[Working title:] The effectiveness of fiscal stimulus policies in a heterogeneous agent model

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Christopher D. Carroll[1] Edmund Crawley[2] Ivan Frankovic[3]
Håkon Tretvoll[4]

Using a heterogeneous agent model calibrated to match the initial MPC and subsequent spending dynamics over four years, we assess the effectiveness of three fiscal stimulus policies employed during recent recessions. Unemployment Insurance (UI) extensions are the clear 'bang for the buck' winner, especially when effectiveness is measured in utility terms. 'Stimulus checks' are second best, and have the advantage (over UI) of being scalable to any desired size. A temporary (two year) cut in the rate of wage taxation is considerably less effective than the other policies, and has negligible benefits in the version of our model without a multiplier.

The views expressed in this paper are those of the authors and do not necessarily represent those of the Federal Reserve Board, the Deutsche Bundesbank or the Eurosystem.

[1] Carrol: Department of Economics, Johns Hopkins University, ccarroll@jhu.edu, https://www.econ2.jhu.edu/people/ccarroll, and National Bureau of Economic Research.
[2] Crawley: Federal Reserve Board, edmund.s.crawley@frb.gov
[3] Frankovic: Deutsche Bundesbank, ivan.frankovic@bundesbank.de
[4] Tretvoll: Statistics Norway, Hakon.Tretvoll@ssb.no

1 Introduction

Fiscal policies that aim to boost consumer spending in recessions have been tried repeatedly in many countries in recent years. The nature of such policies has been quite varied, at least in part because traditional macroeconomic models were unable to provide clear guidance about which policies were likely to be most effective.

But new sources of microeconomic data, such as those from Scandinavian national registries, have recently enabled unprecedentedly fine-grained measurement of the dynamics of different types of consumers' spending patterns in response to income shocks. Simultaneously, advances in Heterogeneous Agent macro modeling have made it possible to construct structural models capable of matching these spending patterns with a reasonably high degree of fidelity. This combination of developments makes it possible, really for the first time, to conduct quantitatively credible structural analyses of the likely effectiveness of such policies.

Because spending dynamics in our model reflects the behavior of utility maximizing consumers, we are able to evaluate the policies not only by their effects on aggregate consumption expenditures, but also directly in terms of the impact on consumers' utility. The principal difference between the two metrics is that the utility-metric evaluation further increases the already considerable advantage that the UI extension exhibited in the consumption-boosting metric; the benefits of the UI extension are greater since the payments are specifically directed to a set of consumers who have high marginal utility.

Our model builds upon a now standard buffer-stock saving model of consumption to which we add features that we believe are important to capture the effects of fiscal stimulus policies. The most important of these is that consumers spend a fixed fraction of their labor income each period, which we call the 'splurge' factor. This spending occurs regardless of their current wealth and fits with the empirical evidence that even high liquid-wealth households have high initial MPCs. By contrast, in a standard buffer-stock model, high-wealth households smooth their consumption through transitory shocks and exhibit low MPCs. We use the model to aggregate consumer utility into a social welfare function. Because low-income consumers have high marginal utility, a standard aggregated welfare function would favor re-distributive policies even in the absence of a recession. To avoid weighting our analysis toward re-distributive policies, we normalize our social welfare criteria such that each policy, implemented in non-recessionary times, has zero welfare benefit to the social planner.

Recessions are unexpected (they are 'MIT shocks') and double the unemployment rate and the average length of unemployment spells. The end of the recession occurs as a Bernoulli process calibrated for an average length of recession of six quarters, leading to a return of the unemployment rate to normal levels over time. In an extension to the model, we allow for an aggregate demand multiplier effect during the recession, following the method introduced by Krueger, Mitman, and Perri (2016). With this extension, during the recession, any reduction in aggregate consumption below its steady-state level directly reduces aggregate productivity and thus labor income. Hence, any policy stimulating consumption will also boost incomes through this aggregate demand multiplier channel.

We parametrize the model in two steps. First, we estimate the extent to which consumers 'splurge' when receiving an income shock. We do so using Norwegian data because it offers the best available evidence on the time profile of the marginal propensity to consume (provided by Fagereng, Holm, and Natvik (2021)). Next we move on to the calibration of the full model on US data taking the splurge-factor as given. In the model, consumers are *ex-ante* heterogeneous: The population consists of types that differ according to their level of education (which affects measured facts about permanent income and income dynamics), and their pure time-discount factors, whose distribution is estimated separately for each education group to match the liquid wealth distribution within that group. In addition, agents experience different histories of idiosyncratic income shocks and periods of unemployment, so that within each type there is *ex-post* heterogeneity induced by different shock realizations.

Our results are intuitive.

In the economy with no multiplier during recessions, the benefit of a sustained wage tax cut is small. One reason there is any benefit at all is that, even for people who have not experienced an unemployment spell, the heightened risk of unemployment during a recession increases the marginal value of income because it helps them build the extra precautionary reserves they desire because of the extra risk. A second benefit is that, by the time a person does become unemployed, the temporary tax reduction will have allowed them to accumulate a larger buffer stock to sustain them during unemployment. Finally, in a recession there are more people who will have experienced a spell of unemployment, and the larger population of beneficiaries means that the consequences of the two prior mechanisms will be greater. But, quantitatively, all of these effects are small.

When a multiplier exists, the tax cut has more benefits, especially if the recession continues long enough that most of the spending induced by the tax cut happens while the economy is still in recession (and therefore the multiplier still is in force). The typical recession, however, ends long before our "sustained" tax cut is reversed, so even in an economy with a multiplier that is powerful during recessions, much of the tax cut's effect on consumption occurs when any multiplier that might have existed in a recession is no longer operative.

In contrast to the tax cut, both the UI extension and the stimulus checks concentrate most of the marginal increment to consumption at times when the multiplier (if it exists) is still powerful. Even leaving aside any multiplier effects, the stimulus checks have more value than the wage tax cut, because at least a portion of them go to people who are unemployed and therefore have both high MPC's and high marginal utilities (while wage tax cuts by definition go only to persons who are employed and earning wages). But the greater bang-for-the-buck of the UI extension reflects the fact that *all* of the recipients are in circumstances in which they have a high MPC and a high marginal utility.

We conclude that extended UI benefits should be the first weapon employed from this arsenal. But a disadvantage is that the total amount of stimulus that can be accomplished with this tool is constrained by the fact that only a limited number of people become unemployed. If more stimulation is called for than can be accomplished via UI extension, checks have the advantage that their effects scale almost linearly in the size of the stimulus. The wage tax cut is also in principle scalable, but it's effects are smaller than those of checks because its recipients have considerably lower MPCs and marginal utility than check and UI recipients. In the real world, a tax cut is also likely the least flexible of the three tools: UI benefits can be further extended, multiple rounds of checks can be sent; but multiple rounds of changes in wage tax rates would likely be administratively and politically more difficult to achieve.

The tools we are using could be reasonably easily modified to evaluate a number of other policies. For example, in the COVID recession, not only was the duration of UI benefits extended, those benefits were supplemented by very substantial extra payments to every UI recipient. We did not calibrate the model to match this particular policy, but the framework could easily accommodate such an analysis.

2 Model

In this section we describe our heterogeneous agent model featuring consumers that differ according to their level of education and their subjective discount factors. We first describe the problem faced by these consumers given the income process they face with permanent and transitory shocks as well as shocks to their employment status. Then we describe how we model the arrival of a recession and the policies that we study as potential responses. Finally, we discuss an extension of the model where we include aggregate demand effects that induce a feedback effect from aggregate consumption to income and hence, amplify the impact of a recession when it occurs.

2.1 The Consumer Problem

A consumer i is characterized by the level of education $e(i)$ and their subjective discount factor β_i. The consumer faces a stochastic income stream, $y_{i,t}$, and chooses to consume some of that income when it arrives (the 'splurge') and then to optimize consumption with what is left over. Therefore, consumption each period for consumer i can be written:

$$c_{i,t} = c_{sp,i,t} + c_{opt,i,t}, \tag{1}$$

where $c_{i,t}$ is total consumption, $c_{sp,i,t}$ is the splurge consumption and $c_{opt,i,t}$ is the consumer's optimal choice of consumption after splurging. Splurge consumption is simply a fraction of income:

$$c_{sp,i,t} = \varsigma y_{i,t}, \tag{2}$$

while the optimized portion of consumption is chosen to maximize lifetime expected consumption:

$$\sum_{t=0}^{\infty} \beta_i^t (1-D)^t \mathbb{E}_0 u(c_{opt,i,t}). \tag{3}$$

We use a standard CRRA utility function, so $u(c) = c^{1-\gamma}/(1-\gamma)$ for $\gamma \neq 1$ and $u(c) = \log(c)$ for $\gamma = 1$, where γ is the coefficient of relative risk aversion. The optimization is subject to the budget constraint given existing market resources $m_{i,t}$ and income state, and a no-borrowing constraint:

$$a_{i,t} = m_{i,t} - c_{i,t} \tag{4}$$

$$m_{i,t+1} = (R/\hat{\Gamma}_{i,t+1})a_{i,t} + y_{i,t+1} \tag{5}$$

$$a_{i,t} \geq 0, \tag{6}$$

where R is the gross interest rate on accumulated assets $a_{i,t}$, and $\hat{\Gamma}_{i,t+1}$ is the realized growth rate of permanent income from period t to $t+1$ discussed further below.

The Income Process Consumers face a stochastic income process with permanent and transitory shocks to income, along with unemployment shocks. In normal times, consumers receive unemployment benefits for two quarters before they run out. Permanent income in the model is described by the following equation:

$$p_{i,t+1} = \psi_{i,t+1}\Gamma_{e(i)}p_{i,t}, \tag{7}$$

where $\psi_{i,t+1}$ is the shock to permanent income and $\Gamma_{e(i)}$ is the average growth rate of income for education group $e(i)$ of the consumer.[1] The realized growth rate of permanent income for consumer i is thus $\hat{\Gamma}_{i,t+1} = \psi_{i,t+1}\Gamma_{e(i)}$. The shock to permanent income is normally distributed with variance σ^2_ψ.

The actual income a consumer receives will be subject to their employment status as well as transitory shocks, $\xi_{i,t}$:

$$y_{i,t} = \begin{cases} \xi_{i,t}p_{i,t}, & \text{if employed} \\ \rho_b p_{i,t}, & \text{if unemployed with benefits} \\ \rho_{nb} p_{i,t}, & \text{if unemployed without benefits} \end{cases} \tag{8}$$

where $\xi_{i,t}$ is normally distributed with variance σ^2_ξ, and ρ_b and ρ_{nb} are the replacement rates for an unemployed consumer that is or is not eligible for unemployment benefits, respectively.

A Markov transition matrix Π generates the unemployment dynamics where the number of states is given by 2 plus the number of periods that unemployment benefits last. An employed consumer can continue being employed, or move to being unemployed with benefits.[2] The first row of Π is thus given by $[1-\pi^{e(i)}_{eu}, \pi^{e(i)}_{eu}, \mathbf{0}]$ where $\pi^{e(i)}_{eu}$ indicates the probability of becoming unemployed from an employed state and $\mathbf{0}$ is a vector of zeros of the appropriate length. Note that we allow this probability to depend of the education group of consumer i and will calibrate this parameter to match the average unemployment rate for each education group. Upon becoming unemployed, all consumers face a probability π_{ue} of transitioning back into employment and a probability $1-\pi_{ue}$ of remaining unemployed with one less period of remaining benefits. After

[1] We model the rate of growth for permanent income for each education group and keep this rate unchanged during periods of unemployment. There is evidence, e.g. in Davis and Wachter (2011), that unemployment, especially in a recession, leads to permanent income loss. This could be added to the model—see Carroll, Crawley, Slacalek, and White (2020) for an example—but is not material to the evaluation of stimulus payments here so we have chosen to keep the model simple.

[2] That is, as long as we assume that there is at least one period of unemployment benefits.

transitioning into the unemployment state where the consumer is no longer eligible for benefits, the consumer will remain in this state until they become employed again. The probability of becoming employed is thus the same for each of the unemployment states and education groups.

2.2 MIT Shocks

We model the arrival of a recession, and the government policy response to it, as an unpredictable event—an MIT shock. We have four types of shock representing a recession and the three different policy responses we consider. The policy responses are usually modeled as in addition to the recession, but we also consider a counterfactual in which the policy response occurs without a recession in order to understand the welfare effects of the policy.

Recession At the onset of a recession, several changes occur. First, the unemployment rate for each education group doubles. Those who would have been unemployed remain so, and an additional number of consumers move from employment to unemployment. Second, conditional on the recession continuing, the employment transition matrix is adjusted so that unemployment remains at the new high level, and the expected length of time for an unemployment spell increases. In our baseline calibration, discussed in detail in section 3.3, we set the expected length of an unemployment spell to one and a half quarters in normal times, and this increases to four quarters in a recession. Third, the end of the recession occurs as a Bernoulli process calibrated for an average length of recession of six quarters. Finally, at the end of a recession, the employment transition matrix switches back to its original probabilities and as a result the unemployment rate tends down over time back to its steady-state level.

Stimulus Check In this policy response, the government sends money to every consumer that directly increases their market resources. The checks are means-tested depending on permanent income. A check for $1,200 is sent to every consumer with permanent income less than $100,000 and this amount is then linearly reduced to zero for consumers with a permanent income greater than $150,000.

Extended Unemployment Benefits In this policy response, unemployment benefits are extended from 2 quarters to 4 quarters. That is, those who become unemployed at the start of the pandemic, or who were already unemployed, will receive unemployment benefits for up to four quarters (including quarters leading up to the recession). Those who become unemployed one quarter into the recession will receive up to three quarters of unemployment benefits. These extended unemployment benefits will occur regardless of whether the recession ends, and no further extensions are granted if the recession continues.

Payroll Tax Cut In this policy response, employee-side payroll taxes are reduced for a period of 8 quarters. During this period, which continues irrespective of whether the recession continues or ends, employed consumers' income is increased by 2 percent. The income of unemployed consumers is unchanged by this policy. Consumers also believe there is a fifty-fifty chance that the tax cut will be extended by another two years if the recession has not ended when the first tax cut expires.[3]

2.3 Aggregate Demand Effects

Our baseline model is a partial equilibrium model that does not include any feedback from aggregate consumption to income. In an extension to the model, we add aggregate demand effects during the recession. With this extension, any changes in consumption away from the steady state consumption level feed back into labor income. Aggregate demand effects are evaluated as:

$$AD(C_t) = \begin{cases} \left(\frac{C_t}{\tilde{C}}\right)^{\kappa}, & \text{if in a recession} \\ 1, & \text{otherwise} \end{cases} \tag{9}$$

where $\tilde{C}$ is the level of consumption in steady state. Idiosyncratic income in the aggregate demand extension is multiplied by $AD(C_t)$:

$$y_{AD,i,t} = AD(C_t) y_{i,t} \tag{10}$$

The series $y_{AD,i,t}$ is then used for each consumers's budget constraint.

3 Parameterizing the model

This section describes how we set the various parameters of the model. First, we estimate the extent to which consumers "splurge" when receiving an income shock. We do so using Norwegian data to be consistent with the best available evidence on the time profile of the marginal propensity to consume provided by Fagereng, Holm, and Natvik (2021). For this exercise we use a version of the model calibrated to the Norwegian economy.

Second, we move on to the calibration of the full model on US data taking the splurge-factor as given. We then have different types of agents that differ according to their level of education and their subjective discount factors. Some parameters are calibrated equally for all of these different types, while some parameters are calibrated separately for each education group. Finally, a distribution of subjective discount factors is estimated separately for each education group to match features of the liquid wealth distribution within that group.

3.1 Estimation of the "splurge" factor

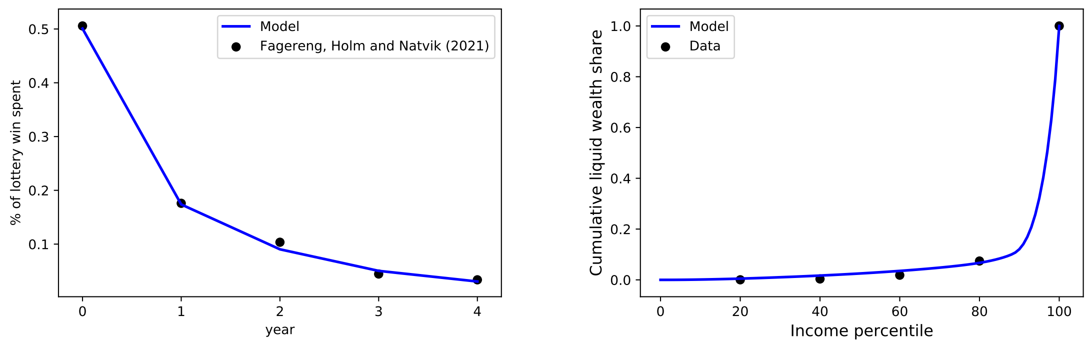
We define splurging as the free spending of current labor income without concern for intertemporal maximization of utility. As we will show in this section, the splurge allows

[3]The belief that the payroll tax cut may be extended makes little difference to the results.

us to capture the shorter and longer term response of consumption to income shocks, especially for consumers with significant liquid wealth, that a standard buffer-stock model cannot. Specifically, we show that our model can account well for the results of Fagereng, Holm, and Natvik (2021), who study the impact of lottery winnings in Norway on consumption using millions of datapoints from the Norwegian population registry. To do so we calibrate our model to reflect the Norwegian economy and estimate the splurge factor, as well as the distribution of discount factors in the population to match two empirical moments.

First, we take from Fagereng, Holm, and Natvik (2021) the marginal propensity to consume out of a one-period income shock. We not only target the initial response of consumption to the income shock, but also the subsequent effect on consumption in years one through four after the shock. The share of lottery winnings expended at different time horizons, as found in Fagereng, Holm, and Natvik (2021), are plotted in figure 1a. Note that the first year expenditure, shown in figure 1a to be around 0.5, is not equivalent to the initial annual MPC because the lottery winnings may occur toward the end of the year. Fagereng, Holm, and Natvik (2021) estimate their data points to an initial annual MPC of 0.63.

Second, we match the steady-state distribution of liquid wealth in the model to its empirical counterpart. Due to the lack of data on the liquid wealth distribution in Norway, we use the corresponding data from the US - assuming that liquid wealth inequality is comparable across these countries.[4] Specifically, we impose as targets the cumulative liquid wealth share for the entire population at the 20th, 40th, 60th and 80th income percentile, which in data from the Survey of Consumer Finance in 2004 equal 0.03 percent, 0.35 percent, 1.84 percent, and 7.42 percent.[5] Hence, 92.6 percent of the total liquid wealth is held by the top income quintile. The data is plotted in figure 1b.



(a) Share of lottery win spent

(b) Distribution of liquid wealth

Figure 1 Targets and model moments from the estimation

[4]Data from the Norwegian tax registry contains information on liquid assets, but not liquid debt. Only total debt is reported, and this is mainly mortgage debt. Therefore, we cannot construct liquid wealth as in for example Kaplan and Violante (2014).

[5]See section 3.2 for details.

For this estimation exercise, the remaining model parameters are calibrated to reflect the Norwegian economy. Specifically, we set the real interest rate to 2 percent annually and the unemployment rate to 4.4 percent, in line with Aursland, Frankovic, Kanik, and Saxegaard (2020). The quarterly probability to survive is calibrated to $1 - 1/160$, reflecting an expected working life of 40 years. Aggregate productivity growth is set to 1 percent annually following Kravik and Mimir (2019). The unemployment net replacement rate is calibrated to 60 percent following OECD (2020). Finally, we set the real interest rate on liquid debt to 13.6 percent and the borrowing constraint to 80 percent of permanent income following data from the Norwegian debt registry Gjeldsregistret (2022).[6]

Estimates of the standard deviations of the permanent and transitory shocks are taken from Crawley, Holm, and Tretvoll (2022) who estimate an income process on administrative data for Norwegian males from 1971 to 2014. The estimated annual variances for the permanent and transitory shocks are 0.004 and 0.033, respectively.[7] As in Carroll, Crawley, Slacalek, Tokuoka, and White (2020), these are converted to quarterly values by multiplying the permanent and transitory shock variances by 1/4 and 4, respectively. Thus, we obtain quarterly standard deviations of $\sigma_\psi = 0.0316$ and $\sigma_\xi = 0.363$.

Using the calibrated model, unexpected lottery winnings are simulated and the share of the lottery spent in each year is calculated. Specifically, each simulated agent receives a lottery win in a random quarter of the first year of the simulation. The size of the lottery win is itself random and spans the range of lottery sizes found in Fagereng, Holm, and Natvik (2021). The estimation procedure minimizes the distance between the target and model moments by selecting the splurge factor and the distribution of discount factors in the population, where the latter are assumed to be uniformly distributed in the range $[\beta - \nabla, \beta + \nabla]$. We approximate the uniform distribution of discount factors with a discrete approximation and let the population consist of 7 different types.

The estimation yields a splurge factor of 0.314 and a distribution of discount factors described by $\beta = 0.989$ and a $\nabla = 0.0179$. Given these estimated parameters and the remaining calibrated ones, the model is able to replicate the time path of consumption in response to a lottery win from Fagereng, Holm, and Natvik (2021) and the targeted distribution of liquid wealth very well, see figure 1.

3.2 Data on permanent income, liquid wealth and education

Before we move on to the parameterization of the full model for the U.S., we describe in detail the data that we use to get measures of permanent income, liquid wealth and the division of households into educational groups. We use data on the distribution of

[6] Specifically, we determine the average volume-weighted interest rate on liquid debt, which consists of consumer loans, credit and payment card debt and all other unsecured debt. To determine the borrowing limit on liquid debt we determine the ratio between total credit card limit divided by total wage income in Norway. We use data from December 2019. Note that although these data let us pin down aggregate quantities, they do not solve the issue referred to in footnote 4, since we cannot link them to the tax registry at the individual level.

[7] As shown in Crawley, Holm, and Tretvoll (2022), an income process of the form that we use here should be estimated using moments in levels not differences. Hence, we take the numbers from column 3 of their Table 4.

liquid wealth from the 2004 wave of the Survey of Consumer Finance (SCF). We restrict our attention to households where the the head of the household is of working age which we define to be in the range from 25 to 62. The SCF-variable “normal annual income” is our measure of the household’s permanent income, and to exclude outliers we drop the observations that make up the bottom 5 percent of the distribution of this variable. The smallest value of permanent income for households in our sample is thus $16,708.

Liquid wealth is defined as in Kaplan and Violante (2014) and consists of cash, money market, checking, savings and call accounts, directly held mutual funds, stocks and bonds. We subtract off liquid debt which is the revolving debt on credit card balances. Note that the SCF does not contain information on cash holdings, so this is imputed with the procedure described in Appendix B.1 of Kaplan and Violante (2014) which also describes the credit card balances that are considered part of liquid debt. We drop any households that have negative liquid wealth.

Households are classified into three educational groups. The first group “Dropout” applies to households where the head of household has not obtained a high school diploma, the second group “Highschool” includes heads of households that have a high school diploma and those who in addition have some years of college education without obtaining a bachelor’s degree, and the third group “College” consists of heads of households who have obtained a bachelor’s degree or higher. With this classification of the education groups, the “Dropout” group makes up 9.3 percent of the population, the “Highschool” group 52.7 percent, and the “College” group 38.0 percent.

With our sample selection criteria we are left with a sample representing about 61.3 million US households.

3.3 Calibrated parameters

With households divided into the three education groups, some parameters, presented in Panel A of table 1, are calibrated equally across all groups, while other parameters, presented in Panel B of table 1, are education-specific. Households are also assumed to be ex-ante heterogeneous in their subjective discount factors in addition to their level of education. For completeness, Panel C of table 1 summarizes the parameters describing how we model a recession and the three policies we consider as potential responses to a recession.

All households are assumed to have log preferences over consumption, so the coefficient of relative risk aversion is set to $\gamma = 1$. We also assume that all households have the same propensity to splurge out of transitory income gains and set $\varsigma = 0.314$, the value estimated in section 3.1. However, each education group is divided into types that differ in their subjective discount factors. The distributions of discount factors for each education group are estimated to fit the distribution of liquid wealth within that group, and this is described in detail in section 3.4. Regardless of type, households face a constant survival probability each quarter. This is set to $1 - 1/160$, reflecting an expected working life of 40 years. The real interest rate on households’ savings is set to 1 percent per quarter.

Panel (A) Parameters that apply to all types		
Parameter	Notation	Value
Risk aversion	γ	1.0
Splurge	ς	0.314
Survival probability, quarterly	$1 - D$	0.994
Risk free interest rate, quarterly (gross)	R	1.01
Standard deviation of transitory shock	σ_ξ	0.346
Standard deviation of permanent shock	σ_ψ	0.0548
Unemployment benefits replacement rate (share of PI)	ρ_b	0.7
Unemployment income w/o benefits (share of PI)	ρ_{nb}	0.5
Avg. duration of unemp. benefits in normal times (quarters)		2
Avg. duration of unemp. spell in normal times (quarters)		1.5
Probability of leaving unemployment	π_{ue}	0.667
Consumption elasticity of aggregate demand effect	κ	0.5

Panel (B) Parameters calibrated for each education group			
	Dropout	Highschool	College
Percent of population	9.3	52.7	38.0
Avg. quarterly PI of "newborn" agent ($1000)	6.2	11.1	14.5
Std. dev. of log(PI) of "newborn" agent	0.32	0.42	0.53
Avg. quarterly gross growth rate of PI (Γ_e)	1.0036	1.0045	1.0049
Unemployment rate in normal times (percent)	8.5	4.4	2.7
Probability of entering unemployment (π_{eu}^e, percent)	6.2	3.1	1.8

Panel (C) Parameters describing policy experiments	
Parameter	Value
Change in unemployment rates in a recession	$\times 2$
Expected unemployment spell in a recession	4 quarters
Average length of recession	6 quarters
Size of stimulus check	$1,200
PI threshold for reducing check size	$100,000
PI threshold for not receiving check	$150,000
Extended unemployment benefits	4 quarters
Length of payroll tax cut	8 quarters
Income increase from payroll tax cut	2 percent
Belief (probability) that tax cut is extended	50 percent

Table 1 Panel (A) shows parameters calibrated the same for all types. Panel (B) shows parameters calibrated for each education group. Panel (C) shows the numbers describing how we model a recession and the three policies we consider. "PI" refers to permanent income.

When consumers are born, they receive an initial level of permanent income. This initial value is drawn from a log-normal distribution which depends on the education level the household is born with. For each education group, the parameters of the distribution are determined by the mean and standard deviation of log-permanent income for households of age 25 in that education group in the SCF 2004. For the "Dropout" group the mean initial value of quarterly permanent income is \$6,200, for the "Highschool" group it is \$11,100, and for the "College" group it is \$14,500. The standard deviations of the log-normal distributions for each group are respectively 0.32, 0.42, and 0.53.

While households remain employed, their income is subject to both permanent and transitory idiosyncratic shocks. These shocks are distributed equally for the three education groups. The standard deviations of these shocks are taken from Carroll, Crawley, Slacalek, Tokuoka, and White (2020) who set the standard deviations of the transitory and permanent shocks to $\sigma_\xi = 0.346$ and $\sigma_\psi = 0.0548$, respectively. Permanent income also grows on average with a growth rate $\Gamma_{e(i)}$ that depends on the level of education. These average growth rates are based on numbers from Carroll, Crawley, Slacalek, and White (2020) who construct age-dependent expected permanent income growth factors using numbers from Cagetti (2003) and fit the age-dependent numbers to their life-cycle model. We construct the quarterly growth rates of permanent income in our perpetual youth model by taking the average of the age-dependent growth rates during a household's working life. The average gross quarterly growth rates that we obtain for the three education groups are then $\Gamma_d = 1.0036$, $\Gamma_h = 1.0045$, and $\Gamma_c = 1.0049$.

Consumers also face the risk of becoming unemployed, and will then have access to unemployment benefits for a certain period. The parameters describing the unemployment benefits in normal times are based on the work of Rothstein and Valletta (2017) who study the effects on household income of unemployment and of running out of eligibility of benefits. The unemployment benefits replacement rate is thus set to $\rho_b = 0.7$ for all households, and when benefits run out, the unemployment replacement rate without any benefits is set to $\rho_{nb} = 0.5$. These replacement rates are set as a share of the households' permanent income, and are based on the inital drop in income upon entering an unemployment spell presented in Figure 3 in Rothstein and Valletta (2017).[8] The duration of unemployment benefits in normal times is set to 2 quarters, so that our Markov transition matrix Π has 4 states. This corresponds to the mean duration of unemployment benefits across US states from 2004 to mid-2008 of 26 weeks reported by Rothstein and Valletta (2017).

The probability of transitioning out of unemployment is the same for all households, and is set to $\pi_{ue} = 2/3$. This implies that the average duration of an unemployment spell in normal times is 1.5 quarters which is also the value used in Carroll, Crawley, Slacalek, and White (2020). However, the different education groups do differ in the probability

[8] See the lines for their UI exhaustee sample including and excluding UI income. Rothstein and Valletta (2017) also point out that "UI benefits replace about 40 percent of the lost earnings on average" (page 894). For a household with two income earners with equal income, this would mean that income drops to 70 percent when one earner becomes unemployed and to 50 percent when benefits run out. In this paper we ignore several of the channels studied by Rothstein and Valletta (2017) such as within household insurance and other social programs that can provide income even after UI benefits have run out.

of transitioning into unemployment in the first place. These probabilities are set to match the average US unemployment rate by education group in 2004.[9] This average was 8.5 percent for the "Dropout" group, 4.4 percent for the "Highschool" group, and 2.7 percent for the "College" group. This implies that the probability of transitioning into unemployment in normal times are $\pi_{eu}^{d} = 6.2$ percent, $\pi_{eu}^{h} = 3.1$ percent and $\pi_{eu}^{c} = 1.8$ percent.

Finally, the strength of the aggregate demand effect in recessions is determined by the consumption elasticity of productivity. This is set to $\kappa = 0.5$

3.4 Estimating the discount factor distributions

Discount factor distributions are estimated separately for each education group to match the distribution of liquid wealth for households in that group. To do so, we let each education group consist of different types that differ in their subjective discount factor, β. The discount factors within each group $e \in \{d, h, c\}$ are assumed to be uniformly distributed in the range $[\beta_e - \nabla_e, \beta_e + \nabla_e]$. The parameters β_e and ∇_e are chosen for each group separately to match the median liquid wealth to permanent income ratio and the 20^{th}, 40^{th}, 60^{th}, and 80^{th} percentile points of the Lorenz curve for liquid wealth for that group. We approximate the uniform distribution of discount factors with a discrete approximation and let each education group consist of 7 different types.

Panel A of Table 2 shows the estimated values of (β_e, ∇_e) for each education group. The panel also shows the minimum and maximum values of the discount factors we actually use in the model when we use a discrete approximation with 7 values to the uniform distribution of discount factors. As is clear from the maximum values, all types in the model have a discount factor below 1.[10]

The minimum values for the discount factors on the other hand, indicate that some of the household types in the model are very impatient, particularly in the Dropout group. This reflects that liquid wealth is very concentrated within that education group with the top quintile holding 96.4 percent of within-group liquid wealth. Such low estimates for discount factors are in line with those obtained in the literature on payday lending.[11]

Panel B of Tabel 2 and Figure 2 show the estimation targets and how well the model manages to fit them. The bottom-right quadrant of Figure 2 also shows how well the model fits the liquid wealth distribution for the population as a whole. The fit is quite close, but the model does produce a population where liquid wealth is slightly more concentrated than in the data.

Finally, panel C of Table 2 shows that the estimated model produces a wealth distribution across the three education groups that is fairly close to the one in the data.

[9] Source: Statista.com.

[10] This is not actually the relevant constraint on the maximum discount factors. Instead we ensure that the Growth Impatience Condition (GIC) discussed in Carroll (2022), is always satisfied. We do so by replacing the highest value of β for each education group with $0.999 \cdot \beta^*$, where β^* is the discount factor where the GIC would hold with equality.

[11] See for example Skiba and Tobacman (2008) who estimate two-week discount rates of 21 percent and Allcott, Kim, Taubinsky, and Zinman (2021) who estimate an initial period discount factor between 0.74 and 0.83 in a model where a period is eight weeks long. Both of these papers use quasi-hyperbolic preferences, so the estimates are not directly comparable to parameters in our model. Nevertheless, they support the point that very high discount rates are necessary to model the part of the population that takes out payday loans at very high interest rates.

Panel (A) Estimated discount factor distributions

	Dropout	Highschool	College
(β_e, ∇_e)	(0.853, 0.165)	(0.956, 0.045)	(0.989,0.008)
(Min, max) in approximation	(0.712, 0.993)	(0.918, 0.994)	(0.982, 0.994)

Panel (B) Estimation targets

	Dropout	Highschool	College
Median LW/PI (data)	4.64	30.2	112.8
Median LW/PI (model)	4.64	30.2	113.5

Panel (C) Non-targeted moments

	Dropout	Highschool	College	Population
Percent of total wealth (data)	0.8	17.9	81.2	100
Percent of total wealth (model)	1.4	23.8	74.9	100
Avg. annual MPC (model, incl. splurge)	0.87	0.77	0.54	0.69

Table 2 Estimated discount factor distributions, estimation targets and non-targeted moments.

The panel also reports the average marginal propensity to consume within a year after an income shock for each education group. This measure of the annual MPC takes into account the initial splurge factor when an income shock is first received as well as the decisions to consume out of additional income over four quarters after the shock. The average annual MPC for the population as a whole is 0.69 in the model which is slightly higher than the 0.63 estimated for Norway by Fagereng, Holm, and Natvik (2021).

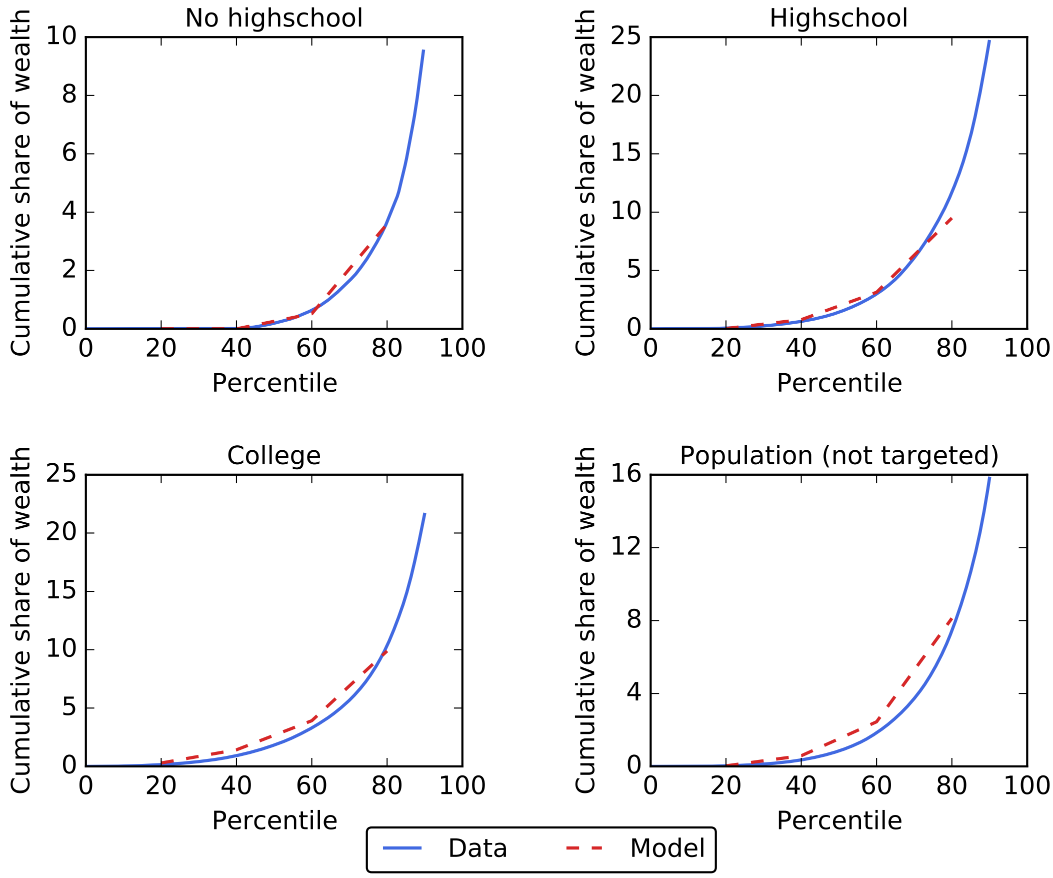


Figure 2 Distributions of liquid wealth within each educational group and for the whole population from the 2004 Survey of Consumer Finance and from the estimated model.

4 Comparing fiscal stimulus policies

In this section we present our results where we compare three policies to provide fiscal stimulus in our calibrated model. The policies we compare are a means tested stimulus check, an extension of unemployment benefits, and a payroll tax cut. Each policy is implemented at the start of a recession, and we compare results both with and without aggregate demand effects being active during the recession. First, we present impulse responses of aggregate income and consumption after the implementation of each policy. Then we compare the policies in terms of their cummulative multipliers and in terms of their effect on a welfare measure that we introduce. Finally, based on these comparisons, we can rank the three policies.

4.1 Impulse responses

The impulse responses that we present for each stimulus policy are constructed as follows:

- A recession hits in quarter 1.
- We compute the subsequent path for the economy without any policy introduced in response to the recession.
- We also compute the subsequent path for the economy with a given policy introduced at the onset of the recession in quarter 1.
- The impulse responses we present are then the *difference* between these two paths for the economy and show the effect of a policy relative to a case where no policy was implemented.
- The solid lines show these impulse responses for an economy where the aggregate demand effects described in section 2.3 are not active, and the dashed lines show impulse repsonses for an economy where the aggregate demand effects are active during the recession.
- Red lines refer to aggregate labor and transfer income, and blue lines refer to consumption.

Note that all graphs show the response of income and consumption for an average recession. Specifically, we simulate recessions lasting from only one quarter up to 20 quarters. We then take the sum of the results across all recessions lengths weighted by the probability of this recession length occuring (given our assumption of an average recession length of six quaters).

4.1.1 Stimulus check

Figure 3 shows the impulse response of income and consumption when stimulus checks are issued in the first quarter of a recession. In the model without a multiplier, the stimulus checks account for over 5 percent of the first quarter's income. In the following quarters there are no further stimulus payments and income remains the same as it would have done without the stimulus check policy. Consumption is about 3 percent higher in the first quarter which includes the splurge response to the stimulus check. Consumption then drops to well below one percent above the counterfactual and the remainder of the stimulus check money is then spent over the next few years. In the model with aggregate demand effects, income in the first quarter is almost 8 percent higher than the counterfactual as the extra spending feeds into higher incomes. Consumption in this model jumps to a higher level than without aggregate demand effects and comes down more slowly as the feedback effects from consumption to income dampen the speed with which income—and hence the splurge—return to zero. After a couple of years, when the recession is most likely over and aggregate demand effects are no longer in place, income is close to where it would be without the stimulus check policy although consumption remains somewhat elevated.

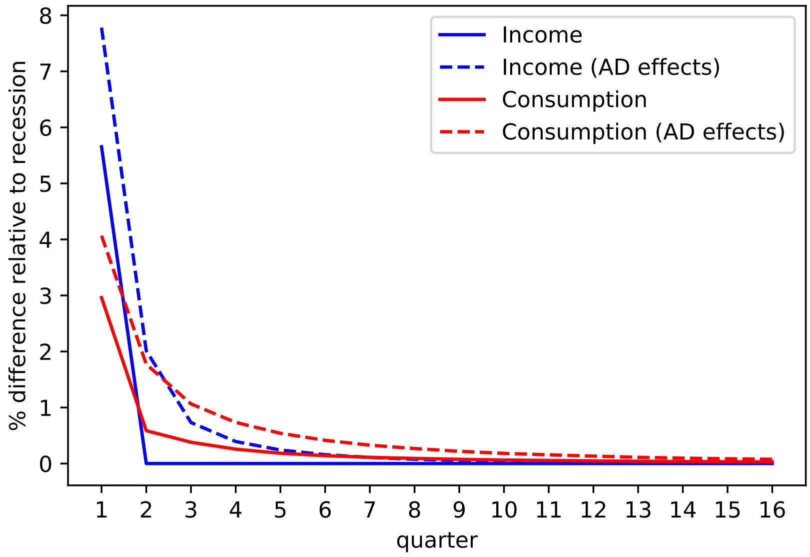


Figure 3 Impulse responses of aggregate income and consumption to a **stimulus check** during recesssions with and without aggregate demand effects

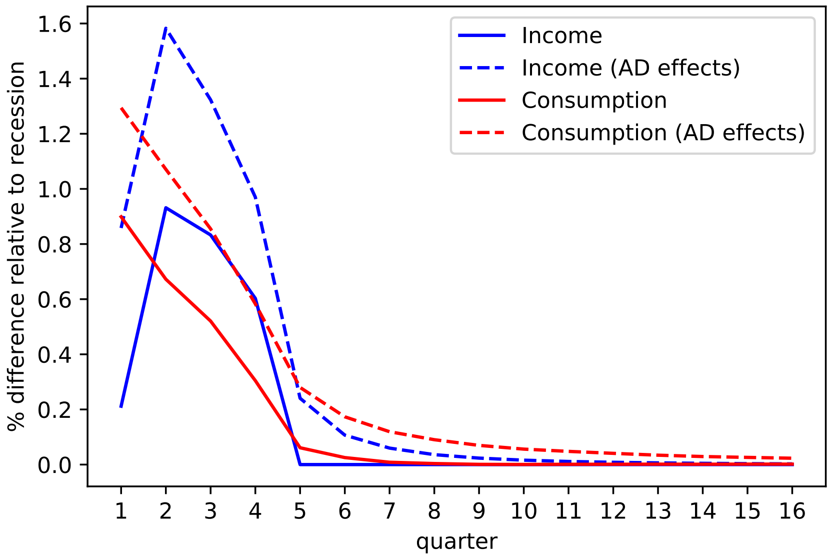


Figure 4 Impulse responses of aggregate income and consumption to a **UI extension** during recesssions with and without aggregate demand effects

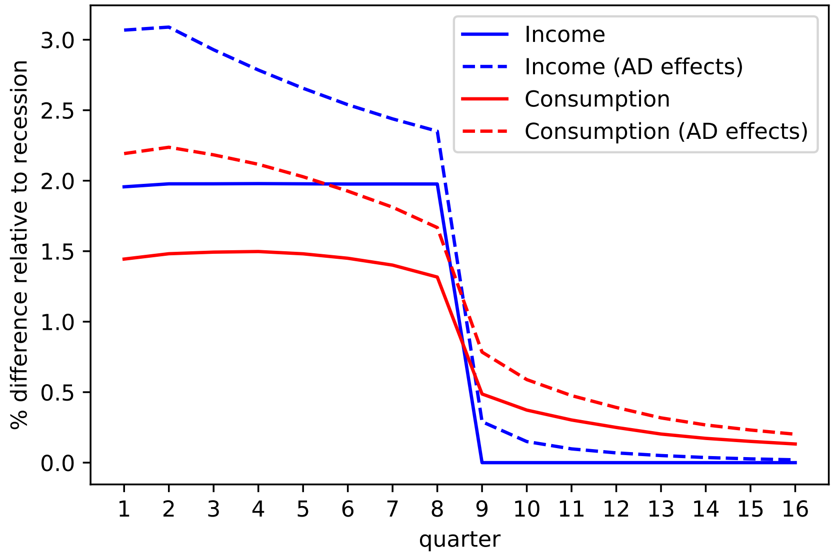


Figure 5 Impulse responses of aggregate income and consumption to a **payroll tax cut** lasting eight quarters during recesssions with and without aggregate demand effects

4.1.2 UI extension

The impulse responses in figure 4 show the response to a policy that extends unemployment benefits from 6 months to 12 months for a period of a year. The path for income, in the model without aggregate demand effects, now depends on the number of consumers who receive the extended unemployment benefits. These consumers are those who have been unemployed for between 6 and 12 months. In the first quarter of the recession the newly unemployed receive unemployment benefits regardless of whether they are extended or not. Therefore, it is in the second and third quarter, when the effects of the recession on long-term unemployment start to materialize, that the extended unemployment insurance payments ramp up. By the fifth quarter, the policy is no longer in effect and income from extended unemployment goes to zero. Consumption in the first quarter jumps up by more than income, prompted both by the increase in expected income and also the reduced need for precautionary saving given the extended insurance. In the model without aggregate demand effects, consumption is only a little above the counterfactual by the time the policy is over. In the model with aggregate demand effects, there is an extra boost to income of about the same size in the first and second quarters. As this extra aggregate-demand induced income goes to employed consumers, more of it is saved and consumption remains elevated several quarters beyond the end of the policy.

4.1.3 Payroll tax cut

The final impulse response graph, Figure 5, shows the impulse response for a payroll tax cut that persists for two years (8 quarters). In the model without aggregate demand effects, income rises by two percent as the take-home pay for employed consumers goes up. After the two year period, income drops back to where it would have been without the payroll tax cut. Consumption jumps close to 1.5 percent in response to the tax cut. Over the period in which the tax cut is in effect, consumption rises somewhat as the stock of precautionary savings goes up, before declining in anticipation of the drop in income at the two year mark. Following the drop in income, consumption drops due to the splurge and then decreases over time as consumers spend out the savings they built up over the period the tax cut was in effect. In the model with aggregate demand effects, income rises over three percent above the counterfactual and then declines steadily as the probability that the recession remains active, and hence the aggregate demands effects in place, goes down over time.[12] In response to the now declining expected path for income over the two years during which the tax cut remains in place, consumption also declines, albeit at a slightly slower pace. Following the end of the policy, the savings stock in the model with aggregate demand effects is high and consumption remains significantly elevated through the period shown.

4.2 Multipliers

In this section we compare the fiscal multipliers across the three stimulus policies. Specifically, we employ the cumulative multiplier, which captures the ratio between the net present value (NPV) of stimulated consumption up to horizon t and the full-horizon NPV of the cost of the policy. We thus define the cumulative multiplier up to horizon t as:

$$M(t) = \frac{NPV(t, \Delta C)}{NPV(\infty, \Delta G)},$$

where ΔC is the additional aggregate consumption spending up to time t in the policy scenario relative to the baseline and ΔG is the total government expenditure caused by the policy. The net present value of a variable X_t is given by $NPV(t, X) = \sum_{s=0}^{t} \left(\prod_{i=1}^{s} \frac{1}{R_i} \right) X_s$.

Figure 6 plots the cumulative multipliers at different horizons, and Table 3 shows the long-run multiplier for each policy. The stimulus check, which is paid out in quarter one, exhibits the largest multiplier on impact. About 70 percent of the total policy expenditure is immediately spent by consumers. After one year and due to the aggregate demand effects, consumption has increased cumulatively by more than the cost of the stimulus check. Over time, the policy reaches a total multiplier of 1.85.

The multiplier is very similar for the UI extension policy. However, since policy spending here is spread out over four quarters (and peaks in quarter two to three), the

[12] Again, consumption tends to first rise due to the build-up of precautionary savings, before falling again as the probability that the recession remains in place declines. This hump-shaped pattern feeds through to income, explaining the upward trend in income during the first two quarters.

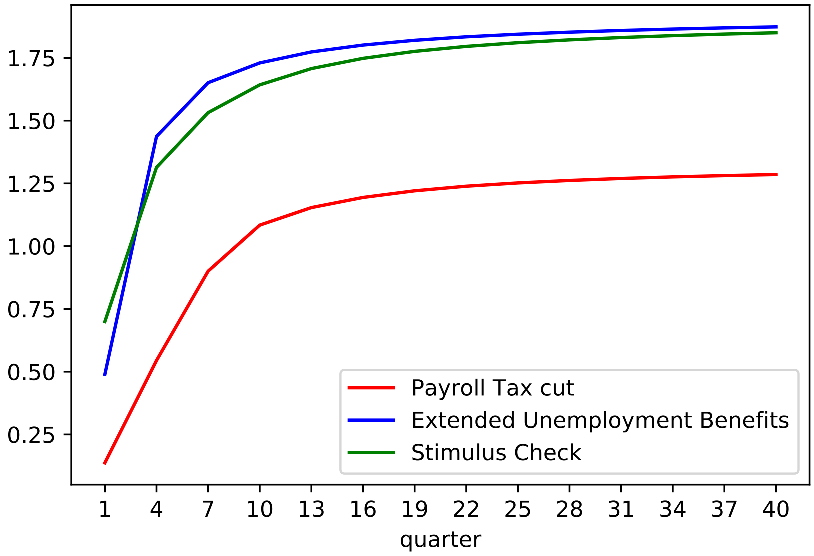


Figure 6 Cummulative Multiplier as a function of the horizon for the three policies. Policies are implemented during a recession with AD effect active.

	Stimulus check	UI extension	Tax Cut
Long-run Multiplier (AD effect)	1.850	1.873	1.285
Long-run Multiplier (1st round AD effect only)	1.481	1.531	1.146
Share of policy expenditure during recession	100.0 %	80.6%	57.6%

Table 3 Long-run cumulative multipliers as well as the share of the policy ocurring during the recession

multiplier in the first quarter is considerably lower than in the case of the stimulus check. The UI extension policy is very targeted in the sense that it provides additional income to only those consumers, who due to unemployment, have large MPCs. However, some of the spending occurs at later quarters, when the recession might have ended. Overall, around 80 percent of the policy expenditure occurs during the recession. In contrast, the stimulus check is paid out fully during the first quarter when, by construction, the recession occurs with certainty. Therefore, the aggregate demand effects are particularly potent for this policy. Hence, while being less targeted and providing stimulus also to agents with low MPCs, the stimulus check ends up with a relatively high overall multiplier due to concentration of spending during the recession.

The payroll tax cut has the lowest multiplier irrespective of the considered horizon. A multiplier of 1 is reached only after around 8 quarters. The total multiplier over the whole simulated period is at approximately 1.3. These relatively small numbers reflect that policy spending lasts for a long time and is thus more likely to occur after the recession has ended. Moreover, only employed consumers with often relatively low

MPCs benefit directly from the payroll tax cut. Therefore, the policy is poorly targeted if the goal is to provide short-term stimulus.

Table 3 contains an additional (middle) row that shows the long-run multiplier for a special case. The aggregate demand effect works through several rounds. First, consumers increase spending due to the stimulus by the policy, which increases income, which in turn boosts consumption. However, this boost in consumption triggers another round of aggregate demand effects, with each round being subsequently smaller in magnitude. The middle row of the table shows the multipliers that result in the special case where we only consider the first-round AD effect. In the case of the tax cut, approximately half of the total stimulus effect occurs in the first round, with that value being somewhat larger for the other two policies. This reflects that the stimulus impact of the tax cut hinges to a larger extent on spillovers from the direct beneficiaries of the policy to those indirectly affected by the aggregate demand effect than is the case for the stimulus check or the UI extension, which directly target high MPC households.

4.3 Welfare

In this section we look at the welfare implications of each stimulus policy. To do so we need a way to aggregate welfare in our model with individual utility functions. Our approach to constructing a welfare measure is based on three ideas:

1. The utility of each consumer is valued equally by the social planner.
2. There is no social benefit to implementing any of the policies outside of a recession.
3. Utility is gained from 'splurge' spending in the same way as other spending.

The first of these would suggest a simple aggregation of individual wel...

Let $\mathcal{W}(\text{policy}, Rec, AD)$ be the aggregated utility function:

$$\mathcal{W}(\text{policy}, Rec, AD) = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=0}^{\infty}\beta_S^t u(c_{it,\text{policy},Rec,AD}) \tag{11}$$

where policy $\in$ {None, Stimulus Check, UI extension, Payroll Tax Cut} is the stimulus policy followed, $Rec \in \{1, 0\}$ is an indicator for whether the policy coincides with the start of a recession or is implemented in non-recessionary times, and $AD \in \{1, 0\}$ is and indicator for whether the aggregate demand effects are active during the recession or not. $c_{it,\text{policy},Rec,AD}$ are the consumption paths (including the splurge) for each consumer i in each scenario. β_S is the social planner's discount factor that we will set to be equal to the inverse of the real interest rate R. N is the number of consumers simulated.

We use the steady-state baseline as a way to convert from welfare units to consumption units. Using this baseline, we define the marginal increase in welfare that occurs when every consumer increases their consumption proportionally to their baseline consumption as:[13]

$$\mathcal{W}^c = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=0}^{\infty}\beta_S^t c_{it,\text{None},0,0}u'(c_{it,\text{None},0,0}). \tag{12}$$

With this definition we consider, in steady-state consumption units $\mathcal{W}^c$, the increase in welfare induced by a policy: $\frac{\mathcal{W}(\text{policy},Rec,AD)-\mathcal{W}(\text{None},Rec,AD)}{\mathcal{W}^c}$. The present value of the fiscal payments made by the government for each policy is $PV(\text{policy}, Rec)$.[14] We subtract the fiscal cost of each policy in steady-state consumption units: $\frac{PV(\text{policy},Rec)}{\mathcal{P}^c}$ where P^c, the marginal cost of increasing every consumer's steady-state consumption proportionally, is given by:

$$\mathcal{P}^c = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=0}^{\infty}R^{-t}c_{it,\text{None},0,0}. \tag{13}$$

Finally, we normalize the welfare benefit by subtracting the welfare effect of the policy in non-recessionary times. This can be thought to encompass both the preferences of society not to redistribute and the negative incentive effects of redistribution in normal times. Our final welfare measure, expressed in units of steady-state consumption, is:

$$\begin{aligned}\mathcal{C}(\text{policy}, Rec, AD) = &\left(\frac{\mathcal{W}(\text{policy}, Rec, AD) - \mathcal{W}(\text{None}, Rec, AD)}{\mathcal{W}^c} - \frac{PV(\text{policy}, Rec)}{\mathcal{P}^c}\right) \\ &- \left(\frac{\mathcal{W}(\text{policy}, 0, 0) - \mathcal{W}(\text{None}, 0, 0)}{\mathcal{W}^c} - \frac{PV(\text{policy}, 0)}{\mathcal{P}^c}\right)\end{aligned} \tag{14}$$

Table 4 shows the welfare benefits of each policy as defined by equation (**??**). The stimulus check and payroll tax cut policies have been adjusted to be the same fiscal size as the unemployment insurance extension.[15] Without aggregate demand effects (the first row of the table), the payroll tax cut has extremely limited welfare benefits. This is because the payroll tax cut goes to consumers who remain employed and therefore does not directly affect the unemployed consumers who are the most hit by the recession. However, employed consumers do reduce their consumption at the onset of the recession due to the increased unemployment risk, so the tax cut helps them more than in non-recessionary times. Similarly, the stimulus check has limited benefit as it mostly goes to employed consumers although it has the benefit over the payroll tax cut of also reaching the unemployed. The extended unemployment insurance policy is the clear 'bang for the buck' winner as all the payments go to unemployed households who are likely to have significantly higher marginal utility for consumption than in non-recessionary times.

The second row of the table shows the welfare benefits in the version of the model with

[13] Note that with log utility, $\mathcal{W}^c = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=0}^{\infty}\beta_S^t = \frac{1}{1-\beta_S}$

[14] For the stimulus check and extended unemployment insurance the payments made by the government are clearly defined and do not depend on aggregate demand effects. For the payroll tax cut, we define the payments as the difference between the take-home pay with and without the tax cut, but ignoring any aggregate demand effects. Aggregate demand effects would increase the value of the tax cut, because incomes would rise, but in fact increase rather than decrease the tax receipts of the government.

[15] As shown in appendix A, the multiplier of the check stimulus is insensitive to its size. Hence, the downscaling of the stimulus check does not alter the impact on consumption per unit of policy expenditure.

aggregate demand effects during the recession. The payroll tax cut now has a noticeable benefit as some of the tax cut gets spent during the recession resulting in higher incomes for all consumers. However, the tax cut is received over a period of two years, and much of this may be after the recession—and hence the aggregate demand effect—is over. Furthermore, because the payroll tax cut goes only to employed consumers who have relatively lower MPCs, the spending out of this stimulus will be further delayed possibly beyond the period of the recession. By contrast, the stimulus check is received in the first period of the recession and goes to both employed and unemployed consumers. The earlier arrival and higher MPCs of the stimulus check recipients means more of the stimulus is spent during the recession leading to greater aggregate demand effects, higher income, and higher welfare. The extended unemployment insurance arrives, on average, slightly later than the stimulus check. However, the recipients, who have been unemployed for at least six months, spend the extra benefits relatively quickly resulting in significant aggregate demand effects during the recession. In contrast to the payroll tax cut, extended unemployment insurance has the benefit of automatically reducing if the recession ends early and less consumers are eligible for the benefit.

	Stimulus check	UI extension	Tax Cut
$\mathcal{C}(\text{policy}, 1, 0)$	0.120	4.157	0.005
$\mathcal{C}(\text{policy}, 1, 1)$	0.570	6.535	0.178

Table 4 Consumption equivalent welfare gains in basis points, calculated for policies implemented in a recession with and without aggregate demand effects

4.4 Comparing the policies

The results presented in section 4.2 and 4.3 indicate that the extension of unemployment benefits is the clear 'bang for the buck' winner. (TODO: discuss targeting vs timing of spending)

5 Robustness

In this section we analyze how sensitive our results are to some of the parameters in the model. In particular, we focus on the degree of risk aversion and the interest rate. These parameters respectively influence the incentive to save through the strength of a precautionary saving motive and through the returns obtained on saving. The aim is to alter these incentives while maintaining the requirement that the distributions of liquid wealth in each education group matches the distribution in the data. Our procedure is therefore to alter the parameter of interest and to repeat the estimation of the degree of 'splurge' spending in consumption and the distributions of discount factors within each education group. We then compute new results using these updated estimates.

	Splurge	Dropout β	Dropout ∇	Highschool β	Highschool ∇	College β	College ∇
$\gamma = 1.0$ (baseline)	0.314	0.800	0.227	0.940	0.063	0.986	0.011
$\gamma = 2.0$	0.307	0.561	0.502	0.853	0.160	0.969	0.030
$\gamma = 3.0$	0.304	0.383	0.4^{*}	0.725	0.302	0.939	0.062

Table 5 Estimates of the Splurge and (β, ∇) for each education group for different values of risk aversion, γ. $*$ indicates a value that is fixed in the estimation — this is necessary in some cases to prevent the estimation procedure from trying negative values for the discount factor of some type.

5.1 Increasing risk aversion

In our baseline calibration consumers have log-preferences over consumption and hence have a risk aversion of $\gamma = 1$. It is quite common in macroeconomic models to use higher degrees of risk aversion, so here we investigate how alternative values of γ would influence our results. The first thing to note is that, in our model, consumers are ex-ante heterogeneous in that they belong to different education groups and have different discount factors. Heterogeneity in discount factors is thus the only device we use to obtain a model where the distribution of liquid wealth can match the data. Thus, when we change risk aversion, the change applies equally to all different types. For the model to continue to match liquid wealth, the distribution of discount factors within each education group must be reestimated.

5.1.1 Estimating discount factor distributions with higher risk aversion

Table 5 displays the values we obtain for the splurge and the discount factor distributions when we increase γ to 2 and 3. The first result is that the splurge is not very sensitive to the degree of risk aversion. The splurge controls the degree of spending that consumers do before considering the trade-off involved in optimally allocating spending over time. Thus a parameter that affects that trade-off does not have a big influence on that parameter.

Furthermore, the first two rows shows results that are quite intuitive when we increase risk aversion from $\gamma = 1.0$ to $\gamma = 2.0$. Increasing risk aversion for all types within an education group makes the precautionary saving motive stronger for all consumers in that group. Ceteris paribus consumers would then increase the amount of liquid wealth they accumulate, and the median liquid wealth to permanent income ratio for the education group would increase. As the higher risk aversion applies equally to all types within the education group this would also decrease the concentration of liquid wealth within the group. Hence, when we reestimate the discount factor distributions for $\gamma = 2.0$ to fit the same liquid wealth distribution as before, we obtain distributions centered on lower values of beta that are more spread out. Thus the updated discount factor distribution counteracts these two effects. Figure 7 shows that with the reestimated discount factor distributions the model continues to match the distribution of liquid wealth as well as in the baseline calibration with the higher risk aversion of $\gamma = 2.0$.[16]

When we increase risk aversion to $\gamma = 3.0$, however, we run into problems when estimating the discount factor distribution for the Dropout education group. For that group the median liquid wealth to permanent income ratio is very low at only 4.64, and the liquid wealth distribution is very concentrated. The highest 20 percent of consumers hold 96.4 percent of the liquid wealth in the Dropout group. With risk aversion increased to $\gamma = 3.0$ for all types within the group, the model cannot match this wealth distribution. The reason is that to fit such a low value of median liquid wealth to permanent income when the strength of the precautionary saving motive is sufficiently increased, we need a discount factor distribution centered around a very low value. But this value places an upper bound on how spread out the discount factor distribution can be, since we can not allow any types in the model to have a negative discount factor. Hence, when the distribution is centered on a low value of β it cannot be dispersed enough to match the high concentration of liquid wealth in the Dropout group in the data.

We deal with this issue by focusing on matching the median liquid wealth to permanent income ratio. Our approach is to fix the value of the spread of the discount factor distribution, ∇, and then estimate the center of the distribution, β to match this ratio. The aim is to fix a value of ∇ as high as possible without running into negative values for the discount factor of the least patient type. We fix the value to $\nabla = 0.4$ and obtain a value for β in line with the intuition discussed above: higher risk aversion and a stronger precautionary saving motive leads to a discount factor distribution centered around a lower value of β in order to match the median liquid wealth to permanent income ratio.

The upper left panel of Figure 7 shows that in this case we cannot obtain distributions of liquid wealth that are as concentrated as in the data. This follows since we cannot allow negative values for the discount factor of any type, and the increased incentive to save affects all the types in the Dropout group making the liquid wealth distribution less concentrated. The bottom right panel of Figure 7 shows that we still match the overall distribution of liquid wealth in the overall population quite closely even for $\gamma = 3.0$. This is due to the fact that the Dropout group only accounts for 9.3 percent of the total population.

TODO: add discussion of potentially allowing heterogeneity in risk aversions?

5.1.2 Results with higher risk aversion

5.2 Altering the interest rate

In this section we consider the impact of increasing or decreasing the interest rate, set to 1 percent per quarter in our baseline calibration. This change does not affect the estimation of the Splurge, but as in section 5.1, the distribution of discount factors

[16] The median liquid wealth to permanent income ratios in Panel B of Table 2 are also matched in these estimations.

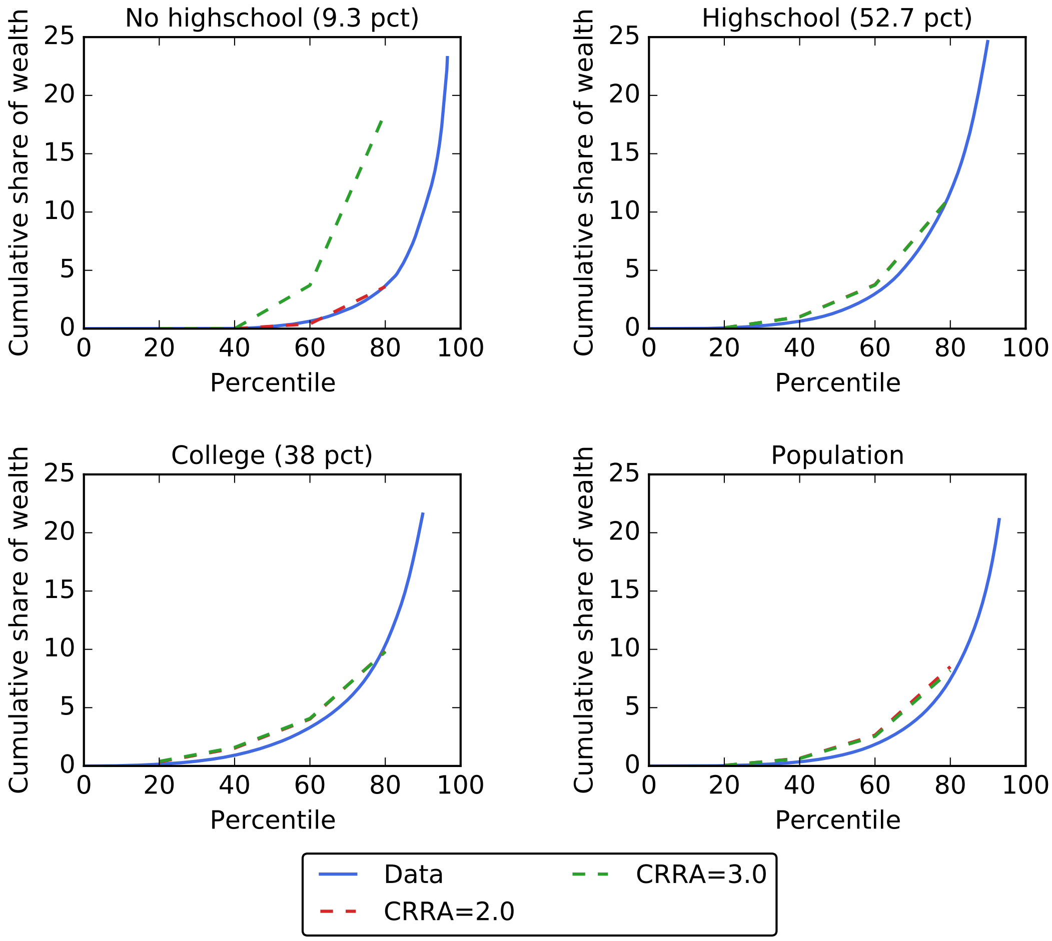


Figure 7 Distributions of liquid wealth within each educational group and for the whole population from the 2004 Survey of Consumer Finance and from the estimated model for different values of risk aversion, γ.

within each education group must be reestimated for the model to continue to match the liquid wealth distributions.

5.2.1 Estimating discount factor distributions for different interest rates

Table 6 shows the values we obtain for the discount factor distributions when we change the quarterly interest rate by either decreasing it to 0.5 percent or increasing it to 1.5 percent. The first row shows results for the lower interest rate. With a lower interest rate and an unchanged discount factor distribution, consumers would tend to substitute away from saving and towards current consumption. They would therefore accumulate less wealth leading to a lower median liquid wealth to permanent income ratio. In all education groups we therefore see that the estimated discount factor distributions are centered around higher values of β to ensure that the model still matches the median

	Dropout		Highschool		College	
	Splurge	β	∇	β	∇	β	∇

	Splurge	Dropout β	Dropout ∇	Highschool β	Highschool ∇	College β	College ∇
$R = 1.005$	0.314	0.803	0.268	0.945	0.063	0.991	0.011
$R = 1.01$ (baseline)	0.314	0.800	0.227	0.940	0.063	0.986	0.011
$R = 1.015$	0.314	0.796	0.226	0.935	0.063	0.981	0.012

Table 6 Estimates of the Splurge and (β, ∇) for each education group for different values of the interest rate R.

liquid wealth to permanent income ratio in the data. Increased patience cancels out the effect of the lower interest rate. Similarly, in the third row, we see the opposite effect when the interest rate is increased to 1.5 percent.

Again, the results are quite intuitive. The first row shows res

5.2.2 Results for different interest rates

6 Conclusion

For many years leading up to the Great Recession, a widely held view among macroeconomists was that countercyclical policy should be left to central banks, because fiscal policy responses were unpredictable in their timing, their content, and their effects. Nevertheless, even during this period, fiscal policy responses to recessions were repeatedly tried – perhaps because the macroeconomists' advice to policymakers – "don't just do something – stand there" – is not politically tenable.

This paper demonstrates that macroeconomic modeling has finally advanced to the point where we can make reasonably credible assessments of the effects of alternative policies of the kinds that have been tried. The key developments have been the advent of national registry datasets that can measure crucial microeconomic phenomena, and the development of tools of heterogeneous agent macroeconomic modeling that can match those micro facts and glean their macroeconomic implications.

We examine three fiscal policy experiments that have actually been implemented in the past: an extension of UI benefits, a stimulus check and a tax cut on labor income. Our model suggests that the extension of UI benefits is a clear "bang for the buck" winner. Not only is it the policy that yields the greatest spending boost during while the recession is ongoing (when multipliers are likely to be strongest), it also leads to the greatest welfare gains. The chief drawback of the UI extension is that its size is limited by the fact that a relatively small share of the population is affected by it. In contrast, stimulus checks are easily scaleable while exhibiting only slightly less recession-period stimulus (in a typical recession). However, since some of the stimulus checks flow to well-off consumers, it does worse than UI extensions when we evaluate welfare consequences. Finally, the tax cut is the least effective both in terms of the multiplier and welfare impact since it only targets employed consumers, and for a typical recession more of its payouts are likely to occur after the recessionary period (when multipliers may exist) has ended.

The tools we are using could be reasonably easily modified to evaluate a number of other policies. For example, in the COVID recession, not only was the duration of UI benefits extended, those benefits were supplemented by very substantial extra payments to every UI recipient. We did not calibrate the model to match this particular policy, but the framework could easily accommodate such an analysis.

Appendices

A Linearity of the check stimulus

Table 7 shows the amount of additional consumption stimulated (as % of baseline consumption) caused by stimulus checks of different sizes as well as their net-present value multiplier. The table shows that the impact of the check stimulus experiment scales roughly linearly with the size of the stimulus check, leaving the multiplier largely unaffected by the size of check.

Size of stimulus check	\$75	\$1200	\$5000
Add. cons. as share of baseline cons. (recession, AD)	0.019	0.308	1.294
Multiplier (recession, AD)	1.849	1.850	1.866

Table 7 Multipliers for different sizes of the stimulus check

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