Micro MPCs and Macro Counterfactuals: The Case of the 2008 Rebates

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Abstract

We present evidence that the high estimated MPCs from the leading household studies result in implausible macroeconomic counterfactuals. Using the 2008 tax rebate as a case study, we calibrate a standard medium-scale New Keynesian model with the estimated micro MPCs to construct counterfactual macroeconomic consumption paths in the absence of a rebate. The counterfactual paths imply that consumption expenditures would have plummeted in spring and summer 2008 and then recovered when Lehman Brothers failed in September 2008. We use narratives and forecasts to argue that these paths are implausible. We then show that standard two-way fixed effect estimates of the micro MPCs are upward biased. When we correct for the biases, we estimate smaller micro MPCs than the previous literature. We also show that reasonable modifications of the model result in general equilibrium forces that dampen rather than amplify micro MPCs. The combination of smaller micro MPCs and dampening general equilibrium forces implies general equilibrium consumption multipliers that are below 0.2.

JEL codes: E21, E27, E62
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1 Introduction

Numerous studies in the last twenty years have used panel data from households to estimate the marginal propensity to consume out of anticipated, temporary changes in income. Some of the leading studies in this area estimate the effects of the temporary tax rebates of 2001 and 2008. For example, the Shapiro and Slemrod (2003, 2009), Johnson et al. (2006), Sahm et al. (2012), Parker et al. (2013), and Broda and Parker (2014) analyses are exemplars in the use of natural experiments to obtain estimates of this key micro parameter of interest to macroeconomists. Moreover, in some of the best examples of entrepreneurial data collection, these authors added special questions to existing household surveys in order to match the household behavior to the timing of its receipt of the rebate. Parker and co-authors found some very high estimates for the marginal propensity to consume (MPC). For example, Parker et al. (2013) found a marginal propensity to spend out the temporary tax rebate of 50 to 90 percent on total consumption within three months of receiving the 2008 tax rebate (p. 2531, Table 3).

Estimates from these studies have motivated the thriving literature on heterogeneous agent models in which some households live hand to mouth because of myopia or financial market imperfections. The estimates have been used to calibrate a wide variety of macro New Keynesian heterogeneous agent models and to argue that temporary tax rebates can have large aggregate multipliers. For example, Kaplan and Violante (2014), Kaplan et al. (2018), and Auclert et al. (forthcoming) calibrate their heterogeneous agent models to match an MPC of 25 percent on the nondurables component of consumption expenditures. Government policy in recent years has been guided by the high MPC estimates.

In this paper, we present evidence that the high estimated MPCs from the leading household studies result in implausible macroeconomic counterfactuals. Using the 2008 tax rebate as a case study, we calibrate a standard medium-scale New Keynesian model with the estimated MPCs to construct counterfactual macroeconomic consumption paths in the absence of a rebate. The counterfactual paths imply that consumption expenditures would have plummeted in spring and summer 2008 and then recovered when Lehman Brothers failed in September 2008. Based on narrative evidence and forecasts, we argue that these paths are implausible and that the actual stimulus effect of the rebates must have been modest. In the second half of the paper, we reconcile the micro estimates with the aggregate data by correcting for upward biases in the micro MPC estimates and by introducing realistic dampening forces in the macro model.

Some earlier work questioned the high MPC estimates in light of aggregate data. In their analyses of the aggregate effects of the tax rebates of 2008, Feldstein (2008) and Taylor (2009) found little evidence of a response in aggregate consumer expenditures and concluded that consumers mostly saved the rebate. However, their aggregate analyses were soon overshadowed by the impressive household-level analysis.

Sahm et al. (2012) also estimated micro MPCs out of the 2008 rebate from rich survey data, but found lower MPCs than the other household-level studies. They noted that a significant part of Parker et al.'s (2013) high MPCs came from spending on motor vehicles, and calculated the implied fraction of actual motor vehicle sales that were induced by the 2008 rebate according to the Parker et al. (2013) estimates. They commented that this estimate was "surprisingly high" given that there were no dramatic shifts in motor vehicle sales around that time.[1] They cautioned, however, that their exercise did not allow for any partial or general equilibrium effects.

Most of the literature has overlooked Sahm et al.'s (2012) important calculation. Figure 1, which updates Ramey (2018), shows actual expenditures on new motor vehicles as the black solid line, along with the implied counterfactual spending estimate depicted by the purple dashed line. This counterfactual is created as the difference between the actual spending and the estimated induced spending from the rebate using Parker et al.'s (2013) estimates.

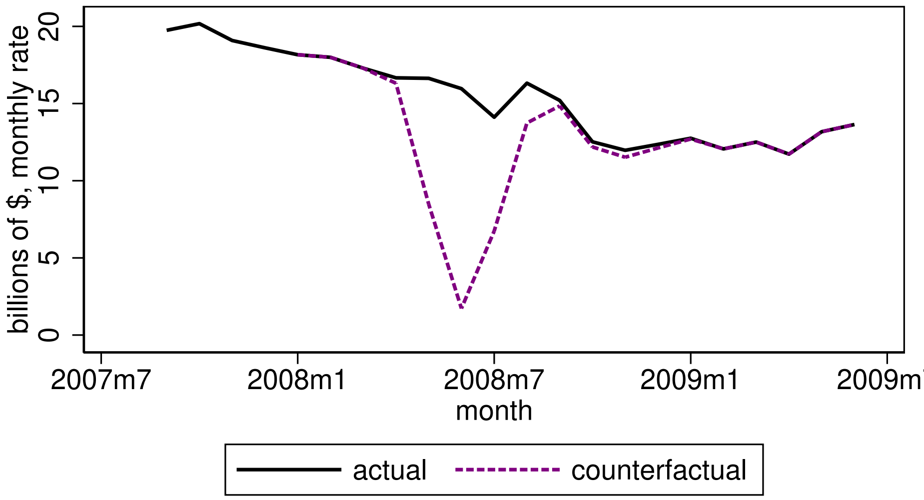
The counterfactual implies that had there been no tax rebates, expenditures on motor vehicles would have declined from $17 billion in March 2008 to less than $3 billion in June 2008 and then would have rebounded sharply in late summer, averaging $14 billion per month in August and September 2008. This counterfactual strains credulity, especially since the lowest actual level of motor vehicle expenditures during the Great Recession was $12 billion in April 2009.[2] The cumulative induced expenditures on motor vehicles implied by the Parker et al. (2013) estimates is over $30 billion.

In the first part of this paper, we extend the logic of the Sahm et al. (2012) exercise to a dynamic general equilibrium setting to study the implications of estimated micro MPCs for the counterfactual path of total consumption in 2008 with no rebates. Our

1. See p. 242 and Table 14 of Sahm et al. (2012). Sahm et al. (2010) compare their own micro MPC estimates to total aggregate consumption in a similar exercise.

2. The appendix contains details of the calculation. It also shows that when we allow consumers to smooth the spending over more months, the counterfactual remains implausible.

Figure 1. Expenditures on New Motor Vehicles: Actual vs. Counterfactual



Note. Based on Sahm, Shapiro, and Slemrod calculations applied to revised data.

method proceeds as follows. We first construct a medium-scale two-good, two-agent New Keynesian (TANK) model in which some households are life-cycle permanent income households and others are "hand-to-mouth" households who consume all their income. We calibrate the fraction of hand-to-mouth households in the economy and their dynamic propensities to spend to match the MPC estimates from the household-level data. In this model, aggregate consumption rises from both the direct micro effect of the rebate on consumption at the household level and the induced macroeconomic effect on income through Keynesian multipliers. We call the sum of these two effects on aggregate consumption per dollar of rebate the *general equilibrium marginal propensity to consume* out of the rebate, or GE-MPC for short. We then use the model to simulate the macroeconomic effects of a path of rebates that matches the timing and size of the actual 2008 rebate, which was announced in February and distributed mostly from April through July 2008. To create the counterfactual path of aggregate consumption in 2008 with no tax rebate, we subtract the model-simulated deviation from steady state from actual aggregate NIPA consumption.

The counterfactual paths created from our baseline simulations with average household MPCs calibrated to the estimates from Parker et al. (2013) imply a deep V-shape from April 2008 through August 2008 had there been no rebates. Specifically, the counterfactual implies that consumption would have collapsed from May through July 2008 and recovered in August and September 2008, when Lehman Brothers failed. The implied decline in consumption expenditures absent the rebate from May through July is larger than any other historical three-month decline, with the exception of the Covid-19 shutdown. Using narrative evidence and forecasts, we argue that this scenario is implausible.

Our claim about counterfactual aggregate consumption paths begs the question: How does one reconcile the high estimated micro MPCs from the literature with the implausible general equilibrium counterfactuals? One possibility is an upward bias in the existing household MPC estimates. A second possibility is that general equilibrium forces, rather than magnifying the micro MPCs, actually dampen them. In the second half of the paper, we explore each of these possibilities and conclude that both are key to explaining the implausible counterfactuals.

We first revisit the micro MPC estimates, building on Kaplan and Violante's (2014) early insights regarding the interpretation of the rebate coefficient as an MPC, as well as on the more recent econometric literature that has uncovered potential problems with event studies in general (e.g. Sun and Abraham (2020), Borusyak and Jaravel (2017), Borusyak et al. (2022).) We find that estimates of MPCs based on the standard equation used to test the permanent income hypothesis are affected by three separate biases: omitted variable bias, forbidden comparisons with previously treated households, and a rebate reporting bias. When we estimate a more general model that corrects these biases on CEX data, the MPC estimates fall significantly: from 0.5 to 0.3 in the full CEX sample and from 0.9 to 0.4 in the sample containing only rebate recipients.

Even with our new lower micro MPC estimates, the model still generates implausible macro counterfactuals because its general equilibrium forces amplify the micro MPCs. However, this model misses an important equilibrium force: In the data the relative price of motor vehicles spikes up after the 2008 rebate. In contrast, the model follows the existing literature in assuming that durable and nondurable goods can be frictionlessly converted. This infinite relative supply elasticity fixes the relative price at 1. Following McKay and Wieland (2021) we then directly model the supply of durable goods and calibrate the relative supply elasticity to 5 based on micro evidence. We find that realistic movements in the relative price of motor vehicles generate substantial dampening in general equilibrium. The counterfactuals are no longer implausible, but the aggregate effects of the rebate are small: less than 20 cents for each dollar.

Three model elements are key to this aggregate effect: (i) the majority of spending from the rebate is on motor vehicles; (ii) the short-run supply curve for motor vehicles is upward sloping; and (iii) demand for motor vehicles is relatively elastic. Thus, the rebate-induced demand for motor vehicles from the hand-to-mouth households results in a rise in the relative price of motor vehicles, which crowds out motor vehicle expenditure by optimizing households. The high demand elasticity implies that even a modest increase in the relative price can lead to substantial crowding out of durable expenditure by the optimizing households. This is true across a range of estimates for the vehicle demand elasticity spanned by Bachmann et al. (2021) and Baker et al. (2019).

Our findings imply that policy prescriptions from Hetergeneous Agent New Keynesian (HANK) models depend importantly on the distribution of spending across nondurable and durable goods, and not only on the overall MPC.[3] Given an overall micro MPC of 0.3 with the distribution of spending from the 2008 rebates, the GE MPC for total consumer expenditures is less than 0.1. If we instead abstract from durable goods and assume an MPC of 0.3 on nondurables, then the GE MPC is 0.4 rather than 0.1. Thus, the nondurable-only model with the same overall MPC predicts too large a stimulus from a tax rebate. This is because intertemporal elasticity of substitution of nondurable demand is much less than for durable demand and the flat Phillips curve makes nondurable supply very elastic, so there is no dampening.

The combination of dampening general equilibrium forces and more modest micro MPC estimates yields macroeconomic counterfactuals that we consider plausible. However, they also imply that the effect of the rebate on consumption expenditures in general equilibrium was modest. With our preferred micro MPC of 0.3, we find that the general equilibrium increase in total consumer spending was only 7 cents per dollar of the total rebate.

The paper is structured as follows. Section 2 provides a brief description of the details of the 2008 tax rebate and the behavior of aggregate disposable income and consumption in 2008. Section 3 presents the counterfactuals constructed from a standard two-agent, two-good New Keynesian model. It then argues that these counterfactual paths are implausible based on narratives, real-time forecasts, and comparisons with other historically-large drops in consumption.

3. Berger and Vavra (2015) and McKay and Wieland (2021, 2022) are some examples that explicitly consider durable goods. Laibson et al. (2022) provide a mapping from notional MPCs to MPXs and vice-versa. Their baseline formula assumes a fixed relative durable price, but a time-varying durable price can be accommodated in the same way as they account for durable adjustment costs.

The remainder of the paper reconciles the micro MPCs with the macro counterfactuals. Section 4 revisits the micro estimates and demonstrates that they are biased upward. Section 5 modifies the model to incorporate more dampening effects in general equilibrium, which in conjunction with the smaller micro MOCs produces plausible macro counterfactual.

Section 6 summarizes and concludes.

2 The 2008 Rebates

In February 2008, Congress and Administration enacted $100 billion in rebates totaling eleven percent of January monthly disposable income. The amount of the rebate received by a household depended on tax status and dependents and was phased out at higher income levels; among the 85 percent of households receiving a check, the average amount was $1,000. Most of the rebates were distributed from April through July 2008 and the timing of distribution was randomized according to the last two digits of the Social Security number.

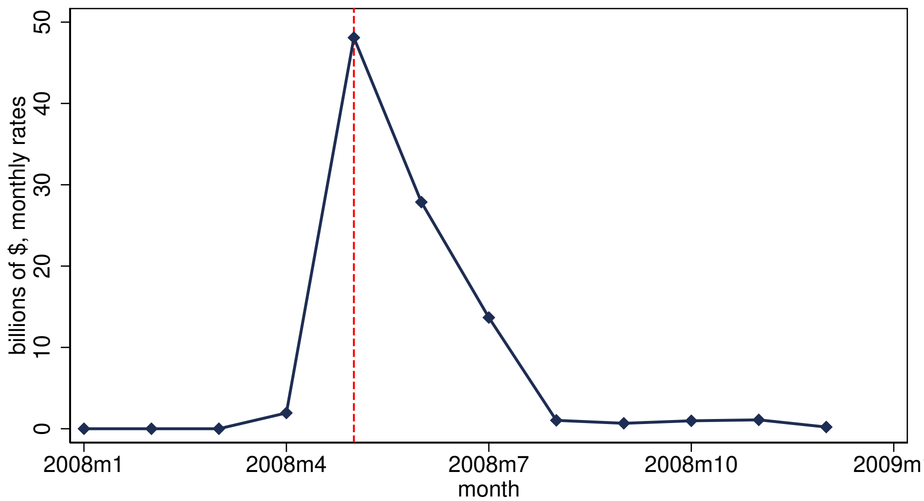
The actual time path of the rebates is shown in Figure 2. The graph shows that almost half of the total amount was distributed in May alone, with most of the remaining rebates distributed in June and July. Figure 3 shows the behavior of real NIPA disposable personal income and consumption expenditure from mid-2007 through mid-2009.[4] The vertical red dashed line indicates May 2008 when almost half of the rebate checks were distributed. The effect of the 2008 tax rebate on disposable income is clearly evident in the spike in real disposable income series. However, real consumption displays only a small bump in the summer of 2008.[5] These patterns in the aggregate data led Feldstein (2008) and Taylor (2009) to conclude that the aggregate impact of the rebate must have been small.

One explanation for the modest consumption changes is that the BEA's smoothing procedures remove any high-frequency movements in personal consumption expenditures. We refute this argument in Appendix C.3: The underlying retail sales data features no spike in expenditure in summer 2008; well-measured components of ex-

4. For better illustration, real income and consumption are normalized to equal nominal values in January 2008 and the scaling of the y-axis is the same across the two graphs so that the variation in quantities can be compared.

5. Appendix C.2 shows the behavior of the nominal series and discusses the behavior of inflation in 2008.

Figure 2. 2008 Tax Rebates



Notes. Data from Shapiro and Slemrod (2009). Rebates are nominal. Vertical red dashed line indicates May 2008.

penditure such as car expenditure feature no spike; and the CEX data that Parker et al. (2013) use to estimate high micro MPCs also features no spike. In short, we find no role for measurement error in explaining the divergence of income and consumption expenditure in Figure 3.

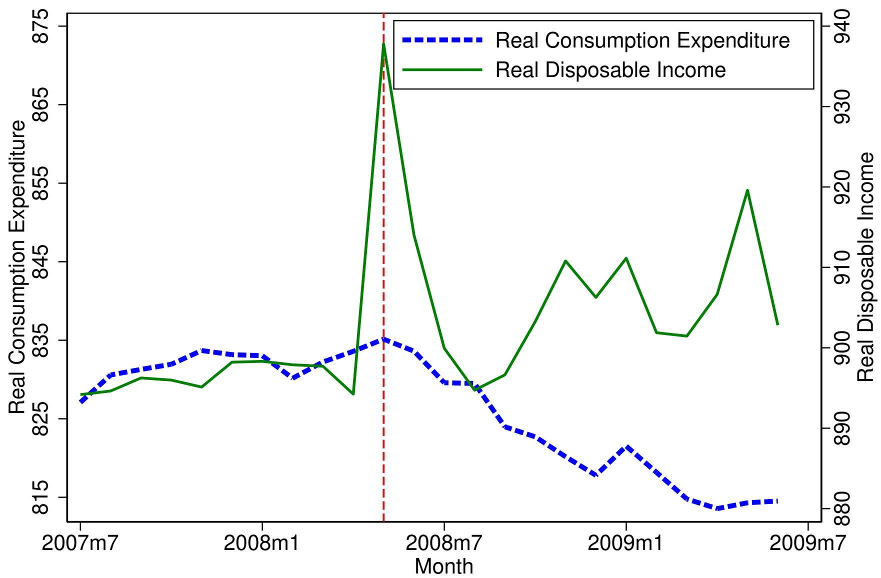
3 Macro Counterfactuals from a New Keynesian Model

We now use a standard medium-scale New Keynesian model, augmented with durable consumer goods, to show that the leading micro MPC estimates for the 2008 rebate lead to implausible counterfactuals for total consumption and motor vehicle expenditures even when we take into general equilibrium forces. We first derive the model-implied counterfactuals and then use forecasts and comparisons with historical drops in consumption to argue that they are implausible.

3.1 Two-Good, Two-Agent New Keynesian Model

We construct general equilibrium counterfactuals by simulating the effects of the rebate on aggregate consumption using a two-agent, two-good, medium-scale New Key-

Figure 3. Real Aggregate Disposable Income and Consumption Expenditure



Source. BEA data. Vertical red dashed line indicates May 2008.

nesian model. In the model, aggregate consumption rises due to both the direct micro effect of the rebate on consumption and the induced macro effect on income through Keynesian multipliers. We call the sum of these two effects on consumption the *general equilibrium marginal propensity to consume* of the rebate, or GE-MPC for short. We then subtract the simulated model deviations from steady state from actual aggregate consumption to create counterfactual paths of aggregate consumption in 2008, i.e., the path of aggregate consumption had there been no rebate.

Our model is based on Ramey's (2021) extension of Galí et al.'s (2007) fiscal two-agent New Keynesian (TANK) model, but calibrated to a monthly frequency. The main addition to the model is a durable consumption good, which we interpret as motor vehicles. This part of the model builds on the recent analysis of durable goods expenditures by McKay and Wieland (2021, 2022).

The two-agent, two-good structure allows us to exactly target the MPCs to a rebate that are estimated in the micro data. In this way, our model will produce the identical increase in demand that we observe at the micro-level even as we abstract from the complexity of micro foundations for hand-to-mouth behavior or durable expenditures.[6] Since the purpose of the model is to show how this increase in demand at the micro-level gets propagated in general equilibrium, we consider a rich set of general equilibrium forces and calibrate their strength in accordance with the evidence. Thus, our approach builds on Auclert et al. (2018) and Wolf (2021), who show that the micro-level increase in demand and the strength of general equilibrium forces are sufficient statistics for how a demand shock gets propagated in general equilibrium, irrespective of the model structure that generates the increase in demand and the general equilibrium forces.

We begin by describing the household's problem in more detail since it is less standard than the other parts of the model. We then briefly summarize the other features, and refer interested readers to the appendix for more details.

Optimizing Households

A measure $1-\gamma$ of ex-ante identical households maximize utility subject to their budget constraints. Optimizing households form a family that provides consumption insurance across household members. To reduce the extremely high willingness to intertemporally substitute durables purchases that arises in standard models,[7] we assume that only a fraction $1-\theta^d$ of all optimizing households decide to reoptimize their durable stock at any point in time. This friction, which is motivated by Evans and Ramey's (1992) model of calculation costs, produces a reversal in durable spending consistent with the evidence (e.g. McKay and Wieland (2021)) and keeps the model tractable because it produces a Calvo-type reduced form.[8]

6. We explored counterfactuals in a heterogeneous agent fixed cost model as in McKay and Wieland (2021). However, this model always produces implausible counterfactuals because it implies a larger increase in demand at the micro level and stronger amplification in general equilibrium. In contrast to our calibrated two-agent model, standard incomplete markets heterogenous agent models imply that the MPC out of the rebate remains positive after three months. This yields both a larger increase in demand at the micro level after three months and implies a larger Keynesian multiplier. However, as we discuss in the model calibration, we find little evidence for positive MPCs after three months.

7. See Koby and Wolf (2020) and McKay and Wieland (2021).

8. In contrast, a conventional convex adjustment cost mechanically induces positive serial correlation in a household's purchasing decisions and thereby overstates the crowding out from higher durable goods prices. For richer models of household durable decisions, see, for example, Carroll and Dunn's (1997) and Attanasio et al.'s (2022) household-level analysis or McKay and Wieland's (2021) general equilibrium analysis.

The utility function for the family of optimizing households is:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t^o)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} + \psi \frac{\int_0^1 D_t^o(i)^{1-\frac{1}{\sigma^d}} di}{1-\frac{1}{\sigma^d}} - \nu \frac{(H_t^o)^{1+\phi}}{1+\phi} \right]$$

where C_t^o is nondurable consumption, $D_t^o(i)$ is the durable stock of household i, and H_t^o is hours worked. For brevity, only the durables stock is indexed by household i since the other arguments are identical across households. The aggregate household budget constraint is

$$\begin{aligned} A_t^o &= \frac{R_{t-1}}{\Pi_t} A_{t-1}^o - C_t^o + W_t H_t^o - X_t^o - OC_t^o - T_t^o + \text{Profits}_t^k + \text{Profits}_t^s \\ X_t^o &= p_t^d \left[\int_0^1 [D_t^o(i) - (1-\delta^d) D_{t-1}^o(i)] di \right] \\ OC_t^o &= \eta \int_0^1 D_t^o(i) di \end{aligned}$$

where R_t is the gross nominal interest rate, Π_t is the gross inflation rate measured in nondurable goods prices, A_t^o are holdings of the nominal bond, W_t is the real wage, T_t^o are net taxes (i.e. taxes less transfers), Profits^k are profits of the capital good producing firms, and Profits^s are profits of the sticky-price firms, which produce nondurable goods. X_t^o is net durable expenditures denominated in nondurable goods, and are the sum of net durable purchases of each household, $D_t^o(i) - (1-\delta^d) D_{t-1}^o(i)$. OC_t are operating costs for the durable good (e.g., gasoline) which are a fraction η of the total durable stock held by all households. The inclusion of operating expenditures also helps produce more realistic elasticities of durable demand.

Optimizing households pick an optimal plan $\{C_t^o, A_t^o, D_t^o(i)\}_{t=0}^{\infty}$ to maximize utility. Labor supply is not chosen by the household, but instead by a union as discussed below. The first order conditions for C_t^o, A_t^o are:

$$\begin{aligned} \lambda_t &= (C_t^o)^{-\frac{1}{\sigma}} \\ \lambda_t &= \beta \frac{R_t}{\Pi_{t+1}} \lambda_{t+1} \end{aligned}$$

where λ is the Lagrange multiplier on the household budget constraint.

We next derive the optimal choice of $D_t^o(i)$ conditional on making an adjustment. Because the durable stock of household i in the problem is separable from the durable stock of other households, the durable part of the optimization problem for household i is simply,

$$\max_{D_t(i)} \sum_{s=0}^{\infty} (\beta\theta^d)^s \left[\psi \frac{D_t(i)^{\frac{\sigma^d-1}{\sigma^d}}}{1-\frac{1}{\sigma^d}} - \lambda_{t+s}\eta D_t(i) \right] - \lambda_t p_t^d D_t(i)$$
$$+ \sum_{s=0}^{\infty} \beta^s (\theta^d)^{s-1}(1-\theta^d)\lambda_{t+s} p_{t+s}^d (1-\delta^d)^s D_t(i)$$

Here $(\theta^d)^s$ is the survival probability of the current durable stock into period s, $\psi \frac{D_t(i)^{\frac{\sigma^d-1}{\sigma^d}}}{1-\frac{1}{\sigma^d}}$ is its contribution to household utility, $\lambda_{t+s}\eta D_t(i)$ is the operating cost while the durable stock remains in place, measured in utils, $\lambda_t p_t^d D_t(i)$ is the purchasing price in utils, and $\lambda_{t+s} p_{t+s}^d (1-\delta^d)^s D_t(i)$ is the resale value of the durable in utils if another adjustment opportunity arises at time $t+s$.

The problem is identical across households that can make an adjustment at time t. Therefore, let D_t^{o*} denote the optimal reset value for the durable stock at time t. In Appendix A we show that the first order conditions of the problem can be written as,

$$D_t^{o*} = \left(\frac{\Omega_{1t}}{\Omega_{2t}}\right)^{\sigma^d}$$
$$\Omega_{1t} = \psi + \beta\theta^d(1-\delta^d)\Omega_{1,t+1}$$
$$\Omega_{2t} = (p_t^d + \eta)\lambda_t - \beta(1-\delta^d)p_{t+1}^d\lambda_{t+1} + \beta\theta^d(1-\delta^d)\Omega_{2,t+1}$$

Ω_1 is the expected present discounted value of a unit of durable varieties and Ω_2 is the expected present discounted value of the user cost. The last two equations express the Ω's recursively.

By defining the total durable stock as

$$D_t^o \equiv \int_0^1 D_t^o(i)di,$$

we obtain the standard durable accumulation equation and durable net expenditure as a function of aggregate variables only,

$$
\begin{aligned}
D_t^o &= (1-\delta^d)D_{t-1}^o + \frac{X_t^o}{p_t} \\
X_t^o &= p_t^d(1-\theta^d)[D_t^{o*} - (1-\delta^d)D_{t-1}^o].
\end{aligned}
$$

D_t^{o*} is the optimal stock of durables for households that adjust. The expression for durable purchases shows that the calculation cost friction directly limits the extensive margin of durable adjustment to $(1-\theta^d)$. In Appendix A we show that the friction also limits the sensitivity of the intensive margin—the term in brackets—to the real interest rate.

Hand-to-Mouth Households

In order for lump-sum transfers to have general equilibrium effects, we require non-Ricardian households. We adopt Galí et al.'s (2007) assumption that a certain fraction γ consume hand-to-mouth. Relative to their set-up, our hand-to-mouth households may consume their income over several periods rather than all at once.

We assume that in steady state, hand-to-mouth households have the same after-tax income and consume the same relative amount of durable and nondurable services as optimizing households,

$$
\begin{aligned}
WH^m - T^m &= WH^o - T^o + \text{Profits}^k + \text{Profits}^s \\
\frac{C^m}{X^m} &= \frac{C^o}{X^o}
\end{aligned}
$$

where variables superscripted by m denote the hand-to-mouth household.

We then directly specify dynamic marginal propensities to consume for nondurable and durable expenditures to match both the allocation across goods and any lagged effects implied by the micro MPC estimates,

$$
\begin{aligned}
C_t^m - C^m + \eta(D_t^m - D^m) &= \sum_{l=0}^{L} mpc_l [W_{t-l} H_{t-l}^m - T_{t-l}^m - (WH^m - T^m)] \prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-k+1}} \\
X_t^m - X^m &= \sum_{l=0}^{L} mpx_l [W_{t-l} H_{t-l}^m - T_{t-l}^m - (WH^m - T^m)] \prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-k+1}} \\
1 &= \sum_{l=0}^{L} (mpc_l + mpx_l) \\
mpx_l &= \frac{\vartheta}{1-\vartheta} mpc_l, \qquad \forall l = 0, ..., L
\end{aligned}
$$

where mpc_l is the marginal propensity to spend on nondurable goods today out of income l periods ago, and mpx_l is the marginal propensity to spend on durable goods today out of income l periods ago. Income that was saved l periods ago for consumption today accrues real interest $\prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-1+1}}$.

Overview of Other Features

The remaining elements of the model are standard. Intermediate goods firms are monopolistically competitive and face a Calvo-style adjustment cost on prices. Intermediate goods can be turned one-to-one into either nondurable goods or durable goods, which implies their relative price is constant and equal to $p_t^d = 1$. In labor markets, unions mark up nominal wages over the marginal rate of substitution and face Calvo-type adjustment costs. The result is that short-run employment fluctuations are driven more by labor demand than labor supply. Firms face an adjustment cost on capital investment, but they can vary their utilization of capital, so capital services are more cyclical than the capital stock. The result is more elastic output supply since it mutes the diminishing returns to labor and prevents real marginal cost from increasing much when output rises. The monetary rule is inertial, with a long-run coefficient of 1.5 on the inflation gap and 1/12 on the monthly output gap. Lump-sum taxes respond to the deviation of government debt from its steady-state values but with a lag of one year. A more complete description with equations is provided in the appendix.

Table 1. Baseline Calibration of the Model

Parameter	Value	Description
β	0.997	Subjective discount factor
ψ	0.189	Weight on durable service flow
σ	0.5	Utility curvature on nondurable consumption
σ^d	1	Utility curvature on durable service flow
θ^d	varies	Calvo parameter on durable adjustment
η	0.018	Durable operating cost
ν	76.918	Weight on disutility of labor
ϕ	1	Inverse of the Frisch elasticity of labor supply
γ	varies	Fraction of Hand-to-Mouth consumers
ϑ	varies	Hand-to-Mouth MPC on durables
δ^d	0.015	Depreciation of durable consumption goods
α	0.36	Exponent on private capital in production function
δ	0.005	Depreciation of private capital
κ	40	Investment adjustment cost parameter
δ_1	0.008	Parameter on linear term of capital utilization cost
δ_2	0.017	Parameter on quadratic term of capital utilization cost
μ_p	1.2	Steady-state price markup
μ_W	1.2	Steady-state wage markup
θ_p	0.917	Calvo parameter on price adjustment
θ_W	0.917	Calvo parameter on wage adjustment
ϵ_p	6.0	Elasticity of substitution between types of goods
ϵ_W	6.0	Elasticity of substitution between types of labor
gy	0.2	Steady-state share of total govt spending to GDP
ϕ_b	0.027	Debt feedback coefficient in fiscal rule
ρ_r	0.947	Monetary policy interest rate smoothing
ϕ_π	1.5	Monetary policy response to inflation
ϕ_{gap}	0.083	Monetary policy response to the output gap

Notes: The model is calibrated at a monthly frequency. The parameter γ is calibrated to either 0.3, 0.5, or 0.9, which corresponds to the micro MPC in the model. The parameter θ^d is calibrated such that for each value of γ to model replicates our empirical targets for the short-term interest elasticity of durable demand. For example, when $\gamma = 0.3$, then $\theta^d = 0.85$. The parameter ϑ is calibrated to match an overall MPC on motor vehicles of 0.3 when $\gamma = 0.3$ and of 0.4 when $\gamma = 0.5$ or $\gamma = 0.9$. This yields $\vartheta = 1.0$ when $\gamma = 0.3$, $\vartheta = 0.8$ when $\gamma = 0.5$, and $\vartheta = 0.44$ when $\gamma = 0.9$. See the text for details.

3.2 Calibration

The calibrated parameters with their descriptions are shown in Table 1. Note that the model is calibrated to a monthly frequency. In addition to the calibrations shown in the table, we calibrate the steady-state transfers by type of household so that hand-to-mouth and life-cycle permanent income households consume the same amount in the steady state. The durable goods parameters are chosen to match the average share of motor vehicle spending in PCE and its depreciation rate in the fixed asset table. Operating costs are based on PCE expenditures on motor vehicle fuels, lubricants, and fluids. The appendix shows more details of the model.

The timing of spending by hand-to-mouth households is important for constructing the counterfactual path of consumption. We assume that the hand-to-mouth households respond to a shock to their disposable income by spreading their spending over three months. Estimates from Broda and Parker (2014) using higher-frequency Nielsen data on nondurable expenditures suggest that two-thirds of expenditure occurs in the month of the rebate, and one-sixth each of the following two months.[9] In our own investigation using CEX data, we find no evidence of additional expenditure after three months.[10] Unfortunately, the CEX does not lend itself to estimate monthly expenditure patterns as most households report expenditures divided equally across the three months within an interview. One exception to this limitation is reported car expenditure, which more precisely identifies the month of purchase. Appendix Table C.8 shows that the car expenditure response occurs in the three months around the rebate. We conservatively choose an equal spread of expenditure since this minimizes the extent of V-shapes in our counterfactuals and is thus more consistent with larger MPCs.

We simulate several versions of the model, across a range of fractions of households who are hand to mouth. We set values for γ, and thus a three-month cumulative MPC, equal to 0.3, 0.5, and 0.9. The lower value, 0.3, reflects our preferred estimate based on our new estimates that correct for several biases (presented in the next section in Table 3, column 4). The other two values, 0.5 and 0.9, are the estimates from our replication of Parker et al. (2013) in the full CEX sample and the subsample of rebate recipients (Appendix Table C.5, column 1).

A key distinction in both the estimates and in our model is the allocation of spending between nondurable goods and motor vehicles. We again calibrate these to empirical

9. Borusyak et al. (2022) also do not find evidence of spending after three months.
10. See the implied 6-month MPC in Table 3, column 4.

estimates. In our preferred specification the MPC on motor vehicles is 0.3 (Table 5). Using the Parker et al. (2013) specifications we obtain an MPC on motor vehicles of 0.4 in the full CEX sample and the subsample of rebate recipients (Table C.6, column 1).

The curvature of durable utility σ^d and the Calvo durable good adjustment probability θ^d determine how sensitive durable demand is to general equilibrium changes in durable prices and the real interest rate. We calibrate these parameters based on estimates of the demand elasticity at the household level, which difference out any local or aggregate general equilibrium price effects.

First, we set the long-run demand elasticity for vehicles to $\sigma^d = -1$ based on an average of three existing household studies.[11] Second, we calibrate the durable Calvo probability θ^d to target an increase in durable demand of 15% over six months in anticipation of a 1% increase in prices, as estimated by Bachmann et al. (2021). [12] The implied parameter value for θ^d varies across values of the fraction of hand-to-mouth consumers since these do not respond to intertemporal price changes. For example when we target an MPC of 0.3, then we obtain $\theta^d = 0.85$.

3.3 General Equilibrium Counterfactuals

With the model constructed and calibrated, we now compute counterfactual paths of consumption that take into account the full dynamic general equilibrium effects. We start the economy in steady state in January 2008, and assume that households do not anticipate in advance the equilibrium path of prices resulting from the rebate until after the first rebate payments are made in April.[13] We feed a path of rebate shocks into the model that matches the relative size and timing of the actual rebate shown in Figure 2.

We use first-order perturbation methods to solve for the general equilibrium impulse responses of the variables to the path of rebates. We then construct macro-

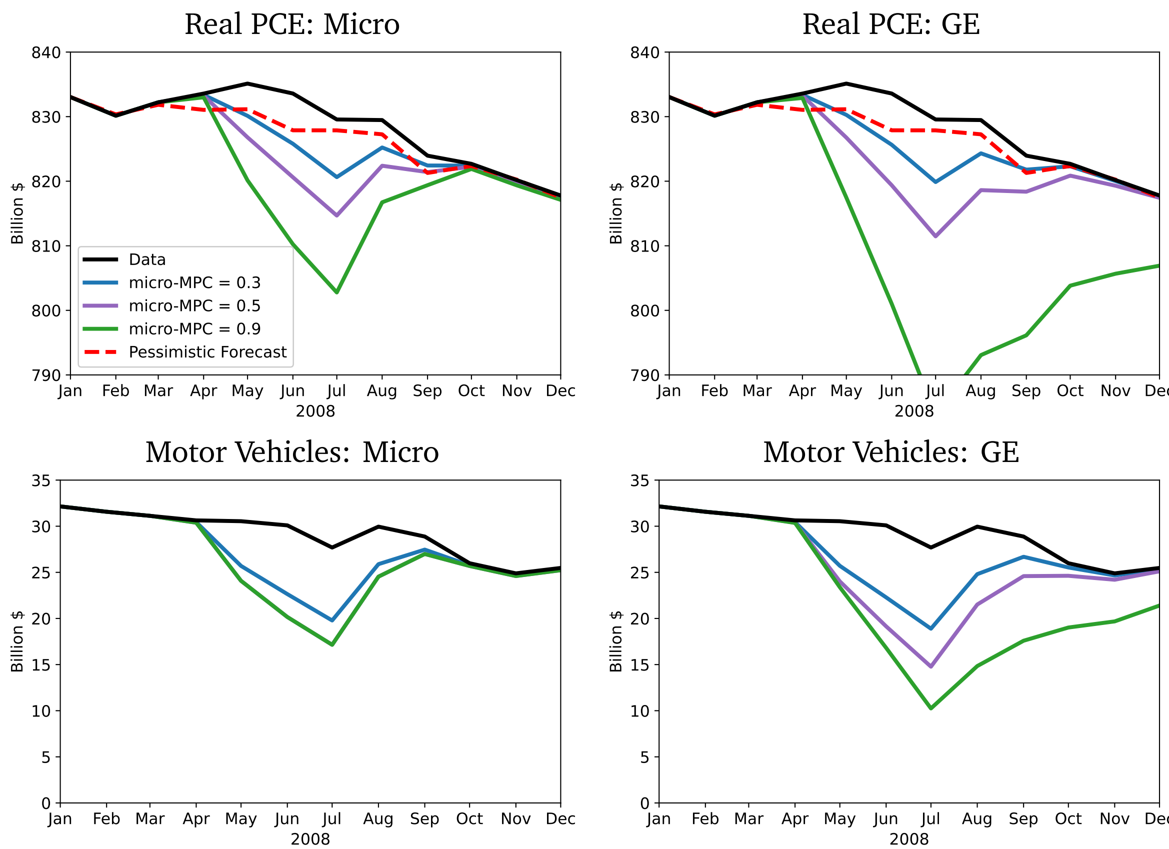
11. McCarthy (1996), Bento et al. (2009), and Dou and Linn (2020).

12. Table A.4., columns 3 and 9. Our calibrated demand elasticity is consistent with Mian and Sufi (2012) estimates for the 2009 Cash-for-Clunkers program. See Appendix C.5 for details.

13. Without this assumption, optimizing households would foresee the future rise in the real interest rate and increase their purchases of durable goods immediately. Because the real interest rate moves very little in the baseline model, this assumption is not very important in this section. However, this assumption is important in Section 5 because there the relative price of motor vehicles moves in equilibrium. In that section we also show that the relative motor vehicle price does not rise until May 2008 (Figure 7), and that motor vehicle expenditure by non-recipient households drops in May 2008 and that there is no unusual increase in motor vehicle expenditures earlier in the sample (Figure 9). These outcomes are consistent with our assumption that households do not anticipate the effects of the rebate on prices.

counterfactuals by subtracting the model-implied impulse response functions for consumer expenditures from the observed consumer expenditure data. Because the model is linearized, the counterfactuals for the tax rebate would be identical if we also fed the model with other shocks that hit the economy at the time.

Figure 4. Counterfactual Real Consumption Expenditures: Baseline Model



Notes. Based on Two-Good, Two-Agent NK model simulations and actual data on rebates and consumption. The micro MPC value refers to the MPC for total consumption.

Figure 4 plots counterfactual total consumption and motor vehicle expenditure paths based on both the micro MPCs, which exclude any general equilibrium effects, and the GE-MPCs, which incorporate full dynamic general equilibrium feedbacks. The counterfactuals in the top left panel that do not allow for general equilibrium effects are the analogs to the Sahm et al. (2012) exercise we showed in the introduction. The figures show prominent, and we will argue implausible, V-shapes for total consumption. According to these counterfactuals, consumption would have collapsed from May through

July 2008 and recovered in August 2008 before beginning the longer downward path starting with the fall of Lehman Brothers.

The top right panel of Figure 4 shows that allowing for general equilibrium effects makes the counterfactual even more V-shaped. The highly transitory nature of the rebate coupled with a flat Phillips curve and interest rate inertia implies that there is little crowding out through the real interest rate. The dominant general equilibrium force is the Keynesian multiplier. Thus, the effects of the rebate are amplified in general equilibrium, particularly as the micro MPCs become larger, so the counterfactual paths become even more V-shaped.

The bottom two panels show the counterfactuals for real motor vehicle expenditure. The left panel only accounts for the direct effect of the rebate, excluding any general equilibrium effects. This exercise is similar to Sahm et al. (2012) except that it accounts for all motor vehicle expenditure, not just new cars.

The right panel includes all general equilibrium effects. The V-shapes of counterfactual motor vehicle expenditure are more even more pronounced than for total PCE. The counterfactual drop in motor vehicle expenditure from April to July ranges from 30% to 60% across the range of MPCs. This reflects that the MPCs on motor vehicles in the micro estimates are large relative to the overall size of motor vehicle expenditures in consumption expenditure, and that these direct expenditures get further amplified in general equilibrium.

3.4 Assessing the Plausibility of the Baseline Counterfactuals

We now use narrative evidence, forecasts, and comparisons with historical consumption drops to argue that all three counterfactuals shown in the last section are implausible. We show that none of the events at that time would have led aggregate consumption to fall dramatically in spring and summer 2008 and then recover just as Lehman Brothers was failing.

January 2008 began with negative economic news. The employment report for the previous December showed a jump in the unemployment rate, leading forecasters and policymakers to worry that a recession was imminent. In response, the Federal Reserve began lowering interest rates in January and Congress and Administration enacted the rebates in February.

Goldman Sachs released their forecast in early January 2008 and were among the first to predict that the U.S. was already in recession. Their forecasts were based on the following assumptions.[14] First, the Fed would cut the federal funds rate target from 4.25 to 2.5 by the end of the year, with the first 50 basis point cut at the next FOMC meeting on January 30th. Second, housing prices would decrease 20 to 25 percent below their peak. Third, Congress and the President would pass a temporary tax break as part of a fiscal stimulus plan later in the year.

Goldman Sachs forecasted no change in real consumption expenditures (PCE) in 2008Q1, a decrease of 0.125 percent (not annualized) in each of 2008Q2 and 2008Q3, and a 0.25 percent increase in 2008Q4. Thus, they forecasted actual declines in real consumption expenditures, but they were tiny in magnitude. Similarly, contemporary forecasts from the Federal Reserve Board Staff (Greenbooks) and the Survey of Professional Forecasters did not predict large drops of consumption in summer 2008. Most forecasters predicted an increase in real consumption and even the most pessimistic forecaster from the Survey of Professional Forecasters ("SPF Min.") predicted only a small decrease in consumption in summer 2008. All these forecasts are shown alongside actual values in the left panel of Figure 5.[15] None predicted that consumption would decline significantly in Summer 2008.

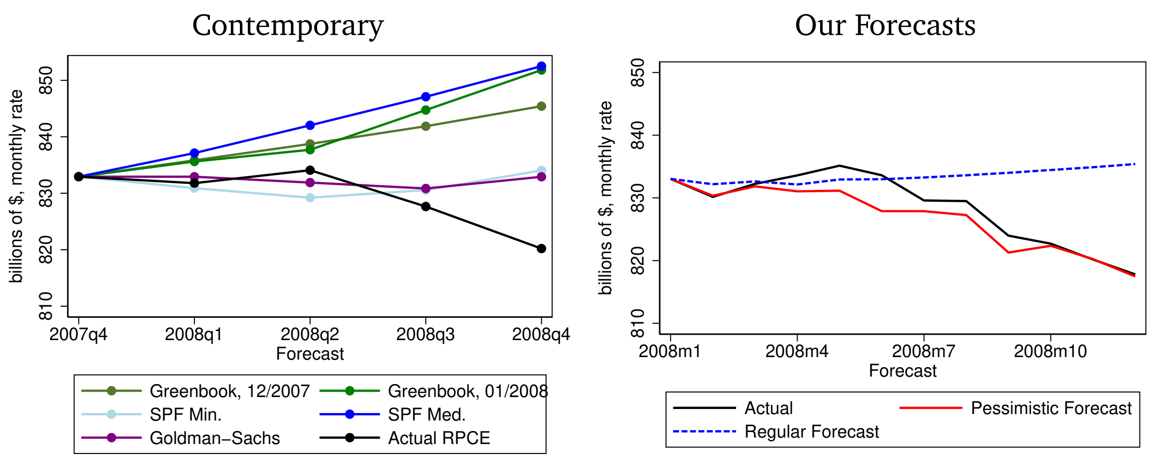
However, the forecasters in January 2008 were not certain the economy was in recession and they did not foresee the rapid run-up in oil prices in spring and summer or the Lehman Brothers failure in September. Crude oil prices rose from $98 per barrel in January 2008 to a peak of $140 per barrel in July 2008 and then fell to $33 per barrel by the end of the year. All these factors could have negatively affected consumption. Thus, we construct our own forecasts that factor in those negative events to create more pessimistic forecasts to compare to our counterfactuals.

Our forecasting model is a monthly-frequency time series model with current and six lags of the following endogenous variables: log real consumption, log real disposable income, log consumption deflator, and the Gilchrist and Zakrajšek (2012) excess bond

14. This summary is based on contemporaneous news accounts, such as the CNN Money article "Recession may already be here," January 10, 2008.

15. In each case, we select the last survey prior to the passage of the Economic Stimulus Act of 2008 since afterward forecasters would include the rebate response as part of their forecast.The January Greenbook actually does incorporate the tax rebates in their consumption forecasts, however, they predict that the rebates will be received in the second half of 2008, not in the second quarter when most of them were received.

Figure 5. Real Consumption Forecasts



Left Panel: Sourced from BEA data, Federal Reserve Board, Survey of Professional Forecasters. All forecasts normalized to monthly real consumption in 2007Q4.

Right Panel: Forecasts are based on information through January 2008, with exception of models in which oil prices are assumed to follow their actual path and Lehman Brothers dummies are included. Real oil prices exogenously follow their actual path in the pessimistic forecast and their forecasted path in the regular forecast; recession dummies and Lehman Brothers bankruptcy dummy variables are included only in the pessimistic forecast.

premium.[16] We estimate two versions of the model. The pessimistic model includes current and six lags of the log of real oil prices, a dummy variable for recession, and a dummy variable for the Lehman Brothers bankruptcy in September 2008 as exogenous variables. The regular model excludes the recession and Lehman dummies and assumes that real oil prices are endogenous, which results in real oil prices remaining roughly constant. We estimate the models on data from 1984m1 - 2019m12 and forecast dynamically starting in January 2008 before the rebates were passed.[17] In Appendix C.4 we show that forecasts based on other variable combinations generally lie between the regular and the pessimistic forecast.

The right panel of Figure 5 shows the actual data and the monthly-frequency forecasts. The regular forecast is similar to the most pessimistic projections of the professional forecasters shown in the left panel. In contrast, our pessimistic forecast predicts noticeably less consumption. The forecast lies below the actual total consumption path

16. We explored the addition of a number of other variables, such as consumer confidence, but they did not noticeably change the forecasts and/or were not statistically significant.

17. We start the estimation period in 1984 because the effects of oil prices on consumption expenditures changed significantly post-1984 (e.g. Edelstein and Kilian (2009)).

from April 2008 through October 2008, which is consistent with some stimulus effect of the rebates. However, the cumulative difference between actual consumption and the most pessimistic forecast is only $20 billion. With a total rebate of $100 billion, the implied GE-MPC is only 0.2 even when we attribute the entire difference to the effects of the rebate.

Figure 4 from the last section shows that this pessimistic forecast (denoted with a dashed red line) lies above all three counterfactuals in the summer of 2008 and does not exhibit any V-shape. Thus, even our pessimistic forecast does not predict the sharp decline in consumption implied by the counterfactuals.

Table 2. Model Counterfactuals Compared to Largest Historical Expenditure Decline

Panel A: Total PCE				
Largest Historical Declines			Model Counterfactuals	
Date	Episode	Decline	Calibration	Decline
Jan-Apr 2020	COVID lockdowns	17.4	micro MPC = 0.9	6.0
Jan-Apr 1980	Credit controls, Volcker	2.9	micro MPC = 0.5	2.7
Aug-Nov 1974	prior spike up	2.3	micro MPC = 0.3	1.6
Apr-Jul 1960	prior spike up	1.8		
Sep-Nov 2008	Lehman Collapse	1.1		
Panel B: Motor Vehicle Expenditures				
Largest Historical Declines			Model Counterfactuals	
Date	Episode	Decline	Calibration	Decline
Jan-Apr 2020	COVID lockdowns	31.2	micro MPC = 0.9	66.7
Aug-Nov 1974	prior spike up	25.3	micro MPC = 0.5	51.9
Jul-Oct 2005	prior spike up	25.3	micro MPC = 0.3	38.2
Jan-Apr 1980	Credit controls, Volcker	24.8		
Sep-Nov 2008	Lehman Collapse	16.9		

Top Panel: Four largest three-month decline of personal consumption expenditures (left three columns) compared three-month decline implied by model counterfactual from April through July 2008 for a total micro MPC of 0.3, 0.5 or 0.9 (right two columns). The Lehman collapse is added as an additional comparison.
Bottom Panel: Four largest three-month decline of motor vehicle expenditures (left three columns) compared three-month decline implied by model counterfactual from April through July 2008 for a total micro MPC of 0.3, 0.5 or 0.9 (right two columns). The Lehman collapse is added as an additional comparison.

Table 2 puts those counterfactual declines into further perspective by comparing them to other episodes since 1959. The counterfactuals predict a 6% decline in PCE from April through July 2008 for a micro MPC of 0.9 and a 2.7% decline in PCE for a micro MPC of 0.5. Such sharp declines over a three-month window are exceedingly rare. Only the COVID-19 lockdowns caused a larger drop in PCE. And only another extreme macroeconomic event — the 1980 Volcker disinflation coupled with credit controls — generates a PCE drop of comparable magnitude to the counterfactual with an MPC of 0.5. The next two largest historical declines in 1960 and 1974 followed anomalous large upward spikes in consumption expenditures.[18] The last line of Panel A shows that the failure of Lehman brothers did not produce such sharp declines in consumption expenditures.

Panel B of Table 2 shows that the implied counterfactuals for motor vehicle expenditures are outside any historical experience since monthly expenditure data became available. With the Parker et al. (2013) micro MPCs the model counterfactual predicts a three-month drop in motor vehicle expenditures from 50% to 70%. Yet the largest observed decline since 1959 is a 30% during the Covid shutdown. Even with a micro MPC of 0.3, the model predicts that, absent the rebate, the summer of 2008 would have been worse than the Covid shutdown and followed by a swift economic recovery.

In short, the counterfactuals imply that the macroeconomy was under extreme stress in the summer of 2008 and only the rebate prevented a decline in consumer expenditures of historic proportions. But whatever caused this stress was short-lived since the counterfactuals show that the economy would have swiftly recovered in a V-shaped manner. Yet, there were no signs of such extreme, short-lived macroeconomic stress in anyone's forecasts. In contrast, historical declines in expenditures similar or smaller than the model counterfactuals are associated with clear macroeconomic events such as Covid-19 and the onset of credit controls in conjunction with the Volcker disinflation. This suggests that the counterfactuals are not plausible.

We draw two main conclusions from this section. First, a comparison of the actual behavior of aggregate consumption with our most pessimistic forecast suggests that the GE-MPC out of the rebate must have been 0.2 or less. Second, this aggregate GE-MPC is inconsistent with the implications of a standard NK model calibrated with the leading micro MPC estimates. Thus, either the existing micro MPC estimates are biased

18. The August 1974 spike occurred when U.S. auto manufacturers announced dramatic price increases for the 1975 model year. In response, consumers rushed to buy the 1974 model year autos before they sold out. We could not determine the source of the anomalous spike in 1960.

upwards or the standard NK model is missing important GE dampening. In the next two sections, we show that both statements are true.

4 Revisiting the Micro MPC Estimates

In this section we provide the first part of our reconciliation of the micro MPC estimates and the macro counterfactuals. We revisit the leading micro MPC estimates and show that they are biased upward. After correcting for the biases, we estimate micro MPCs around 0.3, with almost all the spending on durable goods. Since even these estimates lead to implausible macro counterfactuals in our previous model, we complete the reconciliation in the subsequent section by showing how modifying our macro model to make the supply of durable goods less elastic results in general equilibrium forces that dampen rather than amplify the micro MPCs.

The most widely cited micro MPC estimates, which range from 0.5 to 0.9, come from Parker et al. (2013). The authors worked with the U.S. Bureau of Labor Statistics to add a question about the 2008 Tax Rebate receipt to the monthly Consumer Expenditure Survey (CEX). Since the CEX is a rotating panel survey of household expenditure, this allowed the authors to analyze consumption expenditure alongside rebate receipt in an already established survey. Furthermore, since rebate checks were sent to households based on the last two-digits of their social security number, the timing of treatment (i.e. distribution of the rebate) was effectively random. Parker et al. (2013) leverage the variation in treatment time (i.e., the month in which the household received the rebate) and in some cases the treatment size (i.e. the dollar value of the rebate check) to estimate the causal impact of receiving a rebate on household spending using a standard difference-in-differences (DID) event-study methodology.

In this section, we document and correct for three important upward biases in the Parker et al. (2013) estimation method: (1) An omitted variable bias from not allowing for lagged rebate effects; (2) a bias from "forbidden comparisons" across cohorts with heterogeneous treatment effects; and (3) a rebate reporting bias stemming from a correlation between lagged expenditure and the report of receipt of a rebate. When we correct for these biases, we estimate substantially reduced micro MPCs of around 0.3.

Our econometric analysis builds and expands on questions raised a decade ago by Kaplan and Violante (2014). They noted that the coefficient on the rebate in Parker et al.'s (2013) specification cannot be interpreted as an MPC because it omits the lagged effect of the rebate on changes in consumption. In addition, their discussion of anticipation effects is closely related to the rebate reporting bias we document. Our analysis also builds on the work of Borusyak and Jaravel (2017) and Borusyak et al. (2022) highlighting the problem of "forbidden comparisons" in event studies. We show that we obtain similar reductions in MPC estimates when we use their method.

4.1 Baseline Parker et al. (2013) Specification and Replication

To estimate the causal impact of receiving a check on household consumption, Parker et al. (2013) estimate several versions of a standard regression used for testing the permanent income hypothesis. The version we focus on is,

$$C_{i,t} - C_{i,t-1} = \sum_{s} \beta_{0s} month_s + \beta_1' \mathbf{X}_{i,t} + \beta_2 I(ESP_{i,t}) + u_{i,t} \tag{1}$$

where t indexes the interview (performed once every three months), and i indexes individual households. The regression includes fixed effects for each month ($month_s$), household controls for age and change in household size $X_{i,t}$, and the main variable of interest, I(ESP), which is a dummy variable equal to one if the household received a rebate, i.e., an Economic Stimulus Payment (ESP).

We make two changes to the original Parker et al. (2013) specification for the purposes of our analysis: First, we estimate MPCs for total expenditure using the BEA definitions for PCE because we construct counterfactuals for PCE.[19] The biggest change relative to total expenditure in Parker et al. (2013) is that our estimates net out sales of used vehicles. Second, we drop all households that report receiving a rebate in more than one interview as multiple instances of treatment complicate the interpretation of β_2 as a micro MPC for a single income change.

Columns (1) of Table 3 reports the estimates for β_2 from equation (1). Panel A reports the estimates the treatment effects for the full sample and Panel B for the rebate-only sample. The full sample has more power because households that receive rebates are also being compared to households that never receive the rebate. For this comparison to be valid these groups of households must be on parallel trends. The rebate-only sample does not require this assumption as it only makes comparisons among households that report receiving a rebate, but this comes at the cost of statistical precision.

19. We map the CEX UCC codes into PCE categories using the concordance provided by the BLS: https://www.bls.gov/cex/cepceconcordance.htm

The estimates in column (1) align closely with Parker et al. (2013). We estimate a \$470 response in the full sample (Panel A), compared to \$495 in Parker et al. (2013). Appendix Table C.4 reports the corresponding rebate income, \$950, which implies an MPC of 0.5. Parker et al. (2013) do not report a dollar response for the rebate-only sample but our MPC of above 0.8 in column (1) of Panel B is again very close to their value.

We next show how that these MPC estimates are upward biased.

4.2 Bias from Omitting the Lagged Rebate

The first bias we identify is an omitted variable bias owing to serial correlation in the treatment variable. To understand this bias, suppose the true model for consumer expenditure is

$$C_{it} = \alpha_i + \lambda_t + \beta D_{it} + \epsilon_{it}$$

where α_i and λ_t are fixed effects and D_{it} is a treatment indicator equal to 1 when the household receives a rebate. We assume that the timing of the treatment is random and that households are treated only once.

To align with the baseline specification (1), we take first differences,

$$\Delta C_{it} = \Delta\lambda_t + \beta D_{it} + \eta_{it}, \quad \text{with} \qquad \eta_{it} \equiv -\beta D_{i,t-1} + \Delta\epsilon_{it}.$$

Thus, Parker et al.'s (2013) first-difference specification includes the lagged rebate indicator $D_{i,t-1}$ in the error term η_{it}.

To assess the resulting bias, first define $\hat{X}_t$ as the residual from regressing a variable X_t on a time fixed effect. Then the OLS estimator for the contemporaneous rebate effect can be written as,

$$\begin{aligned} \beta^{OLS} &= \frac{Cov(\hat{\Delta C}_{it}, \hat{D}_{it})}{Var(\hat{D}_{it})} \\ &= \beta - \beta \frac{Cov(\hat{D}_{i,t-1}, \hat{D}_{it})}{Var(\hat{D}_{it})}. \end{aligned}$$

The covariance, $Cov(\hat{D}_{i,t-1}, \hat{D}_{it})$, is negative in a setting with staggered treatment because current treatment reduces the probability of treatment in the following period.

Table 3. Household PCE Response to Rebate

Panel A: Full Sample

	Homogeneous Treatment		Heterogeneous Treatment	
	(1)	(2)	(3)	(4)
Rebate Indicator	470.13**	433.84**	347.40*	261.99
	(213.56)	(206.72)	(211.03)	(182.84)
Lag Rebate Indicator		−173.61	−82.52	−60.92
		(222.27)	(201.72)	(167.69)
Lag Total Expenditure				−0.26***
				(0.03)
Lag Motor Vehicle				−0.74***
				(0.03)
Implied 3-month MPC	0.50	0.46	0.37	0.28
Implied 6-month MPC		0.72	0.64	0.20
6-Month MPC S.E.		(0.48)	(0.49)	(0.37)
Income Decile FE	No	No	No	Yes
Observations	16,962	16,962	16,962	16,962

Panel B: Rebate Recipients Only

	Homogeneous Treatment		Heterogeneous Treatment	
	(1)	(2)	(3)	(4)
Rebate Indicator	764.46**	527.34	601.27	320.72
	(314.81)	(342.40)	(403.52)	(496.73)
Lag Rebate Indicator		−428.09	−178.65	−351.86
		(354.06)	(319.11)	(360.43)
Lag Total Expenditure				−0.29***
				(0.02)
Lag Motor Vehicle				−0.71***
				(0.03)
Implied 3-month MPC	0.82	0.56	0.64	0.34
Implied 6-month MPC		0.65	1.09	0.02
6-Month MPC S.E.		(0.92)	(1.07)	(1.18)
Income Decile FE	No	No	No	Yes
Observations	10,076	10,076	10,076	10,076

Notes: The dependent variable is the change in Personal Consumption Expenditure (PCE). Regressions include interview (time) fixed effects, and household level controls for age, change in number of adults, and change in number of children. Standard errors for the 6-month MPC are estimated via Delta-method. The rebate coefficients in columns (3) and (4) are the weighted average of the interaction between rebate cohort and the (lagged) rebate indicator with weights computed following Sun and Abraham (2021). Standard errors, in parentheses, are clustered at the household level: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

When the treatment effect is positive ($\beta > 0$), β^{OLS} is upward-biased. Intuitively, households treated at t are being compared to households treated at $t-1$, whose consumption is falling as the effect of the rebate on the level of consumption reverses. This contaminated control inflates the OLS estimate of β. Note that β^{OLS} is unbiased under the null of the Permanent Income Hypothesis (PIH) $\beta = 0$. Thus, Equation (1) is a valid test of the PIH, but the point estimates for β_2 cannot be interpreted as MPCs, as previously shown by Kaplan and Violante (2014).

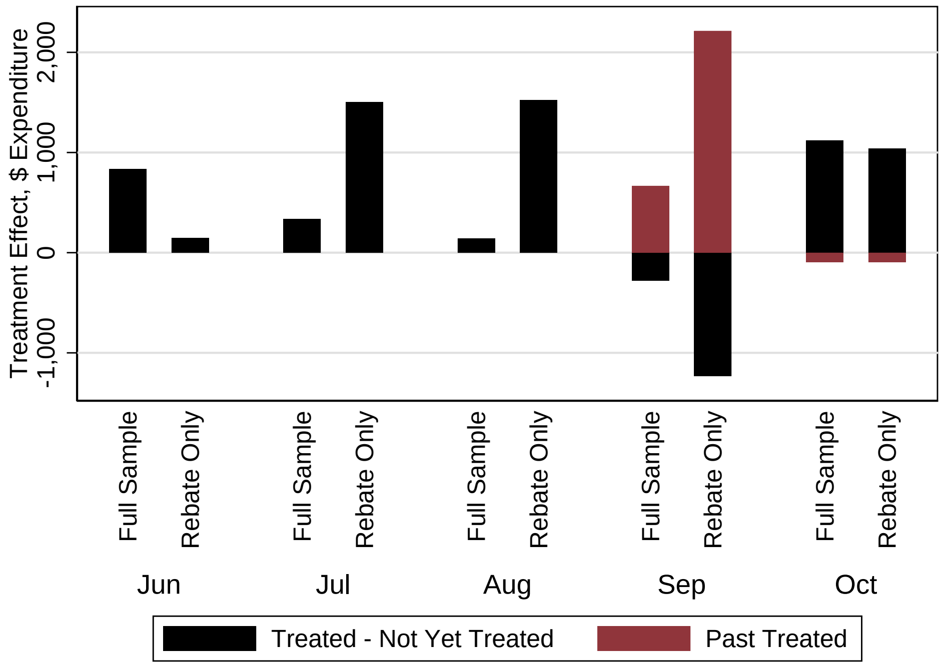
To show the importance of this bias in our setting, Figure 6 plots the period-by-period treatment effects that make up the total treatment effect β_2 in (1). Following Sun (2021) we decompose each period treatment effect into two parts: The contribution from comparing rebate recipients with households that have not yet or will never receive a rebate (black bars) and the contribution from comparing rebate recipients with households that have previously received a rebate (red bars). Due to the three-month rotating panel structure of the CEX and the first rebates being reported in June, the first comparisons with previously treated households are made in September. The red bars for September show that these comparisons imply very large positive treatment effects — \$670 in the full sample and \$2200 in the rebate only sample. But this effect may simply reflect mean-reversion of the June cohort rather than a treatment effect for the September cohort.

To determine how much the estimated propensity to spend in the Parker et al. (2013) equation is inflated by mean-reversion of previously treated units, we estimate an alternative model in which we add a rebate lag to equation (1),

$$(2) \qquad C_{i,t} - C_{i,t-1} = \sum_s \beta_{0,s} month_s + \beta_1' \mathbf{X}_{i,t} + \beta_2 I(ESP_{i,t}) + \beta_3 I(ESP_{i,t-1}) + u_{i,t}$$

Column (2) of Table 3 reports estimates of the contemporaneous effect β_2 and the lagged effect β_3. The contemporaneous spending effect shrinks by \$40 in the full sample, indicating that the original estimates were upward biased. In the rebate-only sample the contemporaneous effect of the rebate falls by almost \$240. In both samples the estimate on the lagged rebate coefficient is negative, consistent with spending reversals causing an upward bias when the lagged rebate variable is omitted. The fact that the bias is more severe in the rebate-only sample is expected since relatively more

Figure 6. TWFE Coefficients in the Full and Rebate Only Samples By Month



Notes. The dependent variable is the change in PCE. Periods after October, 2008, also receive positive weight, however, these weights small and not shown here.

variation in this sample comes from comparing rebate recipients to previously treated households.[20]

4.3 Heterogeneous Treatment Effects and Forbidden Comparisons

The lagged rebate indicator in (2) will account for the typical mean-reversion of consumer expenditure after receiving a rebate. However, Figure 6 shows that the treatment effects of the rebate may vary substantially by date of receipt. For example, in the full sample the propensity to spend is particularly large for the June cohort. We would therefore expect greater mean-reversion for the June cohort than the July cohort. But β_3 in (2) will only account for the average mean-reversion, not for the likely larger mean-reversion of the June cohort. Thus, the comparison of the September cohort with

20. In their Table 5, Parker et al. (2013) report estimates from a specification with a lagged rebate variable. Our estimates in column 2 of Table 3 are consistent with theirs as they also find that the magnitude of the estimate of β_2 declines. But their discussion focuses on the long-run estimates of MPCs implied by this specification, rather than correcting for an omitted variable bias.

the June cohort after accounting for average mean-reversion may still be contaminated by lagged treatment effects.[21]

Formally, suppose the true model for consumer expenditure is

$$C_{it} = \alpha_i + \lambda_t + \beta^i D_{it} + \epsilon_{it}$$

where the rebate effect β^i may now differ across individuals. First differencing to align with the Parker et al. (2013) specification, the equation becomes

$$\Delta C_{it} = \Delta\lambda_t + \beta D_{it} + \gamma D_{i,t-1} + \eta_{it}, \qquad \gamma \equiv -\beta, \qquad \eta_{it} \equiv (\beta^i - \beta) D_{it} - (\beta^i - \beta) D_{i,t-1} + \Delta\epsilon_{it}$$

and the OLS estimator for the contemporaneous rebate effect is,

$$\beta^{OLS} = \beta + \frac{Cov(\widehat{\beta_i D_{it}} - \beta\hat{D}_{it}, \tilde{D}_{it})}{Var(\tilde{D}_{it})} - \frac{Cov(\widehat{\beta_i D_{i,t-1}} - \beta\hat{D}_{i,t-1}, \tilde{D}_{it})}{Var(\tilde{D}_{it})}$$

where $\tilde{D}_{it}$ is the residual from the regression of D_{it} on a time fixed effect and $D_{i,t-1}$. The last covariance represents possible contamination bias from using later treated groups to correct for the spending reversal of earlier treated groups. The first covariance captures that OLS will put relatively more weight on the earlier treated group because there is more variation in the purified treatment $\tilde{D}_{it}$.

A simpler expression can be derived for the case in which there are only three time periods, $t \in \{0, 1, 2\}$. Half the households receive the rebate at $t = 0$. They have an average contemporaneous treatment effect of β^0 and a lagged treatment effect of $-\beta^0$. The other half receive the rebate at $t = 1$ and have an average contemporaneous treatment effect of β^1 and a lagged treatment effect of $-\beta^1$. Then one can show that the average and lagged treatment effects are:

$$\beta^{OLS} = \frac{1}{2}(\beta^0 + \beta^1) + \frac{1}{2}(\beta^0 - \beta^1)$$
$$\gamma^{OLS} = -\frac{1}{2}(\beta^0 + \beta^1) + \frac{1}{2}(\beta^0 - \beta^1)$$

These expression show that if treatment effects are heterogeneous, then the homogeneous OLS estimator will in general be biased. The bias will depend on the sign of

21. We do not need to take a stand on the source of treatment effect heterogeneity. Even if it just reflects sampling noise, the OLS estimates will not recover an average treatment effect.

$\beta^0 - \beta^1$, i.e. whether the earlier treatment effects are larger or smaller than the later treatment effects. If $\beta^0 > \beta^1$, then there is an upward bias. This is because OLS will use the group 1 smaller reversal at $t = 2$ to correct for the group 0 larger reversal at $t = 1$. This correction is too small since $-\beta^0 + \beta^1 < 0$, which implies this counterfactual group will still be contaminated by the lagged treatment effect and inflate the OLS estimates. Furthermore, OLS will also put more weight on earlier treated units which also causes an upward bias if $\beta^0 > \beta^1$. In contrast, if $\beta^0 < \beta^1$ then these two biases reverse and the homogeneous OLS estimator is too small.

To assess the importance of treatment effect heterogeneity in this setting we estimate the following heterogeneous-effects specification:

$$C_{i,t} - C_{i,t-1} = \sum_{s} \beta_{0,s} month_s + \beta_1' \mathbf{X}_{i,t} + \sum_{e=0}^{T} \beta_{2,e} I(ESP_{i,t}) I(ESP_{i,e}) + \sum_{e=0}^{T} \beta_{3,e} I(ESP_{i,t-1}) I(ESP_{i,e}) + u_{i,t} \tag{3}$$

where $\beta_{2,e}$ is the treatment effect of a cohort that received the rebate at $t = e$ and $\beta_{3,e}$ is the corresponding lagged treatment effect. This specification is similar to the solution to heterogeneous treatment effects proposed in Sun and Abraham (2020).

Column (3) of Table 3 reports estimates of the weighted contemporaneous effect $\sum_{e=0}^{T} w_e \beta_{2,e}$ and the weighted lagged effect $\sum_{e=0}^{T} w_e \beta_{3,e}$, where the weights correspond to the OLS weights of the cohorts. Allowing for heterogeneous effects in the full sample reduces the contemporaneous rebate effect by \$90. From Figure 6 we know that the early treatment effects in the full sample are larger than the later treatment effects, which causes an upward bias in the contemporaneous effect. By contrast, in the rebate-only sample allowing for heterogeneous effects increases the contemporaneous treatment effect by \$70 because the later treatment effects are larger.

4.4 Rebate Reporting Bias

We now discuss a bias associated with the correlation between a household's report of rebate receipt and low spending in the previous period in the CEX sample. To show the correlation, we first regress consumer expenditure on an indicator for receiving a

Table 4. Negative effect of future rebate receipt on current expenditure

	Full Sample	Rebate Recipients Only
	(1)	(2)
Lead Rebate Indicator	-863.0^{***}	-574.9^{*}
	(289.0)	(332.5)
Rebate Indicator	-414.5	200.5
	(299.2)	(368.4)
Observations	16,962	10,076

Notes: The dependent variable is the Level of PCE. Regressions include interview (time) fixed effects, and household level controls for age, change in number of adults, and change in number of children.Standard errors, in parentheses, are clustered at the household level: $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

rebate in both the current and the next interview

$$C_{i,t} = \sum_{s} \delta_{0,s} month_s + \delta_1' \mathbf{X}_{i,t+1} + \delta_2 I(ESP_{i,t}) + \delta_3 I(ESP_{i,t+1}) + u_{i,t} \tag{4}$$

where δ_3 captures the effect of future rebate receipt on current spending. We estimate this specification in levels to maintain the same sample as our other regressions.

Column (1) of Table 4 shows a large negative effect of future rebate receipt on current expenditure. This result likely reflects that rebate recipients have lower average consumption on average than non-recepients. In column (2) we therefore restrict the estimation to the rebate only sample, in which there should be no such rebate reporting bias. We find that the estimate remains economically very large at -$575 and statistically significant at the 10% level. This estimate suggests that rebate recipients had unusually low levels of spending in the period before the rebate arrived.

How could the rebate timing not be random? While the true timing of rebates is based on the last two digits of the social security number, the *reported* rebate timing may not be. Consider a household receiving a rebate in May. It should be equally likely sampled by the CEX in either June, July, or August. However, in Appendix Table C.3 we document that households are systematically more likely to report receiving the rebate in the month before the interview (June in this example). This suggests that there could be important recall issues with households more likely to report rebates when they accompany large increases in expenditures. While we believe this is a plausible explanation of the empirical patterns, we also cannot rule out that the estimates in Table 4 reflect a negative anticipation effect.

To understand how this correlation can be a source of bias, suppose the true model embeds some mean reversion in spending,

$$C_{it} = \alpha_i + \lambda_t + \theta C_{i,t-1} + \beta D_{it} + \gamma D_{i,t-1} + \epsilon_{it}$$

where $\theta \in (0,1)$ and rebate assignment is correlated with lagged expenditure $Cov(D_{it}, \epsilon_{i,t-1}) > 0$. We assume $\gamma = -\theta\beta$ so the rebate has a one-time effect on the level of consumer expenditures.

If we estimate the regression in changes and omit lagged expenditure from the regression,

$$\Delta C_{it} = \Delta\lambda_t + \beta D_{it} + \gamma D_{i,t-1} + \eta_{it}, \qquad \eta_{it} \equiv \alpha_i + (\theta - 1)C_{i,t-1} + \Delta\epsilon_{it},$$

then the OLS estimator on the contemporaneous effect is

$$\beta^{OLS} = \beta + \theta \frac{Cov(\alpha_i, \tilde{D}_{it})}{Var(\tilde{D}_{it})} + (\theta - 1)\frac{Cov(\epsilon_{i,t-1}, \tilde{D}_{it})}{Var(\tilde{D}_{it})}$$

where $\tilde{D}_{it}$ is the residual from the regression of D_{it} on a time fixed effect and $D_{i,t-1}$. The first covariance represents a selection bias on permanent consumption: If $\theta \neq 0$, then first differencing no longer removes the household fixed effect. The second term captures the rebate reporting bias. If low lagged expenditure predicts rebate reporting, then this will cause an upward bias in β as consumption growth will be high but not due to the rebate itself.

To address this second source of bias we add lagged consumer expenditure to our regression,

$$\begin{aligned} C_{i,t} - C_{i,t-1} = {} & \sum_s \beta_{0,s} month_s + \beta_1' \mathbf{X}_{i,t} + \sum_{e=0}^{T} \beta_{2,e} I(ESP_{i,t}) I(ESP_{i,e}) \\ & + \sum_{e=0}^{T} \beta_{3,e} I(ESP_{i,t-1}) I(ESP_{i,e}) + \beta_4 C_{i,t-1} + u_{i,t} \end{aligned} \tag{5}$$

Specifically, we control for both lagged total expenditure and lagged motor vehicle expenditure since we later split spending along these lines and including both controls ensures that our treatment effects add up. We also add controls for income deciles in X_{it} to mitigate the selection effect on α_i in the full sample.

Column (4) of Table 3 shows the implied treatment effects. In the full sample the treatment effect shrinks by $90 once the lagged control is included. The implied 3-month MPC is 0.28 after we account for all three biases versus 0.5 in the original specification. In the rebate-only sample adding lagged controls shrinks the treatment effect by $280. The MPC of 0.34 is less than half that in column (1) and very close to our estimates in the full sample.

Because there is no selection on whether a household is treated in the rebate-only sample, the selection on the fixed effect $Cov(\alpha_i, \tilde{D}_{it})$ should be zero: when a household is treated should convey no information on whether consumption growth is high or low over the entire sample period. This suggests that the estimates for the rebate-only in column (4) are the most reliable, in that they account for all the biases we identify. However, the fact that the column (4) estimates for the rebate-only sample are very similar to the full sample suggests that selection on the fixed effect is also unlikely to be important in the full sample. In this sense, column (4) paints a consistent picture that the micro MPC estimates, after correcting for the biases we identify, both estimates round to 0.3.

In Appendix C.6 we also verify that our preferred specification (5) recovers the true MPCs in household data simulated from the model of section 5. In contrast, the estimates from Equation (1) produce upward-biased estimates of the MPC in the simulated household data, consistent with Kaplan and Violante's (2014) argument that estimates from Equation (1) cannot be interpreted as MPCs.

4.5 Comparison to Borusyak et al. (2022) Method

A leading alternative approach to accounting for the bias from omitting lagged treatment variables and treatment effect heterogeneity is the imputation method of Borusyak et al. (2022). Their method imposes a linear fixed effect structure (parallel trends) only on the untreated potential outcomes. In particular, their method begins by estimating potential outcomes for untreated units in order to make proper control group comparisons. They estimate

$$Y_{i,t}(0) \equiv C_{i,t}(0) - C_{i,t-1} = \sum_s \beta_{0,s} month_s + \beta_1' \mathbf{X}_{i,t} + \beta_4 C_{i,t-1} + u_{i,t} \tag{6}$$

where $C_{i,t}(0)$ is consumption of household i if it were not treated at t and $Y_{i,t}(0)$ is the associated change in consumption (so the treatment indicator is 0). Since estimation is only for untreated units, there are no ESP terms in this specification.

If there are no anticipation effects, $Y_{i,t} = Y_{i,t}(0)$ for the untreated and not-yet treated units. The treatment effect for a household i who receives the rebate at t is then $Y_{i,t} - Y_{i,t}(0)$. The aggregate contemporaneous and lagged treatment effects are:

$$\tau_0 = \sum_i \omega_i [Y_{i,E(i)} - Y_{i,E(i)}(0)], \qquad E(i) : \{\text{Treatment date of household i}\}$$
$$\tau_1 = \sum_i \omega_i [Y_{i,E(i)+1} - Y_{i,E(i)+1}(0)]$$

for household weights ω_i.

A significant advantage of the BJS method over our OLS specification is that it does not impose a particular dynamic structure of the treatment effects, since it only imposes structure on untreated outcomes in (6). For example, if the rebate affected the change in consumption beyond one lag as we imposed in (5), then the BJS estimator remains consistent whereas OLS is biased. Furthermore, the BJS estimator imposes no restriction on the form of heterogeneity in the treatment effects. Thus, the BJS estimator overcomes the first two biases we identify—the omitted variable bias and the forbidden comparison bias—by construction. Since the BJS estimator imposes weaker assumptions than OLS it is more likely to be a consistent estimator of the average treatment effect in our setting. However, it is less efficient if the model we imposed for our OLS estimator in (5) is true.[22]

Appendix Table C.7, columns (2) and (4), show that the treatment effects from the BJS procedure are very similar to our final estimates in column (4) of Table 3.[23] The MPC in the full sample is slightly lower at 0.2 and the MPC in the rebate-only sample is slightly higher at 0.37. The average of the two is essentially the same as the average of our OLS estimates. Thus, allowing for more general dynamic treatment effects and heterogeneity than our final estimation equation (5) has only small effects on the implied MPCs.

22. Even when the model is true, the OLS and BJS estimators will generally produce different estimates for the average treatment effect because BJS weighs treated observations using sample weights, whereas OLS will base weights also on the variance of the treatment indicator over time.

23. We use Borusyak et al. (2022)'s **did_imputation** STATA command to construct point estimates and standard errors.

Both Borusyak and Jaravel (2017) and Borusyak et al. (2022) apply versions of the BJS estimator to Broda and Parker's (2014) estimates of MPCs using the Nielsen data. In both cases, they find that the imputation method produces MPC estimates that are half those estimated by Broda and Parker (2014). Thus, our application to the CEX data used by Parker et al. (2013) complements the results of these two studies.

4.6 Composition of Spending

Finally, Table 5 breaks down the total expenditure response to the rebate into the contribution from motor vehicle spending and other expenditures by estimating equation (5) for each component. The estimates imply that motor vehicle expenditures account for almost all of the total expenditure response. The MPC for motor vehicles is 0.3 in the full sample and 0.26 in the rebate only sample. The importance of vehicle spending is consistent with Adams et al. (2009) who find a substantial increase in car demand during the regular tax rebate season and Aaronson et al. (2012) who document large motor vehicle expenditures following minimum wage hikes. By contrast, we find that there is little change in other expenditures: that MPC is -0.02 in the full sample (column 2) and 0.08 in the rebate only sample (column 4).

5 Revisiting the Model

We now revisit our model as even the smaller MPCs estimated in the last section suggest implausible general equilibrium counterfactuals when used to calibrate the model from Section 3. In this section, we revise that model to incorporate realistic dampening forces. The result is a full reconciliation of the micro MPCs and macro counterfactuals.

Standard New Keynesian models assume that intermediate goods can be frictionlessly turned into either nondurable or durable goods, which implies their relative price is constant and equal to $p_t^d = 1$. Figure 7 shows that the relative price of durable goods spikes by around 1.5% relative to trend after households receive the 2008 rebate. We next show that a model with a realistic calibration of the durable supply elasticity generates similar patterns in the relative price and predicts substantial crowding out of durable expenditure in general equilibrium. And since the last section revealed that virtually all of the spending from the rebate was on motor vehicles, the model also predicts that the aggregate effects of the stimulus are modest.

Table 5. Household Spending Response to Rebate by Subcategory:

	Full Sample		Rebate Only Sample	
	Motor Vehicles (1)	Other PCE (2)	Motor Vehicles (3)	Other PCE (4)
Rebate Indicator	283.64***	−21.65	249.55	71.17
	(107.33)	(145.54)	(165.03)	(459.45)
Lag Rebate Indicator	121.65	−182.57	129.64	−481.50
	(93.37)	(133.83)	(119.15)	(343.01)
Lag Total Expenditure	0.02***	−0.28***	0.02***	−0.32***
	(0.01)	(0.03)	(0.01)	(0.02)
Lag Motor Vehicle	−1.04***	0.30***	−1.04***	0.33***
	(0.01)	(0.03)	(0.01)	(0.03)
Implied 3-month MPC	0.30	-0.02	0.26	0.08
Income Decile FE	Yes	Yes	Yes	Yes
Observations	16,962	16,962	10,076	10,076

Notes: Standard errors, in parentheses, are clustered at the household level. Significance is indicated by: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regressions include interview (time) fixed effects, as well as household level controls for age, change in number of adults, and change in number of children. The standard errors for the 6-month MPC are estimated using the Delta-method with the assumption that the coefficients of rebate amount on the rebate indicator are estimated precisely. Rebate sample includes only households that receieve a rebate at some point during our sample period. The rebate coefficients are the weighted average of the interaction between the rebate cohort and a (lagged) rebate indicator where the weights are derived from Sun and Abraham (2021).

5.1 The Model with Less Elastic Supply

We generalize the two-good, two-agent New Keynesian model presented in Section 3 to a model in which the relative supply of durable goods is not perfectly elastic. This part of the model builds on the recent analysis of durable goods expenditures by McKay and Wieland (2021, 2022).

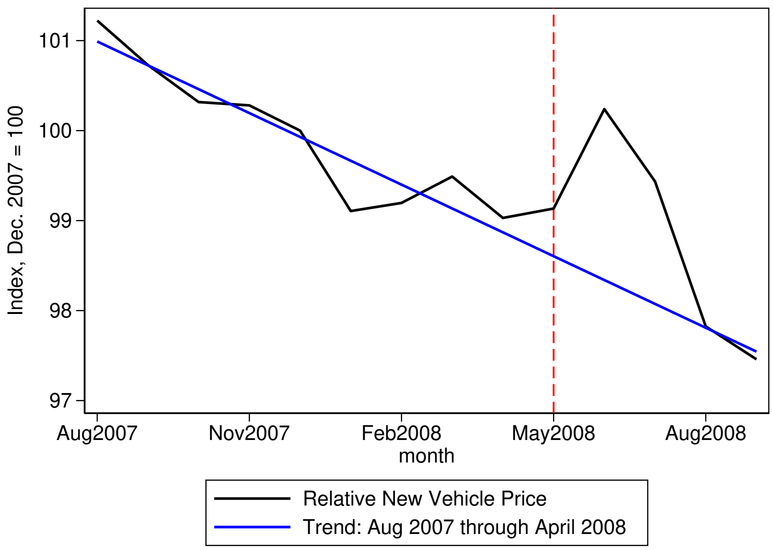
Durable Goods Production

Durable goods are produced competitively using nondurables N_t as inputs,[24]

$$\frac{X_{it}}{p_t^d} = N_{it}\left(\frac{X_t}{\bar{X}}\frac{1}{p_t^d}\right)^{-\zeta}$$

24. In our model all durables are produced domestically. During the rebate period in 2008, 75% of all new vehicles were produced domestically. To the extent that the model does not account for expenditure leakage abroad, it overstates the Keynesian multiplier effect and thus also the transfer multiplier.

Figure 7. Motor Vehicle Relative Prices



Source: BLS research CPI for new motor vehicles divided by core CPI (Williams et al., 2019).

where $\frac{X_{it}}{p_t^d}$ is the real production of durable goods by firm i and ζ is a negative production externality. ζ could alternatively represent a fixed factor of production as in McKay and Wieland (2021). We model it as a production externality because this yields zero profits in durable production.

Real profits from the sale of durable goods are given by

$$\max_{N_{it}} (X_{it} - N_{it}) = \max_{N_{it}} \left[p_t^d N_{it} \left(\frac{X_t}{\bar{X}} \frac{1}{p_t^d} \right)^{-\zeta} - N_{it} \right]$$

Profit maximization yields an upward sloping supply curve,

$$p_t^d = \left(\frac{X_t}{\bar{X}} \right)^{\frac{\zeta}{1+\zeta}}$$

where $\bar{X}$ is steady state durable expenditure, so the steady state relative durable price is normalized to 1. Since durable expenditure is denominated in units of nondurable consumption, the supply elasticity of real durable goods is given by $\frac{1}{\zeta}$.

Calibration

We calibrate the supply elasticity of durable goods $\zeta^{-1} = 5$, which is midway between the elasticities reported in House and Shapiro (2008) and Goolsbee (1998). As with the baseline model, we simulate the model for micro MPCs of 0.3, 0.5, and 0.9.

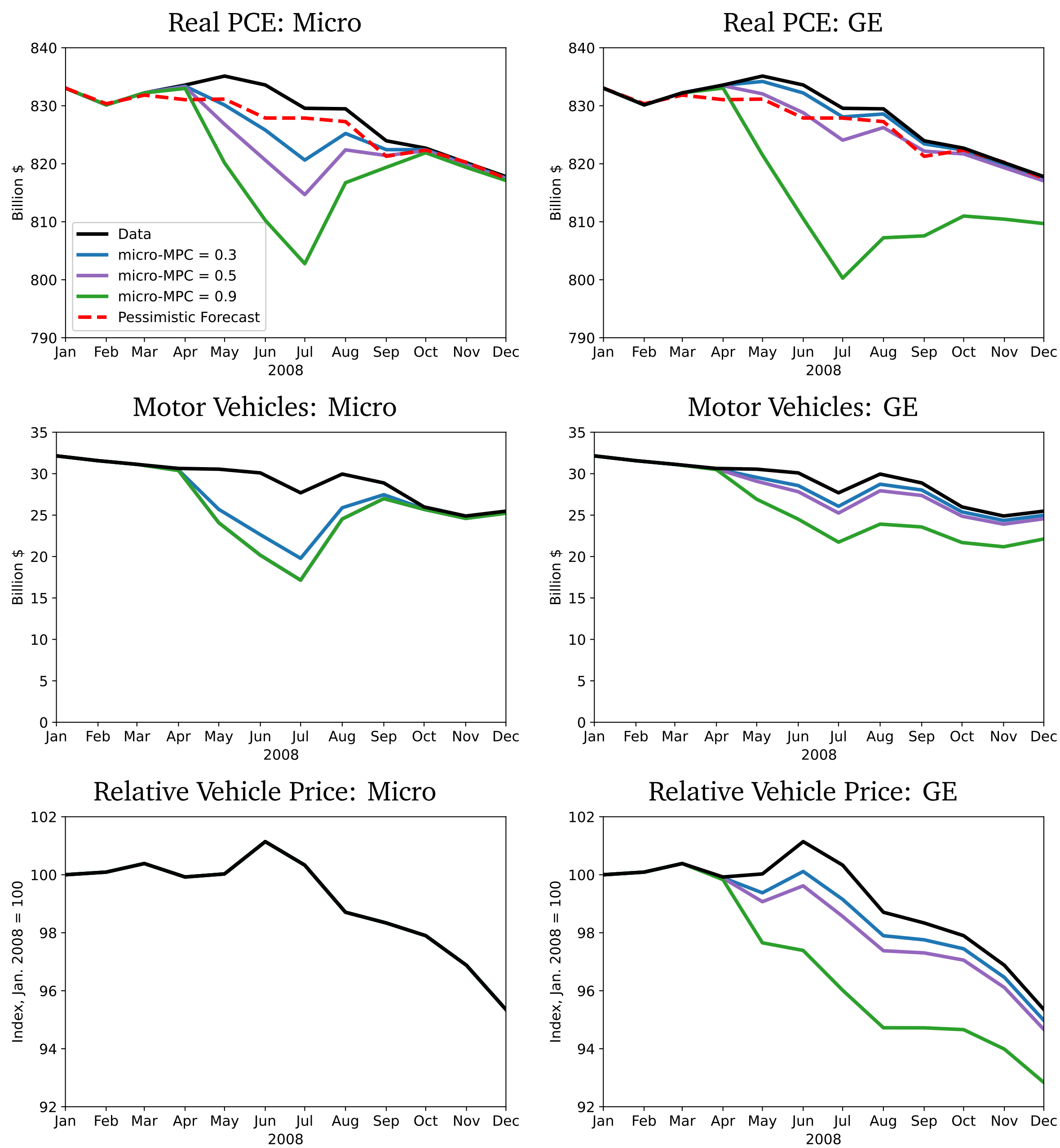
5.2 General Equilibrium Counterfactuals with Less Elastic Supply

Figure 8 plots the counterfactuals for the model with less elastic durable supply. The left column reports the micro counterfactuals (which exclude general equilibrium effects) and the right column reports the general equilibrium counterfactuals. The left column is identical to Figure 4 because the relative durable price only changes in general equilibrium. In the top right panel, we no longer see evidence of sharp V-shapes for total PCE in the general equilibrium counterfactual for our preferred MPC of 0.3. This counterfactual is spanned by the data and the most pessimistic forecast and the decline in PCE spending from April-July is a modest 0.7%, which is well within the historical norm (26 3-month windows have lower PCE growth). For these reasons we no longer consider the counterfactual for our preferred MPC implausible.

By comparing the two middle panels, we see that the general equilibrium response of motor vehicle expenditure to a tax rebate is much less than implied by the micro MPCs, and this difference largely accounts for the dampening of total PCE in general equilibrium. The general equilibrium dampening of the motor vehicles responses stems from the rise in relative motor vehicle price. In our preferred calibration with a micro MPC of 0.3, the tax rebate increases the relative vehicle price by 1.1% in July 2008 followed by a gradual decline. The bottom panel of Figure 8 shows the implied counterfactual relative vehicle price absent the rebate. In our preferred calibration with a micro MPC of 0.3, the June spike in the relative motor vehicle price is muted relative to the data.

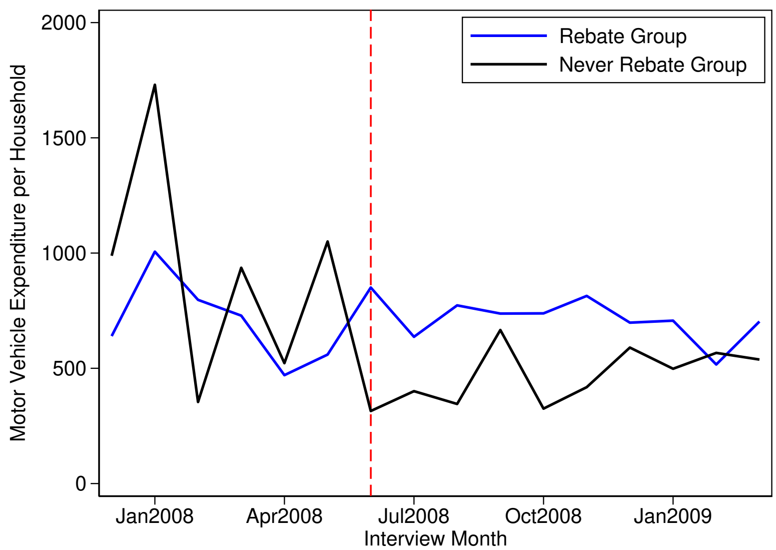
Optimizing households intertemporally substitute away from durable goods because their price is temporarily high; however, there is only a small amount of intratemporal substitution toward nondurable goods. Hand-to-mouth households also reduce their real expenditures on durable goods, but in their case, it is because their MPCs are fixed in nominal terms so the rise in relative prices of durable goods eats up part of their spending.

Figure 8. Counterfactual Real Consumption Expenditures: Less Elastic Supply



Notes. Based on NK model simulations and actual data on rebates and consumption. The micro MPC value refers to the MPC for total consumption.

Figure 9. Motor Vehicle Spending per Household by Rebate Status



Source: CEX and author's calculation. The rebate group is the set of in-sample households that ever report receiving a rebate. The never rebate group is the set of in-sample households that never report receiving a rebate. The red dashed line is June 2008, the first interview month in which expenditure and rebate receipt for May 2008 are recorded.

An implication of this mechanism is that the control group in the household regressions in Section 4 is also affected by the rebate. Specifically, the group of households that does not receive a rebate will reduce its expenditures on motor vehicles because of the temporarily higher motor vehicle price.[25] Figure 9 plots evidence for this mechanism in the CEX data. Motor vehicle expenditure rises in the treated group when the first rebates are reported in June 2008, but it simultaneously falls in the control group.

Table 6. General Equilibrium Marginal Propensity to Consume: Model with Less Elastic Durable Supply

PCE		Motor vehicles		Nondurable goods	
micro	GE	micro	GE	micro	GE
0.30	0.07	0.30	0.09	0.00	−0.03
0.50	0.22	0.40	0.15	0.10	0.07
0.90	1.42	0.40	0.45	0.50	0.97

25. There is also a symmetric crowding out effect for the group of households that do receive rebates, so that the difference in spending—the micro MPC— is unaffected and only the aggregate GE-MPC falls.

Table 6 tabulates the correspondence between the micro MPCs and the GE-MPCs in the model. When the micro MPC is 0.3, the GE-MPC is only 0.07. In this case, the general equilibrium forces of the model dampen the effect of the rebate on consumer expenditure. For a micro MPC of 0.5, this dampening is smaller and the GE-MPC is 0.22. For a micro MPC of 0.9, there is still amplification in general equilibrium resulting in a GE-MPC of 1.42.

The next four columns of Table 6 decompose the MPCs into durable expenditure (motor vehicles) and nondurable expenditure. Note that the durable micro MPC were directly calibrated to the empirical evidence. The dampening in general equilibrium is concentrated in durable expenditure. When the micro MPC on durables is 0.3, then the GE-MPC is only 0.09. There is only a minor change in nondurable expenditure due to a higher real interest rate since this expenditure is not very interest rate sensitive.

Because the durable demand is an important determinant of crowding out, in appendix Table B.1 we investigate the sensitivity of our results to a smaller demand elasticity of -6.4, based on the estimates in Baker et al. (2019), instead of our baseline value of -15. The Baker et al. (2019) value is the lower end of cross-regional durable demand elasticity estimates and, to the extent that it is contaminated by local price responses, it represents a lower bound on the household elasticity. The GE-MPC in this case is 0.12 rather than 0.07 in our baseline calibration. Thus, there is still substantial crowding out in general equilibrium.

The combination of these dampening general equilibrium forces and more modest micro MPC estimates yields macroeconomic counterfactuals that we consider plausible, reconciling the implausible counterfacutals based on the original micro estimates and the model in Section 3. However, they also imply that the effect of the rebate on consumption expenditures in general equilibrium was modest. With our preferred micro MPC of 0.3, we find that the general equilibrium increase in total consumer spending is less than 20 cents per dollar of the total rebate. Thus, our results imply that the stimulative effect of the 2008 rebate was modest.[26]

26. Pennings (2021) estimates a regional transfer multiplier of 0.4 across U.S. States. However, this estimate relies on excluding certain observations as outliers, which when included reduce the multiplier to -0.09. The estimates from the baseline sample are also sensitive to inclusion of a lead treatment effect, which has a multiplier of -0.49, and reduces to contemporaneous multiplier to 0.19. Thus, the cross-state data are consistent with the small aggregate effects implied by our model.

Table 7. General Equilibrium Marginal Propensity to Consume: Model without Durable Goods

PCE	
micro	GE
0.30	0.36
0.50	0.74
0.90	2.54

5.3 Implications for HANK Models

The aggregate effects of the rebate in our model depend importantly on the distribution of spending across nondurable and durable goods, and not only on the average MPC. Table 7 shows the GE-MPC in a model that abstracts from durable goods and calibrates the nondurable micro MPC to the overall response to expenditure.[27] In this model, when the micro MPC for nondurable expenditure (and thus overall expenditure) is 0.30, then the GE-MPC is 0.36. Thus abstracting from durable goods yields the conclusion that the tax rebate is amplified in general equilibrium. By contrast, in our model with durable goods the GE-MPC is only 0.07 (Table 6), which is significantly smaller than the GE-MPC in the nondurables only model. This sizeable difference reflects the stronger general equilibrium effects on durable expenditure, which reflects that durable demand is much more elastic than nondurable demand. Thus, in addition to heterogeneity in wealth and income stressed by the existing literature, we show that heterogeneity in goods is also an important determinant of the quantitative predictions of HANK models.

6 Conclusion

In this paper, we have argued that a standard New Keynesian model calibrated with the leading micro estimates of the marginal propensity to consume out of temporary stimulus payments implies counterfactual paths of consumption that are implausible. Using the 2008 tax rebate as a case study, we presented narrative and forecasting evidence that no events in late spring and summer 2008 should have caused aggregate con-

27. In this model we set the weight on the utility of durables stock to $\psi = 0$, the durable operating cost to $\eta = 0$, and the MPC for durables to $mpx = 0$.

sumption expenditures to plummet and then recover in August and September 2008. Using a two-good, two-agent New Keynesian model with standard amplification and high MPCs, we simulate the effect of the 2008 tax rebates and apply the simulated responses to actual aggregate consumption to create counterfactual paths of consumption had there been no rebate. The resulting counterfactual paths imply that consumption would have exhibited a sharp V-shape in late spring and summer 2008 if there had been no tax rebates. We argue that this counterfactual path is implausible.

We have reconciled the implausible counterfactual with the micro MPC estimates in two ways. First, we identify three biases in standard two-way fixed effects estimates of the micro MPC. When we correct for these biases the estimated micro MPCs that are noticeably lower than those in the literature. Second, we modified our two-good model, which features nondurable consumption goods and durable consumption goods (interpreted as motor vehicles), to incorporate more realistic supply elasticities of durable goods. This modification goes far to creating counterfactual consumption paths that are more plausible. The combination of the modified model and lower micro MPC estimates results in counterfactual paths that are no longer implausible. However, they imply that the general equilibrium consumption multiplier on the 2008 tax rebates was below 0.2.

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Online Appendix

A Model

A.1 Optimizing Households

A measure $1-\gamma$ of ex-ante identical households maximizes utility subject to their budget constraints. The utility function of each household i is

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^o(i)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} + \psi \frac{D_t^o(i)^{1-\frac{1}{\sigma^d}}}{1-\frac{1}{\sigma^d}} - \nu \frac{H_t^o(i)^{1+\phi}}{1+\phi} \right]$$

where $C_t^o(i)$ is nondurable consumption, $D_t^o(i)$ is the durable stock, and $H_t^o(i)$ is hours worked.

We assume that optimizing households face an adjustment friction on durable goods, since otherwise they would exhibit extremely high willingness to intertemporally substitute durables purchases. While households optimize their nondurable consumption every period, they do not optimze their durable holdings every period because they face an Evans and Ramey (1992) type of calculation cost. In particular, individual households experience random variations in the psychic costs of calculating optimal durable goods stocks, which could be due to varying cognitive demands of other events in their daily lives, etc. Only a fraction $1-\theta^d$ draw costs that are low enough to allow them to calculate and hence reoptimize their current durable stock. This friction produces a reversal in durable spending consistent with the evidence (McKay and Wieland (2021)) and keeps the model tractable since it produces a Calvo-type reduced form.

The friction on durable purchases implies that households will generally hold different durables stocks, $D_t^o(i) \neq D_t^o(j)$. We assume optimizing households form a family that provides consumption insurance across household members so nondurable consumption is identical, $C_t^o(i) = C_t^o, \ \forall i$. Labor supply is not chosen by the household, but instead by a union as discussed below. The union sets labor supply to be equal across households so $H_t^o(i) = H_t^o, \ \forall i$.

Integrating across all optimizing households, the utility function for the family is:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t^o)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} + \psi \frac{\int_0^1 D_t^o(i)^{1-\frac{1}{\sigma^d}} di}{1-\frac{1}{\sigma^d}} - \nu \frac{(H_t^o)^{1+\phi}}{1+\phi} \right]$$

The aggregate household budget constraint is

$$A_t^o = \frac{R_{t-1}}{\Pi_t} A_{t-1}^o - C_t^o + W_t H_t^o - X_t^o - OC_t^o - T_t^o + \text{Profits}_t^k + \text{Profits}_t^s$$
$$X_t^o = p_t^d \left[\int_0^1 [D_t^o(i) - (1-\delta^d) D_{t-1}^o(i)] di \right]$$
$$OC_t^o = \eta \int_0^1 D_t^o(i) di$$

where R_t is the gross nominal interest rate, Π_t is the gross inflation rate measured in nondurable goods prices, A_t^o are holdings of the nominal bond, W_t is the real wage, T_t^o are net taxes (i.e. taxes less transfers), Profits^k are profits of the capital good producing firms, and Profits^s are profits of the sticky-price firms, which produce nondurable goods. X_t^o is net durable expenditure denominated in nondurable goods, which is the sum of net durable purchases of each household, $D_t^o(i) - (1-\delta^d) D_{t-1}^o(i)$. OC_t are operating costs for the durable durable good (e.g., gasoline) which is a fraction η of the total durable stock held by all households. The inclusion of operating expenditures helps produce more realistic elasticities of durable demand.

The family picks an optimal plan $\{C_t^o, A_t^o, D_t^o(i)\}_{t=0}^{\infty}$ to maximize utility. The first order conditions for nondurable consumption and assets are:

$$\lambda_t = (C_t^o)^{-\frac{1}{\sigma}}$$
$$\lambda_t = \beta \frac{R_t}{\Pi_{t+1}} \lambda_{t+1}$$

where λ is the Lagrange multiplier on the household budget constraint.

The details of the Calvo adjustment frictions are analogous to those in price or wage setting. We first derive the optimal choice of $D_t^o(i)$ conditional on being able to adjust. Because the durable stock of household i in the problem is separable from the durable stock of other households, the optimization problem for household i is simply,

$$\max_{D_t(i)} \sum_{s=0}^{\infty} (\beta\theta^d)^s \left[\psi \frac{[(1-\delta^d)^s D_t(i)]^{\frac{\sigma^d-1}{\sigma^d}}}{1-\frac{1}{\sigma^d}} - \lambda_{t+s}\eta(1-\delta^d)^s D_t(i) \right] - \lambda_t p_t^d D_t(i)$$
$$+ \sum_{s=1}^{\infty} \beta^s (\theta^d)^{s-1} (1-\theta^d) \lambda_{t+s} p_{t+s}^d (1-\delta^d)^s D_t(i)$$

Here $(\theta^d)^s$ is the survival probability of the current durable stock into period s, $\psi \frac{D_t(i)^{\frac{\sigma^d-1}{\sigma^d}}}{1-\frac{1}{\sigma^d}}$ is its contribution to household utility, $\lambda_{t+s}\eta(1-\delta^d)^s D_t(i)$ is the operating cost while the durable stock remains in place measured in utils, $\lambda_t p_t^d D_t(i)$ is the purchasing price in utils, and $\lambda_{t+s} p^d_{t+s}(1-\delta^d)^s D_t(i)$ is the resale value of the durable in utils if another adjustment opportunity arises at time $t+s$.

The first order condition for $D_t(i)$ is then

$$\psi \sum_{s=0}^{\infty} [\beta\theta^d (1-\delta^d)^{\frac{\sigma^d-1}{\sigma^d}}]^s D_t(i)^{-\frac{1}{\sigma^d}} = p^d_t \lambda_t + \eta \sum_{s=0}^{\infty} [\beta\theta^d(1-\delta^d)]^s \lambda_{t+s}$$
$$- \beta(1-\theta^d)(1-\delta^d) \sum_{s=1}^{\infty} [\beta\theta^d(1-\delta^d)]^{s-1} p^d_{t+s} \lambda_{t+s}$$

The problem is identical across households that can make an adjustment at time t. Therefore, let D^{o*}_t denote the common optimal reset value for the durable stock at time t. The optimal reset value is:

$$D^{o*}_t = \left(\frac{\psi \sum_{s=0}^{\infty} [\beta\theta^d (1-\delta^d)^{\frac{\sigma^d-1}{\sigma^d}}]^s}{p^d_t \lambda_t + \eta \sum_{s=0}^{\infty} [\beta\theta^d(1-\delta^d)]^s \lambda_{t+s} - \beta(1-\theta^d)(1-\delta^d) \sum_{s=1}^{\infty} [\beta\theta^d(1-\delta^d)]^{s-1} p^d_{t+s} \lambda_{t+s}} \right)^{\sigma^d}$$

The first order condition for D^{o*}_t can be written recursively as,

$$\begin{aligned}
D^{o*}_t &= \left(\frac{\Omega_{1t}}{\Omega_{2t}}\right)^{\sigma^d} \\
\Omega_{1t} &= \psi + \beta\theta^d(1-\delta^d)^{\frac{\sigma^d-1}{\sigma^d}} \Omega_{1,t+1} \\
\Omega_{2t} &= (p^d_t + \eta)\lambda_t - \beta(1-\delta^d) p^d_{t+1} \lambda_{t+1} + \beta\theta^d(1-\delta^d)\Omega_{2,t+1} \\
&= \lambda_t \left[p^d_t + \eta - \frac{(1-\delta^d)\Pi_{t+1}}{R_t} p^d_{t+1} \right] + \beta\theta^d(1-\delta^d)\Omega_{2,t+1}
\end{aligned}$$

where Ω_1 is the expected present discounted value of a unit of durable varieties and Ω_2 is the expected present discounted value of the user cost.

By defining the total durable stock among optimizing households as

$$D^o_t \equiv \int_0^1 D^o_t(i) di,$$

we obtain the standard durable accumulation equation and durable net expenditure as a function of aggregate variables only,

$$\begin{aligned}
D^o_t &= (1-\delta^d) D^o_{t-1} + \frac{X^o_t}{p_t} \\
X^o_t &= p^d_t (1-\theta^d)[D^{o*}_t - (1-\delta^d) D^o_{t-1}].
\end{aligned}$$

Using a log-linear approximation to the first order conditions, the elasticity of durable expenditure with respect to the real interest rate is

$$\frac{d\ln X^o}{d\ln R} = \sigma^d \left[\frac{1-\theta^d(1-\delta^d)}{\delta^d}\right]\left[\frac{(1-\delta^d)[1-\beta\theta(1-\delta)]}{R-1+\delta+\eta}\right]$$

The first term in brackets captures the extensive margin response: When $\theta^d > 0$ only a fraction of the durable stock can respond to changes in the real interest rate. The second term in brackets captures the intensive margin. Because of the Calvo friction, households know that any durable purchase cannot be immediately sold next period. Therefore the expected user cost of a durable purchase is not just the contemporaneous user cost $p_t^d + \eta - \frac{(1-\delta^d)p_{t+1}^d \Pi_{t+1}}{R_t}$ but the whole expected present discounted value Ω_{2t}. A short-term change in the real rate has a smaller effect on the expected present discounted value Ω_{2t} because the contemporaneous user cost only accounts for a part of it. Therefore the intensive margin also becomes less sensitive to short-term changes in interest rates because these have a smaller effect on the expected user cost of the durable.

A.2 Hand-to-Mouth Households

In order for lump-sum transfers to have general equilibrium effects, we require non-Ricardian households. We adopt Galí et al.'s (2007) assumption that a certain fraction γ consume hand-to-mouth. Relative to their set-up, our hand-to-mouth households may consume their income over several periods rather than all at once.

We assume that in steady state, hand-to-mouth households have the same after-tax income and consume the same relative amount of durable and nondurable services as optimizing households,

$$WH^m - T^m = WH^o + \text{Profits}^k + \text{Profits}^s - T^o$$
$$\frac{C^m}{X^m} = \frac{C^o}{X^o}$$

where variables superscripted by m denote the hand-to-mouth household.

We then directly specify dynamic marginal propensities to consume for nondurable and durable expenditures to match both the allocation across goods and any lagged effects implied by the micro MPC estimates,

$$
\begin{aligned}
C_t^m - C^m + \eta(D_t^m - D^m) &= \sum_{l=0}^{L} mpc_l [W_{t-l} H_{t-l}^m - T_{t-l}^m - (WH^m - T^m)] \prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-k+1}} \\
X_t^m - X^m &= \sum_{l=0}^{L} mpx_l [W_{t-l} H_t^m - T_{t-l}^m - (WH^m - T^m)] \prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-k+1}} \\
1 &= \sum_{l=0}^{L} (mpc_l + mpx_l) \\
mpx_l &= \frac{\vartheta}{1-\vartheta} mpc_l, \qquad \forall l = 0, ..., L
\end{aligned}
$$

where mpc_l is the marginal propensity to spend on nondurable goods today out of income l periods ago, and mpx_l is the marginal propensity to spend on durable goods today out of income l periods ago. Income that was saved l periods ago for consumption today accrues real interest $\prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-1+1}}$.

The marginal utility to consume for the hand-to-mouth household is

$$\lambda_t^m = (C_t^m)^{-\frac{1}{\sigma}}$$

The durable stock owned by the hand-to-mouth consumers follow an analogous accumulation equation

$$D_t^m = (1-\delta^d) D_{t-1}^m + \frac{X_t^m}{p_t^d}$$

A.3 Wages

A continuum of unions indexed by j provide differentiated labor services to the final good firm that are subsitutable with elasticity ϵ^w. Each period there is a iid probability θ^w that the union cannot adjust the contract wage. In this case, wages will adjust by a fraction χ^w of last periods inflation.

The union imposes the same work hours on optimizing and hand-to-mouth households:

$$H_t^m = H_t^o = H_t$$

The demand for hours from union j at time $t+s$ conditional on having last reset wages at time t is

$$H^d_{t+s}(j) = H^d_{t+s}\left(\frac{W_t(j)(\frac{P_{t+s-1}}{P_{t-1}})^{\chi^w}(\frac{P_t}{P_{t+s}})}{W_{t+s}}\right)^{-\epsilon^w} = H^d_{t+s}W^{\epsilon^w}_{t+s}\left(\frac{P_{t+s}}{P_t}\right)^{\epsilon^w}\left(\frac{P_{t+s-1}}{P_{t-1}}\right)^{-\epsilon^w\chi^w} W_t(j)^{-\epsilon^w}$$

where P_t is the price level at time t.

If the union can adjust its wage at time t it picks the optimal wage to maximize the expected discounted utility of the representative household while this wage prevails:

$$\max_{w^*_t}\sum_{s=0}^{\infty}(\beta\theta^w)^s H^d_{t+s}W^{\epsilon^w}_{t+s}\left(\frac{P_{t+s}}{P_t}\right)^{\epsilon^w}\left(\frac{P_{t+s-1}}{P_{t-1}}\right)^{-\epsilon^w\chi^w}\left[\tilde{\lambda}_{t+s}\left(\frac{P_{t+s-1}}{P_{t-1}}\right)^{\chi^w}\left(\frac{P_{t+s}}{P_t}\right)^{-1}(W^*_t)^{1-\epsilon^w} - \nu H^{\phi}_{t+s}(W^*_t)^{-\epsilon^w}\right]$$

where $\tilde{\lambda} = (1-\gamma)\lambda_t + \gamma\lambda^m_t$

The first order condition for the union is:

$$\begin{aligned}&(\epsilon^w-1)\sum_{s=0}^{\infty}(\beta\theta^w)^s H^d_{t+s}W^{\epsilon^w}_{t+s}\left(\frac{P_{t+s}}{P_t}\right)^{\epsilon^w-1}\left(\frac{P_{t+s-1}}{P_{t-1}}\right)^{-\chi^w(\epsilon^w-1)}\tilde{\lambda}_{t+s}(W^*_t)^{1-\epsilon^w}\\ &= \epsilon^w\nu\sum_{s=0}^{\infty}(\beta\theta^w)^s H^d_{t+s}H^{\phi}_{t+s}W^{\epsilon^w}_{t+s}\left(\frac{P_{t+s}}{P_t}\right)^{\epsilon^w}\left(\frac{P_{t+s-1}}{P_{t-1}}\right)^{-\epsilon^w\chi^w}(W^*_t)^{-\epsilon^w}\end{aligned}$$

We write it recursively using

$$\begin{aligned}F_{1t} &= \nu H^d_t H^{\phi}_t W^{\epsilon^w}_t(W^*_t)^{-\epsilon^w} + \beta\theta^w\Pi^{\epsilon^w}_{t+1}\Pi^{-\chi^w\epsilon^w}_t\left(\frac{W^*_t}{W^*_{t+1}}\right)^{-\epsilon^w}F_{1,t+1}\\ F_{2t} &= H^d_t W^{\epsilon^w}_t\tilde{\lambda}_t(W^*_t)^{1-\epsilon^w} + \beta\theta^w\Pi^{\epsilon^w-1}_{t+1}\Pi^{-\chi^w(\epsilon^w-1)}_t\left(\frac{W^*_t}{W^*_{t+1}}\right)^{1-\epsilon^w}F_{2,t+1}\\ \epsilon^w F_{1t} &= (\epsilon^w-1)F_{2t}\end{aligned}$$

Wage dispersion across unions lead to inefficiency in the labor types used by firms. This creates a wedge between hours worked H_t and effective hours worked H^d_t, which we denote by s^w_t,

$$H_t = s^w_t H^d_t,$$

and which evolves according to,

$$s^w_t = (1-\theta^w)\left(\frac{W^*_t}{W_t}\right)^{-\epsilon^w} + \theta\left(\frac{W_{t-1}}{W_t}\right)^{-\epsilon^w}\Pi^{\epsilon^w}_t s^w_{t-1}$$

A.4 Production of capital goods

The representative capital goods firm chooses investment I_t, the capital stock K_t, and the utilization rate u_t to maximize profits,

$$\max_{\{K_{t+s},I_{t+s},u_{t+s}\}} \sum_{s=0}^{\infty} \beta^s \lambda_{t+s} \text{Profits}_{t+s}^k$$
$$\text{s.t. } \text{Profits}_t^k = R_t^k u_t K_{t-1} - I_t$$
$$K_t = (1-\delta(u_t))K_{t-1} + I_t\left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right]$$

where R_{t+s}^k is the rental rate of capital paid by the final goods firm, $S\left(\frac{I_t}{I_{t-1}}\right)$ is an investment adjustment cost, and $\delta(u)$ is the depreciation rate of capital which is increasing in utilization.

Let ζ_t be the Lagrange multiplier on the capital accumulation equation and define Tobin's q as the relative value of capital to nondurable consumption,

$$q_t = \frac{\zeta_t}{\lambda_t^o}.$$

Then the first order conditions for the representative capital producing firms are,

$$1 = q_t\left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - \left(\frac{I_t}{I_{t-1}}\right) S'\left(\frac{I_t}{I_{t-1}}\right)\right] + \beta\frac{\lambda_{t+1}}{\lambda_t} q_{t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 S'\left(\frac{I_{t+1}}{I_t}\right)$$
$$q_t = \beta\frac{\lambda_{t+1}}{\lambda_t} R_{t+1}^k u_{t+1} + \beta(1-\delta(u_{t+1}))\frac{\lambda_{t+1}}{\lambda_t} q_{t+1}$$
$$R_t^k = \delta'(u_t) q_t$$

A.5 Production of final goods

Final output Y_t is produced using a Cobb-Douglas production function with capital share α,

$$s_t Y_t = Z_t (u_t K_{t-1})^\alpha (H_t^d)^{1-\alpha}$$

where Z_t is aggregate TFP. The wedge s_t captures a distortion from price dispersion, which is described below.

The cost minimization for the representative final goods firm is

$$\min R_t^k u_t K_{t-1} + W_t H_t^d$$
$$\text{s.t. } Z_t (u_t K_{t-1})^\alpha (H_t^d)^{1-\alpha} = s_t Y_t$$

which yields the following first order conditions for capital and labor,

$$R_t^k = \xi_t \alpha \frac{s_t Y_t}{u_t K_{t-1}}$$
$$W_t = \xi_t (1-\alpha) \frac{s_t Y_t}{H_t^d}$$

where ξ_t is the Lagrange multiplier on the production function. Dividing the two first order conditions yields the optimal capital-labor ratio,

$$\frac{u_t K_{t-1}}{H_t^d} = \frac{\alpha}{1-\alpha} \frac{W_t}{R_t^k},$$

which in turn yields the marginal cost of output is,

$$MC_t = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}(R_t^k)^{\alpha} W_t^{1-\alpha} \frac{1}{Z_t}$$

With perfect competition among final goods firms, the real final goods price is equal to marginal cost,

$$p_t^f = MC_t,$$

and final good firms make zero profits.

A.6 Prices

A continuum of retailers purchases final goods at price p_t^f and differentiates these goods with elasticity of substitution ϵ. Retailers can only reset their price with probability θ. The profit maximization problem for setting the reset price is

$$\max_{p_t^*} \sum_{s=0}^{\infty} \beta^s \left(\frac{\lambda_{t+s}}{\lambda_t} \right) \theta^s Y_{t+s} \left[(p_t^*)^{1-\epsilon} \left(\frac{P_{t+s}}{P_t} \right)^{\epsilon-1} - (p_t^*)^{-\epsilon} \left(\frac{P_{t+s}}{P_t} \right)^{\epsilon} p_{t+s}^f \right]$$

The first order condition for the optimal reset price is

$$\epsilon \sum_{s=0}^{\infty} \beta^s \left(\frac{\lambda_{t+s}}{\lambda_t} \right) \theta^s Y_{t+s} \left(\frac{P_{t+s}}{P_t} \right)^{\epsilon} (p_t^*)^{-\epsilon-1} p_{t+s}^f = (\epsilon - 1) \sum_{s=0}^{\infty} \beta^s \left(\frac{\lambda_{t+s}}{\lambda_t} \right) \theta^s Y_{t+s} \left(\frac{P_{t+s}}{P_t} \right)^{\epsilon-1} (p_t^*)^{-\epsilon}$$

which we write recursively as

$$
\begin{aligned}
X_{1t} &= Y_t p_t^f (p_t^*)^{-\epsilon-1} + \beta\theta \left(\frac{\lambda_{t+1}}{\lambda_t}\right)\left(\frac{P_{t+1}}{P_t}\right)^{\epsilon}\left(\frac{p_t^*}{p_{t+1}^*}\right)^{-\epsilon-1} X_{1,t+1} \\
X_{2t} &= Y_t (p_t^*)^{-\epsilon} + \beta\theta \left(\frac{\lambda_{t+1}}{\lambda_t}\right)\left(\frac{P_{t+1}}{P_t}\right)^{\epsilon-1}\left(\frac{p_t^*}{p_{t+1}^*}\right)^{-\epsilon} X_{2,t+1} \\
\epsilon X_{1t} &= (\epsilon-1) X_{2t}
\end{aligned}
$$

The optimal reset price determines aggregate inflation

$$
1 = (1-\theta)(p_t^*)^{1-\epsilon} + \theta \Pi_t^{-(1-\epsilon)}
$$

as well as the relative price distortion

$$
\begin{aligned}
s_t &= \int_0^1 \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} di \\
&= (1-\theta)(p_t^*)^{-\epsilon} + \theta \int_0^1 \left(\frac{P_{t-1}(i)}{P_t}\right)^{-\epsilon} di \\
&= (1-\theta)(p_t^*)^{-\epsilon} + \theta \Pi_t^{\epsilon} s_{t-1}
\end{aligned}
$$

Due to monopoly power, the sticky-price firms make non-zero profits in equilibrium equal to

$$
\text{Profits}_t^s = Y_t (1 - p_t^f)
$$

A.7 Government

The central bank sets the gross nominal interest rate according to the following interest rate rule,

$$
R_t = (1-\rho_r) R_{t-1} + \rho_r \left[R + \phi_\pi (\Pi_t - \bar{\Pi}) + \phi_y \left(\frac{Y_t}{\bar{Y}} - 1\right)\right]
$$

where ρ_r determines the degree of interest rate smoothing, ϕ_π the response to deviations of inflation from target, and ϕ_y the response to deviations of output from target.

The government issues one-period nominal bonds at gross interest R_t to cover debt repayment and any fiscal deficit.

$$
B_t = \frac{R_{t-1}}{\Pi_t} B_{t-1} - T_t
$$

To balance the budget over time, taxes are an increasing function of the debt level,

$$T_t = T + \phi_b(B_{t-k} - \bar{B}) - \epsilon_t.$$

We allow for a lag of k periods in the response of taxes to debt. The shock ϵ_t represents a one-time deficit financed transfer from the government to households.

A.8 Durable Goods Production

Durable goods are produced competitively using nondurables N_t as inputs,

$$\frac{X_{it}}{p_t^d} = N_{it}$$

where $\frac{X_{it}}{p_t^d}$ is the quantity of durable goods produced.

Real profits from the sale of durable goods are

$$\max_{N_{it}} X_{it} - N_{it} = \max_{N_{it}} p_t^d N_{it} - N_{it}$$

Profit maximization yields a flat relative supply curve,

$$p_t^d = 1.$$

A.9 Market Clearing

The goods market clears if total expenditure equals output.

$$Y_t = C_t + I_t + X_t$$

The bond market clears of bonds supplied by the government equal bonds held by households,

$$B_t = A_t$$

A.10 Functional Forms

We assume the following functional forms:

$$\delta(u_t) = \delta_0 + \delta_1(u_t - 1) + \delta_2(u_t - 1)^2$$
$$S\left(\frac{I_t}{I_{t-1}}\right) = \frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2$$

B Additional Counterfactuals

Table B.1 shows the GE-MPCs in a version of the model calibrated to a 2-month durable demand elasticity of -6.4 based on the estimates from Baker et al. (2019).

Table B.1. General Equilibrium Marginal Propensity to Consume: Model with Less Elastic Durable Demand

PCE		Motor vehicles		Nondurable goods	
micro	GE	micro	GE	micro	GE
0.30	0.12	0.30	0.14	0.00	−0.02
0.50	0.31	0.40	0.23	0.10	0.09
0.90	1.54	0.40	0.51	0.50	1.03

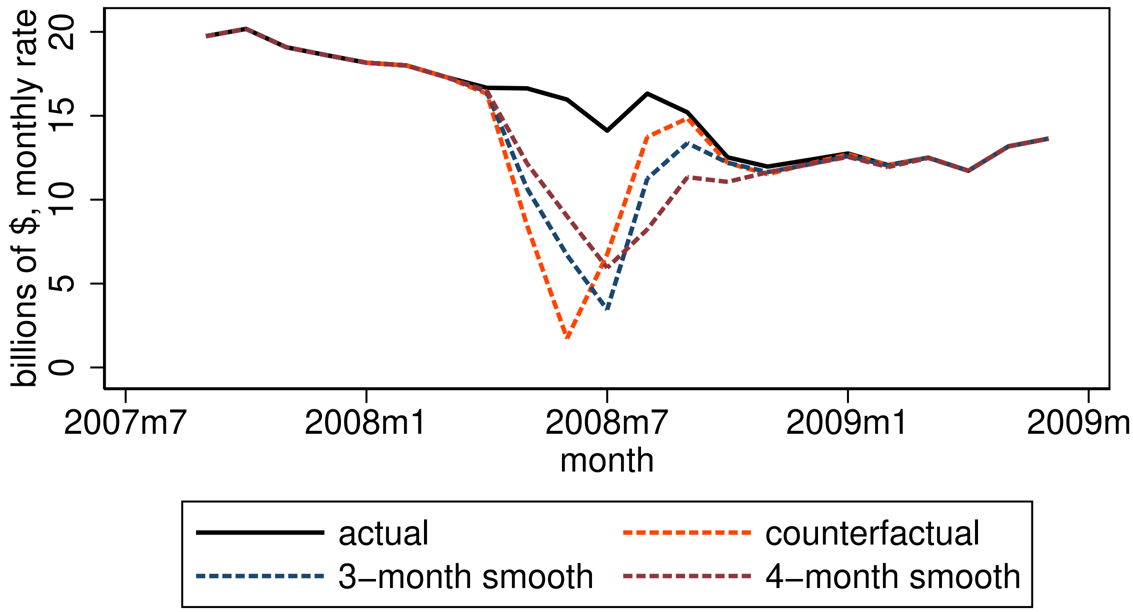
C Empirical Appendix

C.1 Details for Figure 1

The following are details of the Sahm et al. (2012) calculation and our update. Sahm et al. (2012) use Parker et al.'s (2013) estimate of a marginal propensity to spend on new motor vehicles of 0.357 (from Table 7 of Parker et al. (2013)) to calculate induced spending. Following Parker et al. (2013), they assume that the spending is evenly distributed between the current and the next month. They use seasonal factors to seasonally adjust the induced spending. We follow the same procedure to calculate induced spending and then subtract it from actual spending to create the implied counterfactual, which does not account for partial or general equilibrium effects.

The following graph shows counterfactuals from the motor vehicle accounting exercise for different assumptions of how much the spending is smoothed.

Figure C.1. Expenditures on New Motor Vehicles: Alternative Counterfactuals



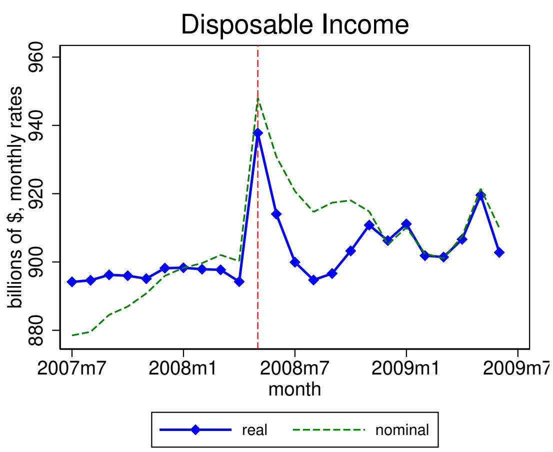
Note. The baseline counterfactual assumes that rebate-induced spending is spread over two months. The two alternatives show the counterfactual with the induced spending spread over three or four months.

C.2 Supplement to 2008 Narrative

This section supplements the 2008 narrative with details and graphs of the behavior of nominal expenditures, prices, and the federal funds rate.

Figure C.2 shows the behavior of nominal NIPA disposable personal income and consumption from mid-2007 through mid-2009, in addition to real NIPA disposable personal income and consumption that we plotted in Figure 3. We normalize real income and consumption to be equal to nominal values in January 2008 for better illustration.

Figure C.2. Aggregate Disposable Income and Consumption



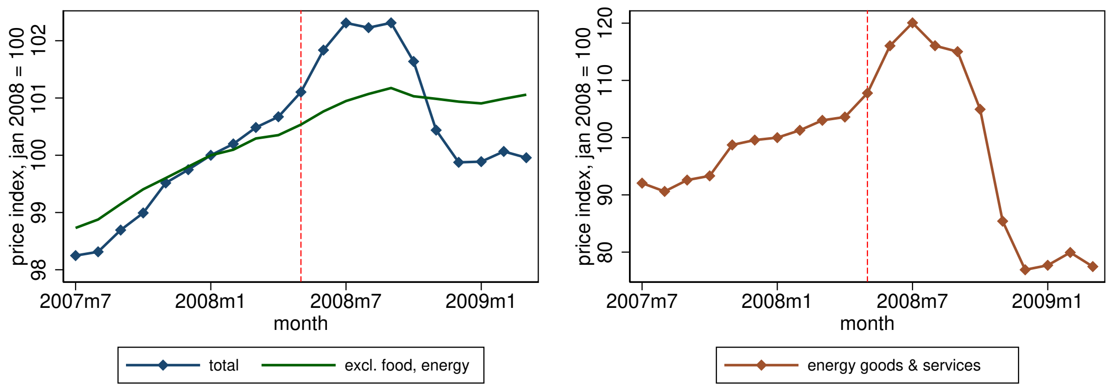
Source. BEA data. Vertical red dashed line indicates May 2008.

The effect of the 2008 tax rebate on disposable income is clearly evident in the spikes in both the nominal and real disposable income series, shown in the left panel. For both disposable income and consumption, however, the nominal and real paths look quite different from each other because of the behavior of inflation. Nominal consumption shows a prominent hump in Summer 2008, but real consumption displays only a small bump.

Figure C.3 shows the price indices for total consumption expenditures and consumption expenditures excluding food and energy. Consider first the behavior of the price deflator for total consumption. The rate of inflation for total consumption accelerated after April, resulting in July prices that were 1.6 percent above April prices. Price levels then reached a plateau and fell after the failure of Lehman Brothers in September, so that by the end of the year the level of prices was slightly lower than at the start of the year.

In contrast, the price index for consumption excluding the volatile food and energy components showed a more modest rate of inflation, averaging 3.4 percent annualized

Figure C.3. Price Indices for Consumption



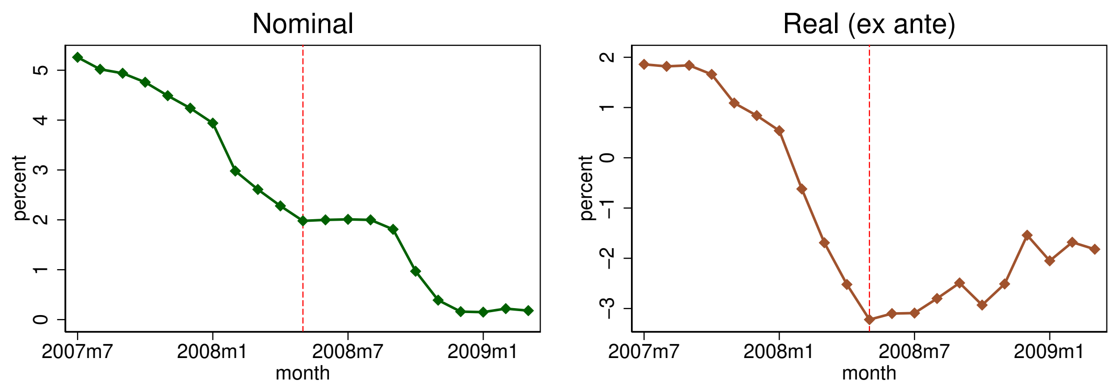
Source. BEA data.

for January through the peak in September 2008. This price level then declined slightly after the collapse of Lehman Brothers.

A key source of volatility of consumer prices in 2008 was the behavior of crude oil prices (not shown). The price for West Texas Intermediate rose from $98 per barrel in January 2008 to a peak of $140 per barrel in July 2008. By the end of 2008, it had fallen to only $33 per barrel.

Turning to interest rates, Figure C.4 shows the behavior of the nominal and ex ante real federal funds rate. The ex ante real federal funds rate is the difference between the nominal federal funds rate and the current month median expected annual inflation rate from the University of Michigan Survey of Consumers. The nominal series shows cuts every month from mid-2007 to May 2008, a leveling off from May through August, and then cuts until the zero lower bound was reached. The combination of the cuts and the higher expected rates of inflation result in negative real interest rates starting in February 2008.

Figure C.4. Federal Funds Rate



Source. FRED, based on Federal Reserve Board of Governors. The ex ante real interest rate is constructed using the current month median expected annual inflation rate from the University of Michigan Survey of Consumers.

C.3 Alternative Measures of Consumption Expenditures

Because the monthly NIPA consumption data are based on combining and smoothing various data sources, we provide supplemental evidence that the patterns we showed for consumption expenditures in Figure 3 are not due to smoothing procedures.

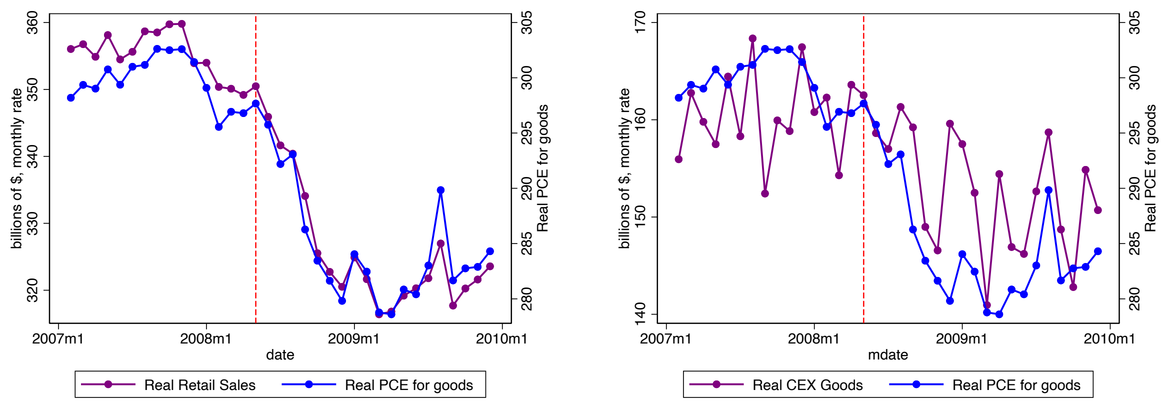
We compare the NIPA measures of personal consumption expenditures (PCE) on goods to two other series: the Census series on retail sales of goods and our own constructed series based on the CEX data that is the basis for the micro estimates.[28] As described by Wilcox (1992), government statisticians use retail sales as an input to monthly consumption, but then make a number of adjustments. To make sure those adjustments are not smoothing out jumps in consumption due to the rebate, we examine the key underlying series as well as our constructed alternative from the CEX. For all series, we use the PCE goods deflator to create real spending series.

Figure C.5 shows the comparisons from 2007 through 2009. Consider first the left side graph, which compares PCE on goods to retail sales. The movements in the two series match up very well over the two years. Both show a slight blip up in May 2008, with the retail series showing a more muted blip. Thus, it is unlikely that BEA smoothing of retail sales would account for the consumption pattern.

The right-hand side graph compares PCE on goods to our aggregates of household spending on goods using CEX micro data. The CEX aggregate is much noisier than either the PCE data or the retail sales data. The CEX series falls from February to March,

28. To construct this series we match categorical spending in the CEX to NIPA spending following the concordance prepared by the BLS staff (Bureau of Labor Statistics, 2019).

Figure C.5. Comparison of PCE to Retail and CEX

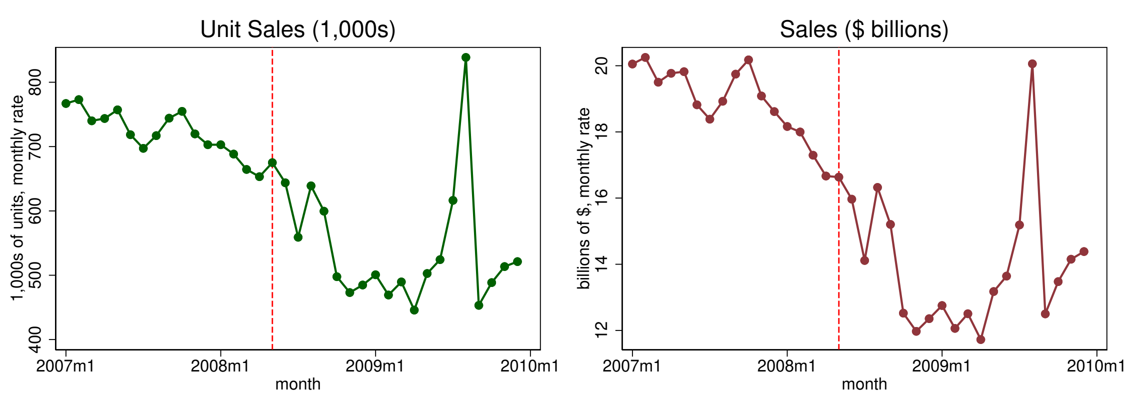


Source. PCE (Personal Consumption Expenditures) from BEA; Retail sales from Census; Authors' aggregation from CEX. Vertical red dashed line indicates May 2008.

recovers in April, and then declines in May and June. These movements look similar to those in other months, suggesting more noise than information.

In Figure C.6 we plot new motor vehicle sales in units (left panel) and in dollars (right panel). Due to mandatory registration new motor vehicle sales are essentially perfectly measured. They are also one of the categories in which Parker et al. (2013) estimate large MPCs. Thus, these data should be informative whether there is an expenditure spike following the 2008 rebate. The unit sales in the left panel show a small blip in May 2008 (red vertical line), but there is little change in dollar sales in the right panel. Neither data series shows a large spike in motor vehicle purchases around the time the rebate is received by household.

Figure C.6. New Motor Vehicle Sales



Source: Unit sales and total sales from BEA.

We conclude that the PCE data is not smoothing out a large jump in consumption when the rebates are distributed.

C.4 Forecast Appendix

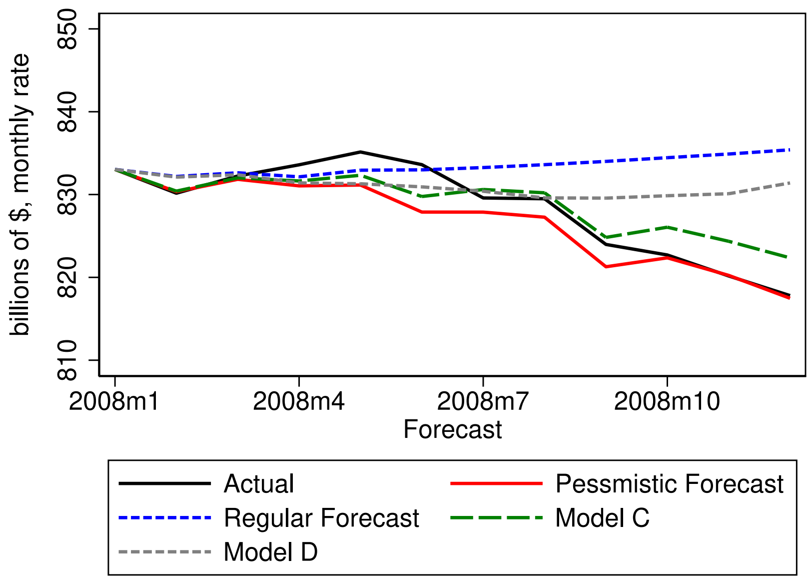
Our forecasting model is a simple monthly-frequency time series model with the following endogenous variables: log real consumption, log real disposable income, log consumption deflator, and the Gilchrist and Zakrajšek (2012) excess bond premium. We also include a dummy variable for recession, log real oil prices, and a dummy variable for the Lehman Brothers bankruptcy in September 2008. We use six lags of each variable. We include current values of the recession dummy, oil prices, and the excess bond premium in the equations for the endogenous variables. We estimate the model on data from 1984m1 - 2019m12 and forecast dynamically starting in January 2008. We start the estimation period in 1984 because the effects of oil prices on consumption expenditures changed significantly post-1984 (e.g. Edelstein and Kilian (2009)).

We produce four forecasts by varying our assumptions on whether oil prices followed their actual path and whether the recession and Lehman Brothers dummies. The most pessimistic forecasts are those in which oil prices are assumed to follow their actual path and in which the recession and Lehman Brothers bankruptcy dummy variables are included in the forecasting equation. The regular forecast excludes the recession and Lehman dummies and models oil prices as endogenous. Model C includes the recession dummies and models oil prices as endogenous, whereas model D excludes the dummies and models oil prices as exogenous. Figure C.7 show that models C and D are spanned by the pessimistic and regular forecast.

C.5 Vehicle Demand Elasticity from Mian and Sufi (2012)

The estimates in Mian and Sufi (2012) from the 2009 Cash-for-Clunkers program imply a two-month demand elasticity ranging from -26 to -30 compared to -26 in our model. Mian and Sufi (2012) argue that cross-city variation in Cash for Clunkers explains between 340k and 398k of additional autos sold in July and August. New vehicle sales in April and May were on average 833,000. Used vehicle sales were 36.5m and 35.5m in 2008 and 2009, implying an average monthly sales volume of 2m. Total baseline vehicle sales over two months are then 5.666m. The increase in vehicle sales estimated by Mian and Sufi then corresponds to $340k/5.666m = 6\%$ to $398k/5.666m = 7\%$ rise. Total expenditure on Cash for Clunkers was $3bn, and the vehicle stock in 2008 was worth $1279.4bn at replacement cost. This translates into a $3/1279.4 = 0.23$ percent reduction in the replacement price. Therefore, the elasticity implied by these estimates ranges from $-6/0.23{=}-26$ to $-7/0.23{=}-30$.

Figure C.7. Our Real Consumption Forecasts



Forecasts are based on information through January 2008, with exception of models in which oil prices are assumed to follow their actual path and Lehman Brothers dummies are included. Real oil prices exogenously follow their actual path in the pessimistic forecast and model D; Recession and Lehman Brothers bankruptcy dummy variables are included in the pessimistic forecast and model C.

C.6 Model Regressions

In this section we simulate data from the model in section 5 and repeat our empirical approach in section 4. Specifically, we simulate data that has the same overlapping structure and the same distribution of rebates as the CEX. Table C.1 shows that the baseline specification in Parker et al. (2013) (1) does not recover the true MPCs because it does not account for the comparison with previously treated units. By contrast, our preferred specification in column 4 of Table 3 correctly recovers the underlying MPC. Table C.2 shows that the bias of TWFE in equation (1) gets worse in the rebate only sample because that sample makes relatively more comparisons with previously treated units.

Table C.1. Rebate Coefficient MPC Estimates in Model: Full Sample

	Dependent Variable: Change in Total Expenditures					
Specification:	Table 3, Column 1			Table 3, Column 4		
True MPC:	0.3	0.5	0.9	0.3	0.5	0.9
Rebate Coeff.	334.1	556.9	1002.0	286.0	476.6	857.4
Implied MPC	0.35	0.59	1.05	0.30	0.50	0.90

Notes: The dependent variable is the change in total expenditures from the previous interview. The rebate size in the model is $950 for all households conditional on receiving a rebate. The rebate only sample includes only households that receieve a rebate at some point during our sample period.

Table C.2. Rebate Coefficient MPC Estimates in Model: Rebate Only Sample

	Dependent Variable: Change in Total Expenditures					
Specification:	Table 3, Column 1			Table 3, Column 4		
True MPC:	0.3	0.5	0.9	0.3	0.5	0.9
Rebate Coeff.	426.3	710.8	1278.3	286.1	476.6	857.3
Implied MPC	0.45	0.75	1.35	0.30	0.50	0.90

Notes: The dependent variable is the change in total expenditures from the previous interview. The rebate size in the model is $950 for all households conditional on receiving a rebate. The rebate only sample includes only households that receieve a rebate at some point during our sample period.

C.7 Reported Rebate Date

Households in the CEX are surveyed every three months for a year in one of three interview schedules: the first month of the quarter (Jan, Apr, Jul, Oct), the second month (Feb-May-Aug-Nov), or the third (Mar-Jun-Sep-Dec). Table C.3 shows the interview schedules based on the month the household reports receiving the rebate. Panel A shows the entire recipient sample, while panel B shows only households that received a check rather than an Electronic Funds Transfer. In each case, the CEX interview schedule should not be related to the date of rebate receipt.

The first column of Panel A shows that in the overall CEX, there are an equal number of households in each interview group. Since the last two-digits of a household's SSN are effectively random, the households *actual* rebate date should have no correlation with the households interview schedule. However, households are more likely to report receiving the rebate the month prior to their interview. For example, households that report receiving their rebate in May are more likely to be interviewed in June. This suggests that some households may incorrectly recall the actual date of their rebate. This could pose an issue for estimation if households are more likely to report receiving their rebate in the same interview that they report higher/lower spending.

Table C.3. Distribution of CEX Interview Schedule

	Panel A: EFT and Check Recipients			
	Overall CEX	May Cohort	June Cohort	July Cohort
Interview Schedule				
Jan-Apr-Jul-Oct	33%	32%	35%	26%
Feb-May-Aug-Nov	34%	29%	37%	39%
Mar-Jun-Sep-Dec	34%	39%	28%	34%

	Panel B: Check Recipients Only		
	May Cohort	June Cohort	July Cohort
Interview Schedule			
Jan-Apr-Jul-Oct	30%	36%	28%
Feb-May-Aug-Nov	34%	35%	40%
Mar-Jun-Sep-Dec	36%	28%	32%

Notes: Data in column 1 come from the entire CEX Sample 2007-2009. Data in columns 2-4 come from our subsample.

Table C.4. First Stage: Rebate Amount Conditional on Rebate Receipt

Panel A: Full Sample				
	Homogeneous Treatment		Heterogeneous Treatment	
	(1)	(2)	(3)	(4)
Rebate Indicator	948.60***	951.10***	950.54***	945.95***
	(10.37)	(10.29)	(10.19)	(10.07)
Lag Rebate Indicator		11.97***	0.59	−2.94**
		(3.17)	(0.54)	(1.20)
Lag Total Expenditure				0.00***
				(0.00)
Lag Motor Vehicle				−0.00
				(0.00)
Income Decile FE	No	No	No	Yes
Observations	16,962	16,962	16,962	16,962

Panel B: Rebate Recipients Only				
	Homogeneous Treatment		Heterogeneous Treatment	
	(1)	(2)	(3)	(4)
Rebate Indicator	931.69***	945.06***	939.42***	946.84***
	(13.11)	(12.73)	(12.53)	(13.25)
Lag Rebate Indicator		24.14***	−2.23	6.43
		(7.73)	(1.92)	(4.30)
Lag Total Expenditure				0.00***
				(0.00)
Lag Motor Vehicle				−0.00***
				(0.00)
Income Decile FE	No	No	No	Yes
Observations	10,076	10,076	10,076	10,076

Notes: The dependent variable is the dollar value of Econoimic Stimulus Payments (ESP) received by the household. Standard errors, in parentheses, are clustered at the household level. Regressions include interview (time) fixed effects, and household level controls for age, change in number of adults, and change in number of children. The rebate coefficients in columns (3) and (4) are the weighted average of the interaction between rebate cohort and the (lagged) rebate indicator with weights computed following Sun and Abraham (2021). Significance is indicated by: $^{*}\, p < 0.1$, $^{**}\, p < 0.05$, $^{***}\, p < 0.01$.

C.8 Estimated MPCs for Motor Vehicles and Parts and Other PCE

Table C.5. Household Total Spending (PSMJ) Response to Rebate

Panel A: Full Sample					
	Homogeneous Treatment		Heterogeneous Treatment		
	(1)	(2)	(3)	(4)	(5)
Rebate Indicator	483.19**	417.87**	325.96	251.71	142.94
	(209.87)	(202.02)	(203.45)	(178.69)	(176.91)
Lag 1 Rebate Indicator		−377.83*	−423.15**	−283.05*	−287.35*
		(214.64)	(202.03)	(159.67)	(165.18)
Lag Total Spending (PSMJ)				−0.50***	−0.50***
				(0.04)	(0.04)
Lag Motor Vehicle (PSMJ)				−0.50***	−0.51***
				(0.05)	(0.05)
Lag Non-durable (PSMJ)				0.36***	0.37***
				(0.06)	(0.06)
Implied 3-month MPC	0.52	0.45	0.35	0.27	0.15
Income Decile FE	No	No	No	Yes	Yes
Exclude 2+ Rebate	No	No	No	No	Yes
Observations	17,229	17,229	17,229	17,229	16,962

Panel B: Rebate Recipients Only					
	Homogeneous Treatment		Heterogeneous Treatment		
	(1)	(2)	(3)	(4)	(5)
Rebate Indicator	779.23**	551.34*	−276.02	266.66	122.10
	(310.22)	(315.93)	(447.00)	(312.34)	(567.69)
Lag 1 Rebate Indicator		−462.55	−1115.93**	−455.68*	−356.20
		(330.43)	(473.21)	(256.80)	(430.14)
Lag Total Spending (PSMJ)				−0.56***	−0.56***
				(0.04)	(0.04)
Lag Motor Vehicle (PSMJ)				−0.44***	−0.45***
				(0.04)	(0.04)
Lag Non-durable (PSMJ)				0.41***	0.42***
				(0.07)	(0.07)
Implied 3-month MPC	0.86	0.61	-0.31	0.30	0.13
Income Decile FE	No	No	No	Yes	Yes
Exclude 2+ Rebate	No	No	No	No	Yes
Observations	10,343	10,343	10,343	10,343	10,076

Notes: The dependent variable is the change in Total Spending (PSMJ). Regressions include interview (time) fixed effects, and household level controls for age, change in number of adults, and change in number of children. Standard errors for the 6-month MPC are estimated via Delta-method. The rebate coefficients in columns (3), (4), and (5) are the weighted average of the interaction between rebate cohort and the (lagged) rebate indicator with weights computed following Sun and Abraham (2021). Standard errors, in parentheses, are clustered at the household level: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.6. Household Motor Vehicles (PSMJ) Response to Rebate

Panel A: Full Sample					
	Homogeneous Treatment		Heterogeneous Treatment		
	(1)	(2)	(3)	(4)	(5)
Rebate Indicator	371.80**	344.36**	307.02**	397.73***	284.85***
	(154.33)	(147.19)	(147.06)	(121.19)	(107.41)
Lag 1 Rebate Indicator		−158.69	−214.69	87.34	77.30
		(154.50)	(138.42)	(93.72)	(95.38)
Lag Total Spending (PSMJ)				0.00	0.00
				(0.01)	(0.01)
Lag Motor Vehicle (PSMJ)				−1.01***	−1.01***
				(0.01)	(0.01)
Lag Non-durable (PSMJ)				0.04**	0.04**
				(0.02)	(0.02)
Implied 3-month MPC	0.40	0.37	0.33	0.43	0.30
Income Decile FE	No	No	No	Yes	Yes
Exclude 2+ Rebate	No	No	No	No	Yes
Observations	17,229	17,229	17,229	17,229	16,962

Panel B: Rebate Recipients Only					
	Homogeneous Treatment		Heterogeneous Treatment		
	(1)	(2)	(3)	(4)	(5)
Rebate Indicator	389.29*	273.37	−428.58	198.38	326.78**
	(231.18)	(229.01)	(371.84)	(178.29)	(157.26)
Lag 1 Rebate Indicator		−235.30	−877.39**	−178.29	149.70
		(255.14)	(432.50)	(127.90)	(124.41)
Lag Total Spending (PSMJ)				−0.01	−0.01
				(0.01)	(0.01)
Lag Motor Vehicle (PSMJ)				−0.99***	−1.01***
				(0.02)	(0.01)
Lag Non-durable (PSMJ)				0.06**	0.06**
				(0.02)	(0.02)
Implied 3-month MPC	0.43	0.30	-0.48	0.22	0.34
Income Decile FE	No	No	No	Yes	Yes
Exclude 2+ Rebate	No	No	No	No	Yes
Observations	10,343	10,343	10,343	10,343	10,076

Notes: The dependent variable is the change in Vehicle Spending (PSMJ). Regressions include interview (time) fixed effects, and household level controls for age, change in number of adults, and change in number of children. Standard errors for the 6-month MPC are estimated via Delta-method. The rebate coefficients in columns (3), (4), and (5) are the weighted average of the interaction between rebate cohort and the (lagged) rebate indicator with weights computed following Sun and Abraham (2021). Standard errors, in parentheses, are clustered at the household level: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.7. Contemporaneous Household PCE Response to Rebate: BJS Method

	Full Sample		Rebate Only Sample	
	(1)	(2)	(3)	(4)
Rebate Indicator	294.2	191.3	917.0	351.0
	(221.5)	(193.3)	(667.8)	(557.4)
Lag Total Expenditure		-0.25^{***}		-0.30^{***}
		(0.039)		(0.050)
Lag Motor Vehicle		-0.75^{***}		-0.71^{***}
		(0.046)		(0.057)
Implied MPC	0.31	0.20	0.96	0.37
Income Decile FE	No	Yes	No	Yes
Observations	12,425	12,425	5,511	5,511

Notes: The dependent variable is the change in PCE. Regressions include interview (time) fixed effects, and household level controls for age, change in number of adults, and change in number of children. Standard errors, in parentheses, are clustered at the household level. Significance is indicated by: $^{*}\,p < 0.1$, $^{**}\,p < 0.05$, $^{***}\,p < 0.01$.

Table C.8. Monthly: Household Motor Vehicle and Parts Spending Response to Rebate

	Full Sample	Rebate Only Sample
	(1)	(2)
Lead 1 Rebate Indicator	129.62**	103.45
	(60.95)	(68.26)
Rebate Indicator	74.80	46.50
	(68.55)	(80.76)
Lag 1 Rebate Indicator	39.82	21.75
	(67.35)	(79.51)
Lag 2 Rebate Indicator	80.48	71.14
	(57.91)	(63.23)
Lag 3 Rebate Indicator	34.21	23.27
	(62.58)	(71.64)
Lag Total Expenditure	0.01	0.03*
	(0.01)	(0.01)
Lag Motor Vehicle	−1.16***	−1.15***
	(0.01)	(0.02)
Income Decile FE	Yes	Yes
Observations	44,996	26,418

Notes: The dependent variable is the change in motor vehicles and parts expenditure. Regressions include month fixed effects, and household level controls for age, change in number of adults, and change in number of children. The rebate coefficients are the weighted average of the interaction between rebate month cohort and the rebate indicators with weights computed following Sun and Abraham (2021). Standard errors, in parentheses, are clustered at the household level: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.