Abstract

We estimate the macroeconomic effects of the 2001 tax rebate by using a structural general equilibrium model. The model, whose dynamics are driven by borrowing-constrained and heterogeneous households, can replicate many of the microeconomic findings, such as a moderate overall marginal propensity to consume (MPC) along with a higher MPC for liquidity-constrained households. At a macroeconomic level, we find very small multipliers for consumption and output, despite the fact that liquidity constrained households increase their spending by more than 60 percent of the rebate upon receipt.
Introduction

Policymakers often try to counteract recessions by taking measures to stimulate household consumption and economic growth. Among these measures, tax rebates have been recently used on two main occasions. The Economic Growth and Tax Relief Reconciliation Act of 2001 and the Economic Stimulus Act of 2008, both included provisions for tax rebates to be mailed directly to households. The effects of tax rebates on household consumption has been the focus of several recent papers. Johnson, Parker and Souleles (2006), Parker, Souleles, Johnson and McClelland (2010), Agarwal, Liu and Souleles (2007), Shapiro and Slemrod (2003, and 2009) show that temporary fiscal stimulus, in the form of a check sent from the Internal Revenue Service (IRS), can boost household consumption and may play an important role in economic downturns. Moreover, Johnson, Parker and Souleles (2006) and Agarwal, Liu and Souleles (2007) find larger responses for non-durable household consumption among liquidity constrained households. They find that the permanent-income hypothesis does not necessarily hold, particularly for households facing a binding borrowing-constraint.

We build and estimate a general equilibrium structural model to match the findings obtained in this reduced-form literature. Our structural model allow us to extend the household-level analysis by evaluating the effect of a tax rebate on aggregate consumption, aggregate output, fiscal multipliers, and intertemporal elasticities of consumption. Furthermore, the model allows us to assess the effects of different financing arrangements and compare the effectiveness of rebates in stimulating consumption and output during recessions.

Our general equilibrium model, which we estimate using moments including those identified in Johnson, Parker, and Souleles (2006), is based on the Aiyagari (1994) model of borrowing-constrained and heterogenous agents. This framework is appropriate because many of the dynamics in this model are driven by a mass of agents bound by a household-level borrowing-constraint. A desire to smooth consumption causes agents at the lower end of the wealth distribution to spend a substantial portion of their rebate upon receipt. The agents’ behaviors in the model are at odds with permanent income hypothesis, mirroring the empirical evidence found in Johnson, Parker, and Souleles (2006), Agarwal, Liu and Souleles (2007), and Stephens (2003). Therefore, our model can accommodate the consumers’ responses to tax rebates found in those studies and is consistent with view that the heterogenous
response to the tax rebate can be attributed to liquidity constraints.

Using our model, we can replicate a few aspects of household behavior as identified by Johnson, Parker and Souleles (2006), Parker, Souleles, Johnson and McClelland (2010), and Agarwal, Liu and Souleles (2007). We find that the marginal propensity to consume (MPC) generated by the model is very similar to that identified in the first two papers, in which the authors examine consumption of nondurable goods. Additionally, we find that the liquidity-constrained households in the model consume about 60 to 70 percent of their rebates upon receipt, which is consistent with the results in the three papers. Furthermore, the model's unconstrained households use the tax rebate to smooth consumption through the trough of a recession generated by a short-lived drop in total factor productivity (TFP). The smoothing behavior is less pronounced as the drop in TFP becomes more long-lived.

Although the tax rebate effects on borrowing-constrained households are particularly strong, the effects on the overall economy are very short-lived. In the model, aggregate consumption spikes in the periods in which the tax rebates are received. This behavior mirrors the actual private consumption expenditure (PCE) and nondurable consumption expenditure, as reported in the data. However, the fiscal multipliers are relatively small. The two quarter cumulative multipliers for consumption are no larger than 0.14, increasing to levels no larger than 0.20 at the two-year horizon. Furthermore, in spite of a positive effect on consumption, the effect on output is negative, even during the periods in which the tax rebates are distributed and spent. The largest cumulative multipliers at the two-quarter horizon are -0.07 and -0.16 at the two-year horizon.

These findings do not necessarily undermine the case for tax rebates, since liquidity-constrained households can increase their contemporaneous consumption and unconstrained households can smooth their consumption through a recession. Furthermore, there may be other frictions documented in other papers that provide other compelling avenues through which tax rebates and other fiscal policies may stimulate economic growth and speed recovery in recession. However, our model does present an alternative to the Keynesian view that increases in household consumption generated by deficit-financed tax rebates generate increases in output and employment.

The structure of the paper is as follows. Section two reviews the literature. Section three explains the features of the 2001 tax rebate, the experiment from Johnson, Parker, and Souleles (2006), and other related studies that provide moments used in our estimation. Section four presents the model and
the solution method. Section five reports the calibration and the estimates of the structural parameters. Section six illustrates the experiments. Section seven reports the results. The final section concludes.

**Literature Review**

Many authors have analyzed predictable changes to household income and used data on household expenditures to test the permanent income hypothesis. Parker (1999) and Souleles (2002) consider changes in tax withholding to measure the effects of changes in income on consumption. Specifically, Parker (1999) using predictable changes in Social Security withholding, Souleles (2002) using changes in withholding owing to the Reagan tax cuts, and Souleles (1999) using tax refunds, find that changes in household level consumption behavior are correlated with the changes in withholding. Instead of using changes in taxes, Stephens (2003) uses the timing of Social Security checks—whose dates are well-known by Social Security recipients—to evaluate whether consumers change their spending patterns upon receipt of their checks. Stephens (2003) finds that households tend to increase spending, and “that the increase is sharpest on the day of the check arrival and is concentrated amongst households for whom Social Security is the primary source of income.”

Shapiro and Slemrod (2003a, 2003b and 2009) take different approach. They rely on specially formulated questions in the Michigan Survey of Consumers Finance to attempt to derive the effects of the 2001 and 2008 tax rebates. Households report that they expect to spend a statistically and economically significant fraction of their rebates on consumption in almost all cases.

More recently Johnson, Parker and Souleles (2006), Agarwal, Liu and Souleles (2007), and Parker, Souleles, Johnson and McClelland (2010) have examined the 2001 and 2008 tax rebates by exploiting the random timing of the rebate. In both of these rebates, the rebate check is mailed on a date that is determined by the second-to-last digit of a tax filer’s Social Security number. All three use the random timing of the rebates to identify household spending, allowing them to separate the effects of the tax rebates from other economic conditions or other unobserved variables. Johnson, Parker and Souleles (2006) and Parker, Souleles, Johnson and McClelland (2010) look at household spending patterns while Agarwal, Liu and Souleles (2007) look
at credit card balance data. All of the authors reject the permanent income hypothesis. Many of studies also report that liquidity-constrained households tend to spend a greater share of the tax rebate on nondurables.

Our model builds directly on these recent empirical studies. We choose the Aiyagari (1994) framework because it accommodates many of these observations. In this model, a non-zero measure of agents are liquidity-constrained and choose to spend a disproportionately high share of their tax rebate check on consumption. Our model also allows us to extend the analysis of the effects of a tax rebate to other features household features that may not be able to be identified by the method used in those three papers. Furthermore, the model offers an alternative approach to estimating fiscal multipliers.


The structural approach has been used to estimate the effect of fiscal policy. Although Ohanian (2009) and Cwik and Wieland (2009) argue that fiscal stimulus cannot be to effective, particularly when household behavior is Ricardian. Nonetheless, a number of structural models have considered non-Ricardian specifications to investigate the effectiveness of fiscal stimulus. Gali, Lopez-Salido, and Valles (2007), Baxter and King (1993), and many, many others have contributed to the literature on fiscal multipliers. Recently, Coenen et. al. (2010) review the effects of fiscal policy in seven structural models used widely by policy institutions. Their models predict that fiscal transfers such as tax rebates have very small effects, the strength of the effects are stronger in the models with hand-to-mouth agents that do not save any income.

For many of these approaches, it is difficult to map a specific tax rebate proposal into these frameworks used to estimate the effects of fiscal shocks. Given the prevalence of countercyclical fiscal policy in developed countries, households undoubtedly expect some sort of fiscal stimulus, possibly tax rebates.

Using an Aiyagari (1994) framework, we look to extend the analysis provided by these studies to answer questions specifically about the 2001 tax rebate. In our model, we change the policy parameters such as tax and trans-
fer rates along a path that is exogenously determined and fully revealed to all agents before the policy is implemented. Given this information, we solve all agents’ policy functions, which are fully informed by this future path of tax rates, debt, and transfers, which will allow us to evaluate the effect of the tax rebate against precisely defined counterfactual experiments in which agents received no rebates.

Empirically Evaluating the 2001 Tax Rebate

To counteract the 2001 economic recession, the United States Congress passed the Economic Growth and Tax Relief Reconciliation Act (EGTRRA, 2001). One of the bill’s provisions provided for a change in the lowest non-zero marginal tax rate. The 15 percent tax rate was reduced to 10 percent for the first $6,000 of taxable income for filers with single filing status, the first $10,000 of income for heads of households, and the first $12,000 of income for married couples filing jointly.\(^1\)

In lieu of applying the 10 percent marginal tax rate at filing time for the 2001 taxes, policymakers mailed checks aimed at stimulating consumption and economic recovery.\(^2\) Over the course of a ten-week period ending in September 2001, the Internal Revenue Service mailed checks to taxpayers. As described by Johnson, Parker and Souleles (2006), each week the checks were mailed to a different cohort of households based on the second to last digit of filers’ Social Security number. Hence, the timing of the tax rebate is random and orthogonal to other household features.

The checks were worth a maximum of $300, $500, or $600 for filers falling into the single, head of household, or married filing jointly respectively. As described in Shapiro and Slemrod (2003), the IRS determined the amount of the rebate check based on the 2000 tax return, any rebate in excess of that to which the filer was entitled on his 2001 return was forgiven. Any shortfall in the rebate could be claimed when the 2001 return was filed in 2002.\(^3\)

\(^1\)Other provisions of the bill included the gradual reduction of other income tax rates. The 28-percent, 31-percent, 36-percent, and 39.6-percent brackets were all reduced between three and four percentage points. Furthermore, the limitation on itemized deductions was similarly phased out, being removed completely for the tax year 2010.

\(^2\)A summary of the act is available from the Joint Committee on Taxation, and is published at http://www.jct.gov/publications.html?func=startdown&id=2003

\(^3\)Most of the provisions sunset in the tax year 2011, although some do not, such as the elimination of the limits on itemized deductions.
cording to Johnson, Parker and Souleles (2006), the total value of the rebate was a little under $40 billion, which is roughly equal to 1.5 percent and 2.2 percent of total contemporaneous quarterly GDP and personal consumption expenditures respectively.

In their experiment, Johnson, Parker and Souleles (2006) exploit the exogenous and random timing of the tax rebate in order to estimate household consumption responses to the tax rebate. Using questions in the Consumer Expenditure Survey (CEX), they are able to identify the period in which households received their rebates as well as the amount of the rebates. They estimate linear relationships in which the change in various categories of consumption are regressed against the receipt of the rebate and several covariates. In addition to the baseline model, they also experiment with a number of other interactions including asset holdings, income, and age.

The specification allows them to estimate the change in consumption in households that received the tax rebate compared to other households that did not receive the tax rebate. To summarize the results that motivate our modeling choices, they find that households increased their spending in strictly nondurable and nondurable goods by as much as 0.152 and 0.247 for every dollar of their rebate received. Furthermore, they find that the low income and low asset groups tend to spend more of their rebates. The low income group, or people with income lower than $34,298 spent a statistically and economically significant 76 percent of their rebates on nondurable consumption. The percent of the rebate spent by the baseline, middle income or the high income groups cannot be statistically differentiated from zero.

Although there are small residual consumption effects in the periods subsequent to the receipt of the rebate check, none of them are statistically signific-

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4The nondurables category differs from the strictly nondurables by the inclusion of some semi-durable goods such as apparel, household healthcare expenditures, and reading materials. See Lusardi (1996) for more information on how Johnson, Parker and Souleles (2006) construct their spending categories. The 0.152 and 0.247 values are estimated by using a subsample of households that includes only those households that received rebates. The 0.152 and 0.247 are smaller than the same values found in the regression that includes all households regardless of whether or not they received rebates, but are closer to the results found in the 2008 rebate.

5There are positive values for the other two groups, but they are not significant at any traditional level of statistical significance.

6The middle income group contains households above the $34,298 cutoff for the low income group, and below $69,000. The high income group contains households with incomes over $69,000.
icant. Households with low liquid assets—defined as less than $1,000—spent a greater amount of their rebate checks in the quarter of receipt compared to either the middle- or high-income groups. The low-income group increased spending on nondurable goods by about 63 cents for every dollar of the rebate received.

In our heterogenous agent model in which we simulate individual household decisions, we attempt to match these two findings: (1) average household spending on nondurable consumption out of the rebate amounted to 0.152 percent of the rebate and (2) the liquidity constrained households spend a greater share of their rebates in the period in which they receive their checks than do the other. We use the Aiyagari (1994) model in which heterogeneous agents are subject to a borrowing-constraint and an idiosyncratic labor productivity shock to endogenously generate borrowing-constrained agents.

The Model

Our model present the main features described in Aiyagari (1994). There is a continuum of households that purchase consumption and investment goods, sell capital and labor in the market at the prevailing capital rental and wage rates, and invest money in government bonds. There is a government that taxes consumption and income, spends on a government consumption good, pays back a one-period bonds’ interests, and borrows by issuing an exogenously determined quantity of one-period bonds. The firm has access to a constant returns to scale Cobb-Douglas technology, and comes to the market to hire labor and rent capital. Using capital and labor inputs, the firm produces a final good that can be turned into investment, government consumption, or private consumption.

The dynamics of the model are as follows. At the beginning of each period, households receive news about their period productivity. Households with limited resources find it is optimal to borrow up to their limit, as noted by Aiyagari (1994). These households are borrowing-constrained and choose next periods net assets equal to the minimum value allowed. These households are likely to consume a large share of their tax rebates, consistent with the evidence posited by Johnson, Parker and Souleles (2006), Johnson, Parker and Souleles (2006), Agarwal, Liu, and Souleles (2007), Parker, Souleles, Johnson and McClelland (2010), and Stephens (2003). The rest of the households, namely the non borrowing-constrained households, hold
varying levels of assets. Their choices of next period assets are determined by their optimizing behaviors conditional on the prices they observe and their idiosyncratic earning shocks.

Our model departs from the Aiyagari (1994) in three ways, which allow us to perform a variety experiments with the tax rebates. First, we add an additional state variable, that is exogenous and determined and represents the households’ social security number; second, we introduce a government sector; third, households are allowed to make a labor decisions. The first modification allows us to simulate the experiment in Johnson, Parker and Souleles (2006) by having multiple cohorts of households who receive their tax rebates at exogenous, predetermined times. This allow us to construct moments that are close to the ones they estimate using the CEX. The second modification allows us to evaluate the effects of different policies for financing the tax rebate. The government is able to finance most of the rebate through higher taxes on consumption, capital income, or labor income. Moreover, the government can take out debt and pay later through lower government consumption or higher future tax rates. Since the rebate provision in EGTRRA was effectively an up-front payment for lower tax rates, the U.S. government paid for the taxes by issuing debt it otherwise would not have had to issue. The inclusion of the government sector allows us to evaluate the crowd-out of this additional government debt. Third, the household is able to choose its level of labor, allowing aggregate labor to respond to the rebate, affecting measured productivity and output. Furthermore, having an exogenously determined household labor would have made the income tax a lump sum tax, which removes the primary distortionary tax used by the government to pay for the tax rebate.

The Households

Let $X$ denote household $i$ state vector:

$$X = \{k, b, \epsilon, s\},$$

where $k$ is capital owned by household $i$, $b$ its quantity of government bonds, $\epsilon$ idiosyncratic labor productivity which evolves over time according to a

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7We choose to construct a quarterly model with only two, instead of ten, cohorts receiving their rebate checks. First, they estimate the consumption response in the three months following the receipt of the rebate. Second, having ten cohorts substantially increases the amount of computational resources required.
Markov process, and $s$ a two state determined variable. Household heterogeneity is generated by idiosyncratic changes in labor productivity.

Household $i$ choose consumption $c$, labor $l$, and next period capital $k'$ and government bonds $b'$. The within-period household preference over consumption and labor is represented by the Cobb-Douglas utility function:

$$U(c, l) = \frac{(c^\gamma (1-l)^{1-\gamma})^{1-\sigma}}{1-\sigma},$$

where $\sigma$ is the coefficient of relative risk aversion and $\gamma$ is the share parameter for consumption. The household problem is described as follows:

$$V_i(X) = \max_{c,l,k',b'} U(c, l) + \beta E[V_i'(k', b', \epsilon', s)]$$

subject to the budget constraint

$$b(1 + r^b(1 - \tau_b)) + \epsilon w(1 - \tau_l) + (1 - \delta + r^k(1 - \tau_k))k + tr(s) \geq (1 + \tau_c)c + k' + b'$$

and the borrowing-constraint, non-negative consumption constraint, and endowment constraint:

$$b' + k' \geq b, 0 \leq l \leq 1, c \geq 0.$$

Let $r^k$ denote interest rate on capital, $r^b$ interest rate on bonds, $\tau_l$ labor tax rate, $\tau_k$ capital income tax, $\tau_c$ consumption tax rate, $\tau_b$ tax on income from bonds, $tr(s)$ government lump sum transfer, which is a function of the state variable $s$. The household derives its income from wages $w$, interests on capital, and interests on government bonds. It pays labor income taxes, capital income taxes, consumption taxes, and taxes on income from bonds, and receives a lump sum transfer from the government. The household is allowed to borrow assets, but its next period net asset position must be at least $b$.

In the model the household can increase either its holdings of government debt or its holdings of productive capital; however, in equilibrium, the returns from these two assets are equal. Therefore, the household is indifferent between the two assets, and her decisions result in a decision for a generic asset $a$, as in Aiyagari (1994). This generic asset is allocated between inelastically demanded government debt and productive capital. In equilibrium, the households’ level of assets, $a = b + k$, sufficiently describes the households’ states.
Aggregation

The household level variables are aggregated into economy-wide variables that are used in the firm’s and government’s problems. The economy-wide variables are typically the capital letter analogues of the household-level variables, and are aggregated over the measure of agents, which we define as the function $\Phi(i, b, k, s)$:

\[
L = \int \epsilon_l(X) d\Phi, \tag{4}
\]
\[
K = \int k(X) d\Phi, \tag{5}
\]
\[
C = \int c(X) d\Phi, \tag{6}
\]
\[
TR = \int tr(X) d\Phi,
\]
\[
B = \int eb(X) d\Phi. \tag{7}
\]

Firms

The competitive representative firm in each sector of the economy has access to a Cobb-Douglas technology:

\[
Y = Z(K)^{\alpha}(L)^{1-\alpha}.
\]

Let $Z$ be total factor productivity (TFP) and $\alpha$ the share of income to capital. Each firm chooses to rent capital $K$ at the rate $r^k$ and hire labor $L$ at the market wage rate $w$. The representative firm has zero profits in equilibrium. The firm’s problem is described as follows:

\[
\max_{K,L} Z(K)^{\alpha}(L)^{1-\alpha} - r^kK - wL. \tag{8}
\]

Government

The government has the following budget constraint:

\[
\tau_c C + \tau_k r^k K + \tau_l w L + B^\prime + \tau_b r^b B = G + TR + (1 + r^b)B. \tag{9}
\]
The resources available to the government are drawn from taxes on consumption, capital, bonds, and labor. Furthermore, the government issues an exogenously determined number of one-period bonds, \( B' \). These resources are used to pay for exogenously determined transfers, \( TR \), one-period bonds repaid, \( B \), and government consumption \( G \).

**Model Equilibrium**

The model equilibrium is defined as

- a set of prices \( w, r^k, \) and \( r^b \) and quantities such that
- each household’s choice of consumption \( c(\cdot) \), labor \( l(\cdot) \), capital \( k'(\cdot) \), and bonds \( b'(\cdot) \) solve its problem while satisfying its budget and borrowing-constraints
- the firm’s choice of capital \( K \) and labor \( L \) solves its profit-maximizing conditions
- the aggregation and market clearing conditions are satisfied
- the government’s choice of government consumption \( (G) \) satisfies its budget constraint.

In each period, the interest rates on capital and bonds must be equal, which makes the individual households indifferent between holding the two types of assets. All of the agents solve their respective objective functions, and all markets clear.

**The Solution Method**

Full details for solving the model are provided in the appendix.

Starting with a set of prices, we solve the household problem with value function iteration and save the household policy function. Using that policy function, we simulate 30,000 households with randomly distributed working abilities for 750 periods, and obtain a distribution of assets, consumption, and labor. We aggregate these values over the measure of households, and solve the remaining first-order necessary conditions to obtain government spending and a new set of prices. We update the prices and we repeat the entire process starting with the household problem until we reach the stopping criteria.
Once prices are solved, we save the information and refer to the distribution of household assets and the set of policy functions, value functions, and prices as the steady state, and use this information to characterize the economy in period 1.

We assume that news of some determined policy or productivity shock is announced at the beginning of period 2. In the case of a hypothetical tax rebate, this means that the $tr$ variable may be set to a higher value in period 3 for one cohort of households, and a higher value in period 4 for the alternate cohort of households. If the news indicates a permanent change, we solve for the ending value function and prices using the method previously outlined. If the news is temporary, we use the information for the initial steady state to characterized the final steady state.

We guess a starting set of prices from periods 2 through the second-to-last period, $T − 1$. Starting in the second to last period, time $T − 1$, we solve the households’ problems given the set of prices. We use the value function in period $T − 1$ and the prices to solve the household problem in period $T − 2$, and continue to iterate backwards to period 2. Starting in period 2, we apply the households’ policy functions and the law of motion on the productivity shocks to simulate the economy. In each period, we aggregate the values and compute new prices. If the new prices satisfy a stopping condition, we stop computing the transition. Otherwise, we update the series of prices and repeat the process until the simulation converges.

**Calibration and Estimation Results**

The model parameters are currently calibrated to the U.S. economy. Table (1) presents the calibration. We are working on estimating the parameters $\beta$, $\gamma$, $\sigma$, $\rho$, $\sigma_\epsilon$ using the method of simulated moments. We plan to match both macro and micro moments. The macro moments are the ratio between consumption and GDP and the ratio between capital and labor. The micro moments are provided by Johnson, Parker and Souleles (2006). Specifically, they include the percentage of liquidity-constrained households, the regression coefficient that measures the average causal effect of rebate receipt on the consumption expenditure, the income distribution.
Table 1: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\beta)</td>
<td>Subjective discount rate</td>
<td>0.99</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>Share parameter for consumption</td>
<td>0.7</td>
</tr>
<tr>
<td>(\sigma)</td>
<td>Coefficient of relative risk aversion</td>
<td>2</td>
</tr>
<tr>
<td>(b)</td>
<td>Minimum net asset position</td>
<td>0</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>Share of income to capital</td>
<td>0.36</td>
</tr>
<tr>
<td>(z)</td>
<td>Total factor productivity</td>
<td>1</td>
</tr>
<tr>
<td>(\delta)</td>
<td>Depreciation rate of capital stock</td>
<td>0.02</td>
</tr>
<tr>
<td>(\rho)</td>
<td>Persistence of the AR(1) process</td>
<td>0.982</td>
</tr>
<tr>
<td>(\sigma_\epsilon)</td>
<td>Standard deviation of the innovation in the AR(1) process</td>
<td>0.15</td>
</tr>
<tr>
<td>(\tau_k)</td>
<td>Capital income tax</td>
<td>0.218</td>
</tr>
<tr>
<td>(\tau_l)</td>
<td>Labor income tax</td>
<td>0.182</td>
</tr>
<tr>
<td>(\tau_c)</td>
<td>Consumption tax</td>
<td>0.08</td>
</tr>
<tr>
<td>(\tau_b)</td>
<td>Tax on income from bonds</td>
<td>0.182</td>
</tr>
</tbody>
</table>

The Experiments

We describe a few experiments that allow us to test the macro implications of tax rebates. In addition to modeling the tax rebate, we consider the rebate effects under different economic conditions as well as different financing arrangements.

The Tax Rebate

We model the tax rebate as a temporary increase in lump-sum transfers whose timing is a function of the household state \(s\). A tax rebate in period \(t\) is distributed to households with state \(s = 0\) in period \(t\) and to households with state \(s = 1\) in period \(t + 1\). Furthermore, we scale the value of our tax rebate such that it is related to the size of the 2001 tax rebate.\(^8\)

\(^8\)Our tax rebate is twice as large as the 2001 tax rebate. The reasons for this are simply for aesthetic purposes, some of the responses to a tax rebate of 1.5 percent of GDP are so small that they show very poorly on graphs. Moreover, we are using global approximation methods and, therefore, there is not really an analytical reason for the results to scale. Doubling the tax rebate doubles the response in all of the aggregate variables.
The Recession

Tax rebates are typically proposed during periods of economic distress. We simulate the model under similar conditions to determine whether or not households’ elasticities of consumption with respect to the transfer depend significantly on the conditions under which the rebate is administered. We model a recession as a determined path of TFP, which is fully known to all households in the model.

Furthermore, given the substantially different economic conditions under which the 2001 and 2008 tax rebates were administered, we simulate recessions of two different lengths. The 2001 tax rebate was meant to stimulate the economy after a drop in output following a large economic expansion before the turn of the century. The 2008 tax rebate occurred in the midst of a large, developing banking crisis. At the time the rebates were received, Bear Sterns had already collapsed and some financial stocks such as Citigroup had declined precipitously. There was a reasonable expectation that the subsequent recession was going to be long and with a slow recovery. Using different persistence in drop in TFP, we can evaluate the effectiveness of the tax rebates under a wider variety of scenarios.

Financing the Rebate

To fund the tax rebate, the government can either borrow more money, raise taxes, or lower government consumption in the period in which the tax rebate is disbursed. These actions guarantee that the government budget constraint is satisfied. However, lowering government consumption is antithetical to the stated purpose of distributing a tax rebate to stimulate the economy, therefore we do not consider any scenarios in which this action is undertaken.

In our experiments, we finance the tax rebate through the issuance of an equivalent amount of debt. We assume that the interest on this debt is financed out of lower government consumption in subsequent periods. We consider two possible alternatives. First, we allow the debt to be slowly and incrementally retired, so that the government stock of debt returns to its steady state levels. Second, we allow the government stock of debt to grow permanently. Financing the debt service and possibly the debt retirement can be done by either lowering government consumption or raising taxes in the future. We consider both scenarios.
Results

Households

Our simulations show that households respond differently to the rebate. We identify and catalog the behavior of three different types of households: households that are strongly liquidity-constrained households, household that are not liquidity-constrained, and households that are loosely constrained. In our calibration, 17 percent of households are strongly liquidity-constrained. This percentage is fairly close to the approximately 20 percent reported in Jappelli (1990).

In figure 1, we present the effect of a tax rebate on a liquidity-constrained household. This household gets its tax rebate in period three. The top panel shows the results for the case in which the rebate is financed using a temporary increase in debt. In this case, the debt is slowly retired to steady state levels by reducing government consumption. The bottom panel shows the case in which the rebate is financed using a permanent increase in debt. Each panel documents three scenarios, one in which there is no drop in TFP (no recession), a short-lived drop in TFP (short recession), and persistent drop in TFP (long recession). Each series represents deviations from the scenario with the same path for TFP, but without tax rebate. The deviations are normalized by the size of the rebate for assets and consumption, which yields an approximate “share of the rebate spent” on the two categories. For labor, the deviations are normalized by the labor effort in the counterfactual, so the graphs show a percent change in labor effort compared to the alternative scenario. Liquidity-constrained households increase their consumption in the period of the tax rebate receipt. In this period, household consumption increases by approximately 65 percent of the rebate amount. The change in consumption spending in the following periods is insignificantly different than zero. These household don’t save any fraction of the rebate; their assets with tax rebate equal their assets without tax rebate as shown in the upper middle panel of figure 1. They also take advantage of their newfound wealth by marginally reducing their labor efforts, as shown in the upper right panel of the figure.

In figure 2, we present the effect of a tax rebate on a typical household with a non-binding borrowing constraint. In normal times, non-liquidity-constrained households have similar levels of consumption with and without tax rebates. Households increase their consumption by a little less than two
percent, using the tax rebate to partially boost their consumption. This increase in consumption, however, is persistent over time. However, the size of the increase in consumption declines with the size and length of the recession. Moreover, these households increase their assets by approximately the full value of rebate in the period of the receipt. The results for the same household in the case of a tax rebate financed with permanent increase in debt are extremely similar, but with a smaller increase in consumption—less than one percent of the rebate gets spent on consumption in each subsequent period.

In figure 3, we present the effect of a tax rebate on a loosely constrained household, defined as a household with very few assets. This household would typically be building up its stock of assets in the absence of a recession. The effect of the tax rebate differs significantly depending on the economic circumstances. In normal times, these households spend almost none of the consumption (upper-left panel), electing entirely to build up assets (upper-middle panel). These households continue to work (upper-right panel) as if nothing happened. In a short-recession, however, the household consumes a non-trivial portion of its rebate, equal to about 26 percent of the rebate (upper-left panel). In a long-recession, less of the rebate is spent on impact, and more of it is used to smooth consumption over the course of the recession. In the case of a permanent increase in taxes, the results are similar but slightly spread out. Specifically, the recession causes the households to move back toward its borrowing-constraint, altering how the household decides to spend its rebate check.

**Aggregate Implications of Household Behavior**

We find that households on average spend 10 to 11 percent of their rebates on consumption. This value is consistent with the results reported by Johnson, Parker and Souleles (2006) and Parker, Souleles, Johnson and McClelland (2010) for the 2001 and 2008 tax rebates respectively. This suggests that, on impact, the effect on aggregate consumption is small. Figure (4) presents the percentage deviation of consumption, output, and investment in the scenario with tax rebate from the baseline scenario without tax rebate. In the upper panel we consider a tax rebate financed by a

---

There are some households with very few assets that are moving toward the borrowing-constraint. The behavior of those households is similar to those that are liquidity-constrained.
temporary increase in debt, while in the lower panel we consider a tax rebate financed by a permanent increase in debt. We obtain similar results for the temporary and the permanent increase in debt. Aggregate consumption increases by about 0.5 percent over the baseline for the two periods in which the rebate is disbursed. The effects on output are negative, but very small. The drop in investment offsets the gains in consumption. Households shift out of savings in physical capital into government debt and consumption, affecting investment. Investment drops by about a percent-and-a-half in each of two quarters. In the scenario in which the tax rebate is financed by temporary debt, investment remains low until the government begins to pay back debt, at which point the capital stock begins to recover. In the scenario in which the tax rebate is financed with a permanent increase in debt, the crowd-out persists in perpetuity. Figure (5) presents the simulations with a small recession and figure (6) presents the simulations with a long recession. These simulations show similar features as those without recession. In fact, while the recession can impact household behavior, this does not translate into economically significant differences in the aggregate measurements. Investment, consumption, and output all move with approximately the same magnitude that they do in the scenario without a recession.

The U.S. economy by the end of 2001 was influenced by substantial shocks, many completely independent of the 2001 tax rebate. We are unable to identify the effect of the tax rebate separately from these other shocks. Nonetheless, we compare consumption and investment against U.S. consumption and investment to show that the model is consistent with some of the developments in the U.S. economy.

In the fourth quarter of 2001, which was the first full quarter after the receipt of the tax rebate, personal consumption increased by 6.41 percent at an annualized rate, about 4.6 percent faster than the previous quarter and 2.9 percent faster than the overall consumption. Personal consumption excluding durable goods, increased by 2.9 percent at an annual rate, a slight three-tenths of a percentage slower than the historical average but 1.6 percent faster than the previous quarter. In the subsequent quarter, namely the first quarter of 2002, consumption in both categories falls to an annual rate significantly below the historical averages.

In our model, normalizing for the size of our rebate, consumption increases at an annual rate of about 0.6 percent; however, due to construction of our model, this increase is spread out over two quarters. Overall, the increase and decrease are smaller than those observed in the data, but share the same
Investment dropped by 21 percent in the fourth quarter of 2001 and subsequently bounced back by margins that significantly exceed the predictions in our model. Nonetheless, our model similarly predicts that investment drops significantly as compared to consumption, a feature reflected in the data on investment. While we would not attribute the magnitude of these changes to the effects of the tax rebate, at first glance, the signs of changes to consumption and investment is consistent with the features of the model.

Fiscal Multipliers

Fiscal multipliers are commonly used to measure the stimulative effect of a fiscal policy on consumption and output. We construct two sets of multipliers, one for output $Y$ and one for consumption $C$. These multipliers describe the cumulative increase in the level of $Y$ and $C$, respectively, over the subsequent $k$ quarters in response to a change in transfers during periods $t$ and $t + 1$.

Formally, the multiplier for output over $k$ quarters is defined as

$$M_Y(k) \equiv \frac{\sum_{i=0}^{k} Y_{t+i}^A - Y_{t+i}}{\sum_{i=0}^{2} T r_{t+i}^A - T r_{t+i}}$$

where $Y_{t+i}$ is output $i$ periods from the first mailing of the tax rates. Variables with the $A$ superscript refer to the alternate scenario, in which the tax rebate is mailed; variables without the $A$ subscript refer to the baseline scenario, without the tax rebate. We report cumulative multipliers at 2, 4, and 8 quarter horizons. The 2 quarter is roughly analogous to the impact multiplier reported in other work. The consumption multiplier is constructed in the same way.

Table (2) presents the fiscal multipliers when the tax rebate is financed by a short-run increase in debt. The left panel reports the consumption multiplier. For a horizon of 2 quarters, this multiplier is positive, but small. For longer horizons, the additional effect of the tax rebate on consumption is still positive, but smaller. The value of our consumption multiplier is lower than that obtained within Keynesian models. The consumption multipliers

\[\text{\textsuperscript{10}The cumulative multipliers are not discounted. Discounting by either the interest rate in the baseline or the counterfactual experiment yields results that are not significantly different at these horizons.}\]
Table 2: Tax Rebate Multipliers: Temporary Debt Increase

<table>
<thead>
<tr>
<th>Recession</th>
<th>Consumption</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 qtr</td>
<td>4 qtr</td>
</tr>
<tr>
<td>None</td>
<td>0.135</td>
<td>0.155</td>
</tr>
<tr>
<td>Short</td>
<td>0.135</td>
<td>0.155</td>
</tr>
<tr>
<td>Long</td>
<td>0.131</td>
<td>0.151</td>
</tr>
</tbody>
</table>

for both long and short recessions are almost identical to those for normal times.

The right panel reports the output multiplier. We find negative output multipliers at any time horizons. Increased government borrowing causes investment to decrease, which lowers the capital stock. This small decrease in the capital stock together with a small decrease in labor yields a negative output multiplier. Unlike the effects on consumption, which diminish quickly after the tax rebates expire, the effects on output are slightly more persistent. However, the output multipliers in absolute value are always smaller the consumption multipliers.

Table 3: Tax Rebate Multipliers: Permanent Debt Increase

<table>
<thead>
<tr>
<th>Recession</th>
<th>Consumption</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 qtr</td>
<td>4 qtr</td>
</tr>
<tr>
<td>None</td>
<td>0.117</td>
<td>0.121</td>
</tr>
<tr>
<td>Short</td>
<td>0.120</td>
<td>0.128</td>
</tr>
<tr>
<td>Long</td>
<td>0.118</td>
<td>0.125</td>
</tr>
</tbody>
</table>

Table (3) presents the fiscal multipliers when the tax rebate is financed by a permanent increase in debt. These multipliers are similar to those associated with the temporary debt increase. The effects on consumption, shown in the left panel, however, are almost completely realized upon the tax rebate receipt. On impact, liquidity-constrained households spend most of their rebates and very little is left to be consumed at later periods. The effects on output, shown in the right panel, are smaller on impact and greater at longer horizons, compared to the scenario of a tax rebate financed by a short-run increase in debt. Overall, however, these fiscal multipliers are small under any experiment and at any horizon.
Conclusion

We estimate a structural general equilibrium model to examine the effect of the 2001 tax rebate on consumption. The empirical evidence that the permanent income hypothesis does not necessarily hold, particularly for poor and liquidity-constrained households, motivates us to build a model with heterogeneous and borrowing-constrained households, following Aiyagari (1994). As a preliminary results of our structural estimation, we obtain a set parameters that approximate the share of liquidity-constrained households in the economy and the share of a tax rebate that is spent by households. About 17 percent of the households in our model are liquidity-constrained, which is close to the 20 percent of U.S. households that are liquidity-constrained, as estimated by Jappelli (1990). Moreover, the average household in our model spends approximately 11 percent of their tax rebate on consumption, which is consistent with the parameters estimated by Johnson, Parker and Souleles (2006) and Parker, Souleles, Johnson and McClelland (2010).

However, these household responses to the tax rebate translate into very small fiscal multipliers for consumption and output, the latter of which is negative. Although consumption increases upon receipt of the tax rebate, this increase is very short-lived. Furthermore, government borrowing to finance the debt crowds out other forms of investment, leading to a drop in the growth rate of productive capital. These results do not depend on whether the tax rebate is financed with a permanent or temporary increase in debt and are consistent across all scenarios examined.

Our finding of small fiscal multipliers is not without precedent. Coenen et. al. (2010) report that many structural models, used by policy organizations around the world, generate very small fiscal multipliers following a shock to transfers. This is specifically true for models without rule-of-thumb households, who spend their entire incomes on consumption. Unlike those models, our model presents only one friction - a borrowing-constraint - and is able to replicate many empirical microeconomic aspects of household behavior. Therefore, our micro-founded general equilibrium model provides an adequate framework for macroeconomic analysis of tax rebates.
References


Appendix

Redefining the Household Problem

For non-negative level of government debt $B$, there exists at least one household that is not borrowing-constrained. Combining this household’s first order necessary conditions on government debt and productive capital, we get the relationship between the two interest rates

$$ r^a \equiv (1 - \delta + (r^k)(1 - \tau_k)) = (1 + r^b(1 - \tau_b)) $$

that must hold in equilibrium. We define $r^a$ as the net after-tax, after depreciation return to holding either asset. We define a generic asset

$$ a = b + k $$

which will allow us to redefine the household problem (1) in terms of three state variables that sufficiently describe the household. The household problem reduces to

$$ V_t(\epsilon, a, s) = \max_{a', l, c} U(c, l) + \beta E[V_{t+1}(\epsilon', a', s)] \quad (11) $$

Approximations

We choose a 10 point grid for assets. The value functions are continuously approximated over the state space using nine-degree Chebychev polynomials.

The level of household productivity $\epsilon$ is approximated by a discrete grid. The grid of levels of productivity and the transition matrix are generated using the method detailed in Tauchen (1986). They are functions of two parameters $\rho$ and $\sigma_\epsilon$, corresponding to the persistence and variance of the labor productivity shocks.

Solving the Household Problem - The Inner Loop

Conditional on a value for next period’s assets ($a'$), the household consumption and labor first order necessary conditions are combined to obtain values for current consumption $c$ and labor ($l$). Therefore, the household problem becomes an optimization problem over the asset space alone.

Starting with an initial guess for the value function $V$ and conditional on a set of interest rates ($r^a$) and wages ($w$), we solve the household problem
and update the value function. This value function iteration is repeated until $V$ converges.

**Solving the Household Problem - The Outer Loop**

**Firms’ FONCs**

\[
\begin{align*}
w_t &= Z_t (1 - \alpha) \left( \frac{K_t}{L_t} \right)^{\alpha} \\
r_t &= Z_t \alpha \left( \frac{K_t}{L_t} \right)^{\alpha - 1}
\end{align*}
\]

**Government Budget Constraint**

\[
\tau_c c_t + \tau_k r_k K_t + \tau_l w_t L_t + B_{t+1} + \tau_b r_b^b B_t = G_t + TR_t + (1 + r_b^b) B_t
\]

**Household FONCs**

Definition of the household problem:

\[
\max_{b_{t+1}, k_{t+1}, c_t} u(c_{t+1}^1, l_t) + \beta E[V_{t+1}(\epsilon_{t+1}, b_{t+1}, k_{t+1})]
\]

\[
-\lambda_t [(1 + \tau_c) c_t + k_{t+1} + b_{t+1} - b_t (1 + r_b^b (1 - \tau_b)) - \epsilon_t w_t n_t (1 - \tau_l) - (1 - \delta + (r_t)(1 - \tau_k)) k_t - tr_t]
\]

\[
-\mu_t [b_{t+1} + k_{t+1} - b_t]
\]

where $\lambda$ and $\mu$ are the Lagrange multipliers on the budget constraint and the borrowing-constraint respectively.

**FONCs:**

\[
(c_t) : u_1(.) - \lambda_t (1 - \tau_c) = 0
\]

\[
(l_t) : u_2(.) + \epsilon_t w_t (1 - \tau_l) = 0
\]

\[
(BC) : (1 + \tau_c) c_t + k_{t+1} + b_{t+1} - b_t (1 + r_b^b (1 - \tau_b)) - \epsilon_t w_t n_t (1 - \tau_l) - (1 - \delta + (r_t)(1 - \tau_k)) k_t - tr_t = 0
\]
Defining the Equilibrium

We define the equilibrium to be

- a set of prices \( w, r^a, r^b \), and \( r^b \)
- a set of household choices \( c(.), k(.), b(.), l(.) \)
- a set of firm choices \( K, L \)
- a set of determined (exogenous) government choices for government bonds \( B \) and tax rates, and an endogenous government expenditure \( G \) over time, such that the household and firm solve their problems, the government budget constraint is satisfied, the aggregation identities are satisfied, and market clearing conditions are satisfied.

Solution Method for Steady State

We start with guesses for the prices \( w, r^a, r^b, \) and \( r^b \).

Step 1: The Household Problem

We use Value Function iteration to solve the household’s problem:

\[
V_t(\epsilon_t, a_t) = \max_{a_{t+1}, l_t, c_t} U(c_t, l_t) + \beta E[V_{t+1}(\epsilon_{t+1}, a_{t+1})]
\]

subject to the borrowing-constraint and budget constraint. The Value Function is approximate by a \( n \)-degree Chebyshev polynomial. The assets \( a_t \) and \( k_t \) are two continuous state variables, while the working ability shock \( \epsilon_t \) is a discretized state variables. The value function iterations are repeated until the solution converges.

Step 2: Simulating a Measure of Households

We simulate \( N \) households for \( M \) periods. We find the optimal decision rules for each simulated household using approximations of the policy functions (the argmax) obtained in Step 1. We choose \( M \) and \( N \) to be large enough such that the empirical cumulative distribution function of the simulation in period \( M \) is a reasonable approximation for the limiting distribution of households.
Step 3: Aggregating Across Households

We integrate over the distribution of households to get $L, C, A$.

Step 4: Updating the Factor Prices

We use the Gauss-Newton algorithm to solve for an updated set of prices. In particular, we are looking for a solution to the following system of nine equations:

\[
\begin{align*}
    w_t &= Z_t (1 - \alpha_1) \left( \frac{K_t}{L_t} \right)^{\alpha_1} \\
    r_t &= Z_t \alpha_1 \left( \frac{K_t}{L_t} \right)^{\alpha_1 - 1} \\
    A_t &= B_t + K_t \\
    \tau_c C_t + \tau_k r_k K_t + \tau_l w_L L_t + B_{t+1} + \tau_b r_b B_t &= G_t + TR_t + (1 + r^b_t) B_t \\
    (1 - \delta + (r_{t+1})(1 - \tau_b)) &= (1 + r^b_{t+1}(1 - \tau_b))
\end{align*}
\]

We need to find values of $w, r^k, r^b, K$, and $G$ that satisfy those first-order conditions, budget constraints, and resource constraints. We update the values of $w, r^a, r^k$, and $r^b$ as a convex combination of the previous iteration values and the new values computed in Step 4. We check for convergence in these five prices. If the distance of the old and new values is smaller than a predetermined criteria, stop. Otherwise return to step 1 with the updated prices and repeat.

Solution Method for Transition

We consider a simulation with $0, \ldots, T$ periods. The beginning steady state characterizes period 0, while the ending steady state (if different) characterizes period $T$. We start with guesses for the prices $w_t, r^k_t, r^b_t$, and $r_t$ for all $t = 1, \ldots, T - 1$. 
Step 1: Solving the Household Problem

Starting at $T-1$, we solve the household problem given prices $w_{T-1}$, $r^a_{T-1}$, $r^b_T$, and $r^k_T$. We compute the value function, $V_{T-1}(.)$. Using the value function $V_{T-1}(.)$, we solve the household’s problem in period $T-2$ given prices in those periods. We repeat the process until time period 1.

Step 2: Simulating the Household

Using the policy functions derived in Step 1, we simulate household behavior. Starting with the measure from period 0, we start in period 1 and simulate through time period $T-1$. We aggregate economic variables in each period. We use government consumption to balance the government budget.

Step 3: Recompute and Update Prices in Each Period

Using the same method in Step 5 of the Steady State procedure, we compute new prices for $w_t$, $r^a_t$, $r^b_t$, $r_t$, and $r^k_t$ for each $t = 1, \ldots, T-1$. We update these prices as a convex combination of the old estimates and the new ones. If prices have converged, stop; otherwise return to Step 1 with these updated prices.
Figure 1: Tax Rebates and Liquidity-Constrained Households
Figure 2. Tax Rebates and Unconstrained Households.
Figure 3: Tax Rebates and Loosely Constrained Households
Figure 4: Macroeconomic Effects of a Tax Rebate
Figure 5: Macroeconomic Effects of a Tax Rebate During a Short Recession
Figure 6: Macroeconomic Effects of a Tax Rebate During a Long Recession