A New Long-Run Economic Model Basis for Projecting the Finances of the U.S. Government

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Abstract: In the official models for projections and policy analysis used by the Treasury and the Social Security and Medicare Trustees, many key variables are assumed as a continuation of past trends. Even the Congressional Budget Office (CBO), with more sophisticated models, makes certain simplifying assumptions. By contrast, in our model, these variables are simultaneously determined by supply and demand, based on logical functional forms and parameter estimates from the literature or empirical analysis. This approach better reflects real economic relationships—between health care spending, the federal budget, and investment in capital—and changing underlying conditions, especially demographics. Within the next twenty or so years, we find the federal government debt will grow significantly beyond historical experience and should be regarded as unsustainable. We project that debt-to-GDP will be 126 percent in 2033, 179 percent in 2043, and 256 percent in 2053, compared to CBO's 115 percent in 2033 and 166 percent in 2053. Real interest rates rise in the long run, ratcheting interest payments, deficits, and debt in a vicious cycle. Our projection of national health expenditures relative to GDP in 2073 is 30.2 percent, compared to 28.5 percent by the Centers for Medicare and Medicaid Services (CMS) in its alternative projection. These higher costs of health care arise from labor shortage effects in an aging economy because health care is produced in a low productivity, labor-dependent sector. Health care expenditure increases further deteriorates the federal budget and lowers consumer welfare. We propose that our model serve as the basis for the Trustees Reports and the Financial Report of the U.S. Government.

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Introduction

There are several official medium- and long-range economic and financial projections of various federal programs, economic sectors, and government budgets in the US. The Social Security and Medicare Trustee's Reports project the finances and welfare measures of their respective programs (10- and 75-year projections), based on historical economic, demographic, and social trends. The Treasury Department produces 75-year projections of the federal government budget in the Financial Report of the U.S. Government, based, in part, on information from the Trustees' Reports. The Centers for Medicare and Medicaid Services (CMS) produce projections of national health care spending (10-year and 75-year). The Congressional Budget Office (CBO) produces outlooks for the federal budget (10- and 30-year) and for Social Security (75-year), based on a macroeconomic simulation model with current law and current policy specifications of budget, tax, and program provisions. There are also other domestic and international producers of broad, sectoral, and programmatic projections inside and outside of government. Many of them highlight the important influence of recent demographics, that is, the retirement of the baby boom generation, the falling birth rate, the aging of the population, the significance of net immigration, and the slow growth in the workforce.

These projections serve an important purpose. For many programs, it is difficult, politically and administratively, as well as disruptive to their beneficiaries and the economy, to alter benefits and revenue sources quickly or frequently, even in the face of major societal and economic changes. This is also true for certain economic sectors and the government budget as a whole. Therefore, when designing policy and planning change, it is essential for smooth and efficient operation that a long-range view be adopted to allow for gradual changes and sufficient advance notice. Long-term projections are also essential to evaluate intergenerational equity, and to gauge sustainability.

Crucially, the underlying models should capture consequential relationships with empirically supported assumptions and functions. Yet the official models mentioned above miss important interactions and connections and only consider non-traditional policy instruments with difficulty. The Social Security Trustees produce their projections independently of the federal budget, as if interest rates, economic growth, and other factors important to the finances of the program are unrelated to the state of the larger budget situation (for instance, growing deficits are in part caused by Social Security). They determine these factors mainly by examining long-term historical trends that are the result of past economic conditions quite different from current and expected future ones. They cannot model, in an integrated fashion, sources of revenue outside of payroll taxes, such as taxes on capital income. The Medicare Trustees and researchers at CMS posit some relationship between health care spending and the economy but just in one direction. That is, they project that health care spending is related to incomes and relative prices but do not model that a growing share of the economy devoted to health care could itself have an influence on the rate of overall income growth and the federal budget.

Both the Social Security and Medicare Trustees consider only labor and ignore the role of capital; there is no savings in their models despite the influence savings may have on interest rates, income growth, and consumer welfare, and how savings may be influenced by various factors and policies. The CBO macroeconomic model is more sophisticated because it includes both capital and labor. But it also fails to incorporate the growing and unique role of the production of health care services in the economy. In particular, it does not endogenously model the relative prices of health care – a key variable in the long-run economy and government budget. These considerations are particularly important for budget

projections because current policy now has the federal government financing directly almost half of all health care spending, through Medicare, Medicaid, veterans' benefits, health insurance exchange subsidies, public health and other programs.

Warshawsky (1991/1994, 1999) uses a long-range macroeconomic simulation model with two output sectors, health care and "everything else," and two factors of production, labor and capital, to begin to address this shortcoming in the official projections. As an added feature, consistent with the literature and observations of rapid increases in relative medical prices and health spending as a share of GDP, health care supply results from a function with proportional labor and capital demands and low productivity. The remainder of economic production is modeled, based on a more traditional production function, with substitutability between capital and labor and a moderate rate of labor productivity improvement. Health care demand and labor supply are mainly the result of demographics; income and very modest price elasticities for health care are introduced in the second paper, as was a model of Social Security spending. There was no full federal government sector, however, nor any impact of or on the federal budget or interest rates.

In Mantus, Warshawsky, and Pang (2023), we update to 2021 base data and substantially enhance the basic simultaneous simulation model from Warshawsky (1991) to address these issues. We keep the essential structure, with a 75-year horizon, but add a federal government sector and consider the relationship between the federal budget and interest rates. Parameter values which are not solved for in the model are generally assumed to equal those found in official projections. Other parameter values are set based on current consensus findings in the literature or our own estimates, but key parameters, in particular, health care prices and real interest rates, are solved for in the model, that is, they are the result of economic functions and relationships. Special effort is made to use the most current matrix of health care spending, by age, gender, and sources of payment which, along with CBO demographic projections, is employed to compute annual demand for health care services (see Appendix B for details). This broad modeling effort is reminiscent of the famous Baumol (1967) equations, which demonstrate the implications of sectoral productivity imbalances for economic growth, relative prices, and government budgets in a model of production with labor. Like the growth models of Ngai and Pissarides (2007), we are even more comprehensive and dynamic than Baumol because we consider the role of, and consequences for, capital as well as labor, although our model is more applied and specific. In Warshawsky, Mantus, and Pang (2024), we updated the model to a 2022 base year and focused on the impact of policy changes, and in Warshawsky and Bokhua (2025), we updated the model again to a 2023 base year and made some important changes in assumptions. This paper uses the latter version but emphasizes the methodology we employ in detail, and contrasts to recent official projections.

Our goal in this work is threefold: (1) to improve the foundations, investigate causes, and thereby enhance the accuracy of projections assessing the financial sustainability of major federal government programs, the federal budget, various economic sectors, and consumer welfare, (2) to integrate various strands of projections in related areas into a consistent and logical whole on a methodologically sound basis to move towards a "general theory" via a unified model of key areas and variables, and (3) to allow for more informed and complete analyses of policy changes. We propose that our model serve as the basis for the Trustees Reports and the Financial report of the U.S. Government.

To summarize the results, we find that, within the next fifteen to twenty years, the deficit relative to national income will grow to levels beyond recent large norms. This is without any consideration of

possible severe recessions, wars, financial panics, bailouts of private or public pensions, reparations, or pandemics during that time. In 2033, we project a federal debt-to-GDP ratio of 126 percent versus 112 percent for CBO, and health spending to GDP ratio of 20.5 percent, somewhat higher than CMS. Over the medium-term and especially long-term, our projections show more severe budget outcomes and spending. In 2053, we project debt to be 256 percent of GDP while CBO projects 166 percent, Medicare spending to GDP at 7.9 percent in 2073 while the Trustees project 7.4 percent in an alternative policy projection, and Social Security spending at 7.4 percent of GDP in 2073 compared to the Trustees' 6.3 percent. These projections indicate that current policy is unsustainable.

This dire outlook is mainly driven by rising expenditures on a rapidly aging population, government health programs and interest payments. We forecast higher and rising health care prices, stemming from low productivity and labor shortages in the health care sector in the context of a macro-economy with a labor force growing slowly or not at all. We also project higher real interest rates resulting from growing deficits and debt. This path leads to a notable deterioration in consumer welfare—measured as growth in consumption less health care expenditures—in the long-term, as interest rates, health care spending, and deficits increase in a vicious cycle and households increase savings to partially maintain rates of investment in the economy even as federal debt crowds it out. As we've shown in our other papers, large health and fiscal policy changes are needed to reduce government deficits, improve welfare, and bring debt to sustainable levels.

This unified model produces key outcome variables found in the Social Security and Medicare Trustees' Reports and the Financial Report of the U.S. Government, filling an important gap in their methodologies. Instead of largely siloed and partial projections, we offer an integrated growth model, based on capital and labor, which reflects the interrelationships of these large social programs, the federal budget, the health care sector, and the economy at large. The advantages are to capture and project co-movements. While CBO uses a broadly similar methodology, we posit that it underestimates the unique role of the health care sector in affecting future economic growth and federal budget deterioration.

A Brief History

To provide context, we now give some basic historical measures over the period 1990 to 2023 (or 2024 where available) that are of model and policy relevance.

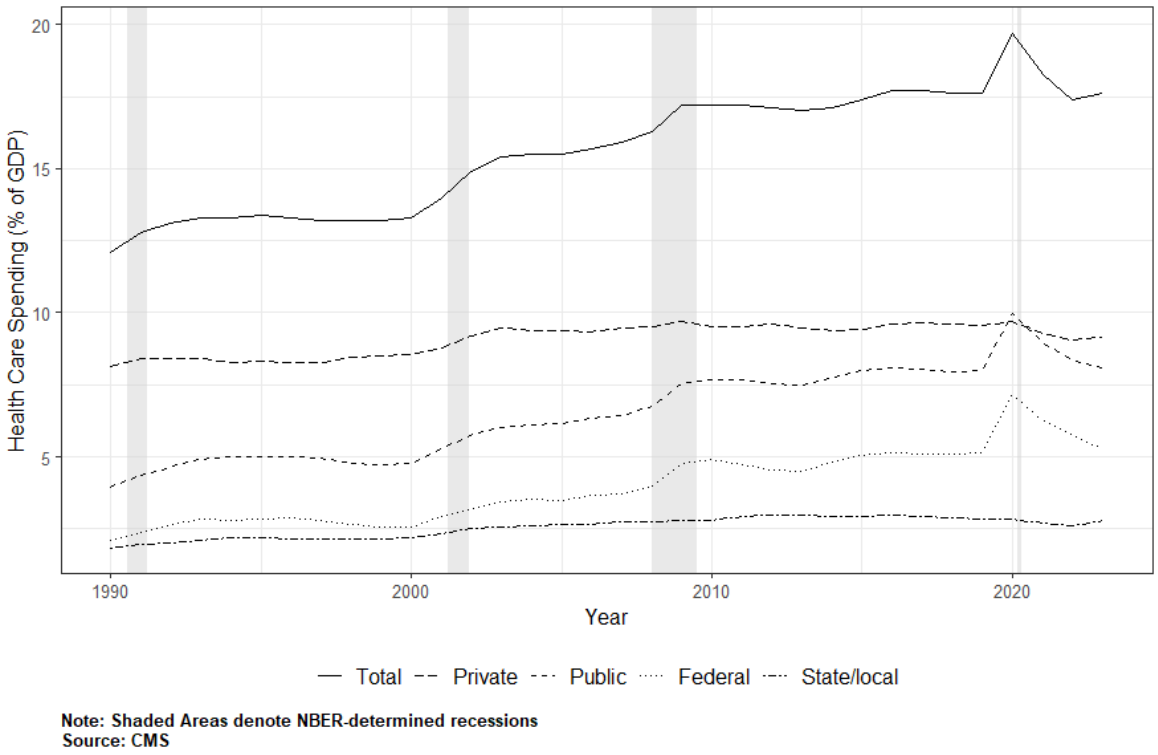


Figure 1-NHE as a share of GDP by Payment Source, 1990-2023

The share of GDP given to health care spending has increased from 12 percent in 1990 to 17.6 percent in 2019 to 19.7 percent in 2020 before falling back to 18.2 percent in 2021 and further to 17.3 percent in 2022, before rising to 17.6 percent in 2023. This large increase happened in waves. Extra spending for the COVID-19 pandemic occurred in 2020 and the share pulled back afterwards, as GDP growth recovered from the 2020 recession and public health spending dropped. Federal government spending increased substantially, from 2 percent in 1990 to 5.6 percent in 2023, as existing programs saw organic growth and new programs were created, like Medicare drug benefits, major Medicaid expansions and subsidies for the health insurance exchanges under the ACA. Private sector spending (employer-sponsored and private insurance and out-of-pocket) grew from about 8 percent of GDP to about 9 percent, while total (federal, state, and local) government spending grew from about 4 to 8.4 percent, which means that the government share of total health care spending increased from a third to almost half. As explained by Skinner, et al. (2022), this increase in total health spending is policy relevant and concerning because “research has demonstrated that nearly all wage and salary increases between 1999 and 2009 for the median-income American worker were absorbed by increases in health care premiums, out-of-pocket expenses, and taxes to fund Medicare and Medicaid, which has resulted in little left over for discretionary purchases or savings.” (p. 710)

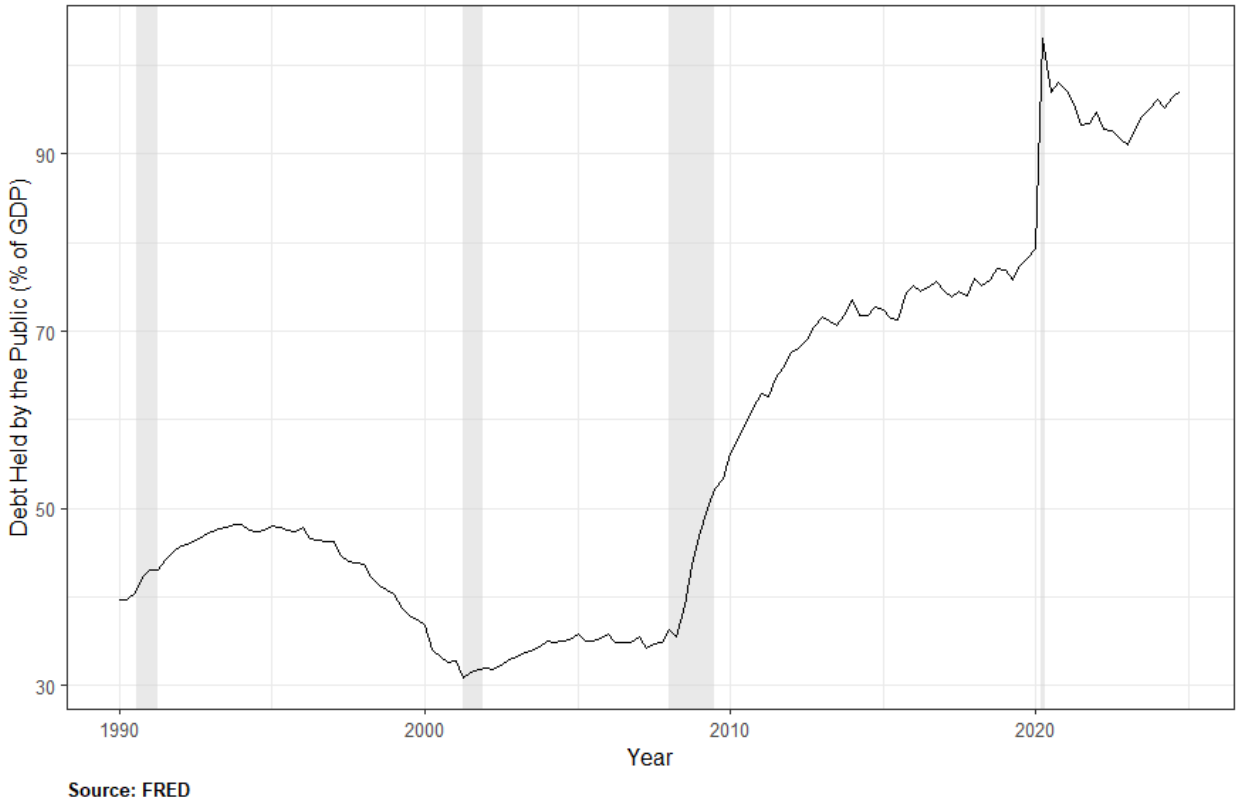


Figure 2 - Year-end Federal Debt as a ratio to GDP, 1990-2024

The ratio of federal debt outstanding held by the public to GDP declined from about 42 percent at the end of 1990 to about 32 percent at the end of 2001, as GDP grew rapidly during that time and federal spending was contained by the Budget Enforcement Act (BEA) of 1990. The BEA was not renewed in 2002, and spending discipline disappeared, and the debt exploded during and following the Great Recession and the pandemic. By first quarter 2020, it had reached 103 percent, a level not seen since the Second World War and total mobilization of the US economy for the global war effort. Despite strong subsequent economic growth, the ratio was nearly 97 percent in 2024.



Figure 3 – Net Federal Interest Payments as a share of GDP, 1990-2024

Part of the reason fiscal discipline was lost is that the cost of debt to the federal budget, as measured by net federal interest payment as a share to GDP, declined with falling debt through 2002, from 3.2 percent in 1991 to about 1.3 percent. It then basically remained at that lower level even as debt exploded, as interest rates fell, especially during and for several years after the Great Recession. The fall of interest rates was caused by many factors, but low inflation, modest economic growth, strong foreign demand for U.S Government bonds, and the considerable easing of monetary policy during the 2008-2009 and 2020 recessions and the incomplete reversal of that easing during the recoveries are particularly important reasons. Most recently, net federal interest spending has exploded with rising debt and interest rates and is now again at an all-time high of 3 percent in 2024. This variable is traditionally a measure of fiscal burden, but it ignores the effect of inflation reducing the real value of debt outstanding. Our model will make that adjustment in this variable and to the deficit.

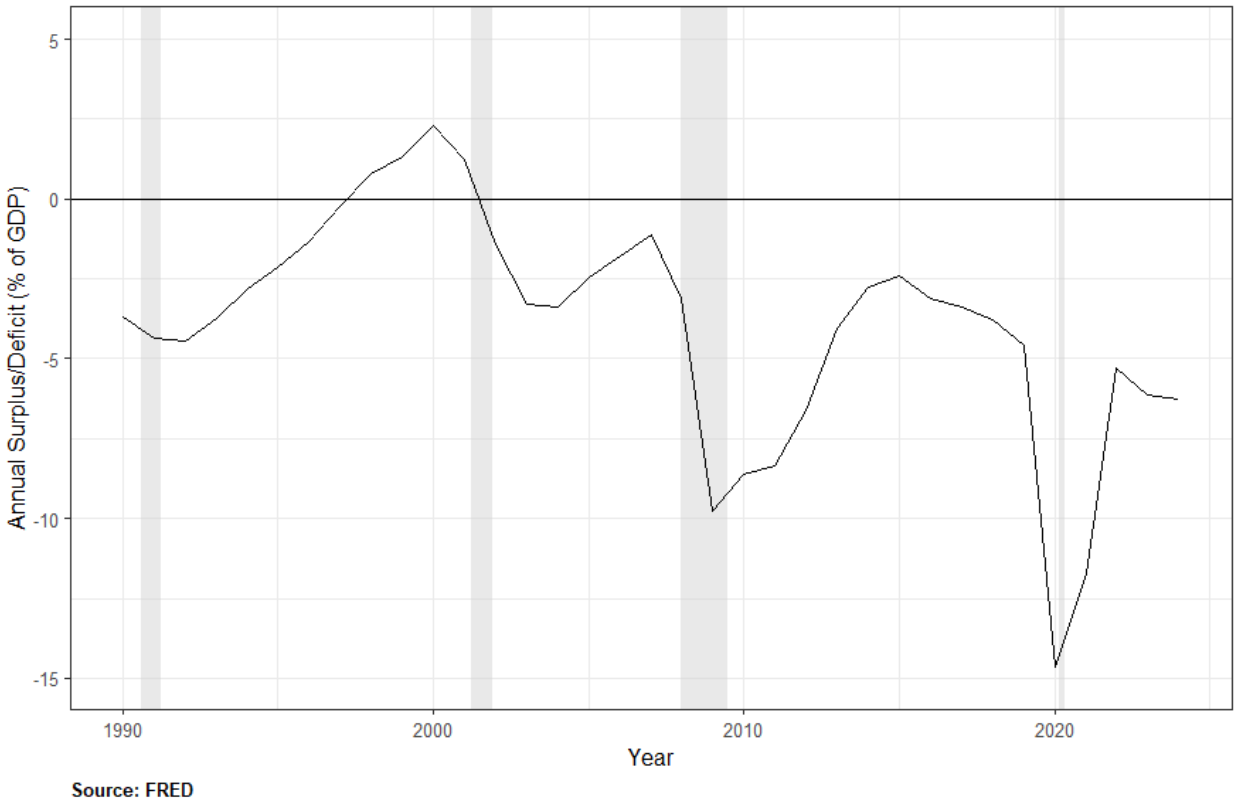
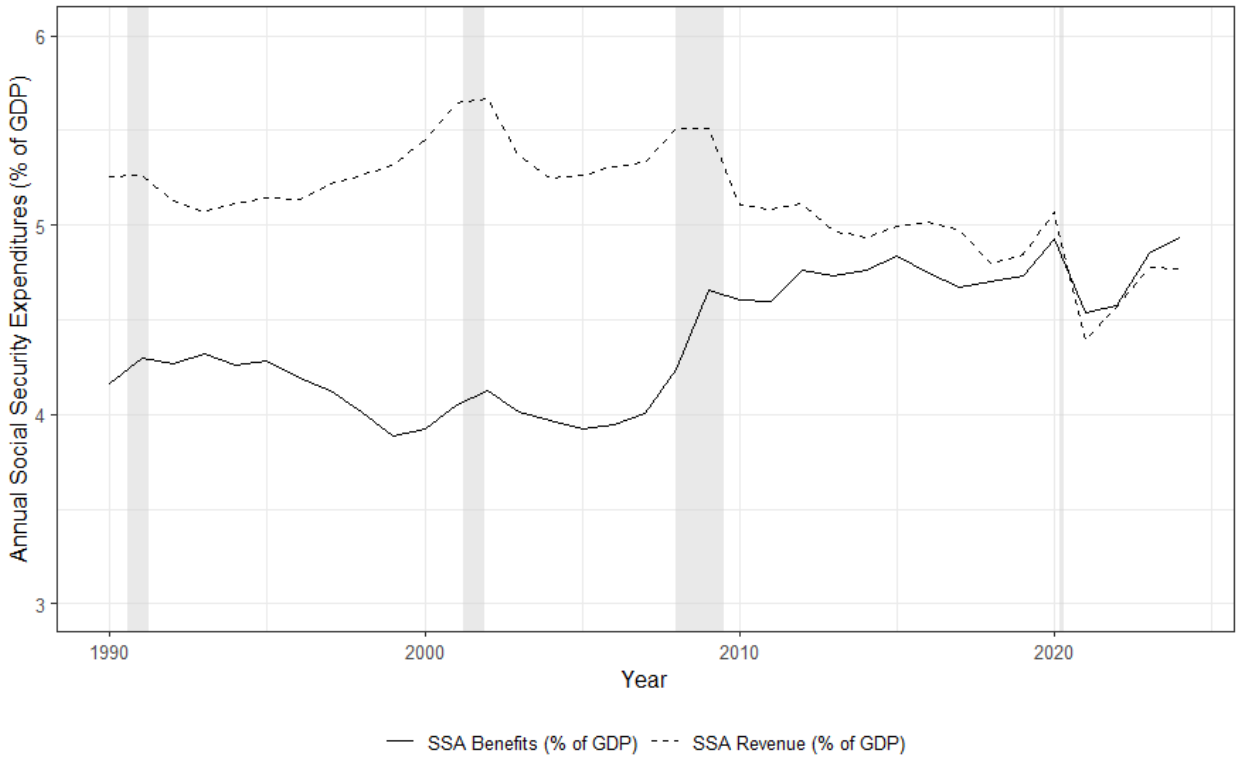


Figure 4 - Federal Budget Surplus (Deficit) as a ratio to GDP, 1990-2024

The loss of fiscal discipline is clearer through the lens of the federal budget surplus (or deficit). In the early 1990s, the deficit was nearly 4.5 percent of GDP, and a blip of surplus of 2.3 percent occurred in 2000 with strong economic growth. Since 2002, there have only been deficits, worsening significantly during recessions. The overall trend, abstracting from the business cycle and booms and busts in tax revenues, is that the deficit as a ratio to GDP is growing larger, most recently to 6.3 percent in 2024 and seems to be moving in the trend line of 6 percent and more.



Source: Social Security Trustees' Report (2024), BEA

Figure 5 - Social Security Expenditures and Revenues as a share of GDP, 1990-2024

Social Security (retirement and disability) expenditures as a share of GDP declined to around 4 percent in the late 1990s with rapid economic growth and favorable demographics. Thereafter, it rose to around 4.9 percent, following the 2008-9 deep recession and a large increase in disability benefits. Despite subsequent economic recovery and growth, and some moderation in disability awards, Social Security spending is now 5.1 percent of GDP with the retirement of the baby boom generation, while program revenues (from payroll taxes and income taxes on benefits) are only 4.7 percent of GDP, and the Trust Fund moves closer to exhaustion.

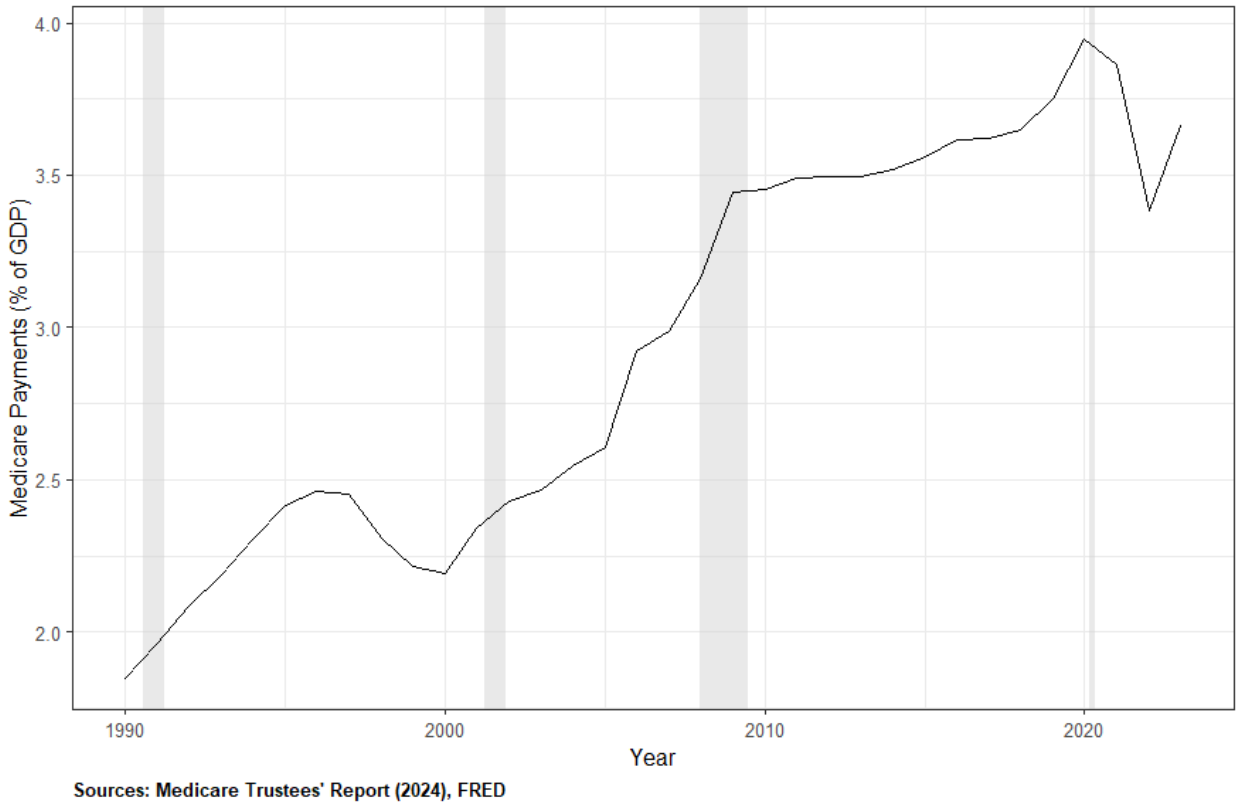


Figure 6 - Medicare Expenditures as a share of GDP, 1990-2023

As another driver of the budget deficit, Medicare spending is growing rapidly, from less than 2 percent of GDP in 1990 to 3.7 percent of GDP by 2023, with a temporary increase in 2020 owing to the pandemic. This trend is due to expansion of the program in terms of the benefits provided and number of enrollees, as well as of steadily increasing medical prices and utilization.

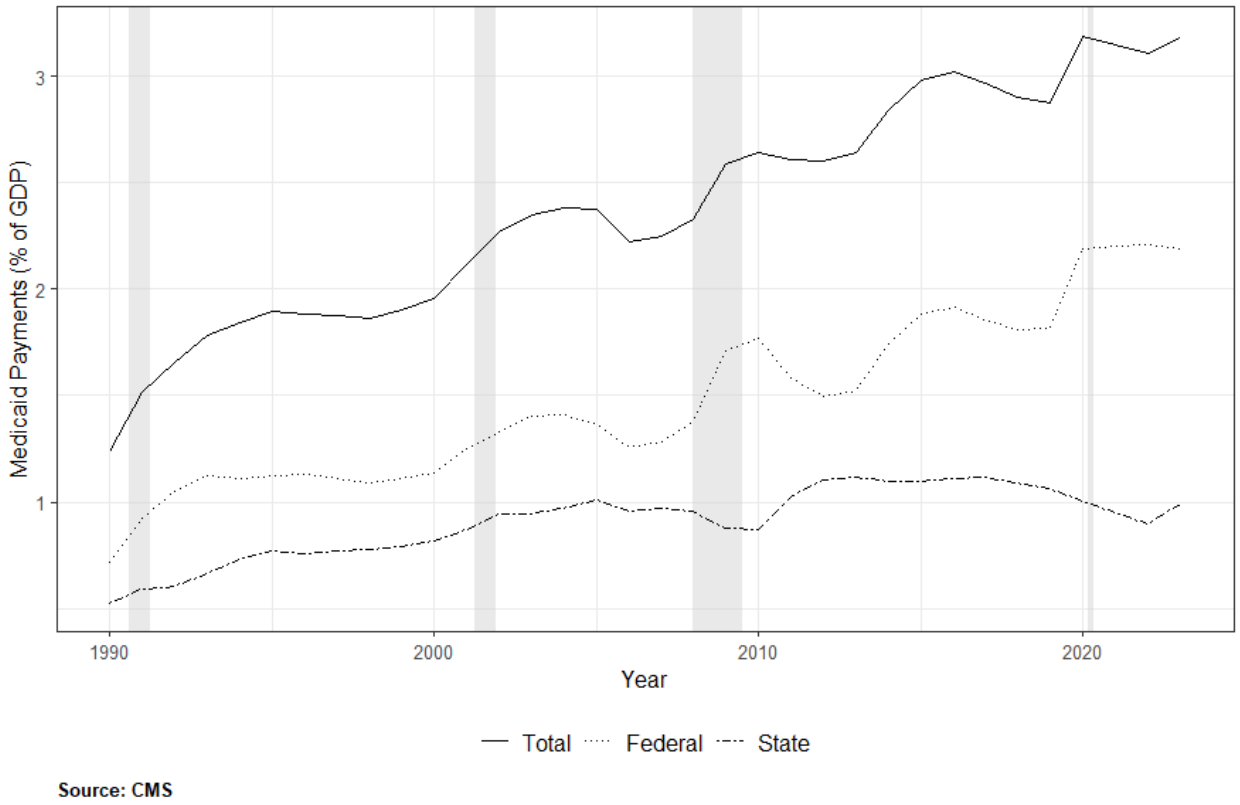
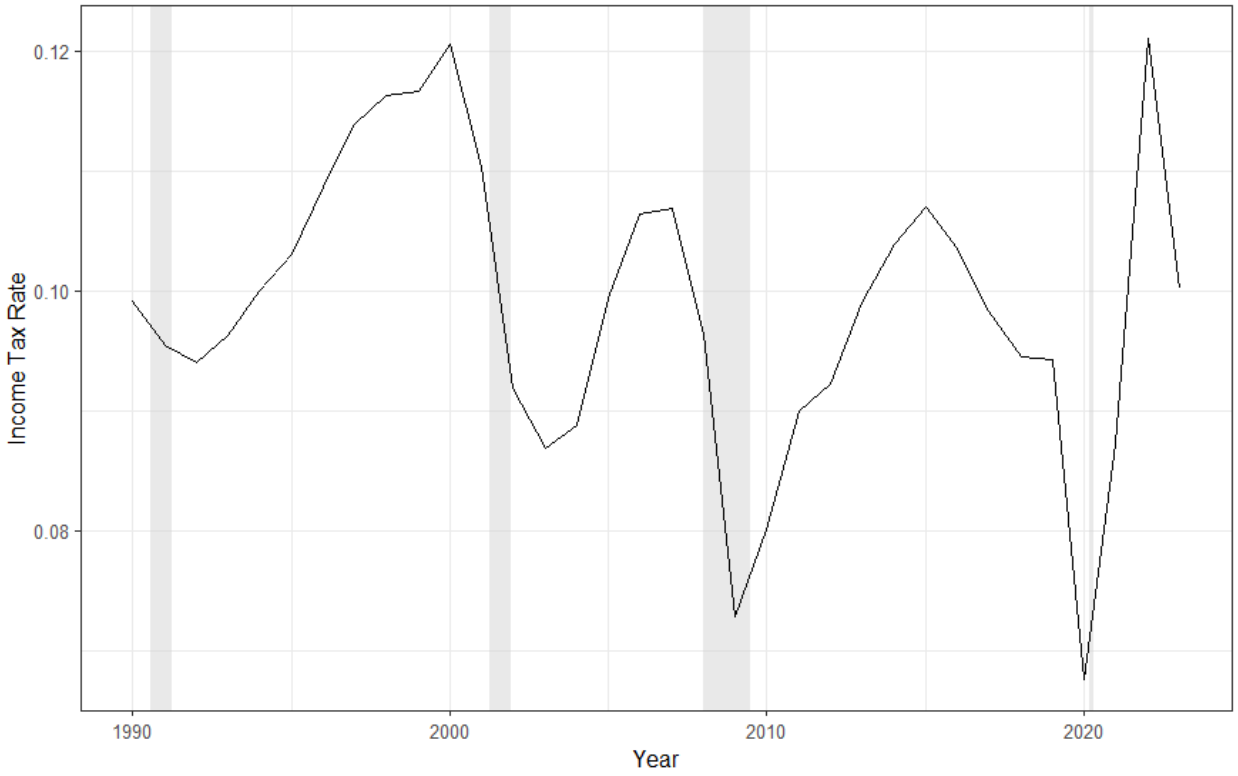


Figure 7 - Medicaid Expenditures as a share of GDP by Source, 1990-2023

Medicaid is another source of budget pressure, for both the federal and state governments. In total, it has increased from 1.25 percent of GDP to 3.1 percent over the 1990-2023 period; the federal share for the program has also increased substantially, from 57 to 67 percent. Growth in the program is due to the same general factors, although not particulars, as for Medicare – natural growth in enrollment, demographic changes (particularly affecting spending for the long-term care benefits for the elderly), increases in medical prices and benefit expansions. For Medicaid especially, significant expansion of benefit eligibility in the ACA and during and following the pandemic, as well as increases in federal cost shares occurred.

According to Edwards (2023), other sources of increases in government spending as a share of GDP over the 2000-2023 period have included veterans (mainly health care), education, refundable tax credits, and food subsidy programs. Federal revenues as a share of GDP do correlate highly with the business cycle and stock market, but generally have not had a noticeable trend, according to Edwards. We confirm that view with our own calculation of parameter τ, defined as the ratio of the sum of personal and corporate income, and other taxes less federal subsidies, to GDP, depicted in Figure 8. In 1990, that ratio was 9.9 percent, in 2023 it was 10.0 percent, averaging 9.9 percent over the period. The impact of the business cycle and stock market is more evident than tax reforms, whether increases or cuts.



Source: Authors

Figure 8 – Ratio of Federal Income Taxes to GDP, 1990-2023

In addition to demographics, the price increases of health care are a major cause of increases in Medicare, Medicaid, health insurance exchange subsidies, and general health care spending and, therefore, budget deficits and debt. From 1990 to 2010, the differential between deflators for personal health care (PHC) and for GDP averaged 1.65 percentage points, but since then, it has shrunk and in some recent years has gone negative, particularly with the rapid general inflation of the early 2020s; over the entire period, the differential averaged 0.7 percentage points. This change in trends is still something of a mystery. Some attribute it to the direct control of prices for most government health care legislated in the ACA, especially for Medicare and Medicaid, and therefore not sustainable in the long-run if health care is not to be rationed or reduced for government beneficiaries. Others attribute the spending slow-down to the spread of high-deductible health plans in the private sector for employer-provided and individual insurance, leading to heightened consumer sensitivity to costs and prices. And yet others think it is a temporary phenomenon, reflecting the lingering effects of the Great Recession and, moreover, does not yet reflect the anti-competitive effects of mergers and increasing concentration among hospitals and physician offices or the introduction of expensive new weight-loss drugs. Over the period 2025 to 2032, CMS (Fiore, et al., 2024) projects that the difference between the annual growth in the deflator for personal health expenditures and for GDP will be 0.6 percent while it estimates it was 0.9 percent in 2024. According to the Medicare Trustees (2024), in their projections based on market demand and not government-imposed constraints, this rate of increase will be 0.75 percent by 2048 before falling to 0.4 percent by 2096. These projected rates of increase are significantly below historical averages.

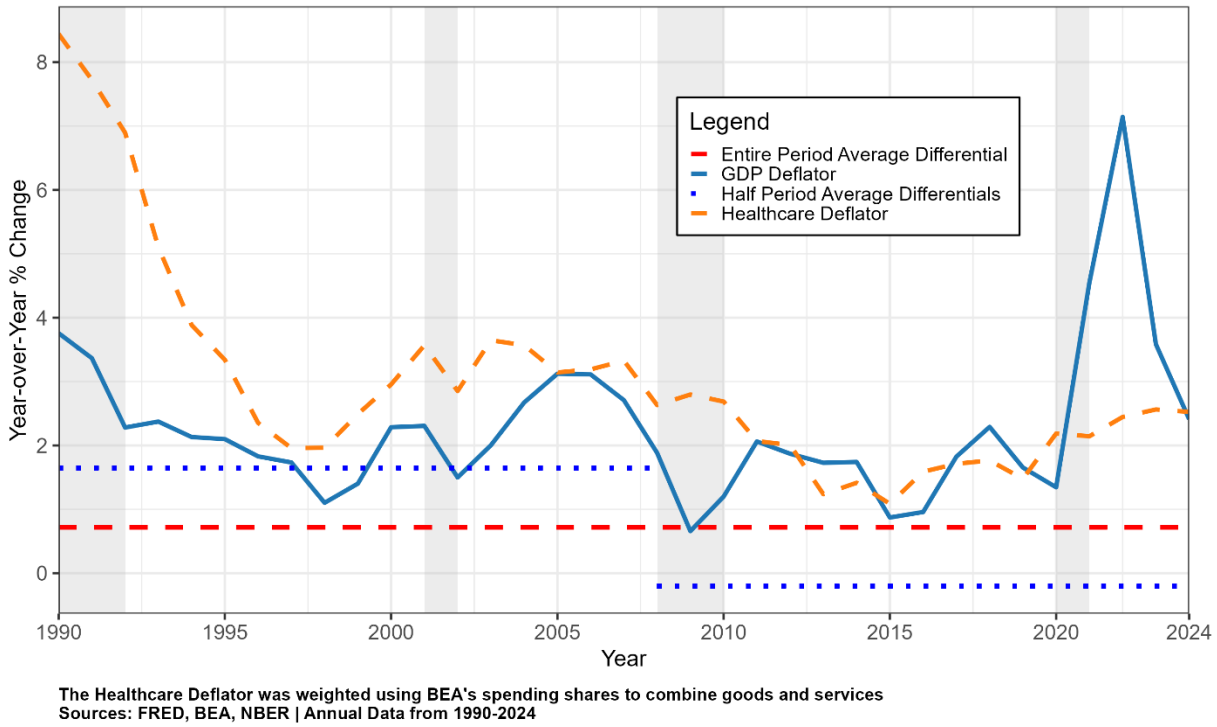


Figure 9 – YoY Change in GDP and Health Care Deflators, 1990-2024

Finally, we measure consumer welfare as the annual rate of growth in real per capita consumption less health care spending. The logic here is that health care, while essential, is mostly viewed as a repairer of ills, and not a direct contributor to human aesthetics, joy, pleasure, satisfaction, nor mainly an investment in improved human productivity. Since 1991, the annual growth rate in this welfare measure has averaged 1.35 percent. It clearly reflects the negative impact of recessions and the dramatic effect of the pandemic when government health care spending rose dramatically while consumer spending dropped and then rose. Ignoring the volatile last two years, the annual rate of growth in real per capita consumption less health care in the last decade has fallen to 1.05 percent.

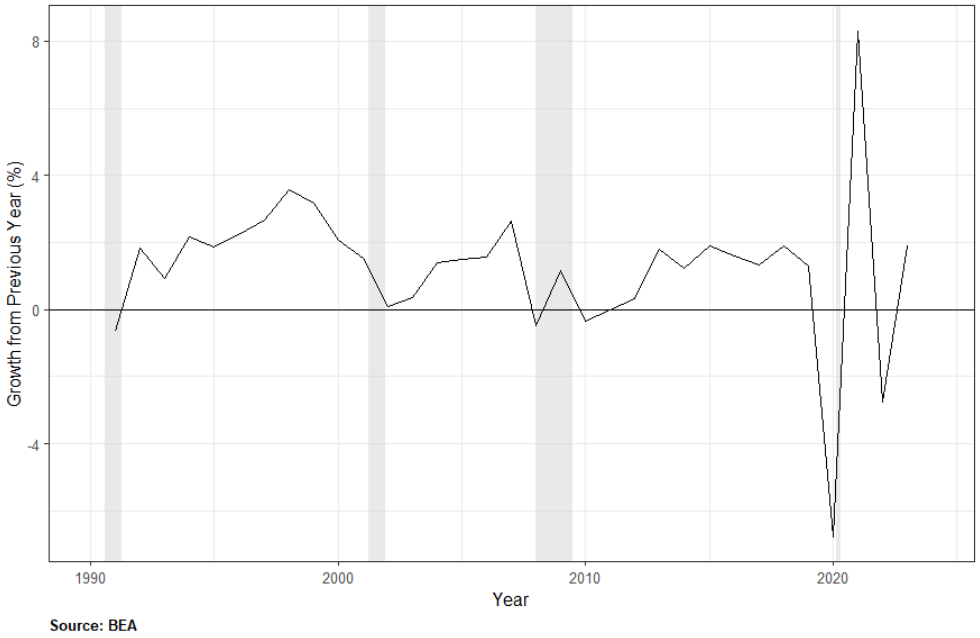


Figure 10. Annual Rate of Growth in Consumer Welfare (Real Per Capita Consumption less Health Care), 1991-2024

Model Development: Structure, Literature Review, Data and Empirical Implementation

The model we design here largely uses a general equilibrium approach in which there are two sectors of production (health care and "everything else") and two factors of production (labor and capital). Output in the rest of the economy ("everything else") is a result of Cobb-Douglas production, that is, there is substitutability of capital and labor (Eq. 1). Health care is produced in a Leontief fashion, that is, the input of labor and capital is in fixed proportions to output (Eq. 2).

$$f_{1t} = \alpha_1 (g_1^t L_{1t})^{1-\beta_1} (K_{1t})^{\beta_1}, \quad (1)$$

$$f_{2t} = min(\frac{L_{2t} g_2^t}{\beta_2}, \frac{K_{2t}}{\beta_3}). \quad (2)$$

Where L indicates labor and K capital employed in the economy, α_1a free parameter to calibrate the model and match the real economy, g_1 improvement in labor productivity in "everything else," g_2 improvement in labor productivity in health care, β_1 capital share in production, β_2 fixed proportion of labor in health care production, β_3 fixed proportion of capital in health care production. The overall economy (gross domestic product, GDP) is the sum of the two sectors, with p_t being the relative price of health care, defined below:

$$Y_t = f_{1t} + p_t f_{2t}. \quad (3)$$

Dynamic changes occur in both sectors in the form of modest labor productivity improvement in the health care sector, g_2, and more significant labor-augmenting technical change in the rest of the economy, g_1. Expenditures on health care are mainly dependent on demographics, with health spending (including long-term services and supports) increasing rapidly with age and generally higher for women than for men. But it also is sensitive to income and, to a lesser extent, relative prices; the specific elasticities used will be explained below.

Investment, with depreciation and initial conditions, determines the amount of capital accumulated in the economy; it is a constant proportion of income, but is also related to the deficit because there is crowd-out although domestic saving increases somewhat, as explained below. Aggregate labor supply is a function of demographic and sociological factors like the labor force participation rates by age and gender; we do not model government policy increasing or decreasing labor resources. Labor and capital are supplied to the health care sector, as determined by the production requirements and the demand for spending, with the remainder going to "everything else," which determines production in the rest of the economy, parceled out, in turn, to government spending and other consumption. Returns to labor and capital are equalized across the two production sectors but are determined in the larger sector ("everything else") by first order conditions, as in Baumol (1967).

We also model a federal government sector. It does some modest amount of investment, but mainly consumes, redistributes, taxes, borrows, and pays interest. Government consumption is the sum of defense spending, as a fixed percentage of GDP, and non-defense spending, related to the size of the population. Personal and corporate income taxes are proportional to income, rising taxes on Social Security benefits are proportional to those benefits, Medicare premiums are proportional to those benefits, and payroll taxes are proportional to earnings. Redistribution includes Social Security benefits and government health care benefits. The deficit is government spending less taxes and premiums plus redistribution and interest payments on outstanding public debt. We use assumptions from CBO research about the direct effect of deficits on investment and savings, detailed below. As deficits rise, growth in capital stock slows, causing relatively higher interest rates. As interest rates rise, federal interest spending rises, increasing deficits. Higher deficits increase interest rates and federal debt, causing increased interest spending. These relationships are a key driver of our projected deterioration in federal finances, as shown below.

For "everything else" production in the Cobb-Douglas function we assume labor-augmenting technical progress is occurring at an annual rate of 1.8 percent. CBO (2022) measures labor productivity (adjusted for business cycle effects) for the overall economy at 1.2 percent annual growth over the period 2008 to 2021, and 1.4 percent for the nonfarm business sector, and projects it to be 1.5 percent and 1.8 percent, respectively, for the next ten years. Given that we separate out the growing but low-productivity health care sector from the overall economy, we take the higher statistic for the non-farm business sector, which excludes the non-profit and government producers more common in health care supply. The Social Security Trustees (2024) project 1.63 and 2.0 percent productivity growth over the next 75 years for the total economy and nonfarm business sector, respectively. These higher numbers seem unwarranted given the more modest performance of the economy in the last fifteen years. Labor's share of all other input is assumed to be 0.63, an important parameter in the Cobb-Douglas function. This is the value currently used by CBO researchers and is close to that found in the empirical literature (see Ohanian (2021)), although the FRB/US model employed at the Federal Reserve Board for forecasting and the analysis of macroeconomic issues uses 72.5 percent.

Leontief production for health care services can be justified on logical grounds. Structures, equipment and software, consistent with the state of medical knowledge and technology, are used by health care workers – physicians, dentists, nurses, therapists, physician assistants, physician office and hospital staff, and others, to produce health care services. Although some limited substitutability may be possible (for example, more software instead of billing clerks), in its essence, health care remains a service where diagnosis, procedures, and, especially care, must be provided by trained, experienced, and empathetic people. This is almost entirely so in some of the subsectors, such as nursing homes and home care, where services are generally quite low-tech and hands-on. It is also true for cutting-edge hospital procedures, where the use of new technology is mostly in addition to, not instead of, labor services of physicians and nurses and orderlies. As econometric evidence, Cowing and Holtmann (1983) on short-stay hospitals finds a limited degree of substitutability among different types of labor, to say nothing of capital. Weisbrod (1991) documents the history of the introduction of different types of new capital technologies and claims that, for the most part, they were not labor-saving devices, and that they increased costs and the relative price of health care services.

Other more recent evidence is consistent with an important role for Baumol's cost disease (low productivity change) in explaining rapid growth in health care expenditures. Colombier (2017) and Hartwig (2011) both estimate pooled regressions using OECD cross-country panel data with wage-manufacturing productivity differentials and relative prices, respectively, as independent cost disease variables. They find that the coefficients on the relevant variables are significant and large, that is, the increase in relative health care prices originates from productivity differentials.

The technological change in health care, although it may sometimes improve health outcomes, increases costs. Smith, et al. (2000) estimate that about half of the growth in real per capita health care costs is attributable to the introduction and diffusion of new medical technology. Chandra and Skinner (2011) find that while there have been cost-reducing innovations in the distant past, such as polio vaccines replacing the need for iron lungs, in the US, the opposite – expensive technologies with small health benefits and no substitution for labor– has been much more common. Widespread and unfocused use of angioplasties, imaging technologies, arthroscopic surgeries for knees, proton-beam therapy for prostate cancer, and other technologies and procedures are given as examples. Agree at al. (2005) find that the use of assistance technology supplements, not substitutes for, formal nursing and home care services.

Another model in the literature broadly similar to ours is Borger, et al. (2008). Focusing just on long-run health care spending and Medicare projections, the authors use a general equilibrium model which develops the parameters in the consumer demand for health, emphasizing the role of medical technology developments. They do not, however, consider differential productivity trends for the health care and "all other" sectors, nor do they say much about government budgets or produce endogenous interest rate, economic growth, and welfare results. They estimate an initially faster but eventually slower rate of increase in health care spending than official projections and medical expenditure growth slows and approaches the rate of income growth in the long-run. Hall and Jones (2007) derive a diminishing marginal utility of non-health consumption and a rising value of life which causes society to increase spending on life extension, which in turn is assumed to be produced by health care spending. Based on their estimates, the health share of GDP reaches 33 percent by mid-century. In a simpler modeling exercise, Fogel (2008) finds that an income elasticity for health services of 1.6, estimated over a century of data, outweighs an accelerating decline in the prevalence of chronic diseases and that

spending increases are also bolstered by the aging of the population. This leads to a projection of an increase in the health care spending to GDP ratio to 29 percent by 2040.

There is a large empirical literature on the elasticity of substitution in production functions for industries and in aggregate for the US and other countries. The extreme cases are Leontief, where the constant elasticity of substitution (CES) is zero, Cobb-Douglas, where the CES is one, and von Neuman, where the CES is infinite (meaning either all capital or all labor are equally able to produce output). In one recent meta-regression analysis for the whole US economy, Knoblach et al. (2020) found a long-run meta-elasticity in the range of 0.45-0.87, below Cobb-Douglas' unity. Focusing on specific sectors, Antoszewski (2019) finds for the global health care sector over the 1995-2011 period and 40 countries that the CES between labor and capital was 0.118, not far from Leontief. Given that we are modeling the US economy as composed of two sectors, and one is Leontief, the other can be Cobb-Douglas and the whole economy can still have a CES close to, but below, one, as shown in Knoblach and Stockl (2019).

Even though we posit there is little scope for substitution of capital for labor in the health care sector, at least as a prudent modeling assumption, it is still possible for there to be modest labor productivity improvements, originating from, say, better labor management or more educated workers. We assume that labor productivity in the overall health care sector increases 0.4 percent annually, based on the results of various studies that hospital productivity increased 0.4 percent in the past, physicians' offices 1.0 percent, and all other provider categories such as nursing homes, home care, and hospices saw no productivity improvements. In particular, Chansky et. al. (2015) estimate that from 1993 to 2012 hospital labor productivity increased 0.5 percent annually, although extending their methods and data to 2018, the Bureau of Labor Statistics (BLS) (2021) finds a compound growth rate of only 0.3 percent, as recent experience is either negative or quite poor. Fisher (2008) estimates that for physicians' offices, annual multifactor productivity growth was 0.8 percent over the period 1983 to 2004. This metric is the percentage change in real outputs not explained by the percentage change in real inputs, which is generally higher than labor productivity growth alone.

The amount of labor input used in the production of health care services is estimated from 2023 BLS data. Hours worked in the health care sector are about 31.8 billion hours, computed as the product of average weekly hours worked, the number of health care employees, and 52 weeks. The ratio of health care expenditures to this estimate of hours worked for 2023 is used as the parameter value for the fixed proportion of labor in the production function. As a share of total hours worked in the economy, the health care sector takes around 11%, about 60 percent of its spending share.

The capital used to produce health care services is estimated using the Bureau of Economic Analysis (BEA) accounts for fixed reproducible wealth in 2023. The aggregate net capital stock (current cost) in the health care sector totals $3.0 trillion and is composed of equipment, buildings, and software categorized by the BEA as capital in ambulatory care, hospitals, social assistance, and government health care. Some other categories are also included, specifically real estate rented to the health care sector and also that which is owned by higher education institutions (medical schools and university hospitals). This produces a ratio of output to capital for health care of 1.6.

We have defined the health care sector fairly narrowly as those subsectors – physicians' offices, hospitals, dentists, nursing homes and home health care and social services, for-profit, non-profit and governmental – most directly involved in providing services to the population. One could extend the definition yet further to the developers and manufacturers of pharmaceuticals and medical devices and

equipment, and even to the marketing of health insurance and collection of premiums, pharmacy sales, general government administration, employers' health centers, auditing services, marketing and so on down the supply chain to get value added and labor requirements, as Werling, et. al. (2014) have done in a full input-output analysis based on the Inforum Long-Term Interindustry Forecasting Tool. In particular, they find that employment in health care is higher as a share of total employment, even greater than the health care share of GDP, than in traditional analyses, when this expansive view is taken.

Although our approach is in the spirit of this style of analysis, with an emphasis on the supply side of health care in fixed factor proportions, we decided to avoid its particular detail for several reasons. First, we do not have access to the substantial industry and interindustry matrix of data and parameters needed. Second, we do not believe that many of these particular auxiliary health care industries are best modeled with Leontief production functions, especially in the long-run and particularly for insurance and retail trade. Third, we think that more aggregation makes better sense when doing long-term analysis because industries, inputs, products and services are known to change, disappear and appear over lengthy time periods. Fourth, although any modeling effort, including ours, involves the use of sometimes incomplete data and many assumptions, we are cautious of such detailed use in large input-output analyses over a long period for analysis. Finally, a more complex model comes across as more of a black box and can make it more difficult to understand cause and effect.

Aggregate output of the "everything else" sector is the result of the deployment of capital and labor not used in the health care sector. The initial level of the total net capital stock at current cost in 2023 is $85.9 trillion, according to the BEA. This is made up of private and public fixed assets, including equipment, structures, and intellectual property products as well as residences at current cost, but not consumer durable goods. The next year's aggregate capital stock in the model is the sum of gross investment and the prior year's capital stock, less deprecation. Depreciation occurs at an annual rate of 5.4 percent, which roughly corresponds to the average in recent years across various categories of equipment, buildings, software, vehicles and other items used in production of output, according to Lasky (2022). Gross investment is assumed initially to be a fixed percentage of income – 21.3 percent – representing the rate of private and public gross investment observed in the last twenty-five years over the business cycle. Public investment includes federal, state and local government expenditures on construction and durable goods. Private investment includes construction of residential buildings as a rental equivalent. In subsequent years, the investment share changes with the government budget deficit, as we will explain.

The aggregate labor force, measured as hours worked, is a multiplicative function of population demographics, labor force participation, unemployment rates by age and gender, and the average hours worked per week. Labor force participation rates are those used in CBO (June 2023) while unemployment rates are 2000-2024 averages by age group and gender, which includes recessions and expansions. We assume an annual decrease of 0.05 percent in average hours worked, as used by the Trustees, even though recent experience is a steeper decline at -.2 percent. The projection of US population demographics, used here and in the demand function for health care spending, is the most recent projection produced by CBO (January 2025), which has a lower birth rate (1.6 children per woman) than the Trustees (1.9), more consistent with the actual experience – a decline to 1.65 children per woman in the last fifteen years. In particular, the age dependency ratio, that is, the number of people 65 and older divided by the number of people aged 20 to 64 increases from .307 in 2023 to .538

at the end of the 75-year period. This is in contrast to the Trustees' projection of .453. The total population increases from 342 to 365 million over the period. The annual labor force growth rate is quite slow, even dropping below zero in 2055 and declining to -0.24% annually by the end of the period. According to CBO, by 2033, with the aging of the population, deaths exceed births. As a result, population growth after that point is driven entirely by net immigration, which can be thought of as the result of a complex mix of policy, enforcement, economics, and geopolitical factors.

First order conditions in the "everything else" sector determine the wage level and cost of capital for the entire economy, and the relative price of health care, as shown below. Details can be found in Appendix A.

$$(1-\beta_1)\alpha_1 g_1^t \left[\frac{K_t-\widehat{K_{2t}}}{g_1^t(L_t-\widehat{L_{2t}})}\right]^{\beta_1} = w_t, \quad (3)$$

$$\beta_1\alpha_1 \left[\frac{K_t-\widehat{K_{2t}}}{g_1^t(L_t-\widehat{L_{2t}})}\right]^{\beta_1-1} = r_t, \quad (4)$$

$$p_t = \frac{A_t}{\widehat{f_{2t}}}, \quad (5)$$

where

$$A_t = \alpha_1(g_1^t(1-\beta_1)(B_t)^{\beta_1}L_t + \beta_1(B_t)^{\beta_1-1}K_t - (B_t)^{\beta_1}(g_1^t(L_t-\widehat{L_{2t}}))),$$

and

$$B_t = \frac{(K_t-\widehat{K_{2t}})}{\left(g_1^t(L_t-\widehat{L_{2t}})\right)}.$$

In addition, following CBO (see Huntley (2014)), we adjust consumption and investment for the impact of the federal budget deficits. We use the central estimates produced by CBO for the first thirty years of the model simulations, that is, in response to each additional dollar's increase in the federal deficit, private saving increases by 55 cents while domestic investment decreases 33 cents, implying a 12-cent increase in net capital inflow from abroad. In our model, this is roughly equivalent to a one basis point increase in the real interest rate for every one percentage point increase in debt-to-GDP over the first three decades of the model, which is on the low-side of reduced-form estimates in the literature (see Mantus and Warshawsky (2022)). We then assume that these savings effects transition over twenty years to the more optimistic CBO assumptions of 61/15 cents for savings increase/investment decline.

The federal government pays interest on the debt at a lower rate than the market cost of capital, that is, it is reduced by a capital risk premium because government debt is regarded by the domestic and international market as low risk with a first claim on the economy's resources. According to market statistics at the Treasury Department, the real long-term interest rate on 10-year Treasury Inflation-Protected Securities (TIPS) was 2.0 percent in February 2025. This is somewhat higher than the historical average over the period since 2000 of about 1.5 percent. Because TIPS consistently make up less than 10 percent of Treasury debt outstanding, we need to add an inflation risk premium to the average historical TIPS yield to get a relevant real long-term government interest rate. There is a large empirical literature estimating the inflation risk premium in the US and in other national markets. Although sometimes, like deflationary periods and in financial panics, the premium is negative, in most times and in most studies, it is positive, often large. According to Kupfer (2018), a comprehensive survey of many studies covering the period 2000 to 2017, subsequently updated by the authors through 2022, the average inflation risk

premium was 0.3 percent, which we add to the 2.0 percent current rate to produce an initial estimate of the real government interest rate of 2.3 percent. We do not model a yield curve.

The model's first year result of the real cost of capital is about 9.8 percent.[1] This implies a capital risk premium of about 7.5 percentage points, which we use as a fixed parameter in our model. This measure of the risk premium is towards the higher end of the current financial literature including recent estimates of the equity risk premium of 4 to 5 percent in Siegel and McCaffrey (2023), but is still plausible given that we include small business and housing capital in our measure of capital which presumably have a higher rate of return than the lower risk corporate sector.

Aggregate output, which equals gross domestic product and income, is divided among three items, as in the classic macroeconomic equation: consumption, investment plus government spending. We explained the determinants of investment above. Consumption is composed of health care spending and everything else. Health care spending demand is a function of demographics, income, and relative prices. We eschew short- and medium-term add-on factors for health care utilization, as have been used in past modeling by us and CMS for temporary business cycle effects. Based on CMS' recent release of official spending profiles by age and gender in select past years, we produce an age and gender and source of payment profile matrix for health care spending demand. A complete explanation of this effort can be found in Appendix B.

Broadly consistent with the assumptions used by CMS in the Medicare Trustees' Report (2024) and its annual projections of health care spending, which in turn is based on an extensive literature review and expert panel opinion, we assume that health spending initially has a positive elasticity of 1.2, declining to 0.9, with respect to income, and a negative elasticity -0.5, declining to -0.56, with respect to relative prices. Specifically, broadly consistent with (but somewhat more optimistic than) CMS methodologies, the price elasticity decreases linearly over the initial ten years and then remains constant, and the income elasticity declines linearly by 0.1 over the first ten years, another 0.1 over the next 15, and another 0.1 in the following 25 years before remaining constant at 0.9. Finally, total health care spending is multiplied by the relative price of that year. Although the government sometimes pays less than market prices for health care provided by its programs, especially in Medicaid and recently in Medicare, in the long run these discounts are not sustainable if services are to be given equivalent to the private sector, as explained in the Medicare Trustees' Report alternative results section. Indeed, as Layton et al. (2020) show empirically, there is a trade-off between program cost and quality.

Consumption is personal consumption expenditures, exports less imports, and state and local government spending. We generally define government spending as just that which is done by the federal government. We set the state government share for Medicaid spending at 41 percent, the recent average, of total Medicaid spending and exclude it from the federal budget. Federal government spending includes defense, fixed at 3.6 percent of GDP, and all other non-defense spending, excluding redistribution and interest payments. Our assumption about defense spending reflects recent experience and discussions, especially the growing threat of conflict with China. Implicitly we assume that there are no actual major wars or other emergencies and contingencies and that there is some limited substitutability between capital (e.g., smart bombs and drones) and labor (trained soldiers and

[1] This is roughly similar to Poterba (1997) who finds that over the period 1954 to 1996 the pretax return on capital in the nonfinancial corporate sector averaged 8.5 percent nominal, based on periods when the labor share was higher than now.

sailors) and some productivity growth in the production of defense. This results in spending at a steady, but not increasing, share of income. The non-defense spending is a fixed real amount in 2023 per person and thereafter increases with population growth. We implicitly assume that services to the public can reflect economy-wide productivity gains (for example, filing Social Security claims on the internet rather than through representatives at field offices), falling food costs for food stamps recipients, and flat real incomes for SSI and other welfare program recipients.

The remainder of the model concerns the federal government sector. The federal deficit is government spending, described above, less taxes, plus benefit transfers plus interest payments. Taxes are composed of four parts: the first is personal and corporate income and inheritance taxes less grants to state and local governments and subsidies, the second is payroll taxes, the third is Medicare premiums, and the fourth is the taxes on Social Security benefits. The first part is modeled as the average (2001-2023) share of the relevant taxes to GDP, about 9.9 percent, times current-adjusted national income in the model (meaning, national income adjusted for increases in employer payments for health insurance, as explained below). The second part is modeled as the historical share since 2000 of Social Security and Medicare payroll taxes to labor income, 11 percent times current-adjusted labor income in the model; 70 percent of this amount goes to Social Security and the rest to Medicare. Medicare premiums, paid by individuals for Parts B and D, are assumed to be 15 percent of total Medicare expenditures, the recent average since the passage of the ACA. Benefit taxes are assumed to increase at 0.15 percentage points of Social Security benefits per year, according to the first ten-year projections in the Trustees' Reports, because various relevant tax parameters are not indexed to inflation or to wage growth. We note that this assumption is somewhat optimistic for the federal budget, as there have been legislative proposals to impose real indexing and is inconsistent with our general tax assumption of full indexation.

As done in the Trustees' Reports, we have to remove from taxable income, both for income and payroll tax purposes, the growth in employer payments for health insurance to employees, which are not included in taxable income. According to the NHE accounts, the share of employer payment for health insurance of total health care spending is 30 percent. So we remove the annual change (increase) from 30 percent of NHE from the GDP and wages that are taxed for general government and social insurance, respectively. We do not remove the entire amount, but rather just the accumulated change, largely due to the increase in relative health care prices, because our calculation of the relevant tax rates already implicitly included the base exclusion. We calculate that this effect reduces the taxable base by about 0.2 percent annually, on average, higher than the .12 percent that the Trustees assume.

Benefit transfers are Social Security and government health benefits. Social Security benefits are modeled as the average replacement rate per the average worker annual wage in taxable employment times the age 65 and older population and the disabled. That replacement rate is 30.2 percent. Government health benefits are based on the health profile matrix described above and includes Medicare, Medicaid, the subsidized insurance exchanges and all other (including veterans). Note that we do not model the complex eligibility rules for Medicaid and the subsidized insurance exchanges, which include income and, sometimes, asset tests, but simply use the recent experience related to demographic factors. Only 44% of "all other" government health care is covered by the federal government, the rest is covered by state and local government, private foundations and other sources.

Interest payments are the current real interest rate on government debt, described above, multiplied by federal government debt outstanding held by the public, which initially stands at $27.3 trillion in 2023.

Government debt grows with the deficit. Because we have no inflation in the model, the government neither pays nominal interest including inflation, nor, implicitly, collects an inflation tax arising from the devaluation of government debt in real terms.

We generally do not model specific provisions of current law, such as taxes, scheduled to take effect or expire in the future, nor do we model any expectations of changes. The model is denominated entirely in real terms and our views of current policy. There is no explicit general price inflation, deflation, business cycle, boom, or Federal Reserve Board in our model, because the focus is on the medium- and long-run horizon, where presumably these short-term economic conditions get washed out.

At this point, it is appropriate to give a brief explanation of the official economic growth models with which we will compare our results. The Trustees, Treasury, and CMS all use a single model of economic growth based on the amount of labor hours worked, in turn mainly dependent on demographics and labor productivity. By contrast, CBO uses a large suite of complex models, based on its own research, literature reviews, and consultations with experts. Of particular relevance to the exercise here are the CBO's forecasting growth model (see Shackleton (2018)), a largely Keynesian formulation, the policy growth model (see CBO 2022 STET presentation), largely a Solow growth model, and the small-scale policy model (see Lasky (2022)). For the first ten years of the projection horizon, CBO models six sectors. The first and largest sector (75 percent of GDP) is non-farm business, and its production function is assumed to be Cobb-Douglas. Output from the farm and non-profit sectors are just based on labor hours and its productivity, while the household sector's production is based only on owner-occupied housing. The two government sectors—federal and state/local—produce output based on labor hours and the depreciation of their capital. Beyond ten years, CBO collapses all of the sectors into one, and output is the result of Cobb-Douglas production and total factor productivity. In this later model, growing federal government deficits directly crowd out private investment for the first 30 years of the projection period at 33 cents on the dollar (stopping thereafter) because the increases in private savings and net foreign investment offsets are insufficient, as we explained above.

Model Projections

We present projections of the major metrics for which we earlier showed historical data. Where applicable, we also show long-term projections from CBO, CMS, Social Security and the Treasury's U.S. Government Financial Report for FY 2024. Generally, our projections are more pessimistic; nonetheless, official estimates serve as important reference points to our projections of heretofore unprecedented rates, shares, and quantities.

As shown in Figure 11, the projected ratio of national health expenditures to GDP increases from 17.6 percent in 2023 to 20.5 percent in 2033, 25.1 percent in 2053, and 37.6 percent at the end of the horizon. This is a faster pace of increase, especially in the latter half of the projection period, than historical experience in a demographically favored time. This can be mostly attributed to accelerating inflation in the health care sector, relative to "all other," but a part of that increased pace is explained solely by the aging of the population and its age-related increased spending on health care (including long-term services and supports). We will look at the projected relative prices below. The total federal and state government share of health care spending (not shown) is projected to increase from 60 percent to 64 percent, largely as a function of the larger role of public spending in the health care provision for the aged, holding current policy constant. CMS (2024) has a lower share of health spending in GDP in the out-years, under current law (CL) but also even without government price controls (illustrative alternative)

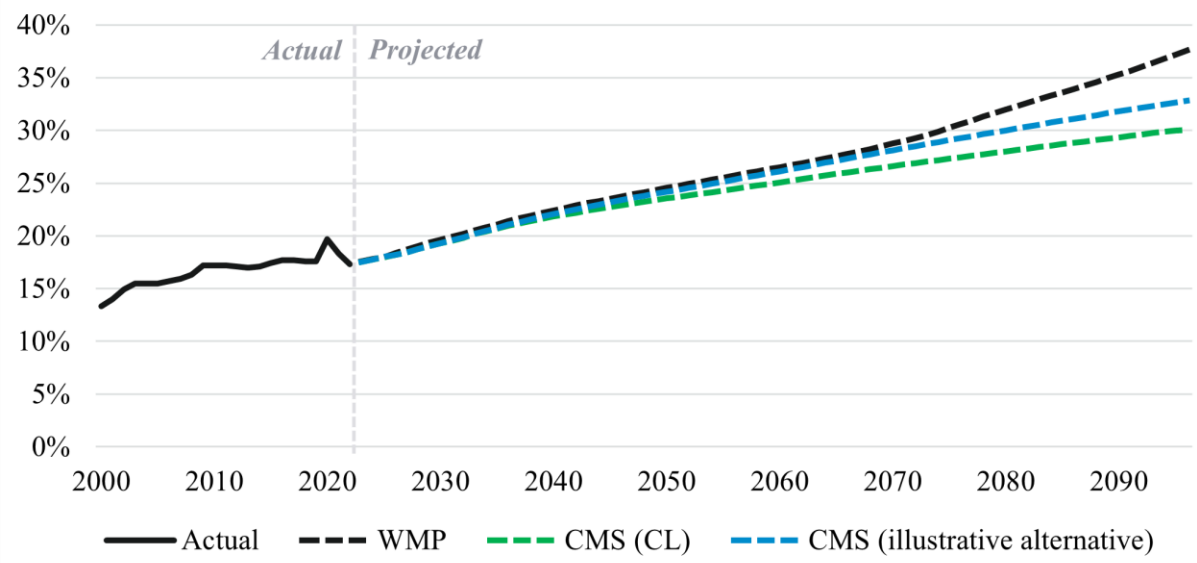


Figure 11. Ratio of National Health Expenditures to GDP, Actual and Projected, 2000-2096

Source: Authors; CMS Projections courtesy of Stephen K. Heffler, Supervisory Economist, CMS.

Figure 12 shows projected federal debt as a ratio to GDP. It increases to 126 percent in 2033, 256 percent in 2053, 504 percent in 2073, and 918 percent at the end of the projection period. The Financial Report (FR) reports a projected level of debt of 535 percent of GDP in 2099. These levels are unprecedented for the US and even for other large countries with currently high ratios, such as Italy, at around 150 percent, and Japan, at around 250 percent. It is also worth noting that Japan has an exceptionally high domestic savings rate and holds large pools of private assets in the central bank

account. Whether the bond market and foreign and domestic investors would support such high US federal debt for the US, rising steadily over time, with no financial crises or outbreaks of inflation, is unlikely, but it is unknowable in advance when break points will occur. According to our model, these debt levels depress investment and capital stock formation and increase interest rates and, as we will see below, consumer welfare. Although there is assumed to be an increase in private savings, that is not enough to offset the effect of deficits. If the markets believed that the US government will not be able to eventually reduce deficits and debt without a spike in inflation or forms of debt non-performance, then the reaction should be relatively quick in terms of higher interest rates and reduced access to borrowing. Based on an empirical analysis estimating sustainable debt limits for 27 OECD countries, including past cases of debt crises, one of us and a co-author found a range between 155 and 210 percent of GDP for the US as its sustainable limit (Warshawsky and Bokhua (2024). One particular estimate comes in at 187 percent, which would occur in less than twenty years in our projection model.

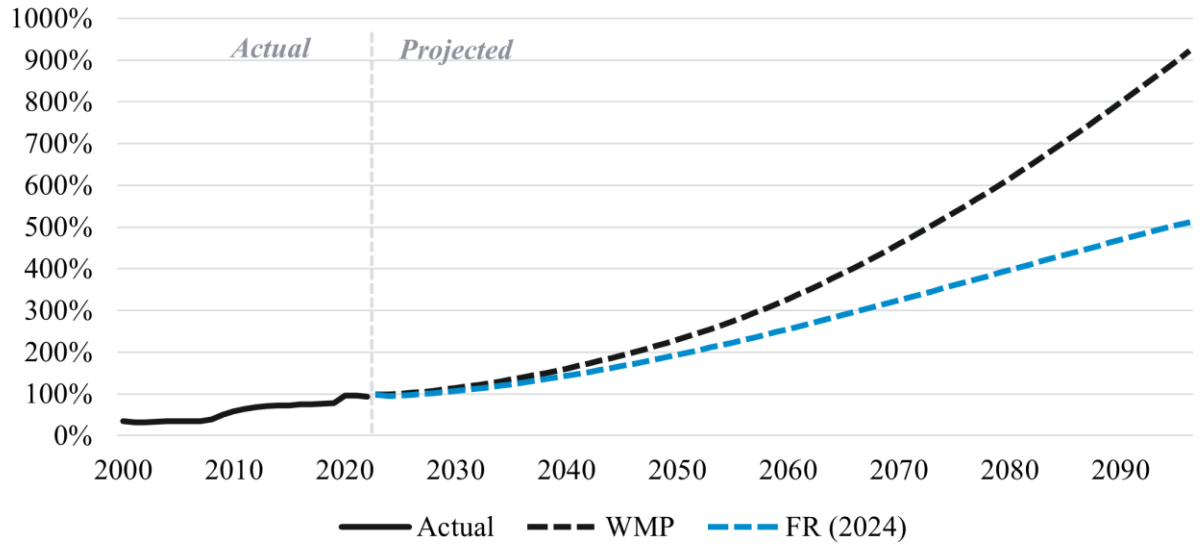


Figure 12. Ratio of Federal Debt Held by the Public to GDP, Actual and Projected, 2000 – 2096

Source: Authors; *Financial Report of the U.S. Government: FY 2024*

Figure 13 shows the projected real interest rate paid by the federal government on its debt. It increases from 2.3 percent currently to 2.9 percent over the next 10 years up to 3.6 percent in 2066, then declines to 2.8 percent by the end of the period because of the decreased demand for capital when labor use stops growing in the "All Other" sector, crowded out by health care as well as an assumed increase in the domestic savings rate. In contrast, the Trustees and the FR assume—rather than determine—an initial increase, then a drop and then an increase over the next couple of decades and then a steady 2.3 percent for the rest of the projection horizon. In the medium and long runs, our real interest rate exceeds the rate of real economic growth by about 1.5 percentage points. CBO projects the real interest rate to increase but never exceed 1.8 percent over the 2024-2054 period, although it should be noted that CBO assumes an upward sloping yield curve even in the long-run, even with stable inflation, and hence the average rate paid by Treasury on debt, which includes short-term, is assumed lower than in our methodology.

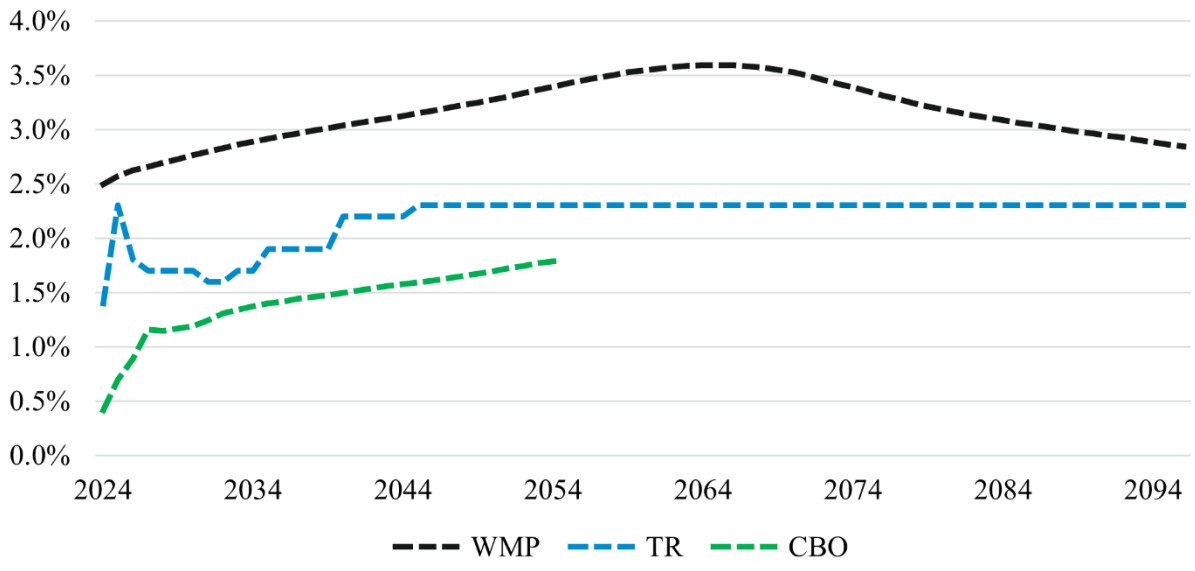


Figure 13. Projected Real Interest Rate on Government Debt, 2023 – 2096

Source: Authors, Social Security Trustees' Report (2024), CBO (2024)

The projected ratio of federal interest payments to GDP is shown in Figure 14. This ratio increases from about 2.0 percent of GDP currently to 3.4 percent in 2033, 8.2 percent in 2053, 16.4 percent in 2073, and 25.1 percent in 2096. These levels would be historically unprecedented. They are below those projected by the Treasury in the FR in the next four decades because it, like the CBO, calculates nominal interest cost but does not subtract out the implied transfer of resources from the public due to the inflation tax on the value of debt. The increase in current spending to service debt leads to the rapid deterioration in the federal deficit, in a vicious cycle.

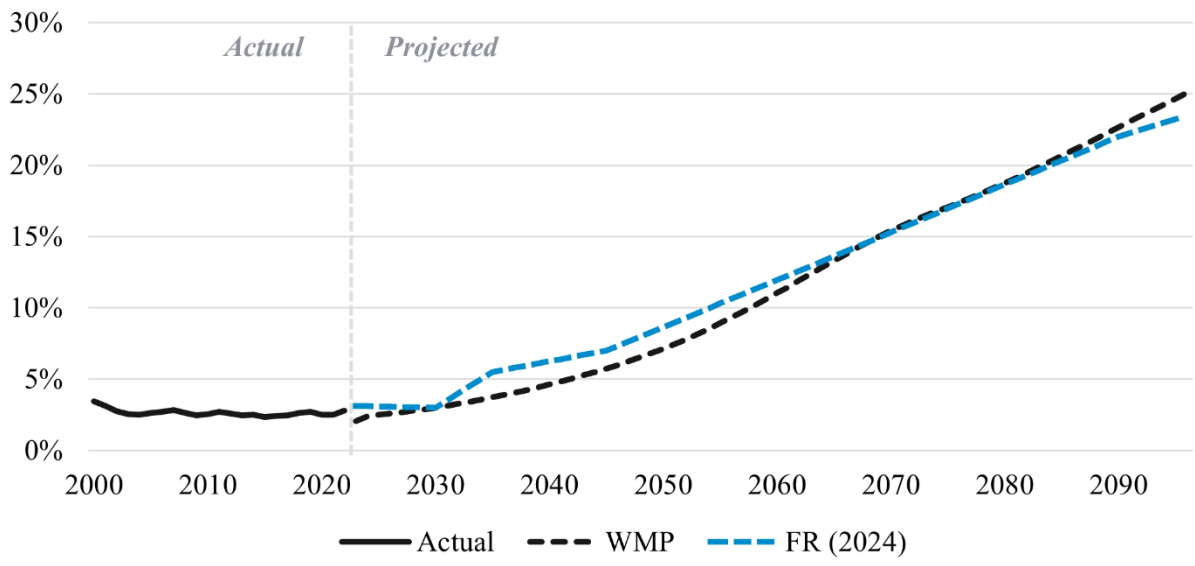


Figure 14. Ratio of Federal Interest Payments to GDP, Actual and Projected, 2000 – 2096

Source: Authors; *Financial Report of the U.S. Government: FY 2024, page 163*

Figure 15 shows the projected federal deficit as a share of GDP. As shown both here and above, the recent level has trended to 6 percent. In our projections, the deficit steadily increases, to 6.9 percent of GDP in 2033, 13.8 percent in 2053, 20.3 in 2073, and 37.8 percent in 2096. As observed around the Great Recession and the pandemic, could federal deficits in the next 75 years become massive, frequent, and last for extended periods? This strikes us as unsustainable and implies a financial crisis on rapid inflation. Concurrently, the Medicare and Social Security Trust Funds will be exhausted in the next ten years. This timing would be disadvantageous to those advocating for social insurance program changes entirely by raising taxes, when those revenues may be more needed to fund the maintenance of other high-priority federal government activities such as defense or welfare programs at a time when deficit reduction will be on the policy agenda. The deficit projections from the Treasury in the Financial Report are lower than ours in the long run because the Treasury projects quite a modest increase in primary deficit, now at 3.3 percent of GDP, only increasing to 4.0 percent in 2045 and then declining to 2.8 percent by 2099. This view reflects the optimistic demographics of the Trustees' Report, continued operation of legislated constraints on health care prices paid by Medicare and Medicaid and other optimistic assumptions about other government spending and increasing revenues. For example, individual income taxes are projected to increase from 21 percent of wages in 2025 to 30 percent in 2099. Despite these favorable assumptions, the Treasury in the FR says, "current policy is not sustainable and must ultimately change." (page 31)

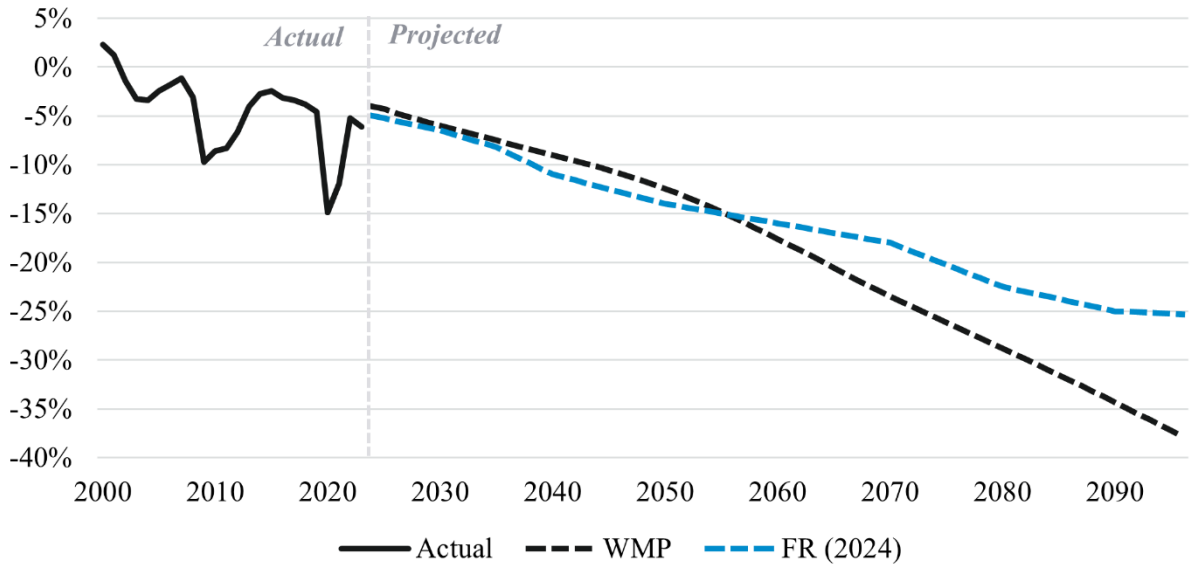


Figure 15. Ratio of the Federal Budget Surplus (Deficit) to GDP, Actual and Projected, 2000 – 2096

Source: Authors; *Financial Report of the U.S. Government: FY 2024*

The projected increase in Social Security payments as a share of GDP, shown in Figure 16, seems modest. Nonetheless, it is sobering, given the longstanding knowledge of the program's financial shortfall and the political difficulty to reform. Our projection of payments as a share of GDP is larger than the forecast of the Trustees because our projection of the population, consistent with CBO's latest, is older and smaller. As seen, the ratio of Social Security benefit payments to GDP increases from around

5 percent now to 6.4 percent in 2053 and 7.9 percent in 2096, in our projections, while for the Trustees, the ratio only increases to 6.4 percent in 2075 before falling to 6.1 percent at the end of the horizon.

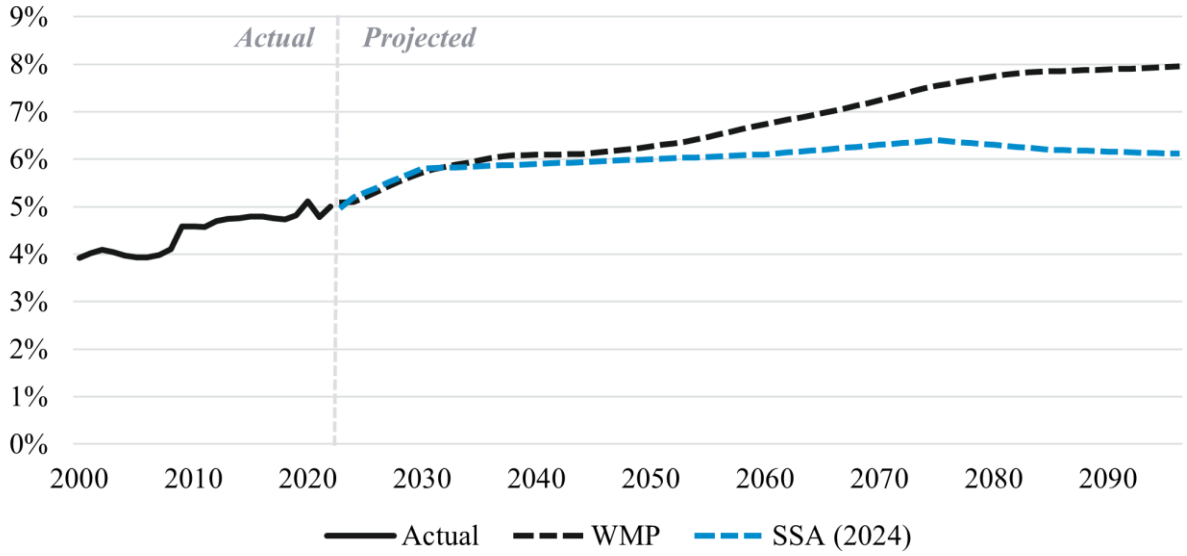


Figure 16. Ratio of Social Security Payments to GDP, Actual and Projected, 2000 – 2095

Source: Authors, Social Security Trustees' Report, 2024

A more significant source of deterioration in government finances—debt and deficit—is is spending on health care. As shown in Figure 17, total government spending on health care (mainly federal but also by the states for Medicaid and other state/local sources) increases from 10.5 percent of GDP currently to 24 percent at the end of the projection horizon. Most of the increase comes from Medicare, which rises from just under 4 percent currently to 10.5 percent, while Medicaid (medical care for lower income populations and long-term services and supports) rises from just over 3 percent to 5.9 percent, and other (including health insurance exchange subsidies, veterans' care, public health, etc.) increases from 2.7 percent to 5.7 percent. Note that we ignore the provision in the ACA law limiting total government spending on insurance exchange subsidies to 0.5 percent of GDP.

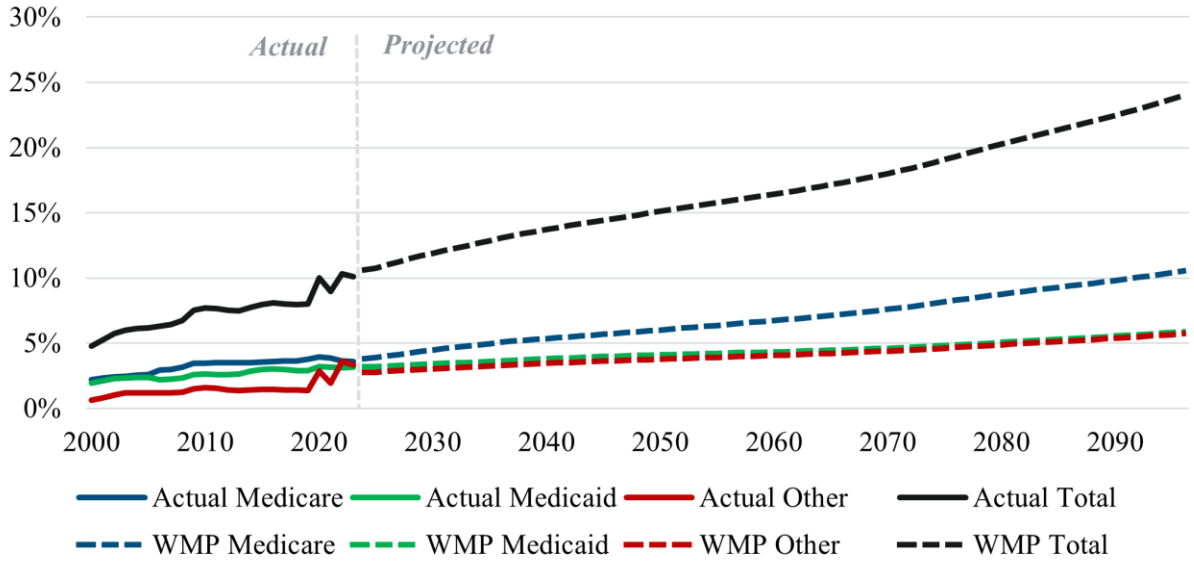


Figure 17. Ratio of Government Health Spending to GDP

Source: Authors.

A part of this increase comes from demographic effects, but most comes from the increase in the relative price of health care services. Official projections include the impact of an assumed relative price increase, but it is smaller than produced by our model and trends downward, whereas we find the relative price increases, on average, at 1.2 percent per year with this annual rate of growth increasing from about 1 percent to 1.4 percent, as shown in Figure 18. The underlying low productivity growth in the health care sector plays a role in this trend. The main driving factor, however, is the increasing scarcity of labor. Future demographic conditions lead to both a slowdown in the growth of the labor force and an increase in the demand for health care. With the lack of substitution of capital for labor, on top of low productivity growth, the health care sector takes a larger and larger share of the economy's labor, drawing from the "all other" sector where labor could have been substituted for capital, whose stock is being starved by the growing deficit. The labor share for health care services rises from about 11 percent in our base year to 27 percent by the end of the period. This absorption of labor increases the rate of growth in the relative price of health care. This is a prime example of Baumol's cost disease but with a vicious dynamic twist given expected future demographic conditions.

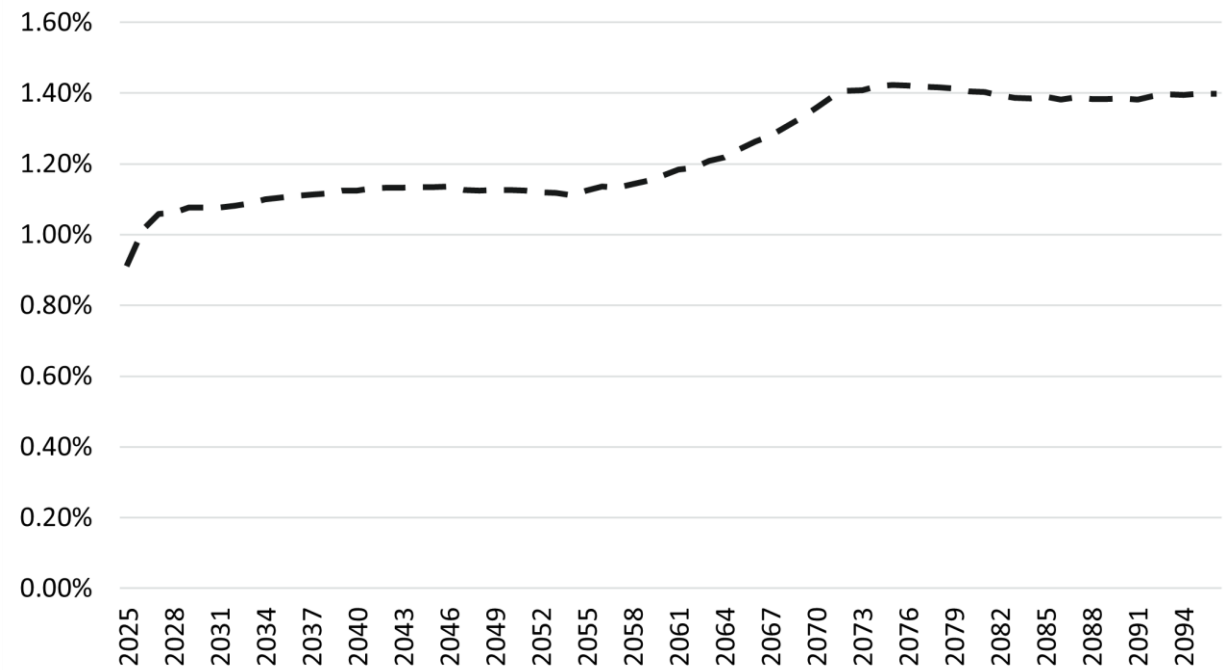


Figure 18. Projected Increase in the Relative Price of Health Care Services, 2023 – 2096

Source: Authors' calculations.

Finally, Table 1 shows the model projection for consumer welfare, measured as the annual rate of growth in real per capita consumption less health care. Welfare grows to an average of about 1.1 percent until 2054, when the rate of health care spending growth noticeably increases, at which point the welfare measure begins a decline to negative growth by 2096. This projection illustrates the eventual zero growth in the standard of living, because of rising federal debt and health care spending. This result contributes to our view that medium- and long-term debt growth is unsustainable politically.

Table 1: Annual Average Welfare Growth

Table 1	**2023-42**	**2043-62**	**2063-82**	**2083-96**
Annual Average (%)	1.08	0.85	-0.10	-0.61

Source: Authors' calculations

Comparison to Official Projections

The Organization for Economic Co-operation and Development (OECD) produces projections of health expenditures in its member countries, including the United States. It has developed a model, broadly similar to ours, with age-expenditure health spending curves (but not apparently considering gender), thereby allowing demographic effects, as well as reflecting the impact of income, productivity constraints (the "Baumol" variable for differential productivity growth), and time-specific effects proxying for technological progress on health spending. Unlike us, however, the OECD assumes that there are death-related health costs, so that half of the assumed extra years of life expectancy translate into higher death-related costs over time and therefore lower health care expenditure for survivors

relative to decedents. Overall this latter assumption produces a somewhat lower level of spending projection than otherwise.[2] The OECD also assumes an income elasticity below one but no sensitivity to price. These assumptions may be sensible for most OECD countries given the near total share of health spending controlled by the government, but less so for the US. It should be noted that the OECD excludes health sector investment from its health spending measure.

For the US, the OECD projects (see Lorenzoni, et al. (2019)) that health spending as a share of GDP to be 20.2 percent in 2030, or a 3.4 percentage points increase in the base scenario. It attributes 33 percent of this increase to demographic effects, 13 percent to "time/technological progress," 42 percent to income, and 12 percent to the Baumol effect.

Within the US, the Centers for Medicare and Medicaid Services (CMS) also produces ten-year projections of national health expenditures, with breakouts by payer, and major services and goods. Its model is significantly reflected in the separate 75-year projections for all health care spending (in memo) and for Medicare (in the Trustees' Report). CMS (March 2022) characterizes its approach, although quite elaborate, as a "top-down, reduced-form model."

According to CMS actuaries and economists, Fiore, et al. (2024), after the federally funded, pandemic-induced massive increase in health spending in 2020, combined with a deep short recession, economic growth exceeded health spending growth through 2022. This led to a decline in the health care share of GDP from 19.7 percent in 2020 (up from 17.6 percent in 2019) to 17.3 percent in 2022. Thereafter, the typical pattern has returned, influenced by demographics, economics, and health-sector-related factors, so that the health share in GDP again rose to 17.6 percent in 2023. CMS projects this trend to continue so that the health share of GDP reaches 19.7 percent by 2031. The particularly high growth rate in health care spending in 2023 is attributed to high Medicaid enrollment, which is expected to subside somewhat with the expiration of COVID-related policies. Overall, however, the continued aging of the population, higher demand for health care relative to income growth and faster growth in health care prices relative to economy wide price growth (a 0.6 percent differential) are the dominant factors, more than the often offsetting projections of Medicare and Medicaid laws and policies.

In terms of the government share of health spending, the pandemic radically raised the share from 45 percent in 2019 to 51 percent in 2020, before slowly subsiding, projected by CMS to reach 46 percent in 2024. Thereafter, the aging of the population and the concomitant turn to Medicare and Medicaid and some expirations of legislated cost containment features and slow economic growth increases the projected government share to 49 percent by 2032.

Although not prominent, CMS (2024 Heffler, et al. memo, Chart 4) also produces 75-year projections of national health expenditures. Focusing on the particular projection without legislated price constraints on Medicare spending, CMS projects that the ratio of health care spending to GDP will steadily rise to 32.8 percent by 2096.

CMS is also responsible for producing the annual Medicare Trustees' Report which has a 75-year horizon. Although this lengthy report covers many aspects of the program and has a complex underlying

[2] This assumption has also been adopted recently by CMS and in the Trustees' Reports and does have a substantial impact over the long-run in reducing health care demand. By contrast, we opt for the simpler traditional approach, bolstered by recent evidence that the rate of health improvement of the U.S. older middle-aged populations has stagnated, owing to more obesity and poorer mental health. See Chapel, et al. (2023) for details.

model, here we focus on the main total projection results. Medicare expenditures represented 3.76 percent of GDP in 2023. Under current law, including price controls, according to the projections of the Board of Trustees (2024), costs increase to 4.64 percent of GDP in 2030, and to 5.86 percent of GDP by 2050, mainly owing to demographics, and then to 6.2 percent of GDP in 2098, with current-law constraint on health care cost growth becoming the most important determinant. Medicare sources of income shift, especially in the next 15 years, and then remain fairly stable. The share from payroll taxes declines and then stabilizes, while the share from taxes on benefits increases over the next 20 years but then stabilizes, premiums increase over the next 20 years and then stabilize, and the share from general revenues increases over the next 15 years. These sources of income are inadequate, however, even with a small Trust Fund and several past payroll tax increases. The Hospital Insurance portion of Medicare runs out of Trust funds by 2036 and 11 percent of benefits would then not be payable, increasing to 13 percent by 2048. If payment update constraints legislated in the ACA in 2010 and in MACRA in 2015 were phased down, as some believe is inevitable (and indeed as recently-introduced bipartisan legislation has proposed) because Medicare beneficiaries would be progressively priced out of the market for health care services, CMS projects that Medicare expenditures would instead reach 6.4 percent of GDP in 2050 and 8.4 percent of GDP in 2098.

According to the Trustees' projections in 2024, Social Security's cost as a percent of GDP is projected to grow from 5.2 percent in 2023 to 5.7 percent in 2033 to a peak of 6.3 percent in 2078 and then decline to 6.1 percent by 2098; this later decline, however, is caused by an unrealistically high assumed ultimate birth rate of 1.9 and high labor productivity in the economy. Social Security income is projected at 4.6 and 4.8 percent of GDP in 2023 and in 2033, respectively. Thereafter income declines slowly, to 4.5 percent for 2098, as the share of employee compensation provided as non-covered fringe benefits, health insurance in particular, increases gradually with rising health care costs. The cash flow balance (the program's deficit) in 2024 is -0.59 percent of GDP; it increases to -0.87 percent by 2033, and reaches its low point, -1.74 percent by 2080. Social Security has significant Trust Funds, but they are depleting rapidly and are together projected to be exhausted by 2035, when 17 percent of scheduled benefits cannot be paid, increasing to 27 percent of benefits by 2098. The summarized actuarial deficit, calculated over 75 years, is 1.23 percent of GDP. The ratio of Social Security taxable payroll to GDP is 35 percent in 2024; it increases to 37 percent by 2033 and then declines gradually to 34 percent by 2090 mainly for the reason noted above – a growing share of non-covered fringe benefits in compensation.

CBO does short-term (10 year) and medium-term (30 year) projections of the budget (revenues and outlays and debt) of the federal government. In its annual projections of January 2025 (short-term) and March (medium-term) 2024, CBO notes that the deficit in 2024, at 6.6 percent of GDP, was much larger than the average experienced from 1970 to 2024 of 3.8 percent but projected it would decline again to 5.5 percent by 2026. Subsequently, deficits increase, so that the deficit is 6.1 in 2035. Deficits further increase to 7.3 percent of GDP in 2044 and to 8.5 percent in 2054.

The projected growth in total deficits is driven in part by increases in interest costs, as net interest outlays almost triple, rising from 2.4 percent of GDP in 2023 to 6.3 percent in 2054. Social Security and Medicare are part of the cause too – Social Security's spending increases from 5.0 percent in 2023 to 5.9 percent in 2034 and thereafter through 2054 and its contribution to the deficit increases from -0.6 percent of GDP in 2024 to -1.4 percent in 2054. Medicare's contribution to deficits is even larger, increasing from -1.6 percent in 2024 to -3.6 percent in 2054. Note that CBO has a somewhat more pessimistic view of the finances of Social Security and Medicare and the overall economy than the

Trustees, and with its recent demographic revisions to show an older and smaller population, its views are likely to become darker in its next projection coming out later this year.

Federal debt outstanding held by the public is estimated by the CBO to be 98 percent of GDP at the end of 2024. It rises to 100 percent in 2025 and surpasses its historical high in 2029 at 107 percent (federal debt was 106 percent of GDP in 1946 upon the conclusion of WWII) and continues to climb, to 139 percent in 2044 and 166 percent in 2054. CBO does employ a limited loop from higher debt to higher interest rates, but its projections are based on current law, not policy, so projected revenues include the effects of the expiration of 2017 tax cuts, as well as of bracket creep.

CBO estimates federal government outlays in 2024 at 23.7 percent of GDP, and outlays decline in 2025 and 2026 to 23.3 percent. Outlays then steadily increase, reaching 24.4 percent in 2035 and 27.3 percent in 2054. Rising interest costs and growth in spending on the major health care programs and Social Security, driven by the aging of the population and growth in age-adjusted real health care costs per person (.9 percent annually faster than GDP growth, but trending down to .6 percent by 2054), boost federal spending. CBO estimates that revenues were 17.1 percent of GDP in 2024, close to the average from 1975 to 2024. Revenues as a share of GDP are projected to rise to 17.8 percent in 2026 with the scheduled current law expiration of the 2017 tax cuts. Over the 2026 – 2035 decade, revenues are 18.1 percent of GDP and increase slowly but steadily to 18.8 percent in 2054, as an increasing share of income is pushed into higher tax brackets.

CBO also does a regular long-range projection of Social Security, last published in August 2024. CBO projects that if Social Security paid benefits as scheduled, spending on the program would increase from 5.1 percent of GDP in 2024 to 6.7 percent in 2098, and revenues would remain around 4.5 percent of GDP over the same period. The combined Trust Funds would be exhausted in 2034. In CBO's projections, Social Security's actuarial deficit over the next 75 years is equal to 1.5 percent of GDP, or 4.3 percent of taxable payroll.

CBO projects that if Social Security outlays were limited to what is payable from annual revenues after the trust funds' exhaustion in 2034, Social Security benefits would be about 23 percent smaller than scheduled benefits in 2035. They would be 28 percent smaller by 2098. These projections are more pessimistic than the Trustees' because of lower birth and economic growth rates.

CBO (May 2024) also considers alternative scenarios for the economy and the budget and their effect on the federal budget. In particular, if, between 2024 and 2054, discretionary spending and revenues were at their 30-year historical averages as a percentage of GDP, then federal debt held by the public in 2054 would exceed 250 percent of GDP. Under that scenario, discretionary spending would equal 7.0 percent of GDP in every year and revenues would equal 17.2 percent of GDP in every year, 1.9 percentage points higher and 1 percentage point lower, respectively, than the averages in CBO's extended baseline projections. Our discretionary spending and revenue projections are closer to this alternative scenario than the baseline. We view the CBO baseline as unrealistic for long-range projections, especially when considering broad fiscal policy and social insurance programs, and not reflective of current policy, albeit reflective of current law.

The Treasury Department, working with the Office of Management and Budget, produces a long-run analysis of fiscal policy, as required supplementary information in the annual Consolidated Financial Report of the U.S. Government. This analysis is essentially an amalgamation of the Trustees' Reports

along with projections of other government spending and revenues. Its underlying assumptions are quite optimistic—projecting steady real interest rates, following the Trustees, with no feedback from deficits and debt or capital shortages, constraining Medicare, Medicaid and exchange subsidy spending to legislated price levels, revenues increasing significantly through personal income-tax bracket creep, high birth rates, and veterans' care costs increasing only with GDP growth. Moreover, the projections jump around considerably from release year to release year with changing initial economic and budget conditions. Nonetheless, the Treasury projections show large increases in debt and interest spending over the 75-year horizon. The debt-to-GDP ratio will reach 535 percent in 2098. Because the Financial Report's optimistic assumptions keep the primary deficit fairly contained, the increase in debt owes to interest spending, which increases from 1.9 percent of GDP in 2022, to 5.1 percent in 2034, 15.2 percent in 2066 and 25.6 percent in 2097. The present value of total federal non-interest expenditures less receipts is $72.7 trillion over 75 years or 4.2 percent of GDP over that period. To keep the debt-to-GDP ratio at its current level, the primary surplus share of GDP must be raised by 4.3 percentage points. This amounts to an increase in revenues of 22.5 percent or a decrease in spending of 19.0 percent.

Table 2 gives a complete summary of these official projections for select future years, and compares them with our projections. As a general statement, we are fairly close to the official projections in the near-term, but we see a worse situation in the medium- and long-term. In particular, our projection is that health care prices are higher and grow faster than the Trustees and CBO who see a cooling off. Compared to CBO, we do not project an increase in federal revenues as a share of GDP, because the actual ratio has been quite stable historically, controlling for business cycle and stock market effects. Medicaid and health insurance exchange subsidy spending as a share of GDP, according to the CBO, grows inexplicably slowly. Our path of health care cost growth starts out similarly to the CBO and Trustees, but diverges significantly – theirs declining, ours increasing. Regarding interest payments, compared to CBO, we are a bit lower because our base real government interest rate is lower than their nominal rates and they apparently do not count the inflation tax on debt value as an offset. As mentioned above, in the long run, our real interest rate is higher than the Trustees'. Using the CBO 2025 population projection, we have a much larger older population, and hence higher benefit payments than the Trustees' and even 2024 CBO projections.

Though somewhat obscure and rarely cited, the Biden Administration, through the Office of Management and Budget (OMB), presented a 25-year projection of the baseline fiscal outlook, in Chapter 3 of the Analytical Perspectives document attached to the annual budget submission to Congress. Assuming current policies, it says that debt rises to 117.4 percent of GDP in 2033 and to 131.2 percent of GDP by 2048. The deficit is projected to reach 6.4 percent of GDP in 2033 before falling to 5.3 percent at the end of the 25-year horizon. Of most relevance to our discussion, OMB assumes relatively low health care inflation, a low real interest rate of 1.1 percent, robust economic growth, Trustees' demographics and high tax revenues.

Although not an official government agency, the Penn Wharton Budget Model (PWBM) is a non-partisan, academically-rigorous and extensively-staffed center that produces general equilibrium projections on the budget, Social Security, and various other policy areas and legislative and regulatory proposals. It is widely cited by analysts and the media. The PWBM (Gokhale and Smetters (2022)) projects that total federal debt held by the public will increase to almost 225 percent of GDP by 2050. They project that spending on federal health care programs will become a much larger share of the

budget than today; in particular, by 2050, Medicare costs 7.1 percent of GDP and Medicaid (federal portion only) 2.5 percent of GDP.

For the longer horizon, they calculate a present value budget shortfall of $93.8 trillion over 75 years, or 7.0 percent of GDP, and over the infinite horizon, a shortfall of $202.9 trillion or 8.2 percent of GDP; a worsening trend over time. To achieve fiscal balance over 75 years, spending would need to be cut by 30 percent or taxes increased by 39 percent. The PWBM (Gokhale and Smetters (2023)) estimate that federal debt cannot exceed about 200 percent of GDP even under favorable market conditions, about 20 years for corrective action after which no amount of future tax increases or spending cuts could avoid the federal government defaulting on its debt- whether explicitly or implicitly (through rapid inflation).

The PWBM budget projections are micro-based, that is, constructed from detailed projections of US demographics and individual amounts of earnings, taxes, and expenditures, distinguished by gender, education and race. These population differences and various assumed trends lead to macro-level changes in economy-wide productivity, which declines significantly over time, according to their model projections. We do not recommend use of “micro-sim” models in official long-run projections because we do not believe that the micro data and estimated relationships are sufficiently thick and stable over long periods of time, at least compared to the macroeconomic approach we use here. Although uncertainty increases with time in general, it is larger for individual components and population segments than for broad aggregates.

Table 2. Comparison of Official Projections with WMP Model Projections for Select Years, as a Share of GDP (%)

	2027	2030	2033	2053	2073	2096
Health Care Spending						
CMS (2024) (alternative scenario)	-	19.3	20.2	24.7	28.7	32.8
WMP	18.7	19.7	20.5	26.2	29.5	37.6
Budget						
CBO (2024-5)						
Debt	103	109	115	166	-	-
Deficit	5.2	5.9	6.5	8.5	-	-
Interest Spending	3.3	3.6	3.9	6.3	-	-
FR (2024)						
Debt	100.1	107.3	116.2	211.2	346.0	510.6
Deficit	5.7	6.5	7.5	14.6	19.4	25.3
Interest Spending	3.1	3.0	4.5	9.6	16.3	23.5
WMP						
Debt	105	114	126	256	504	918
Deficit	5.0	6.0	6.9	13.8	25.1	37.8
Interest Spending	2.7	3.0	3.4	8.2	16.4	25.1
Program Spending						
Social Security						
Trustees	5.5	5.6	5.7	6.0	6.3	6.1
CBO (2024)	5.5	5.8	6.0	5.9	6.4	6.7
WMP	5.4	5.7	5.9	6.4	7.4	7.9
Medicare						
Trustees (alternative)	4.4	4.7	5.2	6.9	7.4	8.4
CBO (2024)	4.1	4.5	5.0	6.9	-	-
WMP	4.1	4.5	4.8	6.2	7.9	10.5
Medicaid						
WMP	3.3	3.4	3.5	4.2	4.7	5.9

Source: Authors and Various Government Publications.

Conclusion and Discussion

In the official models used by the CMS, Treasury, and the Trustees for projections and policy analysis of government budgets, health spending, and benefit program finances, many key variables, like real interest rates, health care costs, economic growth, and others are largely assumed, often based on a continuation of historical trends. By contrast, in our model, these variables are derived simultaneously from contemporaneous supply and demand conditions, based on logical functional forms and consensus parameter estimates. This latter approach provides a more credible and realistic basis for projections and policy analysis. We find that real interest rates and relative health care prices will be rising higher than in official projections, based on the workings of the economy and demographic conditions, which leads to worse budget outcomes (deficits and debt) and Social Security and Medicare program finances in the medium- and long-run than official projections. Our projected fiscal situations are less sustainable than official indications. Moreover, the rate of economic welfare improvement declines under current policy.

This modeling approach enables an analysis of policy alternatives, individually or in combination, based on first principles and basic economic conditions and factors, such as the effects of and on capital and labor, rather than from reduced forms, which are not stable to major changes, or bootlegged data insertions, which can be arbitrary. Among the key insights of our model is that the aging of the population and low birth rates induce a labor shortage that is particularly expensive for health care services where there is low productivity and little effective substitution from capital. Rising health care costs increase deficits which then reduce capital, raising real interest rates. This adverse and ultimately unsustainable cycle of debt and interest rates also deteriorates welfare, measured as real consumption less health care spending.

The model here should replace the current official model serving as the basis for the Trustees' Reports and the Financial Report and the Financial Statement of the US Government. Its parameters and relationships should be reviewed and renewed annually and should serve as the basis for an analysis of long-term changes in program and fiscal policy.

Appendix A. Equations for the Macroeconomic Simulation Model

Production Functions

1. $f_{1t} = \alpha_1 (g_1^t L_{1t})^{1-\beta_1} (K_{1t})^{\beta_1}$ (All other sectors)
2. $f_{2t} = min(\frac{L_{2t} g_2^t}{\beta_2}, \frac{K_{2t}}{\beta_3})$ (Health care sector)

Income Identities

3. $Y_t = f_{1t} + p_t f_{2t}$ (Domestic product, current dollars)
4. $\widehat{f_{2t}} = F(\, demographics, income, prices) = min(\frac{\widehat{L_{2t}}}{\beta_2}, \frac{\widehat{K_{2t}}}{\beta_3})$, with initial income elasticity of 1.2 and price elasticity of -0.5, thereafter declining
5. $C_t = Y_t - I_t - G_t - 0.55 * Df_t$ (Consumption)
   $(= PCE_t + (X_t - M_t) + SLGC_t)$
6. $I_t = a * Y_t - 0.33 * Df_t$ (Investment)
   $(GDPI_t + AGI_t)$
7. $G_t = FGC_t = Def_t(Y_t) + ND_t(demographics)$ (Federal government consumption)
8. $Y_t = w_t L_t + r_t K_t$ (Domestic income)

Factors of Production

9. $K_t = (1 - b) K_{t-1} + I_{t-1}$ (Net capital stock)
10. $L_t = F(demographics, LFPR\ by\ age, avg\ work\ week, UE\ by\ age)$, avg work week decreasing .05% annually (Hours worked)

First Order Conditions

11. $(1 - \beta_1)\alpha_1 g_1^t \left[\frac{K_t - \widehat{K_{2t}}}{g_1^t (L_t - \widehat{L_{2t}})}\right]^{\beta_1} = w_t$ (Wages)
12. $\beta_1 \alpha_1 \left[\frac{K_t - \widehat{K_{2t}}}{g_1^t (L_t - \widehat{L_{2t}})}\right]^{\beta_1 - 1} = r_t$ (Cost of capital)
13. $p_t = \frac{A_t}{\widehat{f_{2t}}}$, (Relative price of output of health care sector)

where

$A_t = \alpha_1 (g_1^t (1 - \beta_1)(B_t)^{\beta_1} L_t + \beta_1 (B_t)^{\beta_1 - 1} K_t - (B_t)^{\beta_1} (g_1^t (L_t - \widehat{L_{2t}})))$,

and

$$B_t = \frac{(K_t - \widehat{K_{2t}})}{\left(g_1^t (L_t - \widehat{L_{2t}})\right)}.$$

Note: $\widehat{L_{2t}}$ is reduced by a factor of g_2^t in the above FOCs.

Federal Government Sector

14. $Df_t = G_t - T_t + Bf_t + R_t$ (Federal government deficit)
15. $T_t = \tau Y_t + \pi(w_t L_t - EGHI_t) + 0.0015t * SS_t + 0.15 * Medicare$ (Net federal taxes)
    where
    τ is the historical share of personal and corporate income taxes less grants to states and local governments and subsidies to domestic product, π is the historical share of Social Security and Medicare payroll taxes in labor income, EGHI is the annual accumulated growth in employer health insurance benefits, assumed to be 30% of NHE, and Social Security benefits are assumed to be taxed, increasing 0.15 percentage points per year for the first ten years, and Medicare premiums for Part B, C, and D are 15 percent of total Medicare spending.
16. $Bf_t = SS_t + GHC_t - 0.39 * p_t * Medicaid - 0.56 * p_t * All\ Other$
    (federal government benefits)
    (assuming 61% of Medicaid spending and 44% of 'All Other' health care spending is federal)
17. $SS_t = l * i * replacement\ rate * total\ labor\ income * retirement\ population,$
    (Social Security)
    where the average replacement rate is assumed to be 30.2%, l and i are parameters to map from the retirement population to the beneficiary population and to adjust earnings down to taxable earnings, respectively, equal to 1.13 and 0.63 based on 2021 data, and the retirement population is those age 65 or older.
18. $GHC_t = p_t *$ (Medicare + Medicaid + Exchanges + All other), (All Gov HC benefits)
    from sources of payments-demographics matrix by age and gender
19. $R_t = D_t(r_t - rp_t)$, (Interest payments)
    where rp is the risk premium, assumed to be 0.075 to produce an initial real government interest rate of 2.3 percent.
20. $D_t = D_{t-1} + Df_{t-1}$ (Federal debt held by public)

$$D_0 = \$27.3\ trillion$$

Appendix B. More Details on Parameter Derivations

Interpretations and empirical foundations of the parameters found in Appendix A appear below. A forthcoming web application will allow you to see how the projection results change with adjustments to several of these parameters.

α_1 is 10.22, a parameter equal to the ratio of the initial 2023 predicted output using our Cobb-Douglas formulation to actual output.

β_1 is 0.37, capital's share of input in the all other production function.

β_2 is $6.5*10^{-3}$, the ratio of labor hours in health care to national health expenditures in 2023.

β_3 is 0.6221, the ratio of output to capital in the health care sector in 2023.

g_1^t is $(1 + 0.018)^{t-1}$, the growth in labor-augmenting technical progress in the Cobb-Douglas formulation for all other output.

g_2^t is $(1 + 0.004)^{t-1}$, the growth in labor productivity in the Leontief health care production formulation.

b is 0.054, the assumed annual rate of capital depreciation.

a is 0.213, the initial share of output which is invested, equal to the average ratio of investment to output 1990 to 2023.

τ and π are 0.099 and 0.11, respectively. τ is the historical share (1990-2023) of personal and corporate income taxes less grants to states and local governments and subsidies to domestic product, π is the historical share of Social Security and Medicare payroll taxes in labor income.

Further, we compute aggregate demand for healthcare ($\widehat{f_{2t}}$) as a function of population and demographic factors, as well as the price of health care and income. This method relies on annual population projection data from CBO by age and sex estimated in their long-term demographic projections. We combine these data with a computed spending profile by age group and gender for 2023 in order to compute personal health care spending (PHC) for a given year. CMS regularly releases spending data by age, sex, and source of payment at both an aggregate and per capita level for select years. The most recent estimates are from 2018 and 2020. Because 2020 was an outlier year for health spending, we use the proportional spending ratios of 2018 to compute health spending for each age, sex, and payer group and scale them linearly to meet corresponding 2023 spending levels.

We assume the share of payer-group spending attributed to each age-sex cohort in 2023 is equivalent to that of 2018. That is, CMS has released 2023 PHC totals for each payer group and we multiply these totals by the 2018 share of spending attributed to each age-sex cohort to compute aggregate spending for that cohort. We then compute per capita spending by dividing these spending estimates by Census population estimates for the same age-sex cohort. For example, according to CMS estimates, 65 to 84 year-old males accounted for 30.5 percent of Medicare expenditures in 2018. We assume this percentage remained the same in 2023. Thus, because PHC associated with Medicare totaled $967 billion in 2021, 65 to 84 year-old males are assumed to have contributed $295 billion to this total. The

Table B1. Estimated Per Capita Personal Health Spending by Age Group and Gender, 2023 ($)

	Medicaid	Medicare	OOP	Private Insurance	Other
Male					
0-18	2,302	2	510	2,075	283
19-44	2,068	59	647	2,425	361
45-64	2,926	1,754	1,658	7,258	868
65-84	2,088	13,111	2,801	3,991	966
85+	4,653	23,911	7,488	6,400	1,655
Female					
0-18	1,992	1	483	1,957	263
19-44	2,567	76	1,046	4,901	546
45-64	2,854	1,843	1,980	7,712	680
65-84	2,717	12,901	3,091	3,530	622
85+	10,197	22,726	8,940	5,569	1,450

per capita estimate for this particular group is $10,820 per year. This process is repeated for each age-sex cohort found in the original CMS estimates for 2018. The complete spending matrix can be found in Table B1. Our annual projected health care spending can thus be expressed as the following:

$$PHC_t = \left(\Sigma_{p\in P}\Sigma_{a\in A}\Sigma_{s\in S}\left(\widehat{CMS}_{aps} * \ cbo_pop_{ast}\right)\right) * \mu(p_t, w_t), \quad (1)$$

where $\widehat{CMS}_{aps}$ is our estimated per capita PHC for age group *a*, payer *p*, and sex *s*, cbo_pop_{ast} is the CBO projection for the US population in age group *a*, sex *s* in year *t*, and $\mu(p_t, w_t)$ is an elasticity adjustment factor, computed as a function of current prices and income. After computing personal health care expenditures for a given year, we then multiply each payer-level PHC estimate by an adjustment factor which maps to NHE, computed as the 2023 ratio. According to CMS, the aggregate ratio of NHE to PHC has been roughly constant over the past 15 years. Because the difference between NHE and PHC includes investment, public health, and the administrative cost of health insurance and government activities, we also make detailed allocations, as allowed by the data, to the federal government overall and to particular programs.

We also use the same population projections from CBO to generate our labor supply estimates. In addition, we use projections of labor force participation rates from CBO (2024) and 2000-2024 average unemployment rates by age group and gender and assume an initial 34.7 hours worked per week which declines by .05% per year, the same as what is assumed in the SSA Trustees' Report. We thus have the following equation for economy hours worked in year *t*:

$$L_t = \left(\Sigma_{s\in S}\Sigma_{a\in A'}(cbo_pop_{ast} * LFPR_{ast} * Emp_{as})\right) * hrs_t * 52, \quad (2)$$

where *a* is an element of *A'* = {[0, 15], [16, 19], [20, 24], [25, 54], [55, 64], [65, 74], [75+]}, $LFPR_{as}$ and Emp_{as} are the labor force participation rate and employment rate for age group *a* and sex *s*, and hrs_t is the hours worked per week for year *t*. Other variables are unchanged from Equation (1).

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