MACROECONOMIC EFFECTS OF REDUCING OASI TO PAYABLE BENEFITS: A COMPARISON OF SEVEN OVERLAPPING GENERATIONS MODELS

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In this paper we evaluate the effects of a reduction in Social Security's Old-Age and Survivors Insurance (OASI) benefits using seven different quantitative general equilibrium overlapping generations (OLG) models. We compare the effects of an anticipated one-third reduction in OASI benefits in 2031 on an economy that maintains currently scheduled benefits. We find many of the models generate qualitatively similar results concerning macroeconomic aggregates; however, the magnitude of the effects vary due to the models' structure and calibration strategies.

Keywords: Social Security, dynamic analysis

JEL Classification: E62, H30, H55

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I. INTRODUCTION

Jaeger Nelson and Kerk Phillips

According to the Congressional Budget Office (2018), if current law did not change, the Social Security Old-Age, Survivors, and Disability Insurance (OASDI) joint trust fund would be exhausted in calendar year 2031. Absent legislative action, following the exhaustion of the trust fund, Old-Age and Survivors Insurance (OASI) benefits would be reduced to payable benefits.[1] In this paper we evaluate a stylized payable benefits scenario taking the form of a one-third reduction in OASI benefits in 2031.[2] We compare the effects of the policy change across seven quantitative overlapping generations models that differ on several dimensions.

Despite significant differences within the models' structures, we find that the models generate broadly similar qualitative results. The effect of a reduction of OASI benefits on the time path of the debt-to-GDP ratio, aggregate capital stock, aggregate labor supply, GDP, wages, and interest rates are more or less consistent across models. The lower level of benefits induces agents to increase their private saving and labor supply. This in turn increases economic output along the projection window. In most models, the reduction in OASI outlays and rise in output lowers the debt-to-GDP ratio by 62-72 percentage points in the long run, relative to the baseline projection where OASI benefits remain at scheduled benefit levels.

Differences within the models' structure provide insight into how modeling choices influence results. For example, including both primary and secondary earners

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[1] The term "payable benefits" refers to the amount of OASI benefits that could be financed by current payroll tax revenue.

[2] This policy experiment is highly stylized and does not reflect any current or pending legislation. The modeling of the OASI program differs across models and the nature of these differences are detailed in Table 2 and Section III.

within a household results in stronger labor supply response as agents adjust hours on the extensive margin. The calibration of agents' preferences determines the strength of their consumption smoothing motive. Models with stronger consumption smoothing motives project larger changes in the aggregate capital stock. The inclusion of liquidity constrained agents results in a significant reduction in aggregate consumption following the benefit reduction in 2031, relative to models that permit all agents to have access to a saving technology and are therefore non-liquidity constrained. Finally, how the interest rate paid on government debt is modeled has important implications for the rise of government debt relative to GDP and the effects of the reduction in OASI benefits.

Section II overviews the Social Security payable benefits policy experiment analyzed in this paper. Section III summarizes the structure of the seven models used in this paper and highlights areas where the models are similar and where they differ. In Section IV we present the simulated effects of the payable benefits scenario and discuss the similarities and differences across model results and how modeling choices played a role in those outcomes.

II. THE POLICY EXPERIMENT

Jaeger Nelson and Kerk Phillips

Each of the models introduced in Section III is used to compute the effects of a payable benefits scenario, proxied via a one-third reduction in OASI benefits, in 2031. Each model contains varying degrees of institutional details pertaining to the OASI benefit structure (see Table 2 and Section III for details). For example, none of the models in this paper include an endogenous benefit claiming age. As always, the results presented in this paper are subject to simplifying assumptions.

To compute the effect of a one-third reduction in OASI benefits, each model is simulated twice. The first simulation is the benchmark economy that does not include the change in OASI benefits (i.e. under scheduled benefits). The second simulation is the counterfactual economy that includes the reduction in OASI benefits (i.e. payable benefits). In the counterfactual economy the policy change is announced in 2018 and viewed as credible from the agents' perspective. Results of the policy change are presented as the counterfactual economy's deviations from the benchmark (either in percentage or percentage point terms).

The models used in this paper require the government's debt to stabilize as a share of GDP in the long run. This is because agents in the model are forward looking and an unsustainable debt path would result in the models failing to solve. Under current law, projected government deficits would have government debt, as a share of GDP, increasing perpetually. To address this, in both the benchmark and counterfactual economies, we assume the government enacts a fiscal policy change that stabilizes the debt-to-GDP level from the year 2050 forward. This type of policy change is referred to as the "closure rule" in fiscal policy models.[3]

Closure rules have two design aspects. The first is their timing and the second is the policy tool used to stabilize the debt. As the objective of this exercise is to evaluate a payable benefits scenario, we chose a closure rule that minimizes its effect on the results. To this end we chose a closure date — year 2050 — far enough into the future to allow the dynamics of the payable benefits scenario to play out undisturbed.[4] For this paper we

[3] For a more in depth discussion regarding closure rules see Moore and Pecoraro (2018*a*).
[4] Extending the closure date beyond 2050 results in some models failing to solve as debt-to-GDP reaches extremely high levels the further the closure date is pushed into the future.

chose to use the least distortionary policy tool available in each model. These policy tools include non-valued government spending and lump sum transfers.[5] All closure rules stabilize stabilize debt-to-GDP immediately and are not phased in over time.

III. THE MODELS

Jaeger Nelson and Kerk Phillips

Seven different general equilibrium overlapping generations model are used in this paper to analyze the effects of a reduction in Social Security OASI payments. While the models differ along many dimensions they do share common traits. A broad overview of model characteristics can be found in Tables 1 and 2.

In each model a period is equal to one year and the economy is populated with a measure of heterogeneous agents.[6] Agents differ in all models by their age, wealth, and income.[7] Some models have additional dimensions of heterogeneity but those three are common across all models. Agents make consumption-saving decisions in each period of life and make a labor-leisure choice during their working career.[8]

Production varies across all models; however, they all take private capital and labor as inputs into their CES production functions.[9] The government collects revenues from agents via a mix of income, payroll, consumption, and lump-sum taxes. Tax treatment on the production side of the economy differs across models. All models include some version of a public pension system. Some models explicitly model the OASI program while others proxy for one via an age and income dependent transfer program. The government is allowed to run a budget surplus or

[5] In some models non-distortionary government spending may go negative. Lump-sum transfers can be equivalently interpreted as lump-sum taxes.
[6] In some models "agents" are individuals while others define "agent" as some concept of the "household".
[7] The way income heterogeneity is modeled differs across models.
[8] Retirement age (and by extension working-age) differ across models.
[9] Some models include other inputs such as public capital and differentiated labor inputs.

deficit in any given period; however, all models require that, in the long run, debt-to-GDP is stabilized. This concept is discussed in Section II.

Models differ on their modeling of the rest of the world. For this paper we chose simulate the models as large open economies (LOE) where possible and closed a LOE wasn't possible. Another area where models differ is in how they model Some models are simulated using steady state demographics while others allow the economy to be simulated with calibrated non-stationary demographics over the projection window.[10]

[INSERT TABLE 1 HERE]

[INSERT TABLE 2 HERE]

A. Congressional Budget Office Model[11]

Jaeger Nelson and Kerk Phillips

In CBO's model, a period is equal to one year and the economy is populated with heterogeneous households that differ according to their age, wealth, labor productivity, and average lifetime earnings. Households begin potentially working and saving at age 21 and live for a maximum of 80 periods. In each period of life households face age-dependent mortality risk. From ages 21-75 households' labor productivity is uncertain and follows a discrete Markov process. Households optimally choose their labor supply on both intensive and extensive margins until age 75, at which point they are forced to retire. In each period, households also make a consumption-saving decision.

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[10] In the long run all models transition to a stationary demographic structure.
[11] A full description of the Congressional Budget Office's OLG model can be found in Nishiyama and Reichling (2015).

Firms are perfectly competitive and have access to a constant-returns-to-scale (CRS) Cobb-Douglas production technology that uses capital and labor as inputs. The government collects tax revenues from a progressive income tax on labor and capital income, payroll taxes, consumption taxes, and a lump-sum tax. The government operates an OASI program that follows current law's Primary Insurance Amount (PIA) benefit formula and proxies for households' average monthly indexed earnings (AMIE) with their average labor income using wage growth as the index.[12] The government also makes transfers to households through lump-sum disability insurance (DI), hospital insurance (HI), and a general lump-sum transfer. Accidental bequests are collected by the government and are redistributed to surviving working-age households in every period. The government is free to operate a budget surplus or deficit in any given period and pays an interest rate on its debt that is a fraction of the rate of return on capital. The government budget also includes a non-distortionary government spending category.

The version of the model used in this paper is a large open economy and uses steady state demographics.[13] In the simulations presented in this paper the debt-to-GDP ratio is stabilized at its endogenous level in 2050 by changing non-valued government spending in each period after 2050.

B. Diamond-Zodrow Model[14]

John Diamond and George Zodrow

In the Diamond-Zodrow (DZ) model, a period is equal to one year and the economy is populated with heterogeneous households that differ according to their age, wealth, and lifetime

[12] Households begin receiving OASI benefits once they turn 65, but they may choose to continue working until age 75 if they see it optimal to do so.
[13] The openness of the economy is controlled by a parameter, χ, where χ is the weight placed on factor prices resulting from a closed economy and $(1-\chi)$ is the weight placed on the initial steady state factor prices in the small open economy case. For our standard baseline case we set $\chi = 0.30$.
[14] A full description of the Diamond-Zodrow Model (DZ) can be found in Zodrow and Diamond (2013).

income level. Households become economically relevant at age 23 and live for 55 periods with certainty. Households work for the first 45 periods of their life before retiring at age 68. In each period of the households' working life they make a labor-leisure and consumption-saving choice to maximize their lifetime utility. Once retired, households make a consumption-saving decision and must save to finance a fixed target bequest. Household consumption is a composite commodity comprised of a composite non-housing good and composite housing service.

The non-housing consumption is produced via a constant-elasticity-of-substitution (CES) aggregator of corporate and non-corporate goods. The housing service is produced via a CES aggregator of owner-occupied housing and rental services. The corporate sector includes all business subject to the corporate income tax. The non-corporate sector encompasses all pass-through entities including S corporations, partnerships, LLCs, LLPs, and sole proprietorships. Corporate and non-corporate sectors have access to their own CES production functions. Owner-occupied housings and rental services — operated by landlords — produce housing services with the same CES production function. Each sector is operated by a "manager" that seeks to maximize the value of their firm in a perfectly competitive environment in the presence of investment adjustment costs. Thus the time paths of investment by firms take into account the costs of adjusting their capital stocks.

The government collects tax revenues from corporate income taxes, progressive labor income taxes, and a proportional tax on capital income. The model includes considerable detail on business taxation, including separate tax treatment of corporate and pass-through entities, separate tax treatment of owner-occupied and rental housing, and separate tax treatment of new and old capital, including explicit calculation of asset values before and after the enactment of reform. The model also includes the progressive taxation of labor income for households at different income levels, and captures differential taxation of different types of capital income (but does not include differential capital income taxes across income groups). Government expenditures include a fixed amount of the composite goods purchased at market prices, transfer payments, and interest payments on existing government debt. Transfer payments include non-Social Security payments and a Social Security system funded by payroll taxes with a cap on earnings of high income households. Benefits are based on wage payments in the highest 35 years of earnings and a replacement rate that varies by wage income levels.

The version of the model used in this paper is a large open economy and uses stationary demographics. In the simulations presented in this paper the debt-to-GDP ratio is stabilized at its endogenous level in 2050 by changing non-valued government spending in each period after 2050.

C. EY QUEST Model[15]

Robert Carroll, James Mackie, and Brandon Pizzola

In the EY QUEST model, a period is equal to one year and the economy is populated with heterogeneous individuals that differ according to their age, wealth, average lifetime earnings, and access to capital markets. Individual's endowment of human capital changes with age — growing early in life and declining later in life. The model also distinguishes between two types of individuals: those that have access to capital markets (savers) and those that do not (non-savers or rule-of-thumb individuals).[16] Households become economically relevant at age 21 and

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[15] A full description of the EY Model can be found in Pizzola, Carroll and Mackie (2018).

[16] The model assumes 50 percent of US households are permanently non-savers and 50 percent are permanently savers across all age cohorts.

live for 55 periods with certainty. In each period of the households' life they make a labor-leisure choice and, if they have access to capital markets, a consumption-saving choice to maximize their lifetime utility.

Firms are perfectly competitive and have access to a CES production function that uses capital and labor as inputs. The model includes industry-specific detail through use of differing costs of capital, factor intensities, and production function scale parameters.[17] Such a specification accounts for differential use of capital and labor between industries as well as distortions in factor prices introduced by the tax system. The cost of capital measure models the extent to which the tax code discriminates by asset type, organizational form, and source of finance. Each of the 36 industries has a corporate and pass-through sector except for owner-occupied housing and government production. Because industry outputs are typically a combination of value added (i.e., the capital and labor of an industry) and the finished production of other industries (i.e., intermediate inputs), each industry's output is modeled as a fixed proportion of an industry's value added and intermediate inputs to capture inter-industry linkages. These industry outputs are then bundled together into consumption goods that consumers purchase.

The government collects tax revenues from income taxes on labor and capital income, payroll taxes, and lump-sum taxes. Government spending is classified as either transfer payments to representative individuals or the provision of public goods. Transfer payments are assumed to be either Social Security payments or other transfer payments. Social Security payments are calculated in the model based on the 35 years in which a representative individual earns the most labor income. Other transfer payments are

[17] The industry detail included in this model corresponds approximately with three-digit North American Industry Classification System (NAICS) codes and is calibrated to a stylized version of the 2014 US economy.

distributed on a per capita basis. Public goods are assumed to be provided by the government in fixed quantities through the purchase of industry outputs as specified in a Leontief function. The government is free to operate a budget surplus or deficit in any given period and pays an interest rate on its debt.

The model is an open economy model that includes both capital and trade flows between the United States and the rest of the world. International capital flows are modeled through the constant portfolio elasticity approach of Gravelle and Smetters (2006). This approach assumes that international capital flows are responsive to the difference in after-tax rates of return in the United States and the rest of the world through a constant portfolio elasticity expression. Products made in the United States are assumed to be imperfect substitutes versus production from the rest of the world (following Armington (1969)). The demographics in the model are stationary. In the simulations presented in this paper the debt-to-GDP ratio is stabilized at its endogenous level in 2050 by changing lump-sum transfers in each period after 2050.

D. The Global Gaidar Model[18]

Seth Benzell, Guillermo Cuevas Lagarda, Laurence Kotlikoff, and Victor Ye

The Global Gaidar Model (GGM) features 17 regions, where each region is contains its own demographic trends and set of fiscal policies. Each region is inhabited by heterogeneous households that differ according to age, wealth, labor productivity, and family composition. Individuals are born at age zero into one of two permanent labor productivity states in the model and live for a maximum of 91 periods. Individuals under the age of 21 are non-working children and are supported by their parents. Upon turning 21, individuals become economically active.

[18] A full description of the Global Gaidar Model (GMM) can be found in Benzell, Kotlikoff and LaGarda (2017).

Between the ages of 23 and 45 individuals have children of their own via fractional births.[19] There is perfect intergenerational immobility. In other words, low skilled children are always born to low skilled parents and the same goes for high skilled individuals. Individuals face mortality risk at every age and maximize their lifetime utility by making a consumption-saving decision in each period and a labor-leisure choice starting at age 21 until retirement, which varies by region. Individuals value the children's well-being via a CARA function of the utility of their children through age 21. Households' preferences are calibrated separately by region. Individuals may leave accidental bequests. Bequests left by each skill type are left uniformly to adult children of the decedent skill types. Bequests received are not idiosyncratic as all children of decedents of the same age and skill type share in the collective bequests of the all such decedents.

Each region's total economic output is comprised of energy and non-energy production. The energy sector models fossil fuel endowments as throwing off a fixed stream of output through the date of exhaustion.[20] The non-energy sector has access to a CRS Cobb-Douglas production technology that uses capital and the two types of labor as inputs. As a result, low skilled and high skilled individuals earn different wage rates. Capital is freely mobile across all regions. The model includes common productivity growth in the form of a fixed growth rate of the time endowment of successive new cohorts, and cohort-specific and region-specific catch up productivity growth.

[19] Fractional births facilitate calibrating realistic age-distributions of each region's population, initially and through time.
[20] In the calibrated version of the model, the fossil-fuel reserves are exhausted in the year 2083.

Each region has a government that collects revenues from natural resources, corporate taxes, payroll taxes, consumption taxes, and income taxes. The model is carefully calibrated to IMF fiscal and economic aggregates. To generate realistic marginal and average corporate tax rates, individuals receive a fraction of gross corporate tax revenues, via a lump-sum rebate, that is proportional to their asset holdings. The government expends resources on health and education that depends on the regions age structure. The government also runs a general expenditure program, a non-age specific transfer program, and a pension program. Each region's pension program transfer a fixed fraction of average lifetime earnings to individuals after they have reached their exogenous retirement age.

The U.S. economy is modeled as a distinct region and is neither a small open economy nor a large open economy as the U.S. is only one of 17 interacting regions in the model. The 17 regions in the model include 99 percent of the world's population. The model also includes age and region-specific net immigration. Every year new immigrants in each skill and age group arrive to — or, on net, depart — each region with the same number and age distribution of children and the same level of assets as natives in the region who share the same age and level of skill. Each region's age- and year-specific net immigration rates are set exogenously based on U.N. projections. Once immigrants join a native cohort, they experience the same age-specific fertility and mortality rates as native-born cohort members. In the simulations presented in this paper the debt-to-GDP ratio is stabilized at its endogenous level in 2050 by changing non-valued government spending in each period after 2050.[21]

[21] Government expenditures were set to approximately stabilize the debt-to-GDP ratio with fixed tax rates, but the latter fluctuate slightly to keep debt-to-GDP precisely fixed after 2050.

E. JCT In-House Model[22]

Rachel Moore and Brandon Pecoraro

In the JCT In-House model, a period is equal to one year and the economy is populated with heterogeneous households that differ according to their age, wealth, family composition (single or married), labor productivity, and average lifetime earnings. Households become economically active at age 25, retire by age 65, and live for a maximum of 66 periods. Households are matched with children, and the number and age of children assigned depends on the household's age, family composition, and productivity type. Individuals in each household optimally choose their labor supply from a discrete set of options - unemployed, part time, or full time - which explicitly captures both extensive and intensive labor decision margins. In the case of married households, this labor supply decision is made jointly by both primary and secondary earners. Individuals face both fixed and variable costs for working, including child-care costs that scale with the number of children within a given household. In addition to their labor supply decision(s), households optimally choose their charitable giving, leisure, consumption, and saving levels. All households derive utility from market consumption, charitable giving, housing services, and home production while they experience disutility from market work. Home production is generated from hours not spent in market work or leisure. Charitable giving occurs due to a warm-glow motive. Housing services are realized from either a rental unit obtained the financial intermediary, or from an owner-occupied home.

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[22] A full description of the JCT In-House Model can be found in Moore and Pecoraro (2018*b*) and Moore and Pecoraro (2019).

Households deposit savings with a representative financial intermediary who maintains a portfolio of investments on their behalf, allocating deposits across investment vehicles optimally in the aggregate, and passing all returns back to households. This portfolio is comprised of corporate and non-corporate equity and bonds, federal government bonds, rental housing property, as well as mortgage and consumer debt to households. There is an exogenous risk-wedge allowing the government to pay a lower interest rate on debt than firms. Households who borrow to finance consumption or housing purchases do so at the portfolio rate of return.

Distinct corporate and non-corporate sectors are perfectly competitive and have access to a CRS production technology that uses government capital, private capital, and labor as inputs. Sectors differ in terms of firm financing and tax treatment. The representative non-corporate firm issues debt to finance operations and pays out distributions to equity holders which are subsequently taxed as ordinary income. The representative corporate firm faces a business-level tax, issues both debt and new equity to finance operations, and pays dividends to equity holders which are subsequently taxed as preferential income. Gains on equity, which are taxed on an accrual-equivalent and preferential basis, occur when firm value increases. Hiring and investment decisions of both firms are made optimally over an infinite planning horizon, and incorporate the incentive effects of tax deductions, credits and expensing applicable to wages, interest, investment, depreciation, and production.

Tax liability on household income is determined by an internal tax calculator that incorporates aspects of tax law as written in the Internal Revenue Code, such as the statutory marginal tax rate schedule, personal and dependent exemptions, as well as key deductions and credits. Distinction is made for different types of capital income so that labor income is taxed jointly with ordinary capital income and preferred capital income receives special tax treatment.

The taxable portion of social security benefits are taxed jointly with other realized income. Accidental bequests are collected by the government and are redistributed to surviving households in every period. The government operates an OASI program that follows current law's PIA benefit formula and proxies for households' AMIE with their average lifetime earnings. Government expenditures also include non-OASI transfer payments to households, capital expenditures, and non-distortionary government spending. The government is free to operate a budget surplus or deficit in any given period.

The version of the model used in this paper is a large open economy.[23] While the total population grows at a constant rate, the proportion of married and single households varies over household ages in a time-invariant fashion. In the simulations presented in this paper the debt-to-GDP ratio is stabilized at its endogenous level in 2050 by changing non-valued government spending in each period after 2050.

F. OG-USA Model[24]

Jason DeBacker and Richard Evans

In THE OG-USA model, a period is equal to one year and the economy is populated with heterogeneous households that differ according to their age, wealth, and lifetime income group (labor productivity). Households become economically relevant at age 21 and live for a maximum of 80 periods. In each period of life households face age-dependent mortality risk. Households receive lump-sum bequests (accidental) in each period of life that varies according to their age and lifetime income group. Households

[23] The JCT In-House Model assumes that 40 percent of newly issued government debt is taken up by foreign investors.
[24] A full description of the OG-USA Model can be found in Evans and DeBacker (2018).

optimally choose their labor supply and make a consumption-saving decision in each period to maximize their lifetime utility.

There is one representative firm that has access to a CES production function that uses uses capital and labor as inputs. The firm pays a corporate income tax and is allowed to expense a percent of capital depreciation. The OG-USA model uses the methodology from DeBacker, Evans and Phillips (2019) to incorporate rich federal tax information into the overlapping generations model by using an open source microsimulation model—Tax-Calculator.[25]

The government collects tax revenues from households and firm. Households labor and capital income are taxed at estimated effective marginal tax rates from the microsimulation model tax calculator. The government spends resources on transfers to households and on government consumption. Transfers are modeled as lump-sum and differ by age and lifetime income group. Transfers are distributed uniformly across households within each age-income group. The government is free to operate a budget surplus or deficit in any given period and pays an interest rate on its debt.

The version of the OG-USA model used in this paper is a closed economy in which all markets within the economy must clear internally.[26] However, there is some capital imports and exports from the demographics as immigrants bring capital with them. The OG-USA model incorporates non-stationary population dynamics that include mortality, fertility, and net immigration by age. In the simulations presented in this paper the debt-to-GDP ratio is stabilized at 200 percent of GDP in 2050 by changing non-valued government spending in each period after 2050.

[25] Tax Calculator: https://github.com/open-source-economics/Tax-Calculator.
[26] The OG-USA model also has a small open economy setting in which the interest rate is fixed at the world interest rate and capital can flow freely across the border to satisfy capital market clearing at the world interest rate.

G. Penn Wharton Budget Model[27]

Efraim Berkovich and Jagadeesh Gokhale

In PWBM's model, a period is equal to one year and the economy is populated with heterogeneous households that differ according to their age, wealth, labor productivity, and average lifetime earnings. Households become economically relevant at age 20 and live for a maximum of 81 periods. In each period of life households face age-dependent mortality risk. Households' labor productivity is uncertain and follows a discrete Markov process. Households optimally choose their labor supply on both intensive and extensive margins until their cohort-dependent retirement date, at which point they are forced to retire. In each period, households also make a consumption-saving decision. There is one representative, price-taking, firm that has access to a CRS Cobb-Douglas production technology that uses capital and labor as inputs. The firm is split into a corporate and pass-through sector. Firms are allowed to issue one-period debt to maximize their profits via the interest rate deduction. Firms are exposed to capital adjustment costs, other expenses, tax credits, and the tax code's preferential treatment of investment and capital depreciation. All tax parameters come from the PWBM microsimulation model and tax module.

The government collects tax revenues from corporate taxes, ordinary taxes on income, preferred taxes on some business income, payroll taxes, and consumption taxes. The government operates an OASI program that follows current law's PIA benefit formula and proxies for households' AMIE with their indexed average labor income. Accidental bequests are collected by the government and are redistributed to surviving

[27] A full description of the Penn Wharton Budget Model's OLG model can be found in PWBM (2018).

households in every period. The government is free to operate a budget surplus or deficit in any given period and pays an exogenous interest rate on its debt that comes from the microsimulation model. The government budget also includes a lump-sum non-distortionary government spending category.

The version of the model used in this paper is a partially open economy where newly issued government debt is partially acquired by foreigners.[28] The model uses demographic projections from the PWBM microsimulation model that includes age-dependent immigration rates. In the simulations presented in this paper the debt-to-GDP ratio is stabilized at its endogenous level in 2050 by changing non-valued government spending in each period after 2050.

IV. DISCUSSION OF RESULTS

Jaeger Nelson and Kerk Phillips

In this section the results of the payable benefit scenario across all seven models outlined in Section III are presented and the similarities and differences across model results are discussed.

The cut in OASI benefits reduces the size of the deficit beginning in 2031 and as a result debt-to-GDP is notably lower in the long run. Additionally, the lower deficit means that the size of the policy change necessary to stabilize the debt-to-GDP level in 2050 is smaller under the payable benefits scenario. The reductions in the debt-to-GDP ratio are consistent across most models (see figure 2), both in terms of the final level and transition path.[29] The GMM model

[28] The PWBM estimates that 40 percent of newly issued government debt is taken up by foreign investors.
[29] Due to an alternative closure rule, the OGUSA model stabilizes debt as a share of GDP at the initial steady state level.

finds a larger reduction in the debt-to-GDP level relative to the other models. This is driven largely by the assumptions regarding the interest rate paid on government debt.

The cut in OASI benefits also increases private saving that pushes up the productive capital stock. This result stems from agents' desire to smooth consumption over their life-cycle. Aggregate capital's response to the payable benefits scenario is qualitatively consistent across models (see figure 3); however, quantitatively the differences are economically significant. The strength of agents' desire to smooth consumption over their lifetime differs across models and accounts for some of the variance in the capital stock's response to the benefit reduction. The immediate rise in the capital stock in the Global Gaidar Model is driven by the capital inflow resulting from an increase in the domestic labor supply. The slower rise in aggregate capital in the JCT In-House Model is driven by firm financing and firms' ability to conduct stock buy-backs.

The reduction in benefits increases agents' labor supply in most models (see figure 4). The results are qualitatively similar across most models, with the OGUSA model finding a reduction in the aggregate labor supply. The JCT In-House Model includes both primary and secondary earners and the non-smooth labor supply response along the transition path is attributed to the indivisible intensive margin choice set and the presences of secondary earners' labor supply response on the extensive margin.

For most models, the increase in the aggregate capital stock and labor supply increase GDP along the transition path (see figure 5). The variability across models stems from the sensitivity of the aggregate capital stock and labor supply to the reduction in benefits.

Despite the increase in GDP, aggregate private consumption falls in each period along the transition path (see figure 6).[30] The presence of households that are liquidity constrained in the EY model results in a sudden drop in aggregate consumption following the reduction in OASI benefits. These households have no mechanism through which to smooth consumption over their life-cycle and the one-third reduction in OASI benefits necessarily comes straight out of their consumption in retirement.

As the productive capital stock rises proportionally more than the labor supply in most models, wages increase along the transition path (see figure 7). Through the same channel, the interest rate agents' earn on their asset holdings falls over time before stabilizing in the long run (see figure 8). Between the increase in the labor supply and wage rate, the OASI program receives more payroll tax revenue under the payable benefits scenario than under scheduled benefits. Furthermore, for those models that incorporate OASI benefits' dependence on agents' average monthly indexed earnings (AMIE), the total reduction in OASI outlays is less than one-third, as agents' average earnings over their lifetime also increased after the reduction in the replacement rates.

A. Other Takeaways

Jaeger Nelson and Kerk Phillips

In this section we discuss other things we learned from the policy experiments conducted in this paper, but also from experiments we ran as part of the OLG Symposium hosted by CBO in December 2018 and conversations that followed.

[30] With the exception of a few years near the end of the projection window in the JCT In-House Model. This result is primarily driven by the periods' proximity to the closure rule. Long-run aggregate consumption is lower under the payable benefit scenario.

The inclusion of non-stationary demographics do not significantly change the effects of a payable benefits scenario over the projection window. However, including non-stationary demographics are likely to be important when projecting levels and the baseline and less when computing deviations from the baseline that result from a policy experiment.

In models with fully rational, forward-looking, and non-liquidity constrained agents, the short-run demand effect is modest to non-existent. However, the inclusion of households that are liquidity constrained has significant implications for the policy's effect on aggregate consumption, but the effects are not reflected by GDP.

The degree of openness in the model economy is critical. After comparing small and large open economies, we use a large open economy to analyze policy changes in the United States. Different modeling groups chose to incorporate different assumptions about how the domestic economy interacts with the rest of the world (through debt issuance and capital flows). The Global Gaidar Model allows the US economy to transition from a large open economy to a much smaller open economy as the rest of the world's growth exceeds that of the US along the projection window. This is a modeling aspect that warrants additional attention.

When comparing policy analysis across models it is crucial to have a common closure rule, both in terms of timing and structure. This is often infeasible as different models contain different policy tools that can be used to stabilize the debt-to-GDP ratio. Furthermore, some models have convergence issues if the date of stabilization occurs too far into the future. Thus there is a balancing act between having stabilization occur far enough in the future that the policy analysis of interest is minimally distorted, and having it early enough that the model can be solved. Furthermore, some models allow the closure rule to phase in over time (say 10 years). We found that gradually adjusting the closure instrument over a fixed time window does not matter as much as the date of debt-to-GDP stabilization when considering the long-run level of debt-to-GDP.

Finally, whether or not the policy change is anticipated or unanticipated appears not to make a big difference when considering macroeconomic aggregates in the long run. Both simulations were run in the CBO model, EY QUEST model, JCT In-House Model, and the Penn Wharton Budget Model and only small effects along the transition were found. This is because the response of households to change in policy 13 years into the future is smooth and modest. However, the difference is likely to have important implications for welfare and distributional analysis.

TABLES AND FIGURES

Table 1

Overview of OLG Model Features I

Model Name	Household Characteristics			Production	Openness	Demographics
	Life-Cycle	Heterogeneity	Choices			
Congressional Budget Office	Max Life: 80 periods Mortality Risk Labor Productivity Risk	Age, Wealth, Labor Productivity, and Average Earnings	Labor/Leisure, Consumption/Saving, and Retirement Age (65—75)	Inputs: Capital and Labor	Large Open	Stationary
Diamond-Zodrow Model	Max Life: 55 periods	Age, Wealth, and Lifetime Income Level	Labor/Leisure, Consumption/Saving, and Bequests	Inputs: Capital and Labor Sector(s): Corporate, non-Corporate, Owner Occupied Housing, and Rental Services	Large Open	Stationary
EY QUEST Model	Max Life: 55 periods	Age, Wealth, Average Earnings, and Access to Capital Markets	Labor/Leisure, and Consumption/Saving	Inputs: Capital and Labor Sector(s): 36 Industries each with a Corporate and Pass-through sector	Large Open	Stationary
Global Gaidar Model	Max Life: 91 periods Mortality Risk	Age, Wealth, Labor Productivity, and Family Composition	Labor/Leisure, and Consumption/Saving	Inputs: Capital, Labor(x2), and Natural Resource Endowment Sector(s): Energy and non-Energy	Global Model	Non-Stationary
Joint Committee on Taxation In-House Model	Max Life: 66 periods Mortality Risk	Age, Wealth, Labor Productivity, and Family Composition	Labor/Leisure, Consumption/Saving, Charitable Giving, and Housing (rent/own)	Inputs: Private Capital, Public Capital, and Labor Sector(s): Corporate and non-Corporate	Large Open	Stationary
OG-USA	Max Life: 80 periods Mortality Risk	Age, Wealth, and Lifetime Income Level	Labor/Leisure, and Consumption/Saving	Inputs: Capital and Labor	Large Open	Non-Stationary
Penn-Wharton Budget Model	Max Life: 81 periods Mortality Risk Labor Productivity Risk	Age, Wealth, Labor Productivity, and Average Earnings	Labor/Leisure, and Consumption/Saving	Inputs: Capital and Labor Sector(s): Corporate and Pass-Through	Large Open	Non-Stationary

Table 2

Overview of OLG Model Features II

Model Name	Government		Closure Rule
	Revenues	Outlays	
Congressional Budget Office	Income tax on capital and labor, payroll taxes, consumption tax, and a lump-sum tax	OASI program that depends on average earnings, lump-sum transfers (general, SSDI, and Medicare), and non-distortionary spending	Non-distortionary government spending Debt-to-GDP stabilized at 2050 level
Diamond-Zodrow Model	Income tax, payroll taxes, proportional tax on capital income, and corporate taxes	Pension program that depends on income level, other transfer payments, and non-distortionary spending	Non-distortionary government spending Debt-to-GDP stabilized at 2050 level
EY QUEST Model	Income tax on capital and labor, payroll taxes, and a lump-sum tax	OASI program that depends on average earnings, other transfer payments, and spending on public goods	Lump-sum transfer payments Debt-to-GDP stabilized at 2050 level
Global Gaidar Model	Income taxes, payroll taxes, consumption taxes, corporate taxes, and natural resource revenues	Pension program that depends on average earnings, non-age specific transfer program, and health and education spending	Non-distortionary government spending[1] Debt-to-GDP stabilized at 2050 level
Joint Committee on Taxation In-House Model	Detailed internal tax calculator for households' tax liability Corporate and non-corporate taxes	OASI program that depends on aggregate average earnings, non-OASI transfer payments, capital expenditures, and non-distortionary spending	Non-distortionary government spending Debt-to-GDP stabilized at 2050 level
OG-USA	Income tax, and corporate taxes	Pension program that depends on income level, and non-distortionary spending	Non-distortionary government spending Debt-to-GDP stabilized at 200 percent of GDP in 2050, for all scenarios
Penn-Wharton Budget Model	Income tax (preferred and ordinary), payroll taxes, consumption tax, and corporate taxes	OASI program that depends on average earnings, and non-distortionary spending	Non-distortionary government spending Debt-to-GDP stabilized at 2050 level

[1] In addition to non-valued government spending, small changes in income and consumption tax rates were necessary to solve the model.

Figure 1

Percentage Point Change in Debt-to-GDP

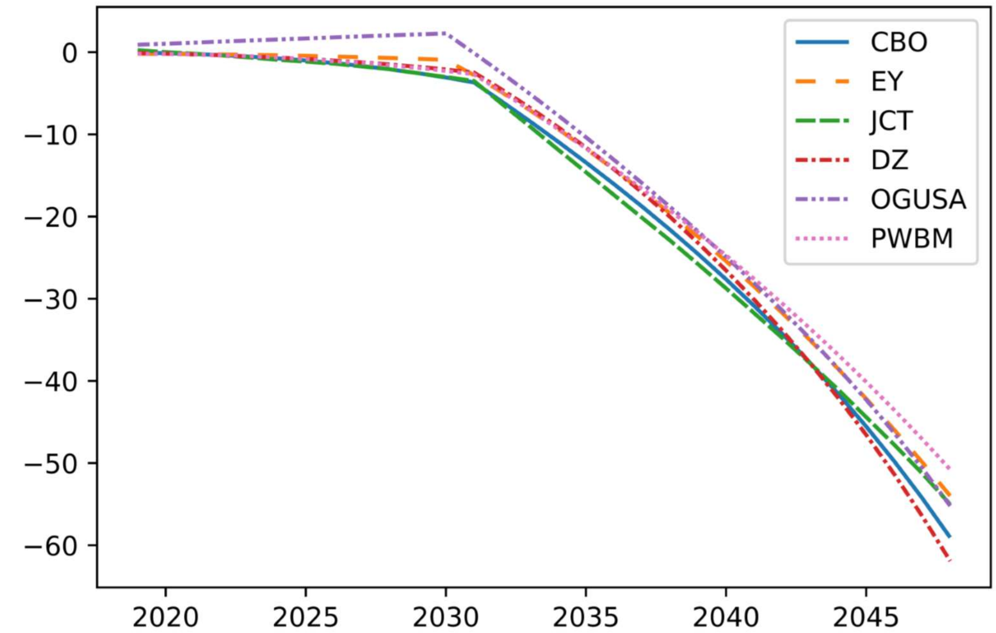


Figure 2

Percentage Point Change in Debt-to-GDP

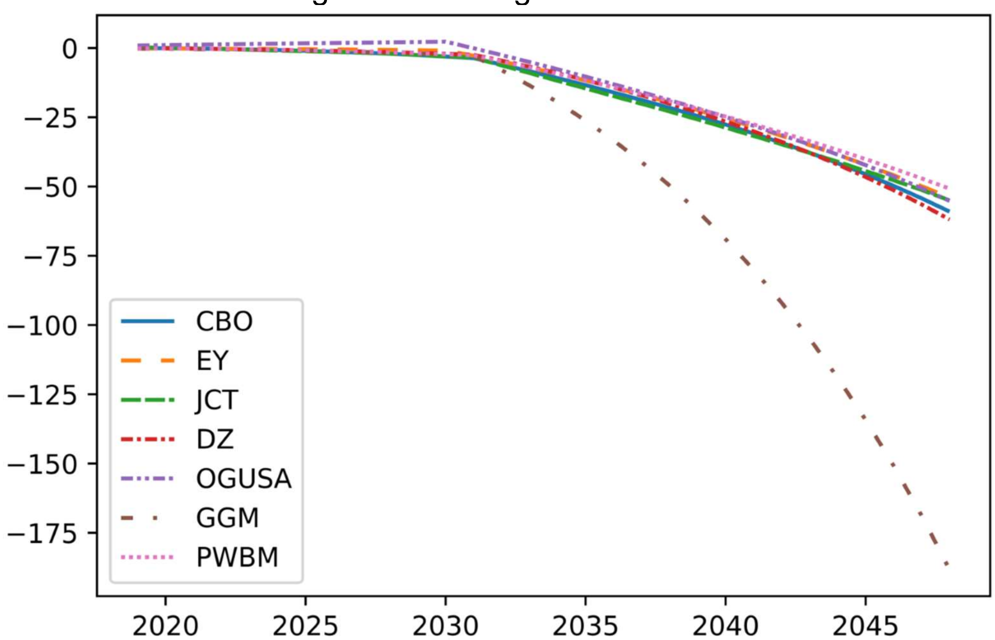


Figure 3
Percentage Change in Aggregate Capital

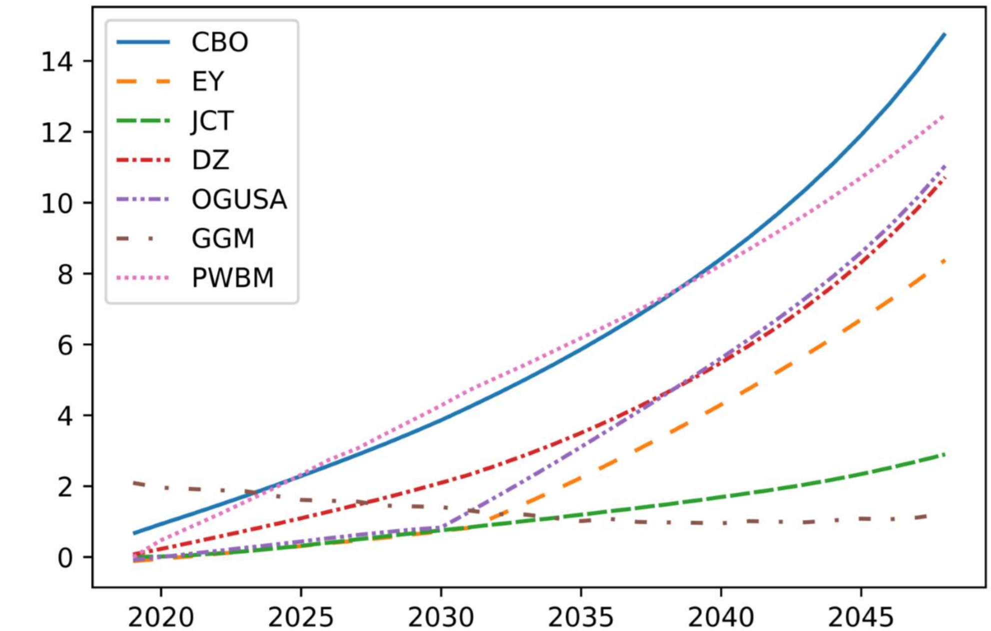


Figure 4
Percentage Change in Aggregate Labor

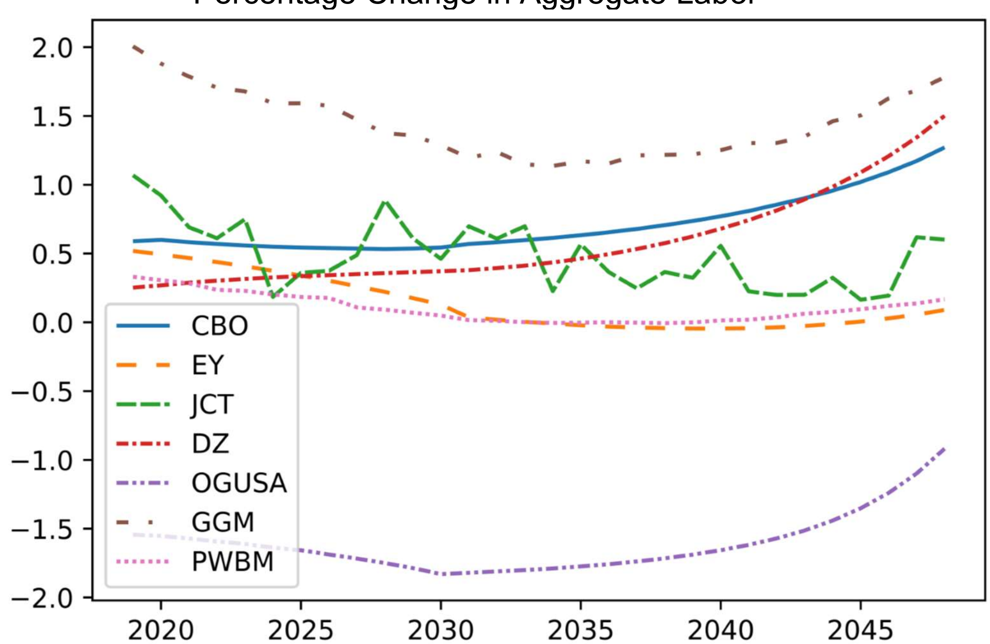


Figure 5
Percentage Change in GDP

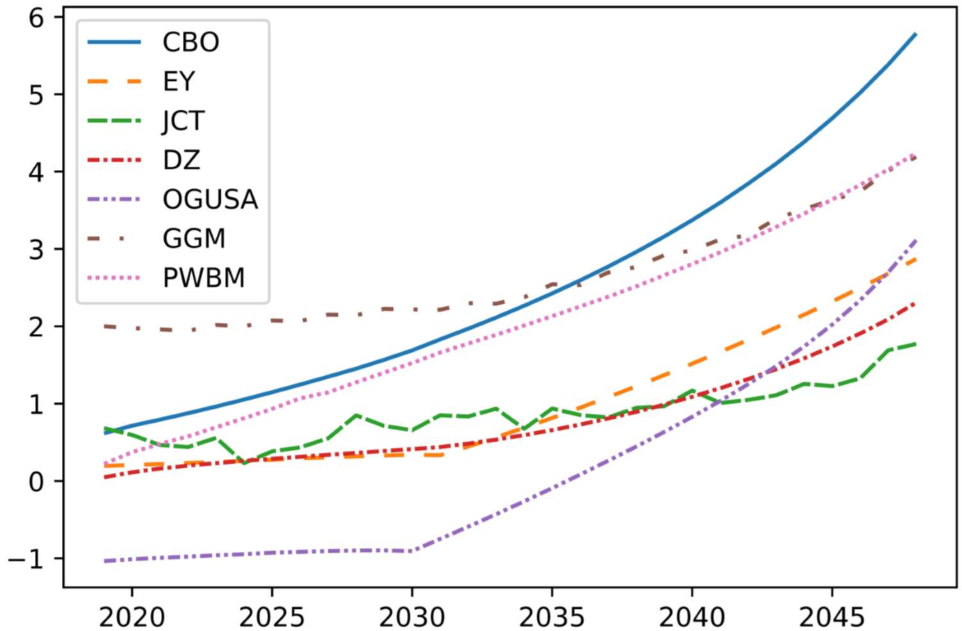


Figure 6
Percentage Change in Aggregate Consumption

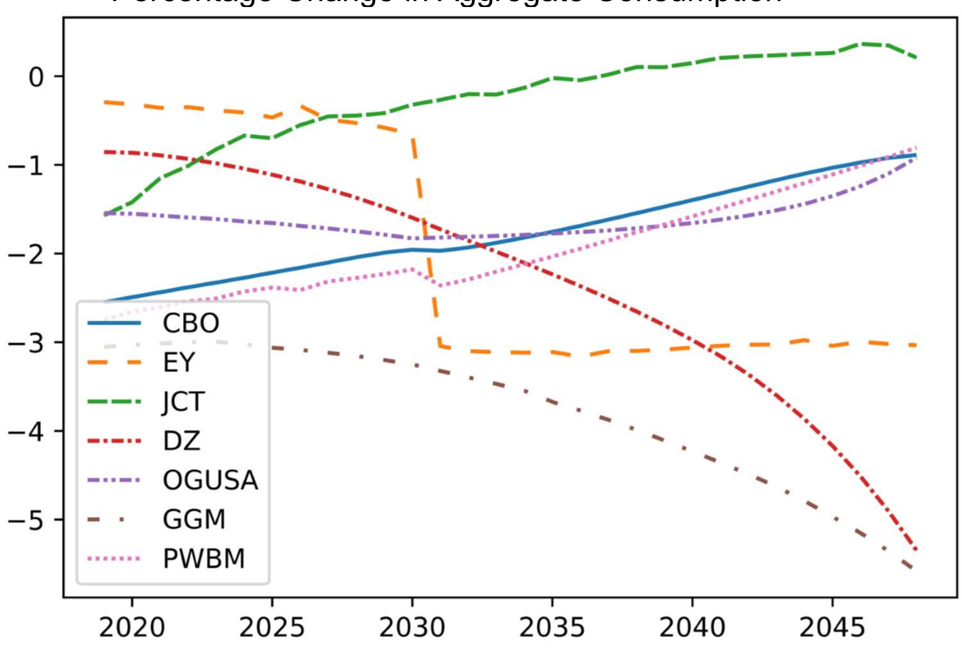


Figure 7
Percentage Change in Wages

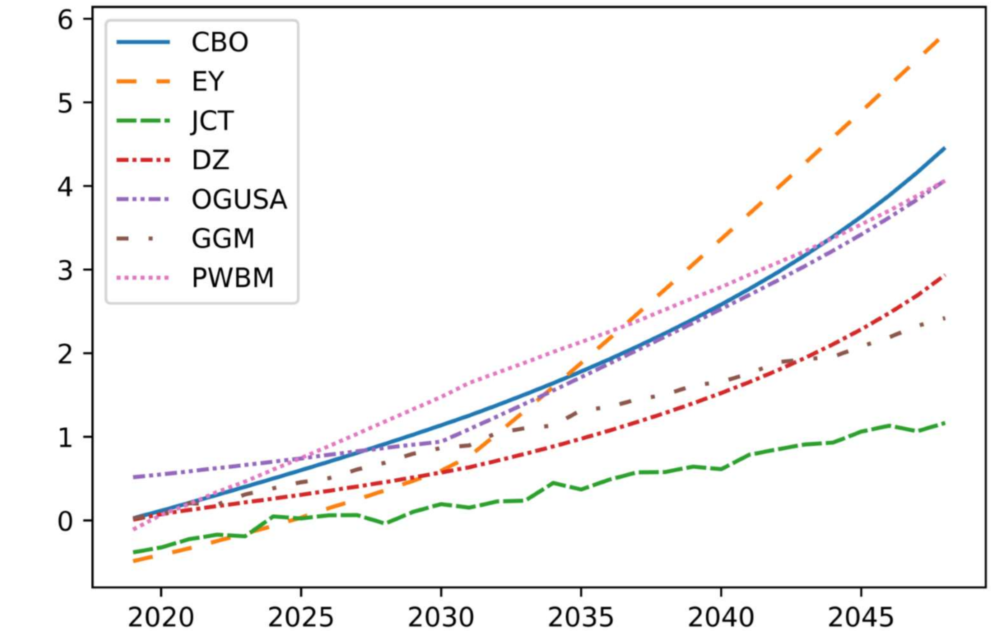
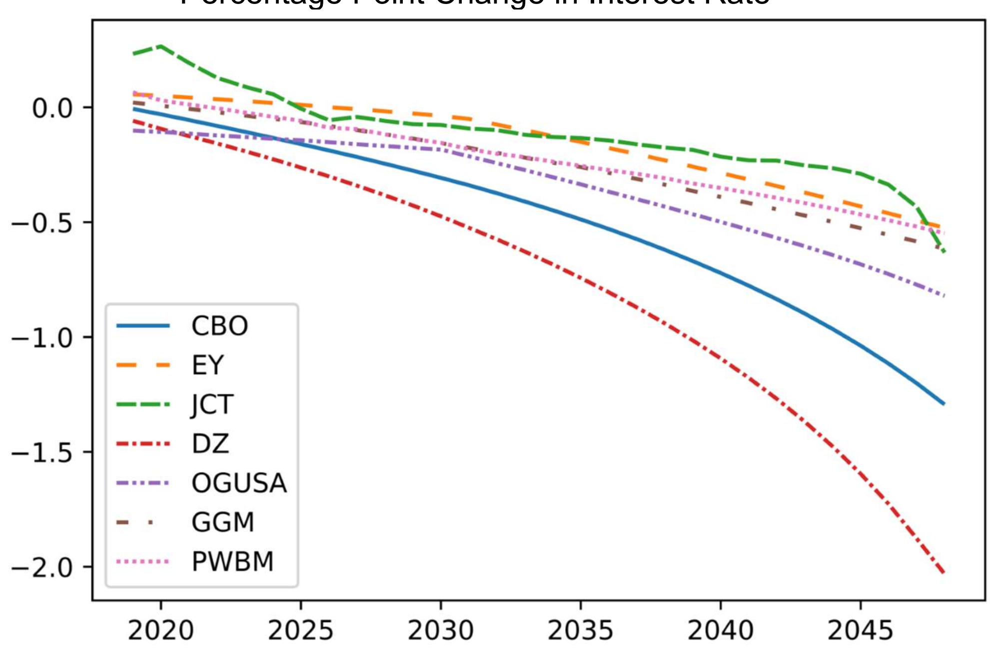


Figure 8
Percentage Point Change in Interest Rate



ACKNOWLEDGMENTS AND DISCLAIMERS

The results in this paper are intended solely to show how the models compare with each other. Both the scenario and the closure rule are highly stylized, so none of these results should be interpreted as forecasts or projections by any of the participating modelers.

DISCLOSURES

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