percent. In other words, in the postcrisis sample, the ERP must have risen to rationalize observed price/earnings ratios. Consider a counterfactual. Hold the ERP constant at 4.3 percent, and decrease r and g. The Gordon formula implies that the price/earnings ratio then needs to be 29.6! That is, the fall in interest rates is quite large, and by itself should have led to a sizable increase in the price/earnings ratio. However, the price/earnings ratio over this entire period (ignoring the crisis) is relatively stable. I conclude that the ERP must have risen significantly.

At first glance, this computation flies in the face of financial market commentary. Investors bemoan that stocks are expensive. My computation implies that the expected return on stocks has indeed fallen. That is, the safe rate fell by 2.6 percent (= 3 – 0.4), and the ERP increased by 1.7 percent (= 6.1 – 4.3), indicating that the expected return on stocks has fallen by 0.9 percent. From an investor's standpoint, returns have fallen significantly. In this sense, stocks are expensive. However, on a relative basis, safe bonds have become even more expensive than stocks. The discount rate on all

Figure 2. Corporate Bond Spreads, 1919–2018[a]



Sources: Krishnamurthy and Vissing-Jorgensen (2012), Federal Reserve, author's calculations.

a. This figure shows the 20-year AAA corporate–Treasury spread versus the publicly held Treasury debt-GDP ratio for 1919 to 2018.

assets has fallen by 0.9 percent, while the discount rate on safe assets has fallen an additional 1.7 percent.

My perspective helps to rationalize corporate financing behavior over the last 20 years. As safe rates have fallen, corporate investment has not risen. Flat corporate investment is inconsistent with a decrease in real rates to all assets. But in a world where the risky cost of capital has not fallen as much as the safe rate, we would not expect to see a substantial increase in corporate investment. Indeed, the form of investment that has risen the most over the last 20 years is residential investment. Due to securitization and the banking system, the discount rate to residential investment is a near safe rate. This perspective also helps rationalize the rise in corporate leverage and share buybacks over the last decade. Firms have engaged in a form of capital structure arbitrage: issue safe bonds at low rates, and buy risky stocks, offering higher rates of return.

CORPORATE BOND SPREADS My figure 2 replicates and updates a figure from my (2012) paper with Annette Vissing-Jorgensen. We observe that there is a strong negative relation between the spread of long-term, AAA-rated corporate bonds over long-term Treasury bonds and the outstanding amount of publicly held government debt, normalized by GDP. We interpret the relation (and provide other evidence in support of the interpretation) as reflecting a demand curve, akin to a money demand curve, for the higher safety and liquidity of Treasury bonds relative to corporate bonds. We also present evidence that the safety demand, though reflected most prominently in the movements of Treasury bond yields, extends to high-grade private assets, including illiquid corporate bond rates and money market rates such as bank deposit rates (which underly the determination of interest rate swap rates).

In my figure 2, I have drawn a solid line through the points from 1919 to 2007, roughly indicating the precrisis demand for safe assets. The points in the figure's upper-right quadrant correspond to the points after 2007. It appears from this graph that the demand curve for safe assets has shifted outward over the last decade. Indeed, the vertical distance between the two curves drawn on the figure is about 80 basis points, suggesting an increased safety premium of just under 1 percent (for a given quantity supplied).

There are further observations that reinforce this point. First, consider the left panel of figure 3 in Rachel and Summers's paper. Though all the yields pictured in the figure have fallen over the last 25 years, it is also evident that the spread between the various yields considered has widened over this same period, with Treasury yields falling more than other yields. The widening in the corporate-Treasury spread over the postcrisis period is particularly striking because stock market volatility has also declined significantly over the last decade. The decline is evident in both measured stock return data or in a volatility index such as the Chicago Board Options Exchange's Volatility Index (VIX). From 1995 to 2006, the VIX averaged about 21 percent; and from 2013 to 2018, it averaged about 15 percent. Corporate bonds, as in the classic Robert Merton (1974) model, are a safe bond minus the value of a put option on the underlying firm's assets. As volatility has decreased, we would expect that the value of this put should have fallen. The decreased put value implies a narrowing of the corporate bond to Treasury spread. Empirically, the opposite is true. Corporate bond rates have not fallen toward Treasury rates over this period (see figure 3 in Rachel and Summers's paper). This fact also implies an increased preference for the safety of Treasury bonds. Furthermore, the corporate bond in my figure 2 is an AAA bond, which is very safe. An increase in demand for safe assets would also decrease AAA rates, albeit less so than in Treasury rates. This suggests that the estimates from my figure 2 are an underestimate of the increase in safe asset premia. If one could construct a hypothetical spread between equities and safe Treasury rates, and make a plot as in figure 2, presumably that plot would reflect the larger shift in the demand for all safe assets. In a sense, the price/earnings computation I offered earlier is two points on such a plot. Thus, these two pieces of evidence are internally consistent and reflect a sizable decrease in the return on safe assets.

My figure 2 gives another way to estimate the impact of the expansion of government debt on interest rates. Rachel and Summers estimate from their model that the expansion of government debt from 1970 to the present contributed to an increase in rates of 1.5–2.0 percent. We can empirically check this estimate from my figure 2. Comparing the points in 1970 with the present points, along the same demand curve, indicates a rise of roughly 1.5 percent in rates. From a very different perspective, I arrive at a similar estimate as Rachel and Summers of the impact of the increase in government debt supply on interest rates.

DISCUSSION I conclude that the discount rate on all assets has fallen, consistent with Rachel and Summers's analysis. My analysis also indicates that the discount rate on safe assets has fallen further than the rate on all assets. I have offered a set of maximal computations for the further safe rate decline, estimating this at between 1 and 2 percent.

I do not interpret these computations as invalidating the analysis of Rachel and Summers. Their model is readily interpretable in terms of safe asset demand. A desire for insurance against income risk is likely best met by holding safe assets. Their Bewley model could be easily repurposed to address safe asset rates. Likewise, a demand for retirement savings that is accommodated via defined-benefit pension plans is likely best met by holding safe assets. The life-cycle model could also be repurposed to address safe asset rates.

Thinking about safe asset demand brings other forces to the fore: savings glut and foreign reserve accumulation, collateral and financial intermediation issues such as a shortage of high-quality liquid assets, and risk preferences of investors.

My analysis also does not invalidate the policy conclusions of Rachel and Summers. Low-equilibrium interest rates mean that the zero lower bound will frequently constrain monetary policy. This is because the central bank sets the rate on a safe asset (that is, reserves). Likewise, U.S. government debt is currently the par excellence of safe assets in the world. If low safe asset rates are driven by a high convenience yield on safe assets, then it follows that the government has more fiscal space when these convenience yields are high. Indeed, this fiscal space conclusion is strengthened in the safe asset convenience yield perspective. A Friedman rule–style argument calls for more issuance of convenience assets (government debt) when the convenience yield is high (Friedman 1969). However, there is another counterbalancing force: if the government issues too much debt, such debt may no longer be viewed by investors as safe, and the convenience yield may disappear. Finally, the safe asset perspective identifies further considerations that are relevant for policy. The private sector, in addition to the government, can create safe assets. Financial intermediaries in particular are safe asset creators, as argued by Caballero and Krishnamurthy (2009); Krishnamurthy and Vissing-Jorgensen (2015); and Tri Vi Dang and others (2017). But private safe assets are inherently fragile and can lead to runs and an increase in systemic risk. Thus, if interest rates are low because of high convenience yields on safe assets, policymakers should also be mindful of systemic risk from the private sector.

REFERENCES FOR THE KRISHNAMURTHY COMMENT

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2008. "An Equilibrium Model of 'Global Imbalances' and Low Interest Rates." *American Economic Review* 98, no. 1: 358–93.

Caballero, Ricardo J., and Arvind Krishnamurthy. 2009. "Global Imbalances and Financial Fragility." *American Economic Review* 99, no. 2: 584–88.

Dang, Tri Vi, Gary Gorton, Bengt Holmström, and Guillermo Ordoñez. 2017. "Banks as Secret Keepers." *American Economic Review* 107, no. 4: 1005–29.

Friedman, Milton. 1969. *The Optimal Quantity of Money, and Other Essays.* Chicago: Aldine.

Krishnamurthy, Arvind, and Annette Vissing-Jorgensen. 2012. "The Aggregate Demand for Treasury Debt." *Journal of Political Economy* 120, no. 2: 233–67.

———. 2015. "The Impact of Treasury Supply on Financial Sector Lending and Stability." *Journal of Financial Economics* 118, no. 3: 571–600.

Merton, Robert C. 1974. "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates." *Journal of Finance* 29, no. 2: 449–70.

GENERAL DISCUSSION Valerie Ramey began noting the importance of the paper and asking if the authors had considered whether the rise of China and its relatively recent integration into global markets had an impact on the long-term real interest rate. She referred to a paper by Fernando Broner and others, which documents that the share of government debt held by foreigners has risen dramatically in industrialized countries.[1] For example, the share of U.S. government debt held by foreigners was about 5 percent in 1970 but now sits just below 50 percent.

Martin Baily commended the paper. He stated that the authors' reasons for studying the advanced economies as a bloc is valid, but that doing so may obscure important variation across countries—particularly, the unique situation of the United States. Baily is not convinced that the United States is in a secular stagnation situation like Japan and Europe, whereas Lawrence Summers has argued so in various news outlets and academic papers. He observed that the United States appears to be in excess demand by a certain definition, given that domestic demand appears to satisfy the economy at full employment while net imports are persistently negative. Furthermore, he expressed skepticism that such excess demand is entirely driven by deficit-financed fiscal stimulus at present.

Baily also noted two observations in support of the idea that investment opportunities have declined, in contrast to some of the discussants' claims. The first observation is that the required rate of return on corporate investing is much higher than the risk-free interest rate and does not appear to adjust downward properly when the risk-free interest rate falls. This would imply a lack of real corporate investment opportunities. The second is that many of the world's economies—including those in Latin America and Africa, but also perhaps Japan and those in Europe—have regulatory regimes that create large barriers for would-be investment opportunities.

Jason Furman also commended the paper. He expressed some concern that research on this topic has focused on testing various "hunches" about the causes of the interest rate decline rather than providing meaningful cost-benefit analyses of various policy options in the new interest rate environment. He suggested that a valuable paper would ask the question raised by Gauti Eggertsson in his comment: How much additional government debt is necessary to achieve sufficiently higher interest rates and improved cyclical performance? He suggested that the models developed by John Williams to study the effects of the zero lower bound (ZLB) on interest rates would enable one to perform this kind of cost-benefit analysis. Even if

1. Fernando Broner, Daragh Clancy, Aitor Erce, and Alberto Martin, "Fiscal Multipliers and Foreign Holdings of Public Debt," ESM Working Paper 30 (Luxembourg: European Stability Mechanism, 2018), https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3153111_code2401764.pdf?abstractid=3153111&mirid=1.

it is the case that substantial additional debt only raises the neutral interest rate by a small amount, it remains of interest to policymakers to quantify the trade-offs between countering the effects of the ZLB with various monetary policies or increasing debt to offset low interest rates.

Susanto Basu discussed the interpretation of the decline in total factor productivity (TFP) growth, which was raised by both the authors and commenters. Although figure 4 in the paper and observations by commenters suggest that the *decline* in TFP growth has pushed the neutral interest rate down by about 2 percentage points, Basu interpreted the authors' discussion to suggest that *increases* in TFP growth would result in lower real rates. The authors' model incorporates channels that could cause real interest rates to rise or fall in response to higher TFP growth via agents' expectations of future consumption growth and agents' saving out of current income, respectively. He asked the authors to comment on why TFP's positive relation with real interest rates appears to dominate in the model.

Donald Kohn remarked that the paper helps enlighten why the neutral rate—*R**—appeared to drop sharply during the financial crisis and has not recovered. He noted that the persistence of excess savings since the crisis can help explain this observation, but that a similar balance of (excess) savings and low investment appeared in the 1980s concurrent with a much higher value of *R**. This suggests that the balance of savings is not the only explanatory factor and that perhaps demand for capital has declined significantly since that time.

Kohn noted that the relation between productivity growth and *R** becomes clearer after distinguishing between the long and short runs. In the long run, productivity gains should be expected to raise *R**; in the short run, productivity gains shift the Phillips curve outward, enabling the central bank to promote higher employment via lower interest rates without fueling inflation.

Robert Gordon noted that the paper attributes the steep decline in *R** to declining population and productivity growth, but that consensus estimates of potential output growth from—say, those of the Congressional Budget Office and the Federal Reserve—do not reflect such steep declines in these factors. One could make the case that potential output has fallen substantially more than that of the consensus, however. For example, comparing realized output growth since 2009 with the implied output growth derived from a simple Okun's law (with a coefficient of one-half on the unemployment gap) would yield an estimate of potential output of about 1 percent, not the 1.9 percent that is currently estimated by the Congressional Budget Office. In addition, Gordon observed that potential growth in labor force participation declined from about 1½ percent each year between the 1960s and 1990s, when females were rapidly joining the labor force, to about ½ percent each year in the last decade. Such a decline would imply that potential GDP growth has fallen from about 3 percent to about 1 percent. This decline also appears to have been concentrated between 2007 and 2012 (as deduced from a formal procedure using a Kalman filter that removes cyclical variation in the unemployment gap). The timing thus tracks closely with the timing of a sharp decline in R^* over the same period.

Gordon also emphasized the role of productivity growth in determining R^*. He observed that in any kind of Solow growth model with steady state ratios of capital to output, a decline in potential output growth produces a decline in steady state investment, implying a strong link between potential output growth and the natural interest rate. He emphasized further that causality is more likely to run from low-productivity growth to lower investment, rather than vice versa.

William Brainard noted that the authors' specification of the investment–saving curve assumes the response of output to the interest rate is the same throughout the sample period, whereas R^* time varies, following a random walk. Given the assumption that output responds to the difference between the current interest rate and R^*, any cyclical or trend variation in the response of output to the interest rate (a_r) will affect the contemporaneous Kalman filter estimate of R^*. There are good reasons to expect time variation in a_r, just as there are for R^*. Perhaps most relevant for this paper, housing investment, one of the most interest-sensitive components of demand during tightening, was likely to be insensitive to rate reductions during the Great Recession, when house prices were well below replacement cost. It would be hard to identify both time-varying shocks to a_r and R^*, but if $a_r > 0$ is smaller during the Great Recession and larger during booms, he conjectured that estimated R^* would be lower during the Great Recession and higher during booms than the authors' estimates.

Brainard also remarked that U.S. interest rates are affected by two factors not included in the theoretical models: the important roles that U.S. Treasuries have acquired as a source of collateral in international financial markets and as a safe haven. During the global financial crisis, which began in the United States, global investors fled to U.S. Treasuries for safety, a factor that helps explain low U.S. rates.

Laurence Meyer observed that there are two common views of government deficits at present. The first is that persistent deficits are unsustainable and generate serious risks. The second view, represented by the conclusions of Rachel and Summers's paper, states that higher deficits raise *R** and offset secular declines in other real variables, on net benefiting the economy. He noted that such conclusions appear to be similar to those of modern monetary theory, whose models are not well regarded by the authors or many in the profession. However, the conclusions do suggest that fiscal policy in advanced economies has performed spectacularly over the last few decades, in particular by reducing risks associated with the ZLB. Meyer said the paper was fascinating and provided a very important decomposition of the forces affecting *R**.

Giorgio Primiceri commented that a forthcoming paper by Kurt Lunsford and Kenneth West studies the relationship between TFP growth and the secular trend in the natural rate from 1880 onward. They find that the positive correlation emerges only after 1970.[2]

Robert Hall said he was surprised by Rachel and Summers's confidence in finding a dramatic departure from Ricardian neutrality—the notion that government borrowing decisions are neutral in equilibrium. Nonneutrality, which produces the relationship between government borrowing and the real interest rate, stems from the introduction of finitely lived agents into their paper's central model. However, he observed that saving has become significantly more concentrated among the wealthy in the last few decades, and that the wealthy are much less likely to increase consumption in anticipation of death. That wealth is concentrated among those who pass on their wealth to future generations makes the introduction of Ricardian nonneutrality a puzzling finding.

James Stock added that the decomposition of forces acting on the real rate is very nice, but ought to include the liquidity and safety premiums that Arvind Krishnamurthy described. He observed that there remains about 1.3 percentage points of unexplained decline in *R** over the observed period, which liquidity and safety demand may reasonably explain without contradicting the main findings of the paper.

Lawrence Summers thanked the participants. He stated that the paper's main finding, that the neutral rate has been driven downward by strong secular forces more than its observed decline reveals, remains valid even after incorporating every criticism provided in the current discussion. In addition, the common position held by Arvind Krishnamurthy and others that the decline mostly reflects the attractive liquidity and safety properties of government debt also supports the paper's main policy implications. In

2. Kurt G. Lunsford and Kenneth D. West, "Some Evidence on Secular Drivers of U.S. Safe Real Interest Rates," *American Economic Journal: Macroeconomics*, forthcoming.

other words, if demand for government bonds is so high, the government ought to satisfy this demand and increase deficits.

Summers said that Gauti Eggertsson's comments on incorporating income uncertainty and the potential effects of rising income inequality are correct and should be incorporated into the analysis. Summers acknowledged three important missing components of the intertemporal framework in the paper: the high propensity to save among the rich, the tendency for monopoly power to reduce investment, and, most important, reduced investment opportunities in recent decades. Summers called this last force a "demassification" of the economy, which is the result of several secular and preference-driven trends. He described, for example, that a cell phone has more computing power than a supercomputer used to; that people prefer small apartments in cities to big houses in suburbs; that law firms need less office space per lawyer; and that nobody wants to build a shopping mall. He remarked that he is not strongly convinced that safety and liquidity preferences will explain the residual in the decomposition of the neutral rate.

With regard to the discussion about equity risk premia, Summers noted that the question demands more attention in the paper, but that he does not perceive it to be as important as Krishnamurthy does, for four reasons. First, the fact that the risk premium appeared to be low in the late 1990s and early 2000s likely reflects price bubbles in those periods and not underlying risk preferences. Second, there is no clear reason why a decline of 2 percentage points in the risk premium over that period, if it did occur, should explain a decline of 2 percentage points in the safe rate. Summers said he would benchmark any estimated change in the risk premium to relate to half that change in the safe rate. Third, the observation that yields on AAA-rated bonds increased after the global financial crisis does not reflect structural changes in safety preferences as much as it does a reassessment of the asset class following high default rates during the crisis. Fourth, he observed that the opinion that the safe rate has declined because the risk premium has risen comes with an important corollary: demand for stocks should be significantly higher than for bonds right now. This view remains far from the prevailing opinion of many who study this topic.

Summers further replied to comments about the importance of safety and liquidity premia that the co-movement across a variety of asset classes—including assets that were once regarded to be severely illiquid, like inflation-protected Treasuries—suggests that the secular forces of focus in the paper are important. Though there may be some role for safety demand, he said, he remains confident in the choice to focus on an intertemporal saving and consumption framework.

He replied to Valerie Ramey's comment by observing that the global current accounts surplus of the industrial countries is roughly zero and has even risen slightly in recent years, implying that any foreign savings demand would be captured in their analysis by treating the advanced economies as a bloc.

Summers agreed with Martin Baily's comment that policies in the rest of the world that increase investment opportunities would raise the advanced economy normal rate. On Baily's claim that the United States is not likely experiencing secular stagnation, he replied that the comment is likely true under the assumption that the U.S. is a closed economy. He agreed that there appears to be some excess demand in the U.S., but noted that estimating the neutral rate under the assumption the U.S. is an open economy is not straightforward but relies on the level of the exchange rate. For example, if the U.S. were to choose to close its current account deficit, the dollar would depreciate against other advanced currencies, and Europe and Japan would face even more severe stagnation and lower interest rates. He emphasized that the analysis examines the industrial world, not only the United States, precisely for this reason.

Summers agreed with Jason Furman that examining the relative costs of having excessive government debt versus excessively low interest rates is important. And Summers acknowledged Susanto Basu's observation that the discussion of the relationship between TFP growth and interest rates in the paper contradicted that in his own statements. He noted that his paper with Christopher Carroll found, across countries, that as people expect to have rising incomes, they do not reduce their savings rates, in line with model predictions.[3] It may be that people rely on saving habits and are slow to adjust their consumption in response to expected future income shocks.

He acknowledged that comments from Donald Kohn and Robert Hall about the timing of sharp declines in R^* are interesting, but that he does not take the sharp declines too seriously, for two reasons. The first is because of the kind of structural investment changes that occurred in the global financial crisis and its aftermath, as William Brainard observed; the second is that the estimates that reveal that sharp downturn in the United States are

3. Christopher D. Carroll and Lawrence H. Summers, "Consumption Growth Parallels Income Growth: Some New Evidence," in *National Saving and Economic Performance*, edited by B. Douglas Bernheim and John B. Shoven (Chicago: University of Chicago Press, 1991), http://econ.jhu.edu/people/ccarroll/papers/CParallelsY.pdf.

found using closed-economy models. These estimates are dubious, he noted, because the U.S. has a fluctuating current account.

Summers thought Brainard's proposal that the slope of the investment-saving curve had shifted after the financial crisis was interesting, and that if he were right, it would help explain why various fiscal effects are now estimated to have slightly larger effects on neutral interest rates.

Summers also replied to Laurence Meyer, who had noted that the paper's conclusion may be construed as support for inflation-financed debt expansion, that he has made clear that he favors a balanced approach to fiscal expansion. He referenced his *Foreign Affairs* article with Jason Furman that outlines the reasons for this balanced approach and potential policy options.[4] He emphasized that he finds the idea that printing money reduces the cost of running deficits, which is the central idea in modern monetary theory, to be nonsense.

Summers noted that he does not find Lunsford and West's evidence on the historical link between TFP growth and neutral interest rates to be especially surprising or important.

He replied to Robert Hall that Ricardian neutrality may break down for many reasons beyond the consumption curvature across the life cycle—for example, simply because consumers are not sophisticated enough to properly reorganize consumption in response to changes in expected national debt. Furthermore, under many versions of the Ricardian Equivalence assumption, the basic conclusion that fiscal policy can afford to be expansionary at present would still hold, as the creation of government liabilities would create safe assets and interest rates would remain unchanged.

4. Jason Furman and Lawrence H. Summers, "Who's Afraid of Budget Deficits?" *Foreign Affairs*, March–April 2019, https://www.foreignaffairs.com/articles/2019-01-27/whos-afraid-budget-deficits.