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**NEW YORK UNIVERSITY**  
**SCHOOL OF LAW**

**Tax Policy Design and Low Interest Rates**  
**Alan Auerbach**

**November 30, 2021**  
Vanderbilt Hall – 208  
Time: 2:15 – 4:15pm  
Session 7

**SCHEDULE FOR FALL 2021 NYU TAX POLICY COLLOQUIUM**  
(All sessions meet from 2:15 - 4:15 pm in Vanderbilt 208, NYU Law School)

1. Tuesday, September 14 – Jake Brooks and David Gamage, The Indirect Tax Canon, Apportionment, and Drafting a Constitutional Wealth Tax.
2. Tuesday, September 28 – Daniel Hemel, Law and the New Dynamic Public Finance.
3. Tuesday, October 12 – Jennifer Blouin, Does Tax Planning Affect Organizational Complexity: Evidence from Check-the-Box
4. Tuesday, October 26 – Manoj Viswanathan, Rethorizing Progressive Taxation
5. Tuesday, November 9 – Ruth Mason & Michael Knoll, [Untangling Undue Burdens ]
6. Tuesday, November 23 – Mindy Herzfeld, Defining Taxes in Economics, Accounting and Law
7. Tuesday, November 30 – Alan Auerbach, Tax Policy Design and Low Interest Rates.

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TAX POLICY DESIGN WITH LOW INTEREST RATES

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William Gale

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Tax Policy Design with Low Interest Rates  
Alan J. Auerbach and William Gale  
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**ABSTRACT**

Interest rates on government debt have fallen in many countries over the last several decades, with markets indicating that rates may stay low well into the future. It is by now well understood that sustained low interest rates can change the nature of long-run fiscal policy choices. In this paper, we examine a related issue: the implications of sustained low interest rates for the structure of tax policy. We show that low interest rates (a) reduce the differences between consumption and income taxes; (b) make wealth taxes less efficient relative to capital income taxes, at given rates of tax; (c) reduce the value of firm-level investment incentives, and (d) substantially raise the valuation of benefits of carbon abatement policies relative to their costs.

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## **I. Introduction**

Interest rates on government debt have been falling in many countries for the last several decades, with markets indicating that rates may stay low well into the future. The recent economic crisis precipitated by the coronavirus only accentuates these trends. As discussed by several authors, sustained low interest rates fundamentally change the nature of long-run fiscal policy choices.<sup>1</sup> In this paper, we examine a related issue: the implications of sustained low interest rates for the structure of tax policy.

At the outset, it is important to distinguish two phenomena: a reduction in all rates of return, and a reduction in yield on government debt relative to other assets. Tax incentives and rules may have different effects on private decisions in scenarios where the private return to capital is low than when the private return to capital remains high, but government debt yields are low.

In fact, the rates of return on all assets have declined and safe asset returns have declined relative to returns on risky assets. The fall in return on all assets is commonly attributed to a glut of global saving, due to changing demographics and increased concentration of income and wealth, that has outpaced investment demand. The fall in return on safe assets relative to risky assets is typically attributed to an investor “flight to safety” and a relative worldwide shortage of safe assets. Most projections expect interest rates to remain lower in the future than they were in the 1980s and 1990s.

Several significant issues in tax policy are affected by the presence of sustained low interest rates. One of the longest standing debates in tax policy addresses the relative merits of

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<sup>1</sup> Elmendorf and Sheiner (2017); Blanchard (2019); Furman and Summers (2019); Auerbach, Gale, and Krupkin (2019); and Gale (2019).

using consumption versus income as a tax base. At the risk of oversimplifying, income taxes generally burden capital more heavily and are more progressive than consumption taxes. Low interest rates reduce the importance of the differences between the two taxes. For example, a pure income tax would burden labor income and all forms of capital income (the normal or “safe” return—the return to waiting—the return to risk, and excess returns from things like luck, skill, and imperfect competition). Consumption taxes burden all the same sources of income except the normal return to capital. In theory, abstracting from timing differences, as the safe return goes to zero, the differences between the two taxes go to zero. On the other hand, one must also take account of the one-time lump sum tax on existing wealth that the introduction of consumption taxes creates, and how a lower rate of return affects it. These combined effects of low interest rates may change the attractiveness of adopting a consumption tax.

Recent years have seen increased attention to wealth taxes. In simplified environments, a wealth tax can be written as an equivalent tax on capital income. As the rate of return falls, the equivalent income tax rate of any given wealth tax rises. That is, a given wealth tax rate becomes more distortionary relative to a given capital income tax as the rate of return falls.

A major focus of potential tax reform has been the treatment of capital gains, given their tax-favored status, their high concentration among the very wealthy, and the distortions that the current method of taxation causes. A key element of the current system of capital gains taxation is the lock-in effect, which discourages the realization of gains to take advantage of deferral of taxation. With very low interest rates, the deferral advantage loses much of its relevance, and this can make relatively simple reforms (such as taxing capital gains at death) achieve results very similar to more complicated schemes (such as taxing capital gains on accrual, even when not realized). Similar considerations indicate that the advantage of investing in a tax-preferred

saving account (e.g., a Roth or traditional IRA or 401(k) plan) is diminished as interest rates decline.

Interest rates also impact firm investment. When firms invest, they can recover investment costs before determining taxable income. Typically, firms must spread those depreciation deductions over time. In contrast, under an expensing regime (or a fractional expensing regime, such as bonus depreciation), firms may claim some or all their depreciation deductions in the year the investment was made. Thus, with a positive discount rate, the present value of the deductions allowed under expensing exceeds the present value of the deductions allowed under standard depreciation regimes. So, as this discount rate goes to zero, the difference in the present value of deductions between the two approaches goes to zero as well.

Policies that address climate change – such as a tax on carbon emissions – induce a stream of future costs (taxes or regulations, for example) and a stream of benefits (a healthier environment and long-term economy). But the benefits are “back loaded” (i.e., postponed) relative to the costs, extending over many generations. Weighing this tradeoff involves many considerations. There is, in fact, a major debate about whether to discount future benefits at all.<sup>2</sup> Assuming that future benefits and costs are discounted, the interest rate used has an enormous effect on the net benefits. As interest rates fall, the benefits of a carbon tax rise relative to the costs. Moreover, because the difference in timing between when people incur the costs and when they receive the benefits is so large, the discount rate employed has an enormous impact on the benefit-cost ratio of abatement policies.<sup>3</sup>

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<sup>2</sup> Stern (2007), Nordhaus (2008), and Weisbach and Sunstein (2009).

<sup>3</sup> The timing difference between costs and benefits and the associated large impact of low interest rates on the desirability of policies applies to a broader range of government activities, notably government investment decisions. See, e.g., Elmendorf and Sheiner (2017).

The next section discusses the evidence and interpretation of declining interest rates. The paper then reviews each of the major tax areas mentioned above. The last section offers a short conclusion.

## **II. The Decline in Interest Rates: Evidence and Interpretations**

### A. Evidence

Figure 1 shows that both real and nominal interest rates on U.S. government debt have been in decline since the mid-1980s. Figure 2 shows similar results for Treasury Inflation-Protected Securities (TIPS). Despite inflationary concerns that emerged earlier this year, as of mid-August nominal rates on Treasury debt remain very low and projected real yields are negative.<sup>4</sup>

Falling interest rates are not simply an American phenomenon. Figure 3 presents time-series data for a composite, global long-term interest rate, formed as the GDP-weighted average of 10-year government interest rates using 18 OECD countries. From a high of roughly 8% around 1995, this global composite rate has consistently declined. Indeed, several European governments including Switzerland, Denmark, Austria, and Germany have paid negative nominal interest rates in recent years.

In general, markets expect interest rates to remain low relative to levels in the past. Federal Reserve officials noted in their September 2020 projections and policy statement that they expect to leave interest rates near zero through at least 2023, which they have continued to reaffirm.<sup>5</sup> Subsequent forecasts by major investment banks such as Goldman Sachs have

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<sup>4</sup> <https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=realyield>.

<sup>5</sup> U.S. Federal Open Market Committee (2020).



followed suit in projecting low interest rates for the foreseeable future.<sup>6</sup> Additionally, the Congressional Budget Office (CBO)'s projections show continued low interest rates under current law for the next ten years, with rates rising as public debt rises and the economy grows (Figure 4).<sup>7</sup>

As shown in Figure 5, the long-term decline in yields on government bonds noted above coincides with a decline in the real yield on corporate bonds, presumably representing a decline in the marginal product of capital. Figure 5 shows real returns on Moody's Aaa, Moody's Baa corporate bonds, and the ICE BofA High Yield Index. Baa is the lowest rating for bonds still considered investment-grade, while the ICE BofA High Yield Index tracks non-investment-grade publicly issued corporate debt. Each series has declined over the past 20 years.

Although yields on both private and government bonds have fallen over time, Figure 6 shows that the yield spread between the two has increased, consistent with the presence of a "flight to safety." The figure shows differences between the yields on 10-year government bonds and Moody's Aaa, Moody's Baa corporate bonds, and the ICE BofA High Yield Index. The spread between government bonds and Baa is a measure of the change in the relative attractiveness of (safe) government bonds versus (risky) corporate debt. As illustrated in the figure, the difference in yield on safe versus risky assets has increased over time.

Figure 7 shows that price-to-earnings (PE) ratios have evolved roughly as expected, given interest rate trends, assuming that these trends also hold for the unobservable rate appropriate for discounting risky equity flows. Lower interest rates should raise PE ratios, as

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<sup>6</sup> Hansen (2020).

<sup>7</sup> The graph displays nominal rates. The projections show interest rates rising more than a low interest rate scenario might suggest. CBO (2021) projects that inflation will stay low, averaging 2.3 percent over the next decade and over the 2021-2050 period.

they imply smaller discounting of future earnings. The figure reports the average annual PE ratio, the five-year simple moving average of the PE ratio (from  $t - 4$  to  $t$ ), and the Shiller PE ratio for the S&P 500 index. The Shiller PE ratio uses the ten-year average of inflation-adjusted earnings per share in order to smooth through fluctuations during the business cycle.<sup>8</sup> Although these ratios reflect the well-known volatility in stock markets, they have clearly risen over the past few decades consistent with declining interest rates.

## B. Interpretations

A substantial literature has developed to explain these trends. Caballero (2006), Caballero and Farhi (2018), and Caballero, Farhi and Gourinchas (2017) argue for the existence of a world-wide shortage of safe assets, a mismatch between the types of assets investors wanted to hold and those that existed. They attribute the growing shortage of safe assets to the fact that the advanced economies – which generate safe assets – were growing at a slower rate than the rest of the world. If the demand for safe assets is proportional to world-wide GDP, then demand was growing faster than supply, driving up the price of safe assets.

A second, related argument is that the increase in world-wide wealth has shifted toward risk-averse investors and/or investors who believe that there is a higher likelihood of bad future outcomes (as discussed in Barro, Mollerus, and Levintal 2014 and Hall 2016). The Great Recession may have further increased people's assessments of risks and encouraged them to buy safer assets. In addition, new government rules and regulations have required institutions to hold more in the way of safe assets (see Blanchard 2019). In all these cases, an increase in demand for safe assets relative to risky ones would drive up the price of safe assets relative to risky ones.

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<sup>8</sup> [https://www.quandl.com/data/MULTPL/SHILLER\\_PE\\_RATIO\\_MONTH-Shiller-PE-Ratio-by-Month](https://www.quandl.com/data/MULTPL/SHILLER_PE_RATIO_MONTH-Shiller-PE-Ratio-by-Month)

Likewise, there are several different explanations of the decline in the marginal product of private capital. First, Bernanke (2005) and Bernanke et al. (2011) show that a global “savings glut,” fueled largely by changes in the external position of emerging and Asian economies, led to higher capital-to-labor ratios and thus lower marginal returns. Second, demographics have evolved. Slower labor force growth raises capital per worker and reduces the marginal return to capital holding investment rates constant. Third, lower rates of productivity growth are naturally linked to lower returns to private capital. Fourth, expectations of future growth can also play an important role. In a standard life cycle model, if people expect their income to grow quickly, they are more likely to borrow more, which would put upward pressure on interest rates. Conversely, if growth is expected to be low, people will borrow less, which reduces upward pressure on interest rates (See Elmendorf and Sheiner 2017 and Council of Economic Advisers 2015 for further discussion).

The presence of a declining marginal product of capital may appear, at first glance, to conflict with the rising capital share of GDP (Piketty, Saez, and Zucman (2018)). While this could be consistent with a fall in the return to capital for a very high (e.g.,  $> 1$ ) elasticity of substitution in production (e.g., Piketty 2014), there are other potential explanations that do not rely on this assumption. For example, noncompetitive rents have probably increased in recent years.<sup>9</sup> A decline in worker power that is related to, but distinct from, the rise in rents could also be playing a role (Stansbury and Summers 2020). In addition, as the role of pass-through business has increased in recent years, some returns to human capital (e.g., of business owners) may have been classified as capital income, for tax or other purposes (Smith et al 2019). Finally, a significant portion of the rise in capital share has to do with housing and with increases in

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<sup>9</sup> Autor, et al. (2020); De Loecker et al. (2020); Gutierrez and Philippon (2017); Power and Frerick (2016).

depreciation (Rognlie 2015). Given these various potential explanations, the rise in the capital share of income is not inconsistent with a decline in the marginal return to capital.

### **III. Implications of Sustained Low Interest Rates for the Structure of Tax Policy**

#### A. Consumption, Wage, and Income Taxes

Low interest rates have important implications for the relative impact of consumption or wage taxation relative to income taxes.

##### *1. Consumption taxes*

Economists have discussed the relative merits of consumption versus income taxes at length. Consumption taxes could be implemented in many forms, with some of the options allowing for progressive rates. Here, we abstract from the differences in design across various consumption tax options and focus on the differences between a consumption tax and an income tax.

Specifically, asset returns include three components: a safe return (the return to waiting), a compensation for risk, and excess returns. Excess returns could represent sheer luck; they could arise because of rents obtained from patents, special expertise or skills, natural monopolies, market power, or restrictive regulations; or they could be due to other factors.

In steady state with constant tax rates over time, a consumption tax differs from an income tax only in its treatment of the safe return. An income tax burdens the safe return while a consumption tax does not. Both taxes impose burdens on the return to risk and on excess

returns, although only the tax on excess returns imposes a burden on the taxpayer in an environment of efficient risk-pooling, a result that dates to Domar and Musgrave (1944).<sup>10</sup>

In the transition from an income tax to a consumption tax a second difference arises: the consumption tax imposes a levy on existing capital, as the present value of consumption includes that consumption financed by existing wealth. A lower government interest rate reduces the difference between consumption and income taxes via two channels. It reduces the safe return, and it likely reduces the levy imposed on existing capital. Simulations in Auerbach (2009), some of which we present in Table 1, develop these results. Based on models developed in Auerbach and Kotlikoff (1987) and Auerbach (1996), the Auerbach (2009) baseline contains a 25 percent proportional income tax with no other taxes or government debt.

The first row of Table 1 presents the results of simulating an immediate shift from the income tax to a proportional consumption tax with equal annual revenue, under the assumption that the rate of return includes neither rents nor returns to risk-taking. The long-run output gain is nearly 8 percent, stemming from the increased saving and investment associated with the reduction in the tax on the safe return and the lower future tax rates made possible by the initial capital levy. The percentage gain in welfare of the representative individual in the long run is smaller than the output gain, because it depends on the value of leisure as well as consumption, but is still sizable, at 4 percent. The efficiency gain is considerably smaller, just over 0.5 percent, because a large share of the long-run gains comes from intergenerational redistribution.<sup>11</sup>

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<sup>10</sup>Domar and Musgrave show that with symmetric taxation of gains and deductions of losses, a proportional tax on a risky asset will cause investors to adjust their holdings of the risky asset so that the distribution of after-tax returns is equal to the distribution of returns in the world with no taxes.

<sup>11</sup> The percentage gain in welfare of the representative individual in the long run is expressed relative to full lifetime resources – the present value of the individual’s labor endowment, out of which consumption and leisure are

Consider now the effects of reducing the rate of return. Before discussing the results of this experiment, it is useful to go through the intuition. As the initial interest rate falls, the efficiency gain from eliminating the tax on the safe return falls. The capital levy remains in place but will be smaller if assets generate a lower return. If one thinks of the capital levy as a government asset providing an infinite stream of future returns that can be used to reduce the consumption tax rate in future years, these returns will be lower if the rate of return is lower. Hence, under the consumption tax, we should expect smaller efficiency gains for a lower initial interest rate.

Despite the clear intuition, there is no simple way of extending the model to incorporate aggregate risk, in which the risky and safe rates of return are determined in equilibrium and the risk premium changes as the tax system and equilibrium change. We consider a simpler experiment, in which the economy's capital intensity is held constant but the initial rate of return to capital is substantially lower. In particular, we lower two parameters: the capital intensity of production and the rate of time preference, so that the capital-output ratio in the initial steady state with the income tax is unchanged while the interest rate is reduced to 40 percent of its original value, from 7.90 percent to 3.16 percent. The second row of Table 1 shows the results of transitioning to a consumption tax under a scenario with lower rates of return and confirms the intuition discussed above. With lower interest rates, all output and welfare measures move substantially closer to zero, particularly the efficiency effects.

But there may be more to the story. To the extent that the observed excess return to capital in the economy represents economic rents rather than returns to risk taking, the capital

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financed. The percentage gain in economic efficiency is calculated as the long-run gain in welfare when generations born prior to the beginning of the transition are compensated for gains or losses in welfare and all subsequent generations share equally the gains (or losses) from the change in tax policy.

levy of the consumption tax will provide a larger stream over time than those generated by the previous consumption tax simulations, which assume no rents. That is, even though the normal rate of return to new investment may be low, the capital levy will capture a share of both the normal returns and the rents from existing capital. If the assumption of perfect competition still holds, then these rents are simply returns to fixed factors and provide an efficient tax base.<sup>12</sup>

To explore how much larger the efficiency gain could be in the presence of economic rents, we consider the extreme case in which the overall rate of return does not fall, with the lower safe rate of return being entirely offset by higher economic rents. That is, the flow from the capital levy is as large as in the base case simulations, but the efficiency gain from eliminating the intertemporal distortion is still smaller because of the lower return to new saving.

The third row of Table 1 provides the results. As expected, the gains in output and efficiency are now much larger, although still smaller than those under the base case, high-interest-rate simulation. Intuitively, the gap remains because even with the restoration of the capital levy's value, getting rid of the intertemporal distortion is still less important with lower rates. Recall, too, that this simulation reflects the extreme assumption that the entire return to the existing capital stock is either economic rent or a normal return to capital. If economic rent accounts for a smaller share of observed returns (e.g., if some of the observed returns represent disguised returns to labor), the effects will be muted.<sup>13</sup>

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<sup>12</sup> Alternatively, economic rents may be due to imperfect competition. If firms are restricting production to levels at which price exceeds marginal cost, and if capital goods markets are among those in which noncompetitive distortions exist, there are additional implications for tax policy (Judd 2002).

<sup>13</sup> The distributional effects of a shift to consumption taxation would also be affected by a change in the composition of the rate of return, given the heterogeneity in the asset portfolios across income groups (e.g., Gentry and Hubbard 1997). In particular, a decline in the normal rate of return, and the smaller impact of exempting that return from taxation, would affect lower income groups more, relative to their net worth, as their capital income is more heavily concentrated among relatively safe, passive investments.

## 2. *Wage taxes*

Both a consumption tax and a wage tax would remove the distortion facing intertemporal consumption decisions. However, a consumption tax imposes a levy on existing capital which raises efficiency under the assumption that this tax is an unanticipated capital levy that can be used to reduce distortionary taxes further. A wage tax provides no such capital levy. Further, by eliminating capital income taxes that those accumulating wealth had expected to pay, the adoption of a wage tax provides a capital bonus in a sense, which has the opposite impact on efficiency of a capital levy, working against the efficiency gains from eliminating the intertemporal consumption distortion. Thus, it is conceivable that transitioning to a wage tax would reduce efficiency even as it removes intertemporal distortions. Indeed, the fourth row of Table 1 shows that, in the baseline model used, an immediate switch to a wage tax would reduce long-term output and welfare.

Now consider the impact of a lower rate of return. As interest rates fall and capital income becomes a smaller share of total income, the differences between a wage tax and an income tax shrink. The capital bonus provided to earlier generations is reduced, as is the efficiency gain from removing the intertemporal distortion. Although these effects work in opposite directions, we know that, as the rate of return converges to zero, the wage tax and the income become identical (assuming there are no rents) and hence the net change in all summary statistics converges to zero. As there is no reason to suspect that one of these effects should phase out more quickly than the other as the initial interest rate goes down, we would expect that a reduction in the initial interest rate would also reduce the impact of a transition to a wage tax. The results in the last row of Table 1 confirm this intuition, showing that all the output and efficiency effects of wage taxes shrink as the rate of return declines.



## B. Taxes on Saving and Wealth

The notion of taxing wealth has received significant attention from academics and policy makers in recent years (Saez and Zucman 2019, Sanders n.d., Warren n.d.). In addition, the U.S. tax code treats capital gains differently than other forms of income such as wages and provides a variety of tax-based incentives for saving. This section examines the impact of low interest rates on each of those policies. We find that lower rates of return raise the distortionary impact of a wealth tax relative to a capital income tax, for given tax rates; reduce the lock-in effect associated with taxing capital gains upon realization rather than on an accrual basis; and reduce the advantage of saving in a tax-based saving incentive plan relative to saving in a conventional asset.

### 1. *Wealth taxes*

The comparison of wealth taxes with income taxes requires some adjustments. Wealth taxes impose annual taxes on a stock (of wealth). As a result, they need to be specified in terms of a rate per unit of time. In contrast, income taxes are imposed on flows (of income). Thus, a 5 percent wealth tax per year would tax (about) 50 percent of initial wealth over a decade, whereas a 5 percent income tax per year would tax 5 percent of income over a decade (Viard 2019).

In the simplest example, where wealth earns a fixed return ( $r$ ), capital income ( $Y$ ) equals wealth ( $W$ ) times the rate of return:

$$Y = r * W, \text{ or}$$

$$Y / r = W$$

Imposing a tax rate of  $t_w$  on each side implies that a wealth tax at rate  $t_w$  implies a capital income tax rate of  $t_w / r$ .

$$(t_w / r) * Y = t_w * W.$$

For example, if  $r = 6$  percent, a 2 percent wealth tax is equivalent to a 33 percent tax on capital income. If  $r = 2$  percent, a 2 percent wealth tax is equivalent to a 100 percent tax on capital income. That is, a wealth tax of a given magnitude is the equivalent of a more distortionary capital income tax as rates of return fall.

Developing the implied income tax rate from a given wealth tax rate may appear to be more complicated than specified above when investors hold assets that vary in return and riskiness. It should be noted, however, that investors are presumably balancing risk and return in their portfolios and on the margin hold both safe and risky assets. Since the wealth tax, if it existed, would be a certain flow given the value of wealth, it makes sense to compare the wealth tax rate to the return on safe assets to generate an effective income tax rate (Auerbach 1991 and Viard 2019).

A related point is that, among those with the same wealth, a wealth tax does not tax differently those with high returns and those with low returns. If excess returns are due to entrepreneurial effort, this feature provides a positive incentive effect (Güvener et al. 2019) but also makes the wealth tax less effective than an equivalent income tax in capturing labor income disguised as business income. If excess returns are due to rents, this feature is less than optimal (Auerbach and Hassett 2015, Rothschild and Scheuer 2016).

Of course, a wealth tax collects revenue even if the current return to capital is zero (Scheuer and Slemrod 2021). One can think about this result in the context of the discussion of the efficiency effects of a shift from a capital income tax to a consumption tax in section 3.A. In the limit, with the rate of return to capital equal to zero, an income tax and a consumption tax

would differ only by the tax the latter imposes on initial wealth, providing a source of efficiency gain from a shift to consumption taxation. A wealth tax, however, would provide a continuing distortion to intertemporal decisions (and would also continue to provide tax revenue).

## 2. Capital gains taxes

A capital gain is the increase in the value of an asset over time. In the U.S. tax system, capital gains are only taxed when they are “realized” – that is, when the asset is sold.<sup>14</sup> Taxation upon realization, rather than taxing gains as they accrue, creates a “lock-in” effect, through which investors can obtain higher post-tax returns from continuing to hold an asset even if the pre-tax return for doing so would be less than for an alternative investment.

To understand the lock-in effect, consider an investor with an asset purchased in the past for \$1, which has already appreciated in value by an amount  $g$ . The investor can either hold the asset for another year, earning an additional nominal return  $r$ , or sell and earn the market nominal rate of return  $i$ . If the investor sells (realizes) the asset and reinvests, terminal wealth is:

$$(1) \quad W_R = (1+g(1-t)) (1+i(1-t)) = (1+g)(1+i) - t[g(1+i(1-t)) + (1+g) i]$$

If the investor holds the asset for another year and then sells, terminal wealth will be:

$$(2) \quad W_H = (1+g)(1+r) - t[(1+g)(1+r) - 1] = (1+g)(1+r) - t[g + (1+g)r]$$

Comparing the terms in brackets in the second version of each expression, we can see that the “hold” strategy enjoys a tax advantage over the “realize” strategy – previously accumulated gains,  $g$ , are taxed one year earlier under the latter, and hence the tax liability has a

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<sup>14</sup> In addition, but not of as much interest for our purposes, realized capital gains are taxed at lower rates than wage or other income and a limited amount of capital losses can be taken as a deduction.

higher accumulated value at the end of the second period because it is multiplied by  $1+i(1-t)$ . Because the second term on far-right hand side of (1) is larger in absolute value than the analogous term in (2) when  $i = r$ , the value of holding the asset ( $W_H$ ) will exceed the value of selling or realizing the gain ( $W_R$ ). Likewise, at some values where  $r < i$ , it will continue to be optimal to hold the asset rather than sell it. This is the lock-in effect.

Approaches to tax gains on accrual or to impose an interest charge on previous realized gains,  $g$ , are aimed at eliminating this deferral advantage (see Vickrey 1939, Auerbach 1991). However, as the real interest rate, and presumably the nominal interest rate, declines, the deferral advantage is reduced.<sup>15</sup> Indeed, with very low nominal interest rates, a more significant deferral advantage arises from the avoidance of any capital gains tax at death, due to the basis step-up that occurs on that occasion.<sup>16</sup>

### 3. *Saving incentives*

Consider an individual who earns  $\$1/(1-t_e)$  in labor income where  $t_e$  is the marginal tax rate on earnings. After paying  $\$t_e/(1-t_e)$  in taxes, the individual is left with  $\$1$  of after-tax income.

If the funds go into a conventional interest-bearing saving account, the individual's after-tax balance after  $T$  years will be:

$$B_1 = (1+r(1-t))^T,$$

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<sup>15</sup> In (1) and (2), the deferral advantage  $W_H - W_R = t^*g^*i^*(1-t)$ , when  $r = i$ . Given that  $t$  and  $g$  are fixed and positive and that  $t$  is between 0 and 1, the value of the expression falls as  $r$  and  $i$  fall.

<sup>16</sup> With very low interest rates, another more important deferral advantage is likely the implicit option of waiting for a lower tax rate to realize gains. While reform proposals to tax gains on accrual automatically deal with this incentive as well, others based on realization do not. However, the latter could be designed to do so, by not only adding an interest charge to offset the time value of deferral, but also taxing gains retrospectively at the rate in force when the gains initially accrued.

where  $r$  is the nominal rate of return and  $t$  is the statutory marginal tax rate on interest income. Note that because the tax system is not indexed for inflation, the tax rate  $t$  in this expression applies to the nominal rate of interest.

In contrast, if the funds were contributed to a Roth IRA account,<sup>17</sup> the investor's after-tax balance would be

$$B_2 = (1+r)^T.$$

It is straightforward to show that the ratio  $B_2/B_1$  falls as the nominal interest rate falls. For example, if  $T = 30$  and  $t = .25$  (and is constant over time), the ratio of  $B_2/B_1$  is 1.5 when  $r = 6$  percent and falls to 1.16 when  $r = 2$  percent. In short, low interest rates reduce the relative advantage that an investor obtains by investing in a Roth IRA relative to a conventional interest-bearing account. Similar calculations would apply to a conventional IRA versus a conventional saving account, but the analysis is slightly more complicated.

### C. Investment Incentives

Policy makers have often used tax incentives to attempt to boost firm investment, either on a cyclical or long-term basis. These incentives have included lower statutory tax rates, accelerated depreciation allowances, and investment tax credits.

We model incentives for firm-level investment in a user-cost-of-capital framework.<sup>18</sup> The user cost of capital is defined as the minimum return a firm needs to earn on an investment to cover economic depreciation, taxes, and the opportunity cost of funds. A lower cost of capital typically translates into more investment.

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<sup>17</sup> We are ignoring early withdrawal penalties. See Burman, Gale, and Krupkin (2019) for further discussion.

<sup>18</sup> Jorgenson (1963); Hall and Jorgenson (1967); and Auerbach (1983).

The cost of capital on a \$1 investment is given by:

$$(3) \quad c = q(r + \delta) \frac{(1-k-uz)}{(1-u)}$$

where  $c$  is the user cost of capital,  $q$  is the price of capital goods (relative to the price of output),  $r$  is the real discount rate the firm uses in consideration of the investment (presumably reflecting the risk-free rate plus the risk involved in the investment),  $\delta$  is the rate of economic depreciation of the asset in question,  $k$  is the value of an investment tax credit,  $u$  is the statutory corporate tax rate, and  $z$  is the present value of tax deductions for depreciation.

To calculate  $z$ , we follow the standard formulation:

$$(4) \quad z = D_0 + \sum_{t=1}^T \frac{1}{(1+r_d+\pi)^t} D_t$$

where  $D_t$  is the allowable deduction in period  $t$  per dollar of investment in period 0,  $T$  is the tax life of the asset,  $r_d$  is the real discount rate applicable to depreciation allowances, and  $\pi$  is the inflation rate, reflecting the fact that depreciation allowances are based on the historic cost of assets and not indexed for inflation. Although the discount rate  $r_d$  should not reflect the riskiness of the firm's investment returns, because it represents a promised government payment, it is unclear whether firms treat such allowances that way.<sup>19</sup>

The cost of capital is increasing in the firm's discount rate ( $r$ ), the rate at which depreciation allowances are discounted ( $r_d$ ), and the economic depreciation rate ( $\delta$ ) and decreasing with the generosity of depreciation deductions ( $D$ ) and the investment tax credit ( $k$ ).

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<sup>19</sup> Summers (1987). Note that there could still be some risk to be considered, because of the possibility that such deductions could be lost (e.g., through bankruptcy) or deferred (because of future net operating losses).

While one might expect the user cost to be increasing in the corporate tax rate ( $u$ ), this result can be overturned if investment subsidies are sufficiently generous.<sup>20</sup> In particular,

$$(5) \quad \frac{dc}{du} = q(r + \delta) \frac{1-k-z}{(1-u)^2}$$

Turning to the impact of lower interest rates on investment incentives, we obtain four results. First, from (3), it follows that a lower interest rate attenuates the impact of the corporate tax rate, with the sign of the smaller (in absolute value) impact depending on the sign of  $(1-k-z)$ . The effect would be zero in a regime with expensing ( $z = 1$ ) and no investment tax credit ( $k = 0$ ), when the corporate tax rate has no impact on the user cost.

Second, a lower interest rate reduces the impact of an investment tax credit on the cost of capital.<sup>21</sup>

Third, if a lower government interest rate also implies a lower  $r_d$ , this raises  $z$  and lowers the cost of capital. Whether this reduction is larger for long-lived or short-lived assets is ambiguous. Long-lived assets receive depreciation allowances over a longer period, which are more heavily discounted, so the value of  $z$  will increase *proportionally* more for long-lived assets; but the value of  $z$  is also lower for long-lived assets, again because allowances extend over a longer period. Hence, the increase in  $z$  from a reduction in the discount rate could be larger or smaller for long-lived assets relative to short-lived assets.<sup>22</sup>

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<sup>20</sup> Indeed, the possibility of the user cost falling with an increase in  $u$  may be even larger to the extent that the discount rate  $r$  falls because of an increased value of interest deductions on borrowed funds.

<sup>21</sup> In (3), the derivative of  $c$  with respect to  $k$  is  $\frac{-q(r + \delta)}{1-u}$ ;  $\frac{d(\frac{dc}{dk})}{dr} = \frac{-q}{1-u} < 0$ .

<sup>22</sup> For example, suppose that assets decay exponentially at rate  $\delta$ , and depreciation allowances are accelerated relative to actual depreciation by a factor  $a$ . Then, for any given  $\delta$ ,  $z = a\delta/(r_d + \pi + a\delta)$ , which clearly increases with a fall in  $r_d$ . However,  $d^2z/dr_d d\delta = (a\delta - r_d - \pi) * a / (r_d + \pi + a\delta)^3$ , meaning that  $z$  is more sensitive to the interest rate for shorter-lived assets (those with higher  $\delta$ ) if  $r_d + \pi < a\delta$ . For short-lived assets (high values of  $\delta$ ), this condition

Finally, again assuming that a lower government interest rate implies a lower  $r_d$ , the effect of accelerated depreciation allowances on the user cost will be attenuated at low interest rates, because the discounting benefit of earlier receipt of deductions would be reduced.<sup>23</sup>

The findings of Zwick and Mahon (2017) suggest that immediate expensing of investment, introduced in recent decades in the U.S. in the form of “bonus” depreciation, stimulates investment because of the immediate deduction, rather than because of the associated increase in the present value of depreciation allowances,  $z$ . This could be due, for example, to firms being liquidity constrained, so that the effective rate at which they discount depreciation allowances is much greater than would otherwise apply. In this case, with the government discount rate substantially lower than that of some private firms, there could be large benefit to the provision of immediate deductions, even if the present value of such deductions, based on market value of  $r_d$  were not increased.<sup>24</sup>

#### D. Carbon Taxes

The climate change induced by carbon emissions has been described as the biggest externality or market failure the world has ever seen.<sup>25</sup> Resolving this problem raises an

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holds; for very long-lived assets ( $\delta \rightarrow 0$ ) and little acceleration of deductions,  $a$ , the condition may not hold, so that the change in the user cost could be u-shaped, higher for short-lived assets and very long-lived assets than for those in between. However, this result depends on the assumed pattern of depreciation allowances and the initial value of  $r_d + \pi$ .

<sup>23</sup> The condition under which this would be true is the same condition derived in the previous footnote. That is, by the symmetry of the expression for  $z$  with respect to  $a$  and  $\delta$ , an increase in  $a$  would have a smaller impact on the user cost for a reduction in the discount rate if  $r_d + \pi < a\delta$ . While this might not be true for the longest-lived assets, such assets have typically been excluded from such accelerated deductions (e.g., the several rounds of bonus depreciation, which applied to equipment but not structures.)

<sup>24</sup> Such a scheme – allowing immediate expensing of an amount equal to  $z$  in place of regular depreciation deductions over time, was proposed by Auerbach and Jorgenson (1980), although the main objective there was to insulate the value of depreciation deductions from fluctuations in future inflation and nominal interest rates.

<sup>25</sup> Stern (2007).



inordinately large number of issues. We focus here on one aspect of that resolution – how lower interest rates impact estimates of the optimal price to impose on carbon emissions, potentially through a carbon tax. To do so, however, requires putting the broader issue in context.<sup>26</sup>

A key concept in climate change is the social cost of carbon (SCC), the economic damage from a one-ton increase in carbon emissions. The Environmental Protection Agency (EPA) defines the SCC as a “comprehensive estimate of climate change damage and includes change in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs.” For example, a recent government study estimated that in 2020, the SCC, using the “central” 3 percent discount rate and averaged across different scenarios, was \$51 (in 2020 dollars).<sup>27</sup>

To estimate a SCC, two types of information are needed: first, an estimate of the economic damage (broadly defined) over time caused by an increase in carbon emissions today; second, a way of discounting future values to the present.

In carbon mitigation, the costs typically commence immediately upon enactment of a policy, or at least early in the process, while the projected benefits are typically only realized after a lengthy delay – sometimes decades and or even centuries later.<sup>28</sup> As a result, even small differences in how people value the future compared to the present can dramatically alter the estimated SCC. For example, almost all the differences between analyses by Stern, who argues in favor of near-term massive climate change mitigation measures, and Nordhaus (2008), who

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<sup>26</sup> We are abstracting from the facts that policy makers could address climate change via many mechanisms – carbon taxes, cap-and-trade systems, command-and-control regulations, trade policies, clean energy subsidies, etc., and that these policies will differ in the timing and magnitude of their effects (Acemoglu et al. 2016).

<sup>27</sup> <https://perma.cc/5B4Q-3T5Q>

<sup>28</sup> The benefits of climate change may also be affected by things that affect the interest rate – e.g., with lower productivity, emissions would likely be lower, and the SCC could be different.

argues in favor of a small, slowly growing response to climate change (a “policy ramp”), boil down to differences in the discount rate employed.

When a policy intervention has costs concentrated in the near term and benefits far into the future, the present value of net benefits is especially sensitive to a permanent reduction in the discount rate.<sup>29</sup> Where there is less consensus in the literature is on how the long-term changes in *interest rates* documented above should change estimates of the *discount rate* used to evaluate climate change mitigation policies.

### 1. *Discounting framework*

The simple Ramsey Rule for optimal saving provides a framework for social discounting:

$$(6) \quad r = \delta + \eta g.$$

In (6),  $r$  represents the risk-free return to capital,  $\delta$  is the pure rate of discount<sup>30</sup> – the rate at which societies discount the *utility* (rather than consumption) of future generations relative to current generations, and  $g$  is the growth rate of consumption broadly defined.<sup>31</sup>

The variable  $\eta$  can be interpreted several ways, with a higher value in each case corresponding to greater aversion to inequality. In terms of intragenerational outcomes, where inequality relates to current income, higher  $\eta$  represents a desire to shift more resources from the rich to the poor (Stern 2007). In terms of intergenerational outcomes, where inequality relates to

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<sup>29</sup> Note that this is the case for many other environmental policies as well and for interventions relating, for example, to human capital investment.

<sup>30</sup> This definition of  $\delta$  is distinct from the rate of depreciation for which it was used above. We use the same parameter in both situations to reflect the standard use in each of the respective literatures.

<sup>31</sup> Equation (6) is the optimal solution when maximizing a welfare function that sums each generation’s utility and assumes utility in each generation takes the CRRA form with parameter  $1-\eta$  (Weisbach and Sunstein 2009).

lifetime income, higher  $\eta$  represents a desire to do less to mitigate carbon taxes, because current generations are poorer than future generations (Nordhaus 2008). In terms of personal outcomes, higher  $\eta$  represents greater risk aversion (that is, a stronger desire to insure oneself against bad outcomes). Clearly, asking one parameter to represent all three items leads to difficulty constructing the best value of the parameter.<sup>32</sup>

## 2. *Discounting – two approaches*

While there is little dispute that the Ramsey rule is a useful starting point for thinking about how to value climate abatement policies over time and across generations, there are two distinct approaches to that rule's implication for discounting. One approach (as followed, for example, in Stern (2007), and sometimes called “prescriptive” or “normative”) is to choose values for the parameters in (6) based on a combination of empirical estimates (for the growth rate,  $g$ ) and ethical values (for the pure rate of discount,  $\delta$ , and the inequality aversion parameter,  $\eta$ ). This is the approach adopted by Stern (2008), who uses  $\delta = 0.1$  percent,  $\eta = 1$ , and  $g = 1.3$  percent to generate an estimate of  $r = 1.4$  percent.<sup>33</sup>

A second approach, sometimes called “descriptive” or “positivist,” argues that the right-hand side of equation (6) may provide some information about how the risk-free rate  $r$  is determined, but that discounting the costs and benefits of carbon abatement projects should occur

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<sup>32</sup> The analogy in analysis of consumption is that in a CRRA utility function, the risk aversion parameter and the intertemporal elasticity substitution are constrained to equal the inverse of each other. However, nothing in the standard CRRA approach requires the same elasticity of substitution between periods and among commodities in the same period, and one can also relax the assumption that ties the rate of intertemporal substitution and the coefficient of risk aversion (Epstein and Zin 1989). Presumably, one can relax these constraints in the social discounting framework as well, and this might be necessary, for example, to reflect stated preferences for high intertemporal redistribution (high  $\eta$ ) and a desire for aggressive policy toward climate change (low  $\eta$ ).

<sup>33</sup> The choice of  $\delta = 0.1$  percent is meant to represent the absence of discounting the welfare of future generations (which would imply  $\delta = 0$ ), adjusted for the possibility of human extinction in the future, in which case there would not be any further future generations to value.

at a rate that is based on market parameters, not any particular parameters of the social welfare function.<sup>34</sup> The logic is simple: along the current path for the economy, the government may intervene by borrowing or lending at the interest rate,  $r$ . Therefore, if it wishes to undertake an investment to abate climate change, it should take into account the opportunity cost of funds and the riskiness of the investment (that is, the correlation of benefits with overall economic growth outcomes). Put another way, investments in climate change abatement should be subject to discounting rules that apply to other potential government investments (including purchases of government debt) or regulations. If it appears that the ethically “correct” discount rate is lower than a market-based discount rate, this implies that the government should consider all ways of investing more for the future, not just investments in climate abatement.

There is some middle ground between these two perspectives, relating to the scale of activity being considered. While the market interest rate might suffice for marginal investment decisions, it is inadequate for large, nonmarginal investments, because such investments would affect the market interest rate. How much the government should invest for the future may then be informed by the social welfare parameters. Again, though, this is true not only for climate change policy, but also for any intertemporal government policies. However, if climate change policy is on a scale larger than anything else contemplated, or if other intertemporal policies cannot be presumed to be close to optimal, the relevance of social welfare parameters may effectively matter primarily when climate change policy is being considered.

### *3. Further issues*

Even if one accepts an approach based on market rates of return, there are still issues to resolve in determining how to discount the elements that make up the SCC. First, one should

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<sup>34</sup> See, e.g., Weisbach and Sunstein (2009).

recognize that, with stochastic productivity growth, the expression for the safe rate of return in (6) must be modified. Under the assumption of an i.i.d. growth rate that is normally distributed with mean  $\mu$  and variance  $\sigma^2$ , expression (6) becomes (Weitzman 2007).

$$(7) \quad r = \delta + \eta\mu - \frac{1}{2}\eta^2\sigma^2$$

which indicates that uncertainty, in leading to precautionary saving, increases capital accumulation and thereby depresses the safe rate of return.<sup>35</sup> While this complication does not affect the argument that one should use the observed rate of return for discounting, it does provide a reason why the observed rate of return might be low.<sup>36</sup>

Second, there is a theoretical argument discussed at great length in the literature that when the future interest rate itself is uncertain, the relevant safe discount rate should decline with the length of the horizon, asymptotically approaching the lowest possible return.<sup>37</sup>

Third, the safe discount rate is appropriate for discounting certain flows, but not necessarily risky ones, if these risky flows have a systemic component. As the return to risky flows, as represented, for example, by the market return to equity, is substantially higher than the safe interest rate, this could substantially increase the appropriate discount rate relative to the one represented in (7). However, Weitzman (2007) argues that while most models have “baked into the cake” the assumption of a one-to-one correlation between overall market returns and returns to climate change (by modeling the cost of carbon taxes as a reduction in output), there might be

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<sup>35</sup> See Weitzman (2007) and Gollier (2012).

<sup>36</sup> Indeed, Weitzman argues that, in the presence of Knightian uncertainty about the distribution of  $g$ , the last two terms on the right-hand side of (7) equal  $-\infty$ , thereby justifying any level of additional saving. Even in a less extreme case, an alternative distributional assumption for  $g$  that admits the possibility of large disasters can rationalize more precaution and a lower safe rate of return (Barro 2006).

<sup>37</sup> E.g., Weitzman (1998); Weitzman and Gollier (2010); and Arrow, et al. (2014).

significantly weaker correlation – that climate change damage will vary across regions of the world, countries, sectors of the income, income levels, and so on. And he notes that with imperfect correlation, the relevant discount rate declines eventually to the risk-free rate, again providing a reason for using a low discount rate for very long-term climate change abatement policy. Becker et al. (2010) note that if climate policies provide substantial payoffs in otherwise bad future states of the world, then discounting at a rate below the risk-free rate could be appropriate.<sup>38</sup>

Finally, to the extent that falling interest rates documented above are part of a general trend that includes the required returns to risky assets (as opposed to an increase in the risk premium that may cause risky and safe returns to move in opposite directions), there is an additional argument for using lower discount rates over short as well as long horizons for discounting uncertain future flows.<sup>39</sup>

#### *4. Interest rates and the social cost of carbon*

Finally, we consider the impact of lower interest rates on optimal climate change policy, as summarized by the SCC, noting that these estimates apply to marginal investment decisions,

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<sup>38</sup> In the terminology of the capital asset pricing model, if the correlation between the output of climate investments and overall economic growth is one, then the appropriate discount rate is the market return to all assets, safe and risky. If the correlation is zero, the appropriate discount rate is the risk-free rate. If the correlation is negative, as might be the case of the payoffs to climate investments are higher when climate change is particularly damaging to economic activity, the appropriate discount rate is below the risk-free rate.

<sup>39</sup> In light of these alternative theoretical perspectives, Drupp et al. (2018) surveyed individuals they identified as social discounting experts (identified by having published papers relating to social discounting according to Google Scholar or Econlit). Of 627 surveyed, 185 provided quantitative responses. The authors found a mean and median social discount rate (SDR) of 2.27 percent and 2 percent, respectively, and more than 75 percent of respondents reported an acceptable range for the SDR that included 2 percent. Views on the pure rate of time preference, however, were varied – the modal value was zero, the median was 0.50 percent, and the mean was 1.10 percent. About 80 percent of the experts thought that both normative and positive dimensions were important for the analysis. Regression analysis indicated that each additional percentage point assigned to the optimal weight on normative issues reduced the respondent's estimate of the correct social discount rate by 0.02 percentage points. Thus, someone who put 100 percent weight on normative issues would prefer a social discount rate that is 2 percentage points below someone who put all weight on positive issues, other things equal.

and that more complicated modeling is needed to evaluate large scale changes. As noted throughout, with policy interventions that generate costs that arise early in the process and benefits that do not arise appreciably until much later, it is easy to show that at lower discount rates, the present discounted value of benefits rises relative to the costs.

Nordhaus (2018) provides quantitative estimates of the substantial difference that discount rates make. For example, in 2020, a reduction in the discount rate from 5 percent to 2.5 percent causes the SCC (and hence the prescribed price of carbon per ton) to rise from 21.7 to 133.4 (both in 2010 dollars). Bauer and Rudebusch (2020) have produced additional estimates, based on the secular decline in safe interest rates documented in section II that also incorporate the declining term structure over very long horizons induced by uncertainty about the future short-term interest rate. For their baseline model, they find that the SCC (in 1989 dollars) based on projections using data through 1990 is 31.8, whereas interest rate projections based on data through 2019 yield a constant-dollar SCC of 68.7. Finally, Carlton and Greenstone (2021) note that reducing the discount rate from 3 percent to 2 percent raises a standard estimate of the SCC used by the Obama Administration from \$50 to \$125.<sup>40</sup>

#### **IV. Conclusion**

It is by now generally recognized that the presence of low interest rates – sustained over time and across countries – has important implications for the fiscal stance of the federal

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<sup>40</sup> Although not related to changes in discount rate assumptions, even higher values of the SCC may apply once one accounts for the deadweight loss incurred from additional future government spending (and taxes) required to deal with climate change. Barrage (2020) estimates that this adjustment can raise conventional estimates by up to one-third. Rennert et al. (2021) and van den Bremer and van der Ploeg (2021) provide further extensions and refinements of the SCC calculation.

government. In this paper, we argue that if low interest rates are expected to persist, there are important implications for the design of tax policy as well.

In general, our results reflect three main themes: in the presence of low interest rates, subsidies to saving and investment are less potent; the wealth tax is bigger and more distortionary relative to an income tax, for given tax rates; and investments with back-loaded benefits (most prominently carbon taxes) are more valuable. This last implication is likely important in other cases we have not yet considered, particularly human capital investment, where expenditures of money and time when young provide benefits possibly decades later. However, another factor to consider in this case, and perhaps others as well, is that lower interest rates may also be associated with lower rates of productivity growth, which might also reduce the future returns to investment. In addition, the implications of low interest rates for government discounting could be affected by the irreversibility of certain policy decisions, which could provide an option value to waiting for the resolution of uncertainty and effectively increase the appropriate discount rate (Dixit and Pindyck 1994). If, as discussed above, lower market interest rates may be due in part to higher uncertainty, this could partially offset the impact of lower interest rates through an increase in option value.

Of course, the future path of interest rates is unknown, so it is not at all certain that rates will remain low. But to the extent that beliefs run toward continued low interest rates, the implications for tax policy design are significant.



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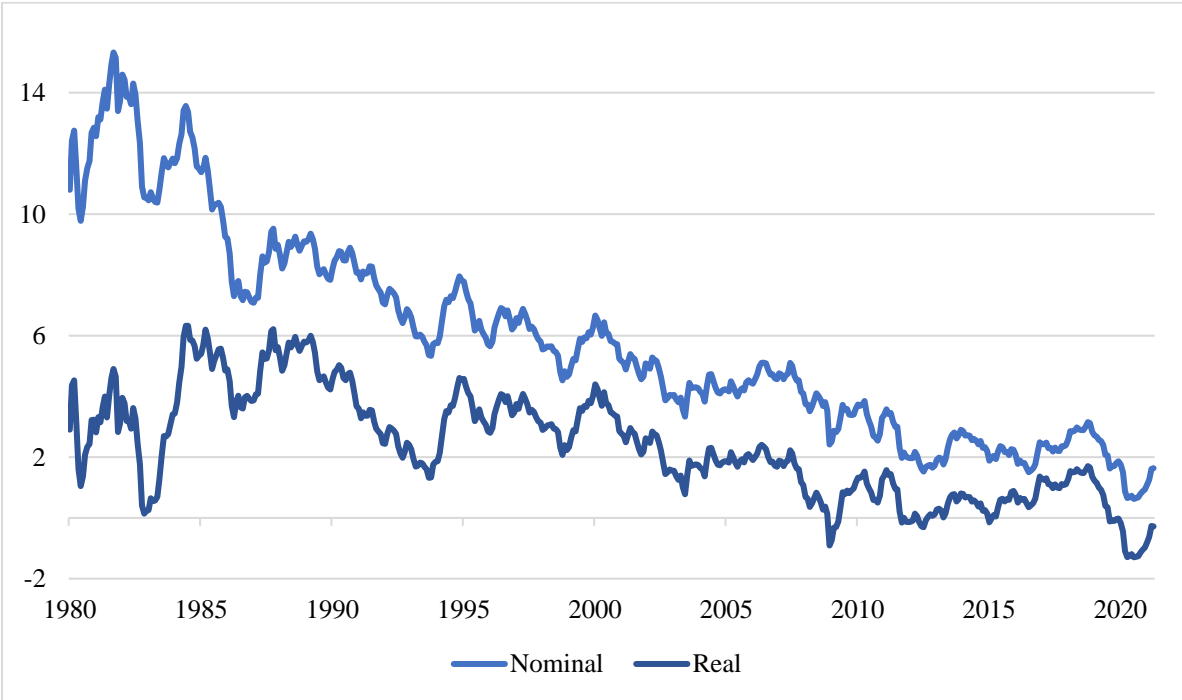
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**Figure 1: Real and Nominal 10 Year Treasury Yields**



Source: Board of Governors of the Federal Reserve System (2021), Bureau of Labor Statistics (2021).  
Real yield is calculated using a five-year lagged moving average of CPI-U.

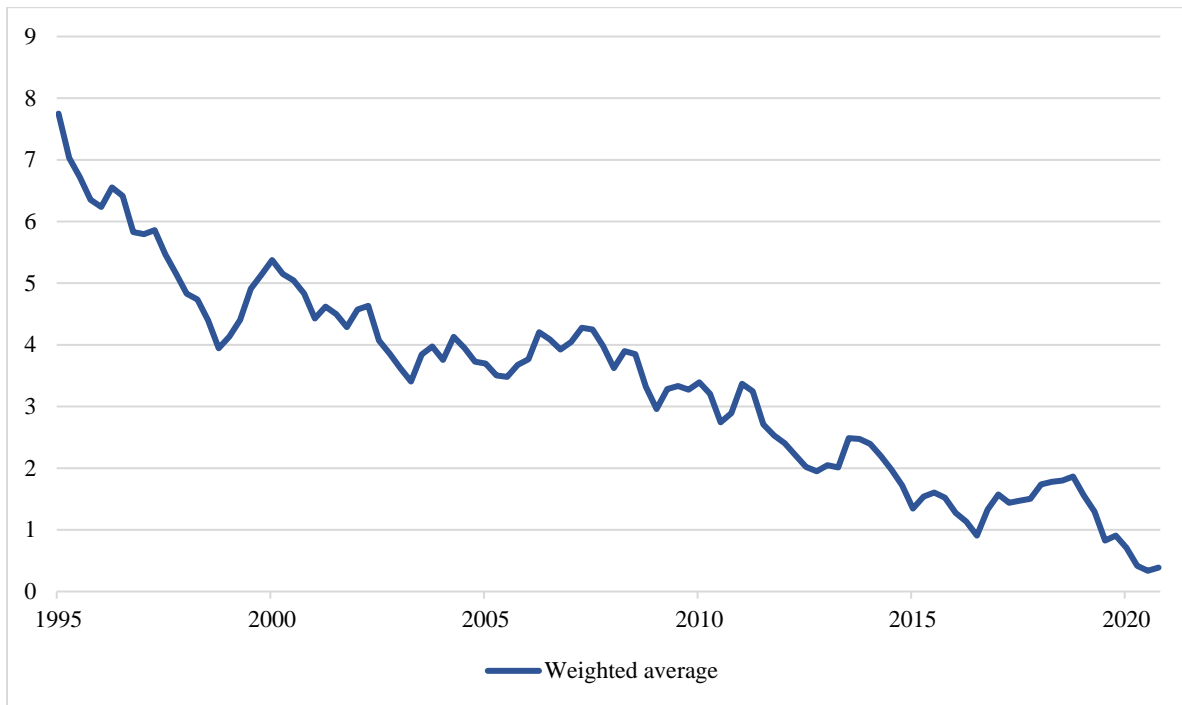
**Figure 2: Treasury Inflation Protected Securities Yield, Constant Maturity**



Source: Board of Governors of the Federal Reserve System (2021).



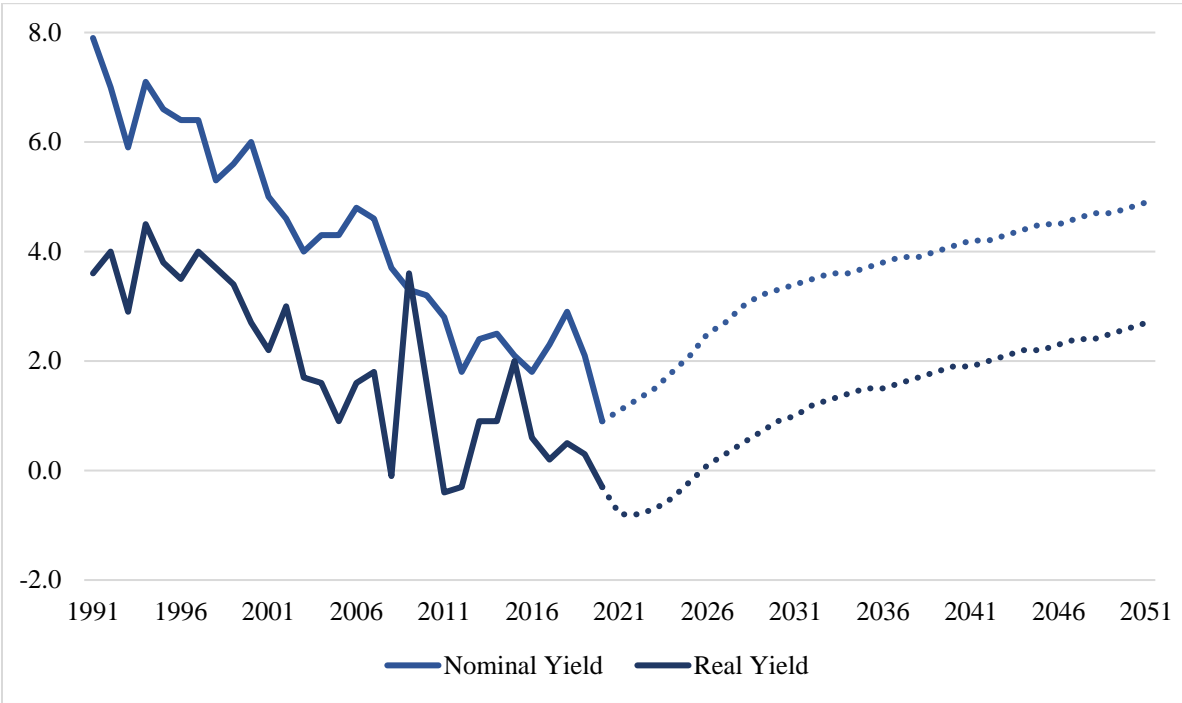
**Figure 3: Nominal Global Long Term Interest Rates**



Source: OECD (2021).

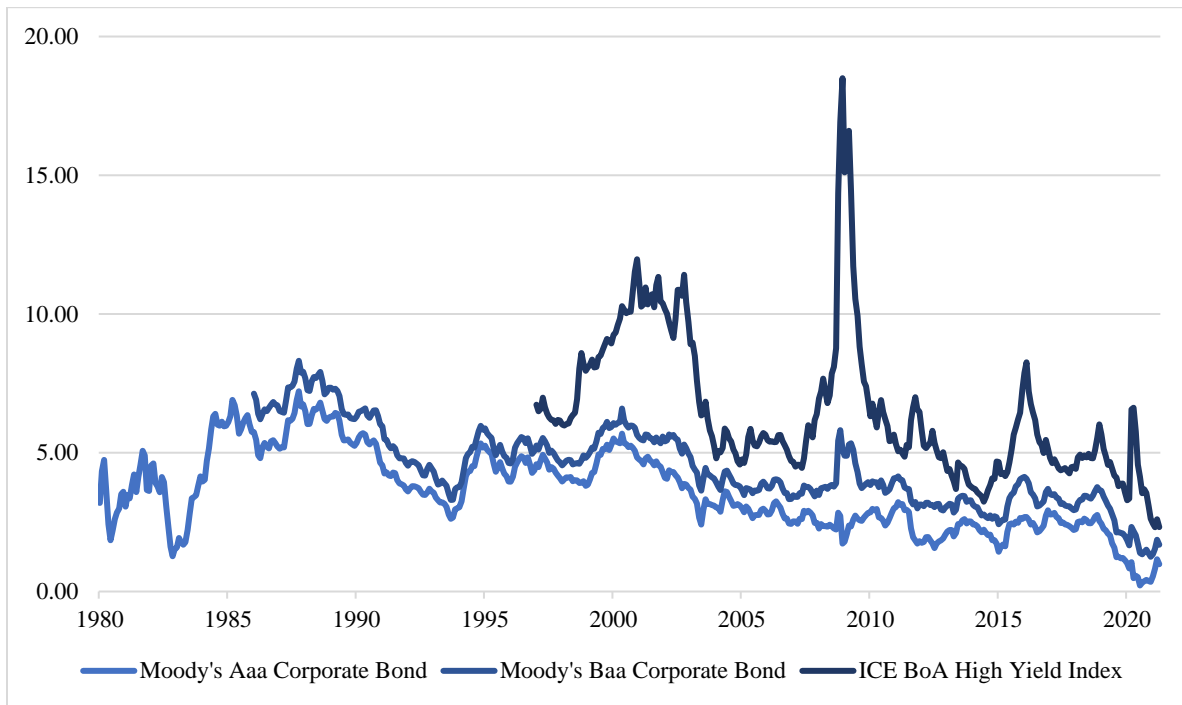
Calculated as a GDP-weighted average of Netherlands, Portugal, Spain, Austria, Italy, UK, Germany, Canada, Japan, France, US, Switzerland, Finland, New Zealand, Sweden, and Australia

**Figure 4: CBO Actual and Projected 10 Year Treasury Yield**



Source: Congressional Budget Office (2021).  
Values for 2021 – 2051 are projected

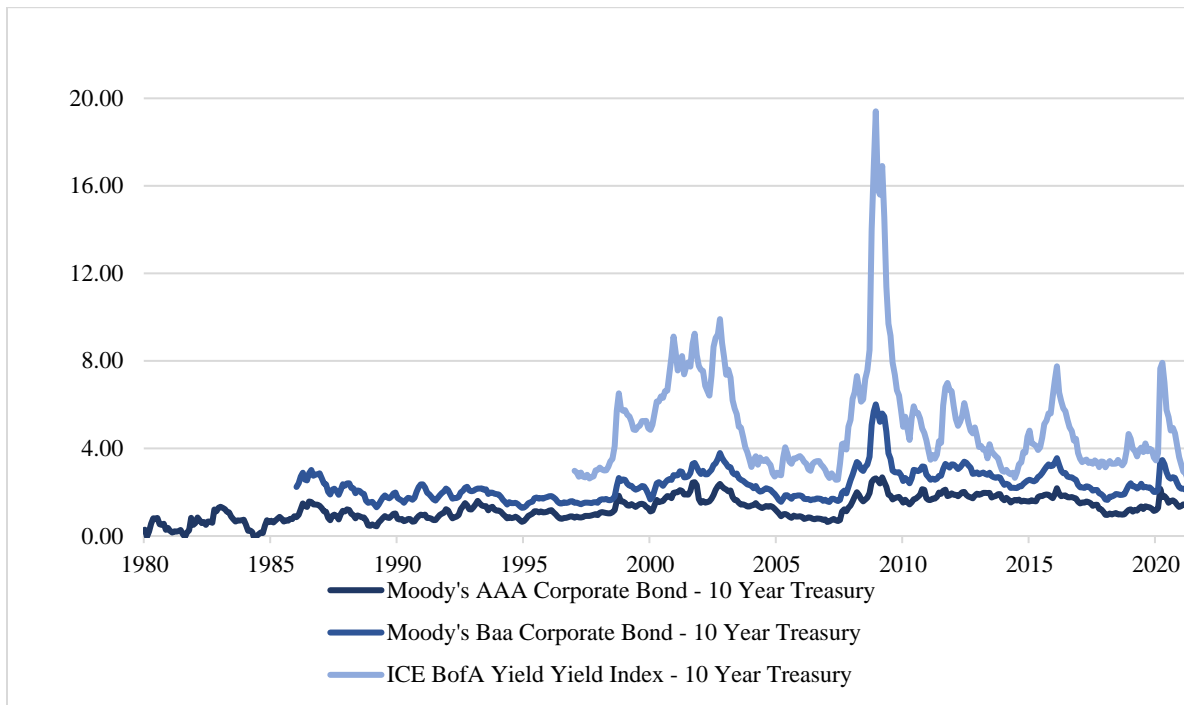
**Figure 5: Real Corporate Bond Yields**



Source: Board of Governors of the Federal Reserve System (2021), Moody's (2021), Ice Data Indices, LLC. (2021), U.S. Bureau of Labor Statistics (2021).

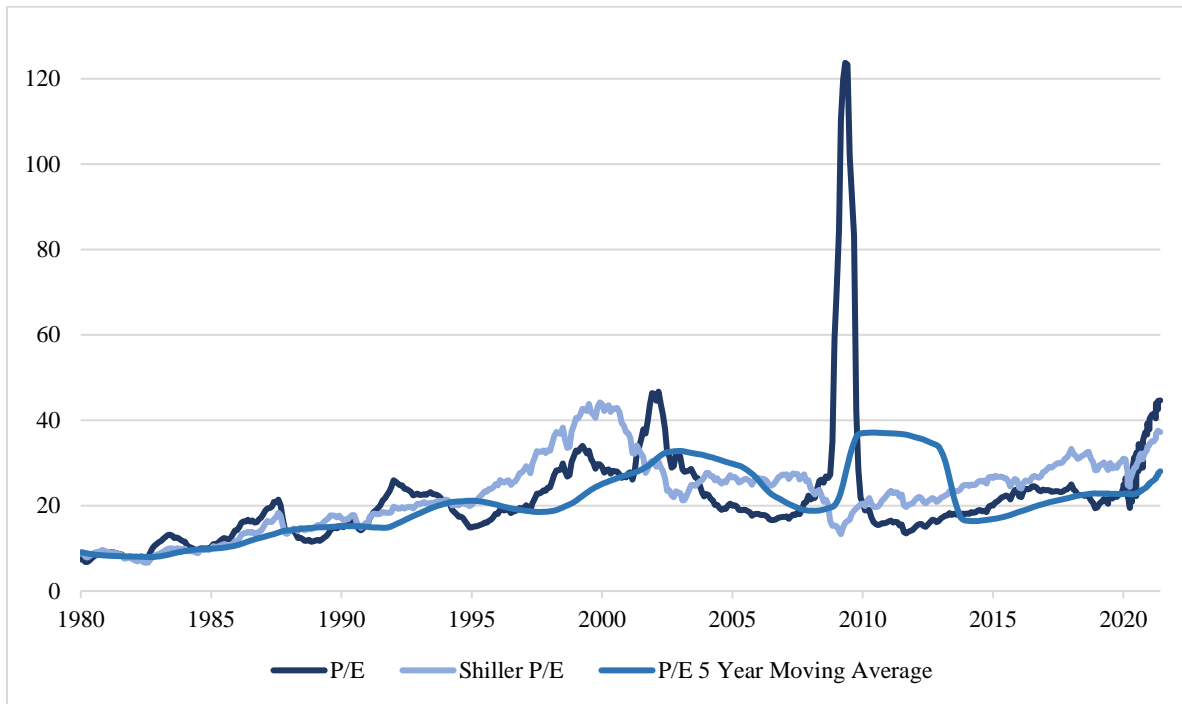
Real yield is calculated using a five-year lagged moving average of CPI-U.

**Figure 6: Corporate Bond Yields Relative to 10 Year Nominal Treasury Yields**



Source: Federal Reserve (2021).

**Figure 7: Price-to-Earnings Ratio for S&P 500**



Source: Quandl

**Table 1. The Long-Run and Efficiency Gains from Adopting a Consumption Tax: Simple Model Simulations**

<u>Simulation</u> <sup>41</sup>	<u>Long Run Output</u>	<u>Percentage Gain In</u>	
		<u>Long Run Welfare</u> <sup>42</sup>	<u>Efficiency</u>
Consumption Tax, Base Case	7.94	3.95	0.55
Consumption Tax, Low Interest Rate	2.77	0.76	0.03
Consumption Tax, Low Interest Rate, Rent <sup>43</sup>	6.42	1.53	0.15
Wage Tax, Base Case	-2.63	-2.78	-1.35
Wage Tax, Low Interest Rate	-0.91	-0.42	-0.14

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<sup>41</sup> Source: Auerbach (2009). All simulations based on the standard Auerbach-Kotlikoff (1987) closed-economy model, starting with an income tax of 25%, except where specified, and no other taxes or national debt. For the base case, preference and production parameters follow the original model's base case assumptions, except that adjustment costs in investment are assumed. For "low interest rate" simulations, the production share of capital is reduced from 0.25 to 0.09, and the rate of time preference are adjusted to hold the initial capital-output ratio fixed while reducing the interest rate to 0.4 times its base case value.

<sup>42</sup> Gains expressed as a percentage of lifetime resources. Long-Run Welfare Gain is gain of generations after the transition is complete. Efficiency Gain is the gain of all generations born post-reform, when lump-sum taxes and transfers are used to neutralize welfare effects of all pre-reform generations.

<sup>43</sup> The presence of rent is simulated by increasing the implicit capital levy, combining a higher rate of consumption tax with a wage subsidy.