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An aggregate model for policy analysis with demographic change[☆]Ellen R. McGrattan^{a,*}, Edward C. Prescott^b^a University of Minnesota and Federal Reserve Bank of Minneapolis, United States^b Arizona State University and Federal Reserve Bank of Minneapolis, United States

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ABSTRACT

Many countries are facing challenging fiscal financing issues as their populations age and the number of workers per retiree falls. Policymakers need transparent and robust analyses of alternative policies to deal with the demographic changes. In this paper, we propose a simple framework that can easily be matched to aggregate data from the national accounts. We demonstrate the usefulness of our framework by comparing quantitative results for our aggregate model with those of a related model that includes within-age-cohort heterogeneity through productivity differences. When we assess proposals to switch from the current tax and transfer system in the United States to a mandatory saving-for-retirement system with no payroll taxation, we find that the aggregate predictions for the two models are close.

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Introduction

Many countries are facing challenging fiscal financing issues as their populations age and the number of workers per retiree falls. In this paper, we propose a simple overlapping generations model with people differing only in age. The model can easily be matched to aggregate data from the national accounts and used to analyze alternative policies when there is demographic change. We demonstrate the usefulness of this aggregate model by comparing its quantitative predictions for U.S. data with those of a related model analyzed in our earlier work in which we allowed for within-age-cohort heterogeneity. (See McGrattan and Prescott (2017).) When we assess an often-discussed proposal to switch from the current tax and transfer system in the United States to a mandatory saving-for-retirement system with no payroll taxation, we find that the aggregate predictions for the two models are close.

The aggregate predictions we report are the welfare gains of switching policy regimes and the resultant changes in national account statistics. If the current system is continued, taxes must be increased because the number of retirees in the United States is projected to grow, and their retirement consumption must be somehow financed. If the system is reformed, payroll taxes and the associated transfers for Social Security and Medicare are to

be phased out, and individuals have to save for their own retirement consumption.¹ Regardless of whether current policy is continued or reformed, we assume that spending on all other government transfer programs and purchases of goods and services remain at their current level as a share of gross national product (GNP).

As in McGrattan and Prescott (2017), we restrict attention to reforms that are by design welfare improving for all individuals. To ensure that no one is made worse off, we broaden the tax base and lower marginal tax rates, at least temporarily, during the transition to the new system. We report results for both a temporary and a permanent change in the workers' tax schedules. We verify in the aggregate model with only one productivity type that there is a welfare gain for all age cohorts, and we show that the gains are close in magnitude to the population-weighted average gains in the McGrattan and Prescott (2017) benchmark model that has more than one productivity type.

We then compare the models' aggregate predictions for statistics in the national accounts and flow of funds, along with factor inputs and prices. Like McGrattan and Prescott (2017), we find that reforming Social Security and Medicare would have a large impact on aggregate statistics. For example, McGrattan and Prescott (2017) predicted that GNP would be 4.5 percentage points below the current trend if current policy is continued and 11.4 percentage points above trend if policy is reformed and workers' tax schedules are changed only temporarily during the transition. For the aggre-

[☆] All supplemental materials are available at users.econ.umn.edu/~erm. The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

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¹ Of course, in practice, saving would be mandatory; otherwise, individuals would want to opt out and apply for transfer programs targeted to the poor.

gate model with one productivity type, we predict that GNP would be 6.3 percentage points below the current trend if current policy is continued and 10.4 percentage points above trend if policy is reformed. Taking differences, the predictions are 15.9 percentage points versus 16.7, respectively. If tax schedules are permanently changed, the differences in GNP predictions are 20.6 percentage points for McGrattan and Prescott (2017) and 19.5 percentage points for the aggregate model proposed here. Moreover, we find similarly close predictions for consumption, investment, factor inputs and incomes, the interest rate, tax revenues, and household net worth.

The model economy

The framework we use is a relatively standard overlapping generations model. The only nonstandard feature that we introduce is the inclusion of multiple business sectors to account for the fact that U.S. Schedule C corporations are subject to the corporate income tax, while pass-through businesses (for example, sole proprietorships, partnerships, and Schedule S corporations) are not. Allowing for differences in these businesses helps us match total incomes and tax revenues.

We consider two versions of the model: the *homogeneous within-cohort* version assumes people differ only in age, and the *heterogeneous within-cohort* version assumes people differ both in age and in their level of productivity. We are interested in comparing results for these two versions of the model to see the impact that within-cohort heterogeneity has on aggregate predictions.

The population

We use $h \in \{1, 2, \dots, H\}$ to index the year since entering the workforce, and we refer to this as *age*. We use $j \in \{1, 2, \dots, J\}$ to index the productivity level of the household members. The measure of age h households with productivity level j at date t is denoted n_t^{hj} , and these parameters define the population dynamics. The measure of people arriving as working-age households with productivity level j at date t is n_t^{1j} , and we assume

$$n_{t+1}^{1j} = (1 + \eta_t)n_t^{1j}, \tag{2.1}$$

with $\sum_j n_0^{1j} = 1$, where η_t is the growth rate of households entering the workforce. The probability of an age $h < H$ household of any type at date t surviving to age $h + 1$ is $\sigma_t^h > 0$.

The households' problem

In each period, households choose consumption c and labor input ℓ to maximize utility, and they take as given their own level of assets a and the law of motion for the aggregate states, $s' = F(s)$. The states in s are the distribution of assets in the economy, the level of government debt, and the aggregate stocks of tangible and intangible capital. The value function of a household of age h with productivity level j satisfies

$$v_h(a, s, j) = \max_{a', c, \ell \geq 0} \{u(c, \ell) + \beta \sigma_{h+1}^h v_{h+1}(a', s', j)\} \tag{2.2}$$

subject to

$$(1 + \tau_{ct})c + a' \sigma_t^h = (1 + i_t)a + y_t - T_t^h(y_t) \tag{2.3}$$

$$y_t = w_t \ell \epsilon^j \tag{2.4}$$

$$s' = F(s), \tag{2.5}$$

where a prime indicates the next period value of a variable, τ_{ct} is the tax on consumption, i_t is the after-tax interest rate, w_t is the before-tax wage rate, ϵ^j is the productivity of an individual of type j , $T_t^h(y_t)$

is the net tax function, and $v_{H+1} = 0$. Households with $h > H_R$ are retired and have $\ell = 0$. The net tax schedule for retirees ($h > H_R$) is $T_t^j(y) = T_t^r(0)$ and is equal to the (negative) transfers to retirees since they have no labor income. The net tax schedule for workers ($h \leq H_R$) is $T_t^h(y) = T_t^w(y)$ and is equal to their total taxes on labor income less any transfers. Savings are in the form of an annuity that makes payments to members of a cohort in their retirement years conditional on them being alive. Effectively, the return on savings depends on the survival probability as well as the interest rate.²

In solving the dynamic program in (2.2), households take the aggregate state s and its evolution as given. Variables that define the aggregate state are time t , the distribution of household assets, the aggregate capital stocks used by the firms in production, and the government's fiscal policy variables. We turn next to a discussion of the firms' problem and government policy.

The firms' problem

There are two sectors indexed by i , and competitive firms in each of these sectors use inputs of capital and labor to produce output with the following technologies:

$$Y_{it} = K_{it}^{\theta_{it}} K_{it}^{\theta_{it}} (\Omega_t L_{it})^{1-\theta_{it}-\theta_{it}}, \tag{2.6}$$

where $i = 1, 2$. The inputs to production are tangible capital K_{it} , intangible capital K_{it} , and labor L_{it} , and outputs in both sectors grow with labor-augmenting technical change at the rate γ :

$$\Omega_{t+1} = (1 + \gamma)\Omega_t. \tag{2.7}$$

Firms in the first sector are subject to the corporate income tax and produce intermediate good Y_{1t} ; the empirical analogues of these firms are Schedule C corporations, sole proprietorships, and partnerships. Firms in the second sector are not subject to the corporate income tax and produce intermediate good Y_{2t} ; the empirical analogues of these firms are pass-through entities like Schedule S corporations. The aggregate production function of the composite final good is

$$Y_t = Y_{1t}^{\theta_1} Y_{2t}^{\theta_2}, \tag{2.8}$$

where $\theta_1 + \theta_2 = 1$. Capital stocks depreciate at a constant rate, so

$$K_{it,t+1} = (1 - \delta_{it})K_{it} + X_{it} \tag{2.9}$$

$$K_{it,t+1} = (1 - \delta_{it})K_{it} + X_{it} \tag{2.10}$$

for $i = 1, 2$, where X_{it} and X_{it} denote tangible and intangible investments in sector i , respectively. Depreciation rates are denoted as δ and are indexed by sector and capital type. With competitive firms, factors of production—labor and both types of capital—in equilibrium are paid their marginal products, which are therefore the same in both sectors.

The accounting profits of Schedule C corporations are given by

$$\Pi_{1t} = p_{1t} Y_{1t} - w_t L_{1t} - X_{1t} - \delta_{1T} K_{1Tt}, \tag{2.11}$$

where p_{1t} is the price of the intermediate good relative to the final good. Accounting profits are equal to sales less compensation, intangible investment, and tangible depreciation. Notice that intangible investments are fully expensed, while tangible investments are capitalized. Distributions to the corporations' owners are given by

$$D_{1t} = (1 - \tau_{1t}^{\pi}) \Pi_{1t} - K_{1T,t+1} + K_{1Tt}, \tag{2.12}$$

² See McGrattan and Prescott (2017), who show that policy predictions are robust across many variations of this basic framework.

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