Optimal Allocation of the COVID-19 Stimulus Checks*

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Abstract

Congress spent $250B sending stimulus checks to individuals. Could the same stimulus have been achieved for less, assuming the government's information is restricted to 2019 tax returns? Using a life-cycle consumption-saving model with heterogeneous consumers, we calculate the consumption responses to $100 increments of cash transfers by, e.g., marital status, income, and number of children. We find the optimal allocation under different constraints using a new algorithm that can rank an arbitrarily-large number of possible allocations. The optimal policy roughly doubles the amount for low-income and younger consumers and can achieve the same stimulus at almost half the cost.

JEL codes: I38; C6; D15.

Keywords: CARES Act; Stimulus Effect; Heterogeneous Consumers; Propensity to Consume.

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1 Introduction

Following the world-wide outbreak of COVID-19 infections, countries around the world responded by closing down businesses for extended periods of time and pumping out unprecedented amounts of money to ameliorate the adverse economic effects of the pandemic. In the United States, the Coronavirus Aid, Relief, and Economic Security (CARES) Act of March 2020 had a budget in the order of two trillion dollars, about $250 billion of which were direct checks to households. The allocation of these "stimulus checks" is the subject of this paper. The actual allocation was a $1,200 dollar check to individuals without children, whether married or not, with a phase-out starting at an annual income of $75,000, going to zero for individuals making $100,000 or more. Married couples without children received $2,400 if their joint income was less than $150,000. For each additional child, there would be an additional $500, which also phased out at higher incomes.

The overall CARES Act is explicitly billed as providing stimulus; i.e., a boost to demand for goods and services, with the household checks "ensuring Americans are seeing direct and fast relief" according to the U.S. Treasury. While it is unclear exactly how the actual allocation of stimulus checks across families was chosen, it appears that economic "need" figured prominently. But how to decide on needs was not discussed and some economists question whether the checks could have been allocated better. For example, Van Nieuwerburgh of Columbia Business School stated to CNBC (June 19th, 2020) "I do question whether this needs to be in the form of stimulus checks. The stimulus checks are not very well targeted to people who need them the most."

Could the allocation of the stimulus checks be improved on? We address this question by deriving the optimal allocation of stimulus checks across households under alternative rules for maximum amounts and income- and child-conditioning. This is non-trivial, even if each household's consumption response were known, because the number of possible allocations is enormous.[1] Using a life-cycle model to calculate the predicted consumption increase from $100 check increments for millions of household types, characterized by, among others, income and family status, and an algorithm that builds on Wang (2020), we show how to accurately and efficiently derive a policy that maximizes aggregate consumption for a given budget.

We find the "optimal" policy, which maximizes how much of the stimulus money will be spent in 2020; however, the methodology is general and provides a closed-form solution to the allocation problem under different objectives, such as a desire to limit inequality, some of which we consider

[1] The number of ways k checks can be allocated to n individuals is bounded below by the binomial coefficient which grows rapidly with the dimension of the choice set, for example, from around 10^{12} to 10^{299} going from $(n, k) = (100, 10)$ to $(1000, 500)$—this is known as "combinatorial explosion."

in the appendix.

We formulate a life-cycle consumption-saving model where consumers are *ex-ante* heterogeneous in marital status, educational attainment, and number of children, but face idiosyncratic shocks to labor productivity and fertility. We use the model to predict the consumption increase—the marginal propensity to consume (MPC)—per $100 dollar received in transfers for different consumers: single or married, having 0–4 children under age 18, of different ages and income-levels in 2019, taking into account predicted future income and fertility. We allow for unemployment probabilities to increase as was observed following the outbreak of COVID-19 and we include the more generous unemployment insurance (UI) benefits after March 2020, but we do not model specific events that affected consumption patterns, such as restaurants being closed or avoided, partly because such events are local in nature. The maximum stimulus is achieved by allocating the highest amount of money to the households with the highest MPCs taking into account that the MPC declines as the allocation gets larger because some households may prefer to save parts of larger checks. It is not surprising that higher stimulus is achieved by allocating more to poorer and younger consumers; however, our algorithm pinpoints exactly *how much* should be allocated to each consumer type.

We derive the optimal policy under alternative allocation constraints as politicians are likely to impose maximum amounts per person for political reasons. In particular, we derive the optimal policy when the government is constrained by all the maximum check amount limits for adults and children specified under the actual policy but with income cut-offs that can be chosen freely (which we assume throughout); the optimal policy when the government can adjust the maximum check amount for adults and children relative to the actual policy; and the optimal policy when the government can condition the stimulus checks on the age of recipients. We restrict the government's information set about households to what is reported on 2019 tax returns because the March 2020 stimulus checks were tied to this information.

We calculate which distribution of checks, subject to alternative constraints, delivers the largest aggregate stimulus. With the same budget a bigger bang-for-the-buck could be achieved by tilting the checks more strongly toward low-income and younger consumers, and we find an exact optimal allocation which depends on household income, marital status, and number of children. If the government is constrained by the maximum limits for adults and children specified under the actual policy, our systematic search delivers allocations that are very similar to those selected by Congress; however, if we allow for higher maximum amounts and/or age-specific checks, the optimal allocation changes substantially. Our results can be used to quantify the relative gains from relaxing specific allocation constraints and the results show clear patterns that can be used to guide policymakers considering similar allocation constraints.

We also study the optimal allocation of potential second-round stimulus checks, as considered by Congress. Conditional on the first allocation round, what is the optimal second-round allocation of stimulus checks under different allocation constraints? We find that the optimal second-round policy is almost indistinguishable from the corresponding optimal first-round policy because first round amounts were too low to substantially alter the distribution of MPCs.

Related literature.—Our life-cycle consumption-saving model is based on a large body of literature dating back to Milton Friedman's celebrated treatise on consumption in 1957. Related work utilizes models of heterogeneous consumers to evaluate the overall impact of the CARES Act. Carroll et al. (2020) estimate the response to stimulus checks using a consumer model, similar to what we do, but they do not consider how to optimally allocate the checks. Consistent with our estimates, they predict that about 20 percent of the stimulus amount will be spent immediately.

A separate related literature uses large administrative datasets such as records from credit card companies to measure changes in consumption after the pandemic hit. Baker et al. (2020) find that recipients on average spent about a third of the stimulus checks within a few weeks with larger effects for poorer consumers, and Chetty et al. (2020) find that stimulus payments to low-income households had large effects on their consumption.

Kargar and Rajan (2020) estimate propensities to consume by comparing the spending on credit- and debit cards over the two weeks after the stimulus checks were received to the spending during the two weeks before the checks were deposited. They find that recipients who live paycheck-to-paycheck spent 68 percent of the stimulus payment immediately, while recipients who save much of their monthly income spent 23 percent. They consider alternative allocations and find that allocating only to singles making less than $10,000 and couples making less than $20,000 would result in a 50 percent higher impact on consumption. We differ from these authors in that we compute, by household type, MPCs for $100 increments in check sizes, which allows us to derive exact optimal allocations under alternative constraints.

Coibion, Gorodnichenko, and Weber (2020) conduct a large-scale survey of U.S. consumers. They find that consumers spent about 40 percent of the stimulus check, saving (including paying down debt) the remaining part. Consistent with our model's predictions, they find that younger, poorer, and larger households spent more. They point out that "stimulus payments were less effective because they were larger than previous ones. As the size of one-time transfers to households rises, diminishing returns induces individuals to consume smaller fractions of their temporarily higher income." Calculating these diminishing returns is an important feature of our approach.

Overall, results from real-time datasets collected after the crisis hit are roughly in agreement with the predictions of our consumer model. But observed responses cannot predict the optimal allocation because one cannot observe how propensities decline as checks get larger as can a model.

2 Model

We formulate a life-cycle consumption-saving model which predicts household-specific consumption responses to stimulus checks. Consumers are forward looking and may save part of the check for either retirement, future child expenses, or to buffer future income risk. Single and married consumers have different propensities to save due to different income and family size transition probabilities. While the consumption needs of a household grow with each additional member, it does not grow proportionally due to economies-of-scale.

2.1 Pre COVID-19

This subsection presents the problem solved by the households in the periods prior to COVID-19.

Households.—The economy is populated by heterogeneous households. The idiosyncratic state of the *household head* (referred to as the *agent*) is denoted by $\omega = (j, a, \eta, e, m, k, \nu)$, where j is age, a is non-negative assets, η is stochastic labor productivity, e is educational attainment, m is marital status, k is the number of children under age 18, and ν is the stochastic labor productivity of the spouse in the event that the agent is married. Both productivity shocks follow finite-state Markov processes. Educational attainment is permanent and takes two values: college or non-college. Similarly, marital status is permanent and takes two values: married or single. The number of children under age 18 follows a finite-state Markov process that depends on the agent's current number of children, age, educational attainment, and marital status. Agents retire at age j_R and live at most J periods. The probability of survival varies with the agent's age, ψ_j.

Income.—Labor productivity varies with the agent's age, educational attainment, and stochastic labor productivity, $\epsilon_{j,\eta,e}$. We assume that labor is supplied inelastically. Retired agents receive Social Security benefits from the government. To reduce computational costs, we build on De Nardi, Pashchenko, and Porapakkarm (2018) and assume that Social Security benefits are tied to the agent's fixed productivity type as given by their educational attainment, SS_e. Spousal income varies with the spouse's labor productivity shock and with the household head's age, educational attainment, number of children, and income, $B_{j,e,k,\eta,\nu}$.

Government.—The government provides Social Security and consumes goods, G. The latter is included to equalize total government expenditures in the model and the data, ensuring that the tax burden in the model is consistent with the data. The government finances its expenditures by means of progressive income taxes, T_y, where y is household income.

Agent's problem.—At time t, agents choose how much to consume, c_t, and how much to save, a_{t+1}. We drop time subscripts and use $'$ to denote next-period variables. The value function is

$$
\begin{aligned}
V(\omega) \quad = \quad & \max_{c\geq 0, a'\geq 0} \; u(c,m,k) + \beta\psi_j \mathbb{E}_{\eta'|\eta}\mathbb{E}_{\nu'|\nu}\mathbb{E}_{k'|(j,e,m,k)} V(\omega') \\
& \text{s.t.} \quad c + a' = a + y - T_y \\
& \qquad\quad y = ra + \mathbb{I}_{j<j_R}\theta\epsilon_{j,\eta,e} + \mathbb{I}_{j\geq j_R} SS_e + \mathbb{I}_{m=1} B_{j,e,k,\eta,\nu},
\end{aligned}
\tag{1}
$$

where θ denotes aggregate labor productivity, r is the real interest rate, $\mathbb{I}_{j<j_R}$ ($\mathbb{I}_{j\geq j_R}$) are indicator functions that equals one for an agent younger than (at least as old as) j_R, and $\mathbb{I}_{m=1}$ is an indicator function that equals one for a married agent.

2.2 Period of COVID-19

This subsection presents the problem solved by the agents during the period of COVID-19.

Labor market implications.—Using administrative payroll data, Cajner et al. (2020) document that younger, older, and low-income workers were more likely to lose their job during the COVID-19 crisis. We model the surge in unemployment as an unexpected one-period unemployment shock and assume that the probability of unemployment varies with the agent's age and earnings. Let $\pi^U(\omega)$ denote the unemployment probability of an agent of type ω.

Let $\xi \in [0,1]$ determine the duration of the unemployment spell. Unemployed agents are eligible for UI benefits which replace a share $b \in [0,1]$ of lost earnings.

Stimulus checks.—We model the COVID-19 stimulus checks as direct transfers to an agent of size $TR \geq 0$.

Financing UI benefits and stimulus checks.—The implications of the stimulus programs depend on the timing of the financing of these programs, but is the optimal allocation of stimulus checks dependent on the level of taxes? We compare the results from two extreme models. In one (our benchmark), the government never increases taxes to finance their increased expenditures; stimulus is tantamount to "manna-from-heaven." In the other, studied in the appendix, tax rates adjust to finance both stimulus checks and UI benefits in 2020. Taxes will change MPCs, but we ask if this happens in a way that affects who should receive stimulus checks. Let T_y^F denote the tax schedule given the choice of financing.

Agent's problem: Employed.—Let $V^W(\omega; TR)$ denote the value function for an agent of type ω that receives an amount TR in stimulus checks and that is employed during the COVID-19 period. Because the shock is transitory, the economy will transition back to the pre-COVID equilibrium, where the value function is as given in Equation (1).[2] We get the following expression for $V^W(s; TR)$:

$$\begin{aligned} V^W(\omega; TR) &= \max_{c\geq 0, a'\geq 0} u(c, m, k) + \beta\psi_j \mathbb{E}_{\eta'|\eta}\mathbb{E}_{\nu'|\nu}\mathbb{E}_{k'|(j,e,m,k)} V(\omega') \\ &\text{s.t.} \quad c + a' = a + y - T_y^F + TR \\ &\qquad\; y = ra + \mathbb{I}_{j<j_R}\theta\epsilon_{j,\eta,e} + \mathbb{I}_{j\geq j_R} SS_e + \mathbb{I}_{m=1} B_{j,e,k,\eta,\nu}. \end{aligned} \tag{2}$$

Consistent with the CARES Act, the stimulus checks are exempt from income taxation.

Agent's problem: Unemployed.—Let $V^U(\omega; TR)$ denote the value function for an agent that is unemployed during the COVID-19 period:

$$\begin{aligned} V^U(\omega; TR) &= \max_{c\geq 0, a'\geq 0} u(c, m, k) + \beta\psi_j \mathbb{E}_{\eta'|\eta}\mathbb{E}_{\nu'|\nu}\mathbb{E}_{k'|(j,e,m,k)} V(\omega') \\ &\text{s.t.} \quad c + a' = a + y - T_y^F + TR \\ &\qquad\; y = ra + \mathbb{I}_{j<j_R}\theta\epsilon_{j,\eta,e}\left[\xi + b(1-\xi)\right] + \mathbb{I}_{j\geq j_R} SS_e + \mathbb{I}_{m=1} B_{j,e,k,\eta,\nu}. \end{aligned} \tag{3}$$

2.3 Planner problem

The planner's objective is to allocate checks to maximize expected consumption in 2020. We consider an alternative problem in Section A.5, where the planner maximizes expected lifetime utility. Let $c^W(\omega; TR)$ ($c^U(\omega; TR)$) denote the consumption of an agent of type ω who is employed (unemployed) during the period of COVID-19 and who receives stimulus TR.

We focus on the optimal allocation of checks for given 2019 household characteristics. Let $\tilde{c}(y, j, m, k; TR)$ denote the *ex-ante* expected consumption in 2020 of an agent with income y, age

[2] We adjust the tax-rate period-by-period to balance the budget during the transition.

j, marital status m, and number of children k in 2019 that receives an amount TR:

$$\begin{aligned}\tilde{c}\left(y,j,m,k;TR\right) &= \psi_j \mathbb{E}_{\eta'|\eta}\mathbb{E}_{\nu'|\nu}\mathbb{E}_{k'|(j,e,m,k)}\mathbb{E}_{(a,\eta,e,\nu)|(y,j,m,k)} \\ &\quad \Big[\pi^U\left(j+1,\eta',e\right)c^U\left(j+1,g_a\left(\omega\right),\eta',e,m,k',\nu';TR\right) \\ &\quad + \left(1-\pi^U\left(j+1,\eta',e\right)\right)c^W\left(j+1,g_a\left(\omega\right),\eta',e,m,k',\nu';TR\right)\Big],\end{aligned} \tag{4}$$

where $g_a\left(\omega\right)$ is the policy function for next period's assets derived from the solution of Equation (1), $\mathbb{E}_{(a,\eta,e,\nu)|(y,j,m,k)}$ is the expected value given the probability distribution over assets, stochastic labor productivity, and educational attainment conditional on agent's income, age, marital status, and number of children, and $\pi^U\left(j+1,\eta',e\right)$ is the age- and labor earnings-specific probability of unemployment.

The planner chooses the amount, TR_g, for each group $g \in \{1,\ldots,G\}$, where groups are defined by marital status, number of children, income, and age. Let $\mathbb{S}_g$ denote the set of agents of idiosyncratic type s that belongs to group g:

$$\mathbb{S}_g \equiv \left\{s=(y,j,m,k) : y \in \left[\underline{y}_g, \overline{y}_g\right], j \in \left[\underline{j}_g, \overline{j}_g\right], m = m_g, k = k_g\right\}. \tag{5}$$

Let B denote the total budget available. The planner's choice set is given by:

$$\mathbb{C}^{TR} \equiv \left\{\mathbf{TR} = (TR_1,\ldots,TR_G) : TR_g \in \left\{\underline{\mathrm{TR}}_g,\ldots,\overline{TR}_g\right\}, \sum_{g=1}^{G}\left(\int \mu\left(s\right)\mathbb{I}_{s\in\mathbb{S}_g}ds \cdot TR_g\right) \leq B\right\}, \tag{6}$$

where $\mu(s)$ is the measure of agents of type s and $\underline{\mathrm{TR}}_g \geq 0$ and $\overline{TR}_g \geq 0$ are group-specific lower and upper bounds on checks. Allowing for group-specific bounds enables us to capture that the maximum check limits under the actual March 2020 policy varied with household size.

The social welfare function is

$$P\left(\mathbf{TR},\lambda;\tilde{c}\right) = \left(\int \tilde{c}\left(s;TR_g \cdot \mathbb{I}_{s\in\mathbb{S}_g}\right)^{\lambda}\mu\left(s\right)ds\right)^{\frac{1}{\lambda}}, \tag{7}$$

where λ is the Atkinson (1970) inequality aversion. The planner's optimization problem is given by

$$\max_{\mathbf{TR}\in\mathbb{C}^{TR}} P\left(\mathbf{TR},\lambda;\tilde{c}\right). \tag{8}$$

2.4 Equilibrium

See Section A.6 for details.

3 Algorithm for computing optimal allocations

We discuss briefly how we find the optimal allocation, building on Wang (2020), with technical details reported in Appendix Section A.6. Given a planner's preferences and social welfare function, household heterogeneity in the valuation of stimulus checks, and allocation constraints, Wang (2020) shows that there exists a closed-form solution to the allocation of a homogeneous good characterized by a resource-invariant optimal allocation queue as long as the planner has Atkinson-CES preferences and the agents' utility functions are increasing and concave.[3] The queue is a list of rankings, such that the optimal allocation assigns check increments starting from the start of the queue (where the MPCs are the largest) and stopping when the budget is exhausted. We search for the optimal check for each household by calculating the MPCs for $100 increments. The ranking in the queue may have first $100 to Smith, then $100 to Jones, and then a second $100 increment to Smith because marginal changes in consumption decrease with the check amount due to the concavity of the utility function.

The queueing problem under Utilitarian planner preferences (i.e., $\lambda = 1$, which we assume in the benchmark model) is conceptually simple as it amounts to ranking MPCs. However, the algorithm is general and allows for non-Utilitarian preferences and more complicated planner objectives. For example, our methodology can be used to compute optimal allocations if politicians desire a trade-off between limiting inequality and maximizing stimulus.

4 Calibration

This section discusses the calibration of the model. See Section A.1 for details.

Life-cycle parameters.—A period in the model is one year. Agents enter the economy at age 18, retire at 65, and survive until at most age 100. We use SSA life-tables for 2020 to obtain age-specific survival probabilities and data from the Panel Study of Income Dynamics (PSID) to derive the probability of being college educated, the probability of being married, and the initial distribution

[3] Other papers that deal with combinatorial discrete choices rely on algorithmic rather than closed-form solutions (e.g., Jia 2008; Antràs, Fort, and Tintelnot 2017; Hu and Shi 2019). The closed-form results in Wang (2020) might not apply to the environments of these papers, where the planner objective function does not permit CES aggregation.

of children.

Following OECD recommendations, we apply the square-root scale in the model to account for economies-of-scale in consumption. The agent's utility from household consumption c is given by

$$u\left(c,m,k\right)=\frac{\left(\frac{c}{\sqrt{HH(m,k)}}\right)^{1-\gamma}-1}{1-\gamma}, \tag{9}$$

where $HH\left(m,k\right)$ is the number of household members. We set γ equal to 2 to match an intertemporal elasticity of substitution of 0.5.

Technology parameters.—We normalize aggregate productivity, θ, such that median household income is equal to 1 in steady state prior to COVID-19. The interest rate, r, is set to 4 percent per year following McGrattan and Prescott (2003). We calibrate the discount factor, β, to match a ratio of aggregate assets to income of 3.

Transition probabilities for number of children.—We use data from the PSID to derive transition probabilities for the number of children (under age 18) by estimating an ordered logistic regression of the number of children at time $t+1$ conditional on the household head's age, marital status, college attainment, and number of children at time t.

Income.—The labor productivity of an agent of type s is given by $\epsilon_{j,\eta,e}=h\left(j,e\right)\exp\left(\eta\right)$, where $h\left(j,e\right)$ is age- and education-specific deterministic labor productivity and η is a stochastic labor productivity shock given by

$$\eta=\rho\eta_{-1}+\varepsilon,\quad \varepsilon\sim N\left(0,\sigma_{\varepsilon}^{2}\right). \tag{10}$$

We use the age- and education-specific life-cycle labor productivity profiles estimated by Conesa et al. (2020). Following the incomplete markets literature, we let the persistence of stochastic productivity shocks, ρ, be equal to 0.980 and let the variance of the shocks, σ^2, be equal to 0.018.

We use data for married individuals in the PSID to estimate spousal income, $B_{j,e,k,\eta,\nu}$. We regress the logarithm of spousal income on the household head's age, college attainment, number of children, and the logarithm of the household head's income to obtain both the type-specific mean and variance of spousal income.

Taxes and transfers.—We calibrate Social Security benefits for non-college and college-educated consumers to match the ratio of average Social Security benefits for college and non-college educated consumers, $\frac{SS_{e=1}}{SS_{e=0}}$, in the Current Population Survey. We calibrate government consumption to match the ratio of government consumption expenditures to GDP. Following Gouveia and Strauss

(1994), we use the income tax function

$$T_y = a_0 \left(y - \left(y^{-a_1} + a_2 \right)^{-\frac{1}{a_1}} \right). \tag{11}$$

We use their estimates for a_0 and a_1, and adjust a_2 period-by-period to balance the government budget.

COVID-19 parameters.—We adjust the unemployment probabilities to match the unemployment probabilities by age groups and wage quintiles documented by Cajner et al. (2020). Lastly, we assume that UI replaces 100 percent of lost earnings and that unemployed agents remain unemployed during all of 2020. Sensitivity analyses reported in Section A.4 show that our results are not sensitive to the choices of ξ and b—largely because we consider the optimal allocation based on 2019 household characteristics.

5 Results

5.1 MPCs

The optimal allocation problem uses the predicted consumption response of each household type receiving a particular check amount. We compute the consumption response following a transfer of \$0–\$24,400 in \$100 increments, which requires calculating more than 70 billion MPCs (see Section A.6 for details).

Table 1 displays the patterns in MPCs by household-type and select income categories for different sizes of the stimulus check. The results are quite intuitive with higher MPCs for households with low income and households with more children. The MPCs decline rapidly with age and income—a pattern similar to that found for the actual stimulus checks by Karger and Rajan (2020); however, our model allows us to predict how quickly the MPCs decline with the size of the check. For the government to maximize the stimulus effect of the checks, the initial population-wide heterogeneity in MPCs and the rate at which MPCs declines with check-size jointly determine the optimal check for each household.

The average MPC for singles without children making less than \$20,000 (per year) receiving a check of \$100 is presented in the first column of Table 1 and takes a value of 56.3 percent. The column labeled, say, \$2,000, shows an MPC of 17.5 percent, which implies that the consumption of this household type is predicted to increase by \$17.5 if the check increases from \$2,000 to \$2,100 ("the MPC when receiving $2,000.") The MPCs decrease rapidly with check size for this household type and is only 14.1 percent for a $5,000 check.

Going down rows of the table, the MPCs decrease rapidly with income and the MPC is only 4.8 percent for singles without children making $80,000–$100,000, even for the smallest check of $100. The highest MPCs of about 100 percent are found for singles with four children making less than $20,000 receiving a check of $100, but also for this case the MPCs decline with check size. The table illustrates our search for the optimal allocation. For example, a single without children and income less than $20,000 tentatively assigned a $2,000 check would be queued behind a single with four children and income in the $40,000–$60,000 range tentatively assigned a $500 check because the propensity to consume out of an additional $100 increment is 17.5 percent for the former and 34.3 percent for the latter. It is also evident that for given household income and number of children, the MPCs for the smallest checks for couples are lower than for corresponding singles (because the chance that one of the two spouses will get a higher-paid job is higher). However, for couples the MPCs decline relatively slower with check sizes (because there are more mouths to feed).

5.2 Optimal allocations under alternative constraints, based on 2019 tax information

We evaluate alternative allocations which may be within the policy-relevant range as they resemble the March 2020 allocation. Consistent with the CARES Act, we assume that the policies are conditioned on information reported on 2019 tax returns. Our first experiment considers check allocations imposing the same maximum amount for singles, couples, and children as the March 2020 allocation and we examine whether different income limits for the reduction in the check amount would be better. The optimal allocation closely mirrors the one chosen by Congress except that our algorithm assigns slightly less to singles and slightly more to couples and finds much steeper phase-out of stimulus checks as income increases compared to the actual allocation. The allocations are depicted in Appendix Figure A.2.

Increase maximum check limits.—What would the optimal check allocation look like if the maximum amount allowed per adult were doubled to $2,400 for singles and $4,800 four couples (keeping $500 limit per child)? The allocation, depicted in Figure 1, deviates sharply from the actual allocation; in particular, for all household types plotted, the very poorest get the new maximum of $2,400 per adult and $500 per child. To remain within the budget, the phase-out has to occur at lower income levels, and the cut-off for childless singles is as low as $25,000 and around $75,000 for childless couples. The optimal phase-out for stimulus checks is higher for larger families with more children even when the maximum check amount is higher and for a couple with four children it is around $125,000, close to the amount where the actual allocation started to phase out. The sharp phase-outs with income is likely unattractive to politicians for reasons of fairness, which is not accounted for in our analysis, but we believe the optimal allocations provide a useful benchmark.[4]

Condition stimulus checks on age.—From Appendix Figure A.1, MPCs are declining with age and, as the age of tax-payers is known, a higher stimulus effect could be achieved with age-dependent stimulus checks. Figure 2 shows, for age-dependent checks with a maximum amount of $2,400 per adult and $500 per child, how the optimal allocation varies with income and age for singles and couples compared with the actual allocation. In this figure, the check allocations are averaged across households with different numbers of children and we show results for 4 age-groups: very young (18–30) and young (31–40) in the left-most panels, and middle-aged (41–50) and older (51–64) in the right-most panels.[5] The actual policy allocates relatively more to the young and middle-aged which is reflecting the higher average number of children in these age groups; however, the differences are minor. In contrast, the optimal policy allocates maximum amounts to the poorest in all age-groups. The amounts go to zero at less than $50,000 for the two older age-groups of singles, while the phase-out for young singles is slower as many in this group have children and low savings, both of which are correlated with high MPCs; see Appendix Tables A.7 and A.8. For married couples, the allocations are near the maximum for the poorest with the amounts not declining until the $170,000 range for the youngest, who are likely to have young children and low savings. For older couples, the poorest receives about the maximum amount, but the checks decline faster with income than the actual allocation, reflecting that the larger amounts allocated to young couples need to be off-set with lower amounts for other groups.

Second round of stimulus checks.—A potential second round of stimulus checks is currently being debated by Congress. Figure 3 considers a second stimulus check conditional on having received a stimulus check (or not) in March 2020. We allow the second-round check to depend on age, with the upper limits for allocations to adults and children doubled compared to the March 2020 policy. We assume the same budget for second-round stimulus. In this figure, we include four lines in each panel, one for each of the age groups, 18–30, 31–40, 41–50, and 51–64. In all cases, but more prominently for couples, the allocation is larger for the younger age-groups. In all panels, the very

[4]See Section A.5 for optimal allocations when the government's preferences exhibit inequality aversion.

[5]We abstract from 65+ year-olds but Section A.3 shows that the results are unaffected by the inclusion of 65+ year-olds.

poorest receive the largest check but the check size decline steeply to zero at less than $50,000 of income for single older consumers and at $100,000-$150,000 for couples with four children. The general pattern is one where the poorest get the maximum amount, the richest get nothing, with a steep phase-out at an income level that varies with marital status, age, and number of children. The optimal second-round policy is almost indistinguishable from the optimal first-round policy because the March 2020 stimulus checks were too small to alter the distribution of MPCs.

Budget savings and additional stimulus relative to actual policy.—In Table 2, we report on a larger number of allocations for different age-conditioning and upper limits for the checks. In column (1), the table summarizes the results in terms of *resource equivalent variation* (REV); i.e, the percentage by which the budget can be reduced while still achieving the stimulus effect of the March 2020 allocation. In column (2), the table show the additional consumption increase as measured by the aggregate percentage point increase in the share that is consumed relative to the actual policy. Our model predicts that 19.3 percent of the stimulus amount will be spent in 2020 under the actual policy.

In row (1), we show the savings that could be obtained with the original check limits but different income limits for the reduction in the check amount. The potential savings are a paltry 0.8 percent, which is mirrored by the finding that the aggregate share consumed only increase by 0.1 percentage points relative to the actual policy.

In the second panel, we further allow for different maximum checks for adults and/or for children. To keep the number of alternatives limited, we chose the experiments of doubling or tripling the $1,200 and $500 maximum check amount per adult and child, respectively. From row (2), doubling the maximum amount for adults—keeping the maximum child amount fixed—could have achieved the same aggregate stimulus effect with a 34.3 percent lower budget. This happens because the adjusted maxima allows for tilting the allocations toward consumers spending a larger share of their checks. As reported in Appendix Table A.9, such a policy would increase the share of the stimulus check consumed by the median household from 12.9 percent under the actual policy to 27.6 percent.

From row (3), if the maximum is $3,600 per adult, the same stimulus could be achieved at 37.5 percent lower cost; which is only a 3.2 percentage point higher saving than the doubling of limits might achieve. Similarly, whereas the double-limits policy increases the share of the stimulus check spent by households by 13.9 percentage points relative to the actual policy, the triple-limit policy increases the share spent by 15.3 percentage points. This limited gain from tripling rather than doubling the limits occurs because the checks to the poorest become so large that they end up saving a large share of the money to smooth their consumption over multiple years. Doubling the maximum check for children—possibly more palatable politically—also is efficient, as this can reduce the cost of the same stimulus by 27.6 percent, see row (4), while a tripling of child amount to $1,500 would allow for savings of 33.5 percent.

From row (6), doubling the maximum check for both adults and children could achieve savings of 36.4 percent, which is only 2.1 percentage points more than could be obtained by doubling the check for adults only. This small incremental amount of savings reflects that, while parents tend to be young with relatively high MPCs, parts of very large checks get saved. This result illustrates the importance of accounting for how each household-type specific MPC declines with the size of the check. Row (7) shows that tripling maxima for both adults and children provides little further potential savings as we find a budget saving of 38.2 percent, which is only marginally higher than the 36.4 percent savings that doubling of the March 2020 maxima can achieve. Very large checks are unlikely to be optimal when the objective is to maximize stimulus spending because consumers will end up saving a substantial share.

Could larger stimulus be achieved by having checks depend on age. Row (9) shows that a modest 1.5 percent savings could be realized by allowing checks to vary across four age-groups if the government must honor the maximum check amounts for adults and children under the March 2020 policy, and row (10) makes the technical point that allowing a finer age-grid makes little difference. We will therefore limit our remaining alternatives to four age-groups.

The bottom panel of Table 2 repeats the analysis for the maximum check sizes analyzed in the second panel, but now allowing the allocations to also vary with age. The patterns are quite similar to those found when age is not a criterion, but the potential savings are about 6–7 percentage points larger. From row (17), the largest savings of 44.7 percent will be realized when there are no constraints on the maximum check amount for adults and children—technically a $20,000 constraint that does not bind—but most of this is achieved already in the case of age-dependent policy with a $2,400 maximum per adult and $500 maximum per child, see row (11). The results for tripling maximums or changing limits per child follow the same patterns as when age is not a criterion allowed, but with the fraction spent being about 4 percentage points higher.

Additional results and sensitivity analysis.—The online appendix reports more technical details and results: it shows allocations under the alternative hypothesis that the checks are tax-financed in 2020, which changes the results little because most taxes are paid by higher-income consumers who will not receive checks in either case; it displays results showing that the optimal allocations are not sensitive to the level of UI benefits; it reports results for the case where the government's objective is to maximize lifetime welfare of check recipients; and it provides additional details about the derivation of the optimal allocation queue.

6 Conclusion

We evaluate how alternative allocations of stimulus checks in March 2020 would have affected aggregate consumption when the consumption increase per dollar received in checks is predicted using a life-cycle consumption-saving model with heterogeneous consumers. Building on an algorithm of Wang (2020), we derive the allocation of stimulus checks across millions of households, subject to allocation constraints such as check maximums imposed by Congress, that leads to the maximum consumption increase for both the March 2020 check and for a potential second round of checks.

Allowing for larger checks to poorer, younger couples with children would allow for the same aggregate stimulus effect at almost half the cost, although we find that if the check maximums get too large, a large fraction will be saved rather than stimulate consumption in 2020. We do not consider political trade-offs, but the patterns of our results should inform the policy choices involved in a potential second round and our approach could be used to predict the consumption effect of any specific set of rules under which the next set of checks might be allocated.

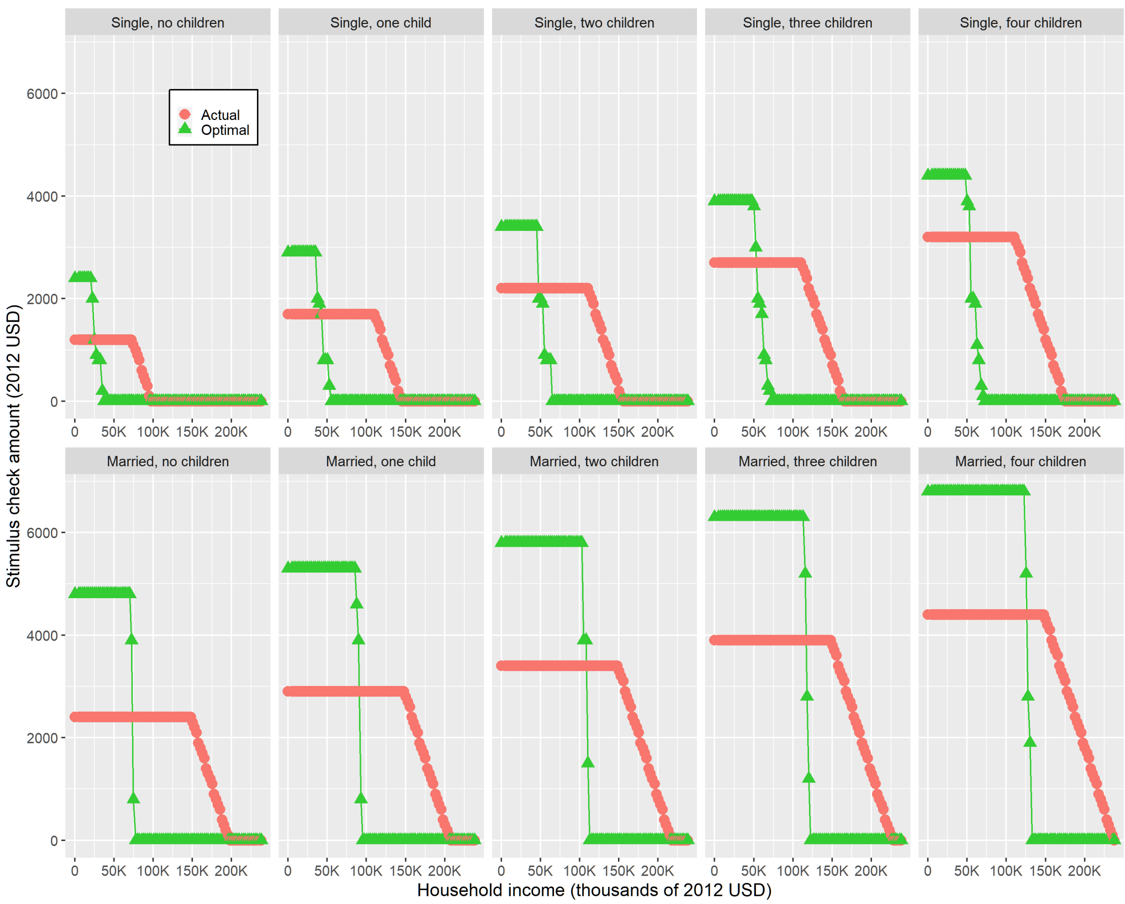
While our primary objective has been to derive the allocation of stimulus checks that leads to the highest 2020 consumption increase, the methodology is general and can be used to study allocations in other settings. A solution to the optimal allocation of a homogeneous good exists as long as the planner has Atkinson-CES preferences and the households' utility function are increasing and concave, even in complex environments with heterogeneous households and potential household-specific allocation constraints. Because the problem admits a closed-form solution, the methodology can be applied to problems with arbitrarily large numbers of possible allocation combinations. Our paper can be used as a roadmap to study optimal allocations in environments where these conditions are met.

Table 1: Dollar Increase in Consumption Following the Receipt of an Additional $100 Conditional on Initial Transfer Amounts

	Initial transfer amount							
	$0	$500	$1,000	$2,000	$3,000	$5,000	$7,500	$10,000
Single with 0 children								
Income: 0–20,000	56.3	36.3	22.6	17.5	17.3	14.1	11.5	11.3
Income: 20,000–40,000	17.4	15.3	12.0	9.9	9.5	8.6	7.8	7.6
Income: 40,000–60,000	8.8	8.4	7.3	6.4	6.3	5.9	5.7	5.7
Income: 60,000–80,000	5.5	5.5	5.3	5.2	5.1	5.1	5.0	5.0
Income: 80,000–100,000	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Single with 2 children								
Income: 0–20,000	96.6	61.9	47.7	31.4	31.4	21.2	16.7	16.7
Income: 20,000–40,000	74.6	50.9	37.9	24.9	24.5	17.3	13.8	13.6
Income: 40,000–60,000	24.8	21.2	16.2	12.2	12.0	9.9	8.6	8.4
Income: 60,000–80,000	11.7	11.1	9.5	7.8	7.8	6.9	6.4	6.3
Income: 80,000–100,000	7.4	7.2	6.7	6.1	6.0	5.8	5.6	5.5
Single with 4 children								
Income: 0–20,000	99.5	61.5	48.9	33.0	32.9	22.1	17.5	17.5
Income: 20,000–40,000	93.6	60.8	44.7	31.3	31.3	21.2	16.4	16.3
Income: 40,000–60,000	48.6	34.3	24.0	17.2	17.0	13.1	10.8	10.6
Income: 60,000–80,000	14.3	13.0	10.7	8.9	8.7	7.8	7.1	7.0
Income: 80,000–100,000	8.0	7.7	7.1	6.4	6.4	6.1	5.9	5.9
Married with 0 children								
Income: 0–20,000	45.0	40.2	33.2	32.9	32.9	30.4	30.2	30.2
Income: 20,000–40,000	33.6	33.6	30.9	27.1	27.1	26.5	26.3	24.4
Income: 40,000–60,000	22.4	22.4	21.7	19.6	19.6	19.2	19.1	17.0
Income: 60,000–80,000	14.5	14.4	14.2	13.5	13.5	13.2	12.6	11.7
Income: 80,000–100,000	10.4	10.3	10.3	10.1	9.9	9.7	9.2	9.0
Married with 2 children								
Income: 0–20,000	38.5	37.2	37.1	35.8	35.4	35.4	29.4	28.3
Income: 20,000–40,000	32.9	32.3	32.3	31.8	31.7	31.3	27.0	24.8
Income: 40,000–60,000	26.6	26.3	26.1	25.9	25.8	25.3	22.9	20.8
Income: 60,000–80,000	21.1	21.0	20.7	20.4	20.2	19.8	18.4	16.9
Income: 80,000–100,000	16.5	16.4	16.3	15.9	15.7	15.3	14.4	13.5
Married with 4 children								
Income: 0–20,000	39.7	38.1	38.1	38.1	37.7	34.7	28.2	27.0
Income: 20,000–40,000	36.5	35.5	33.9	33.9	33.3	31.1	26.8	25.2
Income: 40,000–60,000	32.5	31.7	29.9	29.9	29.6	28.2	25.1	23.4
Income: 60,000–80,000	27.9	26.9	25.9	25.5	25.3	24.3	22.1	20.7
Income: 80,000–100,000	21.8	21.4	20.8	20.4	20.3	19.6	18.2	17.1

Notes: The table reports the marginal propensity to consume out of the next $100 in transfers conditional on initial transfer amount for different household types (single or married, 0, 2, or 4 children, and different household incomes). That is, it reports the value of $MPC^{\$100}(s;TR) = \frac{\Delta c(s)}{(TR+\$100)-TR}$, where $\Delta c(s)$ is the change in consumption of a household of type s whose transfer increases from $TR \geq 0$ to $TR + \$100$.

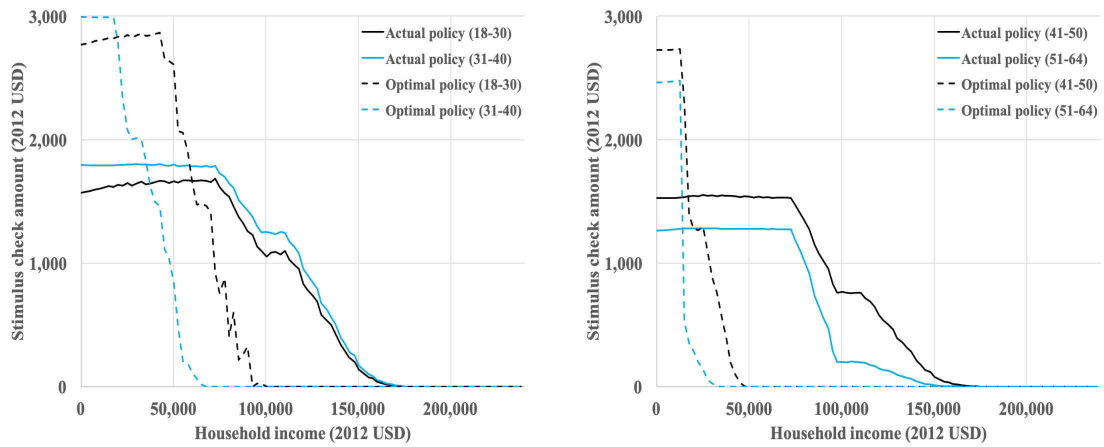
Figure 1: Actual vs. Optimal Allocation by Income and Family Status. Maximum Check Size $2,400 per adult and $500 per child



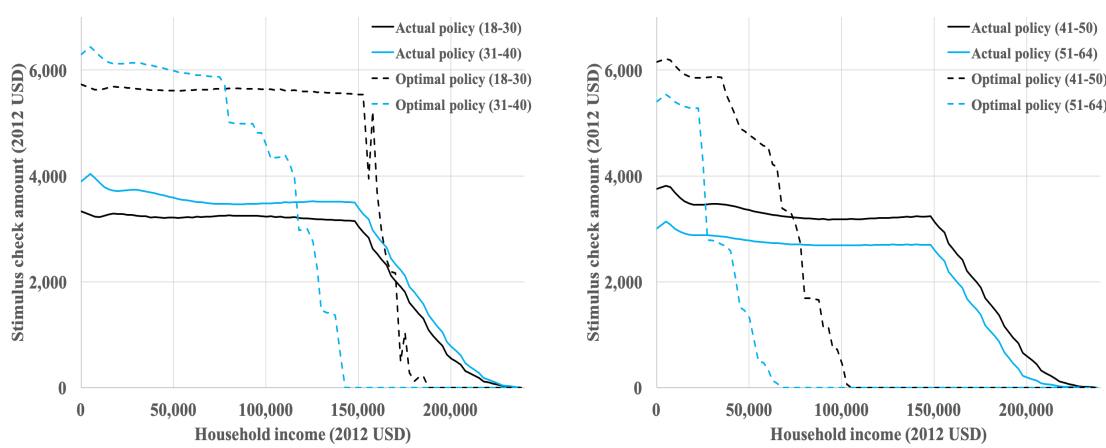
Notes: The figure shows the allocation of stimulus checks by household income and family status (marital status and number of children) for the March 2020 checks (red line) and for the optimal allocation (green line) of the same amount of money calculated under the assumption that the maximum check amount is $2,400 per adult and $500 per child.

Figure 2: Actual vs. Optimal Allocation by Age, Marital Status, and Income. Maximum Check Size $2,400 per adult and $500 per child

(a) Single household heads

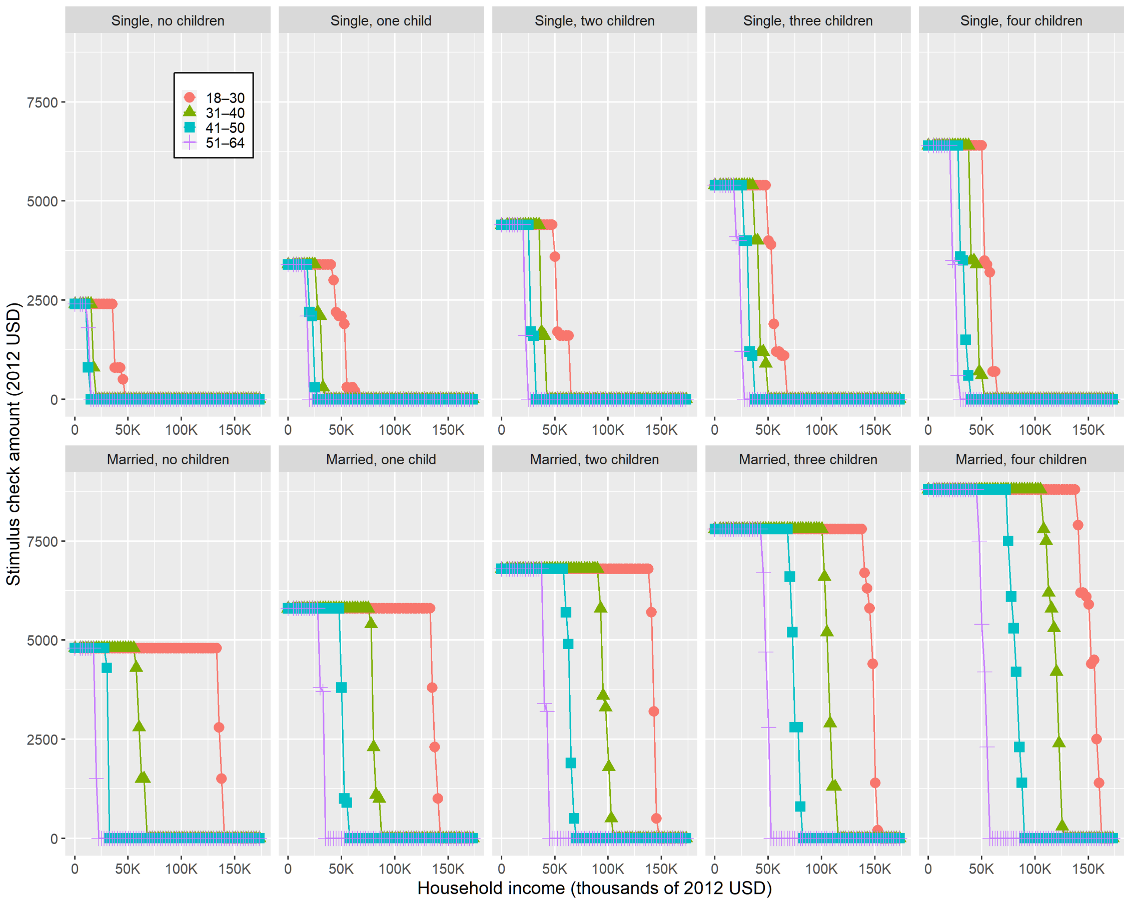


(b) Married household heads



Notes: The top panel shows the average allocation of stimulus checks for single household heads by income and 4 age-groups (18–30, 31–40, 41–50, 51–64) for the March 2020 actual allocation (solid lines) and for the optimal age-dependent allocation (dotted lines) of the same amount of money calculated under the assumption that the maximum check amount is $2,400 per adult and $500 per child. The bottom panel shows the corresponding results for married household heads.

Figure 3: A Second Rounds of Checks. Optimal Second Check by Age, Income, and Family Status. Maximum Check Size $2,400 per adult and $1,000 per child.



Notes: The figure shows the allocation of stimulus by household income, family status (marital status and number of children), and 4 age groups (18–30, 31–40, 41–50, 51–64) for the second allocation round. For the second round of stimulus checks, we first implement the actual March 2020 policy and then compute optimal allocation in round two conditional on the first-round allocation. The optimal policy for the second round is calculated under the assumption that the maximum check amount is $2,400 per adult and $1,000 per child.

Table 2: Budget Savings and Change in the Share of the Aggregate Stimulus Check that is Consumed by the Households Relative to the Actual Policy: Optimal Policy Under Different Constraints

	Allocation Constraints	(1) Budget Savings (%)	(2) Δ Share of Agg. Stimulus Check Consumed (p.p.)
Vary income-eligibility criteria			
(1)	Adjust income-specific eligibility criteria	0.8	0.1
Vary income-eligibility criteria and maximum check amount			
(2)	Double limit for each adult ($2,400)	34.3	10.1
(3)	Triple limit for each adult ($3,600)	37.5	11.6
(4)	Double limit for each child ($1,000)	27.6	7.4
(5)	Triple limit for each child ($1,500)	33.6	9.8
(6)	Double limit for each adult ($2,400) and child ($1,000)	36.4	11.0
(7)	Triple limit for each adult ($3,600) and child ($1,500)	37.9	11.8
(8)	$20,000 limit for each household	38.2	11.9
Vary income-eligibility criteria and condition on age of ref. person			
(9)	4 age groups (18–30, 31–40, 41–50, 51–64)	1.5	0.3
(10)	1-year age groups	2.0	0.4
Vary income-eligibility crit. and max check amount, 4 age groups			
(11)	Double limit for each adult ($2,400)	41.8	13.9
(12)	Triple limit for each adult ($3,600)	44.2	15.3
(13)	Double limit for each child ($1,000)	35.5	10.6
(14)	Triple limit for each child ($1,500)	40.0	12.9
(15)	Double limit for each adult ($2,400) and child ($1,000)	43.0	14.6
(16)	Triple limit for each adult ($3,600) and child ($1,500)	44.3	15.4
(17)	$20,000 limit for each household	44.7	15.6

Notes: The actual policy was income-tested and had a maximum check amount of $1,200 per adult and $500 per child. 19.3 percent of the aggregate stimulus check is consumed by the households under the actual policy. The budget savings (i.e., REV numbers) reported in column (1) specifies the percentage by which the government can reduce total spending on stimulus checks and still achieve the same increase in aggregate consumption as under the actual policy. A value of 0 percent means the government cannot reduce spending at all if it wants to maintain the same increase in aggregate consumption as under the actual policy, whereas a value of 99 percent means the government can reduce total spending by 99 percent and still achieve the same increase in aggregate consumption as under the actual policy. Column (2) reports the percentage point change in the share of the aggregate stimulus check that is consumed by the households relative to the actual policy as given by $\left(\frac{\Delta(C)^{\text{act}}}{B^{\text{opt}}} - \frac{\Delta(C)^{\text{act}}}{B^{\text{act}}}\right)100 = \left(\frac{\Delta(C)^{\text{act}}}{B^{\text{act}}}\frac{REV}{1-REV}\right)100$, where $\Delta(C)^{\text{act}}$ is the change in aggregate consumption due to the stimulus checks under the actual policy, B^{act} is the aggregate amount spent on stimulus checks under the actual policy, and $B^{\text{opt}} = B^{\text{act}}(1 - REV)$.

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7 Online appendix

A.1 Calibration

This section provides additional details about the calibration. A summary of the parameters that are determined outside the equilibrium is reported in Table A.1. Table A.2 provides a corresponding summary of the parameters that are determined jointly in equilibrium.

Life-cycle parameters.—As explained in Section 4 of the paper, we use life-tables for the U.S. Social Security Area (SSA) for the year 2020 to derive age-specific survival probabilities, ψ_j. Life-tables reported by the SSA are gender-specific. We obtain non-gender specific survival probabilities by combining the age- and gender-specific survival probabilities from the SSA with data on the distribution of gender by age reported by the Census. We normalize the mass of 18-year-olds in the model to 1 and adjust the relative mass of individuals by age to match the old-age dependency ratio (that is, the ratio of 65+ to 18–64 year-olds) in the United States.

We use data from the Panel Study of Income Dynamics (PSID) for the period 1997–2017 to obtain the probability of being college educated, the probability of being married, and the initial distribution of children. We assume that 30.3 percent of agents are college-educated, which corresponds to the share of 18+ year-old household heads in the PSID with at least a bachelor's degree or a minimum of 4 years of college education. Similarly, we assume that 43.7 percent of non-college educated agents and 56.4 percent of college educated agents are married, which corresponds to the share of 18+ year-old household heads in the PSID that are married by college attainment. Finally, we let the initial distribution of children be equal to the distribution of children under the age of 18 for 18–25 year-old household heads in the PSID, with the number of children top-coded at 4. We condition the initial distribution of children on the household head's college attainment and marital status. Doing so allows us to account for the observation that young college-educated individuals are less likely to have children than young non-college educated individuals, and that young married individuals are more likely to have children than young non-married individuals. Table A.3 summarizes the initial conditions for college attainment, marital status, and number of children.

Transition probabilities for number of children.—The PSID has been administered on a bi-annual basis since 1997. Because a period in the model is one year, we use data from the PSID for the period 1993–1997 to derive transition probabilities for the number of children under the age of 18. We do this by estimating an ordered logistic regression of the number of children under the age of 18 at time $t+1$ conditional on the household head's age, age squared, marital status, college attainment, and number of children under the age of 18 at time t. The regression results are reported in Table A.4. The transition probabilities for the number of children under the age of 18 are then given by the standard ordered logistic formula:

$$\mathbb{P}\left(k' = i|\boldsymbol{x}\right) = \frac{1}{1+\exp(-\kappa_i + \boldsymbol{x\beta})} - \frac{1}{1+\exp(-\kappa_{i-1} + \boldsymbol{x\beta})}, \tag{12}$$

where $\boldsymbol{x} = \left(k, j, j^2, m, e\right)$ is a vector with the number of children under the age of 18 at time t, the age and age-squared of the agent, the marital status of the agent, and the educational attainment of the agent. Similarly, $\boldsymbol{\beta}$ is a vector of parameters and the κ's are the cutoffs.

Spousal income.—We use data for married individuals in the PSID for the period 1997–2017 to estimate spousal income. To do this, we first estimate the following OLS regression:

$$\ln(y_t^S) = \begin{cases} \beta_0 + \beta_1 \ln(y_t^H) + \beta_2 j_t + \beta_3 j_t^2 + \beta_4 j_t^3 + \beta_5 \mathbb{I}_{e_t=1} + \sum_{q=1}^4 \gamma_q \mathbb{I}_{k_t=q}, & j < j_R \\ \beta_0 + \beta_1 \ln(y_t^H) + \beta_2 j_t + \beta_3 j_t^2 + \beta_4 j_t^3 + \beta_5 \mathbb{I}_{e_t=1} + \sum_{q=1}^4 \gamma_q \mathbb{I}_{k_t=q} + \beta_7 k_t + \beta_8, & j \geq j_R \end{cases} \tag{13}$$

where $\ln(y_t^S)$ and $\ln(y_t^H)$ denote the logarithm of the spouse's and reference person's income, respectively, with income defined as the sum of labor earnings, Social Security benefits, Supplemental Security Income, unemployment insurance benefits, and other transfers. Next, $\mathbb{I}_{e_t=1}$ is an indicator function that is equal to one if the reference person is college-educated and $\mathbb{I}_{k_t=q}$ is an indicator function that is equal to one if the reference person has $q \in \{1, 2, 3, 4\}$ children under the age of 18 at time t. Lastly, β_7 enables us to capture that the "child penalty" (that is, the reduction in average spousal income due to children) is different for young and old individuals, and β_8 allows for differences in the intercept term for young and old individuals.[6] The regression also includes year fixed-effects. The regression results are reported in Table A.5. We use this regression to predict average spousal income conditional on the idiosyncratic state of the household head and use the variance of the residual from this regression to obtain an estimate of the variance of spousal income. Finally, we discretize both the household head's and the spouse's income process by means of the Tauchen method. Households draw their initial productivity shocks from the stationary distribution of the household head's and the spouse's income process.

The benchmark analysis studied in the main text assumes that spousal income shocks are i.i.d. This leads to a correlation between the logarithm of the spouse's and reference person's income of

[6] We do not use any information about the spouse, such as the spouse's age or educational attainment, in our regressions because we do not keep track of the spouse's idiosyncratic state in the model.

0.22, compared to a corresponding correlation of 0.26 in the PSID. The optimal allocation results are robust to allowing for persistent spousal productivity shocks.

Model fit.—Table A.6 compares the distribution of earnings, income, and wealth in the model and the data, none of which were targeted in our calibration, where the data is from Kuhn and Ríos-Rull (2016). In the model, earnings are given by the sum of the reference person's labor earnings and the spouse's earnings, income is given by the sum of earnings plus income from interest earnings and Social Security benefits, and wealth is given by the sum of household savings. The GINI Index for earnings is equal to 0.51 in the model, compared to 0.67 in the data. Similarly, the GINI Index for income is equal to 0.44 in the model and 0.58 in the data, and the GINI Index for wealth is equal to 0.68 in the model and 0.85 in the data. This shows that the model gives an overall reasonable fit of these distributions, but underestimates the magnitude of inequality in earnings, income, and wealth in the United States. The model underestimates inequality because the only sources of inequality are persistent labor productivity shocks and permanent productivity differences by age and educational attainment. The model also abstracts from preference heterogeneity such as heterogeneity in discount factors, which is likely to be an important determinant of inequality, especially wealth inequality. A comparison of the 99–50 ratios show that the model underestimates earnings, income, and wealth inequality because it underestimates the concentration of earnings, income, and wealth in the United States. The following rows show that the model gives a good fit of the 90–50 ratio, the 50–30 ratio, and the mean-to-median ratio for earnings, income, and wealth. Accordingly, while the model underestimates the share of earnings, income, and wealth held at the top of the corresponding distributions, it provides a good fit of these distributions for the parts of the population that were likely to receive stimulus checks under the actual March 2020 policy.

A.2 Household characteristics

This section reports output from the dynamic programming problem developed in Section 2 of the main text that provides additional insights into the determinants of the optimal allocation results.

Table A.7 reports average characteristics for single household heads by income and number of children. For each type, column (1) reports the share of household heads with a college-degree, defined as having at least a bachelor's degree or a minimum of 4 years of college. Richer households are more likely to have a college-educated household head because college-educated individuals have higher average labor productivity. Similarly, as reported in column (2), the average age of the household head is also higher for richer households because deterministic life-cycle labor productivity is increasing in age. Richer households also have higher savings. This can be seen from columns (3) and (4), which report average and median household savings.

A comparison across households of different sizes show that poor households with few children are more likely to have a college-educated household head than households with several children. This follows directly from the initial conditions for college attainment, marital status, and number of children reported in Table A.3 and the transition probabilities for number of children reported in Table A.4, both of which are calculated using data from the PSID. Larger families also have less savings on average. There are two reasons for this. First, households with more children have more people to feed. A larger share of their income is therefore spent on consumption. Second, given the transition probabilities for number of children, childless young households are likely to have a child in the near future. These households thus save a larger share of their income for precautionary reasons.

Recall that the planner's objective in the benchmark analysis is to maximize expected consumption during the period of COVID-19. The planner accomplishes this objective by allocating the stimulus checks to the households with the highest MPCs. Columns (5) and (6) report the percentage value of the average and median MPC by household type following the receipt of a \$100 transfer. As shown in Table A.7, MPCs are monotonically declining in income. To illustrate, single households without children and with an income less than \$20,000 have an average MPC of 56.3 percent, whereas a corresponding household with an income of \$20,000–\$40,000 has an average MPC of 17.4 percent. Larger households with more children have higher MPCs than smaller households. As shown in the table, single households with 2–4 children and with an income below \$40,000 have an average MPC of 74.6–99.5 percent, and a median MPC of at least 83.3 percent. Larger households have higher MPCs than smaller households both because they have less savings and because they have more people to feed. Accordingly, these results indicate that the planner will optimally allocate a larger stimulus check amount to both poorer and larger households.

Table A.8 reports the corresponding average characteristics for married household heads by income and number of children. With the exception of married households with 0 children, richer married households are more likely to have a college-educated household head than poorer households. Similarly, the average age of the household head and average savings are also higher for richer married households. A comparison of Tables A.7 and A.8 show that married households have higher savings than single households. Married households save more because they have two sources of income, the household head and the spouse. The incentive to save is particular high for childless young married households. These households are likely to have a child in the near future, following which they will not only have more mouths to feed, but average spousal income will also decline. The latter follows from the spousal income process estimated in Table A.5, which shows that average spousal income declines with the number of children, part of which is due to a reduction in hours worked.

As for single households, both average and median MPCs are monotonically declining in income for married households. The rate at which the MPC declines, however, is steeper for single households. This follows because married and single households have both different average stocks of savings and different propensity to save due to different income and family size transition probabilities. As a result, whereas low-income married households generally have lower MPCs than low-income single households, high-income married households generally have higher MPCs than high-income single households. In terms of the optimal allocation of stimulus checks, these results imply that the planner will prioritize single poor households over married poor households. That is, single poor households will have a higher position in the planner's allocation queue. In contrast, married high-income households have a higher position in the planner's allocation queue than single high-income households.

Figure A.1 plots average MPCs by household income and 4 household head age-groups (18–30, 31–40, 41–50, 51–64) for single household heads (left panel) and married household heads (right panel). As illustrated in the figure, MPCs are declining in age for both single and married households. Accordingly, a planner that can allocate based on age will optimally prioritize younger household heads over older ones.

A.3 Additional optimal allocation results

Same maximum check limits per adult and child as actual policy.—As mentioned in the main text, we consider check allocations imposing the same maximum amount for singles, couples, and children as the March 2020 allocation and examine whether different income limits for the reduction in the check amount would be better. Figure A.2 shows the actual and optimal allocations separately for 10 panels corresponding to different household types: singles at the top with 0, 1, 2, 3, or 4 children under the age of 18 and married at the bottom. The optimal allocation closely mirrors the one chosen by Congress except that our algorithm assigns slightly less to singles and slightly more to couples and finds much steeper phase-out of stimulus checks as income increases compared to the actual allocation. The optimal stimulus is one where singles generally receive the full check amount up to the limit where the March 2020 phase-out started, while couples generally receive the full amount up to the limit where the March 2020 phase-out went to zero.

Increase maximum check amount per child.—Figure A.3 plots the allocation of stimulus checks by household income and family status (marital status and number of children) for the March 2020 checks and for the optimal allocation of the same amount of money when we maintain the $1,200 maximum check amount per adult but increase the maximum check amount to $1,000 per child. Consistent with the actual policy, the optimal policy allocates more to larger households with more children. The incremental increase in stimulus check amounts, however, is higher under the optimal policy. Consequently, larger families receive higher stimulus check amounts under the optimal policy than under the actual policy.

Note that the optimal policy allocates less to single household heads with income exceeding $50,000 than the actual policy. The optimal policy thus not only calls for a higher maximum check amount per child, it also calls for an adjustment of the income-eligibility criteria for single households. In contrast, the actual income-eligibility criteria for married households are generally consistent with the optimal policy. Consequently, married households with children receive the maximum check amount under both the actual and optimal policy as long as household income does not exceed $125,000. These results follow from the MPC analysis in Section A.2, which shows that the rate at which the MPC declines with household income is steeper for single households than for married ones.

Include 65+ year-olds.—The benchmark analysis reported in the main text studies the optimal allocation of stimulus checks for 18–64 year-olds. This age-group is more likely to participate in the labor force, and are thus more likely to be adversely affected by the labor market implications of COVID-19, while most 65+ year-olds are retired. Their primary sources of income are therefore private pensions and Social Security benefits, neither of which were affected by COVID-19. This paragraph reports the optimal allocation results when the planner also includes 65+ year-olds.

Figure A.4 plots the optimal allocation of stimulus by household income, family status (marital status and number of children), and 5 household head age-groups (18–30, 31–40, 41–50, 51–64, 65–99). The optimal policy is calculated using the same total budget as the actual policy but calculated under the assumption that the maximum check amount is $2,400 per adult and $1,000 per child.[7]

[7] The benchmark analysis restricts the total budget available for stimulus checks to be consistent with the total amount the U.S. government allocated to 18–64 year-olds. This section increases the total budget available for stimulus checks

A comparison of Figure A.4 and Figure 3 in the main text shows that, across all family types and household income levels, the optimal allocation results for 18–30, 31–40, 41–50, and 51–64 year-old household heads are not affected by the inclusion of 65+ year-olds in the allocation queue. In terms of the elderly, our results show that the optimal allocation for 65+ year-olds is very similar to the optimal allocation for 50-64 year-olds. This similarity follows because most 65+ year-olds are between the age of 65–75 due to mortality risk. This age-group has comparatively low MPCs due to high savings. This reduces the average MPCs for 65+ year-olds, which in turn results in a lower position in the planner's optimal allocation queue.

Distribution of the share of the stimulus check that is consumed by the households.—This subsection provides further insights into why the optimal policies lead to a larger increase in aggregate consumption than the actual policy. In particular, for each allocation constraint studied in the main text, we compare the distribution of the share of the stimulus check that is consumed by the households, conditional on receiving a check, as given by the distribution of $\frac{\Delta c(s)}{TR(s)}$, where $TR(s) > 0$ is the stimulus check amount received by a household head of idiosyncratic type s and $\Delta c(s)$ is the type-specific change in household consumption. The results are reported in Table A.9. The first row reports the percentiles for the actual March 2020 policy, which was income-tested and had a maximum check amount of $1,200 per adult and $500 per child. The remaining rows report the corresponding statistics for the optimal policies given the specified allocation constraint.

As reported in Table A.9, the median household consumes only 12.9 percent of its stimulus check under the actual policy. 75 percent of households consume less than 25 percent of their stimulus check, and 25 percent of households consume less than 8 percent of their stimulus check. In contrast, the median household consumes about 30 percent of its stimulus check under the various constrained optimal policies. This follows because the optimal policies are chosen to maximize expected consumption during the period of COVID-19. The optimal policies thus lead to a larger increase in aggregate consumption than the actual policy because the planner prioritizes the households that consume the largest share of their stimulus check. As a result, whereas 10 percent of households consume at most 5.6 percent of their stimulus check under the actual policy, the 10th percentile consumes more than 25 percent of the stimulus check under most of the constrained optimal policies.

to be consistent with the total amount the U.S. government allocated to 18+ year-olds.

A.4 Sensitivity analysis

Manna-from-heaven vs. tax-financed stimulus programs.—Whereas the benchmark analysis reported in the main text assumes that the government never increases taxes to finance their increased expenditures (that is, the amount spent on stimulus checks and unemployment insurance benefits is tantamount to "manna-from-heaven"), this paragraph considers the opposite environment where the increase in government expenditures on stimulus checks and unemployment benefits must be financed from increased 2020 taxes by adjusting the level of a_2 in the income tax function. More precisely, we assume the tax rates are set to finance unemployment benefits and the actual March 2020 stimulus checks and are kept fixed as we consider alternative allocations. To be conservative, we assume that the unemployment spell lasts the entire period of COVID-19 ($\xi = 0$), and that unemployment insurance (UI) benefits replace 100 percent of lost earnings ($b = 1$). This parameterization leads to the largest required tax increase which we, for brevity, refer to as the "tax-financed" model below.

We consider the allocation of stimulus checks assuming that the tax rates have been fixed for the year to cover the actual stimulus checks and we focus on allocation of checks without taking into account that, say, a more efficient allocation of checks (for the purpose of increasing aggregate consumption) might have feed-back effects on tax rates. Figure A.5 plots the optimal allocation of stimulus checks by household income and family status (marital status and number of children) for three models. The "No tax increase ($b = 1$)" lines depict the results from the benchmark "manna-from-heaven" model studied in Section 5 of the main text; the "Tax increase ($b = 1$, $\xi = 0$)" lines depict the results from the tax-financed model; and the "No tax increase ($b = 0$, $\xi = 0.25$)" lines depict the results from the "manna-from-heaven" model without UI benefits (see the following subsection for details). All policies are derived using the same total budget as the actual March 2020 policy but calculated under the assumption that the maximum check amount is $2,400 per adult and $1,000 per child.

A comparison of the benchmark model and the tax-financed model in Figure A.5 shows that the optimal allocations are not sensitive to the choice of extreme assumptions about financing of the COVID-19 related fiscal expenses and, therefore, very likely will not be sensitive to any other maybe more realistic assumptions about tax financing. In particular, the tax-financed model leads to quantitatively similar allocation results as the benchmark "manna-from-heaven" model even though we consider the environment where all fiscal expenses must be financed during the period of the COVID-19 crisis, which requires a large increase in the average tax burden in the economy. Note that the tax-financed model allocates slightly more to single household heads and slightly less to married household heads than the benchmark model. This redistribution from married to single household heads is due to the heterogeneity in MPCs discussed in Section A.2. In particular, the rate at which the MPCs decline with income is steeper for single households than for married ones. The reduction in income due to the required tax increase will thus result in a larger increase in average MPCs for poorer single households than for corresponding married ones. Poorer single households will therefore have a higher position in the planner's allocation queue in the tax-financed model than in the benchmark "manna-from-heaven" model.

Table A.10 compares the aggregate implications of the benchmark and tax-financed model. In particular, for each allocation constraint studied in the main text, columns (1) and (2) report the *Resource Equivalent Variation* numbers (that is, the percentage by which the government can reduce total spending on stimulus checks and still achieve the same increase in aggregate consumption as under the actual policy) for the benchmark "manna-from-heaven" model (no tax increase) and the tax-financed (tax increase) model. With the exception of the optimal allocation, where we only adjust the income-specific eligibility criteria, the tax-financed model always results in larger Resource Equivalent Variations than the benchmark model. To illustrate, consider the results when we vary the income-eligibility criteria and double the maximum check amount for both adults and children (row 7). Whereas the benchmark model suggests that the optimal policy can achieve the same aggregate consumption increase with a 33.6 percent lower budget, the corresponding statistic in the tax-financed model is 42.3 percent.

Finally, for each allocation constraint, columns (3) and (4) report the percentage point change in the share of the aggregate stimulus check that is consumed by the households relative to the actual policy. We find that the tax-financed model always result in larger consumption gains than the benchmark model. To illustrate, consider again the results reported in row (7), where we vary the income-eligibility criteria and double the maximum check amount for both adults and children. Whereas the benchmark model suggests that the optimal policy leads to an 11.1 percentage point increase in the share of the aggregate stimulus check that is consumed by the households relative to the actual policy, the corresponding statistic in the tax-financed model is 20.6 percentage points.[8]

Generosity of unemployment insurance benefits.—Unemployed individuals are eligible for unemployment insurance (UI) benefits. The generosity of these benefits was recently increased following the passage of the Coronavirus Aid, Relief, and Economic Security (CARES) Act. In particular,

[8] 19.3 percent of the aggregate stimulus check is consumed by the households under the actual policy in the benchmark model. The corresponding statistic in the tax-financed model is 28.1 percent.

individuals that collect UI benefits are entitled to an additional $600 per week with the aim of replacing 100 percent of average wages.[9] Motivated by this, we assumed that UI benefits replaced 100 percent of lost earnings, $b = 1$, in the benchmark analysis. This subsection considers an alternative environment without UI benefits, $b = 0$. Because the surge in unemployment did not occur until the second quarter of 2020, we assume that $\xi = 0.25$, which corresponds to an unemployment spell of 9 months.

The optimal allocation results—derived using the same total budget as the actual March 2020 policy, but calculated under the assumption that the maximum check amount is $2,400 per adult and $1,000 per child—are depicted in Figure A.5. A comparison of the benchmark ($b = 1$) and no UI benefits ($b = 0$) model shows that the optimal allocation results are not sensitive to the generosity of the UI benefits. The income-means test (i.e., the stimulus check amount received conditional on household income) for single household heads are slightly more generous under $b = 0$ compared to $b = 1$. This follows because the stimulus check program also acts as a partial unemployment insurance program in the model without UI benefits.

A.5 Alternative Planner objective functions

Maximize expected lifetime utility.—The benchmark analysis studied the optimal allocation of stimulus checks when the planner's objective is to maximize expected consumption during the period of COVID-19. This subsection considers an alternative objective where the planner's objective is to maximize expected lifetime utility. Recall that $V^W(\omega; TR)$ and $V^U(\omega; TR)$ denote the value of an agent of type ω that receives an amount TR in stimulus checks and that is employed and unemployed during the period of the COVID-19 crisis, respectively. Let $\tilde{V}(y, j, m, k; TR)$ denote the *ex-ante* expected lifetime utility of an agent with income y, age j, marital status m, and number of children k that receives an amount TR in stimulus checks:

$$\begin{aligned} \tilde{V}(y, j, m, k; TR) \quad = \quad & \psi_j \mathbb{E}_{\eta'|\eta} \mathbb{E}_{\nu'|\nu} \mathbb{E}_{k'|(j,e,m,k)} \mathbb{E}_{(a,\eta,e,\nu)|(y,j,m,k)} \\ & \Big[\pi^U(j+1, \eta', e) V^U(j+1, g_a(\omega), \eta', e, m, k', \nu'; TR) \\ & + \left(1 - \pi^U(j+1, \eta', e)\right) V^W(j+1, g_a(\omega), \eta', e, m, k', \nu'; TR)\Big]. \end{aligned} \tag{14}$$

[9]Due to the recent increase in the generosity of UI benefits, a large share of unemployed Americans experienced an increase in labor earnings in 2020. Recent evidence from Ganong, Noel, and Vavra (2020) show that the median replacement rate is 134 percent and that about two-thirds of unemployed workers who are eligible for UI benefits will receive benefits that exceed their lost earnings. We abstract from income expansion following unemployment and assume that UI benefits replace at most 100 percent of lost earnings.

The planner's choice set continues to be as given by Equation (6) in the main text. We then get the following expression for the planner's objective function when the objective is to maximize expected lifetime utility:

$$P\left(\mathbf{TR},\lambda;\tilde{V}\right)=\left(\int\tilde{V}\left(s;TR_{g}\cdot\mathbb{I}_{s\in\mathbb{S}_{g}}\right)^{\lambda}\mu\left(s\right)ds\right)^{\frac{1}{\lambda}}. \tag{15}$$

Finally, the planner's optimization problem is given by

$$\max_{\mathbf{TR}\in\mathbb{C}^{TR}}P\left(\mathbf{TR},\lambda;\tilde{V}\right). \tag{16}$$

Figure A.6 compares the optimal allocation results by household income and family status (marital status and number of children) for the two planner objectives under the assumption of Utilitarian planner preferences ($\lambda=1$). The "C-optimal" lines plot the allocations from the benchmark model, when the planner's objective is to maximize expected consumption during the period of COVID-19, and the "V-optimal" lines plot the corresponding allocations, when the planner's objective is to maximize expected lifetime utility (for brevity, referred to as the C-allocation and V-allocation). The two objective functions lead to qualitatively similar allocation patterns with poorer households receiving more than richer households, and larger households getting higher stimulus amounts than smaller households. Note, however, that the V-allocation allocates more to single household heads and less to married ones than the C-allocation. This follows because of the insurance provided by spousal income. In particular, due to the high persistence of productivity shocks, low-income single household heads also have low expected lifetime income, and therefore low expected lifetime utility. In contrast, because the household head's income is only weakly correlated with the spouse's income, low-income married household heads do not necessarily have low expected lifetime utility. Accordingly, the correlation between income at a given point in time and lifetime income is lower for married household heads than single ones. Because the objective of the planner is to maximize expected lifetime utility, the planner therefore prioritizes low-income single household heads over corresponding married ones because the former group experiences a larger marginal change in their expected lifetime utility following the receipt of a stimulus check.

Inequality aversion.—The benchmark analysis focuses on Utilitarian planner preferences, which corresponds to a value of 1 for the Atkinson (1970) inequality aversion, λ, in Equation (7) in the main text. The lower the value of λ, the more the planner cares about the *level* of consumption—or the level of lifetime utility if the planner's objective is to maximize expected lifetime utility—rather than just the marginal change in consumption following the receipt of a stimulus check. A value of

$\lambda = -\infty$ corresponds to a planner whose objective is to equalize the distribution of consumption in the population. The algorithm we implement to solve for the optimal allocation of stimulus checks is based on Wang (2020) and allows for any values of inequality aversion. See the companion website to our paper for optimal allocation results given non-Utilitarian, $\lambda < 1$, planner preferences.

A.6 Technical appendix

Optimal allocation queue.—Deriving the optimal allocation of stimulus checks is far from trivial. First, the value of receiving a particular stimulus check amount varies across households due to household heterogeneity. Second, the allocation problem suffers from combinatorially exploding choice sets (see e.g. Arkolakis and Eckert 2017 and Alva 2018), because there are multiple household types which may receive different amounts, and the optimal allocation for each household depends on the amount given to other households. As the number of household types increases, the state-space of the allocation problem (i.e., the number of idiosyncratic household states) grows exponentially and the choice-space of the problem (i.e., the number of allocation combinations) grows factorially. Third, there are constraints on the maximum amount a particular household can receive.

We derive the optimal allocation of stimulus checks by applying the methodology in Wang (2020). As noted in the main text, given planner preferences and social welfare function, household heterogeneity in the valuation of stimulus checks, allocation constraints, and non-backward bending resource expansion paths, Wang (2020) shows that there exists a closed-form solution to the allocation problem characterized by a resource-invariant optimal allocation queue. The assumption of non-backward bending resource expansion paths holds in our model as long as the planner has Atkinson-CES preferences and the agents' utility function are increasing and concave.

Candidate households enter the queue at different spots to begin receiving allocations. If the allocation problem has a household-specific maximum allocation limit, the candidate household recipient exits the optimal allocation queue if it reaches its limit. This allocation queue characterizes the resource expansion path for the planning problem. Allocations along this path solves the planner's objective for any value of the total stimulus check budget. Different stimulus check budgets provides cut-offs along the queue. All allocation increments for candidate households below the resource cut-off receive allocations. While the allocation queue is independent of the total budget available for stimulus checks, the number of households that can receive stimulus checks is constrained by the total stimulus budget.

We discretize the allocation problem. In particular, we assume that households in group $g \in \{1, \ldots, G\}$ can receive an amount $TR_g \in \{\underline{\mathrm{TR}}_g, \underline{\mathrm{TR}}_g + \delta, \ldots, \overline{TR}_g\}$, where $\delta > 0$ is the incremental increase in the amount of stimulus checks. This problem has an exact analytical solution given any value of δ. As $\delta \to 0$, this problem converges to a continuous allocation problem. Alternatively, the planning problem could be cast as a bounded continuous choice problem. That problem is potentially even more challenging due to the number of possibly binding cases that would need to be considered as part of the constrained maximization problem of allocating to N candidate recipients. Given $2 \times N$ group-specific lower and upper bounds, the number of possibly binding edges of faces forms an exponentially increasing hypercube. See Wang (2020) for the solution to this continuous bounded problem when marginal effects of allocations are constant.

Computational details.—For each household type (marital status, number of children, and age of household head), the allocation problem requires us to compute the value of receiving a particular stimulus check amount at very small household income intervals because the stimulus check amount under the actual March 2020 policy varied with \$5 increments in household income. This requires a very dense state space. We have 83 age groups, 5 child states, 2 marital states, 2 educational states, 65 asset states, and 1,330 labor productivity states, resulting in an idiosyncratic state space of 143,507,000 elements. The model is solved with a continuous choice for saving through backwards induction by means of the vectorized bisection algorithm described in Wang (2019).[10]

To derive the optimal allocation of stimulus checks, we need to compute each household's value of receiving a particular stimulus check amount. Because a large share of the households will be unemployed in 2020, we need to compute these values conditional on employment status (employed or unemployed) during the period of COVID-19. To do so, we first discretize the stimulus check from \$0–\$24,400 in \$100 dollar increments.[11] For each of the 143,507,000 idiosyncratic types, we then have to compute the value of receiving a particular stimulus check amount $TR \in \{0, 100, \ldots, 24, 400\}$ conditional on 2020 employment status. Because households have the option of saving all or part of their stimulus check, this requires us to solve for $143, 507, 000 \times 245 \times 2 = 70, 318, 430, 000$ different household-stimulus-check values.

Consistent with the actual March 2020 policy, eligibility for the stimulus checks in the model is tied to each household's income and family size in the year prior to COVID-19. We split households into 416,560 groups in 2019, where groups are defined by marital status, number of children, age of

[10] In the event of death, the consumer's accidental bequests are transferred to the government.

[11] We approximate the "unbounded" stimulus check limit in the model by \$20,000. A limit of \$24,400 enables us to solve for the value of receiving \$4,400 in the first allocation round and \$20,000 in the second allocation round. See the main text for details.

household head, and household income. We have 476 household income groups in \$500 increments from \$0–\$238,000, and 33 income groups at \$2,500 increments for \$238,000–\$406,000. Given our discretization of the stimulus check amount, this leads to $416,560 \times (245-1) = 101,640,640$ different marginal values of stimulus checks.

Finally, assuming that the objective of the planner is to maximize expected consumption in 2020 and that the planner has Utilitarian preferences ($\lambda = 1$), the planner allocates the first stimulus dollar to the household with the highest marginal change in consumption, the second dollar to the household with the second highest marginal change in consumption, etc. This might involve allocating the first dollar to household i, the second dollar to household $j \neq i$, and the third dollar to household i. This follows because each household's marginal change in consumption is decreasing in the stimulus check amount due to the concavity of the utility function.

As noted in Section A.5, the algorithm we implement to solve for the optimal allocation of stimulus checks is based on Wang (2020) and allows for any values of inequality aversion, $\lambda \leq 1$. Similarly, it allows for other planner objectives such as maximizing expected lifetime utility rather than maximizing expected consumption. The algorithm described in this section can also be used to solve those models after the necessary adjustments have been made. To illustrate, to derive the optimal allocation of stimulus checks for the case when the planner's objective is to maximize expected lifetime utility, we have to derive each household's marginal change in lifetime utility rather than marginal change in consumption following the receipt of a stimulus check of a given amount.

Definition of equilibrium.—Given a fiscal policy $\{SS_e, T_y, G\}$ and a real interest rate r, the pre-COVID-19 steady-state competitive equilibrium consists of household policies $\{c(\omega), a'(\omega)\}$ and an associated value function $\{V(\omega)\}$ such that:

1. Given prices and fiscal policy, consumers maximize utility subject to their constraints.

2. Government policies balances the government budget constraint: $\int T_y(\omega)\mu(d\omega) + D = G + \int SS_e\mu(d\omega)$, where $y = ra + \mathbb{I}_{j<j_R}\theta\epsilon_{j,\eta,e} + \mathbb{I}_{j\geq j_R}SS_e + \mathbb{I}_{m=1}B_{j,e,k,\eta,\nu}$ is household income and $D' = \int(1-\psi_j)(1+r)a'(\omega)\mu(d\omega)$ are accidental bequests.

3. Aggregate income is given by $Y = \int \left(ra(\omega) + \mathbb{I}_{j<j_R}\theta\epsilon_{j,\eta,e} + \mathbb{I}_{m=1}B_{j,e,k,\eta,\nu}\right)\mu(d\omega)$ and aggregate assets are given by $A = \int a(\omega)\mu(d\omega)$.

4. The measure of agents of type $\omega = (j, a, \eta, e, m, k, \nu)$, $\mu(\omega)$, is induced by the exogenous initial distribution, the policy functions, the age-specific mortality risk, and the exogenous stochastic processes for idiosyncratic shocks.

Table A.1: Parameters Determined Outside the Model

Parameter	Description	Source	Value
Life-cycle parameters			
J	Maximum lifespan = 100		83
j_R	Retirement age = 65		48
γ	Risk aversion	IES = 0.5	2.000
ψ_j	Age-specific survival probabilities	SSA Life-tables	
$\mathbb{P}_{k'\|(j,e,m,k)}$	Transition probabilities for number of children	PSID	
Technology and income parameters			
r	Real interest rate	McGrattan and Prescott (2003)	0.040
$f_{j,e}$	Age- and educ.-specific deterministic labor prod.	Conesa et al. (2020)	
ρ	Persistence of ref. person's AR(1) shocks	Incomplete markets literature	0.980
σ^2	Variance of ref. person's AR(1) shocks	Incomplete markets literature	0.018
$B_{j,e,k,\eta,\nu}$	Spousal income if married	PSID	
Taxation			
a_0	Tax parameter	Gouveia and Strauss (1994)	0.258
a_1	Tax parameter	Gouveia and Strauss (1994)	0.768
COVID-19			
Π^U_{j,y_ℓ}	Age- and earnings-specific unemployment prob.	Cajner et al. (2020)	

Notes: The table lists the parameters that are determined outside the model. We use values for the persistence and variance of the reference person's productivity shocks that are common in the incomplete markets literature (see e.g. Storesletten et al. 2004). See the text for details about the spousal income process.

Table A.2: Parameters Determined Jointly in Equilibrium

Parameter	Description	Value	Target	Model
θ	Normalization of model units	0.565	Median household income = 1.000	1.000
β	Discount factor	0.971	Ratio of assets to GDP = 3.000	3.000
$SS_{e=1}$	Social Security college-educated	0.293	Ratio SS college/non-college = 1.193	1.193
g	Government consumption to GDP	0.176	Ratio of gov. cons to GDP = 0.176	0.176

Notes: The table lists the parameters that are determined jointly in equilibrium. Numbers in the model are normalized such that a value of 1.0 corresponds to $58,056 in 2012 USD. Social Security benefits for non-college educated consumers is normalized to match average Social Security benefits of non-college educated individuals in the CPS. The level of government consumption is equal to $G = gY$, where Y is GDP.

Table A.3: Initial Conditions for College Attainment, Marital Status, and Number of Children

Description	Source	Value
College attainment and marital status		
Probability of being college-educated	PSID	0.303
Probability of being married and non-college-educated	PSID	0.437
Probability of being married and college-educated	PSID	0.564
Number of children, non-college-educated and single		
0 children	PSID	0.733
1 child	PSID	0.151
2 children	PSID	0.083
3 children	PSID	0.024
4 children	PSID	0.009
Number of children, college-educated and single		
0 children	PSID	0.975
1 child	PSID	0.024
2 children	PSID	1E-04
3 children	PSID	0.001
4 children	PSID	0.000
Number of children, non-college-educated and married		
0 children	PSID	0.414
1 child	PSID	0.296
2 children	PSID	0.213
3 children	PSID	0.057
4 children	PSID	0.020
Number of children, college-educated and married		
0 children	PSID	0.753
1 child	PSID	0.215
2 children	PSID	0.022
3 children	PSID	0.009
4 children	PSID	0.000

Notes: College attainment and marital status are given by the share of 18+ year-old household heads in the PSID that are married and college-educated, where a college-degree is defined as having at least a bachelor's degree or a minimum of 4 years of college. Initial distribution of children is given by the distribution of children under the age of 18 for 18–25 year-old household heads by marital status and college attainment in the PSID.

Table A.4: Transition Probabilities for Number of Children: Ordered Logistic Regression Results

Dependent variable: Number of children at $t+1$: $k_{t+1} \in \{0, \ldots, 4\}$	
Reference person has 1 child at t: $\mathbb{I}(k_t = 1)$	4.970
	(0.093)
Reference person has 2 children at t: $\mathbb{I}(k_t = 2)$	8.720
	(0.147)
Reference person has 3 children at t: $\mathbb{I}(k_t = 3)$	12.969
	(0.215)
Reference person has 4 children at t: $\mathbb{I}(k_t = 4)$	17.569
	(0.338)
Age of reference person	-0.082
	(0.011)
Age squared of reference person	3E-04
	(1E-04)
Marital status of reference person: $\mathbb{I}(m_t = 1)$	0.387
	(0.052)
College attainment of reference person: $\mathbb{I}(e_t = 1)$	0.134
	(0.047)
Cut 1	0.659
	(0.215)
Cut 2	4.479
	(0.210)
Cut 3	9.005
	(0.228)
Cut 4	13.359
	(0.286)
Pseudo R^2	0.6912
Number of observations	27,660

Notes: The table reports results from an ordered logistic regression of the household head's number of children under the age of 18 at time $t+1$ on the household head's number of children under the age of 18 at time t, a quadratic in the household head's age at time t, the marital status of the household head at time t, and the college attainment of the household head at time t. Number of children has been top-coded at 4. Standard errors in parentheses. Data source: PSID.

Table A.5: Spousal Income: Ordinary Least Squares Regression Results

Dependent variable: Logarithm of spousal income	
Logarithm of reference person's income	0.134
	(0.012)
Age of reference person	0.164
	(0.014)
Age squared of reference person	-0.003
	(3E-04)
Age cubed of reference person	1E-05
	(2E-06)
College attainment of reference person: $\mathbb{I}(e = 1)$	0.206
	(0.016)
Reference person has 1 child: $\mathbb{I}(k = 1)$	-0.168
	(0.020)
Reference person has 2 children: $\mathbb{I}(k = 2)$	-0.302
	(0.021)
Reference person has 3 children: $\mathbb{I}(k = 3)$	-0.462
	(0.033)
Reference person has 4 children: $\mathbb{I}(k = 4)$	-0.786
	(0.058)
Reference person is 65+: $\mathbb{I}(j \geq j_R)$	-0.223
	(0.039)
Interaction between 65+ dummy and number of children: $\mathbb{I}(j \geq j_R)k$	0.173
	(0.059)
Constant term	-3.407
	(0.217)
R^2	0.1405
Number of observations	30,410

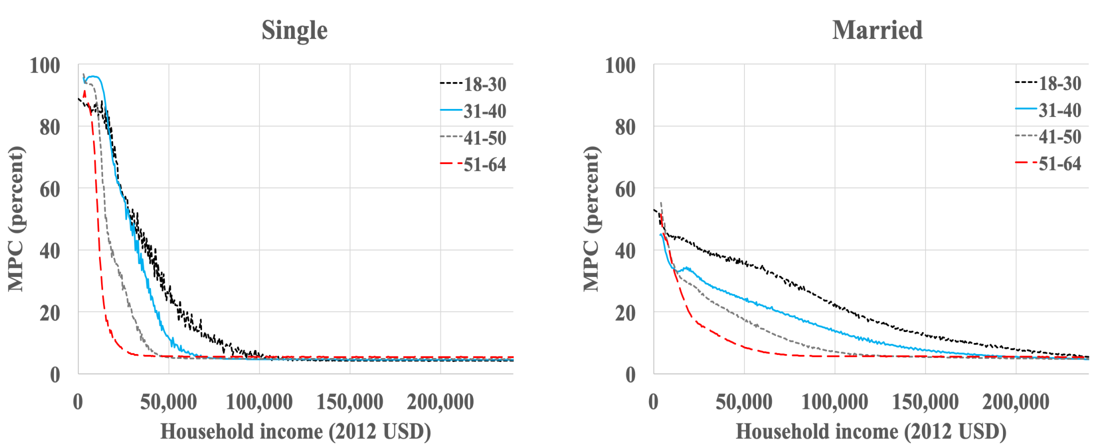
Notes: The table reports results from an ordinary least squares regression of the logarithm of spousal income on the logarithm of the household head's income, a cubic in the age of the household head, the educational attainment of the household head, the household head's number of children under the age of 18, a dummy variable for whether or not the household head is at least 65 years old, and an interaction term between the 65+ dummy variable and the number of children of the household head. The regression also includes year fixed-effects. Income is given by the sum of labor earnings, Social Security benefits, Supplemental Security Income, unemployment insurance benefits, and other transfers. Number of children has been top-coded at 4. The sample is restricted to married household heads. Standard errors in parenthesis. Data source: PSID.

Table A.6: Distribution of Earnings, Income, and Wealth: Model vs. Data

	Earnings		Income		Wealth	
Statistics	Data	Model	Data	Model	Data	Model
GINI Index	0.67	0.51	0.58	0.44	0.85	0.68
99–50 ratio	17.46	6.82	14.78	6.64	96.81	21.62
90–50 ratio	4.15	3.06	3.33	2.95	11.56	8.89
50–30 ratio	3.21	1.77	1.64	1.57	5.50	5.36
Mean-to-median ratio	1.96	1.38	1.85	1.42	6.49	2.99

Notes: The table compares the distribution of earnings, income, and wealth in the model and the data. In the model, earnings are given by the sum of the reference person's labor earnings and the spouse's earnings; income is given by the sum of earnings plus income from interest earnings and Social Security benefits; and wealth is given by the sum of household savings. Data source: Kuhn and Ríos-Rull (2016).

Figure A.1: Marginal Propensity to Consume (MPC) by Age, Marital Status, and Income



Notes: The left panel plots the average marginal propensity to consume (approximated by the dollar change in consumption following the receipt of a $100 transfer) by age group and household income for single household heads. The right panel plots the corresponding statistic for married household heads.

Table A.7: Average Characteristics for Single Household Heads by Income and Number of Children

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Savings ($)		MPC (%)		
Household head type	College (%)	Age	Average	Median	Average	Median	Pop. (%)
Single with 0 children							
Income: 0–20,000	18.2	35.0	2,723	11	56.3	66.2	2.40
Income: 20,000–40,000	20.6	38.5	25,273	6,742	17.4	6.8	6.22
Income: 40,000–60,000	23.5	41.7	81,386	56,522	8.8	5.1	5.10
Income: 60,000–80,000	26.1	43.9	158,104	134,966	5.5	4.8	3.47
Income: 80,000–100,000	28.6	45.3	244,085	224,411	4.8	4.7	2.32
Single with 1 child							
Income: 0–20,000	15.8	31.3	453	0	85.4	93.6	0.71
Income: 20,000–40,000	20.0	33.8	6,999	381	43.3	42.9	1.81
Income: 40,000–60,000	24.5	35.9	32,062	12,438	14.5	6.2	1.39
Income: 60,000–80,000	28.0	37.4	74,586	47,470	8.7	5.1	0.89
Income: 80,000–100,000	31.0	38.5	127,654	95,999	5.8	5.0	0.56
Single with 2 children							
Income: 0–20,000	12.8	31.0	112	0	96.6	99.4	0.66
Income: 20,000–40,000	18.0	33.0	2,611	0	74.6	83.3	1.74
Income: 40,000–60,000	23.5	34.4	16,472	3,332	24.8	15.9	1.33
Income: 60,000–80,000	27.8	35.5	45,523	25,277	11.7	5.7	0.84
Income: 80,000–100,000	31.0	36.3	84,949	60,781	7.4	5.3	0.52
Single with 3 children							
Income: 0–20,000	10.6	31.1	35	0	98.5	99.9	0.26
Income: 20,000–40,000	16.1	32.8	1,136	0	88.7	96.2	0.71
Income: 40,000–60,000	21.9	34.0	9,441	551	39.1	37.7	0.54
Income: 60,000–80,000	26.6	34.9	31,009	14,837	13.5	6.2	0.34
Income: 80,000–100,000	29.9	35.5	63,176	44,745	8.2	5.5	0.21
Single with 4 children							
Income: 0–20,000	8.5	31.7	14	0	99.5	100.0	0.11
Income: 20,000–40,000	13.9	33.1	609	0	93.6	98.8	0.32
Income: 40,000–60,000	19.5	34.1	6,218	30	48.6	49.8	0.24
Income: 60,000–80,000	24.3	34.9	23,519	9,523	14.3	6.9	0.15
Income: 80,000–100,000	27.7	35.4	51,753	34,865	8.0	5.7	0.09

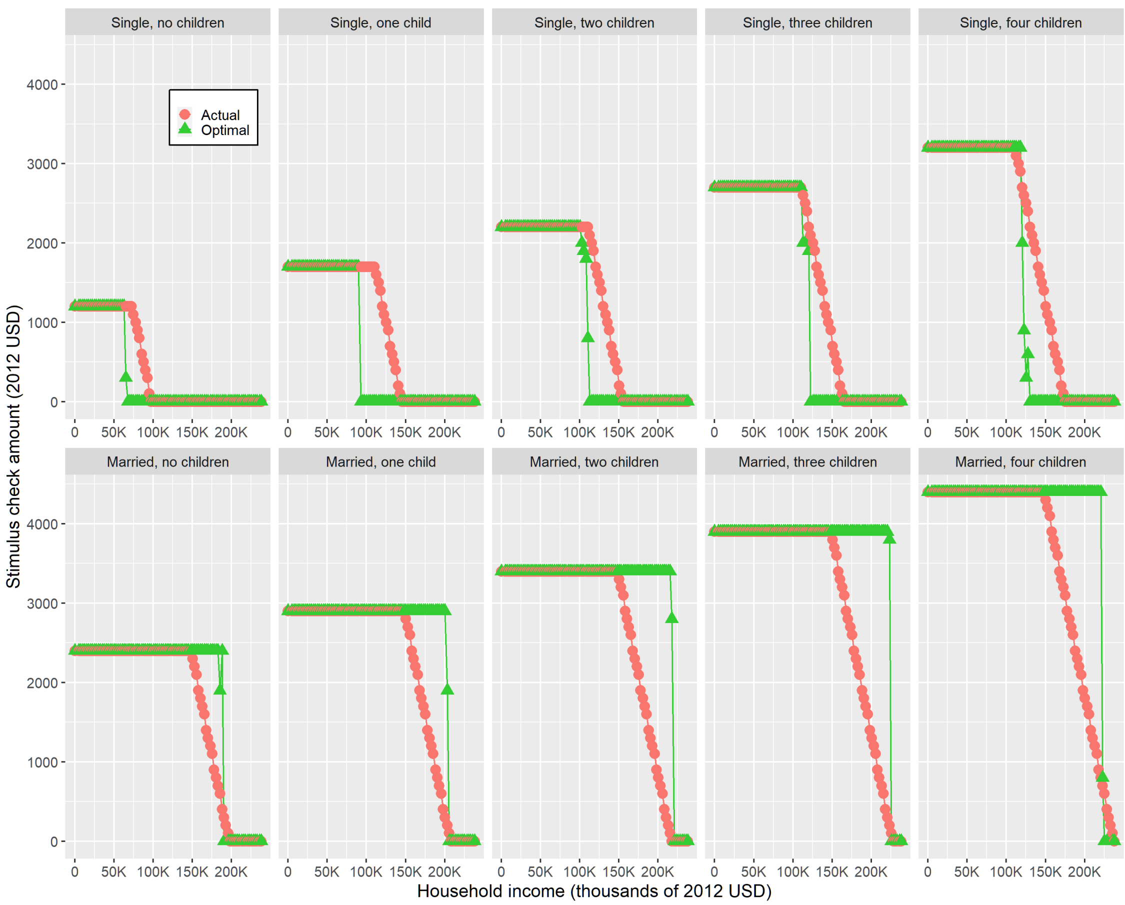
Notes: The table reports summary statistics for single household heads by income and number of children. For each type, the columns report the percentage of household heads with a college degree, average age of the household head, average and median savings, average and median marginal propensity to consume (approximated by the dollar change in consumption following the receipt of a $100 transfer), and the relative size of the population of that type.

Table A.8: Average Characteristics for Married Household Heads by Income and Number of Children

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Savings ($)		MPC (%)		
Household head type	College (%)	Age	Average	Median	Average	Median	Pop. (%)
Married with 0 children							
Household income: 0–20,000	35.9	25.7	19,655	2,146	45.0	46.8	0.22
Household income: 20,000–40,000	32.5	33.3	65,354	21,796	33.6	34.2	1.47
Household income: 40,000–60,000	31.4	39.7	150,517	83,060	22.4	18.3	2.09
Household income: 60,000–80,000	33.9	43.0	246,180	184,281	14.5	6.6	1.96
Household income: 80,000–100,000	35.1	45.5	334,455	285,319	10.4	5.8	1.66
Married with 1 child							
Household income: 0–20,000	26.5	25.3	17,540	1,913	40.9	41.3	0.13
Household income: 20,000–40,000	27.6	31.2	46,377	13,653	33.0	33.9	0.85
Household income: 40,000–60,000	30.3	35.8	93,625	39,794	24.9	23.4	1.11
Household income: 60,000–80,000	34.5	38.1	147,147	77,194	18.0	15.2	0.96
Household income: 80,000–100,000	36.4	40.1	197,839	126,662	13.3	9.8	0.77
Married with 2 children							
Household income: 0–20,000	16.8	26.5	19,524	2,311	38.5	37.8	0.17
Household income: 20,000–40,000	21.6	31.2	42,055	13,431	32.9	32.1	1.22
Household income: 40,000–60,000	27.5	34.5	73,881	30,013	26.6	26.4	1.62
Household income: 60,000–80,000	32.6	36.0	107,768	52,550	21.1	20.3	1.38
Household income: 80,000–100,000	35.1	37.4	139,015	80,662	16.5	15.7	1.09
Married with 3 children							
Household income: 0–20,000	12.8	28.1	20,340	3,737	39.2	38.3	0.10
Household income: 20,000–40,000	18.5	31.9	37,862	11,706	33.3	32.0	0.78
Household income: 40,000–60,000	25.9	34.4	59,717	21,966	28.7	27.6	1.05
Household income: 60,000–80,000	31.2	35.4	81,329	39,794	23.7	23.5	0.89
Household income: 80,000–100,000	33.5	36.3	101,020	56,184	18.9	18.8	0.71
Married with 4 children							
Household income: 0–20,000	9.7	29.8	18,629	3,379	39.7	39.0	0.07
Household income: 20,000–40,000	15.7	32.7	31,182	10,009	36.5	34.0	0.57
Household income: 40,000–60,000	24.0	34.6	45,465	15,308	32.5	30.0	0.78
Household income: 60,000–80,000	29.5	35.3	58,858	22,139	27.9	26.5	0.66
Household income: 80,000–100,000	31.4	35.9	71,226	36,195	21.8	21.0	0.53

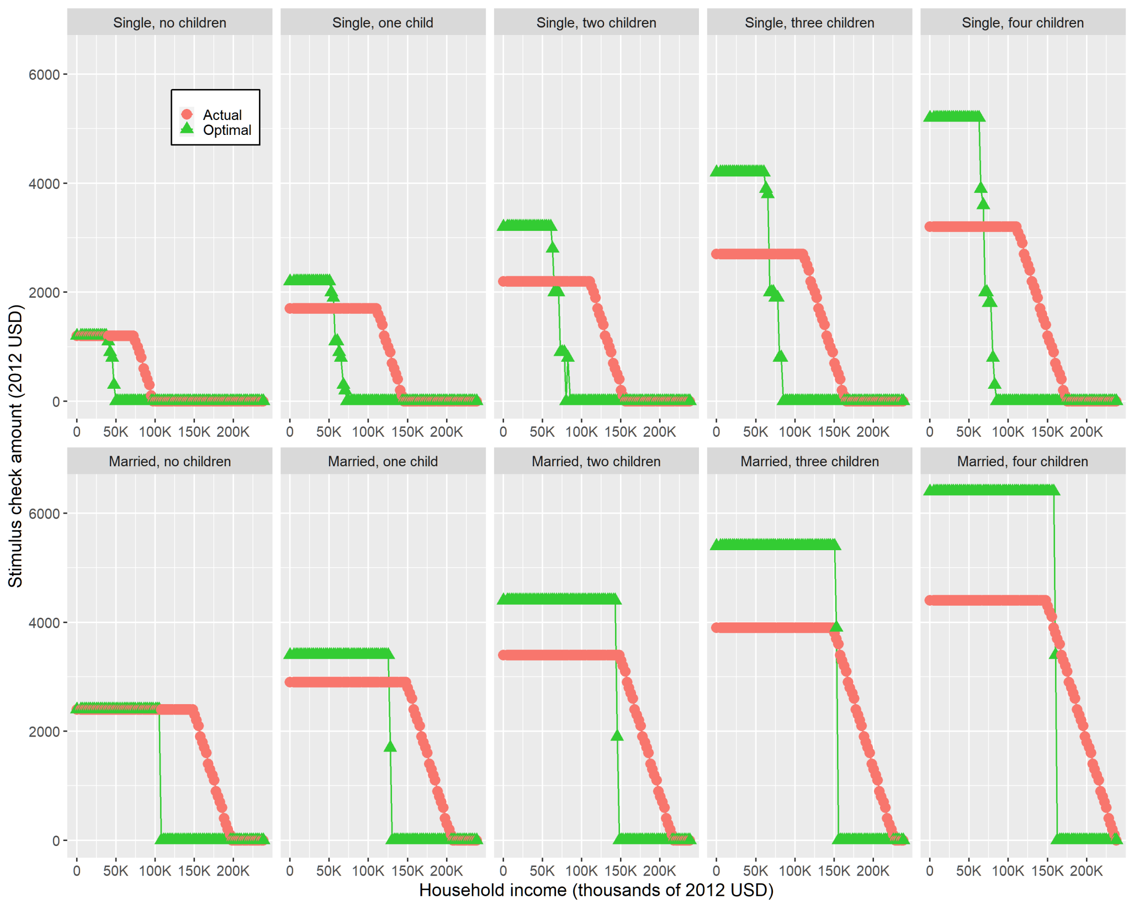
Notes: The table reports summary statistics for married household heads by income and number of children. For each type, the columns report the percentage of household heads with a college degree, average age of the household head, average and median savings, average and median marginal propensity to consume (approximated by the dollar change in consumption following the receipt of a $100 transfer), and the relative size of the population of that type.

Figure A.2: Actual vs. Optimal Allocation by Income and Family Status if Maximum Check is as in March 2020



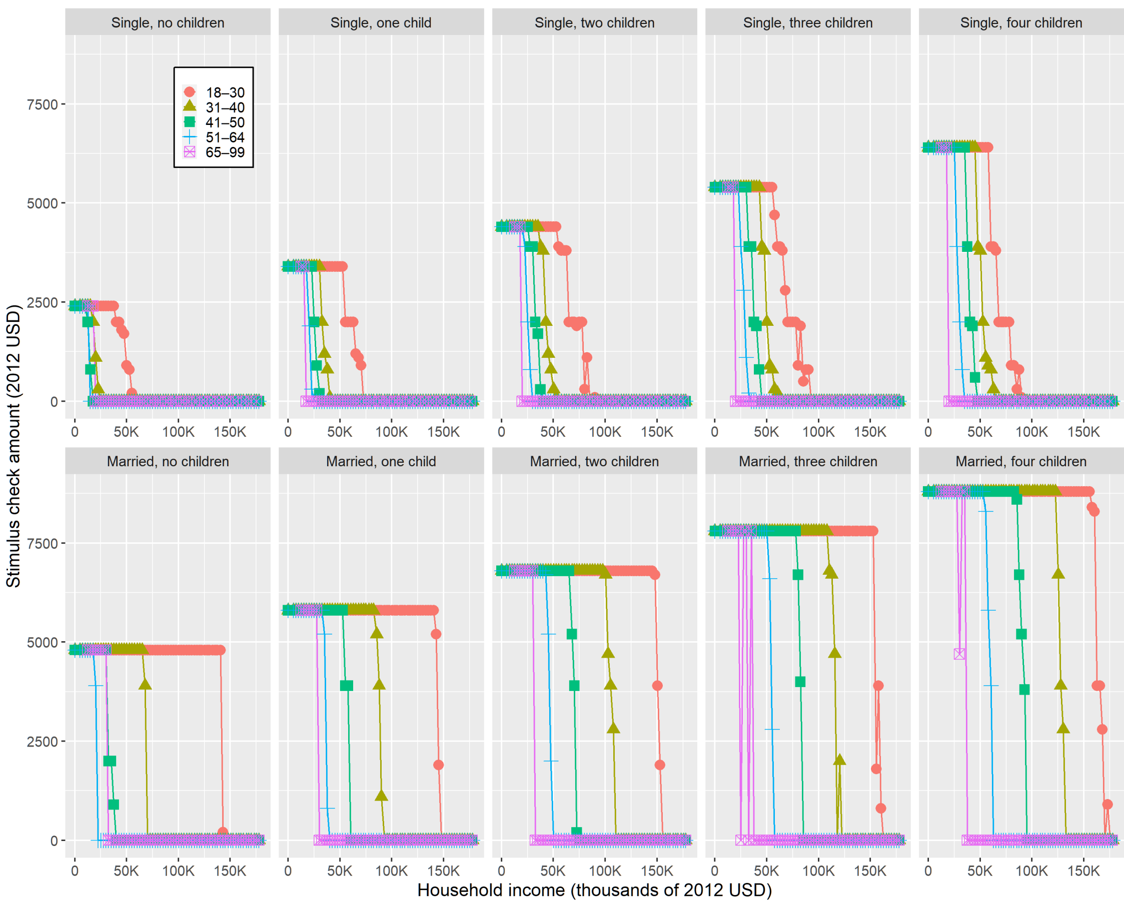
Notes: The figure shows the allocation of stimulus checks by household income and family status (marital status and number of children) for the March 2020 checks (red line) and for the optimal allocation (green line) of the same amount of money calculated under the assumption that the maximum check amount is $1,200 per adult and $500 per child.

Figure A.3: Actual vs. Optimal Allocation by Income and Family Status. Maximum Check Size $1,200 per adult and $1,000 per child



Notes: The figure shows the allocation of stimulus checks by household income and family status (marital status and number of children) for the March 2020 checks (red line) and for the optimal allocation (green line) of the same amount of money calculated under the assumption that the maximum check amount is $1,200 per adult and $1,000 per child.

Figure A.4: Optimal Allocation by Age, Income, and Family Status. Maximum Check Size $2,400 per adult and $1,000 per child



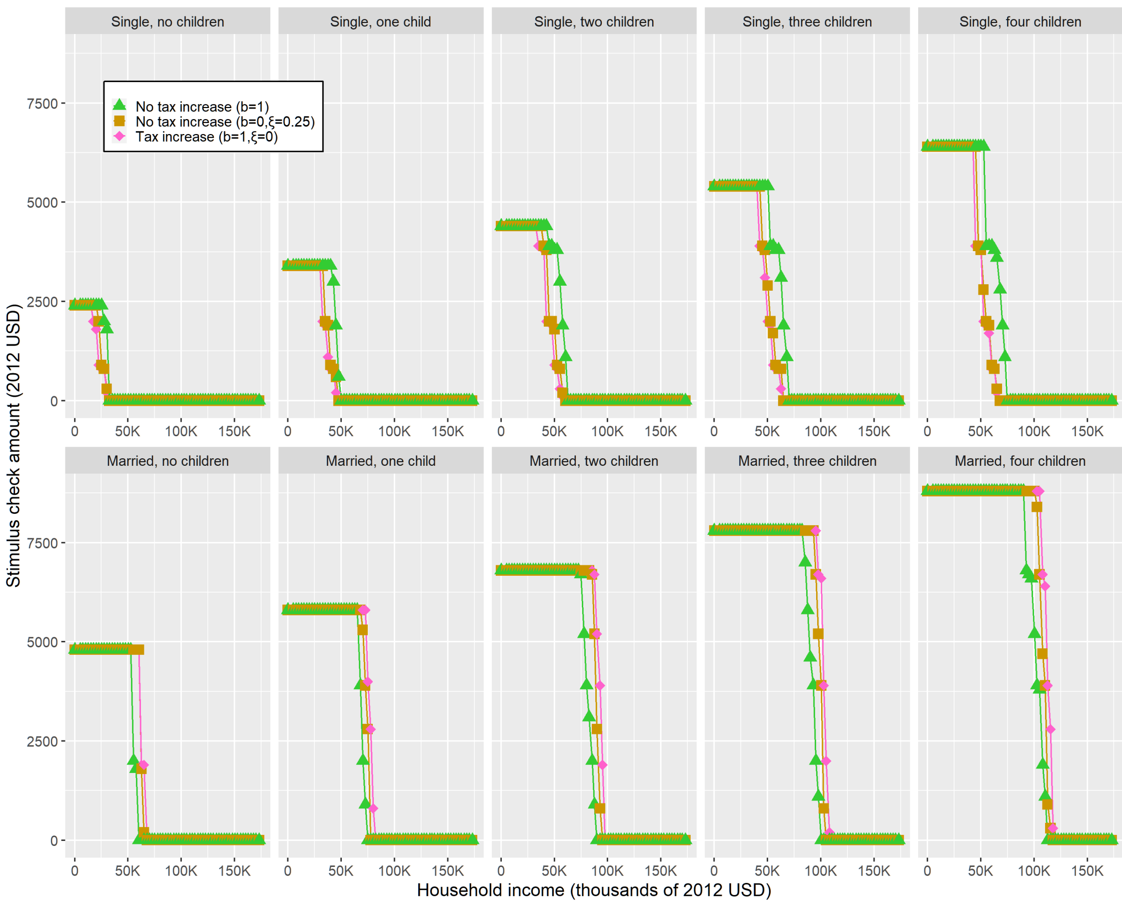
Notes: The figure shows the optimal allocation of stimulus by household income, family status (marital status and number of children), and 5 age-groups (18–30, 31–40, 41–50, 51–64, 65–99). The optimal policy is calculated using the same total budget as the actual policy but calculated under the assumption that the maximum check amount is $2,400 per adult and $1,000 per child.

Table A.9: Distribution of the Share of the Stimulus Check that is Consumed by the Household

		Percentiles of Distribution (%)						
	Allocation Constraint	P1	P10	P25	P50	P75	P90	P99
(1)	**Actual policy**	4.8	5.6	7.7	12.9	24.6	34.6	54.3
Vary income-eligibility criteria								
(2)	Adjust income-specific eligibility criteria	5.6	6.6	8.7	14.6	25.9	36.3	54.3
Vary income-eligibility criteria and max. check amount								
(3)	Double limit for each adult ($2,400)	19.1	20.4	23.1	27.6	33.0	42.2	47.6
(4)	Triple limit for each adult ($3,600)	23.1	24.1	26.4	30.2	35.6	42.3	47.1
(5)	Double limit for each child ($1,000)	14.1	15.1	17.5	23.6	31.8	41.1	48.8
(6)	Triple limit for each child ($1,500)	19.0	20.0	23.1	28.3	33.4	39.8	49.0
(7)	Double limit for each adult ($2,400) and child ($1,000)	21.6	22.3	24.2	29.7	35.5	40.3	44.4
(8)	Triple limit for each adult ($3,600) and child ($1,500)	23.7	25.0	26.8	30.2	37.8	42.7	47.4
(9)	$20,000 limit for each household	24.2	25.5	27.3	30.2	38.0	43.1	47.4
Vary inc.-elig. crit. and cond. on age of ref. person								
(10)	4 age groups (18–30, 31–40, 41–50, 51–64)	5.4	5.5	5.8	14.1	29.2	40.4	55.5
(11)	1-year age groups	5.2	5.5	6.0	14.0	29.0	43.3	56.8
Vary inc.-elig. crit. and max check amount, 4 age groups								
(12)	Double limit for each adult ($2,400)	22.6	24.1	27.3	32.6	37.8	44.0	48.1
(13)	Triple limit for each adult ($3,600)	26.6	27.5	30.3	33.9	41.6	45.5	52.6
(14)	Double limit for each child ($1,000)	15.6	17.7	21.4	28.4	36.1	45.9	51.7
(15)	Triple limit for each child ($1,500)	21.0	22.7	25.9	31.7	37.7	42.9	51.7
(16)	Double limit for each adult ($2,400) and child ($1,000)	24.7	25.7	28.7	33.6	38.9	44.3	48.3
(17)	Triple limit for each adult ($3,600) and child ($1,500)	27.0	28.3	30.4	34.1	42.4	46.1	53.9
(18)	$20,000 limit for each household	27.3	28.6	30.8	34.0	43.2	46.5	54.2

Notes: For each policy, the table reports the percentiles of the distribution of the share of the stimulus check that is consumed by the household, conditional on receiving checks. That is, it reports the distribution of $\frac{\Delta c(s)}{TR(s)}100$, where $TR(s) > 0$ is the stimulus check amount received by a household head of type s and $\Delta c(s)$ is the type-specific change in household consumption. The actual policy was income-tested and had a maximum check amount of $1,200 per adult and $500 per child.

Figure A.5: Optimal Allocation by Income and Family Status. Maximum Check Size $2,400 per adult and $1,000 per child. Sensitivity Analysis: Benchmark, Lower UI Benefits, Tax-financed



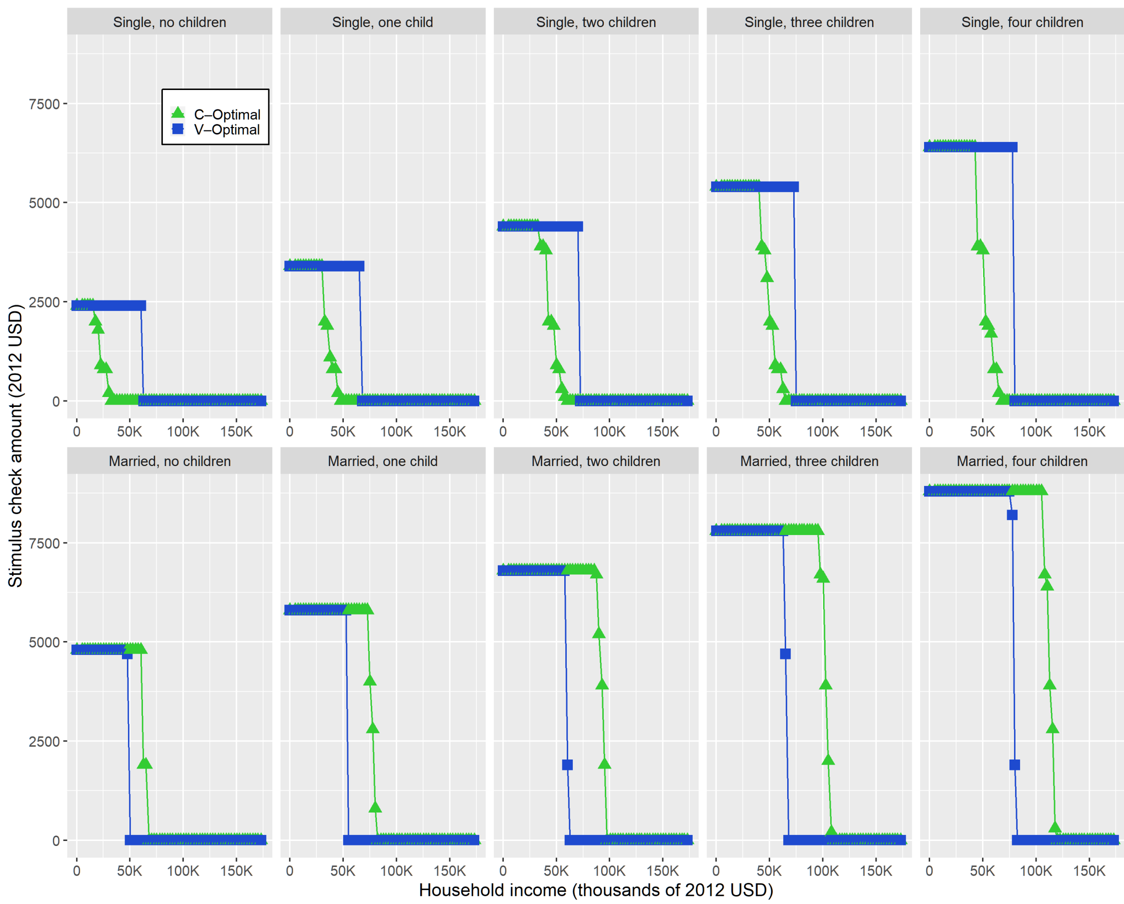
Notes: The figure depicts the allocation of stimulus checks by household income and family status (marital status and number of children) for the benchmark "manna-from-heaven" model (No tax increase, $b = 1$), "manna-from-heaven" model with lower UI benefits (No tax increase, $b = 0$, and $\xi = 0.25$), and tax-financed model (Tax increase, $b = 1$, and $\xi = 0$). The policies are derived using the same amount of money as the actual March 2020 policy but calculated under the assumption that the maximum check amount is $2,400 per adult and $1,000 per child.

Table A.10: Budget Savings (REV) and Change in the Share of the Aggregate Stimulus Check that is Consumed by the Households Relative to the Actual Policy. Optimal Policy Under Different Constraints: "Manna-from-heaven" (No tax increase) vs. Tax-Financed (Tax increase)

	Allocation Constraints	(1)	(2)	(3)	(4)
		REV (%)		$\left(\frac{\Delta(C)^{\text{act}}}{B^{\text{act}}}\frac{REV}{1-REV}\right)$ (p.p.)	
		No tax inc.	Tax inc.	No tax inc.	Tax inc.
Vary income-eligibility criteria					
(1)	Adjust income-specific eligibility criteria	0.8	0.6	0.1	0.2
Vary inc.-elig. crit. and maximum check amount					
(2)	Double limit for each adult ($2,400)	34.3	40.4	10.1	19.0
(3)	Triple limit for each adult ($3,600)	37.5	42.6	11.6	20.9
(4)	Double limit for each child ($1,000)	27.6	33.7	7.4	14.2
(5)	Triple limit for each child ($1,500)	33.6	38.8	9.8	17.8
(6)	Double limit for each adult ($2,400) and child ($1,000)	36.4	42.3	11.0	20.6
(7)	Triple limit for each adult ($3,600) and child ($1,500)	37.9	42.8	11.8	21.0
(8)	$20,000 limit for each household	38.2	42.9	11.9	21.1
Vary inc.-elig. crit. and condition on age of ref. person					
(9)	4 age groups (18–30, 31–40, 41–50, 51–64)	1.5	1.8	0.3	0.5
(10)	1-year age groups	2.0	2.2	0.4	0.6
Vary inc.-elig. crit. and max check amount, 4 age groups					
(11)	Double limit for each adult ($2,400)	41.8	48.0	13.9	25.9
(12)	Triple limit for each adult ($3,600)	44.2	49.8	15.3	27.8
(13)	Double limit for each child ($1,000)	35.5	41.6	10.6	20.0
(14)	Triple limit for each child ($1,500)	40.0	45.6	12.9	23.5
(15)	Double limit for each adult ($2,400) and child ($1,000)	43.0	49.1	14.6	27.1
(16)	Triple limit for each adult ($3,600) and child ($1,500)	44.3	49.8	15.4	27.8
(17)	$20,000 limit for each household	44.7	49.8	15.6	27.9

Notes: The actual policy was income-tested and had a maximum check amount of $1,200 per adult and $500 per child. 19.3 percent of the aggregate stimulus check is consumed by the households under the actual policy in the benchmark "manna-from-heaven" model. The corresponding statistic in the tax-financed model is 28.1 percent. The budget savings (i.e., REV numbers) reported in columns 1 ("manna-from-heaven") and 2 (tax-financed) specify the percentage by which the government can reduce total spending on stimulus checks and still achieve the same increase in aggregate consumption as under the actual policy. A value of 0 percent means the government cannot reduce spending at all if it wants to maintain the same increase in aggregate consumption as under the actual policy, whereas a value of 99 percent means the government can reduce total spending by 99 percent and still achieve the same increase in aggregate consumption as under the actual policy. Columns 3 ("manna-from-heaven") and 4 (tax-financed) report the percentage point change in the share of the aggregate stimulus check that is consumed by the households relative to the actual policy as given by $\left(\frac{\Delta(C)^{\text{act}}}{B^{\text{opt}}} - \frac{\Delta(C)^{\text{act}}}{B^{\text{act}}}\right)100 = \left(\frac{\Delta(C)^{\text{act}}}{B^{\text{act}}}\frac{REV}{1-REV}\right)100$, where $\Delta(C)^{\text{act}}$ is the change in aggregate consumption due to the stimulus checks under the actual policy, B^{act} is the aggregate amount spent on stimulus checks under the actual policy, and $B^{\text{opt}} = B^{\text{act}}(1 - REV)$.

Figure A.6: Optimal Allocation by Income and Family Status. Maximum Check Size $2,400 per adult and $1,000 per child. Alternative Planner Objective Functions: Maximize Expected Consumption in 2020 vs. Maximize Expected Lifetime Utility



Notes: The figure shows the allocation of stimulus checks by household income and family status (marital status and number of children) under two objectives for the planner: maximize expected consumption in 2020 (C-optimal) and maximize expected lifetime utility (V-optimal). The allocations are derived using the same total budget as the actual March 2020 policy but calculated under the assumption that the maximum check amount is $2,400 per adult and $1,000 per child.