AN OVERVIEW OF A NEW OVERLAPPING GENERATIONS MODEL WITH AN EXAMPLE APPLICATION IN POLICY ANALYSIS

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of the
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CONTENTS

INTRODUCTION

In December 2018, the staff of the Joint Committee on Taxation ("Joint Committee staff"), along with other developers of six overlapping generations ("OLG") models, participated in a macroeconomic modeling symposium organized by the Congressional Budget Office ("CBO").[1] A primary purpose of the symposium was to assess the effects of different modeling assumptions on macroeconomic and budgetary projections of a given fiscal policy change. In response to the 2018 CBO Long-Term Budget Outlook,[2] which projected that the trust fund reserves for Old-Age and Survivors and Disability Insurance ("OASDI") will be exhausted by 2031 in the absence of legislative action, the group analyzed a stylized payable-benefits scenario. While the emphasis of the CBO modeling symposium was on expenditure policy, rather than tax policy, the Joint Committee staff used this as an opportunity to assess the structure of a new generation OLG model under development by the Joint Committee staff. The results of this analysis were presented in a panel discussion as part of the annual spring symposium of the National Tax Association ("NTA"), and published in the *National Tax Journal*.[3] In an effort to reach a broader audience, in this report the Joint Committee staff reproduces and expands upon the *National Tax Journal* publication.[4]

The OLG model used by the Joint Committee in the macroeconomic modeling symposium has been recently developed by Joint Committee staff for purposes of enhancing the Joint Committee staff's ability to provide the Congress with estimates of the budgetary impact of proposed "major tax legislation" that reflect any changes to macroeconomic growth.[5] This new model is to be used along with the existing macroeconomic models employed by the Joint

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[1] The models used by participating developers in the macroeconomic modeling symposium include the Congressional Budget Office OLG model, Diamond-Zodrow model, EY QUEST model, Global Gaidar Model, Joint Committee on Taxation OLG model, OG-USA model, and Penn Wharton Budget Model.

[2] Congressional Budget Office, 2018. *The 2018 Long-Term Budget Outlook*. Congressional Budget Office, Washington, D.C., www.cbo.gov/publication/53919.

[3] Jaeger Nelson, Kerk Phillips, Seth Benzell, Robert Carroll, Guillermo Cuevas, Jason DeBacker, John Diamond, Jagadeesh Gokhale, Laurence Kotlikoff, James Mackie, Rachel Moore, Brandon Pizzola, Kent Smetters, Victor Ye, and George Zodrow, "Macroeconomic Effects of Reducing OASI Benefits: A Comparison of Seven Overlapping-Generations Models," *National Tax Journal*, vol. 72, no. 4, December 2019, pp. 671, 692.

[4] The staff of the Joint Committee on Taxation welcomes comments from interested readers who have studied modeling of the Federal tax system. Direct comments to Chief of Staff, Thomas A. Barthold, and Deputy Chief of Staff, Robert P. Harvey, Joint Committee on Taxation, 502 Ford House Office Building, Washington, D.C. 20515-6453.

[5] "Major tax legislation" is generally defined as any tax legislation that results in a gross budget effect (as conventionally estimated) of at least a quarter percent of Gross Domestic Product in any year of the budget period.

Committee staff to prepare macroeconomic analysis of proposed changes in tax policy.[6] In this document, the Joint Committee staff supplements the description of the findings presented the NTA symposium with an overview of the new OLG model and discussion of the results of the analysis.[7]

[6] See, *Overview of Joint Committee Macroeconomic Modeling* (JCX-33-18), April 23, 2018. This document can be found on the Joint Committee on Taxation website at www.jct.gov.

[7] This document may be cited as follows: Joint Committee on Taxation, *An Overview Of A New Overlapping Generations Model With An Example Application In Policy Analysis* (JCX-22R-20), October 22, 2020. This document can be found on the Joint Committee on Taxation website at www.jct.gov.

THE JCT-OLG MODEL[8]

The Joint Committee OLG ("JCT-OLG") model was developed for purposes of enhancing the Joint Committee staff's ability to provide the Congress with macroeconomic analysis of major tax legislation. The model features substantial heterogeneity across households, capturing variation in filing status, number of dependents, residential status, and tax-preferred consumption choices. This variation allows for the explicit modeling of key provisions in the Internal Revenue Code within the macroeconomic framework, such as the statutory tax rate schedules for ordinary and preferential income, standard and itemized deductions, and major credits.

The lifecycle of each household within the JCT-OLG model begins at age 25 with working ages continuing through age 64, after which point individuals must retire and can live up to age 90. The 66 overlapping age cohorts are ex ante heterogeneous with respect to a combination of family composition (single or married), labor productivity types[9] (five profiles),[10] and wealth endowments (40 levels). The number and age of children assigned to a given household depends jointly on household age, family composition, and productivity type. Both the average and the distribution of dependents by demographic group were calibrated to statistics computed from the Joint Committee's Individual Tax Model, which makes use of taxpayer data from the Internal Revenue Service's Statistics of Income division.[11]

All households maximize the present discounted value of their life-time well-being by choosing market consumption, charitable giving, housing services (within an owner-occupied residence or a rental residence), home production,[12] and market work. Throughout working

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[8] For a detailed description of the model, see Rachel Moore and Brandon Pecoraro, "Macroeconomic Implications of Modeling the Internal Revenue Code in a Heterogeneous-Agent Framework," *Economic Modelling,* vol. 87, April 2020, pp. 72-91 and Rachel Moore and Brandon Pecoraro, "A Tale of Two Bases: Progressive Income Taxation of Capital and Labor Income," *Working Paper,* September 2019, available at https://ssrn.com/abstract=3367192. The Joint Committee staff continues work to improve the functionality of this OLG model.

[9] The model measures labor productivity in terms of the value of output the individual produces per hour with whatever amount of physical capital (*e.g.*, tools) are provided to him or her. To better reflect the observed variance in the wages individuals earn, the model has five different productivity types for each adult individual within single and married households of a given age. These factors follow an age-profile that reflects increases in individuals' productive ability as they age and participate in the labor force.

[10] In the time since the modeling symposium, the JCT-OLG model has been expanded to include eight profiles, each for single and married households. This allows the model to better capture the observed distribution of income and wealth.

[11] Joint Committee on Taxation, *Estimating Changes in the Federal Individual Income Tax: Description of the Individual Tax Model* (JCX-75-15), April 23, 2015. This document is also available on the Joint Committee on Taxation website at www.jct.gov.

[12] The concept of "home production" permits the individual to give up what would otherwise be purely leisure time and use that time to produce an at-home good or service and value that home-produced good or service similarly to a market-purchased good or service. For example, a meal made from scratch in the home rather than a

ages, individuals may choose between unemployment, part-time employment, or full-time employment. In the case of married households, this labor supply decision is made jointly by both primary and secondary earners. All individuals begin to receive Old Age and Survivor's Insurance ("OASI") benefits at the mandatory retirement age of 65. The benefit amount depends on an individual's average annual wage income and is computed based on the Social Security Administration's Primary Insurance Amount formula.[13]

Households choose to borrow or save over their lifetimes to finance desired consumption patterns. Savings are deposited with a financial intermediary that maintains a portfolio of investments on behalf of deposit-holding households. This portfolio is comprised of private equity and bonds, rental housing property, mortgage and consumer debt, and a portion of federal government bonds.[14] Since the model does not account for investment risk, a lower return on government bonds is assumed. Otherwise, investment adjusts until all net rates of return are equal across investment vehicles. To account for savings held in tax-deferred and tax-exempt accounts, the JCT-OLG model allows for the taxable portion of the household's portfolio income to change over their lifecycle. Households who own their residence may use their real property as collateral to borrow more than renting households, and homeowners may take a reverse mortgage to run down assets later in life. Households who die unexpectedly before the maximum age of 90 leave accidental bequests, while those living to 90 leave no bequests.

Federal tax liability on household income is computed by an internal tax calculator that explicitly models key tax provisions of the Internal Revenue Code. This calculator distinguishes different types of capital income so that labor income can be taxed jointly with ordinary capital income and preferred capital income can receive special tax treatment. For working-age households, the payroll tax is applied to individual wage income up to the applicable threshold. In two-earner households, the payroll tax is applied separately to each earner accounting for spousal differences in OASI-covered earnings and the implied effect on future OASI benefits. For retirees, the taxable portion of social security benefits is taxed jointly with other realized income. Tax revenue collected by the government is used to finance productive government infrastructure, OASI, other transfer payments to households and other government program expenditure.[15]

Output is produced by corporate and non-corporate firms using public capital, private capital, and labor as inputs. Firms own productive private capital, and each period make investment and hiring decisions to maximize the after-tax present discounted value of their

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meal purchased at a restaurant or changing the motor oil in one's automobile rather than taking the automobile to a service center for an oil change.

[13] As a modeling simplification, the Joint Committee staff adopts the common assumption that individuals do not predict the effect of changes to labor supply on future Social Security benefits when making optimal decisions.

[14] The model allows for foreign entities to purchase new issues of federal government bonds.

[15] Unlike infrastructure and transfers, remaining government expenditure does not directly affect the household's perceived level of well-being.

equity. The legal-entity distinction across firms is important because of differences in the financing of operations and tax treatment of income. Non-corporate firms issue debt to finance operations and pay out distributions to equity holders, which are subsequently taxed as ordinary income at the household level. Corporate firms face a business-level tax, issue both debt and equity to finance operations, and pay dividends to equity holders, which are subsequently taxed primarily as preferential income at the household level.

THE CBO MODELING SYMPOSIUM

A. Description of the CBO Modeling Symposium

The CBO projected in 2018 that the OASDI joint trust fund will be exhausted in calendar year 2031 under present law. At that time, absent legislative action that would allocate funds to the depleted trust, or unify the Federal budget, the Social Security Administration would be unable to be able to pay currently scheduled benefits in full. In a 'payable-benefits' scenario that may result, benefits paid to current retirees would be reduced to a level that can be financed by current program revenue.

Participants in the modeling symposium were asked to use their respective OLG models to analyze the macroeconomic and budgetary consequences of a stylized payable-benefits scenario. In this scenario, the government announces in 2018 a credible commitment to reduce OASI benefits paid to current and future retirees by one-third beginning in 2031 and continuing indefinitely. That is, beginning in 2018, households within the models anticipate a future reduction in OASI benefits and have 13 years to prepare for the permanent policy change by altering their consumption, savings, labor, and other relevant plans over the remainder of their lifecycle.

To perform the analysis, each model must be used to simulate the economy twice. The first simulation is a 'scheduled-benefits' scenario, which projects the evolution of the economy if OASI benefits are paid as scheduled out of the general fund regardless of the financial situation of the OASDI trust fund. This simulation incorporates present tax law and government spending such that changes to the debt-to-GDP ratio follow that projected by the CBO in their *2018 Long-Term Budget Outlook*. The second simulation is the payable-benefits scenario, which deviates only from the first simulation in that OASI benefits are reduced by one-third beginning in 2031. The results are presented in terms of the percent deviation of key macroeconomic variables in the alternative payable-benefits scenario relative to the baseline scheduled-benefits scenario.

A technical limitation arises in OLG models when fiscal deficits or surpluses are expected to increase faster than the rate of GDP growth, which is a characteristic of both the scheduled-benefits and payable-benefits scenario. Because households within the models can anticipate changes in fiscal conditions, they will be unable to make optimal economic decisions if they expect a permanently unstable economic future. This prevents the models from "solving" - or completing the simulations. Consequentially, it is necessary to make counter-factual "fiscal balancing" assumptions about the expected path of debt for these models.[16] To deal with this issue, government spending, other than that for Social Security benefits, is adjusted sufficiently to stabilize the debt-to-GDP ratio in the year 2050. As this limits the window in which both scenarios can reliably be analyzed, results are not reported for time periods following the fiscal balancing changes to government spending. That is, no results are reported for years after 2050.

[16] For a deeper discussion, see Rachel Moore and Brandon Pecoraro, "Dynamic Scoring: An Assessment of Fiscal Closing Assumptions," *Public Finance Review,* vol. 48, no. 3, April 2020, pp. 340-353.

B. Summary of Estimated Macroeconomic Effects

The policy experiment posed for the CBO modeling symposium involved policy changes to the outlays provided in the Social Security program. Nevertheless, the results discussed below highlight certain aspects of the design of the JCT-OLG model that would also be important in the analysis of major tax legislation.

The seven OLG models used in the symposium generally project qualitatively similar changes to key macroeconomic aggregates from the baseline scheduled-benefits scenario to the alternative payable-benefits scenario: Households perceive the reduction in OASI benefits in 2031 as a reduction in their wealth otherwise available for consumption in retirement. Working age households anticipating the change after the announcement in 2018, increase both their savings and labor supply to maintain a smooth path of consumption over their lifecycle. This makes more capital and labor available to firms. Firms begin to accumulate productive capital to use with additional labor input in the production of more output. While the federal debt-to-GDP ratio begins to decrease in response to higher output from the anticipation effect starting in 2018, it decreases at a faster rate after 2031 when governments outlays on OASI benefits are reduced.

Figure 1 shows the time paths of policy-induced changes to key macroeconomic aggregates, expressed relative to the baseline scenario, both for the JCT-OLG model and the average of the six other models used in the symposium. To emphasize the range of results presented in the symposium, the minimum and maximum response projected by any of the other six models are also reported for each year in the figure.

The increase in aggregate labor input projected by the JCT-OLG model is relatively larger and more volatile than the average projection of the other six models. This occurs because the JCT-OLG model incorporates extensive and intensive labor supply margins for both single and married households, each generating distinct responses to the policy.[17] That is, unlike some of the other models, the JCT-OLG model permits households to choose whether to enter or leave the labor force, the "extensive margin," or, if employed, to increase or decrease their hours of work, the "intensive margin." First, single workers substitute full-time work at older ages for full-time work at younger ages when they are less productive and earn a relatively lower wage rate. Second, married primary workers continue full-time work relatively longer before complete retirement from the labor force to offset the loss in lifetime income from reduced benefits. Finally, employment choices of married secondary earners tend to be relatively sensitive to changing economic conditions.[18] Secondary earners near retirement age at the time of the policy increase employment, a response which weakens over time as younger cohorts have more time to

[17] The discrete labor supply choice set available to individuals in the JCT-OLG model causes the time path of aggregate labor input response to appear less 'smooth' than the other models, all of which allow for infinitesimal, continuous labor supply changes.

[18] It is an empirical regularity that secondary earners have relatively more elastic labor supply. For a survey of the literature, see Michael P. Keane, "Labor Supply and Taxes: A Survey," *Journal of Economic Literature,* vol. 49, no. 4, 2011, 961-1075.

adjust behavior ahead of the known future policy change. These workers tend to change the quantity of labor they supply in response to subsequent changes to labor demand.

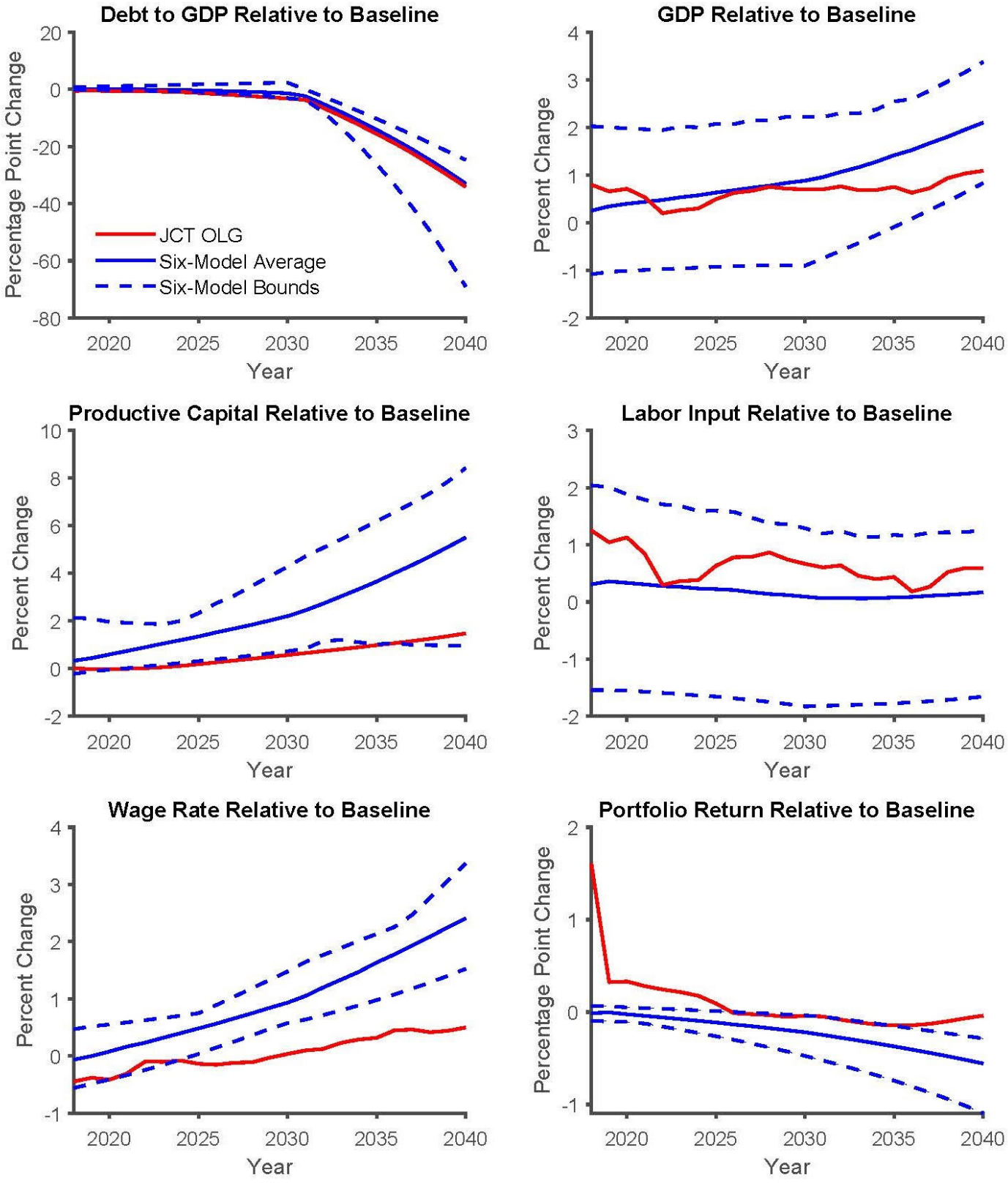
The increase in the stock of productive private capital projected by the JCT-OLG model is lower than the average projection of the other models and is the lowest projection across all models for the first decade following the policy announcement. This occurs because the JCT-OLG model incorporates explicit equity and debt financing of operations by firms that own their productive capital. The equity value of firms immediately rises following the policy announcement due to the increased labor supply increasing the productivity of capital. Corporate firms choose to perform stock buybacks and capital gains are generated for shareholders, which is reflected by discrete jump in the rate of return to the investment portfolio. The additional stock of savings produced by households who substitute saving for consumption is therefore not immediately transformed into productive capital as it is in the other models which generally pass all new savings directly into productive capital investment.[19] Firms only begin to accumulate additional productive capital once borrowing costs fall sufficiently to make increased capital investment an optimal choice. Combined with the relatively large increase in aggregate labor input, the relatively small increase in the capital stock results in a projected path for the real wage rate that is lower than the average projection of wage growth in the other models.

Despite a relatively large projected increase in aggregate labor supply, the slower accumulation of productive capital projected by the JCT-OLG model immediately following the policy announcement results in an increase in GDP that is slightly lower than the average projection of the other models. While a lower path for GDP might by itself imply a higher path for the federal debt-to-GDP ratio, the reduction in the debt-to-GDP is instead similar across models. This is partially due to different baseline paths for the debt-to-GDP ratio, but also the relatively larger amount of tax revenue generated from labor supply increases in the OLG model.

Although the policy modeled for this experiment did not involve changes to tax provisions, the JCT-OLG's internal tax calculator has an indirect effect on behavior through the joint taxation of wages and ordinary capital income, and the differential treatment of preferential capital income. For this example, the capital gains generated by firm behavior results in a greater share of capital income treated as preferential for tax purposes. The shift from ordinary to preferential capital income in the years following the policy change results in less ordinary income for many households, and thus a lower effective marginal tax rate on wage income, encouraging more labor supply. This 'portfolio effect,' unique to the JCT-OLG model, allows capital income changes to affect labor supply incentives.

[19] Increases in the stock of savings are directly transformed into productive capital in models where firms do not own their own capital, and rather rent it from households or another entity such as a financial intermediary.

Figure 1


Debt to GDP Relative to Baseline
Percentage Point Change
Year
JCT OLG
Six-Model Average
Six-Model Bounds
GDP Relative to Baseline
Percent Change
Year
Productive Capital Relative to Baseline
Percent Change
Year
Labor Input Relative to Baseline
Percent Change
Year
Wage Rate Relative to Baseline
Percent Change
Year
Portfolio Return Relative to Baseline
Percentage Point Change
Year

C. Assessment of the Projected Changes to Household Well-Being

To illustrate the policy-induced changes in households' well-being, the Joint Committee staff analyzed the consumption equivalent variation ("CEV") for the average single and married household in each age cohort.[20] The CEV is a measure of household well-being changes associated with changes in economic or policy conditions, expressed in terms of household consumption. Figure 2 reports the CEV as the proportion by which the present discounted value of a household's lifetime consumption within the JCT-OLG model must be changed in the baseline scheduled-benefits scenario in order for that household to be just as well off in the alternative payable-benefits scenario. A positive value for a household's CEV implies that the household is better off in the alternative scenario, while a negative CEV value implies the opposite.

The CEV values for the average single and married households are similar in magnitude for a given age cohort, as the reduction in OASI benefits under the payable-benefits scenario is proportional to scheduled benefits. However, the CEV values over age cohorts varies substantially and evolves in a nonmonotonic fashion. This variation can be attributed to the effect that the policy change has directly on anticipated and actual OASI benefits, and indirectly on wages and the real rate of return to private financial wealth, that households face over their lifecycle.

Households born in years 1928-1940 and aged 78-90 at the time of the policy announcement in 2018, die with certainty in the model by the time OASI benefits are reduced in 2031. These retired households are therefore only affected indirectly by the unanticipated change to the rate of return on their portfolio of financial wealth. Although the rate of return increases immediately following the policy announcement, these older households have little return-bearing wealth remaining. On average, these households therefore have negligible changes to their lifetime well-being under the payable-benefits scenario, with CEV values close to zero.

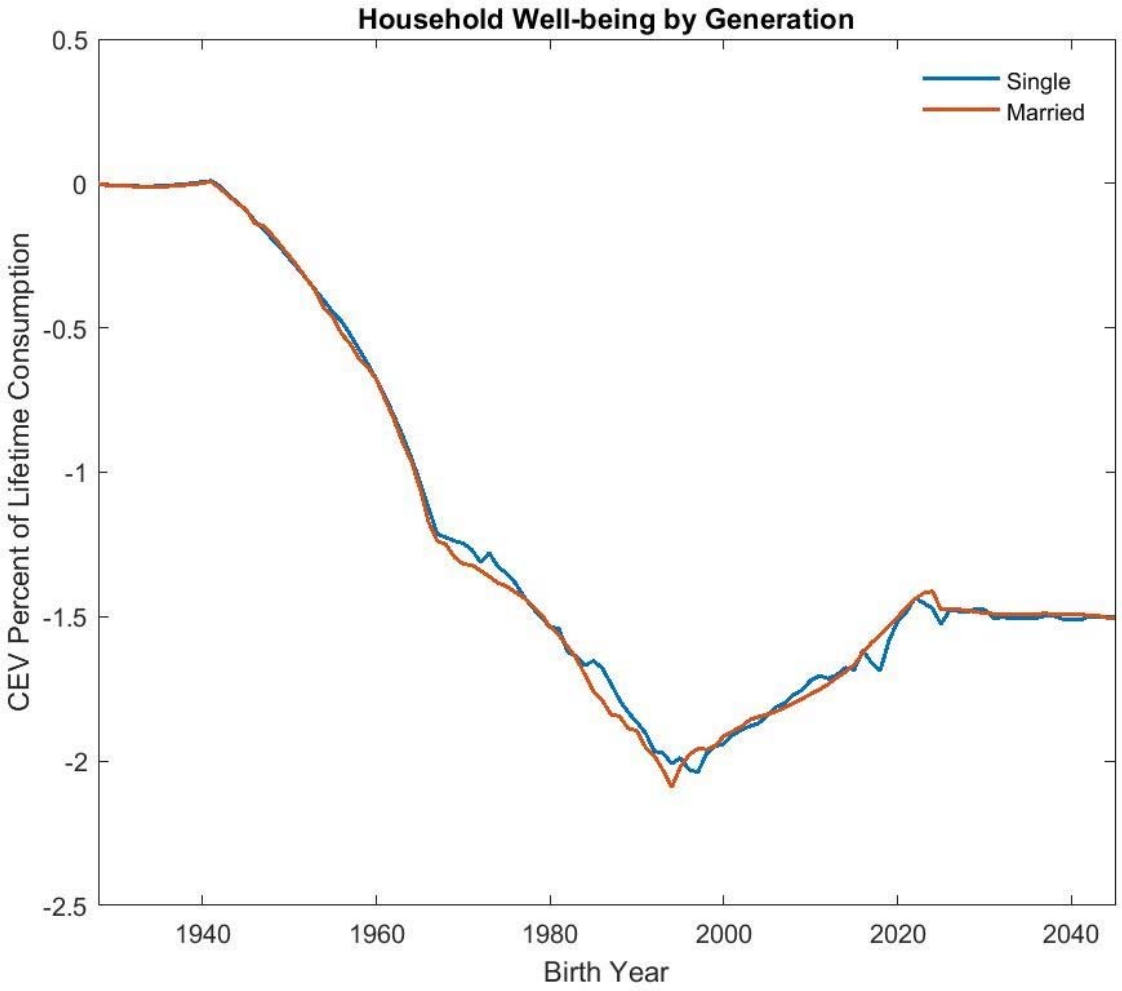
Households born in years 1941-1966 and aged 77-52 at the time of the policy announcement, live in the model at least one year under a regime with reduced OASI benefits. These households are worse off under the payable-benefits scenario, with the negative effect from unanticipated reduced OASI benefits outweighing potentially positive effects from changes in the rate of return to financial wealth. The pattern of increasingly negative CEV values for households over birth years indicates that younger cohorts are worse off than older cohorts because they spend more years with reduced benefits. The younger cohorts can increase labor supply for some years before retirement to make up for the loss in expected consumption, but this comes at the expense leisure time and home production activities.

[20] Measuring changes in households' well-being is often referred to as "household welfare analysis" in economics literature. Household welfare analysis was not performed across models in the OLG modeling symposium.

The slope of the CEV schedule changes for households born between 1966-1993, as these households experience all years of retirement under the reduced benefits regime in addition to adverse price effects during working ages. In particular, these households face a reduction in the real wage rate and real return to savings that result from the increase in aggregate labor supply and savings following the policy announcement, which is unanticipated at the beginning of their planning horizon. While older households will have fewer working years with the lower wage rate before retirement, younger households that enter the workforce shortly before the time of the announcement will experience more working years with the lower wage rate. In addition, the younger households experience a reduction in the real rate of return to savings at the point in their lifecycle when their portfolio of financial wealth has reached its peak. It is for these reasons that CEV values continue to decline over birth years through 1993 for married households, and 1996 for single households.

Households born after 1992 enter the model to start their working life at 25 after the policy announcement. While they are worse off under the payable-benefits scenario, they have losses in the present value of their lifetime consumption that are smaller than the immediately preceding households which are only modestly older. Because these households begin their planning horizons after the policy announcement, they anticipate all policy and price changes. The pattern of the policy-induced changes to the real wage rate – the immediate decrease and eventual increase – is therefore fully internalized when making their lifetime decisions. While older households face a relatively lower return to labor when they enter the workforce, younger households face a relatively higher return to labor when they begin working. The CEV values for these households, while negative, increase over birth years through 2024. Households born after 2024 live their entire working lives in the new economic steady state, which coincides with the period of imposed fiscal balance.

Figure 2


Household Well-being by Generation
Single
Married
CEV Percent of Lifetime Consumption
0.5
0
-0.5
-1
-1.5
-2
-2.5
1940
1960
1980
2000
2020
2040
Birth Year