Reducing Inequality: Lessons from an Overlapping Generations Model with Two-Sided Altruism

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Abstract

This paper explores behavior and policy based reforms targeted to reduce Income and Wealth Inequality. I define an Overlapping Generations Model in which agents exhibit Two-Sided Altruism for a period of their lives to help understand the role of Altruism in Wealth Inequality. I also provide agents with a Pension and 401(k) to participate in to augment their own savings as a means of deriving the effects of differentiated choice of savings on capital accumulation and ultimately wealth inequality. I find that personal/household behavior changes with regards to contribution rates have a -4.6% impact on wealth inequality when increased by 300% (5% of after-tax income to 15% of after tax income). I also test the re-distributional effects of a wealth tax on wealth inequality using four different levels of effectiveness, and find that a 50% effective wealth tax reduces wealth inequality by 27% and a 33% effective tax reduces wealth inequality by 21%.

Acknowledgement

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1 Introduction

1.1 OLG Model

The overlapping-generations model (OLG henceforth) provides a way to link economics agents together and show dynamic outcomes of a variety of endogenous and exogenous changes. The model was initially derived by Allais in 1947 Allais (1947) and subsequently expanded on by Samuelson (1958) and then by Diamond (1965). My implementation of the model follows Diamond's to some extent, but is influenced largely by Auerbach & Kolitkoff Auerbach et al. (1987) both of who provided perhaps the largest contributions to the model since it's creation. I propose similar restrictions on gifts and bequests as in Altig Altig and Davis (1993), but the both the size and income heterogeneity follow Evans and DeBacker (2017) and with respect to cohorts Nishiyama (2002).

1.2 Altruism

"For they have never really treated the economic man as perfectly selfish: no one could be relied on better to endure toil and sacrifice with the unselfish desire to make provision for his family; and his normal motives have always been tacitly assumed to include the family affections. But if they include these, why should they not include all other altruistic motives the action of which is so far uniform in any class at any time and place, that it can be reduced to general rule?"Marshall (1920) Marshall recognized the need for economics to include the notion of altruism into it's discourse and ultimately into it's theory. The inclusion of altruism into a general form utility function, accounts for the additional concerns of a homo economicus, removing the traditional one-dimensional perspective. It is also important to note that dynamics do not change to a large degree with this addition, when altruism is operative[1] it alleviates the dynamic inefficiency concerns and transforms the household into an infinitely lived dynasty which is a more common representation. When talking about altruism it is important to define several key terms.

Definition 1.1. Two-Sided Altruism: Total utility concerns for both Parents and Children from an agent at the same time.

Definition 1.2. Ascending Altruism: Total utility concern from a child to parent(s) in the form of a gift(s).

Definition 1.3. Descending Altruism Total utility concern from a parent to a child(ren) in the form of a bequest(s).

This model makes use of two-sided altruism a la Barro or Kimball, where the addition of age heterogeneity adjusts the type of altruism a household is currently "engaged in".

Bequests are the more commonly discussed form of intergenerational transfers because they are generally larger in size than gifts, and are easily quantified. Empirical evidence for bequests can be seen in the life insurance market where, heads of household (or both parents) indicate their desire for their family to not loose a large amount of utility should they die. In the event of death, their family will receive an agreed upon dollar amount to make-up for the loss. Another common form of bequests are inheritances, although they may be more common, they are not a one time event,

[1] Bequests and or gifts (both in the case of two-sided altruism) are positive.

rather they can occur throughout the live of the family members through vehicles such as house purchases, college tuition, wedding gifts, as well as traditional lump-sum transfers. Gifts are often less quantifiable, and therefore have received less attention, but in different cultures can be a large part of all household intergenerational transfers. Gifts can take the form of nursing home care, simple cash gifts, paying of rent and or medical care. These are not exhaustive lists, but provide a basis for understanding the model's paramaterization as well as the logic.

Since the Great Recession of 2008, there has been a growing interest in inequality, both in wealth and income. Movements such as Occupy Wall Street are born of this general concern, and the "movement" has made it to the fore-front of U.S. politics in recent years. Luckily there is a large amount of empirical research from Thomas Piketty and Emmanuel Saez (Piketty and Saez (2003)) on historical levels of inequality in the U.S and abroad. A common measure of the overall level of inequality in an economy or country is the Gini Coefficient, which measures the difference between the observed cumulative income distribution and the perfectly equal income distribution. In my model I am concerned with Wealth and Income Inequality as bequests and savings behaviors are generally good vehicles for the transmission of wealth across time and across generations. Investment growth since the 2008 Recession has spurred new interest in Wealth Inequality as it's compounding nature has left many families behind. Income Inequality while of interest to many is not a feature often studied by OLG models, `OG-USA` takes income as given as do many other models using real data sources, which complicates their ability to impact income through policy reform. Wealth is an easier target for policy changes because of it's forward looking nature; Wealth begets Wealth. Layered on top of this distinction is the fact that income is not the sole determinant of wealth,"A significant proportion of high-income households also save very little; and not all low-income households are non-savers. Indeed a substantial proportion of low-income households save a great deal"Venti and Wise (1998). Empirically the U.S. saves 7% of their income[2], this does not mean all households do, but it does provide a reason to focus on wealth inequality, both to understand its causes, and to understand effective policy aimed at reducing wealth inequality.

I find that changing behavior such as reducing the agents marginal propensity to consume for low-income agents has little effect on wealth or income inequality. The capital stock effects resulting from increased savings do not significantly reduce the wealth Gini Coefficient. Adjusting Income and Consumption taxation policies such that higher income households pay more, did reduce income inequality marginally, but had no resulting effect on wealth inequality. I implemented a wealth tax to redistribute the wealth of households in the top 10% of the income distribution to the households in the bottom 90%. I found that assuming net capital capture capital flight of 50% wealth inequlaity was reduced by 27%. Additionally a wealth tax that is only 10% effective in taxing wealth still had stronger effects on wealth inequality than did personal saving or contribution rate augmentation.

2 The Role of Saving and Altruism in Capital Accumulation

Intergenerational transfers are at the fundamental core of savings, wealth, and growth. Transfers most commonly take the form of Bequests and Gifts, and as such the vast majority of literature on the topic utilizes these two forms exclusively. Present literature rests on two major papers, Barro

[2]https://fred.stlouisfed.org/series/PSAVERT

(1974) and Diamond (1965). Barro shows that if consumers have an operative bequest motive, and they experience a lump-sum reduction in taxes, but the government also issues government bonds equal to the reduction, then there is no aggregate effect on resource allocation. Formally known as the Ricardian Equivalence Theorem, it supports the a priori operative bequest motive. A bequest motive is then operative when its equilibrium is determined by tangency condition rather than a corner solution. Operative bequest motives are the subject and assumptions of the bulk of research on intergenerational altruism, however not all models support the Equivalence Theorem holding, Dynan et al. (2002). Diamond provided an economic framework in which a steady state equilibrium exists and supports, several key assumptions that help to build the fundamental preference relationships necessary for intergenerational altruism, Diamond (1965).

While the framework of overlapping-generation (OLG) models, and operative bequest motives is used throughout the variety of research on altruism, there have been numerous attempts at proposing models that accurately capture the bequest and gift motives, while also considering capital stock effects, labor supply effects such as the approach by Altig and Davis (1993) which introduces a new utility function, and expands generations past the traditional 2 periods. Kimball (1987) was able to define feasible bounds for the weights applied to bequest and gift preferences as an addition to Abel (1985b) using the Buiter-Carmichael-Burbridge utility function, his identified bounds help eliminate the "Hall of Mirrors" effect[3].

Buiter, Carmichael, and Burbridge all contributed to each other, during the late 70's into the late 80's, their work inspired and contributed to Andrew Abel, Miles Kimball and other economists who subsequently focused on intergenerational altruism. Buiter and Carmichael (1984) analyzed altruistic gift motives from child to parent and along with Burbidge (1983) who were able to prove that Barro was correct that with operative gift motives the Ricardian Equivalence Theorem holds, and when the inverse is true it does not. Burbridge (1984) further contributed by providing additional support for the operative bequest and gift motive, and for neither motive being operative, again supporting Ricardian Equivalence Theorem.

A major sticking point in many OLG intergenerational altruism models is dynamic consistency, in that they assume it despite the assumption not being consistent with the notion of rationality or selfishness. It is though a requirement for the successful derivation of infinite-series applications of utility as derived by Strotz (1955).

There has been a resurgence of interest in the offerings of the OLG model, particularly it it's usefulness in policy analysis. Currently the Congressional Budget Office, Federal Reserve System, UPenn Wharton Budget Model, and many others make use of various formations of the OLG model. Along with the prevalence of the OLG model, comes new ways of understanding the logic of the model and specific applications. Axiomatic approaches seen in Galperti and Strulovici (2017) provide new definitions such as Pure and Direct Altruism, which help to provide clarity on the meaning of theoretical attempts to model a uniquely humanistic element. The evolution of computing power has allowed for large scale OLG Models that can simulate large populations (>1 million) for the purpose of policy analysis. `OG-USA` by Evans and DeBacker (2017) is a large-scale model, that is provided open-source through the Policy Simulation Library. The model's documentation and supporting papers[4] provide a strong basis for tax policy analysis in a pythonic implementation. Python

[3]This refers to high levels of parent or child utility preference from the agent's perspective. If these bounds are not enforced according to Kimball, agents would prefer to have their future ancestors reduced to poverty such that they can provide bequests and gifts, which goes against the logic of altruism.

[4]See DeBacker et al. (2019) and Evans and Phillips (2014) and DeBacker et al. (2014).

allows for increased heterogeneity, but also dramatically increases the solution time and computing requirements[5] My model is implemented in `Dynare` a popular tool used in solving and simulating DSGE models. Regardless of the software used, simulations provide the ability to introduce more agents, and more variation among agents; both of which are useful in policy analysis.

The majority of intergenerational altruism theory attempts to introduce model adjustments or expansions. This paper does not attempt to introduce such changes, instead I show how using this framework and body of theoretical knowledge I can provide an application of an extended Diamond OLG Model to illustrate general equilibrium effects derived from policy changes. This model (`OLG-2ALT`) builds on previously defined characteristics of OLG models, altruism, household savings and consumption models to provide in-depth policy analysis on macroeconomic impacts and on wealth inequality.

[5]My model usually solves in under 30 seconds to 10 minutes for the stochastic version, while `OG-USA` solves in 2-4 hours dependent upon processor speed.

3 Defining the OLG-2ALT Model

The agents in this model are households, this is assumed for two reasons, one because of the U.S. tax filing structure captures households which provides an empirical basis, and because it allows for the "creation" of future generations. Households are differentiated by age; they are "born" at $s = 0$, they are "young" until age E (s=21) at which they enter the workforce. The activity of agents younger than age E are disregarded (read: held constant). Households work and earn income, consume and or save all of this income, either for consumption in future periods or out of some concern for familial utility. All households live for 80 years[6] and work from age E-R where R (s=65) is their retirement age[7]. Households then are retired until age S (s=80) when they die, during retirement they earn no income, unless they benefit from a pension, capital gains or government transfer, but they still consume and pay taxes. A household of age $s = 1...S$ and ability type $j = 1...J$ at age E earns some $w_{t,j,s} \in \{W_t\}_{t=1}^{\infty}$. Households in the model are assigned to some $\lambda_{t,j,s} \in \{\lambda_1, \lambda_2, \lambda_J\}_{t=1}^{\infty}$ ability type which determines the wage income life-cycle path of wages for all households. Households have children at age F (s=26)[8] while population growth rate is marginal in the U.S., (I extend this in Section 4) the majority of growth comes from migration, I do allow for fertility rates above replacement as necessary for organic population growth.

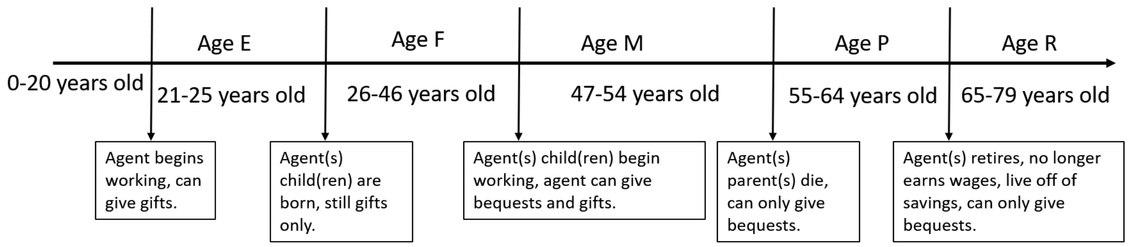

Figure 1: Timeline of Households Life Events and Cohort Distinctions

4 Population: Growth & Dynamics

The U.S. population in 2017 grew 0.64%[9] with the majority coming from migration, as organic growth has been negative since 2008. To account for this change and its impacts on inequality and policy effectiveness the model needs to include both the possibility of positive and negative growth. Population growth dynamics can have an out-sized effect on government transfers to households, and their distributional intentions. I describe the population data, sources, methods and descriptive statistics in section 4.2. To understand the current population distribution I define several equations, the number of households alive in any one period is simply N_t, where the growth rate is $\varrho_{n,t}$, and

[6] Average life expectancy of males and females in the U.S. is 78.6 years, I simply this to 80 years. Since I do not include mortality or fertility, I use the Actuarial Life Table for 2016 which at $s = 0$ gives us an 80 year life expectancy https://www.ssa.gov/oact/STATS/table4c6.html.

[7] All subsequent sections will define the economically active period of a households life as E to R, this distinction is crucial to understanding aggregate functions and determining population cohorts for reform analysis.

[8] https://www.cdc.gov/nchs/fastats/births.htm Although this is the actual median age in the U.S. it is not the age at which college educated or married women give birth, that would be about 29 years and since I am using 21 as my first year of "real life" perhaps I should move this out.

[9] https://www.census.gov/library/visualizations/interactive/population-increase-2018.html

the population alive at any time t is,

$$N_t = \sum_{s=E}^{S} \xi_{t,j,s} \tag{4.1}$$

4.1 is simply the number of households alive at time t that are economically active.

$$\tilde{N}_t = \sum_{s=E}^{P} \xi_{t,j,s} \tag{4.2}$$

$\tilde{N}_t$ in 4.2 is the working population that supply labor to the firm.

$$\varrho_{t,j,s} = \frac{N_t}{N_{t-1}} - 1 \tag{4.3}$$

$$\tilde{\varrho}_{t,j,s} = \frac{\tilde{N}_t}{\tilde{N_{t-1}}} - 1 \tag{4.4}$$

where the working population growth rate is found using 4.4

$$\Xi_{t+1} = \sum_{s=E}^{S} \varrho_{t,s}\xi_{t,j,s} \tag{4.5}$$

4.5 shows that the population alive at time $t+1$ equals the population growth rate (ϱ) times the population alive at time t. I define several additional population cohorts of interest in section 6.

4.1 Cohort Design

Cohorts are differentiated by age, income and size. I used 2018 data for calculating the cohort data as it was the first year of the new tax code under the Tax Cuts and Jobs Act. This conveniently allows me to set the corporate tax rate on firm profits at 21%. whereby there are 7 lifetime Income profiles (ability type), where each household or agent is assigned to an income profile for their entire lives. The path of that income profile can be seen in 2 where the each path represents the percentage share of the income distribution that the household belong to.

$$\lambda_j = [0.25, 0.25, 0.2, 0.1, 0.1, 0.09, 0.01] \tag{4.6}$$

The first group contains households with income less than 25th percentile, where the second group's income is from the 25th to the 50th percentile, the third group runs from the median to the 70th percentile, the fourth group from 70th to 80th and and the fifth group from the 80 to the 90th percentile. The sixth group includes households from the 90th to 99th percentile, while the seventh and final group is the 99th to 100th percentile or the 1%.

4.1.1 Inter-Cohort Heterogeneity

Cohorts are primarily differentiated by age, which changes the life events, and altruistic ability of households. There are five cohorts in the model alive at any one time made up of households of various ages.

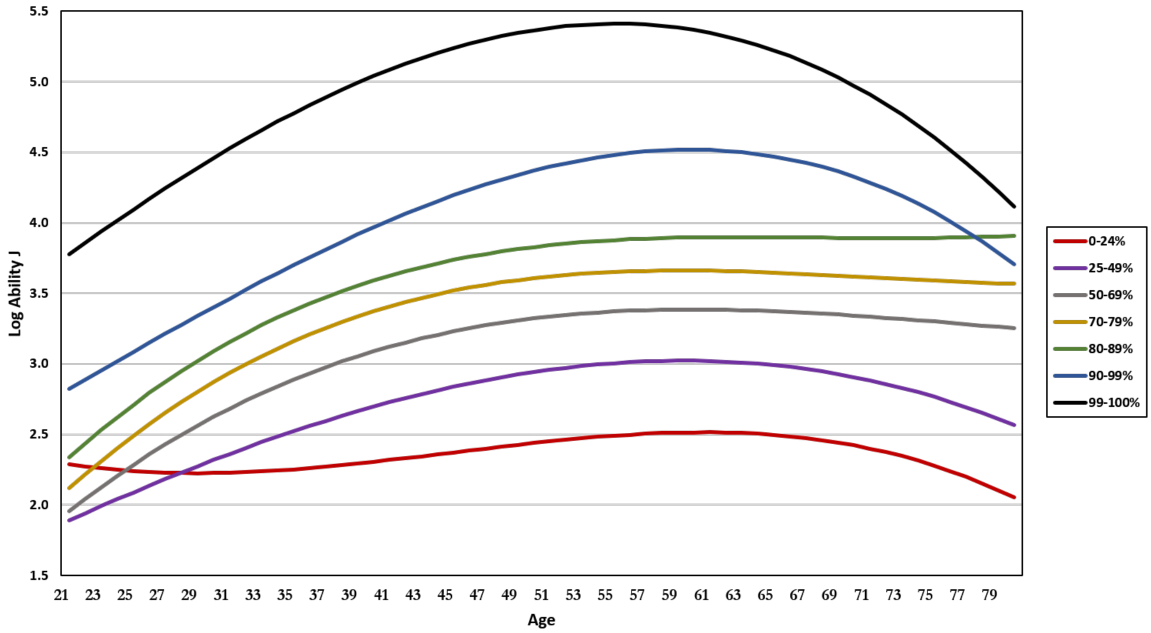

Figure 2: Log of Income Ability Paths of s ∈ [20,80] and j ∈ [1,7]

Table 1: Income Group Statistics

Income Group	Median Income	Effective Tax Rate	% of Population	% of Income
1	$54,999.50	9.59%	21.04%	10.17%
2	$149,990.50	12.90%	29.98%	25.46%
3	$307,499.50	18.31%	21.89%	23.04%
4	$567,499.50	24.75%	9.87%	10.94%
5	$1,302,499.50	31.56%	9.37%	11.02%
6	$5,947,499.50	35.81%	7.18%	12.71%
7	$10,000,000.00	36.29%	0.66%	6.66%

Table 2: Cohort Descriptions

Cohort	Age	Defining Characteristics	Population Weight
E	21 to 25 years old	First year of economic activity, can give gifts to parents	10.341%
F	26 to 46 years old	Children are born, can only give gifts	40.202%
M	47 to 54 years old	Parents and Children alive, can give both Bequests and Gifts	14.944%
P	55 to 64 years old	Parents are dead, can only give bequests to children	18.107%
R	65 to 79 years old	Retired, lives off of savings, can only leave bequests	16.406%

4.1.2 Intra-Cohort Heterogeneity

Cohorts contain variation in life-cycle income groups such that each cohort has representation of each group (1-7). Income groups combined with age determine the share of wage as seen in 2, as well as the share of government transfers. I discuss this more in-depth in 8.

Table 3: Cohort Population by Income Group

Cohort E		Cohort F		Cohort M		Cohort P		Cohort R	
1	2.03%	1	8.53%	1	3.12%	1	4.13%	1	3.23%
2	2.89%	2	12.15%	2	4.45%	2	5.88%	2	4.61%
3	2.11%	3	8.87%	3	3.25%	3	4.30%	3	3.36%
4	0.95%	4	4.00%	4	1.47%	4	1.94%	4	1.52%
5	0.90%	5	3.80%	5	1.39%	5	1.84%	5	1.44%
6	0.69%	6	2.91%	6	1.07%	6	1.41%	6	1.10%
7	0.06%	7	0.27%	7	0.10%	7	0.13%	7	0.10%
9.63%		40.53%		14.85%		19.62%		15.37%	

4.2 Population & Income

Income data of U.S.households can be obtained relatively easily from the Census Current Population Survey, which provides detailed data on households with a skew towards lower income households. To model the U.S. income distribution we need to include all household income levels. To accomplish this I turn to the IRS Statistics of Income data which provides tax return data from 2018 for all filers. We are only interested in households, so returns filed with the status of Married Filling Jointly are used to determine the size of the population being studied. I combined the detailed lower income household data from the CPS and the total population and general distribution of the SOI to develop 2000 income bins each representing a \$5,000 range starting at \$0 to the highest income reported by the SOI \$10,000,000[10]. The small income ranges allow us to capture impacts of reforms on all levels of income and resolve some of the missing details in the data without altering the distribution from reality. The next step is to add in age distribution data for my defined household population, and determine the growth rate[11]. Age data comes from the census which provides age and sex estimates of the U.S. population, I removed any age over 80 ($S = 80 = D$) and scaled the remaining population to fit my household population data[12]. This gives us the total population by age for our baseline (2018), but in order to accurately model the population overtime we need to estimate the population growth rate. The census also conveniently provides bi-annual population growth rate estimates, with the most recent being 2017, where they estimate the growth rate until 2060[13]. This model requires that we extend that estimate to determine the steady state growth rate of .46% which is used to scale the population for all 160 periods.

[10]There are over 16,000 households at this income level or higher, while the SOI gets us around some of the top-coding it does not resolve this issue and in absence of more detailed data all incomes at this level are assumed to be equal to \$10,000,000.

[11]I do not differentiate between net-births and deaths and migration for the population growth rate, because neither accurately fit my model, nor are they provided by age, which would be required. To see my growth rate calculations over the model life and steady-state growth rate convergence see: https://github.com/Ben-cmyk/OLG-Inequality/blob/master/g_rates_supp.xlsx

[12]https://www2.census.gov/programs-surveys/popest/technical-documentation/file-layouts/2010-2018/nc-est2018-agesex-res.csv

[13]https://www.census.gov/data/tables/2017/demo/popproj/2017-summary-tables.html

5 Households

Household derive utility from three choices, their own consumption, their concern for their parents total[14] utility, and their concern for their children's total utility. The period utility function 5.1 is twice continuously differentiable with $u' \geq 0$, $u'' \leq 0$, $\lim_{c\to 0} u'(c) = \infty$, and $\lim_{c\to\infty} u'(c) = 0$.

$$\begin{aligned} u(c_{t,j,s}, c_{t+1,j,s+1}) &= \frac{c_t^{1-\sigma}}{1-\sigma} + \beta\frac{c_{t+1}^{1-\sigma}}{1-\sigma} \quad \text{where} \quad \sigma \neq 1 \\ u(c_{t,j,s}, c_{t+1,j,s+1}) &= \ln(c_{t,j,s}) + \beta_{t,j,s}^{s-1}\ln(c_{t+1,j,s+1}) \quad \text{where} \quad \sigma = 1 \end{aligned} \tag{5.1}$$

I maintain traditional notation by representing total utility concern for parents in 5.6, as in Kimball (1987), and Altig and Davis (1993), but I provide a delineation such that it is apparent what a household is using as a vehicle to represent such concern. Parental total utility concern is represented in 5.2, where gifts are defined as $(g^g_{t,j,s})$, and $(g^g_{t+1,j,s+1})$, the superscript g denotes that is given away, where as in 5.4 the superscript r denotes received. Gifts are determined by β^{s-1} the gift giving households period t intertemporal consumption discount factor, and ϕ the gift giving households "concern" for their parents. Gifts are augmented by $(1 + \varrho_{t,s})$ the population growth rate.

$$V^p_{t,j,s} = \phi\Big[(g^g_{t,j,s}) + \beta^{s-1}_{t,j,s}\big[(1+\varrho_{t,s})(g^g_{t+1,j,s+1})\big]\Big] \tag{5.2}$$

$$V^c_{t,j,s} = \gamma\Big[(b^g_{t,j,s}) + \beta^{s-1}_{t,j,s}\big[(1+\varrho_{t,s})(b^g_{t+1,j,s+1})\big]\Big] \tag{5.3}$$

Households choose consumption $\{c_{t,j,s}\}_{s=E}^S$, gifts to parents $\{g^g_{t,j,s}\}_{s=E}^P$, and bequests to children $\{b^g_{t,j,s}\}_{s=M}^S$ to maximize their intertemporal utility function,

$$U_t = \begin{cases} u(c_{t,j,s}, c_{t+1,j,s+1}) + V^p_{t,j,s} + V^c_{t,j,s}, & \text{for } M \leq s \leq P \\ u(c_{t,j,s}, c_{t+1,j,s+1}) + V^p_{t,j,s}, & \text{for } E \leq s \leq M \\ u(c_{t,j,s}, c_{t+1,j,s+1}) + V^c_{t,j,s}, & \text{for } M \leq s \leq S \end{cases}$$

where β, ϕ and $\gamma \in [0,1]$ are the households consumption time preference, parental total utility preference and child total utility preference respectively. Utility is log-linear although that is not a necessary condition for dynamic efficiency because the logic of two-sided altruism allows for negative bequest and or gift relationships between parent and child.$v^p_{t,j,s}$ represents the households parents period utility, and $v^c_{t,j,s}$ represents the households children period utility. Bequest and gift decisions only occur when parent and child households are alive, in this model that occurs beginning at M ($s = 47$) for bequests until the household reaches age P. Gifts occur beginning at $s = E$ and can occur for any period until P which is the households parents age S. The period budget constraint that agents maximize is,

$$\begin{aligned} \theta_{t,j,s} = s_{t,j,s}(1+r_t) + w_{t,j,s} + g^r_{t,j,s} + b^r_{t,j,s} + \tau^r_{t,j,s} + \omega_{t,j,s} + \psi_{t,j,s} \\ -c_{t,j,s} - g^g_{t,j,s} - b^g_{t,j,s} - \tau^t_{t,j,s}, \end{aligned} \tag{5.4}$$

[14]This is a key distinction, within the lifetime optimization problem a household only cares about total utility, and does not derive utility from the size of the gift.

$$\forall t, j \quad \text{and} \quad M \leq s \leq P$$

when agents are "retired" ($s \geq R$) they face the following adjusted budget constraint:

$$\begin{aligned} \theta_{t,j,s} = s_{t,j,s}(1+r_t) + g^r_{t,j,s} + \tau^r_{t,j,s} + ben^{DC}_{t,j,s} + ben^{DB}_{t,j,s} \\ -c_{t,j,s} - b^g_{t,j,s} - \tau^t_{t,j,s,} \end{aligned} \tag{5.5}$$

$$\forall t, j \quad \text{and} \quad R \leq s \leq S$$

The period t budget constraint represents a household who's parents and children are alive as it incorporates both gifts and bequests, this is only true for age M. Household wealth is captured by $\theta_{t,j,s}$ which takes the net of the left-hand and right hand components to provide a mechanism to transfer and grow wealth period to period[15]. Gifts and bequests grow at a rate of $(1+\varrho_{t,s})$ to account for population dynamics. The left-hand side of 5.4 is all of the "purchases" a household makes which includes consumption, capital savings with a rate of return r, gifts to parents, bequests to children, and a lump-sum tax transfer to the government, $\tau^t_{t,j,s}$. Participation in retirement schemes requires contributions made to the firm to fund, $\psi_{t,j,s}$ is the current household stored capital stock from contributions to a defined-benefit plan, and $\omega_{t,j,s}$ household stored capital stock from contributions to a defined-contribution plan. Households then receive some wage income $w_{t,j,s}$ supplying labor inelastically to a single representative firm, receive gifts from their children, $g^r_{t,j,s}$, and bequests from their parents, $b^r_{t,j,s}$. The household contributes to retirement plans and as such receives benefits commensurate in $ben^{DB}_{t,j,s}$ and $ben^{DC}_{t,j,s}$ which represent their defined benefit and defined contribution "payouts" respectively as seen in 5.5 when they are retired.

5.1 Optimality Conditions

I define the life-time household optimization problem in the periods where parents and children are both alive, and the household is working, as they are both the longest period in the households economically active life. In 5.5 I made adjustments to include the lack of parents and no wage income, this does however alter the Euler Equations as households are only maximizing consumption and their familial utilities, which we remove the concern for parents utility as they are no longer alive. We would then only have two FOC's, 5.9, and 5.11. The household maximizes 5.6 subject to 5.1,

$$\begin{aligned} \max \quad U_{t,j,s} = \sum_{s=E}^{S}\sum_{j=1}^{J} \ln(c_{t,j,s}) + \phi(g^g_{t,j,s}) + \gamma(b^g_{t,j,s}) + \beta^{s-1}_{t,j,s} \\ \Big[\ln(c_{t+1}) + \phi\big[(1+\varrho_{t,s})(g^g_{t+1,j,s+1})\big] + \gamma\big[(1+\varrho_{t,s})(b^g_{t+1,j,s+1})\big]\Big] \end{aligned} \tag{5.6}$$

[15] This may be trivial for households at the extremes of the income distribution, but for those who rely on wage income and modest investments it captures the possibility for greater generational mobility.

subject to:

$$
\begin{aligned}
s_{t,j,s}(1+r_t) + w_{t,j,s} + g^r_{t,j,s} + b^r_{t,j,s} + \tau^r_{t,j,s} + \omega_{t,j,s} + \psi_{t,j,s} - c_{t,j,s} - g^g_{t,j,s} - b^g_{t,j,s} - \tau^t_{t,j,s},\\
-\frac{1}{(1+r_{t+1})}\Big[c_{t+1,j,s+1} + \theta_{t+1,j,s+1} + (1+\varrho_{t,s})g^g_{t+1,j,s+1} + (1+\varrho_{t,s})b^g_{t+1,j,s+1} + \tau^t_{t+1,j,s+1},\\
s_{t+1,j,s+1}(1+r_{t+1}) - \omega_{t+1,j,s+1} - \psi_{t+1,j,s+1} - w_{t+1,j,s+1} - (1+\varrho_{t,s})g^r_{t+1,j,s+1}\\
-(1+\varrho_{t,s})b^r_{t+1,j,s+1} - \tau^r_{t+1,j,s+1}\Big]
\end{aligned}
\tag{5.7}
$$

$$\forall t, j \quad \text{and} \quad M \leq s > P$$

Using 5.4, 5.6, and 5.1 we can setup the Lagrangian as,

$$
\begin{aligned}
\mathcal{L} = \sum_{s=1}^{s}\sum_{j=1}^{J} U_{t,j,s}\lambda\Bigg[s_{t,j,s}(1+r_t) + w_{t,j,s} + g^r_{t,j,s} + b^r_{t,j,s} + \tau^r_{t,j,s} + \omega_{t,j,s} + \psi_{t,j,s}\\
-c_{t,j,s} - g^g_{t,j,s} - b^g_{t,j,s} - \tau^t_{t,j,s}, - \frac{1}{(1+r_{t+1})}\Big[c_{t+1,j,s+1} + \theta_{t+1,j,s+1} + (1+\varrho_{t,s})g^g_{t+1,j,s+1}\\
+(1+\varrho_{t,s})b^g_{t+1,j,s+1} + \tau^t_{t+1,j,s+1,} - s_{t+1,j,s+1}(1+r_{t+1}) - \omega_{t+1,j,s+1} - \psi_{t+1,j,s+1} - w_{t+1,j,s+1}\\
-(1+\varrho_{t,s})g^r_{t+1,j,s+1} - (1+\varrho_{t,s})b^r_{t+1,j,s+1} - \tau^r_{t+1,j,s+1}\Big]\Bigg]
\end{aligned}
\tag{5.8}
$$

$$\forall t, j \quad \text{and} \quad F < s > P$$

From 5.1 the optimization problem for every household of age M and ability type j at time t and $t+1$ has the following first order conditions,

$$
\begin{aligned}
u'(c_{t,j,s}) &= \beta(1+r_{t+1})u'(c_{t+1,j,s+1})\\
\text{in log form} \quad \frac{c_{t+1}}{c_t} &= \beta(1+r_{t+1})
\end{aligned}
\tag{5.9}
$$

$$
\begin{aligned}
u'(c_{t,j,s}) &= \frac{\phi\beta}{(1+\varrho_{t,s})}(1+r_{t+1})u'(c_{t+1,j,s+1})\\
\text{in log form} \quad \frac{c_{t+1}}{c_t} &= \frac{\phi\beta}{(1+\varrho_{t,s})}(1+r_{t+1})
\end{aligned}
\tag{5.10}
$$

$$
\begin{aligned}
u'(c_{t,j,s}) &= \frac{\gamma\beta}{1+\varrho_{t,s}}(1+r_{t+1})u'(c_{t+1,j,s+1})\\
\text{in log form} \quad \frac{c_{t+1}}{c_t} &= \frac{\gamma\beta}{(1+\varrho_{t,s})}(1+r_{t+1})
\end{aligned}
\tag{5.11}
$$

5.9 shows that the marginal rate of substitution between consumption in t and $t+1$ is equal to the time-discounted after-tax rate of return on savings.The FOC governing gifts to parents from children (5.10) shows that with operative gift motives, the intertemporal discount factor ϕ is equal to the discounted marginal rate of substitution from a child's consumption for parents consumption.The FOC for transfers is 5.11.

6 Saving Behaviors

6.1 Assumptions of Savings Behaviors

To understand how savings behavior impacts the period wealth of each household it is necessary to define total period assets which includes returns on savings (capital gains), bequests from parents, gifts from children, transfers from the government, and wage income. Gifts and Bequests in my model are only in capital form, therefore we need to endogenize these as assets available for use in any application needed by the household. 6.1 defines the total non-labor income at the end of period t as the last periods non-labor income, scaled by the savings rate $\zeta_{t-1,j,s-1}$. This becomes useful when determining wealth and savings rates in the simulation.

$$x_{t,j,s} = \zeta_{t-1,j,s-1}\left[(1-\tau^k)(b^r_{t-1,j,s-1} + g^r_{t-1,j,s-1})\right] \tag{6.1}$$

where $x_{t,j,s}$ is assumed to be taxable contributions to an IRA account or brokerage, this is taxed on a per-period basis, as seen in 8.1.

6.2 Defined Benefit Plans

In this model Defined Benefit plans (DB) provide income to a household of age R until death. From 3 they retire at age R and they receive[16] a pension from the single representative firm in the economy commensurate to their years of service and average contributions. It is assumed that this income does not change unless a reform occurs which will impact the pension plan in any way. I represent this income in the households budget constraint as $\psi_{t,j,s}$.To determine the total annual pension income for a single household, I define 6.15 where the households yearly payment is equal to some percentage of their final year of pay. Since the DB plan is invested, compounding might make the fund dramatically over-funded, in this case the employees still only receive their normal benefits. To define the defined benefit or funded pension plan scheme I need three equations, one that outlines how an employee (household) contributes to the plan, another that shows how the stored capital from every period contribution is invested, third an equation that determines the payout "rule" to each household during retirement

$$con^{DB}_{t,j,s} = (\wp^{DB}_{t,j,s})w_{t,j,s} \quad \forall t,j, \quad \text{and} \quad E \le s \le R \tag{6.2}$$

$$\begin{gathered} \psi_{t,j,s} = [(1+r_{t-1})\psi_{t-1,j,s-1}] + con^{DB}_{t-1,j,s-1} \quad \forall t,j, \quad \text{and} \quad E \le s \le R \\ \psi_{t+1,j,s+1} = [(1+r_t)\psi_{t,j,s}] + con^{DB}_{t,j,s} \quad \forall t,j, \quad \text{and} \quad E \le s \le R \end{gathered} \tag{6.3}$$

$$\psi_{t,j,s} = [(1+r_{t-1})\psi_{t-1,j,s-1}] - (1-\tau^k)ben^{DB}_{t-1,j,s-1} \quad \forall t,j, \quad \text{and} \quad R \le s \le D \tag{6.4}$$

$$ben^{DB}_{t,j,s} = wr^{DB}_{t-1,j,s-1}(w_{t-1,j,s-1}) \quad \forall t,j, \quad \text{and} \quad R \le s \le D \tag{6.5}$$

[16]In this model the firm does not contribute, rather they "manage the assets" and then payout to the employee upon retirement based off of 6.13.

$$\Psi_t = \sum_{s=E}^{S}\sum_{j=1}^{J}\psi_{t,j,s} \quad \forall t \tag{6.6}$$

$$BEN_t^{DB} = \sum_{s=R}^{S}\sum_{j=1}^{J} swr_{t,j,s}^{DB}(w_{t-1,j,s-1}) \quad \forall t \tag{6.7}$$

$$\breve{N}_t = \sum_{s=E}^{R}\xi_{t,j,s} \quad \forall t \tag{6.8}$$

$$\breve{\breve{N}}_t = \sum_{s=R}^{S}\xi_{t,j,s} \quad \forall t \tag{6.9}$$

The income represented by 6.15 is the annual payout that a household would receive, based on their income level and a multiplier and D-R which is the number of years of retirement where they will receive the annual payout.

6.3 Defined Contribution Plans

DB plans provide a fixed level of annual income to households, based on predetermined factors, households do not choose this payment. DC plans introduce the ability to choose a contribution rate of after-tax income. Households can choose to contribute all of their savings 5% $\leq$ because they earn a higher income level, which is then compounded at r_t, r_{t+1}. It is assumed that the investment option is the same within the companies DC plan and outside, meaning that their is no arbitrage opportunity available only to those who have access to DC plans, moreover contributions are considered to be Roth alleviating challenging decisions as to how to contribute and when to withdraw in retirement. Implicitly households only withdraw assets from the plan at age R as that is the only time when they are not working. We can represent the income earned from DC plans as

$$con_{t,j,s}^{DC} = (\wp_{t,j,s}^{Dc})[(1-\tau^k)w_{t,j,s}] \quad \forall t, j, \quad \text{and} \quad E \leq s \leq R \tag{6.10}$$

$$\begin{gathered} \omega_{t,j,s} = [(1+r_{t-1})\omega_{t-1,j,s-1}] + con_{t-1,j,s-1}^{DC} \quad \forall t, j, \quad \text{and} \quad E \leq s \leq R \\ \omega_{t+1,j,s+1} = [(1+r_t)\omega_{t,j,s}] + con_{t,j,s}^{DC} \quad \forall t, j, \quad \text{and} \quad E \leq s \leq R \end{gathered} \tag{6.11}$$

$$\omega_{t,j,s} = [(1+r_{t-1})\omega_{t-1,j,s-1}] - ben_{t-1,j,s-1}^{DC} \quad \forall t, j, \quad \text{and} \quad R \leq s \leq D \tag{6.12}$$

$$ben_{t,j,s}^{DC} = wr_{t-1,j,s-1}^{DC}(\omega_{t-1,j,s-1}) \quad \forall t, j, \quad \text{and} \quad R \leq s \leq D \tag{6.13}$$

$$\Omega_t = \sum_{s=E}^{S}\sum_{j=1}^{J}\omega_{t,j,s} \quad \forall t \tag{6.14}$$

$$BEN_t^{DC} = \sum_{s=R}^{S} \sum_{j=1}^{J} swr_{t,j,s}^{DC}(w_{t-1,j,s-1}) \quad \forall t \tag{6.15}$$

$$\ddot{N}_t = \sum_{s=E}^{R} \xi_{t,j,s} \quad \forall t \tag{6.16}$$

$$\ddddot{N}_t = \sum_{s=R}^{S} \xi_{t,j,s} \quad \forall t \tag{6.17}$$

6.4 Defined Benefit and Define Contribution Combination

Americans have experienced a decrease in the availability of DB plans as companies shift towards DC plans for cost reduction benefits and due to demographic shifts. I show that DC plans can be much more lucrative to those who are able to contribute the full 5% and have a household income on the higher end of the range proposed in Section 2, but . Many American households today have access to both plans, either via a legacy plan for a current employer, or from two jobs. Households total income from these two plans will vary as the percentage of income from DC vs. DB plans shifts. In the simulation, the weight applied to each form of savings behavior will vary, but each household will have access to either. In the aggregate I calibrate the prevalence of DB and DC plans to the ratio in 2017 26% and 66% respectively[17]. I define the total contributions from the households as,

$$CON_t = \sum_{s=E}^{R} \sum_{j=1}^{J} con_{t,j,s}^{DB} + con_{t,j,s}^{DC} \quad \forall t, j \tag{6.18}$$

$$RET_t = \sum_{s=E}^{S} \sum_{j=1}^{J} \Omega_t + \Psi_t \quad \forall t \tag{6.19}$$

7 Firm Theory and Profit Maximization

7.1 Firm Theory

There is a single representative firm which produces output Y with the constant elasticity of substitution production function being $F(K_t, L_t)$. I use an ACMS CES function as defined originally in Arrow et al. (1961) for two main reasons, the first is because it can be shown to be a nested case of the Cobb-Douglas for $\varepsilon = 1$ which satisfies the Inada Conditions, and second because it does a reasonably good job in estimating empirical results Miller (2008). Z_t is a scaling parameter for total

[17] This is the access rate as defined by the BLS in https://www.bls.gov/ncs/ebs/benefits/2018/ownership/civilian/table02a.pdf, where participation is much lower for 401(k) plans (83 vs 71 take-up rate).

factor productivity (TFP), set exogenously, and ε is the elasticity of substitution between capital and labor. This firm equation takes the form of:

$$Y_t = F(K_t),(L_t) = e^{z_t}\left[(\alpha)^{\frac{1}{\varepsilon}}(K_t)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\alpha)^{\frac{1}{\varepsilon}}(L_t)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{7.1}$$

$$Y_t = e^{z_t}(K_t)^{\alpha}(L_t)^{1-\alpha} \text{ when } \varepsilon = 1 \tag{7.2}$$

TFP evolves according to a Markov Process which is given by,

$$z_t = \rho_z z_{t-1} + \epsilon_t \tag{7.3}$$

where ρ_z is the persistence of the Markov process and the shocks, ϵ_t, are normally distributed with mean zero and standard deviation σ, $\epsilon_t \in \mathcal{N}(0, \sigma^2)$

7.2 Profit Maximization

The firm maximizes profits subject to w_t and r_t, the wage and rental rate of capital respectively. We can represent the firms profit function as

$$\Pi_t = (1-\tau^{corp})\left[F(K_t, L_t) - (w_t)L_t\right] - (r_t + \delta)K_t + \tau^{corp}\delta^{\tau}K_t \tag{7.4}$$

where τ^{corp} is the corporate tax rate which is assumed to be 21% in accordance with the TCJA and δ is the capital depreciation rate and δ^{τ} is a depreciation expense refund which also follows the TCJA rate. We take the partial derivative of 7.4 w.r.t to capital and get

$$r_t = (1-\tau^{corp})e^{z_t\frac{\varepsilon-1}{\varepsilon}}\left[\alpha\frac{Y_t}{K_t}\right]^{\frac{1}{\varepsilon}} - \delta + \tau^{corp}\delta^{\tau} \tag{7.5}$$

Again we take the partial derivative of 7.4 w.r.t to labor and get

$$w_t = e^{z_t\frac{\varepsilon-1}{\varepsilon}}\left[(1-\alpha)\frac{Y_t}{L_t}\right]^{\frac{1}{\varepsilon}} \tag{7.6}$$

8 Government Theory: Revenue and Budget

8.1 Taxes

There are three types of taxes in my model, consumption, income, and capital gains. I set the consumption tax rate based off of the average sales tax from all states, and the capital gains tax set to align with the literature as the true rate varies dependent upon volume and size of trading. Income tax rates are set at there true 2018 levels based on the mean income of each income group.

8.2 Government Revenue

The government taxes wages, consumption, and capital as a lump-sum from 5.4 through $\tau^{t}_{t,j,s}$, and transfers to households through $\tau^{r}_{t,j,s}$. Firms are taxed on their gross income and are allowed to add back their depreciation expense reducing their total liability. The government spends G_t (to fund the transfer program[18]) and transfers to households the rest.

$$Rev_t = \underbrace{(1-\tau^{corp})\left[F(K_t, L_t) - (w_t)L_t\right] - \tau^{corp}\delta^{\tau} K_t}_{\text{corporate tax revenue}} + \sum_{s=E}^{S}\sum_{j=1}^{J} \left[\underbrace{\tau^{c}_{t,j,s} c_{t,j,s} + \tau^{k}_{t,j,s}\left[g^{g}_{t,j,s} + b^{g}_{t,j,s} + g^{r}_{t,j,s} + b^{r}_{t,j,s} + ben^{DB}_{t,j,s} + s_{t,j,s}\right] + \tau^{l}_{t,j,s} w_{t,j,s}}_{\text{household tax revenue}}\right] \quad \forall t \tag{8.1}$$

Following the revenue function, the Government's budget is,

$$D_t = G_t + TR_t \quad \forall t, j \tag{8.2}$$

where G_t is the governments consumption of goods, and TR_t is the total transfers made to households. 8.2 shows that the government consumes and transfers back to households all of their revenue from firms and households.

8.3 Government Transfers

From the Revenue function I am able to define how transfers are determined using,

$$TR_t = \frac{REV_t}{\varphi_{t,j,s} z_{t,j,s}} \quad \forall t \tag{8.3}$$

in the households budget constraint $\tau^{r}_{t,j,s}$ is determined by the government as the share of the budget they receive which is divided among the entire population unevenly.

$$\tau^{r}_{t,j,s} = \frac{TR_t}{N_t} \tag{8.4}$$

where $\varphi_{t,j,s}$ is the incidence of the transfer and is applied to households unequally akin to current welfare policies for the baseline model. This may be changed in reforms to target specific age or income groups.

9 Equilibrium and Market Clearing Conditions

9.1 Goods, Labor, and Capital Market clearing Conditions

Proposition 1. The Equilibrium for households with perfect foresight is a vector of prices $\{w_t, R_t\}_{t=1}^{T}$, households optimal value functions $\{V_t^*\}$, quantities of choice variables $\{c_t, b_t, g_t\}$ and the aggregate variable quantities $\{K_t, L_t, Y_t, C_t, G_t\}$ $\forall$ t.

[18] This is a trivial addition, the government doesn't run without employees and or consuming some amount of goods. This is included for additional calibration accuracy and adds to the models attempt to be a realistic representation.

I have shown that Firms maximize profits 7.4, Households maximize their utility 5.6. An equilibrium is then when all three markets clear (with Walras' Law we only need two but I define all three), the Labor Market, the Capital Market and the Goods Market. The labor market clearing function is straightforward as labor is supplied inelastically by all economically active households where,

$$L_t = \tilde{N}_t \quad \forall t \tag{9.1}$$

the total labor supplied in the economy is equal to the number of economically active households. The capital market clearing function requires that we account for the entire capital stock in the economy which includes retirement schemes asset pools, and the individual savings of all economically active households.

$$K_{t+1} = \sum_{s=E}^{S} \sum_{j=1}^{J} \Omega_{t,j,s} + \Psi_{t,j,s} + S_{t,j,s} \quad \forall t \tag{9.2}$$

which shows that the aggregate investment in the economy is equal to the sum of all household savings in period t The good market clears such that

$$Y_t = F(K_t, L_t) = \tilde{N}_t c_{t,j,s} + K_{t+1} - (\Omega_{t,j,s} + \Psi_{t,j,s} + S_{t,j,s}) - (1-\delta)K_t + G_t \quad \forall t \tag{9.3}$$

the consumption by plus the total investment is equal to the total output from the representative firm.

10 Results

I am using `Dynare` Adjemian et al. (2011) (v4.5.7) to run my model[19] as it provides a host of features and is capable of calculating my model as well as simulate a stochastic version after determining the steady state. My implementation differs slightly from the described equations previously as I account for taxes directly in the original equation for each variable. I tested two agent behavior changes, and three policy reforms aimed at improving inequality.

10.1 Steady State Results

In Table 4 the baseline values for selected variables are listed. These will be compared to reform/behavior adjustments to understand their general equilibrium impact. The baseline Wealth Gini Coefficient[20] was 0.83 which is close to the estimated U.S. Gini (≈.85). The steady state income inequality, is overestimated by 26% as the income Gini coefficient for 2017 for households was .48 compared to the models steady state of .65. Expanded household income data would allow for a

[19]Code files are located in my `Github`: https://github.com/Ben-cmyk/OLG-Altruism/tree/Ben-cmyk-v01

[20]The Gini is given by $G = \dfrac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2\sum_{i=1}^{n}\sum_{j=1}^{n} x_j} = \dfrac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n\sum_{i=1}^{n} x_i} = \dfrac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n^2\bar{x}}$

closer representation of income inequality, as the current publicly available data leaves a lot to be desired.

Table 4: Baseline Values and Prices

Variable	**Value**	**Variable**	**Value**
$\overline{Y}$	1.512	$\overline{RET}$	0.724
$\overline{K}$	6.805	$\overline{G^g}$	1.084
$\overline{\Theta}$	4.237	$\overline{B^g}$	0.067
$\overline{Rev}$	6.442	$\overline{C}$	0.034
$\overline{TR}$	1.932	$\overline{\Pi}$	4.509
$\overline{W}$	0.491	$\overline{R}$	1.025

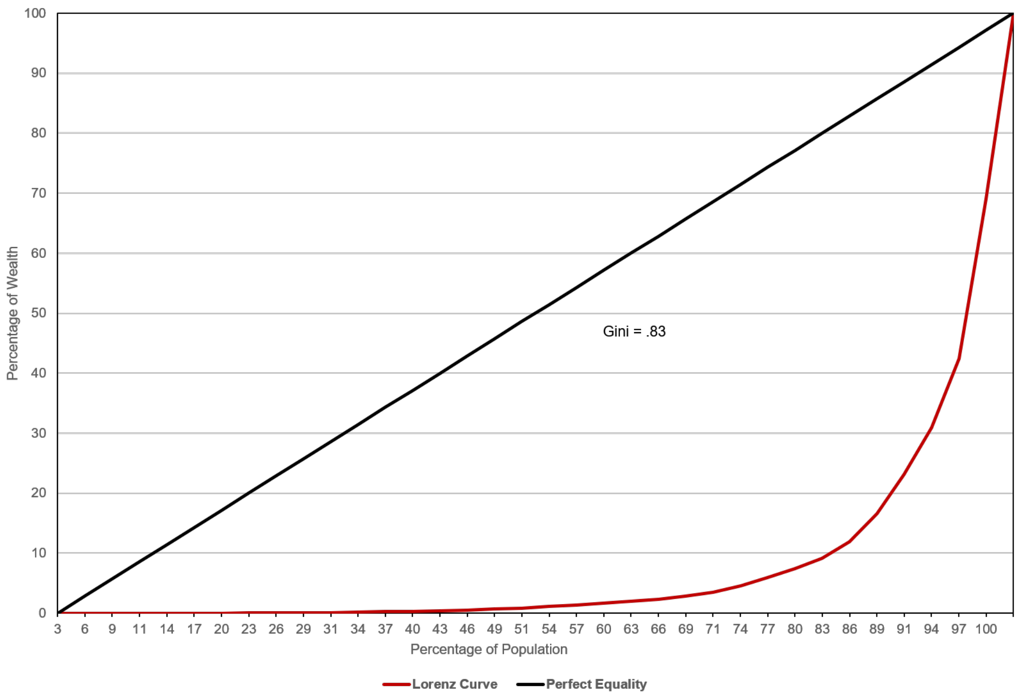

Figure 3: Baseline Lorenz Curve of Household Wealth

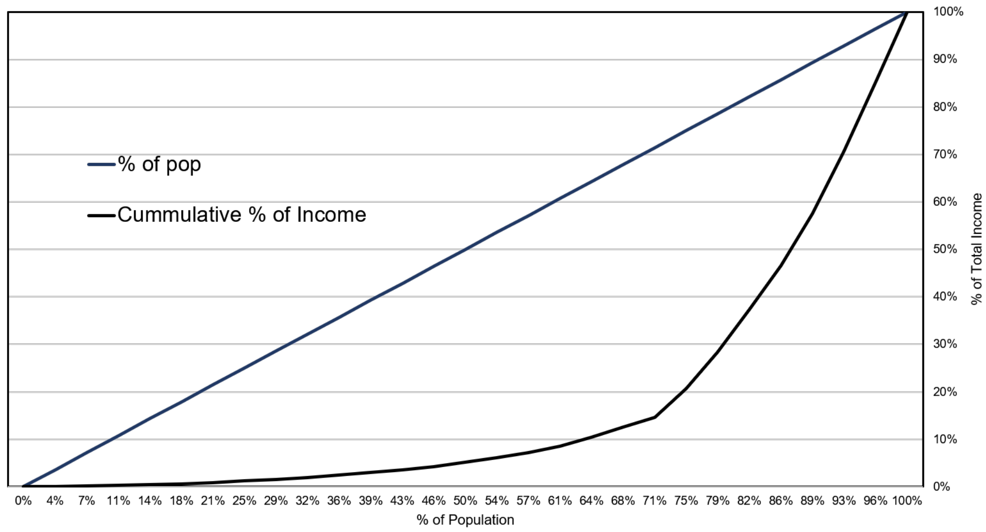

Figure 4: Steady State Income Inequality

10.2 Idiosyncratic Behavior Changes

This section describes three separate changes to household behavior aimed at understand the effects of low-income groups exhibiting outsized saving/altruistic behavior.

10.2.1 Strong Altruism Motive for Low-Income Households

The baseline levels of altruism are set relatively low for the lowest income group, ϕ and γ at 1% and 3% respectively. A motivator that is often discussed in capital accumulation is escaping poverty, agents who seek to escape poverty, must either earn higher wages which is not possible from the baseline and will only occur within aggregate productivity shocks. Absent such shocks, low income individuals need to either increase their savings rate (10.2.2) or from the altruistic perspective sacrifice some of their consumption and current wealth to increase that of subsequent or previous generations. There is both cultural and social evidence that saving rates differ due to parental preference. That is to say, children of immigrants who place a high cultural value on saving or transmission of wealth share the same behavior even 2-3 generations later[21]. To determine the wealth impacts of low income households becoming highly altruistic I adjust the model such that the lowest income group has double, and triple the baseline altruistic utility concern.

[21] See Kraay and McKenzie (2014) for more on escaping poverty, and Fuchs-Schündeln et al. (2019) for empirics on cultural Altruism.

Table 5: Idiosyncratic Shock to Income Group 1's Altruism

	Overall Level of Altruism		
Variable	-50%	200%	300%
Y	-0.030%	0.060%	0.120%
Rev	-0.083%	0.167%	0.334%
$\theta_{t,1,E}$	-4.696%	8.937%	17.272%
$\theta_{t,1,F}$	-4.462%	8.478%	16.365%
$\theta_{t,1,M}$	-4.365%	8.133%	15.473%
$\theta_{t,1,P}$	-4.115%	7.639%	14.494%
RET	0.198%	-0.395%	-0.789%
K	-0.091%	0.183%	0.365%
S	-3.662%	7.324%	14.649%
Gini Coefficient	0.123%	-0.230%	-0.442%

Doubling the overall level of altruism had relatively insignificant effects on wealth inequality, cutting the overall levels in half decreased inequality. This is due to the impacts on the rate of return, as altruism increased among the low-income so did savings, increasing the supply of capital driving down the overall rate of return which negated the gains in wealth from increased bequest and gift size. Increasing the level of altruism has outsized negative general equilibrium effects compared to the impact on low income household wealth. Expanding this same change to higher income groups has similar negative effects on wealth inequality.

10.2.2 Augmenting Contribution Rates

Altruism appears to be a weaker option for a household to escape poverty, and to decrease inequality. Apart from increasing intergenerational transfers households have the option of increasing their savings rate through two mechanisms; contribution rates, and the pure savings rate. Contribution rates are initially set at $\approx 5\%$ for each retirement scheme, increasing the household specific contribution rate and or the overall rate should increase the capital stock and therefore overall output from the firm.

Table 6: Increases in Contribution Rates to Retirement Schemes

	Overall Contribution Rates		
Variable	-100%	200%	300%
Y	-6.467%	7.812%	13.263%
Rev	-5.966%	7.205%	12.232%
$\theta_{t,1,E}$	-4.251%	5.967%	10.600%
x	-0.176%	0.217%	0.368%
W	-6.467%	7.812%	13.263%
C	-0.405%	0.488%	0.827%
RET	-19.564%	27.358%	49.025%
K	-18.339%	25.60%	45.847%
S	-3.189%	3.853%	6.541%
Gini Coefficient	2.908%	-2.932%	-4.578%

Increases in the overall contribution rates decreased overall inequality by almost 5%. Retirement assets grew despite a decrease in the rate of return, which had large effects on wealth inequality, each subsequent increase in the overall contribution rate increased the lowest income households wealth and decreased overall wealth at the the top by 20.21%. This reduction led to a gini coefficient of .78, where as the decrease in contribution rates led to an increase in the gini to .84. Overall the negative effects to the rate of return from the capital stock dynamic resulted in a larger impact on the 1% wealth, than the increase in contribution rates had on retirement assets of the bottom 25%. Altruism appears to be a weaker tool for increasing wealth in comparison to increasing contribution rates, this may be due to the after-tax, after-consumption decision rule binding gifts and bequests which make them smaller. If this were to be lifted this dynamic may be reversed to some extent dependent upon the degree of altruism.

10.2.3 Augmenting the Household Saving Rate

Historically the personal saving rate has been around 5-7% which is tracked through the PSAVERT. Peaking most recently in 2012 at $\approx$ 13% and again in March of this year at the same level the rate has been mostly constant over the past decade. This does not divorce the fact that a few low income individuals/households do save a high percentage of their income relative to the their peers. High-Income households generally save more on average, but this is also not consistent; the ability to save is dependent upon multiple factors and high or low incomes do not determine the level of saving. I compare the wealth inequality outcomes of the bottom 25% saving less than they currently do, saving more, and saving significantly more than current empirical estimates. Overall low-income households choosing to save more does not have a large impact on wealth inequality.

Table 7: Increasing and Decreasing Beta

	Increases and Decreases in β		
Variable	0.97	0.85	0.75
Y	-0.463%	0.972%	2.281%
Rev	-0.506%	1.056%	2.466%
$\theta_{t,1,E}$	-6.640%	12.925%	28.511%
x	-0.013%	0.028%	0.064%
W	-0.462%	0.972%	2.281%
C	0.525%	-1.056%	-2.387%
RET	3.120%	-6.108%	-13.468%
K	-1.395%	25.600%	7.073%
S	-57.241%	115.313%	261.160%
Gini Coefficient	0.497%	-0.965%	-2.142%

The results in Table 7 appear similar in direction to increasing contribution rates, however increases in β do not appear to have as strong as an effect on reducing inequality. The gini coefficient decreased to .79 when β was decreased to .75 from .93 its baseline value. Retirement assets in general decreased, but the increase in personal savings was large enough to counteract the decrease such that the lowest income households wealth increased to $\approx$25% higher than its baseline value. Increases in contribution rates and β appear to have strong positive effects on reducing overall wealth inequality.

10.3 Tax Policies

The calibrated taxation levels were determined by the 2018 tax brackets, a possible (and popular) solution to reduce inequality is to increase income tax on the wealthy (income groups 6 and 7) which increases overall government revenue. Higher government revenue allows for a sudo re-distribution of income as the the poor receive a disproportionate amount of government transfers relative to their size in the population. The reasoning for such a change follows that high income earners "need" less of their income to survive or enjoy life than lower income earners do. The policy I propose to test this is to , increase the ETR among groups 6 and 7 such that group 7 bears the highest incidence of the new tax scheme.

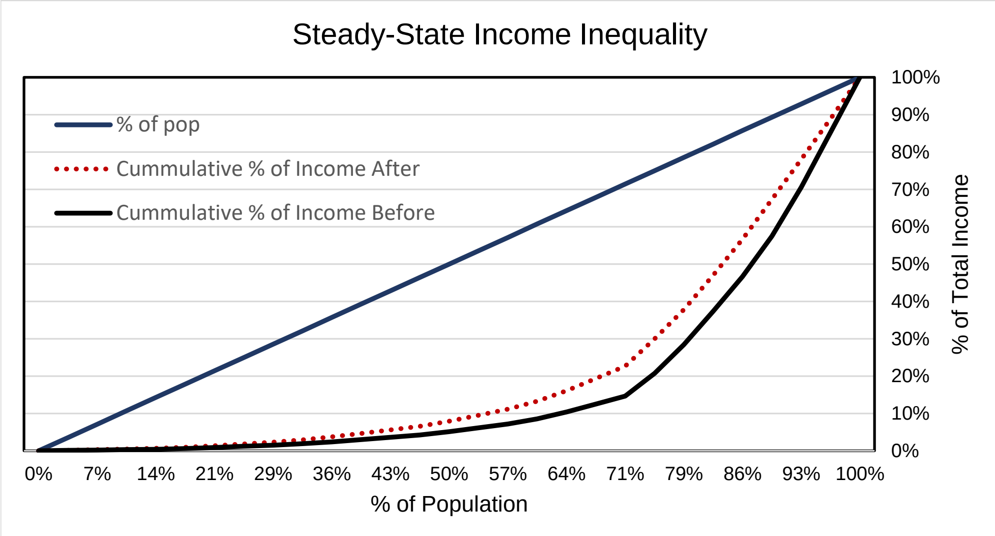

Figure 5: Income Inequality after Tax Rate Increase for top 10%

Table 8: Progressive Tax Rates

Income Percentile	**ETR Before**	**ETR After**	% Δ
0-25	9.59%	9.59%	0.0%
25-50	12.90%	12.90%	0.0%
50-70	18.31%	18.31%	0.0%
70-80	24.75%	24.75%	0.0%
80-90	31.56%	31.56%	0.0%
90-99	35.81%	50.00%	39.63%
99-100	36.29%	70.00%	92.89%
Mean ETR	24.17%	31.02%	28.31%

Table 9: Biggest Movers after Tax Policy

Variable	**Value**	**Variable**	**Value**
After-Tax $w_{t,2,E}$	4.50%	$\theta_{t,7,R}$	0.30%
$\theta_{t,2,P}$	1.22%	$c_{t,7,E}$	-3.21%
$\omega_{t,7,E}$	-4.03%	$g^g_{t,7,E}$	-6.57%
After-Tax $w_{t,7,P}$	-4.41%	$\omega_{t,2,F}$	5.21%
$\theta_{t,1,E}$	0.006%	$ret_{t,7,E}$	-3.15%

The tax policy was effective at changing after tax wages which for the lower income households did increase their overall wealth, ultimately this did not have a strong effect on wealth inequality as the gini decreased by 1% because of the negative effects to the rate of return. This tax policy had a strong positive impact on income inequality, reducing the Gini from .65 to .58. Larger changes could be made, but it may take tax rates double for the top income households which is not likely to be a popular idea. Expanding the tax increases to income groups 5 and 6 might also provide a large increase in revenue, potentially providing low-income households with higher government transfers. This is also not a popular policy, as both groups make up a more sizable percentage of the population than do the top 10%.

10.3.1 Eliminating Consumption Taxation

Consumption taxes are generally regarded as a regressive tax, because they disproportionately effect lower income households despite being a flat rate. The tax revenue generated from consumption is the second largest in this model, a reduction in the total tax revenue means that lower income households receive less in the form of transfers. This raises the question, does the ability to save more, for lower income households outweigh the costs of eliminating the consumption tax? To determine this I test if the elimination of a consumption tax for all income levels and the subsequent revenue decrease, decreases inequality and if the gains from lower income households is greater than that of the economy with a consumption tax.

Variable	%Δ
Y	13.253%
Rev	4.071%
$\theta_{t,1,E}$	3.322%
x	-0.013%
W	13.253%
C	0.819%
RET	48.988%
K	45.809%
S	6.480%
Gini Coefficient	-4.788%

Table 10: Eliminating Consumption Tax

Eliminating the consumption tax had positive benefits towards almost every variable except for those of the wealthy. Output, revenue, and the capital stock all had large increases when the consumption tax was removed. In addition to the general increases, the gini coefficient decreased to almost 5% less than it's original value. Eliminating the consumption tax had multiple positive general equilibrium effects, paying for itself through an increase in revenue, while decreasing inequality.

10.4 Implementing a Wealth Tax

While the feasibility of a Wealth Tax has been called into question, it is a popular proposal for reducing wealth inequality. Senators Warren and Sanders have both proposed similar plans with slightly different cuttoffs for wealth, and different effective rates. Emanuel Saez, and Gabriel Zucman, and Thomas Piketty have provided much of the available wealth and income inequality statistics both from a historical context and from an ongoing perspective. They also likely overestimate the tax revenue that a wealth tax would generate. Wealthy households are very good at escaping the estate tax which is the closest tax we have to a wealth tax. There are many challenges that a tax on wealth presents both logistically, and socially. The beneficial component to the model is that agents cannot avoid a wealth tax, so I can compare the effectiveness of different levels of wealth capture. In my model wealth is given by,

$$\theta_{t,j,s} = s_{t,j,s}(1 + r_t) + w_{t,j,s} + g^r_{t,j,s} + b^r_{t,j,s} + \tau^r_{t,j,s} + \omega_{t,j,s} + \psi_{t,j,s} - c_{t,j,s} - g^g_{t,j,s} - b^g_{t,j,s} - \tau^t_{t,j,s}, \tag{10.1}$$

Introducing a Wealth Tax which aims to redistribute the Wealth from the top 10% (Income Groups 6 & 7) to the bottom 90% requires a few adjustments. First, a percentage of current period wealth is taxed which reduces the top 10% wealth via, $\tau^w_{t,7,s}$. Assets taken from the top 10% are pooled by,

$$\Theta^w_t = \sum_{s=E}^{S} \sum_{j=6}^{7} \theta_{t,j,s} \tag{10.2}$$

and distributed similarly to Government Transfers, except the top 10% are exempt from receiving them. They are dispersed such that the bottom 25% recive the most maxing out at 10% for the 80th-90th percentile.$\{\varphi^w_j\}^5_{j=1} = [0.30, 0.25, 0.2, 0.15, 0.1]$ Transfers are distributed according to,

$$\tau^{wr}_{t,j,s} = \frac{\Theta^w_t}{\{\varphi^w_j\}^5_{j=1}} \quad \forall t \tag{10.3}$$

The Wealth Tax was set at 12.5% of Wealth for households in the 10% of the wealth distribution.

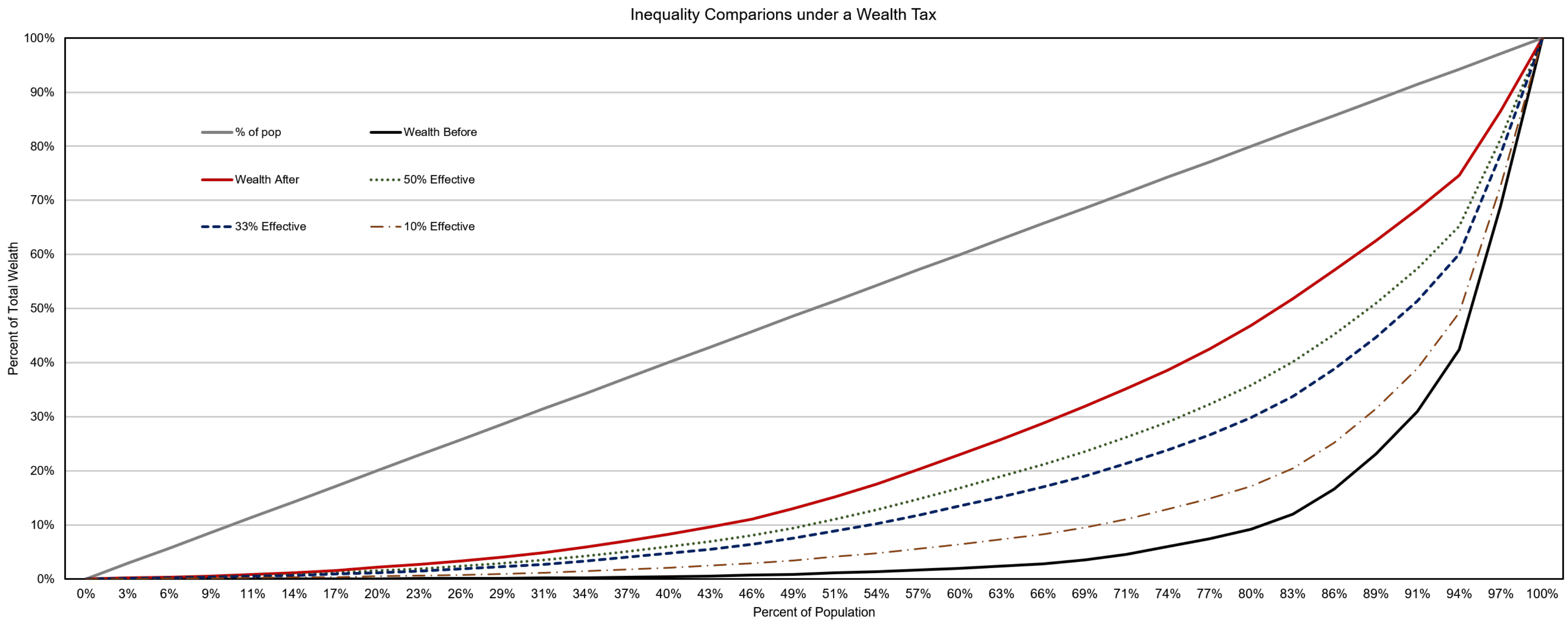

Figure 6: Lorenz Curves for Wealth Tax

The Steady-State Gini from my model was .834 which is compared to $\approx$ .85 for the U.S. After the Wealth Tax was implemented the Gini fell to .512 (a 38% reduction) this however is the best case. Using a variation of the above assumptions a Wealth Tax that is 50% effective reduces Wealth Inequality to .61 or a 27% reduction. A 33% effective Wealth Tax reduces Wealth Inequality to .66 or a 21% reduction. Using the extreme case of 10% effectiveness, the Gini falls only to .77 or an 8% reduction. It is important to note that these figures including the tax on Wealth can not be directly compared to current wealth tax plans. My model incorporates government transfers as a component of household wealth, which can be viewed as a form of UBI in place of other benefits provided by the government in real life such as social services, infrastructure, healthcare and safety which can not be represented here. Extending the model to include such aspects would improve the comparability and would likely reduce wealth of the oldest hosuehold the most[22]

11 Conclusion

The increase in the personal savings rate or retirement scheme contributions at a global level in the model showed strong positive effects in decreasing wealth inequality. Lower income households are generally unable to afford such an increase, especially a 200 or 300% increase, the only way they would be able to increase these rates is through an aggregate productivity shock. If the government were to eliminate the consumption tax a primarily regressive tax, lower income households could fund the cost of increasing savings while maintaining current consumption levels. This combined effect would allow for increased government revenue, increased output, and lower inequality with a gini coefficient of .753. These increases do come at a cost, the rate of return in the market suffers and subsequently so do the higher income households; from a pure cost and benefits perspective the benefits outweigh the loss in wealth as output climbs almost 26% with this combined effect. Determining what level of inequality is acceptable is out of the scope of this paper, this paper then provides additional insight into policy decisions for low income households and the general equilibrium effects of policies aimed at reducing wealth inequality primarily from a bottom up perspective. This highlights several expansions that could be easily implemented, wealth taxes are very popular currently in the media and some of public opinion, and while this model can easily include such a tax it would fail to capture the complex dynamics that come with capital flight. Several other rather simple extensions are the inclusion of a progressive consumption tax, and a new government transfer redistribution scheme, aimed at eliminating inequality. The policy proposals in this paper are not extreme in their attempts to redistribute wealth, and their lack of "bite" highlights the overwhelming importance of rates of return. Slight changes in rates of return (-.60%) led to much larger reductions in wealth inequality. This dynamic illustrates the potential that farther reaching policies or a multi-faceted approach to reducing inequality may exhibit larger returns to scale than the policies in this paper. Implementing a Wealth Tax has strong positive effects on Wealth Inequality even at low levels of taxation, but caution must be used when deciding the thresholds for taxation. France has shown that a wealth tax that targets individuals not high enough in the wealth distribution can have very harmful effects on capital flight, something this model can not capture. Current plans proposed by Senators Warren and Sanders are similar in setup to the model, but feature very different outcomes. This does not suggest that a wealth tax is not

[22]The U.S. spends the majority of its budget on Medicare and Social Security, and Defense. Medicare and Social Security alone make up 34% of the 2020 FY budget.

feasible, rather that expectations should be tempered. If the goal of such a wealth tax is reducing wealth inequality, then even low levels of taxation or capital capture will likely be successful in reducing inequality by a measurable amount.

References

Abel, A. B. (1987). Operative gift and bequest motives.

Adjemian, S., Bastani, H., Juillard, M., Karamé, F., Maih, J., Mihoubi, F., Perendia, G., Pfeifer, J., Ratto, M., and Villemot, S. (2011). Dynare: Reference manual version 4. Dynare Working Papers 1, CEPREMAP.

Allais, M. (1947). *Économie & intérêt: présentation nouvelle des problèmes fondamentaux relatifs au rôle économique du taux de l'intérêt et de leurs solutions*. Librairie des publications officielles.

Altig, D. and Davis, S. J. (1993). Borrowing constraints and two-sided altruism with an application to social security. *Journal of Economic Dynamics and Control*, 17(3):467–494.

Arrow, K. J., Chenery, H. B., Minhas, B. S., and Solow, R. M. (1961). Capital-labor substitution and economic efficiency. *The review of Economics and Statistics*, pages 225–250.

Arrow, K. J. and Kruz, M. (2013). *Public investment, the rate of return, and optimal fiscal policy*. RFF Press.

Auerbach, A. J., Kotlikoff, L. J., et al. (1987). *Dynamic fiscal policy*. Cambridge University Press.

Barro, R. J. (1974). Are government bonds net wealth? *Journal of political economy*, 82(6):1095–1117.

Buiter, W. H. and Carmichael, J. (1984). Government debt: comment. *The American Economic Review*, 74(4):762–765.

Burbidge, J. B. (1983). Government debt in an overlapping-generations model with bequests and gifts. *The American Economic Review*, 73(1):222–227.

Charles, K. K. and Hurst, E. (2003). The correlation of wealth across generations. *Journal of political Economy*, 111(6):1155–1182.

DeBacker, J., Evans, R. W., Magnusson, E., Phillips, K. L., Ramnath, S. P., Swift, I., et al. (2014). The distributional effects of redistributional tax policy. *BYU Macroeconomics and Computational Laboratory Working Paper*, 8.

DeBacker, J., Evans, R. W., and Phillips, K. L. (2019). Integrating microsimulation models of tax policy into a dge macroeconomic model. *Public Finance Review*, 47(2):207–275.

Diamond, P. A. (1965). National debt in a neoclassical growth model. *The American Economic Review*, 55(5):1126–1150.

Dynan, K. E., Skinner, J., and Zeldes, S. P. (2002). The importance of bequests and life-cycle saving in capital accumulation: A new answer. *American Economic Review*, 92(2):274–278.

Evans, R. W. and DeBacker, J. (2017). Og-usa: Documentation for the large-scale dynamic general equilibrium overlapping generations model for us policy analysis. *December, version*.

Evans, R. W. and Phillips, K. L. (2014). Olg life cycle model transition paths: Alternate model forecast method. *Computational Economics*, 43(1):105–131.

Fuchs-Schündeln, N., Masella, P., and Paule-Paludkiewicz, H. (2019). Cultural determinants of household saving behavior.

Galperti, S. and Strulovici, B. (2017). A theory of intergenerational altruism. *Econometrica*, 85(4):1175–1218.

Kimball, M. S. (1987). Making sense of two-sided altruism. *Journal of Monetary Economics*, 20(2):301–326.

Kraay, A. and McKenzie, D. (2014). Do poverty traps exist? assessing the evidence. *Journal of Economic Perspectives*, 28(3):127–48.

Marshall, A. (1920). *Principle Of Economics*. Macmillan and Co., Ltd., 8th edition.

Michel, P., Thibault, E., and Vidal, J.-P. (2006). Intergenerational altruism and neoclassical growth models. *Handbook of the economics of giving, altruism and reciprocity*, 2:1055–1106.

Miller, E. (2008). *An assessment of CES and Cobb-Douglas production functions*. Congressional Budget Office.

Nishiyama, S. (2002). Bequests, inter vivos transfers, and wealth distribution. *Review of Economic Dynamics*, 5(4):892–931.

Piketty, T. and Saez, E. (2003). Income inequality in the united states, 1913–1998. *The Quarterly journal of economics*, 118(1):1–41.

Ramsey, F. P. (1928). A mathematical theory of saving. *The economic journal*, 38(152):543–559.

Rausch, S. (2009). Computation of equilibria in olg models with many heterogeneous households. In *Macroeconomic Consequences of Demographic Change*, pages 11–42. Springer.

Samuelson, P. A. (1958). An exact consumption-loan model of interest with or without the social contrivance of money. *Journal of political economy*, 66(6):467–482.

Solon, G. (1992). Intergenerational income mobility in the united states. *The American Economic Review*, pages 393–408.

Strotz, R. H. (1955). Myopia and inconsistency in dynamic utility maximization. *The review of economic studies*, 23(3):165–180.

Venti, S. F. and Wise, D. A. (1998). The cause of wealth dispersion at retirement: Choice or chance? *The American Economic Review*, 88(2):185–191.

Appendix A Simulation Variables and Values

Table 11: Parameter Values

Parameter	Value	Description
β^{s-1}	0.930	Intertemporal Discount Factor
α	0.330	Capital Share of Production
ϕ	0.030	Households weight of parents utility
γ	0.070	Households weight of parents utility
ε	1.0	Constant Elasticity of Substitution between Capital and Labor
δ	0.080	Capital Depreciation Rate
G_t	0.300	Government Expenditure on goods
τ_t^c	0.064	Tax Rate on Consumption
τ_t^k	0.160	Tax Rate on Capital Stock
τ_t^{corp}	0.150	Tax Rate on Firm Profits
$\tau_{t,1,s}^l$	0.003	Tax Rate on Wages (labor) of wage profile 1
$\tau_{t,2,s}^l$	0.045	Tax Rate on Wages (labor) of wage profile 2
$\tau_{t,3,s}^l$	0.059	Tax Rate on Wages (labor) of wage profile 3
$\tau_{t,4,s}^l$	0.063	Tax Rate on Wages (labor) of wage profile 4
$\tau_{t,5,s}^l$	0.066	Tax Rate on Wages (labor) of wage profile 5
$\tau_{t,6,s}^l$	0.084	Tax Rate on Wages (labor) of wage profile 6
$\tau_{t,7,s}^l$	0.240	Tax Rate on Wages (labor) of wage profile 7
δ_t^τ	0.010	Depreciation Expense allowed to Firm
ϱ_t	0.005	Population Growth Rate
$\varphi_{t,1,E}$	0.105	Household share of Government Transfers at age E of wage profile 1
$\varphi_{t,2,E}$	0.015	Household share of Government Transfers at age E of wage profile 2
$\varphi_{t,3,E}$	0.011	Household share of Government Transfers at age E of wage profile 3
$\varphi_{t,4,E}$	0.009	Household share of Government Transfers at age E of wage profile 4
$\varphi_{t,5,E}$	0.006	Household share of Government Transfers at age E of wage profile 5
$\varphi_{t,6,E}$	0.003	Household share of Government Transfers at age E of wage profile 6
$\varphi_{t,7,E}$	0.002	Household share of Government Transfers at age E of wage profile 7
$\varphi_{t,1,F}$	0.154	Household share of Government Transfers at age F of wage profile 1
$\varphi_{t,2,F}$	0.022	Household share of Government Transfers at age F of wage profile 2
$\varphi_{t,3,F}$	0.015	Household share of Government Transfers at age F of wage profile 3
$\varphi_{t,4,F}$	0.013	Household share of Government Transfers at age F of wage profile 4
$\varphi_{t,5,F}$	0.009	Household share of Government Transfers at age F of wage profile 5
$\varphi_{t,6,F}$	0.004	Household share of Government Transfers at age F of wage profile 6
$\varphi_{t,7,F}$	0.002	Household share of Government Transfers at age F of wage profile 7
$\varphi_{t,1,M}$	0.112	Household share of Government Transfers at age M of wage profile 1
$\varphi_{t,2,M}$	0.016	Household share of Government Transfers at age M of wage profile 2
$\varphi_{t,3,M}$	0.011	Household share of Government Transfers at age M of wage profile 3
$\varphi_{t,4,M}$	0.010	Household share of Government Transfers at age M of wage profile 4
$\varphi_{t,5,M}$	0.006	Household share of Government Transfers at age M of wage profile 5
$\varphi_{t,6,M}$	0.003	Household share of Government Transfers at age M of wage profile 6

Table 11 – Continued

Parameter	Value	Description
$\varphi_{t,7,M}$	0.002	Household share of Government Transfers at age M of wage profile 7
$\varphi_{t,1,P}$	0.098	Household share of Government Transfers at age P of wage profile 1
$\varphi_{t,2,P}$	0.014	Household share of Government Transfers at age P of wage profile 2
$\varphi_{t,3,P}$	0.010	Household share of Government Transfers at age P of wage profile 3
$\varphi_{t,4,P}$	0.008	Household share of Government Transfers at age P of wage profile 4
$\varphi_{t,5,P}$	0.006	Household share of Government Transfers at age P of wage profile 5
$\varphi_{t,6,P}$	0.003	Household share of Government Transfers at age P of wage profile 6
$\varphi_{t,7,P}$	0.001	Household share of Government Transfers at age P of wage profile 7
$\varphi_{t,1,R}$	0.231	Household share of Government Transfers at age R of wage profile 1
$\varphi_{t,2,R}$	0.033	Household share of Government Transfers at age R of wage profile 2
$\varphi_{t,3,R}$	0.023	Household share of Government Transfers at age R of wage profile 3
$\varphi_{t,4,R}$	0.020	Household share of Government Transfers at age R of wage profile 4
$\varphi_{t,5,R}$	0.013	Household share of Government Transfers at age R of wage profile 5
$\varphi_{t,6,R}$	0.007	Household share of Government Transfers at age R of wage profile 6
$\varphi_{t,7,R}$	0.003	Household share of Government Transfers at age R of wage profile 7
$\wp_t^{DB}$	0.050	Household Percentage Contribution to Defined Benefit Plan
$\wp_t^{DC}$	0.050	Household Percentage of Wage Contribution to Defined Contribution Plan
IGE_t	0.400	Intergenerational Elasticity of Income
P_t^w	1.100	Parental Wage Determinant
A	1.650	Total Factor Productivity Augmentation
$swr_{t,j,s}^{DB}$	0.020	Safe Withdrawl rate of Defined Benefit Assets when Retired
$swr_{t,j,s}^{DC}$	0.020	Safe Withdrawl rate of Defined Contribution Assets when Retired
ζ_t^{db}	0.282	Scaling factor on household defined benefit contributions
ζ_t^{dc}	0.638	Scaling factor on household defined contirbution contributions
$z_{t,1,E}$	0.101	Population at ageE of wage profile 1
$z_{t,2,E}$	0.144	Population at ageE of wage profile 2
$z_{t,3,E}$	0.105	Population at ageE of wage profile 3
$z_{t,4,E}$	0.047	Population at ageE of wage profile 4
$z_{t,5,E}$	0.045	Population at ageE of wage profile 5
$z_{t,6,E}$	0.034	Population at ageE of wage profile 6
$z_{t,7,E}$	0.003	Population at ageE of wage profile 7
$z_{t,1,F}$	0.425	Population at ageF of wage profile 1
$z_{t,2,F}$	0.606	Population at ageF of wage profile 2
$z_{t,3,F}$	0.442	Population at ageF of wage profile 3
$z_{t,4,F}$	0.199	Population at ageF of wage profile 4
$z_{t,5,F}$	0.189	Population at ageF of wage profile 5
$z_{t,6,F}$	0.145	Population at ageF of wage profile 6
$z_{t,7,F}$	0.013	Population at ageF of wage profile 7
$z_{t,1,M}$	0.156	Population at ageM of wage profile 1
$z_{t,2,M}$	0.222	Population at ageM of wage profile 2
$z_{t,3,M}$	0.162	Population at ageM of wage profile 3
$z_{t,4,M}$	0.073	Population at ageM of wage profile 4

Table 11 – Continued

Parameter	Value	Description
$z_{t,5,M}$	0.069	Population at ageM of wage profile 5
$z_{t,6,M}$	0.053	Population at ageM of wage profile 6
$z_{t,7,M}$	0.005	Population at ageM of wage profile 7
$z_{t,1,P}$	0.206	Population at ageP of wage profile 1
$z_{t,2,P}$	0.293	Population at ageP of wage profile 2
$z_{t,3,P}$	0.214	Population at ageP of wage profile 3
$z_{t,4,P}$	0.097	Population at ageP of wage profile 4
$z_{t,5,P}$	0.092	Population at ageP of wage profile 5
$z_{t,6,P}$	0.070	Population at ageP of wage profile 6
$z_{t,7,P}$	0.006	Population at ageP of wage profile 7
$z_{t,1,R}$	0.161	Population at ageR of wage profile 1
$z_{t,2,R}$	0.230	Population at ageR of wage profile 2
$z_{t,3,R}$	0.168	Population at ageR of wage profile 3
$z_{t,4,R}$	0.076	Population at ageR of wage profile 4
$z_{t,5,R}$	0.072	Population at ageR of wage profile 5
$z_{t,6,R}$	0.055	Population at ageR of wage profile 6
$z_{t,7,R}$	0.005	Population at ageR of wage profile 7
lab	NaN	Innelastic Labor Supplied by Households of age E to R-1
$\lambda_{t,1,E}$	0.005	Share of total Wage of cohort ageE of wage profile 1
$\lambda_{t,2,E}$	0.009	Share of total Wage of cohort ageE of wage profile 2
$\lambda_{t,3,E}$	0.011	Share of total Wage of cohort ageE of wage profile 3
$\lambda_{t,4,E}$	0.011	Share of total Wage of cohort ageE of wage profile 4
$\lambda_{t,5,E}$	0.012	Share of total Wage of cohort ageE of wage profile 5
$\lambda_{t,6,E}$	0.018	Share of total Wage of cohort ageE of wage profile 6
$\lambda_{t,7,E}$	0.104	Share of total Wage of cohort ageE of wage profile 7
$\lambda_{t,1,F}$	0.006	Share of total Wage of cohort ageF of wage profile 1
$\lambda_{t,2,F}$	0.011	Share of total Wage of cohort ageF of wage profile 2
$\lambda_{t,3,F}$	0.014	Share of total Wage of cohort ageF of wage profile 3
$\lambda_{t,4,F}$	0.015	Share of total Wage of cohort ageF of wage profile 4
$\lambda_{t,5,F}$	0.016	Share of total Wage of cohort ageF of wage profile 5
$\lambda_{t,6,F}$	0.023	Share of total Wage of cohort ageF of wage profile 6
$\lambda_{t,7,F}$	0.135	Share of total Wage of cohort ageF of wage profile 7
$\lambda_{t,1,M}$	0.008	Share of total Wage of cohort ageM of wage profile 1
$\lambda_{t,2,M}$	0.013	Share of total Wage of cohort ageM of wage profile 2
$\lambda_{t,3,M}$	0.016	Share of total Wage of cohort ageM of wage profile 3
$\lambda_{t,4,M}$	0.017	Share of total Wage of cohort ageM of wage profile 4
$\lambda_{t,5,M}$	0.018	Share of total Wage of cohort ageM of wage profile 5
$\lambda_{t,6,M}$	0.028	Share of total Wage of cohort ageM of wage profile 6
$\lambda_{t,7,M}$	0.159	Share of total Wage of cohort ageM of wage profile 7
$\lambda_{t,1,P}$	0.010	Share of total Wage of cohort ageP of wage profile 1
$\lambda_{t,2,P}$	0.018	Share of total Wage of cohort ageP of wage profile 2
$\lambda_{t,3,P}$	0.022	Share of total Wage of cohort ageP of wage profile 3

Table 11 – Continued

Parameter	Value	Description
$\lambda_{t,4,P}$	0.023	Share of total Wage of cohort ageP of wage profile 4
$\lambda_{t,5,P}$	0.025	Share of total Wage of cohort ageP of wage profile 5
$\lambda_{t,6,P}$	0.037	Share of total Wage of cohort ageP of wage profile 6
$\lambda_{t,7,P}$	0.214	Share of total Wage of cohort ageP of wage profile 7

Appendix B Dynare Code

Below is the Dynare code, please do not try and copy this into dynare, copying on pdf's is awful at best. I have provided every file needed to recreate the results, and this thesis on my github at : https://github.com/Ben-cmyk/OLG-Altruism.

```
@#define simulation_periods=162
//*****************************************************************************
//Define variables
//*****************************************************************************
var C         $C_{t}$                  (long_name='Aggregate Consumption')
    cE        $c_{t,j,E}$              (long_name='consumption in period t at age E')
    cE1       $c_{t,1,E}$              (long_name='consumption in period t at age E of wage profile 1')
    cE2       $c_{t,2,E}$              (long_name='consumption in period t at age E of wage profile 2')
    cE3       $c_{t,3,E}$              (long_name='consumption in period t at age E of wage profile 3')
    cE4       $c_{t,4,E}$              (long_name='consumption in period t at age E of wage profile 4')
    cE5       $c_{t,5,E}$              (long_name='consumption in period t at age E of wage profile 5')
    cE6       $c_{t,6,E}$              (long_name='consumption in period t at age E of wage profile 6')
    cE7       $c_{t,7,E}$              (long_name='consumption in period t at age E of wage profile 7')
    cF        $c_{t,j,F}$              (long_name='consumption in period t at age F')
    cF1       $c_{t,1,F}$              (long_name='consumption in period t at age F of wage profile 1')
    cF2       $c_{t,2,F}$              (long_name='consumption in period t at age F of wage profile 2')
    cF3       $c_{t,3,F}$              (long_name='consumption in period t at age F of wage profile 3')
    cF4       $c_{t,4,F}$              (long_name='consumption in period t at age F of wage profile 4')
    cF5       $c_{t,5,F}$              (long_name='consumption in period t at age F of wage profile 5')
    cF6       $c_{t,6,F}$              (long_name='consumption in period t at age F of wage profile 6')
    cF7       $c_{t,7,F}$              (long_name='consumption in period t at age F of wage profile 7')
    cM        $c_{t,j,M}$              (long_name='consumption in period t at age M')
    cM1       $c_{t,1,M}$              (long_name='consumption in period t at age M of wage profile 1')
    cM2       $c_{t,2,M}$              (long_name='consumption in period t at age M of wage profile 2')
    cM3       $c_{t,3,M}$              (long_name='consumption in period t at age M of wage profile 3')
    cM4       $c_{t,4,M}$              (long_name='consumption in period t at age M of wage profile 4')
    cM5       $c_{t,5,M}$              (long_name='consumption in period t at age M of wage profile 5')
    cM6       $c_{t,6,M}$              (long_name='consumption in period t at age M of wage profile 6')
    cM7       $c_{t,7,M}$              (long_name='consumption in period t at age M of wage profile 7 ')
    cP        $c_{t,j,P}$              (long_name='consumption in period t at age P')
    cP1       $c_{t,1,P}$              (long_name='consumption in period t at age P of wage profile 1')
    cP2       $c_{t,2,P}$              (long_name='consumption in period t at age P of wage profile 2')
    cP3       $c_{t,3,P}$              (long_name='consumption in period t at age P of wage profile 3')
    cP4       $c_{t,4,P}$              (long_name='consumption in period t at age P of wage profile 4')
    cP5       $c_{t,5,P}$              (long_name='consumption in period t at age P of wage profile 5')
    cP6       $c_{t,6,P}$              (long_name='consumption in period t at age P of wage profile 6')
    cP7       $c_{t,7,P}$              (long_name='consumption in period t at age P of wage profile 7')
    cR        $c_{t,j,R}$              (long_name='consumption in period t at age R')
    cR1       $c_{t,1,R}$              (long_name='consumption in period t at age R of wage profile 1')
    cR2       $c_{t,2,R}$              (long_name='consumption in period t at age R of wage profile 2')
    cR3       $c_{t,3,R}$              (long_name='consumption in period t at age R of wage profile 3')
    cR4       $c_{t,4,R}$              (long_name='consumption in period t at age R of wage profile 4')
    cR5       $c_{t,5,R}$              (long_name='consumption in period t at age R of wage profile 5')
    cR6       $c_{t,6,R}$              (long_name='consumption in period t at age R of wage profile 6')
    cR7       $c_{t,7,R}$              (long_name='consumption in period t at age R of wage profile 7')
    K         $K_{t}$                  (long_name='Capital Stock')
    Y         $Y_{t}$                  (long_name='Output')
    W         $W_{t}$                  (long_name='Aggregate Wage')
    Pi
    WPost     $W_{t}^{p}$              (long_name='Aggregate After-Tax Wage')
    wE        $w_{t,j,E}$              (long_name='Cohort age E share of total wages')
    wE1       $w_{t,1,E}$              (long_name='Cohort age E share of total wages of wage profile 1')
    wE2       $w_{t,2,E}$              (long_name='Cohort age E share of total wages of wage profile 2')
    wE3       $w_{t,3,E}$              (long_name='Cohort age E share of total wages of wage profile 3')
    wE4       $w_{t,4,E}$              (long_name='Cohort age E share of total wages of wage profile 4')
    wE5       $w_{t,5,E}$              (long_name='Cohort age E share of total wages of wage profile 5')
    wE6       $w_{t,6,E}$              (long_name='Cohort age E share of total wages of wage profile 6')
    wE7       $w_{t,7,E}$              (long_name='Cohort age E share of total wages of wage profile 7')
    wF        $w_{t,j,F}$              (long_name='Cohort age E share of total wages')
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    wF1       $w_{t,1,F}$              (long_name='Cohort age F share of total wages of wage profile 1')
    wF2       $w_{t,2,F}$              (long_name='Cohort age F share of total wages of wage profile 2')
    wF3       $w_{t,3,F}$              (long_name='Cohort age F share of total wages of wage profile 3')
    wF4       $w_{t,4,F}$              (long_name='Cohort age F share of total wages of wage profile 4')
    wF5       $w_{t,5,F}$              (long_name='Cohort age F share of total wages of wage profile 5')
    wF6       $w_{t,6,F}$              (long_name='Cohort age F share of total wages of wage profile 6')
    wF7       $w_{t,7,F}$              (long_name='Cohort age F share of total wages of wage profile 7')
    wM        $w_{t,j,M}$              (long_name='Cohort age M share of total wages')
    wM1       $w_{t,1,M}$              (long_name='Cohort age M share of total wages of wage profile 1')
    wM2       $w_{t,2,M}$              (long_name='Cohort age M share of total wages of wage profile 2')
    wM3       $w_{t,3,M}$              (long_name='Cohort age M share of total wages of wage profile 3')
    wM4       $w_{t,4,M}$              (long_name='Cohort age M share of total wages of wage profile 4')
    wM5       $w_{t,5,M}$              (long_name='Cohort age M share of total wages of wage profile 5')
    wM6       $w_{t,6,M}$              (long_name='Cohort age M share of total wages of wage profile 6')
    wM7       $w_{t,7,M}$              (long_name='Cohort age M share of total wages of wage profile 7')
    wP        $w_{t,j,P}$              (long_name='Cohort age P share of total wages')
    wP1       $w_{t,1,P}$              (long_name='Cohort age P share of total wages of wage profile 1')
    wP2       $w_{t,2,P}$              (long_name='Cohort age P share of total wages of wage profile 2')
    wP3       $w_{t,3,P}$              (long_name='Cohort age P share of total wages of wage profile 3')
    wP4       $w_{t,4,P}$              (long_name='Cohort age P share of total wages of wage profile 4')
    wP5       $w_{t,5,P}$              (long_name='Cohort age P share of total wages of wage profile 5')
    wP6       $w_{t,6,P}$              (long_name='Cohort age P share of total wages of wage profile 6')
    wP7       $w_{t,7,P}$              (long_name='Cohort age P share of total wages of wage profile 7')
    R         $R_{t}$                   (long_name='Rental Rate of Capital')
    Theta     $\Theta_{t}$             (long_name='Aggregate Household Wealth')
    thetaE    $\theta_{t,j,E}$         (long_name='Household Wealth in period t')
    thetaE1   $\theta_{t,1,E}$         (long_name='Household Wealth in period t at age E of wage profile 1')
    thetaE2   $\theta_{t,2,E}$         (long_name='Household Wealth in period t at age E of wage profile 2')
    thetaE3   $\theta_{t,3,E}$         (long_name='Household Wealth in period t at age E of wage profile 3')
    thetaE4   $\theta_{t,4,E}$         (long_name='Household Wealth in period t at age E of wage profile 4')
    thetaE5   $\theta_{t,5,E}$         (long_name='Household Wealth in period t at age E of wage profile 5')
    thetaE6   $\theta_{t,6,E}$         (long_name='Household Wealth in period t at age E of wage profile 6')
    thetaE7   $\theta_{t,7,E}$         (long_name='Household Wealth in period t at age E of wage profile 7')
    thetaF    $\theta_{t,j,F}$         (long_name='Household Wealth in period t')
    thetaF1   $\theta_{t,1,F}$         (long_name='Household Wealth in period t at age F of wage profile 1')
    thetaF2   $\theta_{t,2,F}$         (long_name='Household Wealth in period t at age F of wage profile 2')
    thetaF3   $\theta_{t,3,F}$         (long_name='Household Wealth in period t at age F of wage profile 3')
    thetaF4   $\theta_{t,4,F}$         (long_name='Household Wealth in period t at age F of wage profile 4')
    thetaF5   $\theta_{t,5,F}$         (long_name='Household Wealth in period t at age F of wage profile 5')
    thetaF6   $\theta_{t,6,F}$         (long_name='Household Wealth in period t at age F of wage profile 6')
    thetaF7   $\theta_{t,7,F}$         (long_name='Household Wealth in period t at age F of wage profile 7')
    thetaM    $\theta_{t,j,M}$         (long_name='Household Wealth in period t')
    thetaM1   $\theta_{t,1,M}$         (long_name='Household Wealth in period t at age M of wage profile 1')
    thetaM2   $\theta_{t,2,M}$         (long_name='Household Wealth in period t at age M of wage profile 2')
    thetaM3   $\theta_{t,3,M}$         (long_name='Household Wealth in period t at age M of wage profile 3')
    thetaM4   $\theta_{t,4,M}$         (long_name='Household Wealth in period t at age M of wage profile 4')
    thetaM5   $\theta_{t,5,M}$         (long_name='Household Wealth in period t at age M of wage profile 5')
    thetaM6   $\theta_{t,6,M}$         (long_name='Household Wealth in period t at age M of wage profile 6')
    thetaM7   $\theta_{t,7,M}$         (long_name='Household Wealth in period t at age M of wage profile 7')
    thetaP    $\theta_{t,j,P}$         (long_name='Household Wealth in period t ate age P')
    thetaP1   $\theta_{t,1,P}$         (long_name='Household Wealth in period t at age P of wage profile 1')
    thetaP2   $\theta_{t,2,P}$         (long_name='Household Wealth in period t at age P of wage profile 2')
    thetaP3   $\theta_{t,3,P}$         (long_name='Household Wealth in period t at age P of wage profile 3')
    thetaP4   $\theta_{t,4,P}$         (long_name='Household Wealth in period t at age P of wage profile 4')
    thetaP5   $\theta_{t,5,P}$         (long_name='Household Wealth in period t at age P of wage profile 5')
    thetaP6   $\theta_{t,6,P}$         (long_name='Household Wealth in period t at age P of wage profile 6')
    thetaP7   $\theta_{t,7,P}$         (long_name='Household Wealth in period t at age P of wage profile 7')
    thetaR    $\theta_{t,j,R}$         (long_name='Household Wealth in period t at age R')
    thetaR1   $\theta_{t,1,R}$         (long_name='Household Wealth in period t at age R of wage profile 1')
    thetaR2   $\theta_{t,2,R}$         (long_name='Household Wealth in period t at age R of wage profile 2')
    thetaR3   $\theta_{t,3,R}$         (long_name='Household Wealth in period t at age R of wage profile 3')
    thetaR4   $\theta_{t,4,R}$         (long_name='Household Wealth in period t at age R of wage profile 4')
    thetaR5   $\theta_{t,5,R}$         (long_name='Household Wealth in period t at age R of wage profile 5')
    thetaR6   $\theta_{t,6,R}$         (long_name='Household Wealth in period t at age R of wage profile 6')
    thetaR7   $\theta_{t,7,R}$         (long_name='Household Wealth in period t at age R of wage profile 7')
    wthetaE1
wthetaE2
wthetaE3
wthetaE4
wthetaE5
wthetaE6
wthetaE7
wthetaF1
wthetaF2
wthetaF3
wthetaF4
wthetaF5
wthetaF6
wthetaF7
wthetaM1
wthetaM2
wthetaM3
wthetaM4
wthetaM5
wthetaM6
wthetaM7
wthetaP1
wthetaP2
wthetaP3
wthetaP4
wthetaP5
wthetaP6
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wthetaP7
wthetaR1
wthetaR2
wthetaR3
wthetaR4
wthetaR5
wthetaR6
wthetaR7
tauwTheta
wTheta
tautw1
tautw2
tautw3
tautw4
tautw5
wthetaE
wthetaF
wthetaM
wthetaP
wthetaR

    S     $S_{t}$        (long_name='Aggregate Savings')
    sE    $s_{t,j,E}$    (long_name='household savings in period t at age E')
    sE1   $s_{t,1,E}$    (long_name='household savings in period t at age E of wage profile 1')
    sE2   $s_{t,2,E}$    (long_name='household savings in period t at age E of wage profile 2')
    sE3   $s_{t,3,E}$    (long_name='household savings in period t at age E of wage profile 3')
    sE4   $s_{t,4,E}$    (long_name='household savings in period t at age E of wage profile 4')
    sE5   $s_{t,5,E}$    (long_name='household savings in period t at age E of wage profile 5')
    sE6   $s_{t,6,E}$    (long_name='household savings in period t at age E of wage profile 6')
    sE7   $s_{t,7,E}$    (long_name='household savings in period t at age E of wage profile 7')
    sF    $s_{t,j,F}$    (long_name='household savings in period t at age F')
    sF1   $s_{t,1,F}$    (long_name='household savings in period t at age F of wage profile 1')
    sF2   $s_{t,2,F}$    (long_name='household savings in period t at age F of wage profile 2')
    sF3   $s_{t,3,F}$    (long_name='household savings in period t at age F of wage profile 3')
    sF4   $s_{t,4,F}$    (long_name='household savings in period t at age F of wage profile 4')
    sF5   $s_{t,5,F}$    (long_name='household savings in period t at age F of wage profile 5')
    sF6   $s_{t,6,F}$    (long_name='household savings in period t at age F of wage profile 6')
    sF7   $s_{t,7,F}$    (long_name='household savings in period t at age F of wage profile 7')
    sM    $s_{t,j,M}$    (long_name='household savings in period t at age M')
    sM1   $s_{t,1,M}$    (long_name='household savings in period t at age M of wage profile 1')
    sM2   $s_{t,2,M}$    (long_name='household savings in period t at age M of wage profile 2')
    sM3   $s_{t,3,M}$    (long_name='household savings in period t at age M of wage profile 3')
    sM4   $s_{t,4,M}$    (long_name='household savings in period t at age M of wage profile 4')
    sM5   $s_{t,5,M}$    (long_name='household savings in period t at age M of wage profile 5')
    sM6   $s_{t,6,M}$    (long_name='household savings in period t at age M of wage profile 6')
    sM7   $s_{t,7,M}$    (long_name='household savings in period t at age M of wage profile 7')
    sP    $s_{t,j,P}$    (long_name='household savings in period t at age P')
    sP1   $s_{t,1,P}$    (long_name='household savings in period t at age P of wage profile 1')
    sP2   $s_{t,2,P}$    (long_name='household savings in period t at age P of wage profile 2')
    sP3   $s_{t,3,P}$    (long_name='household savings in period t at age P of wage profile 3')
    sP4   $s_{t,4,P}$    (long_name='household savings in period t at age P of wage profile 4')
    sP5   $s_{t,5,P}$    (long_name='household savings in period t at age P of wage profile 5')
    sP6   $s_{t,6,P}$    (long_name='household savings in period t at age P of wage profile 6')
    sP7   $s_{t,7,P}$    (long_name='household savings in period t at age P of wage profile 7')
    X     $X_{t}$        (long_name='Aggregate Intergenerational Household Transfers')
    xE    $x_{t,j,E}$    (long_name='Intergenerational Household Transfers at period t at age E')
    xE1   $x_{t,1,E}$    (long_name='Intergenerational Household Transfers at period t at age E of wage profile 1')
    xE2   $x_{t,2,E}$    (long_name='Intergenerational Household Transfers at period t at age E of wage profile 2')
    xE3   $x_{t,3,E}$    (long_name='Intergenerational Household Transfers at period t at age E of wage profile 3')
    xE4   $x_{t,4,E}$    (long_name='Intergenerational Household Transfers at period t at age E of wage profile 4')
    xE5   $x_{t,5,E}$    (long_name='Intergenerational Household Transfers at period t at age E of wage profile 5')
    xE6   $x_{t,6,E}$    (long_name='Intergenerational Household Transfers at period t at age E of wage profile 6')
    xE7   $x_{t,7,E}$    (long_name='Intergenerational Household Transfers at period t at age E of wage profile 7')
    xF    $x_{t,j,F$     (long_name='Intergenerational Household Transfers at period t at age F')
    xF1   $x_{t,1,F}$    (long_name='Intergenerational Household Transfers at period t at age F of wage profile 1')
    xF2   $x_{t,2,F}$    (long_name='Intergenerational Household Transfers at period t at age F of wage profile 2')
    xF3   $x_{t,3,F}$    (long_name='Intergenerational Household Transfers at period t at age F of wage profile 3')
    xF4   $x_{t,4,F}$    (long_name='Intergenerational Household Transfers at period t at age F of wage profile 4')
    xF5   $x_{t,5,F}$    (long_name='Intergenerational Household Transfers at period t at age F of wage profile 5')
    xF6   $x_{t,6,F}$    (long_name='Intergenerational Household Transfers at period t at age F of wage profile 6')
    xF7   $x_{t,7,F}$    (long_name='Intergenerational Household Transfers at period t at age F of wage profile 7')
    xM    $x_{t,j,M}$    (long_name='Intergenerational Household Transfers at period t at age M')
    xM1   $x_{t,1,M}$    (long_name='Intergenerational Household Transfers at period t at age M of wage profile 1')
    xM2   $x_{t,2,M}$    (long_name='Intergenerational Household Transfers at period t at age M of wage profile 2')
    xM3   $x_{t,3,M}$    (long_name='Intergenerational Household Transfers at period t at age M of wage profile 3')
    xM4   $x_{t,4,M}$    (long_name='Intergenerational Household Transfers at period t at age M of wage profile 4')
    xM5   $x_{t,5,M}$    (long_name='Intergenerational Household Transfers at period t at age M of wage profile 5')
    xM6   $x_{t,6,M}$    (long_name='Intergenerational Household Transfers at period t at age M of wage profile 6')
    xM7   $x_{t,7,M}$    (long_name='Intergenerational Household Transfers at period t at age M of wage profile 7')
    xP    $x_{t,j,P}$    (long_name='Intergenerational Household Transfers at period t at age P')
    xP1   $x_{t,1,P}$    (long_name='Intergenerational Household Transfers at period t at age P of wage profile 1')
    xP2   $x_{t,2,P}$    (long_name='Intergenerational Household Transfers at period t at age P of wage profile 2')
    xP3   $x_{t,3,P}$    (long_name='Intergenerational Household Transfers at period t at age P of wage profile 3')
    xP4   $x_{t,4,P}$    (long_name='Intergenerational Household Transfers at period t at age P of wage profile 4')
    xP5   $x_{t,5,P}$    (long_name='Intergenerational Household Transfers at period t at age P of wage profile 5')
    xP6   $x_{t,6,P}$    (long_name='Intergenerational Household Transfers at period t at age P of wage profile 6')
    xP7   $x_{t,7,P}$    (long_name='Intergenerational Household Transfers at period t at age P of wage profile 7')
    xR    $x_{t,j,R}$    (long_name='Intergenerational Household Transfers at period t at age R')
    xR1   $x_{t,1,R}$    (long_name='Intergenerational Household Transfers at period t at age R of wage profile 1')
    xR2   $x_{t,2,R}$    (long_name='Intergenerational Household Transfers at period t at age R of wage profile 2')
    xR3   $x_{t,3,R}$    (long_name='Intergenerational Household Transfers at period t at age R of wage profile 3')
    xR4   $x_{t,4,R}$    (long_name='Intergenerational Household Transfers at period t at age R of wage profile 4')
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xR5    $x_{t,5,R}$       (long_name='Intergenerational Household Transfers at period t at age R of wage profile 5')
xR6    $x_{t,6,R}$       (long_name='Intergenerational Household Transfers at period t at age R of wage profile 6')
xR7    $x_{t,7,R}$       (long_name='Intergenerational Household Transfers at period t at age R of wage profile 7')
Gg     $G_{t}^{g}$       (long_name='Aggregate Gifts to Parents from Children')
ggE    $g_{t,j,E}^{g}$   (long_name='Gifts to Parents from Children in period t at age E')
ggE1   $g_{t,1,E}^{g}$   (long_name='Gifts to Parents from Children in period t at age E of wage profile 1')
ggE2   $g_{t,2,E}^{g}$   (long_name='Gifts to Parents from Children in period t at age E of wage profile 2')
ggE3   $g_{t,3,E}^{g}$   (long_name='Gifts to Parents from Children in period t at age E of wage profile 3')
ggE4   $g_{t,4,E}^{g}$   (long_name='Gifts to Parents from Children in period t at age E of wage profile 4')
ggE5   $g_{t,5,E}^{g}$   (long_name='Gifts to Parents from Children in period t at age E of wage profile 5')
ggE6   $g_{t,6,E}^{g}$   (long_name='Gifts to Parents from Children in period t at age E of wage profile 6')
ggE7   $g_{t,7,E}^{g}$   (long_name='Gifts to Parents from Children in period t at age E of wage profile 7')
ggF    $g_{t,j,F}^{g}$   (long_name='Gifts to Parents from Children in period t at age F')
ggF1   $g_{t,1,F}^{g}$   (long_name='Gifts to Parents from Children in period t at age F of wage profile 1')
ggF2   $g_{t,2,F}^{g}$   (long_name='Gifts to Parents from Children in period t at age F of wage profile 2')
ggF3   $g_{t,3,F}^{g}$   (long_name='Gifts to Parents from Children in period t at age F of wage profile 3')
ggF4   $g_{t,4,F}^{g}$   (long_name='Gifts to Parents from Children in period t at age F of wage profile 4')
ggF5   $g_{t,5,F}^{g}$   (long_name='Gifts to Parents from Children in period t at age F of wage profile 5')
ggF6   $g_{t,6,F}^{g}$   (long_name='Gifts to Parents from Children in period t at age F of wage profile 6')
ggF7   $g_{t,7,F}^{g}$   (long_name='Gifts to Parents from Children in period t at age F of wage profile 7')
ggM    $g_{t,j,M}^{g}$   (long_name='Gifts to Parents from Children in period t')
ggM1   $g_{t,1,M}^{g}$   (long_name='Gifts to Parents from Children in period t at age M of wage profile 1')
ggM2   $g_{t,2,M}^{g}$   (long_name='Gifts to Parents from Children in period t at age M of wage profile 2')
ggM3   $g_{t,3,M}^{g}$   (long_name='Gifts to Parents from Children in period t at age M of wage profile 3')
ggM4   $g_{t,4,M}^{g}$   (long_name='Gifts to Parents from Children in period t at age M of wage profile 4')
ggM5   $g_{t,5,M}^{g}$   (long_name='Gifts to Parents from Children in period t at age M of wage profile 5')
ggM6   $g_{t,6,M}^{g}$   (long_name='Gifts to Parents from Children in period t at age M of wage profile 6')
ggM7   $g_{t,7,M}^{g}$   (long_name='Gifts to Parents from Children in period t at age M of wage profile 7')
Bg     $B_{t}^{g}$       (long_name='Aggregate Bequests from Parents to Children')
bgM    $b_{t,j,M}^{g}$   (long_name='Bequest from Parents to Children in period t at age M')
bgM1   $b_{t,1,M}^{g}$   (long_name='Bequests from Parents to Children in period t at age M of wage profile 1')
bgM2   $b_{t,2,M}^{g}$   (long_name='Bequests from Parents to Children in period t at age M of wage profile 2')
bgM3   $b_{t,3,M}^{g}$   (long_name='Bequests from Parents to Children in period t at age M of wage profile 3')
bgM4   $b_{t,4,M}^{g}$   (long_name='Bequests from Parents to Children in period t at age M of wage profile 4')
bgM5   $b_{t,5,M}^{g}$   (long_name='Bequests from Parents to Children in period t at age M of wage profile 5')
bgM6   $b_{t,6,M}^{g}$   (long_name='Bequests from Parents to Children in period t at age M of wage profile 6')
bgM7   $b_{t,7,M}^{g}$   (long_name='Bequests from Parents to Children in period t at age M of wage profile 7')
bgP    $b_{t,j,P}^{g}$   (long_name='Bequest from Parents to Children in period t at age P')
bgP1   $b_{t,1,P}^{g}$   (long_name='Bequests from Parents to Children in period t at age P of wage profile 1')
bgP2   $b_{t,2,P}^{g}$   (long_name='Bequests from Parents to Children in period t at age P of wage profile 2')
bgP3   $b_{t,3,P}^{g}$   (long_name='Bequests from Parents to Children in period t at age P of wage profile 3')
bgP4   $b_{t,4,P}^{g}$   (long_name='Bequests from Parents to Children in period t at age P of wage profile 4')
bgP5   $b_{t,5,P}^{g}$   (long_name='Bequests from Parents to Children in period t at age P of wage profile 5')
bgP6   $b_{t,6,P}^{g}$   (long_name='Bequests from Parents to Children in period t at age P of wage profile 6')
bgP7   $b_{t,7,P}^{g}$   (long_name='Bequests from Parents to Children in period t at age P of wage profile 7')
bgR    $b_{t,j,R}^{g}$   (long_name='Bequest from Parents to Children in period t at age R')
bgR1   $b_{t,1,R}^{g}$   (long_name='Bequests from Parents to Children in period t at age R of wage profile 1')
bgR2   $b_{t,2,R}^{g}$   (long_name='Bequests from Parents to Children in period t at age R of wage profile 2')
bgR3   $b_{t,3,R}^{g}$   (long_name='Bequests from Parents to Children in period t at age R of wage profile 3')
bgR4   $b_{t,4,R}^{g}$   (long_name='Bequests from Parents to Children in period t at age R of wage profile 4')
bgR5   $b_{t,5,R}^{g}$   (long_name='Bequests from Parents to Children in period t at age R of wage profile 5')
bgR6   $b_{t,6,R}^{g}$   (long_name='Bequests from Parents to Children in period t at age R of wage profile 6')
bgR7   $b_{t,7,R}^{g}$   (long_name='Bequests from Parents to Children in period t at age R of wage profile 7')
Gr     $G_{t}^{r}$       (long_name='Aggregate Gifts recieved from Children to Parents')
grM    $g_{t,j,M}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at age M')
grM1   $g_{t,1,M}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageM of wage profile 1')
grM2   $g_{t,2,M}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageM of wage profile 2')
grM3   $g_{t,3,M}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageM of wage profile 3')
grM4   $g_{t,4,M}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageM of wage profile 4')
grM5   $g_{t,5,M}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageM of wage profile 5')
grM6   $g_{t,6,M}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageM of wage profile 6')
grM7   $g_{t,7,M}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageM of wage profile 7')
grP    $g_{t,j,P}^{r}$   (long_name='Gifts recieved from Children to Parents in period t')
grP1   $g_{t,1,P}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageP of wage profile 1')
grP2   $g_{t,2,P}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageP of wage profile 2')
grP3   $g_{t,3,P}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageP of wage profile 3')
grP4   $g_{t,4,P}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageP of wage profile 4')
grP5   $g_{t,5,P}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageP of wage profile 5')
grP6   $g_{t,6,P}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageP of wage profile 6')
grP7   $g_{t,7,P}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageP of wage profile 7')
grR    $g_{t,j,R}^{r}$   (long_name='Gifts recieved from Children to Parents in period t')
grR1   $g_{t,1,R}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageR of wage profile 1')
grR2   $g_{t,2,R}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageR of wage profile 2')
grR3   $g_{t,3,R}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageR of wage profile 3')
grR4   $g_{t,4,R}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageR of wage profile 4')
grR5   $g_{t,5,R}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageR of wage profile 5')
grR6   $g_{t,6,R}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageR of wage profile 6')
grR7   $g_{t,7,R}^{r}$   (long_name='Gifts recieved from Children to Parents in period t at ageR of wage profile 7')
Br     $B_{t}^{r}$       (long_name='Aggregate Bequests recieived from Children to Parents')
brE    $b_{t,j,E}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age E')
brE1   $b_{t,1,E}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age E of wage profile 1')
brE2   $b_{t,2,E}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age E of wage profile 2')
brE3   $b_{t,3,E}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age E of wage profile 3')
brE4   $b_{t,4,E}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age E of wage profile 4')
brE5   $b_{t,5,E}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age E of wage profile 5')
brE6   $b_{t,6,E}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age E of wage profile 6')
brE7   $b_{t,7,E}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age E of wage profile 7')
brF    $b_{t,j,F}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age F')
brF1   $b_{t,1,F}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age F of wage profile 1')
brF2   $b_{t,2,F}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age F of wage profile 2')
brF3   $b_{t,3,F}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age F of wage profile 3')
brF4   $b_{t,4,F}^{r}$   (long_name='Beqests recieved from Children to Parents in period t at age F of wage profile 4')
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brF5    $b_{t,5,F}^{r}$            (long_name='Beqests recieved from Children to Parents in period t at age F of wage profile 5')
brF6    $b_{t,6,F}^{r}$            (long_name='Beqests recieved from Children to Parents in period t at age F of wage profile 6')
brF7    $b_{t,7,F}^{r}$            (long_name='Beqests recieved from Children to Parents in period t at age F of wage profile 7')
brM        $b_{t,j,M}^{r}$              (long_name='Beqests recieved from Children to Parents in period t at age M')
brM1    $b_{t,1,M}^{r}$    (long_name='Beqests recieved from Children to Parents in period t at age M of wage profile 1')
brM2    $b_{t,2,M}^{r}$    (long_name='Beqests recieved from Children to Parents in period t at age M of wage profile 2')
brM3    $b_{t,3,M}^{r}$    (long_name='Beqests recieved from Children to Parents in period t at age M of wage profile 3')
brM4    $b_{t,4,M}^{r}$    (long_name='Beqests recieved from Children to Parents in period t at age M of wage profile 4')
brM5    $b_{t,5,M}^{r}$    (long_name='Beqests recieved from Children to Parents in period t at age M of wage profile 5')
brM6    $b_{t,6,M}^{r}$    (long_name='Beqests recieved from Children to Parents in period t at age M of wage profile 6')
brM7    $b_{t,7,M}^{r}$    (long_name='Beqests recieved from Children to Parents in period t at age M of wage profile 7')
Omega      $\Omega_{t}$                 (long_name='Aggregate Defined Contirbution Assets')
omegaE     $\omega_{t,j,E}$             (long_name='Defined Contribution Assets in period t at age E')
omegaE1    $\omega_{t,1,E}$             (long_name='Defined Contribution Assets in period t at age E of wage profile 1')
omegaE2    $\omega_{t,2,E}$             (long_name='Defined Contribution Assets in period t at age E of wage profile 2')
omegaE3    $\omega_{t,3,E}$             (long_name='Defined Contribution Assets in period t at age E of wage profile 3')
omegaE4    $\omega_{t,4,E}$             (long_name='Defined Contribution Assets in period t at age E of wage profile 4')
omegaE5    $\omega_{t,5,E}$             (long_name='Defined Contribution Assets in period t at age E of wage profile 5')
omegaE6    $\omega_{t,6,E}$             (long_name='Defined Contribution Assets in period t at age E of wage profile 6')
omegaE7    $\omega_{t,7,E}$             (long_name='Defined Contribution Assets in period t at age E of wage profile 7')
omegaF     $\omega_{t,j,F}$             (long_name='Defined Contribution Assets in period t at age F')
omegaF1    $\omega_{t,1,F}$             (long_name='Defined Contribution Assets in period t at age F of wage profile 1')
omegaF2    $\omega_{t,2,F}$             (long_name='Defined Contribution Assets in period t at age F of wage profile 2')
omegaF3    $\omega_{t,3,F}$             (long_name='Defined Contribution Assets in period t at age F of wage profile 3')
omegaF4    $\omega_{t,4,F}$             (long_name='Defined Contribution Assets in period t at age F of wage profile 4')
omegaF5    $\omega_{t,5,F}$             (long_name='Defined Contribution Assets in period t at age F of wage profile 5')
omegaF6    $\omega_{t,6,F}$             (long_name='Defined Contribution Assets in period t at age F of wage profile 6')
omegaF7    $\omega_{t,7,F}$             (long_name='Defined Contribution Assets in period t at age F of wage profile 7')
omegaM     $\omega_{t,j,M}$             (long_name='Defined Contribution Assets in period t at age M')
omegaM1    $\omega_{t,1,M}$             (long_name='Defined Contribution Assets in period t at age M of wage profile 1')
omegaM2    $\omega_{t,2,M}$             (long_name='Defined Contribution Assets in period t at age M of wage profile 2')
omegaM3    $\omega_{t,3,M}$             (long_name='Defined Contribution Assets in period t at age M of wage profile 3')
omegaM4    $\omega_{t,4,M}$             (long_name='Defined Contribution Assets in period t at age M of wage profile 4')
omegaM5    $\omega_{t,5,M}$             (long_name='Defined Contribution Assets in period t at age M of wage profile 5')
omegaM6    $\omega_{t,6,M}$             (long_name='Defined Contribution Assets in period t at age M of wage profile 6')
omegaM7    $\omega_{t,7,M}$             (long_name='Defined Contribution Assets in period t at age M of wage profile 7')
omegaP     $\omega_{t,j,P}$             (long_name='Defined Contribution Assets in period t at age P')
omegaP1    $\omega_{t,1,P}$             (long_name='Defined Contribution Assets in period t at age P of wage profile 1')
omegaP2    $\omega_{t,2,P}$             (long_name='Defined Contribution Assets in period t at age P of wage profile 2')
omegaP3    $\omega_{t,3,P}$             (long_name='Defined Contribution Assets in period t at age P of wage profile 3')
omegaP4    $\omega_{t,4,P}$             (long_name='Defined Contribution Assets in period t at age P of wage profile 4')
omegaP5    $\omega_{t,5,P}$             (long_name='Defined Contribution Assets in period t at age P of wage profile 5')
omegaP6    $\omega_{t,6,P}$             (long_name='Defined Contribution Assets in period t at age P of wage profile 6')
omegaP7    $\omega_{t,7,P}$             (long_name='Defined Contribution Assets in period t at age P of wage profile 7')
omegaR     $\omega_{t,j,R}$             (long_name='Defined Contribution Assets in period t at age R')
omegaR1    $\omega_{t,1,R}$             (long_name='Defined Contribution Assets in period t at age R of wage profile 1')
omegaR2    $\omega_{t,2,R}$             (long_name='Defined Contribution Assets in period t at age R of wage profile 2')
omegaR3    $\omega_{t,3,R}$             (long_name='Defined Contribution Assets in period t at age R of wage profile 3')
omegaR4    $\omega_{t,4,R}$             (long_name='Defined Contribution Assets in period t at age R of wage profile 4')
omegaR5    $\omega_{t,5,R}$             (long_name='Defined Contribution Assets in period t at age R of wage profile 5')
omegaR6    $\omega_{t,6,R}$             (long_name='Defined Contribution Assets in period t at age R of wage profile 6')
omegaR7    $\omega_{t,7,R}$             (long_name='Defined Contribution Assets in period t at age R of wage profile 7')
bendb1     $ben_{t,1,R}^{db}$           (long_name='Defined Benefit benefits paid in period t')
bendb2     $ben_{t,2,R}^{db}$           (long_name='Defined Benefit benefits paid in period t')
bendb3     $ben_{t,3,R}^{db}$           (long_name='Defined Benefit benefits paid in period t')
bendb4     $ben_{t,4,R}^{db}$           (long_name='Defined Benefit benefits paid in period t')
bendb5     $ben_{t,5,R}^{db}$           (long_name='Defined Benefit benefits paid in period t')
bendb6     $ben_{t,6,R}^{db}$           (long_name='Defined Benefit benefits paid in period t')
bendb7     $ben_{t,7,R}^{db}$           (long_name='Defined Benefit benefits paid in period t')
Psi        $\Psi_{t}$                   (long_name='Aggregate Defined Benefit Assets')
psiE       $\psi_{t,j,E}$               (long_name='Defined Benefit Assets in period t at age E')
psiE1    $\psi_{t,1,E}$            (long_name='Defined Benefit Assets in period t at age E of wage profile 1')
psiE2    $\psi_{t,2,E}$            (long_name='Defined Benefit Assets in period t at age E of wage profile 2')
psiE3    $\psi_{t,3,E}$            (long_name='Defined Benefit Assets in period t at age E of wage profile 3')
psiE4    $\psi_{t,4,E}$            (long_name='Defined Benefit Assets in period t at age E of wage profile 4')
psiE5    $\psi_{t,5,E}$            (long_name='Defined Benefit Assets in period t at age E of wage profile 5')
psiE6    $\psi_{t,6,E}$            (long_name='Defined Benefit Assets in period t at age E of wage profile 6')
psiE7    $\psi_{t,7,E}$            (long_name='Defined Benefit Assets in period t at age E of wage profile 7')
psiF       $\psi_{t,j,F}$               (long_name='Defined Benefit Assets in period t at age F')
psiF1    $\psi_{t,1,F}$            (long_name='Defined Benefit Assets in period t at age F of wage profile 1')
psiF2    $\psi_{t,2,F}$            (long_name='Defined Benefit Assets in period t at age F of wage profile 2')
psiF3    $\psi_{t,3,F}$            (long_name='Defined Benefit Assets in period t at age F of wage profile 3')
psiF4    $\psi_{t,4,F}$            (long_name='Defined Benefit Assets in period t at age F of wage profile 4')
psiF5    $\psi_{t,5,F}$            (long_name='Defined Benefit Assets in period t at age F of wage profile 5')
psiF6    $\psi_{t,6,F}$            (long_name='Defined Benefit Assets in period t at age F of wage profile 6')
psiF7    $\psi_{t,7,F}$            (long_name='Defined Benefit Assets in period t at age F of wage profile 7')
psiM       $\psi_{t,j,M}$               (long_name='Defined Benefit Assets in period t at age M')
psiM1    $\psi_{t,1,M}$            (long_name='Defined Benefit Assets in period t at age M of wage profile 1')
psiM2    $\psi_{t,2,M}$            (long_name='Defined Benefit Assets in period t at age M of wage profile 2')
psiM3    $\psi_{t,3,M}$            (long_name='Defined Benefit Assets in period t at age M of wage profile 3')
psiM4    $\psi_{t,4,M}$            (long_name='Defined Benefit Assets in period t at age M of wage profile 4')
psiM5    $\psi_{t,5,M}$            (long_name='Defined Benefit Assets in period t at age M of wage profile 5')
psiM6    $\psi_{t,6,M}$            (long_name='Defined Benefit Assets in period t at age M of wage profile 6')
psiM7    $\psi_{t,7,M}$            (long_name='Defined Benefit Assets in period t at age M of wage profile 7')
psiP       $\psi_{t,j,P}$               (long_name='Defined Benefit Assets in period t at age P')
psiP1    $\psi_{t,1,P}$            (long_name='Defined Benefit Assets in period t at age P of wage profile 1')
psiP2    $\psi_{t,2,P}$            (long_name='Defined Benefit Assets in period t at age P of wage profile 2')
psiP3    $\psi_{t,3,P}$            (long_name='Defined Benefit Assets in period t at age P of wage profile 3')
psiP4    $\psi_{t,4,P}$            (long_name='Defined Benefit Assets in period t at age P of wage profile 4')
psiP5    $\psi_{t,5,P}$            (long_name='Defined Benefit Assets in period t at age P of wage profile 5')
psiP6    $\psi_{t,6,P}$            (long_name='Defined Benefit Assets in period t at age P of wage profile 6')
psiP7    $\psi_{t,7,P}$            (long_name='Defined Benefit Assets in period t at age P of wage profile 7')
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psiR      $\psi_{t,j,R}$             (long_name='Defined Benefit Assets in period t at age R')
psiR1    $\psi_{t,1,R}$            (long_name='Defined Benefit Assets in period t at age R of wage profile 1')
psiR2    $\psi_{t,2,R}$            (long_name='Defined Benefit Assets in period t at age R of wage profile 2')
psiR3    $\psi_{t,3,R}$            (long_name='Defined Benefit Assets in period t at age R of wage profile 3')
psiR4    $\psi_{t,4,R}$            (long_name='Defined Benefit Assets in period t at age R of wage profile 4')
psiR5    $\psi_{t,5,R}$            (long_name='Defined Benefit Assets in period t at age R of wage profile 5')
psiR6    $\psi_{t,6,R}$            (long_name='Defined Benefit Assets in period t at age R of wage profile 6')
psiR7    $\psi_{t,7,R}$            (long_name='Defined Benefit Assets in period t at age R of wage profile 7')
condbE     $con_{t,j,E}^{db}$          (long_name='Defined Benefit Contributions to Retirement Assets in period t at age E')
condbE1    $con_{t,1,E}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 1')
condbE2    $con_{t,2,E}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 2')
condbE3    $con_{t,3,E}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 3')
condbE4    $con_{t,4,E}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 4')
condbE5    $con_{t,5,E}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 5')
condbE6    $con_{t,6,E}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 6')
condbE7    $con_{t,7,E}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 7')
condbF     $con_{t,j,F}^{db}$          (long_name='Defined Benefit Contributions to Retirement Assets in period t at age F')
condbF1    $con_{t,1,F}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 1')
condbF2    $con_{t,2,F}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 2')
condbF3    $con_{t,3,F}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 3')
condbF4    $con_{t,4,F}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 4')
condbF5    $con_{t,5,F}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 5')
condbF6    $con_{t,6,F}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 6')
condbF7    $con_{t,7,F}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 7')
condbM     $con_{t,j,M}^{db}$          (long_name='Defined Benefit Contributions to Retirement Assets in period t at age M')
condbM1    $con_{t,1,M}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 1')
condbM2    $con_{t,2,M}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 2')
condbM3    $con_{t,3,M}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 3')
condbM4    $con_{t,4,M}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 4')
condbM5    $con_{t,5,M}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 5')
condbM6    $con_{t,6,M}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 6')
condbM7    $con_{t,7,M}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 7')
condbP     $con_{t,j,P}^{db}$          (long_name='Defined Benefit Contributions to Retirement Assets in period t at age P')
condbP1    $con_{t,1,P}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 1')
condbP2    $con_{t,2,P}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 2')
condbP3    $con_{t,3,P}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 3')
condbP4    $con_{t,4,P}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 4')
condbP5    $con_{t,5,P}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 5')
condbP6    $con_{t,6,P}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 6')
condbP7    $con_{t,7,P}^{db}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 7')
condcE     $con_{t,j,E}^{dc}$          (long_name='Defined Contribution Contributions to Retirement Assets in period t at age E')
condcE1    $con_{t,1,E}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 1')
condcE2    $con_{t,2,E}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 2')
condcE3    $con_{t,3,E}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 3')
condcE4    $con_{t,4,E}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 4')
condcE5    $con_{t,5,E}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 5')
condcE6    $con_{t,6,E}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 6')
condcE7    $con_{t,7,E}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageE of wage profile 7')
condcF     $con_{t,j,F}^{dc}$          (long_name='Defined Contribution Contributions to Retirement Assets in period t at age F')
condcF1    $con_{t,1,F}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 1')
condcF2    $con_{t,2,F}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 2')
condcF3    $con_{t,3,F}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 3')
condcF4    $con_{t,4,F}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 4')
condcF5    $con_{t,5,F}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 5')
condcF6    $con_{t,6,F}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 6')
condcF7    $con_{t,7,F}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageF of wage profile 7')
condcM     $con_{t,j,M}^{dc}$          (long_name='Defined Contribution Contributions to Retirement Assets in period t at age M')
condcM1    $con_{t,1,M}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 1')
condcM2    $con_{t,2,M}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 2')
condcM3    $con_{t,3,M}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 3')
condcM4    $con_{t,4,M}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 4')
condcM5    $con_{t,5,M}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 5')
condcM6    $con_{t,6,M}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 6')
condcM7    $con_{t,7,M}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageM of wage profile 7')
condcP     $con_{t,j,P}^{dc}$          (long_name='Defined Contribution Contributions to Retirement Assets in period t at age P')
condcP1    $con_{t,1,P}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 1')
condcP2    $con_{t,2,P}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 2')
condcP3    $con_{t,3,P}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 3')
condcP4    $con_{t,4,P}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 4')
condcP5    $con_{t,5,P}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 5')
condcP6    $con_{t,6,P}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 6')
condcP7    $con_{t,7,P}^{dc}$        (long_name='Defined Benefit Contributions to Retirement Assets in period t at ageP of wage profile 7')
Taut       $T_{t}$                     (long_name='Aggregate Transfers to households in period t')
tautE      $\tau_{t,j,E}^{t}$          (long_name='Transfer to household in period t at age E')
tautE1    $\tau_{t,1,E}^{t}$        (long_name='Transfer to household in period t at ageE of wage profile 1')
tautE2    $\tau_{t,2,E}^{t}$        (long_name='Transfer to household in period t at ageE of wage profile 2')
tautE3    $\tau_{t,3,E}^{t}$        (long_name='Transfer to household in period t at ageE of wage profile 3')
tautE4    $\tau_{t,4,E}^{t}$        (long_name='Transfer to household in period t at ageE of wage profile 4')
tautE5    $\tau_{t,5,E}^{t}$        (long_name='Transfer to household in period t at ageE of wage profile 5')
tautE6    $\tau_{t,6,E}^{t}$        (long_name='Transfer to household in period t at ageE of wage profile 6')
tautE7    $\tau_{t,7,E}^{t}$        (long_name='Transfer to household in period t at ageE of wage profile 7')
tautF      $\tau_{t,j,F}^{t}$          (long_name='Transfer to household in period t at age F')
tautF1    $\tau_{t,1,F}^{t}$        (long_name='Transfer to household in period t at ageF of wage profile 1')
tautF2    $\tau_{t,2,F}^{t}$        (long_name='Transfer to household in period t at ageF of wage profile 2')
tautF3    $\tau_{t,3,F}^{t}$        (long_name='Transfer to household in period t at ageF of wage profile 3')
tautF4    $\tau_{t,4,F}^{t}$        (long_name='Transfer to household in period t at ageF of wage profile 4')
tautF5    $\tau_{t,5,F}^{t}$        (long_name='Transfer to household in period t at ageF of wage profile 5')
tautF6    $\tau_{t,6,F}^{t}$        (long_name='Transfer to household in period t at ageF of wage profile 6')
tautF7    $\tau_{t,7,F}^{t}$        (long_name='Transfer to household in period t at ageF of wage profile 7')
tautM      $\tau_{t,j,M}^{t}$          (long_name='Transfer to household in period t at age M')
tautM1    $\tau_{t,1,M}^{t}$        (long_name='Transfer to household in period t at ageM of wage profile 1')
tautM2    $\tau_{t,2,M}^{t}$        (long_name='Transfer to household in period t at ageM of wage profile 2')
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tautM3     $\tau_{t,3,M}^{t}$         (long_name='Transfer to household in period t at ageM of wage profile 3')
tautM4     $\tau_{t,4,M}^{t}$         (long_name='Transfer to household in period t at ageM of wage profile 4')
tautM5     $\tau_{t,5,M}^{t}$         (long_name='Transfer to household in period t at ageM of wage profile 5')
tautM6     $\tau_{t,6,M}^{t}$         (long_name='Transfer to household in period t at ageM of wage profile 6')
tautM7     $\tau_{t,7,M}^{t}$         (long_name='Transfer to household in period t at ageM of wage profile 7')
tautP       $\tau_{t,j,P}^{t}$           (long_name='Transfer to household in period t at age P')
tautP1     $\tau_{t,1,P}^{t}$         (long_name='Transfer to household in period t at ageP of wage profile 1')
tautP2     $\tau_{t,2,P}^{t}$         (long_name='Transfer to household in period t at ageP of wage profile 2')
tautP3     $\tau_{t,3,P}^{t}$         (long_name='Transfer to household in period t at ageP of wage profile 3')
tautP4     $\tau_{t,4,P}^{t}$         (long_name='Transfer to household in period t at ageP of wage profile 4')
tautP5     $\tau_{t,5,P}^{t}$         (long_name='Transfer to household in period t at ageP of wage profile 5')
tautP6     $\tau_{t,6,P}^{t}$         (long_name='Transfer to household in period t at ageP of wage profile 6')
tautP7     $\tau_{t,7,P}^{t}$         (long_name='Transfer to household in period t at ageP of wage profile 7')
tautR       $\tau_{t,j,R}^{t}$           (long_name='Transfer to household in period t at age R')
tautR1     $\tau_{t,1,R}^{t}$         (long_name='Transfer to household in period t at ageR of wage profile 1')
tautR2     $\tau_{t,2,R}^{t}$         (long_name='Transfer to household in period t at ageR of wage profile 2')
tautR3     $\tau_{t,3,R}^{t}$         (long_name='Transfer to household in period t at ageR of wage profile 3')
tautR4     $\tau_{t,4,R}^{t}$         (long_name='Transfer to household in period t at ageR of wage profile 4')
tautR5     $\tau_{t,5,R}^{t}$         (long_name='Transfer to household in period t at ageR of wage profile 5')
tautR6     $\tau_{t,6,R}^{t}$         (long_name='Transfer to household in period t at ageR of wage profile 6')
tautR7     $\tau_{t,7,R}^{t}$         (long_name='Transfer to household in period t at ageR of wage profile 7')
RET         $RET_{t}$                    (long_name='Aggregate Retirement Assets of Households')
retE        $ret_{t,j,E}$                (long_name='Retirement Assets of household in period t at age E ')
retE1     $ret_{t,1,E}$              (long_name='Retirement Assets of household in period t at ageE of wage profile 1')
retE2     $ret_{t,2,E}$              (long_name='Retirement Assets of household in period t at ageE of wage profile 2')
retE3     $ret_{t,3,E}$              (long_name='Retirement Assets of household in period t at ageE of wage profile 3')
retE4     $ret_{t,4,E}$              (long_name='Retirement Assets of household in period t at ageE of wage profile 4')
retE5     $ret_{t,5,E}$              (long_name='Retirement Assets of household in period t at ageE of wage profile 5')
retE6     $ret_{t,6,E}$              (long_name='Retirement Assets of household in period t at ageE of wage profile 6')
retE7     $ret_{t,7,E}$              (long_name='Retirement Assets of household in period t at ageE of wage profile 7')
retF        $ret_{t,j,F}$                (long_name='Retirement Assets of household in period t at age F')
retF1     $ret_{t,1,F}$              (long_name='Retirement Assets of household in period t at ageF of wage profile 1')
retF2     $ret_{t,2,F}$              (long_name='Retirement Assets of household in period t at ageF of wage profile 2')
retF3     $ret_{t,3,F}$              (long_name='Retirement Assets of household in period t at ageF of wage profile 3')
retF4     $ret_{t,4,F}$              (long_name='Retirement Assets of household in period t at ageF of wage profile 4')
retF5     $ret_{t,5,F}$              (long_name='Retirement Assets of household in period t at ageF of wage profile 5')
retF6     $ret_{t,6,F}$              (long_name='Retirement Assets of household in period t at ageF of wage profile 6')
retF7     $ret_{t,7,F}$              (long_name='Retirement Assets of household in period t at ageF of wage profile 7')
retM        $ret_{t,j,M}$                (long_name='Retirement Assets of household in period t at age M')
retM1     $ret_{t,1,M}$              (long_name='Retirement Assets of household in period t at ageM of wage profile 1')
retM2     $ret_{t,2,M}$              (long_name='Retirement Assets of household in period t at ageM of wage profile 2')
retM3     $ret_{t,3,M}$              (long_name='Retirement Assets of household in period t at ageM of wage profile 3')
retM4     $ret_{t,4,M}$              (long_name='Retirement Assets of household in period t at ageM of wage profile 4')
retM5     $ret_{t,5,M}$              (long_name='Retirement Assets of household in period t at ageM of wage profile 5')
retM6     $ret_{t,6,M}$              (long_name='Retirement Assets of household in period t at ageM of wage profile 6')
retM7     $ret_{t,7,M}$              (long_name='Retirement Assets of household in period t at ageM of wage profile 7')
retP        $ret_{t,j,P}$                (long_name='Retirement Assets of household in period t at age P')
retP1     $ret_{t,1,P}$              (long_name='Retirement Assets of household in period t at ageP of wage profile 1')
retP2     $ret_{t,2,P}$              (long_name='Retirement Assets of household in period t at ageP of wage profile 2')
retP3     $ret_{t,3,P}$              (long_name='Retirement Assets of household in period t at ageP of wage profile 3')
retP4     $ret_{t,4,P}$              (long_name='Retirement Assets of household in period t at ageP of wage profile 4')
retP5     $ret_{t,5,P}$              (long_name='Retirement Assets of household in period t at ageP of wage profile 5')
retP6     $ret_{t,6,P}$              (long_name='Retirement Assets of household in period t at ageP of wage profile 6')
retP7     $ret_{t,7,P}$              (long_name='Retirement Assets of household in period t at ageP of wage profile 7')
retR        $ret_{t,j,R}$                (long_name='Retirement Assets of household in period t at age R')
retR1     $ret_{t,1,R}$              (long_name='Retirement Assets of household in period t at ageR of wage profile 1')
retR2     $ret_{t,2,R}$              (long_name='Retirement Assets of household in period t at ageR of wage profile 2')
retR3     $ret_{t,3,R}$              (long_name='Retirement Assets of household in period t at ageR of wage profile 3')
retR4     $ret_{t,4,R}$              (long_name='Retirement Assets of household in period t at ageR of wage profile 4')
retR5     $ret_{t,5,R}$              (long_name='Retirement Assets of household in period t at ageR of wage profile 5')
retR6     $ret_{t,6,R}$              (long_name='Retirement Assets of household in period t at ageR of wage profile 6')
retR7     $ret_{t,7,R}$              (long_name='Retirement Assets of household in period t at ageR of wage profile 7')
REV         $REV_{t}$                    (long_name='Aggregate Government Tax Revenue')
Gbudg       $G_{t}^{budg}$               (long_name='Government Budget')
Gt          $G_{t}$                      (long_name='Government Consumption from Revenue')
xpreE1      $x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreE2 $x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreE3 $x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreE4 $x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreE5 $x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreE6$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreE7$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreF1$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreF2$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreF3$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreF4$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreF5$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreF6$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreF7$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreM1$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreM2$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreM3$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreM4$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreM5$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreM6$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreM7$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreP1$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreP2$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreP3$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreP4$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreP5$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreP6$x_{t,E,1}$                  (long_name='Pre-tax non-wage income at age E of wage profile 1')
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xpreP7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreR1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreR2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreR3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreR4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreR5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreR6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreR7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
Xpre$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostE1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostE2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostE3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostE4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostE5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostE6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostE7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostF1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostF2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostF3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostF4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostF5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostF6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostF7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostM1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostM2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostM3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostM4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostM5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostM6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostM7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostP1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostP2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostP3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostP4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostP5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostP6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostP7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
Spost$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostE1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostE2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostE3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostE4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostE5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostE6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostE7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostF1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostF2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostF3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostF4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostF5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostF6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostF7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostM1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostM2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostM3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostM4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostM5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostM6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostM7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostP1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostP2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostP3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostP4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostP5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostP6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostP7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostR1$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostR2$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostR3$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostR4$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostR5$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostR6$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostR7$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
Cpost$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostE$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostF$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostM$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostP$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
cpostR$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostE$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostF$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostM$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
spostP$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreE$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreF$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreM$x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreP $x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
xpreR $x_{t,E,1}$                (long_name='Pre-tax non-wage income at age E of wage profile 1')
junk
z
;
```

```
varexo L          $L_{t}$                    (long_name='Innelastic Labor Supplied by Households of age E to R-1')
 A              $A$                    (long_name='Total Factor Productivity Augmentation')
    ;

//****************************************************************************
//Define parameters
//****************************************************************************
parameters betaE1
betaF1
betaM1
betaP1
betaR1
betaE2
betaF2
betaM2
betaP2
betaR2
betaE3
betaF3
betaM3
betaP3
betaR3
betaE4
betaF4
betaM4
betaP4
betaR4
betaE5
betaF5
betaM5
betaP5
betaR5
betaE6
betaF6
betaM6
betaP6
betaR6
betaE7
betaF7
betaM7
betaP7
betaR7
    alpha          $\alpha$               (long_name='Capital Share of Production')
    phi            $\phi$                 (long_name='Households weight of parents utility')
    rho
    phi1
    tauc
    gamma          $\gamma$               (long_name='Households weight of parents utility')
    gamma1         $\gamma_{t,1,s}$       (long_name='Household weight of parents utility of wage profile 1')
    varepsilon     $\varepsilon$          (long_name='Constant Elasticity of Substitution between Capital and Labor')
    delta          $\delta$               (long_name='Capital Depreciation Rate')
    govtconsump    $G_{t}$                (long_name='Government Expenditure on goods')
    tauk           $\tau_{t}^{k}$         (long_name='Tax Rate on Capital Stock')
    taucorp        $\tau_{t}^{corp}$      (long_name='Tax Rate on Firm Profits')
    taul1          $\tau_{t,1,s}^{l}$     (long_name='Tax Rate on Wages (labor) of wage profile 1')
    taul2          $\tau_{t,2,s}^{l}$     (long_name='Tax Rate on Wages (labor) of wage profile 2')
    taul3          $\tau_{t,3,s}^{l}$     (long_name='Tax Rate on Wages (labor) of wage profile 3')
    taul4          $\tau_{t,4,s}^{l}$     (long_name='Tax Rate on Wages (labor) of wage profile 4')
    taul5          $\tau_{t,5,s}^{l}$     (long_name='Tax Rate on Wages (labor) of wage profile 5')
    taul6          $\tau_{t,6,s}^{l}$     (long_name='Tax Rate on Wages (labor) of wage profile 6')
    taul7          $\tau_{t,7,s}^{l}$     (long_name='Tax Rate on Wages (labor) of wage profile 7')
    deltatau       $\delta_{t}^{\tau}$    (long_name='Depreciation Expense allowed to Firm')
    varrho         $\varrho_{t}$          (long_name='Population Growth Rate')
    wvarphi1
    wvarphi2
    wvarphi3
    wvarphi4
    wvarphi5
    varphiE1    $\varphi_{t,1,E}$    (long_name='Household share of Government Transfers at age E of wage profile 1')
    varphiE2    $\varphi_{t,2,E}$    (long_name='Household share of Government Transfers at age E of wage profile 2')
    varphiE3    $\varphi_{t,3,E}$    (long_name='Household share of Government Transfers at age E of wage profile 3')
    varphiE4    $\varphi_{t,4,E}$    (long_name='Household share of Government Transfers at age E of wage profile 4')
    varphiE5    $\varphi_{t,5,E}$    (long_name='Household share of Government Transfers at age E of wage profile 5')
    varphiE6    $\varphi_{t,6,E}$    (long_name='Household share of Government Transfers at age E of wage profile 6')
    varphiE7    $\varphi_{t,7,E}$    (long_name='Household share of Government Transfers at age E of wage profile 7')
    varphiF1    $\varphi_{t,1,F}$    (long_name='Household share of Government Transfers at age F of wage profile 1')
    varphiF2    $\varphi_{t,2,F}$    (long_name='Household share of Government Transfers at age F of wage profile 2')
    varphiF3    $\varphi_{t,3,F}$    (long_name='Household share of Government Transfers at age F of wage profile 3')
    varphiF4    $\varphi_{t,4,F}$    (long_name='Household share of Government Transfers at age F of wage profile 4')
    varphiF5    $\varphi_{t,5,F}$    (long_name='Household share of Government Transfers at age F of wage profile 5')
    varphiF6    $\varphi_{t,6,F}$    (long_name='Household share of Government Transfers at age F of wage profile 6')
    varphiF7    $\varphi_{t,7,F}$    (long_name='Household share of Government Transfers at age F of wage profile 7')
    varphiM1    $\varphi_{t,1,M}$    (long_name='Household share of Government Transfers at age M of wage profile 1')
    varphiM2    $\varphi_{t,2,M}$    (long_name='Household share of Government Transfers at age M of wage profile 2')
    varphiM3    $\varphi_{t,3,M}$    (long_name='Household share of Government Transfers at age M of wage profile 3')
    varphiM4    $\varphi_{t,4,M}$    (long_name='Household share of Government Transfers at age M of wage profile 4')
    varphiM5    $\varphi_{t,5,M}$    (long_name='Household share of Government Transfers at age M of wage profile 5')
    varphiM6    $\varphi_{t,6,M}$    (long_name='Household share of Government Transfers at age M of wage profile 6')
    varphiM7    $\varphi_{t,7,M}$    (long_name='Household share of Government Transfers at age M of wage profile 7')
    varphiP1    $\varphi_{t,1,P}$    (long_name='Household share of Government Transfers at age P of wage profile 1')
    varphiP2    $\varphi_{t,2,P}$    (long_name='Household share of Government Transfers at age P of wage profile 2')
    varphiP3    $\varphi_{t,3,P}$    (long_name='Household share of Government Transfers at age P of wage profile 3')
```

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    varphiP4    $\varphi_{t,4,P}$    (long_name='Household share of Government Transfers at age P of wage profile 4')
    varphiP5    $\varphi_{t,5,P}$    (long_name='Household share of Government Transfers at age P of wage profile 5')
    varphiP6    $\varphi_{t,6,P}$    (long_name='Household share of Government Transfers at age P of wage profile 6')
    varphiP7    $\varphi_{t,7,P}$    (long_name='Household share of Government Transfers at age P of wage profile 7')
    varphiR1    $\varphi_{t,1,R}$    (long_name='Household share of Government Transfers at age R of wage profile 1')
    varphiR2    $\varphi_{t,2,R}$    (long_name='Household share of Government Transfers at age R of wage profile 2')
    varphiR3    $\varphi_{t,3,R}$    (long_name='Household share of Government Transfers at age R of wage profile 3')
    varphiR4    $\varphi_{t,4,R}$    (long_name='Household share of Government Transfers at age R of wage profile 4')
    varphiR5    $\varphi_{t,5,R}$    (long_name='Household share of Government Transfers at age R of wage profile 5')
    varphiR6    $\varphi_{t,6,R}$    (long_name='Household share of Government Transfers at age R of wage profile 6')
    varphiR7    $\varphi_{t,7,R}$    (long_name='Household share of Government Transfers at age R of wage profile 7')
    weierpdbE1
weierpdbF1
weierpdbM1
weierpdbP1
weierpdbR1
weierpdbE2
weierpdbF2
weierpdbM2
weierpdbP2
weierpdbR2
weierpdbE3
weierpdbF3
weierpdbM3
weierpdbP3
weierpdbR3
weierpdbE4
weierpdbF4
weierpdbM4
weierpdbP4
weierpdbR4
weierpdbE5
weierpdbF5
weierpdbM5
weierpdbP5
weierpdbR5
weierpdbE6
weierpdbF6
weierpdbM6
weierpdbP6
weierpdbR6
weierpdbE7
weierpdbF7
weierpdbM7
weierpdbP7
weierpdbR7
weierpdcE1
weierpdcF1
weierpdcM1
weierpdcP1
weierpdcR1
weierpdcE2
weierpdcF2
weierpdcM2
weierpdcP2
weierpdcR2
weierpdcE3
weierpdcF3
weierpdcM3
weierpdcP3
weierpdcR3
weierpdcE4
weierpdcF4
weierpdcM4
weierpdcP4
weierpdcR4
weierpdcE5
weierpdcF5
weierpdcM5
weierpdcP5
weierpdcR5
weierpdcE6
weierpdcF6
weierpdcM6
weierpdcP6
weierpdcR6
weierpdcE7
weierpdcF7
weierpdcM7
weierpdcP7
weierpdcR7
gammaM1
gammaM2
gammaM3
gammaM4
gammaM5
gammaM6
gammaM7
gammaP1
gammaP2
gammaP3
gammaP4
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gammaP5
gammaP6
gammaP7
gammaR1
gammaR2
gammaR3
gammaR4
gammaR5
gammaR6
gammaR7
phiE1
phiE2
phiE3
phiE4
phiE5
phiE6
phiE7
phiF1
phiF2
phiF3
phiF4
phiF5
phiF6
phiF7
phiM1
phiM2
phiM3
phiM4
phiM5
phiM6
phiM7
    weierpdb       $\wp_{t}^{DB}$          (long_name='Household Percentage Contribution to Defined Benefit Plan')
    weierpdc       $\wp_{t}^{DC}$          (long_name='Household Percentage of Wage Contribution to Defined Contribution Plan')
    IGE            $IGE_{t}$               (long_name='Intergenerational Elasticity of Income')
    Pw             $P_{t}^{w}$             (long_name='Parental Wage Determinant')
    wrdb           $swr_{t,j,s}^{DB}$      (long_name='Safe Withdrawl rate of Defined Benefit Assets when Retired')
    swrdc          $swr_{t,j,s}^{DC}$      (long_name='Safe Withdrawl rate of Defined Contribution Assets when Retired')
    zetadb         $\zeta_{t}^{db}$        (long_name='Scaling factor on household defined benefit contributions')
    zetadc         $\zeta_{t}^{dc}$        (long_name='Scaling factor on household defined contirbution contributions')
    zE1            $z_{t,1,E}$            (long_name='Population at ageE of wage profile 1')
    zE2            $z_{t,2,E}$            (long_name='Population at ageE of wage profile 2')
    zE3            $z_{t,3,E}$            (long_name='Population at ageE of wage profile 3')
    zE4            $z_{t,4,E}$            (long_name='Population at ageE of wage profile 4')
    zE5            $z_{t,5,E}$            (long_name='Population at ageE of wage profile 5')
    zE6            $z_{t,6,E}$            (long_name='Population at ageE of wage profile 6')
    zE7            $z_{t,7,E}$            (long_name='Population at ageE of wage profile 7')
    zF1            $z_{t,1,F}$            (long_name='Population at ageF of wage profile 1')
    zF2            $z_{t,2,F}$            (long_name='Population at ageF of wage profile 2')
    zF3            $z_{t,3,F}$            (long_name='Population at ageF of wage profile 3')
    zF4            $z_{t,4,F}$            (long_name='Population at ageF of wage profile 4')
    zF5            $z_{t,5,F}$            (long_name='Population at ageF of wage profile 5')
    zF6            $z_{t,6,F}$            (long_name='Population at ageF of wage profile 6')
    zF7            $z_{t,7,F}$            (long_name='Population at ageF of wage profile 7')
    zM1            $z_{t,1,M}$            (long_name='Population at ageM of wage profile 1')
    zM2            $z_{t,2,M}$             (long_name='Population at ageM of wage profile 2')
    zM3            $z_{t,3,M}$            (long_name='Population at ageM of wage profile 3')
    zM4            $z_{t,4,M}$            (long_name='Population at ageM of wage profile 4')
    zM5            $z_{t,5,M}$            (long_name='Population at ageM of wage profile 5')
    zM6            $z_{t,6,M}$            (long_name='Population at ageM of wage profile 6')
    zM7            $z_{t,7,M}$            (long_name='Population at ageM of wage profile 7')
    zP1            $z_{t,1,P}$            (long_name='Population at ageP of wage profile 1')
    zP2            $z_{t,2,P}$            (long_name='Population at ageP of wage profile 2')
    zP3            $z_{t,3,P}$            (long_name='Population at ageP of wage profile 3')
    zP4            $z_{t,4,P}$            (long_name='Population at ageP of wage profile 4')
    zP5            $z_{t,5,P}$            (long_name='Population at ageP of wage profile 5')
    zP6            $z_{t,6,P}$            (long_name='Population at ageP of wage profile 6')
    zP7            $z_{t,7,P}$            (long_name='Population at ageP of wage profile 7')
    zR1            $z_{t,1,R}$            (long_name='Population at ageR of wage profile 1')
    zR2            $z_{t,2,R}$            (long_name='Population at ageR of wage profile 2')
    zR3            $z_{t,3,R}$            (long_name='Population at ageR of wage profile 3')
    zR4            $z_{t,4,R}$            (long_name='Population at ageR of wage profile 4')
    zR5            $z_{t,5,R}$            (long_name='Population at ageR of wage profile 5')
    zR6            $z_{t,6,R}$            (long_name='Population at ageR of wage profile 6')
    zR7            $z_{t,7,R}$            (long_name='Population at ageR of wage profile 7')
    lab            $lab$                   (long_name='Innelastic Labor Supplied by Households of age E to R-1')
    lambdaE1    $\lambda_{t,1,E}$    (long_name='Share of total Wage of cohort ageE of wage profile 1')
    lambdaE2    $\lambda_{t,2,E}$    (long_name='Share of total Wage of cohort ageE of wage profile 2')
    lambdaE3    $\lambda_{t,3,E}$    (long_name='Share of total Wage of cohort ageE of wage profile 3')
    lambdaE4    $\lambda_{t,4,E}$    (long_name='Share of total Wage of cohort ageE of wage profile 4')
    lambdaE5    $\lambda_{t,5,E}$    (long_name='Share of total Wage of cohort ageE of wage profile 5')
    lambdaE6    $\lambda_{t,6,E}$    (long_name='Share of total Wage of cohort ageE of wage profile 6')
    lambdaE7    $\lambda_{t,7,E}$    (long_name='Share of total Wage of cohort ageE of wage profile 7')
    lambdaF1    $\lambda_{t,1,F}$    (long_name='Share of total Wage of cohort ageF of wage profile 1')
    lambdaF2    $\lambda_{t,2,F}$    (long_name='Share of total Wage of cohort ageF of wage profile 2')
    lambdaF3    $\lambda_{t,3,F}$    (long_name='Share of total Wage of cohort ageF of wage profile 3')
    lambdaF4    $\lambda_{t,4,F}$    (long_name='Share of total Wage of cohort ageF of wage profile 4')
    lambdaF5    $\lambda_{t,5,F}$    (long_name='Share of total Wage of cohort ageF of wage profile 5')
    lambdaF6    $\lambda_{t,6,F}$    (long_name='Share of total Wage of cohort ageF of wage profile 6')
    lambdaF7    $\lambda_{t,7,F}$    (long_name='Share of total Wage of cohort ageF of wage profile 7')
    lambdaM1    $\lambda_{t,1,M}$    (long_name='Share of total Wage of cohort ageM of wage profile 1')
    lambdaM2    $\lambda_{t,2,M}$    (long_name='Share of total Wage of cohort ageM of wage profile 2')
    lambdaM3    $\lambda_{t,3,M}$    (long_name='Share of total Wage of cohort ageM of wage profile 3')
```

```
    lambdaM4    $\lambda_{t,4,M}$    (long_name='Share of total Wage of cohort ageM of wage profile 4')
    lambdaM5    $\lambda_{t,5,M}$    (long_name='Share of total Wage of cohort ageM of wage profile 5')
    lambdaM6    $\lambda_{t,6,M}$    (long_name='Share of total Wage of cohort ageM of wage profile 6')
    lambdaM7    $\lambda_{t,7,M}$    (long_name='Share of total Wage of cohort ageM of wage profile 7')
    lambdaP1    $\lambda_{t,1,P}$    (long_name='Share of total Wage of cohort ageP of wage profile 1')
    lambdaP2    $\lambda_{t,2,P}$    (long_name='Share of total Wage of cohort ageP of wage profile 2')
    lambdaP3    $\lambda_{t,3,P}$    (long_name='Share of total Wage of cohort ageP of wage profile 3')
    lambdaP4    $\lambda_{t,4,P}$    (long_name='Share of total Wage of cohort ageP of wage profile 4')
    lambdaP5    $\lambda_{t,5,P}$    (long_name='Share of total Wage of cohort ageP of wage profile 5')
    lambdaP6    $\lambda_{t,6,P}$    (long_name='Share of total Wage of cohort ageP of wage profile 6')
    lambdaP7    $\lambda_{t,7,P}$    (long_name='Share of total Wage of cohort ageP of wage profile 7')
    n
    g
    tauw
    ;
//****************************************************************************
//Set Parameters
//****************************************************************************
betaE1=0.993;
betaF1=0.992;
betaM1=0.991;
betaP1=0.995;
betaR1=0.997;
betaE2=0.983;
betaF2=0.982;
betaM2=0.978;
betaP2=0.987;
betaR2=0.985;
betaE3=0.96;
betaF3=0.957;
betaM3=0.953;
betaP3=0.965;
betaR3=0.962;
betaE4=0.926;
betaF4=0.922;
betaM4=0.92;
betaP4=0.937;
betaR4=0.932;
betaE5=0.891;
betaF5=0.887;
betaM5=0.882;
betaP5=0.91;
betaR5=0.896;
betaE6=0.835;
betaF6=0.83;
betaM6=0.82;
betaP6=0.85;
betaR6=0.841;
betaE7=0.765;
betaF7=0.742;
betaM7=0.7;
betaP7=0.85;
betaR7=0.8;
alpha=.25;
gammaM1=0.003;
gammaM2=0.012;
gammaM3=0.03;
gammaM4=0.09;
gammaM5=0.15;
gammaM6=1.8;
gammaM7=2.4;
gammaP1=0.015;
gammaP2=0.021;
gammaP3=0.033;
gammaP4=0.123;
gammaP5=0.165;
gammaP6=0.261;
gammaP7=0.3;
gammaR1=0.027;
gammaR2=0.03;
gammaR3=0.057;
gammaR4=0.141;
gammaR5=0.18;
gammaR6=0.3;
gammaR7=0.51;
phiE1=0.001;
phiE2=0.004;
phiE3=0.01;
phiE4=0.03;
phiE5=0.05;
phiE6=0.6;
phiE7=0.8;
phiF1=0.005;
phiF2=0.007;
phiF3=0.011;
phiF4=0.041;
phiF5=0.055;
phiF6=0.087;
phiF7=0.1;
phiM1=0.009;
phiM2=0.01;
phiM3=0.019;
```

```
phiM4=0.047;
phiM5=0.06;
phiM6=0.1;
phiM7=0.17;
rho=.9;
phi=.03;
phi1=.03;
tauc=0.0635;
tauw=.0;
gamma=.07;
gamma1=.07;
varepsilon=.87;
delta=.08;
govtconsump=.19;
tauk=.16;
taucorp=.21;
taul1=.0959;
taul2=0.1290;
taul3=0.1831;
taul4=0.2475;
taul5=0.3156;
taul6=0.3581;
taul7=0.3629;
deltatau=.01;
varrho=.0046;
wvarphi1=.30;
wvarphi2=.25;
wvarphi3=.20;
wvarphi4=.15;
wvarphi5=.10;
varphiE1=0.000014;
varphiE2=0.00056;
varphiE3=0.00098;
varphiE4=0.0014;
varphiE5=0.0056;
varphiE6=0.0238;
varphiE7=0.1078;
varphiF1=0.000016;
varphiF2=0.00064;
varphiF3=0.00112;
varphiF4=0.0016;
varphiF5=0.0064;
varphiF6=0.0272;
varphiF7=0.1232;
varphiM1=0.000019;
varphiM2=0.00076;
varphiM3=0.00133;
varphiM4=0.0019;
varphiM5=0.0076;
varphiM6=0.0323;
varphiM7=0.1463;
varphiP1=0.000022;
varphiP2=0.00088;
varphiP3=0.00154;
varphiP4=0.0022;
varphiP5=0.0088;
varphiP6=0.0374;
varphiP7=0.1694;
varphiR1=0.000029;
varphiR2=0.00116;
varphiR3=0.00203;
varphiR4=0.0029;
varphiR5=0.0116;
varphiR6=0.0493;
varphiR7=0.2233;
weierpdbE1=0.00283783783783784;
weierpdbF1=0.00324324324324325;
weierpdbM1=0.00364864864864865;
weierpdbP1=0.004935;
weierpdbR1=0.00121621621621622;
weierpdbE2=0.0068918918918919;
weierpdbF2=0.00729729729729731;
weierpdbM2=0.00891891891891893;
weierpdbP2=0.009834;
weierpdbR2=0.00608108108108109;
weierpdbE3=0.0162162162162162;
weierpdbF3=0.0174324324324325;
weierpdbM3=0.0190540540540541;
weierpdbP3=0.020052;
weierpdbR3=0.0154054054054054;
weierpdbE4=0.03;
weierpdbF4=0.0316216216216216;
weierpdbM4=0.0324324324324324;
weierpdbP4=0.033525;
weierpdbR4=0.0275675675675676;
weierpdbE5=0.0441891891891892;
weierpdbF5=0.0458108108108108;
weierpdbM5=0.0478378378378379;
weierpdbP5=0.049695;
weierpdbR5=0.0421621621621622;
weierpdbE6=0.0668918918918919;
weierpdbF6=0.068918918918919;
```

```
weierpdbM6=0.072972972972973;
weierpdbP6=0.074634;
weierpdbR6=0.0644594594594595;
weierpdbE7=0.0952702702702703;
weierpdbF7=0.104594594594595;
weierpdbM7=0.121621621621622;
weierpdbP7=0.1246701;
weierpdbR7=0.0810810810810811;
weierpdcE1=0.00472972972972974;
weierpdcF1=0.00540540540540541;
weierpdcM1=0.00608108108108109;
weierpdcP1=0.00337837837837838;
weierpdcR1=0.00202702702702703;
weierpdcE1=0.00472972972972974;
weierpdcF1=0.00540540540540541;
weierpdcM1=0.00608108108108109;
weierpdcP1=0.008225;
weierpdcR1=0.00202702702702703;
weierpdcE2=0.0114864864864865;
weierpdcF2=0.0121621621621622;
weierpdcM2=0.0148648648648649;
weierpdcP2=0.01639;
weierpdcR2=0.0101351351351352;
weierpdcE3=0.0270270270270271;
weierpdcF3=0.0290540540540541;
weierpdcM3=0.0317567567567568;
weierpdcP3=0.03342;
weierpdcR3=0.0256756756756757;
weierpdcE4=0.05;
weierpdcF4=0.0527027027027027;
weierpdcM4=0.0540540540540541;
weierpdcP4=0.055875;
weierpdcR4=0.0459459459459459;
weierpdcE5=0.0736486486486487;
weierpdcF5=0.0763513513513514;
weierpdcM5=0.0797297297297298;
weierpdcP5=0.082825;
weierpdcR5=0.0702702702702703;
weierpdcE6=0.111486486486487;
weierpdcF6=0.114864864864865;
weierpdcM6=0.121621621621622;
weierpdcP6=0.12439;
weierpdcR6=0.107432432432433;
weierpdcE7=0.158783783783784;
weierpdcF7=0.174324324324324;
weierpdcM7=0.202702702702703;
weierpdcP7=0.2077835;
weierpdcR7=0.135135135135135;
IGE=.4;
Pw=1.0;
wrdb=.02;
swrdc=.04;
zetadb=.282;
zetadc=.638;
zE1=0.0597142305955902;
zE2=0.022119517657222;
zE3=0.00999993977159027;
zE4=0.00284796277535981;
zE5=0.00133190119278124;
zE6=0.000265733250092364;
zE7=2.89009531907856E-05;
zF1=0.251297387089775;
zF2=0.0930863034741425;
zF3=0.0420830798721091;
zF4=0.0119851766796392;
zF5=0.00560508418628774;
zF6=0.0011182940941387;
zF7=0.000121624844677889;
zM1=0.0920594388348682;
zM2=0.0341009230548839;
zM3=0.015416573814535;
zM4=0.00439060927867971;
zM5=0.00205334767220442;
zM6=0.000409672093892395;
zM7=4.45556361691278E-05;
zP1=0.121667744838515;
zP2=0.0450685172265898;
zP3=0.0203748772846152;
zP4=0.00580272415479562;
zP5=0.00271374868029179;
zP6=0.000541431497063192;
zP7=5.88856921262256E-05;
zR1=0.095293959658796;
zR2=0.0352990635946501;
zR3=0.0159582372188295;
zR4=0.0045448739290117;
zR5=0.00212549232014674;
zR6=0.000424065978272398;
zR7=0.000046121104466962;
lambdaE1=0.000715337139440487;
lambdaE2=0.00155300432176486;
lambdaE3=0.00303993587095183;
```

```
lambdaE4=0.00561389329634598;
lambdaE5=0.0131829814393483;
lambdaE6=0.061583932655037;
lambdaE7=0.11040898197889;
lambdaF1=0.000720374880501728;
lambdaF2=0.00197990833960928;
lambdaF3=0.00413380552808001;
lambdaF4=0.00766995973023856;
lambdaF5=0.0175873549684394;
lambdaF6=0.0777884218033762;
lambdaF7=0.134395080038186;
lambdaM1=0.000772293201783766;
lambdaM2=0.00229826078695363;
lambdaM3=0.00476038440173941;
lambdaM4=0.0087798921923066;
lambdaM5=0.0199802897953073;
lambdaM6=0.0912170896277818;
lambdaM7=0.150459932566709;
lambdaP1=0.000792513545407478;
lambdaP2=0.00235210666895758;
lambdaP3=0.00484162708123959;
lambdaP4=0.0088964071477459;
lambdaP5=0.0203077323989276;
lambdaP6=0.0938786668469383;
lambdaP7=0.150289831747993;
n=.0046;
g=0.0002;



model;

z= A ;

Y = exp(z)*((K(-1)^alpha)*(L^(1-alpha)));

R = (1-taucorp)*(((exp(z))*(alpha*((L/K(-1))^1-alpha))));

W = exp(z)*(((1-alpha)*((K(-1)/L)^alpha)));

Pi=(1-taucorp)*(Y-(W*L));

wE1=lambdaE1*((1-taul1)*W);

wE2=lambdaE2*((1-taul2)*W);

wE3=lambdaE3*((1-taul3)*W);

wE4=lambdaE4*((1-taul4)*W);

wE5=lambdaE5*((1-taul5)*W);

wE6=lambdaE6*((1-taul6)*W);

wE7=lambdaE7*((1-taul7)*W);

wF1=lambdaF1*((1-taul1)*W);

wF2=lambdaF2*((1-taul2)*W);

wF3=lambdaF3*((1-taul3)*W);

wF4=lambdaF4*((1-taul4)*W);

wF5=lambdaF5*((1-taul5)*W);

wF6=lambdaF6*((1-taul6)*W);

wF7=lambdaF7*((1-taul7)*W);

wM1=lambdaM1*((1-taul1)*W);

wM2=lambdaM2*((1-taul2)*W);

wM3=lambdaM3*((1-taul3)*W);

wM4=lambdaM4*((1-taul4)*W);

wM5=lambdaM5*((1-taul5)*W);

wM6=lambdaM6*((1-taul6)*W);

wM7=lambdaM7*((1-taul7)*W);

wP1=lambdaP1*((1-taul1)*W);

wP2=lambdaP2*((1-taul2)*W);

wP3=lambdaP3*((1-taul3)*W);

wP4=lambdaP4*((1-taul4)*W);
```

```
wP5=lambdaP5*((1-taul5)*W);
wP6=lambdaP6*((1-taul6)*W);
wP7=lambdaP7*((1-taul7)*W);
wE=wE1+wE2+wE3+wE4+wE5+wE6+wE7;
wF=wF1+wF2+wF3+wF4+wF5+wF6+wF7;
wM=wM1+wM2+wM3+wM4+wM5+wM6+wM7;
wP=wP1+wP2+wP3+wP4+wP5+wP6+wP7;
WPost=wE+wF+wM+wP;
sE1=(1-betaE1)*(wE1);
sE2=(1-betaE2)*(wE2);
sE3=(1-betaE3)*(wE3);
sE4=(1-betaE4)*(wE4);
sE5=(1-betaE5)*(wE5);
sE6=(1-betaE6)*(wE6);
sE7=(1-betaE7)*(wE7);
sF1=(1-betaF1)*(wF1);
sF2=(1-betaF2)*(wF2);
sF3=(1-betaF3)*(wF3);
sF4=(1-betaF4)*(wF4);
sF5=(1-betaF5)*(wF5);
sF6=(1-betaF6)*(wF6);
sF7=(1-betaF7)*(wF7);
sM1=(1-betaM1)*(wM1);
sM2=(1-betaM2)*(wM2);
sM3=(1-betaM3)*(wM3);
sM4=(1-betaM4)*(wM4);
sM5=(1-betaM5)*(wM5);
sM6=(1-betaM6)*(wM6);
sM7=(1-betaM7)*(wM7);
sP1=(1-betaP1)*(wP1);
sP2=(1-betaP2)*(wP2);
sP3=(1-betaP3)*(wP3);
sP4=(1-betaP4)*(wP4);
sP5=(1-betaP5)*(wP5);
sP6=(1-betaP6)*(wP6);
sP7=(1-betaP7)*(wP7);
sE = sE1 + sE2 + sE3 + sE4 + sE5 + sE6 + sE7;
sF = sF1 + sF2 + sF3 + sF4 + sF5 + sF6 + sF7;
sM = sM1 + sM2 + sM3 + sM4 + sM5 + sM6 + sM7;
sP = sP1 + sP2 + sP3 + sP4 + sP5 + sP6 + sP7;
S = sE + sF + sM + sP;
spostE1=(1-tauk)*((1-betaE1)*(wE1));
spostE2=(1-tauk)*((1-betaE2)*(wE2));
spostE3=(1-tauk)*((1-betaE3)*(wE3));
spostE4=(1-tauk)*((1-betaE4)*(wE4));
spostE5=(1-tauk)*((1-betaE5)*(wE5));
```

```
spostE6=(1-tauk)*((1-betaE6)*(wE6));
spostE7=(1-tauk)*((1-betaE7)*(wE7));
spostF1=(1-tauk)*((1-betaF1)*(wF1));
spostF2=(1-tauk)*((1-betaF2)*(wF2));
spostF3=(1-tauk)*((1-betaF3)*(wF3));
spostF4=(1-tauk)*((1-betaF4)*(wF4));
spostF5=(1-tauk)*((1-betaF5)*(wF5));
spostF6=(1-tauk)*((1-betaF6)*(wF6));
spostF7=(1-tauk)*((1-betaF7)*(wF7));
spostM1=(1-tauk)*((1-betaM1)*(wM1));
spostM2=(1-tauk)*((1-betaM2)*(wM2));
spostM3=(1-tauk)*((1-betaM3)*(wM3));
spostM4=(1-tauk)*((1-betaM4)*(wM4));
spostM5=(1-tauk)*((1-betaM5)*(wM5));
spostM6=(1-tauk)*((1-betaM6)*(wM6));
spostM7=(1-tauk)*((1-betaM7)*(wM7));
spostP1=(1-tauk)*((1-betaP1)*(wP1));
spostP2=(1-tauk)*((1-betaP2)*(wP2));
spostP3=(1-tauk)*((1-betaP3)*(wP3));
spostP4=(1-tauk)*((1-betaP4)*(wP4));
spostP5=(1-tauk)*((1-betaP5)*(wP5));
spostP6=(1-tauk)*((1-betaP6)*(wP6));
spostP7=(1-tauk)*((1-betaP7)*(wP7));
spostE = spostE1 + spostE2 + spostE3 + spostE4 + spostE5 + spostE6 + spostE7;
spostF = spostF1 + spostF2 + spostF3 + spostF4 + spostF5 + spostF6 + spostF7;
spostM = spostM1 + spostM2 + spostM3 + spostM4 + spostM5 + spostM6 + spostM7;
spostP = spostP1 + spostP2 + spostP3 + spostP4 + spostP5 + spostP6 + spostP7;
Spost = spostE + spostF + spostM + spostP;
condcE1=zetadc*((weierpdcE1*wE1));
condcE2=zetadc*((weierpdcE2*wE2));
condcE3=zetadc*((weierpdcE3*wE3));
condcE4=zetadc*((weierpdcE4*wE4));
condcE5=zetadc*((weierpdcE5*wE5));
condcE6=zetadc*((weierpdcE6*wE6));
condcE7=zetadc*((weierpdcE7*wE7));
condcF1=zetadc*((weierpdcF1*wF1));
condcF2=zetadc*((weierpdcF2*wF2));
condcF3=zetadc*((weierpdcF3*wF3));
condcF4=zetadc*((weierpdcF4*wF4));
condcF5=zetadc*((weierpdcF5*wF5));
condcF6=zetadc*((weierpdcF6*wF6));
condcF7=zetadc*((weierpdcF7*wF7));
condcM1=zetadc*((weierpdcM1*wM1));
condcM2=zetadc*((weierpdcM2*wM2));
condcM3=zetadc*((weierpdcM3*wM3));
condcM4=zetadc*((weierpdcM4*wM4));
```

```
condcM5=zetadc*((weierpdcM5*wM5));
condcM6=zetadc*((weierpdcM6*wM6));
condcM7=zetadc*((weierpdcM7*wM7));
condcP1=zetadc*((weierpdcP1*wP1));
condcP2=zetadc*((weierpdcP2*wP2));
condcP3=zetadc*((weierpdcP3*wP3));
condcP4=zetadc*((weierpdcP4*wP4));
condcP5=zetadc*((weierpdcP5*wP5));
condcP6=zetadc*((weierpdcP6*wP6));
condcP7=zetadc*((weierpdcP7*wP7));
condcE = condcE1+condcE2+condcE3+condcE4+condcE5+condcE6+condcE7;
condcF = condcF1+condcF2+condcF3+condcF4+condcF5+condcF6+condcF7;
condcM = condcM1+condcM2+condcM3+condcM4+condcM5+condcM6+condcM7;
condcP = condcP1+condcP2+condcP3+condcP4+condcP5+condcP6+condcP7;
condbE1=zetadb*((weierpdbE1*((wE1)+(taul1*wE1))));
condbE2=zetadb*((weierpdbE2*((wE2)+(taul2*wE2))));
condbE3=zetadb*((weierpdbE3*((wE3)+(taul3*wE3))));
condbE4=zetadb*((weierpdbE4*((wE4)+(taul4*wE4))));
condbE5=zetadb*((weierpdbE5*((wE5)+(taul5*wE5))));
condbE6=zetadb*((weierpdbE6*((wE6)+(taul6*wE6))));
condbE7=zetadb*((weierpdbE7*((wE7)+(taul7*wE7))));
condbF1=zetadb*((weierpdbF1*((wF1)+(taul1*wF1))));
condbF2=zetadb*((weierpdbF2*((wF2)+(taul2*wF2))));
condbF3=zetadb*((weierpdbF3*((wF3)+(taul3*wF3))));
condbF4=zetadb*((weierpdbF4*((wF4)+(taul4*wF4))));
condbF5=zetadb*((weierpdbF5*((wF5)+(taul5*wF5))));
condbF6=zetadb*((weierpdbF6*((wF6)+(taul6*wF6))));
condbF7=zetadb*((weierpdbF7*((wF7)+(taul7*wF7))));
condbM1=zetadb*((weierpdbM1*((wM1)+(taul1*wM1))));
condbM2=zetadb*((weierpdbM2*((wM2)+(taul2*wM2))));
condbM3=zetadb*((weierpdbM3*((wM3)+(taul3*wM3))));
condbM4=zetadb*((weierpdbM4*((wM4)+(taul4*wM4))));
condbM5=zetadb*((weierpdbM5*((wM5)+(taul5*wM5))));
condbM6=zetadb*((weierpdbM6*((wM6)+(taul6*wM6))));
condbM7=zetadb*((weierpdbM7*((wM7)+(taul7*wM7))));
condbP1=zetadb*((weierpdbP1*((wP1)+(taul1*wP1))));
condbP2=zetadb*((weierpdbP2*((wP2)+(taul2*wP2))));
condbP3=zetadb*((weierpdbP3*((wP3)+(taul3*wP3))));
condbP4=zetadb*((weierpdbP4*((wP4)+(taul4*wP4))));
condbP5=zetadb*((weierpdbP5*((wP5)+(taul5*wP5))));
condbP6=zetadb*((weierpdbP6*((wP6)+(taul6*wP6))));
condbP7=zetadb*((weierpdbP7*((wP7)+(taul7*wP7))));
condbE = condbE1+condbE2+condbE3+condbE4+condbE5+condbE6+condbE7;
condbF = condbF1+condbF2+condbF3+condbF4+condbF5+condbF6+condbF7;
condbM = condbM1+condbM2+condbM3+condbM4+condbM5+condbM6+condbM7;
condbP = condbP1+condbP2+condbP3+condbP4+condbP5+condbP6+condbP7;
```

```
omegaE1=(1+R(-1))*condcE1(-1);

omegaE2=(1+R(-1))*condcE2(-1);

omegaE3=(1+R(-1))*condcE3(-1);

omegaE4=(1+R(-1))*condcE4(-1);

omegaE5=(1+R(-1))*condcE5(-1);

omegaE6=(1+R(-1))*condcE6(-1);

omegaE7=(1+R(-1))*condcE7(-1);

omegaF1=((1+R(-1))*omegaE1(-1))+condcF1(-1);

omegaF2=((1+R(-1))*omegaE2(-1))+condcF2(-1);

omegaF3=((1+R(-1))*omegaE3(-1))+condcF3(-1);

omegaF4=((1+R(-1))*omegaE4(-1))+condcF4(-1);

omegaF5=((1+R(-1))*omegaE5(-1))+condcF5(-1);

omegaF6=((1+R(-1))*omegaE6(-1))+condcF6(-1);

omegaF7=((1+R(-1))*omegaE7(-1))+condcF7(-1);

omegaM1=((1+R(-1))*omegaF1(-1))+condcM1(-1);

omegaM2=((1+R(-1))*omegaF2(-1))+condcM2(-1);

omegaM3=((1+R(-1))*omegaF3(-1))+condcM3(-1);

omegaM4=((1+R(-1))*omegaF4(-1))+condcM4(-1);

omegaM5=((1+R(-1))*omegaF5(-1))+condcM5(-1);

omegaM6=((1+R(-1))*omegaF6(-1))+condcM6(-1);

omegaM7=((1+R(-1))*omegaF7(-1))+condcM7(-1);

omegaP1=((1+R(-1))*omegaM1(-1))+condcP1(-1);

omegaP2=((1+R(-1))*omegaM2(-1))+condcP2(-1);

omegaP3=((1+R(-1))*omegaM3(-1))+condcP3(-1);

omegaP4=((1+R(-1))*omegaM4(-1))+condcP4(-1);

omegaP5=((1+R(-1))*omegaM5(-1))+condcP5(-1);

omegaP6=((1+R(-1))*omegaM6(-1))+condcP6(-1);

omegaP7=((1+R(-1))*omegaM7(-1))+condcP7(-1);

omegaR1=((1+R(-1))*omegaP1(-1));

omegaR2=((1+R(-1))*omegaP2(-1));

omegaR3=((1+R(-1))*omegaP3(-1));

omegaR4=((1+R(-1))*omegaP4(-1));

omegaR5=((1+R(-1))*omegaP5(-1));

omegaR6=((1+R(-1))*omegaP6(-1));

omegaR7=((1+R(-1))*omegaP7(-1));

omegaE = omegaE1+omegaE2+omegaE3+omegaE4+omegaE5+omegaE6+omegaE7;

omegaF = omegaF1+omegaF2+omegaF3+omegaF4+omegaF5+omegaF6+omegaF7;

omegaM = omegaM1+omegaM2+omegaM3+omegaM4+omegaM5+omegaM6+omegaM7;

omegaP = omegaP1+omegaP2+omegaP3+omegaP4+omegaP5+omegaP6+omegaP7;

omegaR = omegaR1+omegaR2+omegaR3+omegaR4+omegaR5+omegaR6+omegaR7;

Omega = omegaE + omegaF + omegaM + omegaP + omegaR;

psiE1=(1+R(-1))*condbE1(-1);

psiE2=(1+R(-1))*condbE2(-1);

psiE3=(1+R(-1))*condbE3(-1);

psiE4=(1+R(-1))*condbE4(-1);

psiE5=(1+R(-1))*condbE5(-1);
```

```
psiE6=(1+R(-1))*condbE6(-1);
psiE7=(1+R(-1))*condbE7(-1);
psiF1=((1+R(-1))*psiE1(-1))+condbF1(-1);
psiF2=((1+R(-1))*psiE2(-1))+condbF2(-1);
psiF3=((1+R(-1))*psiE3(-1))+condbF3(-1);
psiF4=((1+R(-1))*psiE4(-1))+condbF4(-1);
psiF5=((1+R(-1))*psiE5(-1))+condbF5(-1);
psiF6=((1+R(-1))*psiE6(-1))+condbF6(-1);
psiF7=((1+R(-1))*psiE7(-1))+condbF7(-1);
psiM1=((1+R(-1))*psiF1(-1))+condbM1(-1);
psiM2=((1+R(-1))*psiF2(-1))+condbM2(-1);
psiM3=((1+R(-1))*psiF3(-1))+condbM3(-1);
psiM4=((1+R(-1))*psiF4(-1))+condbM4(-1);
psiM5=((1+R(-1))*psiF5(-1))+condbM5(-1);
psiM6=((1+R(-1))*psiF6(-1))+condbM6(-1);
psiM7=((1+R(-1))*psiF7(-1))+condbM7(-1);
psiP1=((1+R(-1))*psiM1(-1))+condbP1(-1);
psiP2=((1+R(-1))*psiM2(-1))+condbP2(-1);
psiP3=((1+R(-1))*psiM3(-1))+condbP3(-1);
psiP4=((1+R(-1))*psiM4(-1))+condbP4(-1);
psiP5=((1+R(-1))*psiM5(-1))+condbP5(-1);
psiP6=((1+R(-1))*psiM6(-1))+condbP6(-1);
psiP7=((1+R(-1))*psiM7(-1))+condbP7(-1);
psiR1=((1+R(-1))*psiP1(-1));
psiR2=((1+R(-1))*psiP2(-1));
psiR3=((1+R(-1))*psiP3(-1));
psiR4=((1+R(-1))*psiP4(-1));
psiR5=((1+R(-1))*psiP5(-1));
psiR6=((1+R(-1))*psiP6(-1));
psiR7=((1+R(-1))*psiP7(-1));
psiE = psiE1+psiE2+psiE3+psiE4+psiE5+psiE6+psiE7;
psiF = psiF1+psiF2+psiF3+psiF4+psiF5+psiF6+psiF7;
psiM = psiM1+psiM2+psiM3+psiM4+psiM5+psiM6+psiM7;
psiP = psiP1+psiP2+psiP3+psiP4+psiP5+psiP6+psiP7;
psiR = psiR1+psiR2+psiR3+psiR4+psiR5+psiR6+psiR7;
Psi = psiE + psiF + psiM + psiP + psiR;
bendb1 = taul1*(wrdb*wP1);
bendb2 = taul2*(wrdb*wP2);
bendb3 = taul3*(wrdb*wP3);
bendb4 = taul4*(wrdb*wP4);
bendb5 = taul5*(wrdb*wP5);
bendb6 = taul6*(wrdb*wP6);
bendb7 = taul7*(wrdb*wP7);
retE1=omegaE1+psiE1;
retE2=omegaE2+psiE2;
retE3=omegaE3+psiE3;
```

```
retE4=omegaE4+psiE4;
retE5=omegaE5+psiE5;
retE6=omegaE6+psiE6;
retE7=omegaE7+psiE7;
retF1=omegaF1+psiF1;
retF2=omegaF2+psiF2;
retF3=omegaF3+psiF3;
retF4=omegaF4+psiF4;
retF5=omegaF5+psiF5;
retF6=omegaF6+psiF6;
retF7=omegaF7+psiF7;
retM1=omegaM1+psiM1;
retM2=omegaM2+psiM2;
retM3=omegaM3+psiM3;
retM4=omegaM4+psiM4;
retM5=omegaM5+psiM5;
retM6=omegaM6+psiM6;
retM7=omegaM7+psiM7;
retP1=omegaP1+psiP1;
retP2=omegaP2+psiP2;
retP3=omegaP3+psiP3;
retP4=omegaP4+psiP4;
retP5=omegaP5+psiP5;
retP6=omegaP6+psiP6;
retP7=omegaP7+psiP7;
retR1=omegaR1+psiR1;
retR2=omegaR2+psiR2;
retR3=omegaR3+psiR3;
retR4=omegaR4+psiR4;
retR5=omegaR5+psiR5;
retR6=omegaR6+psiR6;
retR7=omegaR7+psiR7;
retE = retE1+retE2+retE3+retE4+retE5+retE6+retE7;
retF = retF1+retF2+retF3+retF4+retF5+retF6+retF7;
retM = retM1+retM2+retM3+retM4+retM5+retM6+retM7;
retP = retP1+retP2+retP3+retP4+retP5+retP6+retP7;
retR = retR1+retR2+retR3+retR4+retR5+retR6+retR7;
RET = retE + retF + retM + retP + retR;
ggE1=phiE1*(sE1);
ggE2=phiE2*(sE2);
ggE3=phiE3*(sE3);
ggE4=phiE4*(sE4);
ggE5=phiE5*(sE5);
ggE6=phiE6*(sE6);
ggE7=phiE7*(sE7);
ggF1=phiF1*(sF1);
```

```
ggF2=phiF2*(sF2);
ggF3=phiF3*(sF3);
ggF4=phiF4*(sF4);
ggF5=phiF5*(sF5);
ggF6=phiF6*(sF6);
ggF7=phiF7*(sF7);
ggM1=phiM1*(sM1);
ggM2=phiM2*(sM2);
ggM3=phiM3*(sM3);
ggM4=phiM4*(sM4);
ggM5=phiM5*(sM5);
ggM6=phiM6*(sM6);
ggM7=phiM7*(sM7);
ggE = sE1 + sE2 + sE3 + sE4 + sE5 + sE6 + sE7;
ggF = sF1 + sF2 + sF3 + sF4 + sF5 + sF6 + sF7;
ggM = sM1 + sM2 + sM3 + sM4 + sM5 + sM6 + sM7;
Gg = ggE + ggF + ggM;
bgM1=(1-phiM1)*((gammaM1)*(sM1));
bgM2=(1-phiM2)*((gammaM2)*(sM2));
bgM3=(1-phiM3)*((gammaM3)*(sM3));
bgM4=(1-phiM4)*((gammaM4)*(sM4));
bgM5=(1-phiM5)*((gammaM5)*(sM5));
bgM6=(1-phiM6)*((gammaM6)*(sM6));
bgM7=(1-phiM7)*((gammaM7)*(sM7));
bgP1=gammaP1*(sP1);
bgP2=gammaP2*(sP2);
bgP3=gammaP3*(sP3);
bgP4=gammaP4*(sP4);
bgP5=gammaP5*(sP5);
bgP6=gammaP6*(sP6);
bgP7=gammaP7*(sP7);
bgR1=gammaR1*(omegaR1+bendb1);
bgR2=gammaR2*(omegaR2+bendb2);
bgR3=gammaR3*(omegaR3+bendb3);
bgR4=gammaR4*(omegaR4+bendb4);
bgR5=gammaR5*(omegaR5+bendb5);
bgR6=gammaR6*(omegaR6+bendb6);
bgR7=gammaR7*(omegaR7+bendb7);
bgM = bgM1 + bgM2 + bgM3 + bgM4 + bgM5 + bgM6 + bgM7;
bgP = bgP1 + bgP2 + bgP3 + bgP4 + bgP5 + bgP6 + bgP7;
bgR = bgR1 + bgR2 + bgR3 + bgR4 + bgR5 + bgR6 + bgR7;
Bg = bgM + bgP + bgR;
grM1=ggE1;
grM2=ggE2;
grM3=ggE3;
grM4=ggE4;
```

```
grM5=ggE5;

grM6=ggE6;

grM7=ggE7;

grP1=ggF1;

grP2=ggF2;

grP3=ggF3;

grP4=ggF4;

grP5=ggF5;

grP6=ggF6;

grP7=ggF7;

grR1=ggM1;

grR2=ggM2;

grR3=ggM3;

grR4=ggM4;

grR5=ggM5;

grR6=ggM6;

grR7=ggM7;

grM = grM1+grM2+grM3+grM4+grM5+grM6+grM7;

grP = grP1+grP2+grP3+grP4+grP5+grP6+grP7;

grR = grR1+grR2+grR3+grR4+grR5+grR6+grR7;

Gr = grM + grP + grR;

brE1=bgM1;

brE2=bgM2;

brE3=bgM3;

brE4=bgM4;

brE5=bgM5;

brE6=bgM6;

brE7=bgM7;

brF1=bgP1;

brF2=bgP2;

brF3=bgP3;

brF4=bgP4;

brF5=bgP5;

brF6=bgP6;

brF7=bgP7;

brM1=bgR1;

brM2=bgR2;

brM3=bgR3;

brM4=bgR4;

brM5=bgR5;

brM6=bgR6;

brM7=bgR7;

brE = brE1+brE2+brE3+brE4+brE5+brE6+brE7;

brF = brF1+brF2+brF3+brF4+brF5+brF6+brF7;

brM = brM1+brM2+brM3+brM4+brM5+brM6+brM7;

Br = brE + brF + brM;
```

```
xpreE1=(brE1);
xpreE2=(brE2);
xpreE3=(brE3);
xpreE4=(brE4);
xpreE5=(brE5);
xpreE6=(brE6);
xpreE7=(brE7);
xpreF1=(brF1);
xpreF2=(brF2);
xpreF3=(brF3);
xpreF4=(brF4);
xpreF5=(brF5);
xpreF6=(brF6);
xpreF7=(brF7);
xpreM1=(brM1+grM1);
xpreM2=(brM2+grM2);
xpreM3=(brM3+grM3);
xpreM4=(brM4+grM4);
xpreM5=(brM5+grM5);
xpreM6=(brM6+grM6);
xpreM7=(brM7+grM7);
xpreP1=(grP1);
xpreP2=(grP2);
xpreP3=(grP3);
xpreP4=(grP4);
xpreP5=(grP5);
xpreP6=(grP6);
xpreP7=(grP7);
xpreR1=(grR1);
xpreR2=(grR2);
xpreR3=(grR3);
xpreR4=(grR4);
xpreR5=(grR5);
xpreR6=(grR6);
xpreR7=(grR7);
xpreE = xpreE1 + xpreE2 + xpreE3 + xpreE4 + xpreE5 + xpreE6 + xpreE7;
xpreF = xpreF1 + xpreF2 + xpreF3 + xpreF4 + xpreF5 + xpreF6 + xpreF7;
xpreM = xpreM1 + xpreM2 + xpreM3 + xpreM4 + xpreM5 + xpreM6 + xpreM7;
xpreP = xpreP1 + xpreP2 + xpreP3 + xpreP4 + xpreP5 + xpreP6 + xpreP7;
xpreR = xpreR1 + xpreR2 + xpreR3 + xpreR4 + xpreR5 + xpreR6 + xpreR7;
Xpre = xpreE + xpreF + xpreM + xpreP + xpreR;
xE1=(1-tauk)*(brE1);
xE2=(1-tauk)*(brE2);
xE3=(1-tauk)*(brE3);
xE4=(1-tauk)*(brE4);
xE5=(1-tauk)*(brE5);
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```
xE6=(1-tauk)*(brE6);
xE7=(1-tauk)*(brE7);
xF1=(1-tauk)*(brF1);
xF2=(1-tauk)*(brF2);
xF3=(1-tauk)*(brF3);
xF4=(1-tauk)*(brF4);
xF5=(1-tauk)*(brF5);
xF6=(1-tauk)*(brF6);
xF7=(1-tauk)*(brF7);
xM1=(1-tauk)*(brM1+grM1);
xM2=(1-tauk)*(brM2+grM2);
xM3=(1-tauk)*(brM3+grM3);
xM4=(1-tauk)*(brM4+grM4);
xM5=(1-tauk)*(brM5+grM5);
xM6=(1-tauk)*(brM6+grM6);
xM7=(1-tauk)*(brM7+grM7);
xP1=(1-tauk)*(grP1);
xP2=(1-tauk)*(grP2);
xP3=(1-tauk)*(grP3);
xP4=(1-tauk)*(grP4);
xP5=(1-tauk)*(grP5);
xP6=(1-tauk)*(grP6);
xP7=(1-tauk)*(grP7);
xR1=(1-tauk)*(grR1);
xR2=(1-tauk)*(grR2);
xR3=(1-tauk)*(grR3);
xR4=(1-tauk)*(grR4);
xR5=(1-tauk)*(grR5);
xR6=(1-tauk)*(grR6);
xR7=(1-tauk)*(grR7);
xE = xE1 + xE2 + xE3 + xE4 + xE5 + xE6 + xE7;
xF = xF1 + xF2 + xF3 + xF4 + xF5 + xF6 + xF7;
xM = xM1 + xM2 + xM3 + xM4 + xM5 + xM6 + xM7;
xP = xP1 + xP2 + xP3 + xP4 + xP5 + xP6 + xP7;
xR = xR1 + xR2 + xR3 + xR4 + xR5 + xR6 + xR7;
X = xE + xF + xM + xP + xR;
cE1=(wE1+xE1)-(((1-phiE1))*(sE1));
cE2=(wE2+xE2)-(((1-phiE2))*(sE2));
cE3=(wE3+xE3)-(((1-phiE3))*(sE3));
cE4=(wE4+xE4)-(((1-phiE4))*(sE4));
cE5=(wE5+xE5)-(((1-phiE5))*(sE5));
cE6=(wE6+xE6)-(((1-phiE6))*(sE6));
cE7=(wE7+xE7)-(((1-phiE7))*(sE7));
cF1=(wF1+xF1)-(((1-phiF1))*(sF1));
cF2=(wF2+xF2)-(((1-phiF2))*(sF2));
cF3=(wF3+xF3)-(((1-phiF3))*(sF3));
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```
cF4=(wF4+xF4)-(((1-phiF4))*(sF4));

cF5=(wF5+xF5)-(((1-phiF5))*(sF5));

cF6=(wF6+xF6)-(((1-phiF6))*(sF6));

cF7=(wF7+xF7)-(((1-phiF7))*(sF7));

cM1=(wM1+xM1)-((1-(phiM1+gammaM1))*(sM1));

cM2=(wM2+xM2)-((1-(phiM2+gammaM2))*(sM2));

cM3=(wM3+xM3)-((1-(phiM3+gammaM3))*(sM3));

cM4=(wM4+xM4)-((1-(phiM4+gammaM4))*(sM4));

cM5=(wM5+xM5)-((1-(phiM5+gammaM5))*(sM5));

cM6=(wM6+xM6)-((1-(phiM6+gammaM6))*(sM6));

cM7=(wM7+xM7)-((1-(phiM7+gammaM7))*(sM7));

cP1=(wP1+xP1)-(((1-gammaP1))*(sP1));

cP2=(wP2+xP2)-(((1-gammaP2))*(sP2));

cP3=(wP3+xP3)-(((1-gammaP3))*(sP3));

cP4=(wP4+xP4)-(((1-gammaP4))*(sP4));

cP5=(wP5+xP5)-(((1-gammaP5))*(sP5));

cP6=(wP6+xP6)-(((1-gammaP6))*(sP6));

cP7=(wP7+xP7)-(((1-gammaP7))*(sP7));

cR1=((1-gammaR1)*(omegaR1+bendb1))+xR1;

cR2=((1-gammaR2)*(omegaR2+bendb2))+xR2;

cR3=((1-gammaR3)*(omegaR3+bendb3))+xR3;

cR4=((1-gammaR4)*(omegaR4+bendb4))+xR4;

cR5=((1-gammaR5)*(omegaR5+bendb5))+xR5;

cR6=((1-gammaR6)*(omegaR6+bendb6))+xR6;

cR7=((1-gammaR7)*(omegaR7+bendb7))+xR7;

cE = cE1 + cE2 + cE3 + cE4 + cE5 + cE6 + cE7;

cF = cF1 + cF2 + cF3 + cF4 + cF5 + cF6 + cF7;

cM = cM1 + cM2 + cM3 + cM4 + cM5 + cM6 + cM7;

cP = cP1 + cP2 + cP3 + cP4 + cP5 + cP6 + cP7;

cR = cR1 + cR2 + cR3 + cR4 + cR5 + cR6 + cR7;

C = cE + cF + cM + cP + cR;

cpostE1=(1-tauc)*((wE1+xE1)-(((1-phiE1))*(spostE1)));

cpostE2=(1-tauc)*((wE2+xE2)-(((1-phiE2))*(spostE2)));

cpostE3=(1-tauc)*((wE3+xE3)-(((1-phiE3))*(spostE3)));

cpostE4=(1-tauc)*((wE4+xE4)-(((1-phiE4))*(spostE4)));

cpostE5=(1-tauc)*((wE5+xE5)-(((1-phiE5))*(spostE5)));

cpostE6=(1-tauc)*((wE6+xE6)-(((1-phiE6))*(spostE6)));

cpostE7=(1-tauc)*((wE7+xE7)-(((1-phiE7))*(spostE7)));

cpostF1=(1-tauc)*((wF1+xF1)-(((1-phiF1))*(spostF1)));

cpostF2=(1-tauc)*((wF2+xF2)-(((1-phiF2))*(spostF2)));

cpostF3=(1-tauc)*((wF3+xF3)-(((1-phiF3))*(spostF3)));

cpostF4=(1-tauc)*((wF4+xF4)-(((1-phiF4))*(spostF4)));

cpostF5=(1-tauc)*((wF5+xF5)-(((1-phiF5))*(spostF5)));

cpostF6=(1-tauc)*((wF6+xF6)-(((1-phiF6))*(spostF6)));

cpostF7=(1-tauc)*((wF7+xF7)-(((1-phiF7))*(spostF7)));

cpostM1=(1-tauc)*((wM1+xM1)-(((1-(phiM1+gammaM1))*(spostM1))));
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cpostM2=(1-tauc)*((wM2+xM2)-(((1-(phiM2+gammaM2))*(spostM2))));
cpostM3=(1-tauc)*((wM3+xM3)-(((1-(phiM3+gammaM3))*(spostM3))));
cpostM4=(1-tauc)*((wM4+xM4)-(((1-(phiM4+gammaM4))*(spostM4))));
cpostM5=(1-tauc)*((wM5+xM5)-(((1-(phiM5+gammaM5))*(spostM5))));
cpostM6=(1-tauc)*((wM6+xM6)-(((1-(phiM6+gammaM6))*(spostM6))));
cpostM7=(1-tauc)*((wM7+xM7)-(((1-(phiM7+gammaM7))*(spostM7))));
cpostP1=(1-tauc)*((wP1+xP1)-(((1-gammaP1))*(spostP1)));
cpostP2=(1-tauc)*((wP2+xP2)-(((1-gammaP2))*(spostP2)));
cpostP3=(1-tauc)*((wP3+xP3)-(((1-gammaP3))*(spostP3)));
cpostP4=(1-tauc)*((wP4+xP4)-(((1-gammaP4))*(spostP4)));
cpostP5=(1-tauc)*((wP5+xP5)-(((1-gammaP5))*(spostP5)));
cpostP6=(1-tauc)*((wP6+xP6)-(((1-gammaP6))*(spostP6)));
cpostP7=(1-tauc)*((wP7+xP7)-(((1-gammaP7))*(spostP7)));
cpostR1=(1-tauc)*(((1-gammaR1)*(omegaR1+bendb1))+xR1);
cpostR2=(1-tauc)*(((1-gammaR2)*(omegaR2+bendb2))+xR2);
cpostR3=(1-tauc)*(((1-gammaR3)*(omegaR3+bendb3))+xR3);
cpostR4=(1-tauc)*(((1-gammaR4)*(omegaR4+bendb4))+xR4);
cpostR5=(1-tauc)*(((1-gammaR5)*(omegaR5+bendb5))+xR5);
cpostR6=(1-tauc)*(((1-gammaR6)*(omegaR6+bendb6))+xR6);
cpostR7=(1-tauc)*(((1-gammaR7)*(omegaR7+bendb7))+xR7);
cpostE = cpostE1 + cpostE2 + cpostE3 + cpostE4 + cpostE5 + cpostE6 + cpostE7;
cpostF = cpostF1 + cpostF2 + cpostF3 + cpostF4 + cpostF5 + cpostF6 + cpostF7;
cpostM = cpostM1 + cpostM2 + cpostM3 + cpostM4 + cpostM5 + cpostM6 + cpostM7;
cpostP = cpostP1 + cpostP2 + cpostP3 + cpostP4 + cpostP5 + cpostP6 + cpostP7;
cpostR = cpostR1 + cpostR2 + cpostR3 + cpostR4 + cpostR5 + cpostR6 + cpostR7;
Cpost = cpostE + cpostF + cpostM + cpostP + cpostR;
wthetaE1=((((1-phiE1))*(spostE1))*(1+R))+retE1;
wthetaE2=((((1-phiE2))*(spostE2))*(1+R))+retE2;
wthetaE3=((((1-phiE3))*(spostE3))*(1+R))+retE3;
wthetaE4=((((1-phiE4))*(spostE4))*(1+R))+retE4;
wthetaE5=((((1-phiE5))*(spostE5))*(1+R))+retE5;
wthetaE6=(1-tauw)*(((((1-phiE6))*(spostE6))*(1+R))+retE6);
wthetaE7=(1-tauw)*(((((1-phiE7))*(spostE7))*(1+R))+retE7);
wthetaF1=(((((1-phiF1))*(spostF1))+(wthetaE1(-1)))*(1+R))+retF1;
wthetaF2=(((((1-phiF2))*(spostF2))+(wthetaE2(-1)))*(1+R))+retF2;
wthetaF3=(((((1-phiF3))*(spostF3))+(wthetaE3(-1)))*(1+R))+retF3;
wthetaF4=(((((1-phiF4))*(spostF4))+(wthetaE4(-1)))*(1+R))+retF4;
wthetaF5=(((((1-phiF5))*(spostF5))+(wthetaE5(-1)))*(1+R))+retF5;
wthetaF6=(1-tauw)*((((((1-phiF6))*(spostF6))+(wthetaE6(-1)))*(1+R))+retF6);
wthetaF7=(1-tauw)*((((((1-phiF7))*(spostF7))+(wthetaE7(-1)))*(1+R))+retF7);
wthetaM1=((((1-(phiM1+gammaM1))*(spostM1))+(wthetaF1(-1)))*(1+R))+retM1;
wthetaM2=((((1-(phiM2+gammaM2))*(spostM2))+(wthetaF2(-1)))*(1+R))+retM2;
wthetaM3=((((1-(phiM3+gammaM3))*(spostM3))+(wthetaF3(-1)))*(1+R))+retM3;
wthetaM4=((((1-(phiM4+gammaM4))*(spostM4))+(wthetaF4(-1)))*(1+R))+retM4;
wthetaM5=((((1-(phiM5+gammaM5))*(spostM5))+(wthetaF5(-1)))*(1+R))+retM5;
wthetaM6=(1-tauw)*(((((1-(phiM6+gammaM6))*(spostM6))+(wthetaF6(-1)))*(1+R))+retM6);
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wthetaM7=(1-tauw)*(((((1-(phiM7+gammaM7))*(spostM7))+(wthetaF7(-1)))*(1+R))+retM7);

wthetaP1=(((((1-gammaP1))*(spostP1))+(wthetaM1(-1)))*(1+R))+retP1;

wthetaP2=(((((1-gammaP2))*(spostP2))+(wthetaM2(-1)))*(1+R))+retP2;

wthetaP3=(((((1-gammaP3))*(spostP3))+(wthetaM3(-1)))*(1+R))+retP3;

wthetaP4=(((((1-gammaP4))*(spostP4))+(wthetaM4(-1)))*(1+R))+retP4;

wthetaP5=(((((1-gammaP5))*(spostP5))+(wthetaM5(-1)))*(1+R))+retP5;

wthetaP6=(1-tauw)*((((((1-gammaP6))*(spostP6))+(wthetaM6(-1)))*(1+R))+retP6);

wthetaP7=(1-tauw)*((((((1-gammaP7))*(spostP7))+(wthetaM7(-1)))*(1+R))+retP7);

wthetaR1=(wthetaP1(-1))+retR1;

wthetaR2=(wthetaP2(-1))+retR2;

wthetaR3=(wthetaP3(-1))+retR3;

wthetaR4=(wthetaP4(-1))+retR4;

wthetaR5=(wthetaP5(-1))+retR5;

wthetaR6=(1-tauw)*((wthetaP6(-1))+retR6);

wthetaR7=(1-tauw)*((wthetaP7(-1))+retR7);

wthetaE = wthetaE1 + wthetaE2 + wthetaE3 + wthetaE4 + wthetaE5 + wthetaE6 + wthetaE7;

wthetaF = wthetaF1 + wthetaF2 + wthetaF3 + wthetaF4 + wthetaF5 + wthetaF6 + wthetaF7;

wthetaM = wthetaM1 + wthetaM2 + wthetaM3 + wthetaM4 + wthetaM5 + wthetaM6 + wthetaM7;

wthetaP = wthetaP1 + wthetaP2 + wthetaP3 + wthetaP4 + wthetaP5 + wthetaP6 + wthetaP7;

wthetaR = wthetaR1 + wthetaR2 + wthetaR3 + wthetaR4 + wthetaR5 + wthetaR6 + wthetaR7;

wTheta = wthetaE + wthetaF + wthetaM + wthetaP + wthetaR;

tauwTheta = wthetaE6 + wthetaE7 + wthetaP6 + wthetaP7 + wthetaM7 + wthetaM6 + wthetaF7 + wthetaF6 + wthetaE7 + wthetaE6;

tautw1=wvarphi1*tauwTheta;

tautw2=wvarphi2*tauwTheta;

tautw3=wvarphi3*tauwTheta;

tautw4=wvarphi4*tauwTheta;

tautw5=wvarphi5*tauwTheta;

REV = (Y-Pi)+((C-Cpost)+((S-Spost))+((Xpre-X))+((W-WPost)));

Gt = govtconsump*REV;

Taut = REV - Gt;

Gbudg = Taut + Gt;

tautE1=varphiE1*Taut;

tautE2=varphiE2*Taut;

tautE3=varphiE3*Taut;

tautE4=varphiE4*Taut;

tautE5=varphiE5*Taut;

tautE6=varphiE6*Taut;

tautE7=varphiE7*Taut;

tautF1=varphiF1*Taut;

tautF2=varphiF2*Taut;

tautF3=varphiF3*Taut;

tautF4=varphiF4*Taut;

tautF5=varphiF5*Taut;

tautF6=varphiF6*Taut;

tautF7=varphiF7*Taut;

tautM1=varphiM1*Taut;
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tautM2=varphiM2*Taut;

tautM3=varphiM3*Taut;

tautM4=varphiM4*Taut;

tautM5=varphiM5*Taut;

tautM6=varphiM6*Taut;

tautM7=varphiM7*Taut;

tautP1=varphiP1*Taut;

tautP2=varphiP2*Taut;

tautP3=varphiP3*Taut;

tautP4=varphiP4*Taut;

tautP5=varphiP5*Taut;

tautP6=varphiP6*Taut;

tautP7=varphiP7*Taut;

tautR1=varphiR1*Taut;

tautR2=varphiR2*Taut;

tautR3=varphiR3*Taut;

tautR4=varphiR4*Taut;

tautR5=varphiR5*Taut;

tautR6=varphiR6*Taut;

tautR7=varphiR7*Taut;

tautE = tautE1 + tautE2 + tautE3 + tautE4 + tautE5 + tautE6 + tautE7;

tautF = tautF1 + tautF2 + tautF3 + tautF4 + tautF5 + tautF6 + tautF7;

tautM = tautM1 + tautM2 + tautM3 + tautM4 + tautM5 + tautM6 + tautM7;

tautP = tautP1 + tautP2 + tautP3 + tautP4 + tautP5 + tautP6 + tautP7;

tautR = tautR1 + tautR2 + tautR3 + tautR4 + tautR5 + tautR6 + tautR7;

thetaE1=((((1-phiE1))*(spostE1))*(1+R))+retE1+tautE1+tautw1;

thetaE2=((((1-phiE2))*(spostE2))*(1+R))+retE2+tautE2+tautw2;

thetaE3=((((1-phiE3))*(spostE3))*(1+R))+retE3+tautE3+tautw3;

thetaE4=((((1-phiE4))*(spostE4))*(1+R))+retE4+tautE4+tautw4;

thetaE5=((((1-phiE5))*(spostE5))*(1+R))+retE5+tautE5+tautw5;

thetaE6=((((1-phiE6))*(spostE6))*(1+R))+retE6+tautE6-((tauw)*(((((1-phiE6))*(spostE6))*(1+R))+retE6));

thetaE7=((((1-phiE7))*(spostE7))*(1+R))+retE7+tautE7-((tauw)*(((((1-phiE7))*(spostE7))*(1+R))+retE7));

thetaF1=(((((1-phiF1))*(spostF1))+(thetaE1(-1)))*(1+R))+retF1+tautF1+tautw1;

thetaF2=(((((1-phiF2))*(spostF2))+(thetaE2(-1)))*(1+R))+retF2+tautF2+tautw2;

thetaF3=(((((1-phiF3))*(spostF3))+(thetaE3(-1)))*(1+R))+retF3+tautF3+tautw3;

thetaF4=(((((1-phiF4))*(spostF4))+(thetaE4(-1)))*(1+R))+retF4+tautF4+tautw4;

thetaF5=(((((1-phiF5))*(spostF5))+(thetaE5(-1)))*(1+R))+retF5+tautF5+tautw5;

thetaF6=(((((1-phiF6))*(spostF6))+(thetaE6(-1)))*(1+R))+retF6+tautF6-((tauw)*((((((1-phiF6))*(spostF6))+(wthetaE6(-1)))*(1+R))+retF6));

thetaF7=(((((1-phiF7))*(spostF7))+(thetaE7(-1)))*(1+R))+retF7+tautF7-((tauw)*((((((1-phiF7))*(spostF7))+(wthetaE7(-1)))*(1+R))+retF7));

thetaM1=((((1-(phiM1+gammaM1))*(spostM1))+(thetaF1(-1)))*(1+R))+retM1+tautM1+tautw1;

thetaM2=((((1-(phiM2+gammaM2))*(spostM2))+(thetaF2(-1)))*(1+R))+retM2+tautM2+tautw2;

thetaM3=((((1-(phiM3+gammaM3))*(spostM3))+(thetaF3(-1)))*(1+R))+retM3+tautM3+tautw3;

thetaM4=((((1-(phiM4+gammaM4))*(spostM4))+(thetaF4(-1)))*(1+R))+retM4+tautM4+tautw4;

thetaM5=((((1-(phiM5+gammaM5))*(spostM5))+(thetaF5(-1)))*(1+R))+retM5+tautM5+tautw5;

thetaM6=((((1-(phiM6+gammaM6))*(spostM6))+(thetaF6(-1)))*(1+R))+retM6+tautM6-((tauw)*(((((1-(phiM7+gammaM6))*(spostM6))+(wthetaF6(-1)))*(1+R))+retM6));

thetaM7=((((1-(phiM7+gammaM7))*(spostM7))+(thetaF7(-1)))*(1+R))+retM7+tautM7-((tauw)*(((((1-(phiM7+gammaM7))*(spostM7))+(wthetaF7(-1)))*(1+R))+retM7));
```

```
thetaP1=(((((1-gammaP1))*(spostP1))+(thetaM1(-1)))*(1+R))+retP1+tautP1+tautw1;

thetaP2=(((((1-gammaP2))*(spostP2))+(thetaM2(-1)))*(1+R))+retP2+tautP2+tautw2;

thetaP3=(((((1-gammaP3))*(spostP3))+(thetaM3(-1)))*(1+R))+retP3+tautP3+tautw3;

thetaP4=(((((1-gammaP4))*(spostP4))+(thetaM4(-1)))*(1+R))+retP4+tautP4+tautw4;

thetaP5=(((((1-gammaP5))*(spostP5))+(thetaM5(-1)))*(1+R))+retP5+tautP5+tautw5;

thetaP6=(((((1-gammaP6))*(spostP6))+(thetaM6(-1)))*(1+R))+retP6+tautP6-((tauw)*((((((1-gammaP6))*(spostP6))+(wthetaM6(-1)))*(1+R))+retP6));

thetaP7=(((((1-gammaP7))*(spostP7))+(thetaM7(-1)))*(1+R))+retP7+tautP7-((tauw)*((((((1-gammaP7))*(spostP7))+(wthetaM7(-1)))*(1+R))+retP7));

thetaR1=(thetaP1(-1))+retR1+tautR1+tautw1;

thetaR2=(thetaP2(-1))+retR2+tautR2+tautw2;

thetaR3=(thetaP3(-1))+retR3+tautR3+tautw3;

thetaR4=(thetaP4(-1))+retR4+tautR4+tautw4;

thetaR5=(thetaP5(-1))+retR5+tautR5+tautw5;

thetaR6=(thetaP6(-1))+retR6+tautR6-((tauw)*((wthetaP6(-1))+retR6));

thetaR7=(thetaP7(-1))+retR7+tautR7-((tauw)*((wthetaP7(-1))+retR7));

thetaE = thetaE1 + thetaE2 + thetaE3 + thetaE4 + thetaE5 + thetaE6 + thetaE7;

thetaF = thetaF1 + thetaF2 + thetaF3 + thetaF4 + thetaF5 + thetaF6 + thetaF7;

thetaM = thetaM1 + thetaM2 + thetaM3 + thetaM4 + thetaM5 + thetaM6 + thetaM7;

thetaP = thetaP1 + thetaP2 + thetaP3 + thetaP4 + thetaP5 + thetaP6 + thetaP7;

thetaR = thetaR1 + thetaR2 + thetaR3 + thetaR4 + thetaR5 + thetaR6 + thetaR7;

Theta = thetaE + thetaF + thetaM + thetaP + thetaR;

K =(RET(-1)+Spost(-1));

junk=0.9*junk(+1);

end;

initval;
C       =1.6282;
cE      =0.107939;
cE1     =0.00367245;
cE2     =0.00636567;
cE3     =0.00777104;
cE4     =0.00815547;
cE5     =0.00862627;
cE6     =0.0127245;
cE7     =0.0606232;
cF      =0.139751;
cF1     =0.00475447;
cF2     =0.00824181;
cF3     =0.0100614;
cF4     =0.0105591;
cF5     =0.0111687;
cF6     =0.0164747;
cF7     =0.0784906;
cM      =0.199403;
cM1     =0.00678928;
cM2     =0.0117563;
cM3     =0.014352;
cM4     =0.0150621;
cM5     =0.0159316;
cM6     =0.0235014;
cM7     =0.11201;
cP      =0.221696;
cP1     =0.0075496;
cP2     =0.0130726;
cP3     =0.0159587;
cP4     =0.0167482;
cP5     =0.017715;
cP6     =0.0261312;
cP7     =0.12452;
cR      =6.95941;
cR1     =0.998618;
cR2     =0.997607;
cR3     =0.997078;
cR4     =0.996934;
cR5     =0.996757;
cR6     =0.995215;
cR7     =0.977201;
L       =4.2374;
K       =1.69592;
Y       =7.67496;
W       =0.817184;
```

```
WPost   =0.676776;
wE      =0.115052;
wE1     =0.00391838;
wE2     =0.00678494;
wE3     =0.00828287;
wE4     =0.00869262;
wE5     =0.00919443;
wE6     =0.0135626;
wE7     =0.0646161;
wF      =0.148891;
wF1     =0.00507084;
wF2     =0.00878051;
wF3     =0.010719;
wF4     =0.0112493;
wF5     =0.0118987;
wF6     =0.0175516;
wF7     =0.0836209;
wM      =0.175962;
wM1     =0.00599281;
wM2     =0.010377;
wM3     =0.0126679;
wM4     =0.0132946;
wM5     =0.0140621;
wM6     =0.0207427;
wM7     =0.0988247;
wP      =0.236872;
wP1     =0.00806725;
wP2     =0.013969;
wP3     =0.017053;
wP4     =0.0178966;
wP5     =0.0189297;
wP6     =0.0279229;
wP7     =0.133033;
R       =1;
Theta   =38.8251;
thetaE  =0.74833;
thetaE1 =0.0366158;
thetaE2 =0.0517946;
thetaE3 =0.0734375;
thetaE4 =0.0946369;
thetaE5 =0.122885;
thetaE6 =0.159718;
thetaE7 =0.209243;
thetaF  =2.40712;
thetaF1 =0.116933;
thetaF2 =0.165966;
thetaF3 =0.234742;
thetaF4 =0.301632;
thetaF5 =0.39074;
thetaF6 =0.508606;
thetaF7 =0.688503;
thetaM  =6.03054;
thetaM1 =0.29032;
thetaM2 =0.413826;
thetaM3 =0.583478;
thetaM4 =0.746951;
thetaM5 =0.96466;
thetaM6 =1.25802;
thetaM7 =1.77328;
thetaP  =13.6518;
thetaP1 =0.652113;
thetaP2 =0.932929;
thetaP3 =1.31192;
thetaP4 =1.67416;
thetaP5 =2.15646;
thetaP6 =2.81688;
thetaP7 =4.10733;
thetaR  =15.9873;
thetaR1 =0.753649;
thetaR2 =1.08488;
thetaR3 =1.51882;
thetaR4 =1.92774;
thetaR5 =2.47193;
thetaR6 =3.2381;
thetaR7 =4.9922;
S       =0.0473743;
sE      =0.00805363;
sE1     =0.000274287;
sE2     =0.000474946;
sE3     =0.000579801;
sE4     =0.000608484;
sE5     =0.00064361;
sE6     =0.000949379;
sE7     =0.00452313;
sF      =0.0104224;
sF1     =0.000354959;
sF2     =0.000614636;
sF3     =0.00075033;
sF4     =0.000787449;
sF5     =0.000832908;
sF6     =0.00122861;
sF7     =0.00585346;
```

```
sM      =0.0123173;
sM1     =0.000419497;
sM2     =0.000726388;
sM3     =0.000886754;
sM4     =0.000930622;
sM5     =0.000984345;
sM6     =0.00145199;
sM7     =0.00691773;
sP      =0.016581;
sP1     =0.000564708;
sP2     =0.000977829;
sP3     =0.00119371;
sP4     =0.00125276;
sP5     =0.00132508;
sP6     =0.0019546;
sP7     =0.00931232;
X       =0.0367286;
xE      =0.000698734;
xE1     =0.0000201294;
xE2     =0.0000414302;
xE3     =0.0000505769;
xE4     =0.000053079;
xE5     =0.0000561431;
xE6     =0.0000828158;
xE7     =0.000394559;
xF      =0.000969694;
xF1     =0.0000279354;
xF2     =0.0000574964;
xF3     =0.00007019;
xF4     =0.0000736623;
xF5     =0.0000779147;
xF6     =0.000114931;
xF7     =0.000547565;
xM      =0.034527;
xM1     =0.00117402;
xM2     =0.00203308;
xM3     =0.00248217;
xM4     =0.00260502;
xM5     =0.00275547;
xM6     =0.00406549;
xM7     =0.0194117;
xP      =0.000244372;
xP1     =0.00000752545;
xP2     =0.0000130308;
xP3     =0.0000159077;
xP4     =0.0000166946;
xP5     =0.0000176584;
xP6     =0.0000260476;
xP7     =0.000147507;
xR      =0.000288803;
xR1     =0.00000889371;
xR2     =0.0000154001;
xR3     =0.0000188;
xR4     =0.00001973;
xR5     =0.000020869;
xR6     =0.0000307835;
xR7     =0.000174327;
Gg      =0.0307933;
ggE     =0.00805363;
ggE1    =0.00000692276;
ggE2    =0.0000119872;
ggE3    =0.0000146337;
ggE4    =0.0000153576;
ggE5    =0.0000162442;
ggE6    =0.0000239615;
ggE7    =0.000135694;
ggF     =0.0104224;
ggF1    =0.00000895886;
ggF2    =0.0000155129;
ggF3    =0.0000189377;
ggF4    =0.0000198746;
ggF5    =0.0000210219;
ggF6    =0.000031009;
ggF7    =0.000175604;
ggM     =0.0123173;
ggM1    =0.0000105877;
ggM2    =0.0000183334;
ggM3    =0.0000223809;
ggM4    =0.0000234881;
ggM5    =0.000024844;
ggM6    =0.0000435598;
ggM7    =0.000207532;
Bg      =0.0428712;
bgM     =0.000831826;
bgM1    =0.0000239636;
bgM2    =0.0000493217;
bgM3    =0.0000602106;
bgM4    =0.0000631892;
bgM5    =0.000066837;
bgM6    =0.0000985903;
bgM7    =0.000469714;
bgP     =0.00116067;
```

```
bgP1    =0.0000395295;
bgP2    =0.0000684481;
bgP3    =0.0000835595;
bgP4    =0.0000876932;
bgP5    =0.0000927556;
bgP6    =0.000136822;
bgP7    =0.000651863;
bgR     =0.0408787;
bgR1    =0.00139071;
bgR2    =0.00240835;
bgR3    =0.00294034;
bgR4    =0.00308586;
bgR5    =0.00326408;
bgR6    =0.0048159;
bgR7    =0.0229735;
Gr      =0.000866445;
grM     =0.000224801;
grM1    =0.00000692276;
grM2    =0.0000119872;
grM3    =0.0000146337;
grM4    =0.0000153576;
grM5    =0.0000162442;
grM6    =0.0000239615;
grM7    =0.000135694;
grP     =0.000290919;
grP1    =0.00000895886;
grP2    =0.0000155129;
grP3    =0.0000189377;
grP4    =0.0000198746;
grP5    =0.0000210219;
grP6    =0.000031009;
grP7    =0.000175604;
grR     =0.000350726;
grR1    =0.0000105877;
grR2    =0.0000183334;
grR3    =0.0000223809;
grR4    =0.0000234881;
grR5    =0.000024844;
grR6    =0.0000435598;
grR7    =0.000207532;
Br      =0.0428712;
brE     =0.000831826;
brE1    =0.0000239636;
brE2    =0.0000493217;
brE3    =0.0000602106;
brE4    =0.0000631892;
brE5    =0.000066837;
brE6    =0.0000985903;
brE7    =0.000469714;
brF     =0.00116067;
brF1    =0.0000395295;
brF2    =0.0000684481;
brF3    =0.0000835595;
brF4    =0.0000876932;
brF5    =0.0000927556;
brF6    =0.000136822;
brF7    =0.000651863;
brM     =0.0408787;
brM1    =0.00139071;
brM2    =0.00240835;
brM3    =0.00294034;
brM4    =0.00308586;
brM5    =0.00326408;
brM6    =0.0048159;
brM7    =0.0229735;
Omega   =1.08878;
omegaE  =0.0220613;
omegaE1 =0.000751354;
omegaE2 =0.00130102;
omegaE3 =0.00158825;
omegaE4 =0.00166682;
omegaE5 =0.00176304;
omegaE6 =0.00260064;
omegaE7 =0.0123902;
omegaF  =0.0584525;
omegaF1 =0.00199074;
omegaF2 =0.00344711;
omegaF3 =0.00420814;
omegaF4 =0.00441631;
omegaF5 =0.00467126;
omegaF6 =0.0068905;
omegaF7 =0.0328284;
omegaM  =0.133959;
omegaM1 =0.00456231;
omegaM2 =0.00789994;
omegaM3 =0.00964403;
omegaM4 =0.0101211;
omegaM5 =0.0107054;
omegaM6 =0.0157914;
omegaM7 =0.0752348;
omegaP  =0.291078;
omegaP1 =0.00991339;
```

```
omegaP2 =0.0171657;
omegaP3 =0.0209554;
omegaP4 =0.0219921;
omegaP5 =0.0232617;
omegaP6 =0.0343129;
omegaP7 =0.163477;
omegaR  =0.583224;
omegaR1 =0.0198631;
omegaR2 =0.0343944;
omegaR3 =0.0419877;
omegaR4 =0.0440649;
omegaR5 =0.0466087;
omegaR6 =0.0687517;
omegaR7 =0.327554;
bendb1  =0.00000420795;
bendb2  =0.000010577;
bendb3  =0.0000170726;
bendb4  =0.0000188507;
bendb5  =0.00002099;
bendb6  =0.0000469105;
bendb7  =0.000639091;
Psi     =0.559589;
psiE    =0.0113387;
psiE1   =0.000342398;
psiE2   =0.000600937;
psiE3   =0.000743786;
psiE4   =0.000782865;
psiE5   =0.000830631;
psiE6   =0.00124606;
psiE7   =0.00679202;
psiF    =0.0300424;
psiF1   =0.000907199;
psiF2   =0.00159221;
psiF3   =0.00197069;
psiF4   =0.00207424;
psiF5   =0.00220079;
psiF6   =0.00330148;
psiF7   =0.0179958;
psiM    =0.0688498;
psiM1   =0.00207908;
psiM2   =0.00364896;
psiM3   =0.00451635;
psiM4   =0.00475365;
psiM5   =0.00504368;
psiM6   =0.00756619;
psiM7   =0.0412419;
psiP    =0.149603;
psiP1   =0.00451761;
psiP2   =0.00792878;
psiP3   =0.00981354;
psiP4   =0.0103292;
psiP5   =0.0109594;
psiP6   =0.0164405;
psiP7   =0.0896142;
psiR    =0.299755;
psiR1   =0.0090518;
psiR2   =0.0158866;
psiR3   =0.0196631;
psiR4   =0.0206962;
psiR5   =0.0219589;
psiR6   =0.0329413;
psiR7   =0.179557;
condbE  =0.00565896;
condbE1 =0.000170886;
condbE2 =0.000299918;
condbE3 =0.000371212;
condbE4 =0.000390716;
condbE5 =0.000414555;
condbE6 =0.000621887;
condbE7 =0.00338979;
condbF  =0.00732337;
condbF1 =0.000221146;
condbF2 =0.000388129;
condbF3 =0.000480392;
condbF4 =0.000505632;
condbF5 =0.000536483;
condbF6 =0.000804795;
condbF7 =0.00438679;
condbM  =0.00865489;
condbM1 =0.000261354;
condbM2 =0.000458698;
condbM3 =0.000567736;
condbM4 =0.000597565;
condbM5 =0.000634025;
condbM6 =0.000951121;
condbM7 =0.00518439;
condbP  =0.0116508;
condbP1 =0.000351823;
condbP2 =0.000617478;
condbP3 =0.00076426;
condbP4 =0.000804415;
condbP5 =0.000853495;
```

```
condbP6 =0.00128036;
condbP7 =0.00697898;
condcE  =0.0110105;
condcE1 =0.000374989;
condcE2 =0.000649319;
condcE3 =0.00079267;
condcE4 =0.000831884;
condcE5 =0.000879907;
condcE6 =0.00129794;
condcE7 =0.00618376;
condcF  =0.0142488;
condcF1 =0.00048528;
condcF2 =0.000840295;
condcF3 =0.00102581;
condcF4 =0.00107656;
condcF5 =0.0011387;
condcF6 =0.00167968;
condcF7 =0.00800252;
condcM  =0.0168395;
condcM1 =0.000573512;
condcM2 =0.000993075;
condcM3 =0.00121232;
condcM4 =0.00127229;
condcM5 =0.00134574;
condcM6 =0.00198508;
condcM7 =0.00945752;
condcP  =0.0226686;
condcP1 =0.000772036;
condcP2 =0.00133683;
condcP3 =0.00163197;
condcP4 =0.0017127;
condcP5 =0.00181157;
condcP6 =0.00267222;
condcP7 =0.0127313;
Taut    =5.00773;
tautE   =0.701083;
tautE1  =0.0350541;
tautE2  =0.0490758;
tautE3  =0.0701083;
tautE4  =0.0911407;
tautE5  =0.119184;
tautE6  =0.154238;
tautE7  =0.182281;
tautF   =0.801237;
tautF1  =0.0400619;
tautF2  =0.0560866;
tautF3  =0.0801237;
tautF4  =0.104161;
tautF5  =0.13621;
tautF6  =0.176272;
tautF7  =0.208322;
tautM   =0.951469;
tautM1  =0.0475735;
tautM2  =0.0666029;
tautM3  =0.0951469;
tautM4  =0.123691;
tautM5  =0.16175;
tautM6  =0.209323;
tautM7  =0.247382;
tautP   =1.1017;
tautP1  =0.0550851;
tautP2  =0.0771191;
tautP3  =0.11017;
tautP4  =0.143221;
tautP5  =0.187289;
tautP6  =0.242374;
tautP7  =0.286442;
tautR   =1.45224;
tautR1  =0.0726121;
tautR2  =0.101657;
tautR3  =0.145224;
tautR4  =0.188792;
tautR5  =0.246881;
tautR6  =0.319493;
tautR7  =0.377583;
RET     =1.64836;
retE    =0.0334;
retE1   =0.00109375;
retE2   =0.00190196;
retE3   =0.00233204;
retE4   =0.00244969;
retE5   =0.00259367;
retE6   =0.00384669;
retE7   =0.0191822;
retF    =0.0884948;
retF1   =0.00289794;
retF2   =0.00503932;
retF3   =0.00617883;
retF4   =0.00649055;
retF5   =0.00687205;
retF6   =0.010192;
retF7   =0.0508242;
```

```
retM    =0.202809;
retM1   =0.00664139;
retM2   =0.0115489;
retM3   =0.0141604;
retM4   =0.0148748;
retM5   =0.0157491;
retM6   =0.0233576;
retM7   =0.116477;
retP    =0.440681;
retP1   =0.014431;
retP2   =0.0250945;
retP3   =0.030769;
retP4   =0.0323212;
retP5   =0.034221;
retP6   =0.0507534;
retP7   =0.253091;
retR    =0.882979;
retR1   =0.0289149;
retR2   =0.050281;
retR3   =0.0616508;
retR4   =0.0647611;
retR5   =0.0685676;
retR6   =0.101693;
retR7   =0.507111;
REV     =7.15391;
Gbudg   =7.15391;
Gt      =2.14617;
xpreE1  =0.0000239636;
xpreE2  =0.0000493217;
xpreE3  =0.0000602106;
xpreE4  =0.0000631892;
xpreE5  =0.000066837;
xpreE6  =0.0000985903;
xpreE7  =0.000469714;
xpreF1  =0.0000395295;
xpreF2  =0.0000684481;
xpreF3  =0.0000835595;
xpreF4  =0.0000876932;
xpreF5  =0.0000927556;
xpreF6  =0.000136822;
xpreF7  =0.000651863;
xpreM1  =0.00139764;
xpreM2  =0.00242033;
xpreM3  =0.00295497;
xpreM4  =0.00310122;
xpreM5  =0.00328032;
xpreM6  =0.00483986;
xpreM7  =0.0231092;
xpreP1  =0.00000895886;
xpreP2  =0.0000155129;
xpreP3  =0.0000189377;
xpreP4  =0.0000198746;
xpreP5  =0.0000210219;
xpreP6  =0.000031009;
xpreP7  =0.000175604;
xpreR1  =0.0000105877;
xpreR2  =0.0000183334;
xpreR3  =0.0000223809;
xpreR4  =0.0000234881;
xpreR5  =0.000024844;
xpreR6  =0.0000435598;
xpreR7  =0.000207532;
Xpre    =0.0437377;
spostE1 =0.000230401;
spostE2 =0.000398954;
spostE3 =0.000487033;
spostE4 =0.000511126;
spostE5 =0.000540633;
spostE6 =0.000797479;
spostE7 =0.00379943;
spostF1 =0.000298166;
spostF2 =0.000516294;
spostF3 =0.000630277;
spostF4 =0.000661457;
spostF5 =0.000699642;
spostF6 =0.00103203;
spostF7 =0.00491691;
spostM1 =0.000352377;
spostM2 =0.000610166;
spostM3 =0.000744873;
spostM4 =0.000781722;
spostM5 =0.00082685;
spostM6 =0.00121967;
spostM7 =0.00581089;
spostP1 =0.000474354;
spostP2 =0.000821377;
spostP3 =0.00100271;
spostP4 =0.00105232;
spostP5 =0.00111307;
spostP6 =0.00164187;
spostP7 =0.00782235;
Spost   =0.0397944;
```

```
cpostE1 =0.00347912;
cpostE2 =0.00603048;
cpostE3 =0.00736185;
cpostE4 =0.00772604;
cpostE5 =0.00817205;
cpostE6 =0.0120545;
cpostE7 =0.0574311;
cpostF1 =0.00450415;
cpostF2 =0.00780779;
cpostF3 =0.00953153;
cpostF4 =0.0100031;
cpostF5 =0.0105805;
cpostF6 =0.0156072;
cpostF7 =0.0743572;
cpostM1 =0.00641473;
cpostM2 =0.0111077;
cpostM3 =0.0135602;
cpostM4 =0.0142311;
cpostM5 =0.0150527;
cpostM6 =0.0222049;
cpostM7 =0.105831;
cpostP1 =0.00714889;
cpostP2 =0.0123788;
cpostP3 =0.0151117;
cpostP4 =0.0158593;
cpostP5 =0.0167748;
cpostP6 =0.0247442;
cpostP7 =0.117911;
cpostR1 =0.935206;
cpostR2 =0.934259;
cpostR3 =0.933764;
cpostR4 =0.933629;
cpostR5 =0.933463;
cpostR6 =0.932019;
cpostR7 =0.915149;
Cpost   =7.15046;
cpostE  =0.102255;
cpostF  =0.132391;
cpostM  =0.188402;
cpostP  =0.209929;
cpostR  =6.51749;
spostE  =0.00676505;
spostF  =0.00875477;
spostM  =0.0103466;
spostP  =0.0139281;
xpreE   =0.000831826;
xpreF   =0.00116067;
xpreM   =0.0411035;
xpreP   =0.000290919;
xpreR   =0.000350726;
z=0.5;
end;

shock_vals_L=cumprod((1+n)*ones(@{simulation_periods},1))
shock_vals_A =cumprod((1+g)*ones(@{simulation_periods},1))
shocks;
var A;
periods 1:@{simulation_periods};
values (shock_vals_A);
var L;
periods 1:@{simulation_periods};
values (shock_vals_L);
end;

steady;
simul(periods=@{simulation_periods});
```