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 reasonable modifications of the model result in general equilibrium forces that dampen rather than amplify micro MPCs. We also show that standard two-way fixed effects OLS techniques lead to biased estimates of micro MPCs. When we correct for the biases, we estimate smaller micro MPCs than the previous literature. The combination of smaller micro MPCs and dampening general equilibrium forces implies general equilibrium consumption multipliers that are below 0.2.

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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. Shapiro and co-authors found smaller marginal propensities to consume (MPCs), around 30 percent, but Parker and co-authors found some very high estimates. 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 would have recovered when Lehman Brothers failed in September 2008. We use narratives and forecasts to argue that these paths are implausible.

In their early 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 suggested that consumers mostly saved the rebate. However, their aggregate analyses were soon overshadowed by the impressive household-level analysis conducted by Parker et al. (2013) and Broda and Parker (2014), which estimated very high propensities to consume out of the rebates.

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 conducted an interesting analysis using the Parker et al. (2013) estimates. In particular, they used the Parker et al. (2013) estimate of the marginal propensity to spend the 2008 rebate on new vehicles to calculate the implied fraction of actual motor vehicle sales that were induced by the rebate. They noted 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.

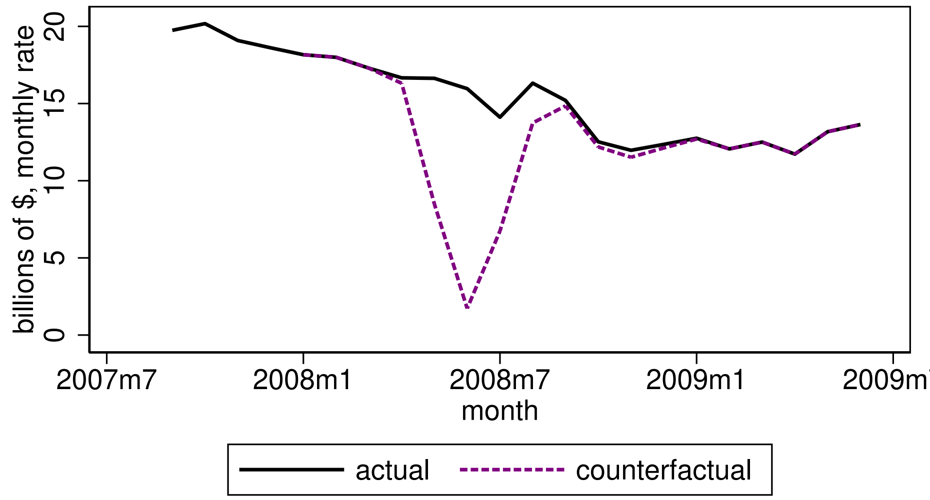
Most of the literature has overlooked Sahm et al.'s (2012) important calculation. Ramey (2018), however, used their estimates of the induced motor vehicle spending to demonstrate how striking the implied counterfactual path was of motor vehicle sales relative to the actual path. Here we produce her graph with revised aggregate data. Figure 1 shows actual expenditures on new motor vehicles as the green 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.

The graph shows that had there been no tax rebates, expenditures on motor vehicles would have declined by over 85 percent from $17.3 billion in March 2008 to only $2.6 billion in June 2008 and then would have rebounded sharply in late summer, averaging $14.4 billion per month in August and September 2008. The cumulative induced expenditures on motor vehicles implied by the Parker et al. (2013) estimates is $34 billion. This counterfactual strains credulity, especially since the lowest actual level of motor vehicle expenditures during the Great Recession was $11.7 billion in April 2009.[2]

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.

In 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 consumption in 2008 with no rebates. Our method proceeds as follows. We first construct a medium-scale two-good, two-agent New Keynesian (TG-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 divide actual aggregate NIPA consumption by the ratio of the model-simulated consumption path to the model steady state.

The counterfactual paths created from our baseline simulations average household MPCs calibrated to the estimates from Parker et al. (2013) imply that the path of aggregate consumption in the U.S. economy would have been V-shaped 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.

Our argument that the counterfactual path of consumption is implausible rests on three pillars: (i) a credible macroeconomic model that produces dynamic general equilibrium responses of aggregate consumption to rebates; (ii) the absence of other factors that would have led to a collapse of consumption in summer 2008; and (iii) aggregate monthly consumption data that accurately capture the spending effects of the rebates. For the first pillar, we use a standard New Keynesian model that features the type of general equilibrium amplification that is widely used in the literature and policy models. We allow more lags in the response to spending to the rebate than estimated in order to mute the V-shape, yet the implied paths are still implausible. For the second pillar, we demonstrate that other events, such as the dramatic peaking of gasoline and other energy prices in July 2008 or the bankruptcy of Lehman Brothers in September 2008, were unlikely to have induced a V-shape of consumption absent rebates. Our evidence is based on both professional forecasts at the time and our own time series forecasts using a variety of alternative assumptions. Neither the professional forecasts nor any of the variations on our forecasting model predict a V-shape in consumption in late spring and summer of 2008. For the third pillar, we present evidence that monthly NIPA consumption does not mismeasure the consumption response during that period. To explore the possibility that aggregate consumption rose more than is reflected in the monthly NIPA numbers, we study how alternative measures of consumption, such as unit sales of automobiles, retail sales, and our own aggregates constructed from the Consumer Expenditure Survey (CEX), behaved during this period. We find no evidence of a burst in aggregated consumption from any of those sources that would be consistent with a high MPC.

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 that general equilibrium forces, rather than magnifying the micro MPCs, actually dampen them. A second possibility is an upward bias in the existing household MPC estimates. We explore each of these explanations and conclude that both are key to explaining the implausible counterfactuals.

To assess the impact of dampening general equilibrium forces, we recalibrate our New Keynesian model, which has a perfectly elastic relative supply of durable goods, to one with a supply elasticity of five. We find that this dampening goes far toward eliminating implausible counterfactuals. However, this dampening means that even high micro MPCs do not result in sizeable Keynesian general equilibrium multipliers.

Key to the quantitatively important crowding out of durables are *both* that durable goods have a much more elastic demand than nondurable goods and that nondurables cannot be frictionlessly converted into durable goods. The highly transitory nature of the rebate coupled with a flat Phillips curve and interest rate inertia implies that the real interest rate (in terms of nondurables) moves very little in our DSGE model. Thus, there is little crowding out through the real interest rate on either nondurable or durable goods. Instead, the relative price of durables is the key price that accounts for crowding out of durable demand. For this price to rise with durable demand, it must be that durable and nondurable goods are not perfect substitutes in production. And for this price to have significant effects on durable demand, the durable demand elasticity must be large. We calibrate the durable demand elasticity to micro-level evidence in Bachmann et al. (2021). Our model predicts a 1% increase in relative motor vehicle prices, consistent with what we observe with the data.

More broadly, our findings suggest that Hetergoenous Agent New Keynesian (HANK) models should explicitly model durable goods demand and supply.[3] While our preferred MPC in the model—0.34—is typical in the HANK literature (Kaplan et al., 2018), the composition of spending between durables and nondurables has important implications for policy predictions of the model: 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 0.34 on nondurables, then the GE MPC is 0.5, five times as large. Thus, the nondurable-only model with the same overall MPC predicts too large a stimulus from a tax rebate. This is because durable demand is much more elastic than nondurable demand and therefore subject to stronger general equilibrium feedback effects.

3. Notable exceptions include Berger and Vavra (2015) and McKay and Wieland (2021, 2022). 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.

We then consider the possibility of an upward bias in the existing household MPC estimates as a source of the implausible counterfactuals. Our work builds and expands on Kaplan and Violante's (2014) early insights that led them to question the interpretation of the rebate coefficient as an MPC and to analyze the possible impact of anticipation effects on the estimates. We also build on a 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 selection on lagged expenditure. When we estimate a more general model that corrects these biases on CEX data, the MPC estimates fall significantly: from 0.53 to 0.30 in the full CEX sample and from 0.87 to 0.37 in the sample containing only rebate recipients.

We also apply Borusyak et al.'s (2022) new method for avoiding forbidden comparisons to show that these MPC estimates are similar to ours. Our findings thus complement the results of Borusyak and Jaravel's (2017) and Borusyak et al.'s (2022) application of their new method to Broda and Parker's (2014) Nielsen data, which covers a narrow group of consumer goods. For those data as well, their new method yields significantly smaller estimates of the MPC.

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 0.34, we find that the general equilibrium increase in total consumer spending was only 7 cents per dollar of the total rebate.

Section 2 begins with a narrative of details of the 2008 tax rebate and the behavior of other key variables in 2008. It then presents alternative measures of consumption expenditures that support the patterns indicated by the NIPA data. Finally, it presents contemporaneous forecasts as well as our forecasts for consumption in 2008 before the rebate was passed. Section 3 presents the counterfactual experiments. It begins by presenting a medium-scale New Keynesian model with two goods and two types of agents. It then calibrates the model and uses it to perform DSGE simulations of the effects of rebates. It uses the simulated impulse responses to infer what actual consumption would have been had there been no rebate. It then modifies the model to incorporate more dampening effects in general equilibrium to produce alternative counterfactual paths. Section 4 re-examines the micro MPC estimates. It demonstrates three likely biases affecting past micro MPC estimates and then re-estimates the MPC from CEX data in a way that addresses those biases. Section 5 summarizes and concludes.

2 The U.S. Macroeconomy in 2008

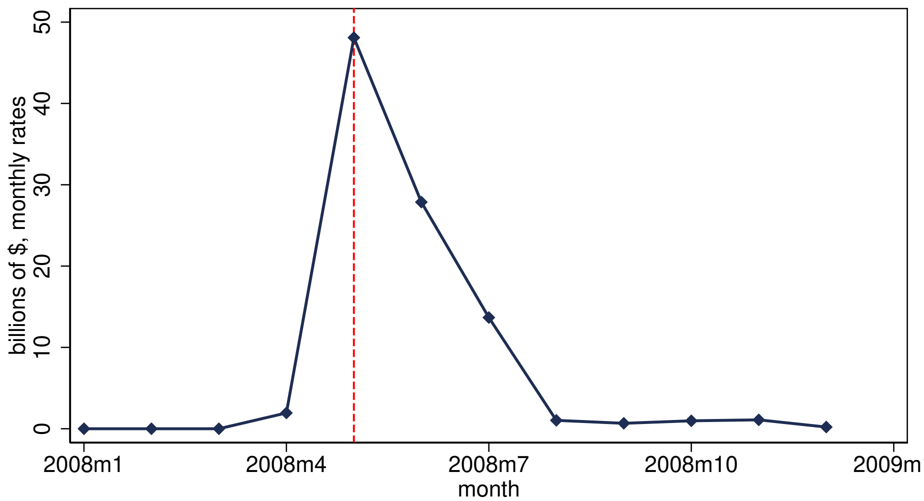
This section sets the stage for thinking about the plausibility of counterfactual paths by reviewing the tax rebates and the behavior of other key macroeconomic aggregates in 2008. The first subsection reviews the nature and timing of the tax rebates and then shows the behavior of disposable income, consumption, inflation, oil prices, and monetary policy. The second subsection provides alternative measures of consumption expenditures that support the patterns displayed in the standard NIPA measures. The third subsection shows two types of forecasts of consumption in 2008. The first type is professional forecasts of aggregate consumption, based on information before the rebates were passed. The second is our own set of time series forecasts of consumption during the Summer 2008.

2.1 Narrative of 2008

In early January 2008, numerous forecasters and policymakers began to discuss the possibility of a recession in 2008. The employment report released on January 4, 2008 showed a jump in the unemployment rate from 4.7 percent to 5 percent in December; this jump followed an earlier rise from a low of 4.4 percent in May 2007. After release of the report, Goldman Sachs forecasted that the U.S. was either in a recession or would enter one shortly, but predicted that it would be a mild downturn. That forecast assumed that the federal funds rate target would be cut 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.

In fact, the Federal Reserve enacted an inter-meeting cut in the funds rate of 75 basis points on January 23rd, and another 50 basis points at the January 30th FOMC meeting. The Greenbook forecasts prepared for that meeting did not predict declines in GDP or consumption expenditures in any quarter during 2008, but the New York Federal Reserve Bank's Blackbook was more pessimistic, predicting an annualized decline in real

Figure 2. 2008 Tax Rebates



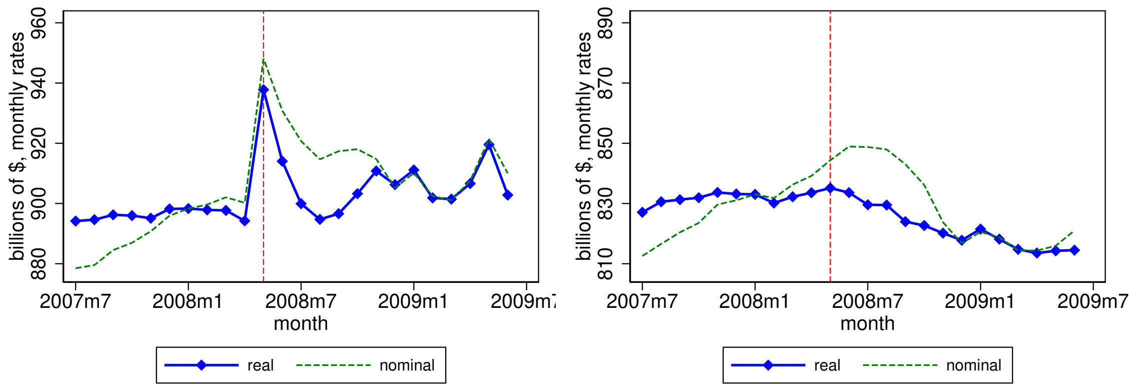
Notes. Data from Shapiro and Slemrod (2009). Rebates are nominal. Vertical red dashed line indicates May 2008.

GDP of -0.8 percent in the first quarter of 2008 with a recovery starting in the second quarter.

The Congress and Administration also recognized that the economy was slowing. They began to discuss tax rebates in January and quickly enacted them in February 2008. Both houses of Congress passed the legislation in the first week of February and President Bush signed it on February 13th. As a result, $100 billion in rebates were distributed from April through July 2008 to approximately 85 percent of households. The $100 billion in rebates was large, totaling eleven percent of January disposable income (measured on a monthly basis). The amount of the rebate depended on tax status and dependents and was phased out at higher income levels. Among households receiving a check, the average amount was $1,000. 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 nominal and real NIPA disposable personal income and consumption from mid-2007 through mid-2009. The vertical red dashed line indicates May 2008 when almost half of the rebate checks were distributed. We normalize

Figure 3. Aggregate Disposable Income and Consumption



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

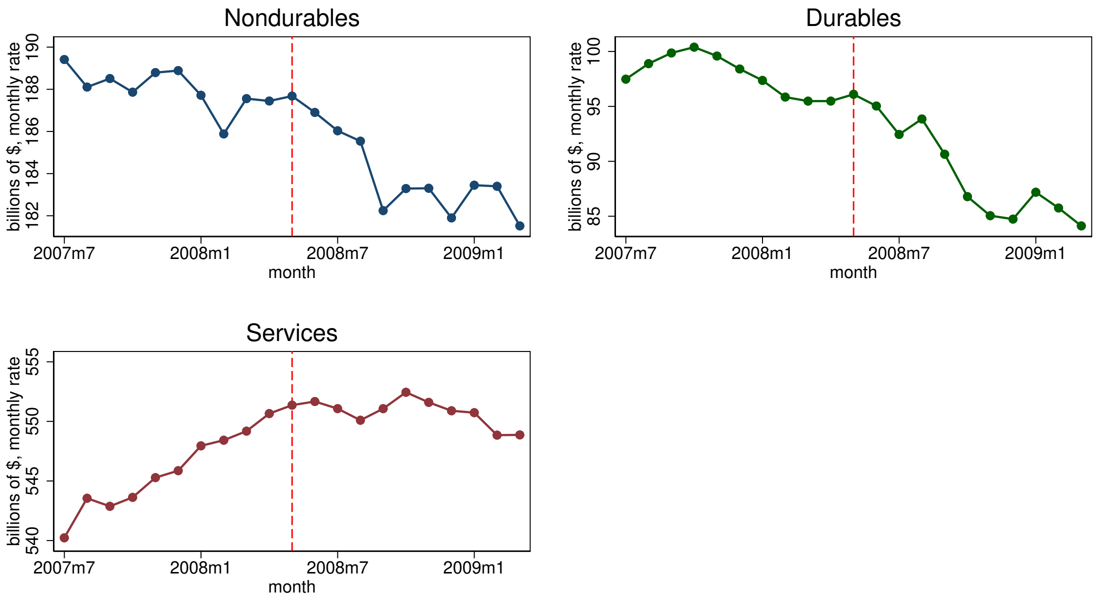
real income and consumption to be equal to nominal values in January 2008 for better illustration. The scaling of the y-axis is the same across the two graphs so that the variation in quantities can be compared.

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. After falling in February, real consumption rises to a peak in May 2008 before falling through the end of 2008. The sharpest decline is between August 2008 and September 2008, and was likely due to the shock wave caused by the fall of Lehman Brothers in mid-September. Nominal consumption shows a prominent hump in Summer 2008, but real consumption displays only a small bump.

Figure 4 shows real consumption expenditures disaggregated by type: nondurable goods, durable goods, and services. In general, consumption of goods (both nondurable and durable) decline over this period whereas consumption of services rises. In none of the three aggregates is there much evidence of a big boost to spending in May through July 2008.

We now turn to the behavior of other key factors that might have influenced consumption expenditures. The first is the behavior of consumer prices. Figure 5 shows the price indices for total consumption expenditures and consumption expenditures excluding food and energy, transformed to logarithms so that the slope of the path indicates

Figure 4. Real Consumption Expenditures by Type of Product



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

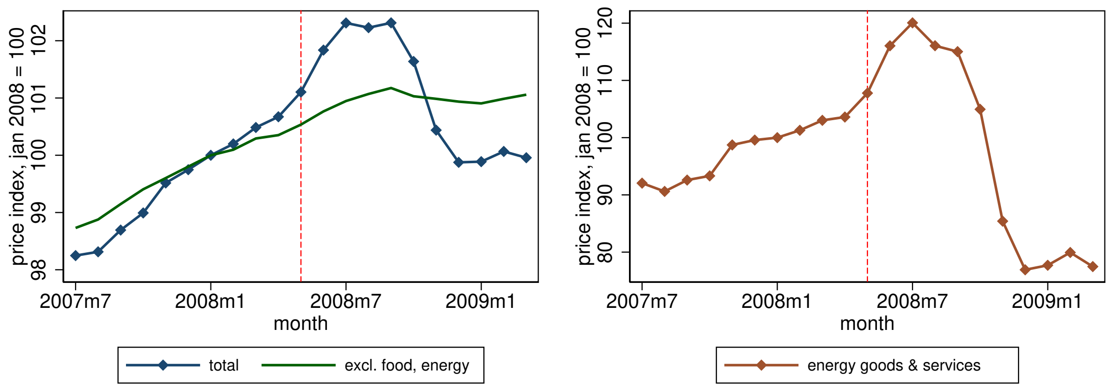
the inflation rate. Consider first the behavior of the price deflator for total consumption. The rate of inflation for total consumption accelerated after April, resulting in July prices that were 1.6 percent above April prices. Price levels then reached a plateau and fell after the failure of Lehman 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 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.

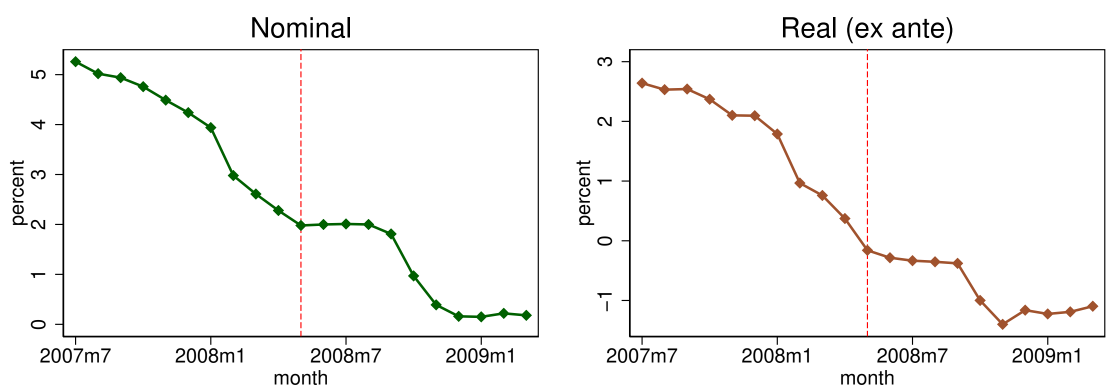
Turning to interest rates, Figure 6 shows the behavior of the nominal and ex ante real federal funds rate. The ex ante real federal funds rate is the difference between the nominal federal funds rate and the current month median expected annual inflation

Figure 5. Log Price Indices for Consumption



Source. BEA data.

Figure 6. Federal Funds Rate



Source. FRED, based on Federal Reserve Board of Governors. The ex ante real interest rate is constructed using the annualized monthly rate of inflation in PCE.

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.

To summarize, these graphs reveal several key aspects of 2008. First, the rebate was large relative to aggregate disposable income. Second, most of the rise in nominal consumption in the first half of 2008 was due to inflation. Real consumption expenditures show a bounce from February to the peak in May 2008, the month with the largest rebate payments, but the magnitude is modest. Third, consumer expenditure prices were volatile during 2008. Oil prices and the PCE deflator hit a peak in July and then fell. Fourth, the Fed paused the downward trajectory of the funds rate near the end of May; however the ex post real rate turned negative in Summer 2008 because of the behavior of inflation.

2.2 Alternative Measures of Consumption Expenditures

In this section, we show alternative measures of consumption expenditures. The motivation is twofold. First, because the monthly NIPA consumption data are based on combining and smoothing various data sources, we want to provide supplemental evidence that the patterns we showed in consumption expenditures in the last section are not due to smoothing procedures. Second, since the micro estimates suggest that a large portion of the rebate was spent on motor vehicles, it is useful to look at the behavior of aggregate spending on motor vehicles.

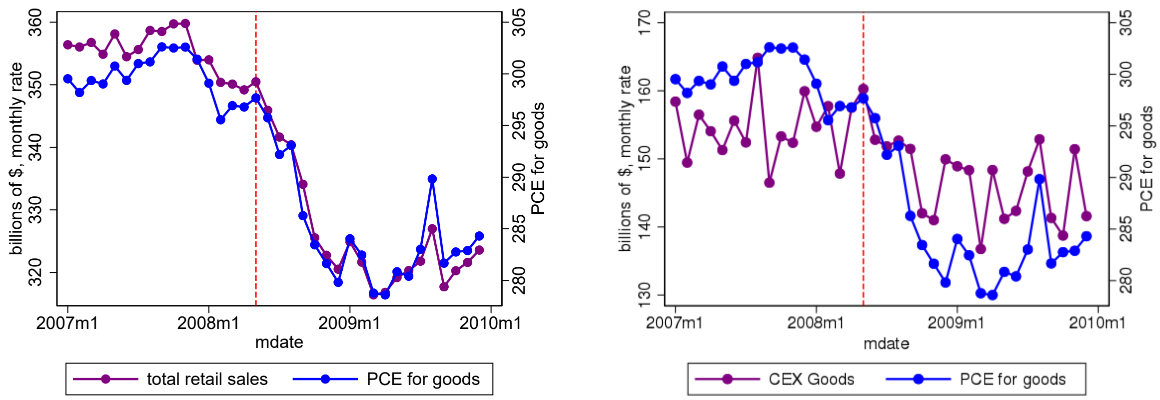
We first compare the NIPA measures of personal consumption expenditures (PCE) on goods to two other series: the Census series on retail sales of goods and our our own constructed series based on the CEX data that is the basis for the micro estimates.[4] As described by Wilcox (1992), government statisticians 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 7 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

4. 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 7. 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.

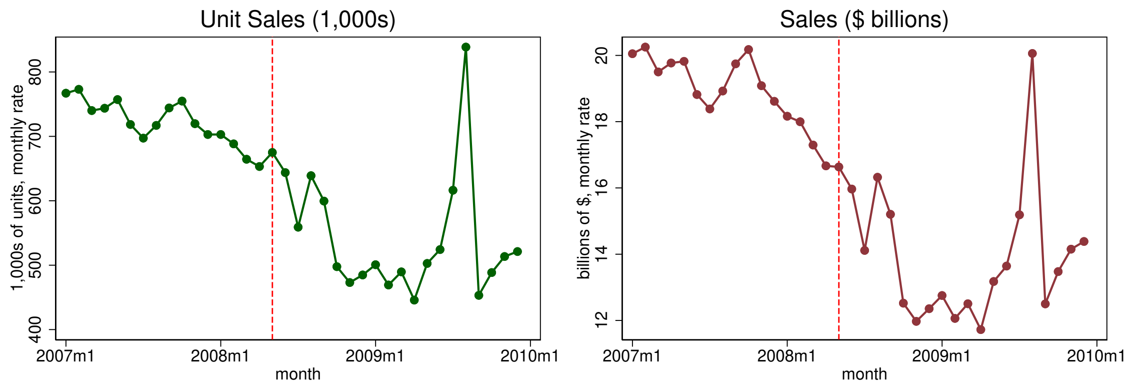
either the PCE data or the retail sales data. The CEX series falls from February to March, recovers in April, and then declines in May and June. These movements look similar to those in other months, suggesting more noise than information. We conclude that the PCE data is not smoothing out a large jump in consumption when the rebates are distributed.

Finally, we consider detailed data on new motor vehicle expenditures since expenditures on motor vehicles and parts constitute the main part of the high MPC estimated by Parker et al. (2013). Another advantage of focusing on motor vehicles is the very high quality of the data. Figure 8 shows sales of new motor vehicles to consumers, measured as units on the left-hand side and as billions of dollars on the right-hand side.

Both the unit measure and the dollar measure of sales follow a downward trend from 2007 to early 2009. The unit sales measure shows a small blip in May 2008. This small blip contrasts with the huge spike that occurs later in August 2009 in response to the cash-for-clunkers program. As Sahm et al.'s (2012) accounting exercise demonstrates, the high MPC estimated by Parker et al. (2013) implies that the bulk of all sales of new motor vehicles in spring and summer 2008 were induced by rebate.

Figure 9 shows the relative price of new motor vehicles to the core CPI. The new motor vehicles price series is the BLS' research CPI for new motor vehicles, which incorporates rich transactions-level data from J.D. Powers (Williams et al., 2019). The blue line shows the trend in the CPI for new motor vehicles from August 2007 to April 2008. The actual series displays a prominent jump upward in June and July 2008 relative

Figure 8. New Motor Vehicle Sales to Consumers



Source. BEA.

to trend. This rise in the relative price of new motor vehicles in the data is important to keep in mind when we discuss the implications of our two-good, two-agent New Keynesian model with less elastic durable goods supply in Section 3.

2.3 Forecasts of Consumption in 2008

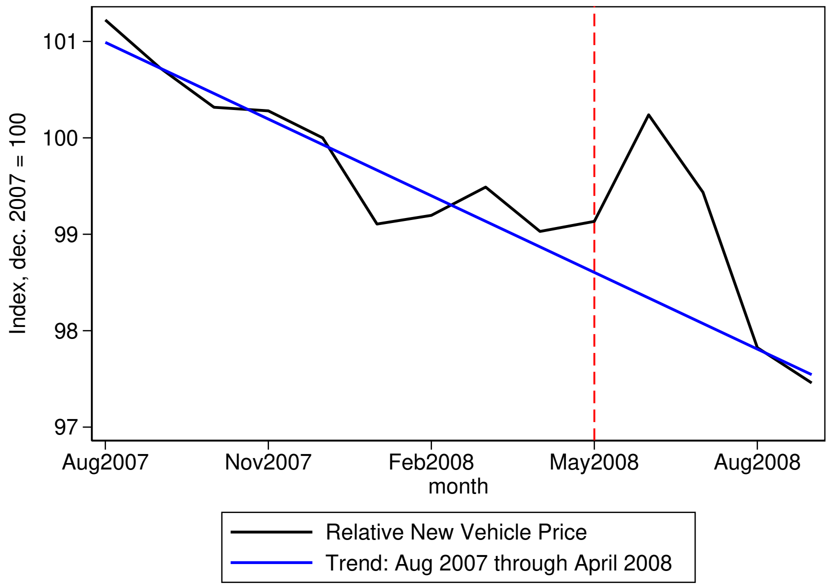
In this section, we present both contemporary forecasts by professional forecasters and our own forecasts that incorporate some of the negative events that occurred in 2008.

2.3.1 Contemporary Forecasts

As discussed in the narrative section above, the employment report released on January 4, 2008 led policymakers and forecasters to raise their probabilities of recession. We begin by discussing the Goldman Sachs forecast released on January 9, 2008, since they were among the first to predict that the U.S. was already in recession. The Goldman Sachs forecast also contained the following key predictions.[5] 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

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

Figure 9. Relative New Vehicle Price



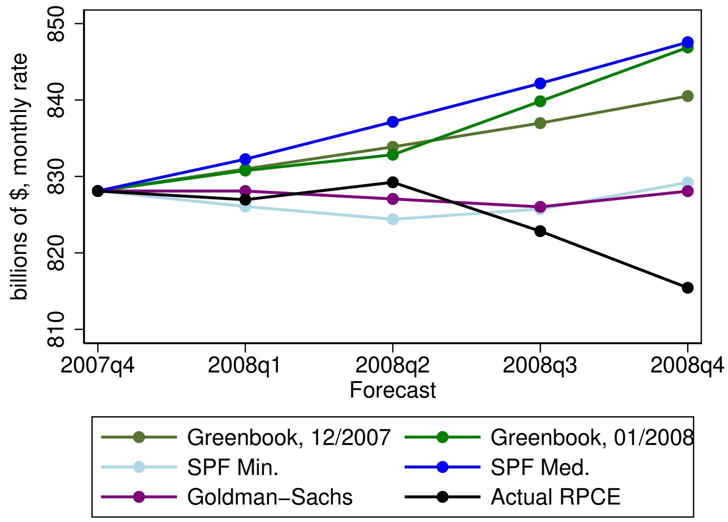
Source. BLS.

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.

They 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 only predicted a small decrease in consumption in summer 2008. We show all these forecasts alongside actual values in figure 10.[6]

6. 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 10. Contemporary Real Consumption Forecasts



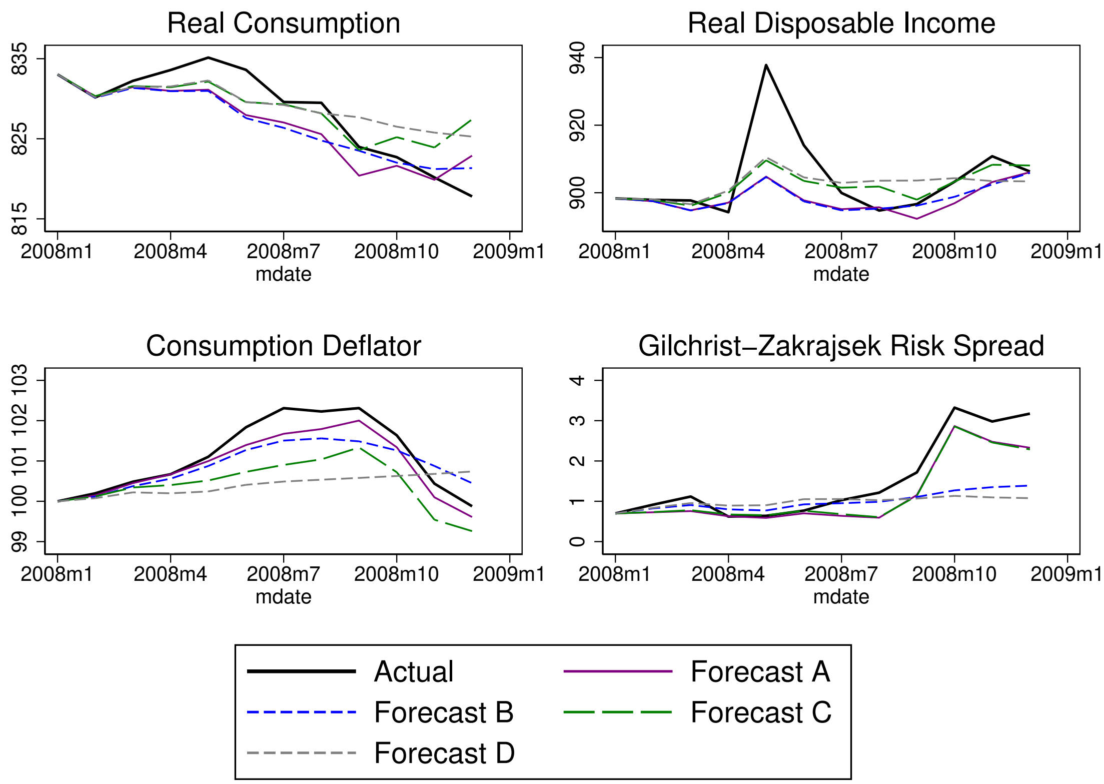
Source. BEA data, Federal Reserve Board, Survey of Professional Forecasters. All forecasts normalized to monthly real consumption in 2007Q4.

2.3.2 Our 2008 Consumption Forecasts

In the last section, we showed that even the more pessimistic forecasts did not predict a significant U-shape or V-shape of real consumption between the second and third quarters of 2008. However, the forecasts in January 2008 did not foresee the rapid run-up in oil prices in spring and summer or the failure of Lehman Brothers in September, both of which could have affected consumption. Thus, we construct our own forecasts that factor those negative events in to create more pessimistic forecasts to compare to our counterfactuals.

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 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. We use six lags of each variable, except for the Lehman Brothers dummy variable where we use current and two lags. We include current values of the recession dummy, oil prices, and the excess

Figure 11. Forecasts from Our Four Models



Forecasts are based on information through January 2008, with exception of models in which oil prices are exogenous and Lehman Brothers dummies are included. Real oil prices are assumed to be exogenous in Models A and B; Lehman Brothers bankruptcy dummy variables are included in Models A and C.

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 the exogeneity of oil prices and whether Lehman Brothers went bankrupt. The most pessimistic forecasts are those in which oil prices are assumed to follow their actual path exogenously and in which the Lehman Brothers bankruptcy dummy variable is included in the forecasting equation. We keep the current and lagged recession dummy variable in all forecasts; if we omit them, the forecasts are substantially more optimistic.

Figure 11 shows the forecasts for the four endogenous variables in each of the four models. The most pessimistic forecast (Forecast A) assumes both exogenous oil prices and that Lehman Brothers went bankrupt in September 2008. The reason that allowing oil prices to respond exogenously leads to a more pessimistic forecast is that the alternative model in which oil prices respond *endogenously* does not predict a rise in spring and summer 2008, but instead predicts a gentle drift down until they plummet after the bankruptcy of Lehman Brothers in September 2008. None of the forecasts hints at a V-shape path of consumption in 2008.

3 Macro Counterfactuals

In this section, we begin by constructing a medium-scale New Keynesian (NK) model that allows us to generate counterfactual paths of consumption expenditures that include general equilibrium feedbacks. We then simulate the response of consumer expenditures to rebates and apply the results to actual consumer expenditures to create counterfactual paths had there been no rebates.

3.1 Two-Good, Two-Agent New Keynesian Model with Hand-to-Mouth Consumers and Durable Goods

We construct a two-good, two-agent New Keynesian (TG-TANK) model, which features both nondurable and durable goods and both optimizing and hand-to-mouth agents. Most elements of our model are standard for a medium-scale New Keynesian model. In particular, it builds on the model analyzed by Ramey (2021), which is an extension of Galí et al.'s (2007) fiscal NK model. 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).

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, 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.[7]

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 expenditure denominated in nondurable goods, and are the sum of

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

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 are 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.

Optimizing households pick an optimal plan $\{C_t^o, A_t^o, D_t^o(i), X_t^o\}_{t=0}^{\infty}$ 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:

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

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

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,

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

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 also show that the friction 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,

$$
\begin{aligned}
WH^m - T^m &= WH^o - T^o \\
\frac{C^m}{X^m} &= \frac{C^o}{X^o}
\end{aligned}
$$

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,

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

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 $\prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-1+1}}$.

This formulation allows us to exactly target the MPCs for both durable and total expenditure to a rebate that is estimated in the micro data. In this way, our model will produce the increase in demand that we observe at the micro-level even as we abstract from the complexity of micro-level decisions such as precautionary savings and fixed costs (see e.g. McKay and Wieland, 2021, 2022, for such models). Indeed, even more complex models would have to match the exact same increase in demand since this is directly measurable from the micro data.

The value added of our model is instead to show how this increase in demand gets propagated in general equilibrium. For this reason we consider a rich set of standard general equilibrium forces and carefully calibrate their strength in accordance with the evidence. Following the arguments in Auclert et al. (2018) and Wolf (2021), so long as our model matches the same micro-level increase in demand and the same strength of general equilibrium forces, it will produce very similar counterfactuals to the rebate as more complex models that also match these statistics.[8] In this sense, our model is well-specified to answer the question at hand, while more complex models may not be solvable in general equilibrium using current methods.

Durable Goods Production

Durable goods are produced competitively using nondurables N_t as inputs,

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

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 $\frac{1}{\zeta}$.

Summary of the Model's Other Features

8. Such models may, however, give very different answers to policies that we do not consider here.

We summarize the other features of the model only briefly since they are standard. The market for nondurable goods features sticky prices and sticky wages and noncompetitive product and labor markets. Intermediate goods firms are monopolistically competitive and face a Calvo-style adjustment cost on prices. In labor markets, households mark up 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. However, 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 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.

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

9. Borusyak et al. (2022) also do not find evidence of spending after three months.

10. See the implied 6-month MPC in Table 5, column 4.

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
mpx	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	0.1	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 0.34, 0.52, or 0.86, which corresponds to the aggregate 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 $\gamma = 0.34$, then $\theta^d = 0.844$. See the text for details.

most household report expenditures divided equally across the three months within an interview. 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 the overall quarterly MPC, equal to 0.34, 0.52, and 0.86. The lower value, 0.34, reflects our preferred estimate based on our new estimates that correct for several biases (Table 5, column 4, averaging panel A and B). The other two values, 0.52 and 0.86, are the estimates we obtain from Parker et al. (2013) in the full CEX sample and the subsample of rebate recipients (Table C.7, 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 estimates. In our preferred specification the MPC on motor vehicles is 0.31 (Table 7, averaging columns 1 and 3). Using the Parker et al. (2013) specifications we obtain an MPC on motor vehicles of 0.4 in the full CEX sample and 0.43 in the subsample of rebate recipients (Table C.8, column 1).

The supply and demand elasticities for durable goods are two important parameters for the general equilibrium outcomes of the model. We set the durable good supply elasticity $\zeta^{-1} = \infty$, implying perfectly elastic supply of durable goods. We later allow for a less elastic supply of durable goods.

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 to hit two empirical targets. First, we target a long-run demand elasticity for vehicles of -1 based on an average of three existing studies. McCarthy (1996) estimates a price elasticity of demand of -0.87 using cross-sectional data from a vehicle purchase survey. Bento et al. (2009), also using cross-sectional data, estimate a car ownership elasticity with respect to the implicit rental price of -0.82, which they argue should be interpreted as a long-run elasticity. And Dou and Linn (2020) estimate a price elasticity of demand of -1.5 using variation from permanent changes in fuel efficiency standards. This target implies $\sigma^d = 1$. Second, we 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).[11] This target fixes the value of Calvo probability, θ^d.

Crucially, these studies estimate demand elasticities at the household level and thereby difference out any general equilibrium price effects. The implied parameter values for σ^d and θ^d vary 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 0.34, the implied parameters are $\gamma = 0.34$ and $\theta^d = 0.844$.

Our demand elasticity for motor vehicles is at the upper end of estimates from cross-regional studies. 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,[12] compared to -26 in our model.[13] The estimates in Baker et al. (2019) instead imply an elasticity of -6.4.[14] We do not calibrate our baseline model to these data since these estimates may understate the true demand elasticity if there are regional price responses to local demand, such as variable dealer mark-ups. However, we explore robustness to different values of the demand elasticity in the appendix.

3.3 Macro 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

11. Bachmann et al. (2021) estimate that each perceived percentage point of the July 2020 VAT cut in Germany raised durable expenditure in the second half of 2020 by 15% (Table A.4., columns 3 and 9). The total VAT change was 3 percentage points, but the analysis in Bachmann et al. (2021) suggests that only around 2 percentage points were passed through to final goods prices. As a result they estimate that the VAT drop raised durable expenditure by 36% over this period.

12. 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.

13. The demand elasticity in our model is higher over two months than over six months because the effective real interest rate is higher if prices rise two months from now than six months from now.

14. Their Table 2, column 1, imply a 9.1% and a 3.7% increase in sales in the two months before a 1% anticipated increase in sales taxes. The implied elasticity is -(9.1 + 3.7)/2 = -6.4.

the first rebate payments are made in April.[15] 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-counterfactuals by subtracting the model-implied impulse response functions for consumer expenditures from the observed consumer expenditure data.[16]

Figure 12 plots counterfactuals based on both the micro MPCs, excluding any general equilibrium effects, and on the GE-MPCs, which incorporate full dynamic general equilibrium feedbacks. The figure shows the results for both total consumer expenditure (real PCE) and motor vehicle expenditure.[17] The micro counterfactual graphs in the left column are the analogs to the Sahm et al. (2012) counterfactual for motor vehicles, except that we assume that expenditure is equally spread over three months rather than over two months and we assume a greater fraction of the rebate is spent on motor vehicles. The figures show prominent, and we have argued implausible, V-shapes for both total expenditure and motor vehicle expenditure, even for micro MPCs for total consumption expenditures as low as 0.34.

The graphs in the right column of Figure 12 plot the corresponding counterfactuals in general equilibrium. In this standard New Keynesian model, the general equilibrium forces amplify the effects, particularly as the micro MPCs become larger, so the counterfactual paths become even more V-shaped.

To quantify the total change in consumption following the rebate, we compute micro MPCs and GE-MPCs over a twelve month period in response to the rebate shock.[18] Table 2 shows the correspondence between the micro MPCs (which equal the fraction of hand-to-mouth households) and general equilibrium MPCs. When the micro MPC is 0.34, the amplification is modest so that the GE-MPC for total consumption is only 24 percent higher (0.42) than the micro MPC. In contrast, when the micro MPC is 0.86, the GE-MPC is almost triple the micro MPC. The general equilibrium spending response is non-linear in the micro MPC just as the simple Keynesian multiplier is non-linear.[19]

---

15. Without this assumption, optimizing households would foresee the future rise in motor vehicle prices and would increase their purchases immediately.

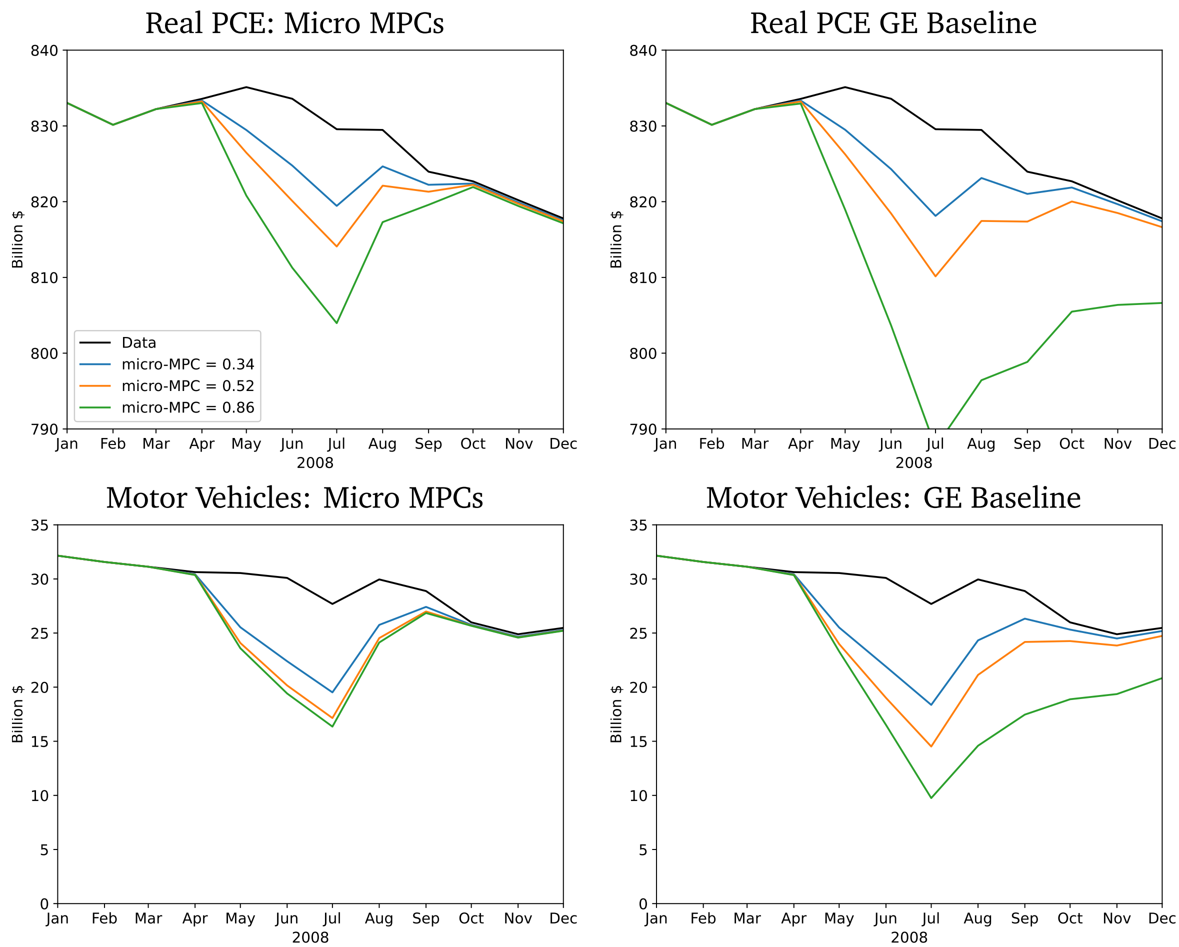
16. Because the model is linearized, the counterfactuals for the tax rebate would be identical if we also fed the model with other shocks that hit the economy at the time.

17. Appendix Figure B.1 shows the counterfactual for nominal PCE and motor vehicle expenditure.

18. GE-MPCs are computed in terms of real quantities.

19. The simple Keynesian multiplier on rebates is mpc/(1-mpc). For example, for a micro MPC of 0.34, the Keynesian multiplier is only 0.5; for a micro MPC of 0.86, the Keynesian multiplier is 6.1.

Figure 12. Counterfactual Real Consumption Expenditures: Baseline Model



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

How do we reconcile the high micro MPCs with these implausible counterfactuals? To answer this question, we now explore modifications of the standard New Keynesian model that dampen rather than amplify the micro MPCs. In the next section, we re-examine the micro MPC estimates.

There are a number of ways to introduce dampening forces in general equilibrium that might help solve the puzzle of the implausible counterfactual. Possibilities include less accommodative monetary policy or lower elasticity of aggregate output.[20] We instead choose the most straightforward way to do this in our two-good model, which is

20. The elasticity of aggregate output will be lower if prices and wages are more flexible, the labor supply elasticity is lower, or there is less scope for varying the utilization of capital.

Table 2. General Equilibrium Marginal Propensity to Consume: Baseline Model

PCE		Motor vehicles		Nondurable goods	
micro	GE	micro	GE	micro	GE
0.34	0.42	0.31	0.38	0.03	0.04
0.52	0.76	0.4	0.58	0.12	0.18
0.86	2.4	0.43	1.17	0.43	1.22

to make the supply of durable goods less elastic. Our baseline calibration assumes a perfectly elastic relative supply of durable goods, which mimics the results one would obtain in a one-good model.[21] We thus calibrate the elastic supply of durable goods more realistically, by changing the supply elasticity of durable goods from $\zeta^{-1} = \infty$ to $\zeta^{-1} = 5$ which is midway between the elasticities reported in House and Shapiro (2008) and Goolsbee (1998).

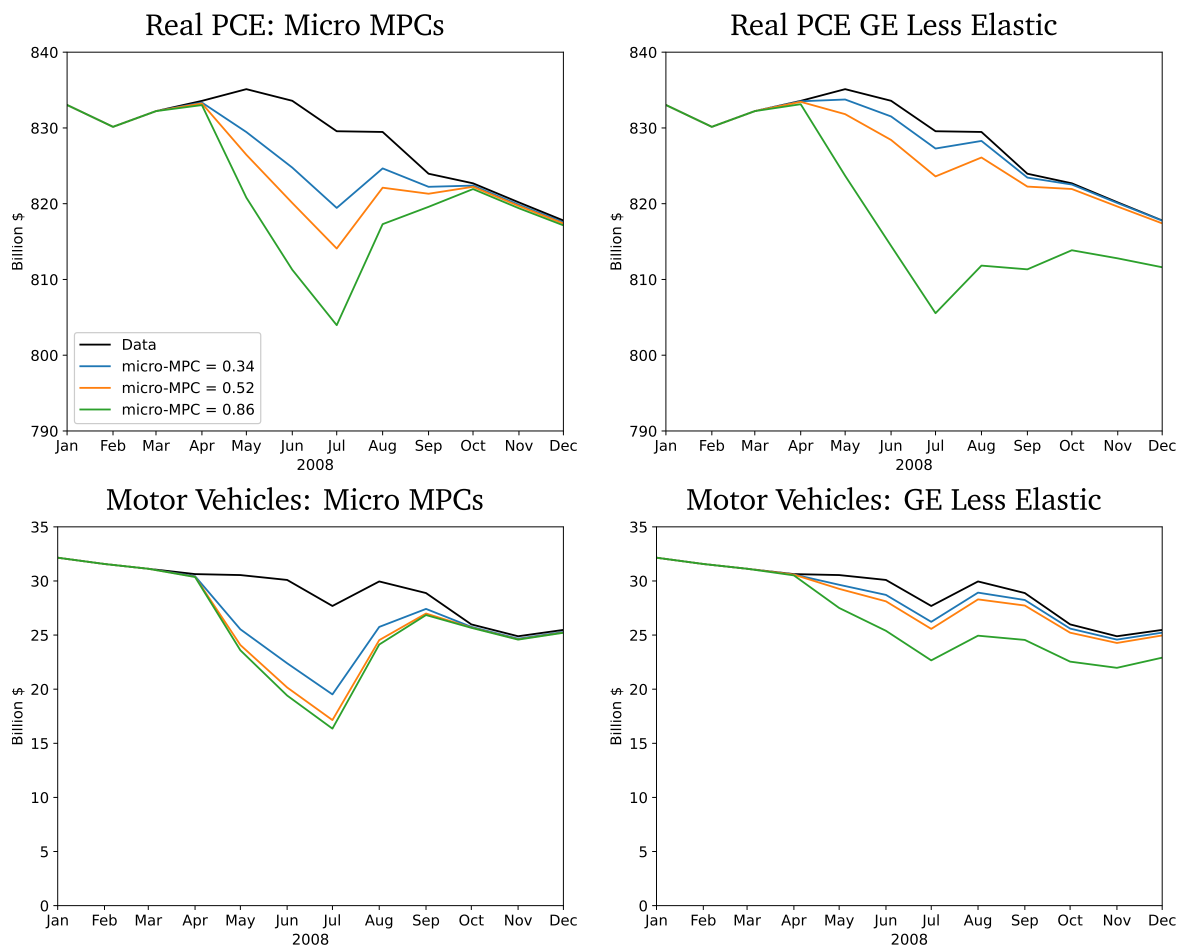
Figure 13 plots the corresponding counterfactuals for the revised model. The left column reports the same micro counterfactuals (which exclude general equilibrium effects) from the previous graph for comparison purposes and the right column reports the new general equilibrium counterfactuals based on less elastic durable goods supply. For total PCE we no longer see evidence of sharp V-shapes in the general equilibrium counterfactual. This change occurs because the general equilibrium response of motor vehicle expenditure to a tax rebate is much less than implied by the micro MPCs.

Our preferred micro MPC estimate also shows a continuous decline of the counterfactual consumer expenditure path for both total expenditure and motor vehicles. In particular, this estimate implies that motor vehicles decline further as Lehman Brother fails in September 2008. In contrast, with a micro MPC of 0.52 or 0.86, motor vehicle expenditure in July 2008 is at or below the level of spending when Lehman Brothers fails.

Table 3 shows the correspondence between the micro MPCs and the GE-MPCs. When the micro MPC is 0.34, 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 0.52, this dampening is smaller and the GE-MPC is 0.22. For a micro MPC of 0.86, there is still amplification in general equilibrium resulting in a GE-MPC of 1.31.

21. Recall that in our model durable goods are produced competitively using nondurables as inputs, so a perfectly elastic supply means that the two goods are perfect substitutes in production.

Figure 13. Counterfactual Real Consumption Expenditures: Less Elastic Durable Supply Model



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

The next four columns 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 0.31, then the GE-MPC is only 0.08. By contrast, the GE-MPC on nondurables, 0.03, falls to -0.01. The dampening of nondurable expenditure largely reflects the role of operating cost that scale with the durable stock but in the national accounts are recorded as a nondurable expenditure.

Table 3. General Equilibrium Marginal Propensity to Consume: Model with Less Elastic Durable Supply

PCE		Motor vehicles		Nondurable goods	
micro	GE	micro	GE	micro	GE
0.34	0.07	0.31	0.08	0.03	−0.01
0.52	0.22	0.4	0.13	0.12	0.09
0.86	1.31	0.43	0.45	0.43	0.86

The general equilibrium dampening of the consumption responses stems from the rise in relative durable goods prices. In our preferred calibration with a micro MPC of 0.34, the tax rebate increases the relative durable price by 1.1% in July 2008 followed by a gradual decline (see Appendix Figure B.3). 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.

Appendix Table B.1 shows that there is still substantial crowding out of durable expenditure if we instead calibrate the durable demand elasticity to -6.4—the lower end of cross-regional estimates. The GE-MPC in this case is 0.15 rather than 0.07 in our baseline calibration. To the extent that local estimates of the demand elasticity are contaminated by local price responses, this calibration represents a lower bound for the durable demand elasticity.

These results have broader implications for heterogeneous agent models. While many models in the literature are calibrated to match micro MPCs around 0.34, these models typically include only nondurable spending and therefore abstract from the stronger general equilibrium forces on durable expenditure.[22] Table 4 shows the GE-MPC in a model that abstracts from durable goods and calibrates the nondurable micro MPC to the overall response to expenditure.[23] In this model, when the micro-MPC for nondurable expenditure (and thus overall expenditure) is 0.34, then the GE-MPC is 0.49. Thus abstracting from durable goods yields the conclusion that the tax rebate

22. Notable exceptions include Berger and Vavra (2015), McKay and Wieland (2021), and McKay and Wieland (2022).

23. 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 $mpx = 0$.

is amplified in general equilibrium. By contrast, in our model with durable goods the GE-MPC is only 0.07 (Table 3), 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.

In short, our results suggest that heterogeneous agent models should not only important to match an overall micro MPC for total expenditures, but also its composition across nondurable and durable expenditure, as well as their relative general equilibrium effects. 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.

Table 4. General Equilibrium Marginal Propensity to Consume: Model without Durable Goods

PCE		Motor vehicles		Nondurable goods	
micro	GE	micro	GE	micro	GE
0.34	0.49	0.0	0.0	0.34	0.49
0.52	0.96	0.0	0.0	0.52	0.96
0.86	3.29	0.0	−0.0	0.86	3.29

4 The Micro MPC Estimates

We now reconsider the micro MPC estimates. 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. For this specification, Parker et al. (2013) estimate the following regression,

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

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 document and correct for three important upward biases in the Parker et al. (2013) results: (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 selection bias stemming from a correlation between lagged expenditure and the report of receipt of a rebate. When we correct for these biases, we estimate micro MPCs of 0.3 to 0.37.

Our work builds and expands on prescient work by Kaplan and Violante (2014) that raised questions about the interpretation of the estimates of β_2. They noted that β_2 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 selection bias we document. We show how that correcting for these biases, as well as the "forbidden comparisons" problem, substantially reduces the micro MPCs.

4.1 Baseline Parker et al. (2013) Results

We make two changes to the original Parker et al. (2013) specification: First, we estimate MPCs for total expenditure using the BEA definitions for PCE because we construct counterfactuals for PCE. 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 more than one rebate as multiple instances of treatment complicate the interpretation of β_2 as a micro MPC for a single rebate.

Columns (1) of Table 5 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.

While the samples are not exactly identical, the estimates are extremely close. We estimate a \$507.2 response in the full sample (Panel A), compared to \$494.5 in Parker et al. (2013). Appendix Table C.4 reports the corresponding rebate income, \$949, which implies an MPC of 0.53 in our specification versus their 0.52. Parker et al. (2013) do not report a dollar response for the rebate-only sample but our MPC of 0.87 in column (1) of Panel B is again very close to their 0.91.

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

4.2 Bias from Omitting the Lagged Rebate

To understand why omitting a lagged rebate variable is a source of 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} 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,

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

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 is,

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

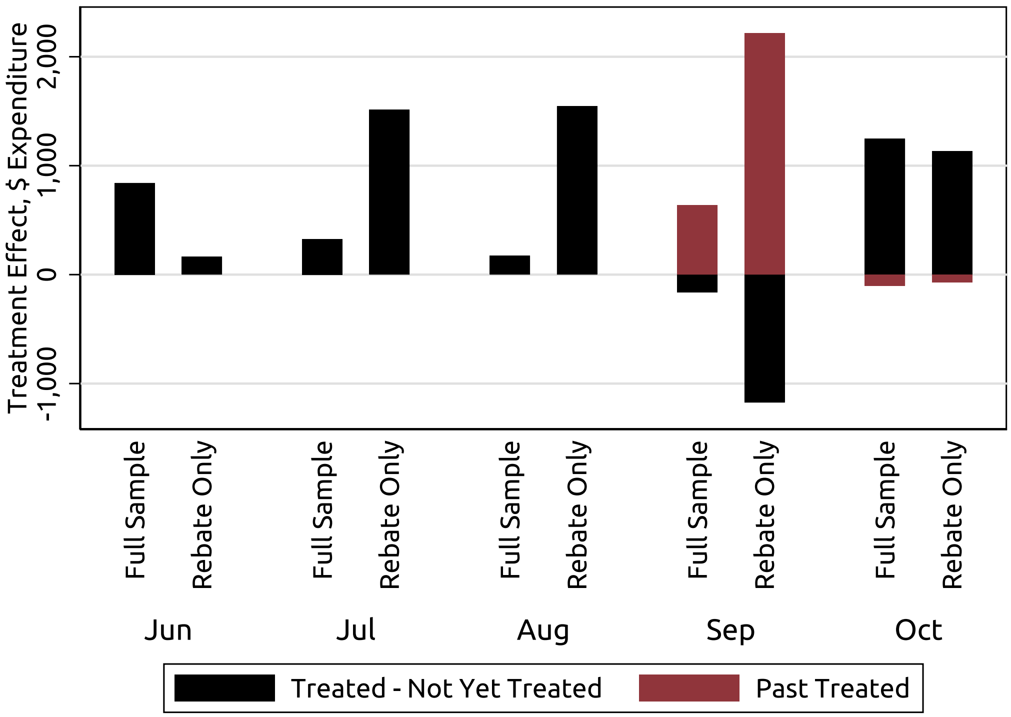
In a setting with staggered treatment $Cov(\hat{D}_{i,t-1}, \hat{D}_{it}) < 0$ because current treatment reduces the probability of treatment in the following period. When the treatment effect is positive ($\beta > 0$), then β^{OLS} is upward-biased. Intuitively, households treated at t are being compared 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 has been previously pointed out by Kaplan and Violante (2014).

To show the importance of this bias, Figure 14 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 — \$638 in the full sample and \$2216 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),

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

Figure 14. 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.

Column (2) of Table 5 reports estimates of the contemporaneous effect β_2 and the lagged effect β_3. The contemporaneous spending effect shrinks by $42.1 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 $266.7. 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 variation in this sample comes from comparing rebate recipients to previously treated households.[24]

24. 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 5 are consistent with theirs as they also find that 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.

4.3 Forbidden Comparisons

The lagged rebate indicator in (2) will account for the typical mean-reversion of consumer expenditure after receiving a rebate. However, Figure 14 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 the June cohort after accounting for average mean-reversion may still be contaminated by lagged treatment effects.

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. In first differences, the equation becomes

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

For simplicity, consider 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 $\beta^0 - \beta^1$, 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. By contrast, if $\beta^0 < \beta^1$ then the homogeneous OLS estimator is downward biased since then the correction for group 0 is too big.

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

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

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.

Column (3) of Table 5 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 \$82.8. From Figure 14 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 \$89.6 because the later treatment effects are larger.

4.4 Selection on Lagged Expenditure

We next show that reporting a rebate is correlated with low spending in the previous period. We first regress consumer expenditure on an indicator for receiving a rebate in both the current and the next interview

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

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 6 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 selection bias. We find that the estimate remains economically very large -\$562 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 be sampled in 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 previous month. 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 6 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,

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

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 selection on lagged expenditures. If low lagged expenditure predicts rebate assignment, 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,

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

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 5 shows the implied treatment effects. In the full sample the treatment effect shrinks by \$100.2 once the lagged control is included. The implied 3-month MPC is 0.3 after we account for all three biases versus 0.53 in the original specification. In the rebate-only sample adding lagged controls shrinks the treatment effect by \$279. The MPC of 0.37 is less than half that in column (1) and very close to our estimates in the full sample. The consistency of estimates in column (4) across samples suggests that selection on the fixed effect in the full sample it is not very important.

In Appendix C.3 we also verify that our preferred specification (5) recovers the true MPCs in household data simulated from the model of section 3. 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 Alternative Estimators

As an alternative approach to accounting for the bias from omitting lagged treatment variables and treatment effect heterogeneity we adopt the method in Borusyak et al. (2022).[25] Their method consists of imputing a counterfactual spending path based on untreated and not-yet-treated households, and then aggregating the implied treatment effects among the treated population using equal weights.[26] By avoiding comparisons with previously treated households, the BJS method avoids the first two biases. The identifying assumptions are that there are no anticipation effects and that the untreated households are on parallel trends with the treated households, so we include the lagged level of total and motor vehicle expenditure to account for selection into reported treatment. Appendix Table C.9 shows that the treatment effects from the BJS are very similar to our final estimates in column (4) of Table 5.

4.6 Composition of Spending

Finally, Table 7 breaks down the total expenditure response to the rebate into the contribution from motor vehicle spending and other expenditures. Comparing column (2) with column (4) we see that motor vehicle expenditures account for almost all of the expenditure response. The MPC for motor vehicles is 0.33 in the full sample and 0.3 in the rebate only sample and are statistically significant in both cases. By contrast, other expenditures in column (3) have an MPC of -0.02 in the full sample and 0.07 in the rebate only sample.

5 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 consumption 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

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

26. See Appendix for details.

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 modified our two-good model, which features nondurable consumption goods and durable consumption goods (interpreted as motor vehicles), to allow more realistic supply elasticities of durable goods. This modification goes far to creating counterfactual consumption paths that are more plausible. Second, we re-estimated the micro MPCs in the CEX data using new methods that overcome problems with standard OLS estimates of treatment effects. The new method results in estimated MPCs that are noticeably lower than those in the literature. 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.

Table 5. Household PCE Response to Rebate

Panel A: Full Sample

	Homogeneous Treatment Effect		Heterogeneous Treatment Effect	
	(1)	(2)	(3)	(4)
Rebate Indicator	507.16**	465.09**	388.34*	288.14
	(218.39)	(209.97)	(215.28)	(187.34)
Lag Rebate Indicator		−201.28	−88.58	−51.77
		(233.02)	(207.44)	(168.51)
Lag Total Expenditure				−0.26***
				(0.03)
Lag Motor Vehicle				−0.74***
				(0.03)
Implied 3-month MPC	0.53	0.49	0.41	0.30
Implied 6-month MPC		0.76	0.72	0.23
6-Month MPC S.E.		(0.49)	(0.50)	(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 Effect		Heterogeneous Treatment Effect	
	(1)	(2)	(3)	(4)
Rebate Indicator	811.07**	544.36	633.99	355.01
	(323.27)	(344.12)	(406.07)	(500.40)
Lag Rebate Indicator		−481.50	−203.34	−345.32
		(374.61)	(325.30)	(361.87)
Lag Total Expenditure				−0.29***
				(0.02)
Lag Motor Vehicle				−0.71***
				(0.03)
Implied 3-month MPC	0.87	0.58	0.67	0.37
Implied 6-month MPC		0.63	1.14	0.06
6-Month MPC S.E.		(0.93)	(1.08)	(1.19)
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: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 6. Negative effect of future rebate receipt on current expenditure

	Full Sample (1)	Rebate Recipients Only (2)
Lead Rebate Indicator	-866.5^{***}	-562.0^{*}
	(289.5)	(335.9)
Rebate Indicator	-383.4	246.1
	(303.8)	(377.8)
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: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7. 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	308.41^{***}	-20.28	286.72^{*}	68.29
	(114.69)	(145.54)	(173.35)	(460.16)
Lag Rebate Indicator	129.58	-181.36	138.07	-483.39
	(94.72)	(133.82)	(120.18)	(343.67)
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	0.33	-0.02	0.30	0.07
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).

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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,

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

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

$\lambda_{t+s}p^d_{t+s}(1-\delta^d)^s D_t(i)$ 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

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

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:

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

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

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

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,

$$WH^m - T^m = WH^o - T^o$$
$$\frac{C^m}{X^m} = \frac{C^o}{X^o}$$

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,

$$C_t^m - C^m + \eta(D_t^m - D^m) = \sum_{l=0}^{L} mpc_l [W_{t-l} H_{t-l}^m - T_{t-l}^m - (WH^m - T^m)] \prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-k+1}}$$

$$X_t^m - X^m = \sum_{l=0}^{L} mpx_l [W_{t-l} H_t^m - T_{t-l}^m - (WH^m - T^m)] \prod_{k=1}^{l} \frac{R_{t-k}}{\Pi_{t-k+1}}$$

$$1 = \sum_{l=0}^{L} (mpc_l + mpx_l)$$

$$mpx_l = \frac{\theta}{1-\theta} mpc_l, \qquad \forall l = 0, \ldots, L$$

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

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

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,

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

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,

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

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

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

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

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

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

$$\epsilon X_{1t} = (\epsilon - 1) X_{2t}$$

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,

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

where $\frac{X_{it}}{p_t^d}$ is the real production of durable goods by firm i and ζ is a negative production externality.

Real profits from the sale of durable goods are

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

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 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 $\frac{1}{\zeta}$.

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,

$$B_t = A_t \tag{6}$$

A.10 Functional Forms

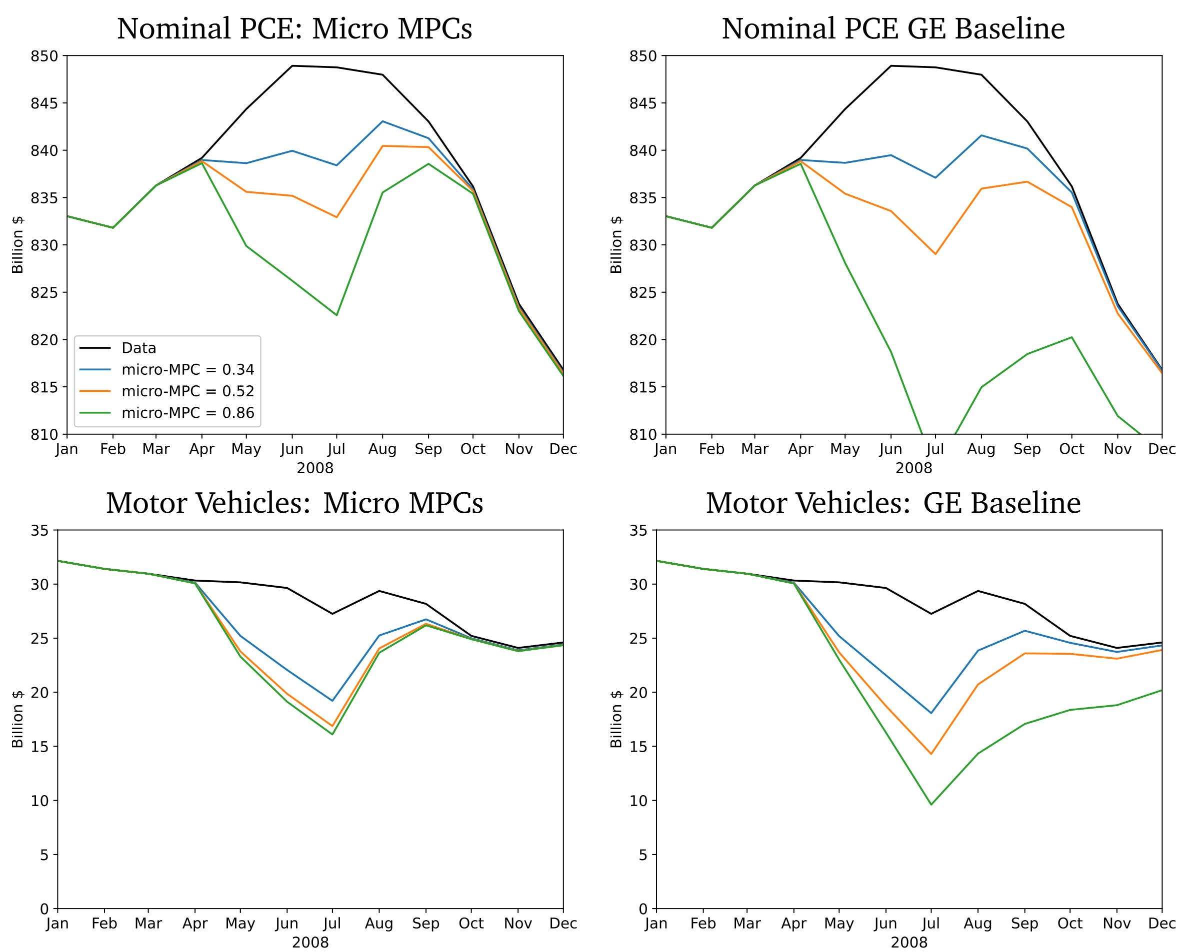
We assume the following functional forms:

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

B Additional Counterfactuals

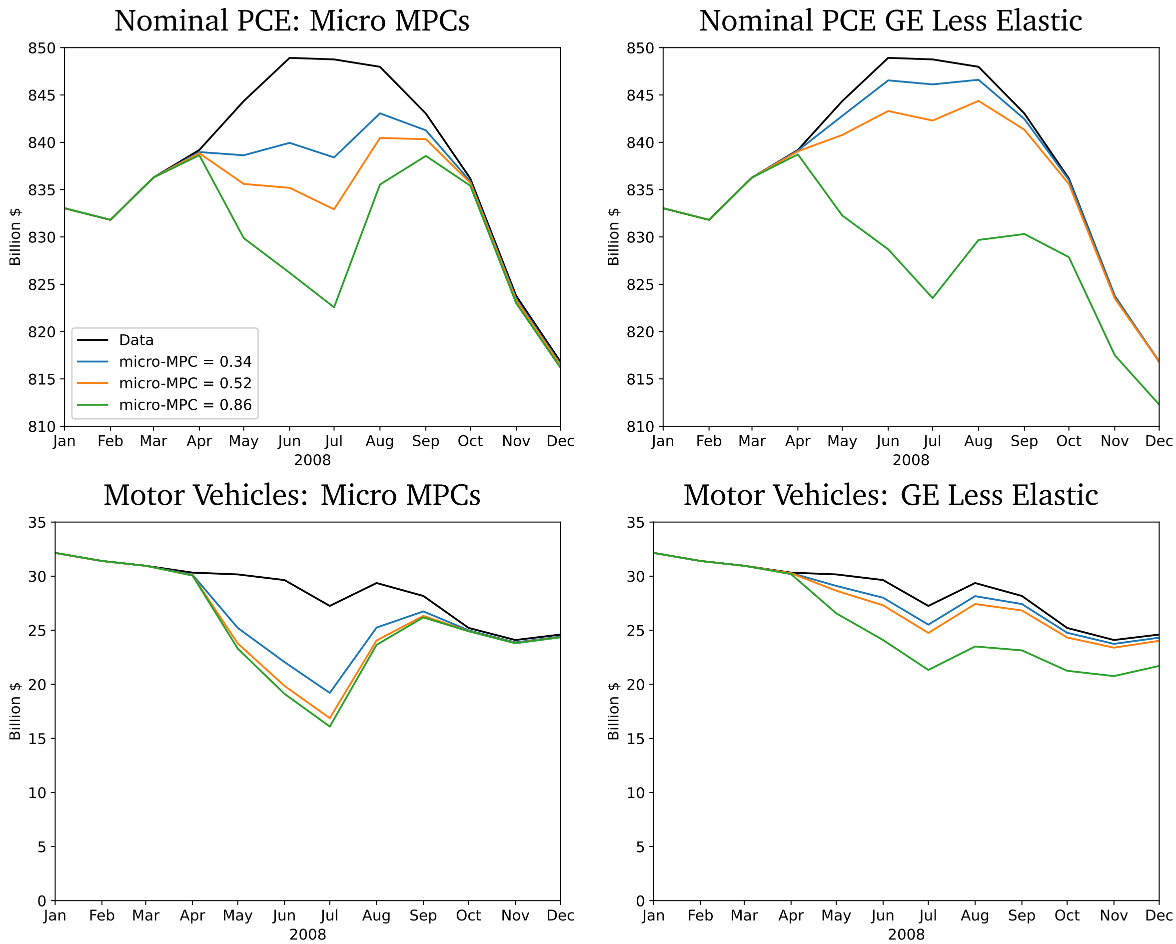
Figures B.1 and B.2 display the counterfactuals for nominal PCE and nominal motor vehicle expenditure.

Figure B.1. Counterfactual Nominal Consumption Expenditures: Baseline Model



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 B.2. Counterfactual Nominal Consumption Expenditures: Less Elastic Durable Supply Model



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 B.3 shows the impact of the tax rebate shock on the relative price of durables in the model with less elastic durable supply.

Table B.1 shows the GE-MPCs in a version of the model calibrated to a 2-month durable demand elasticity of -6.4.

C Data 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

Figure B.3. Impact of Tax Rebate on Relative Durable Price in the Model with less elastic Durable Supply

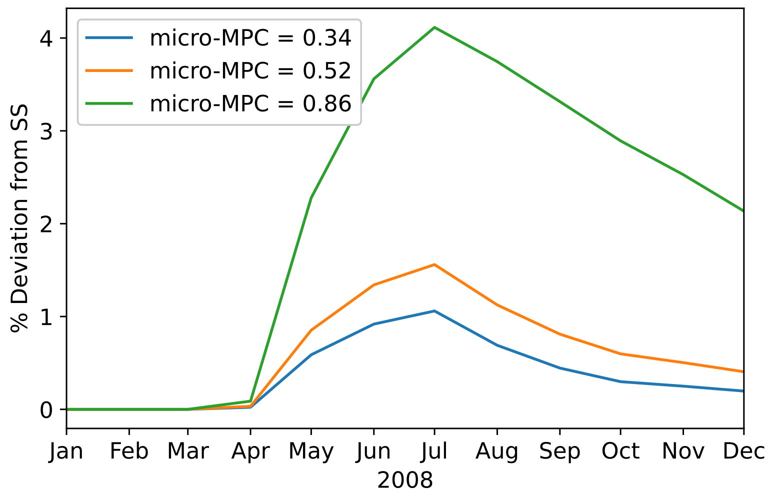


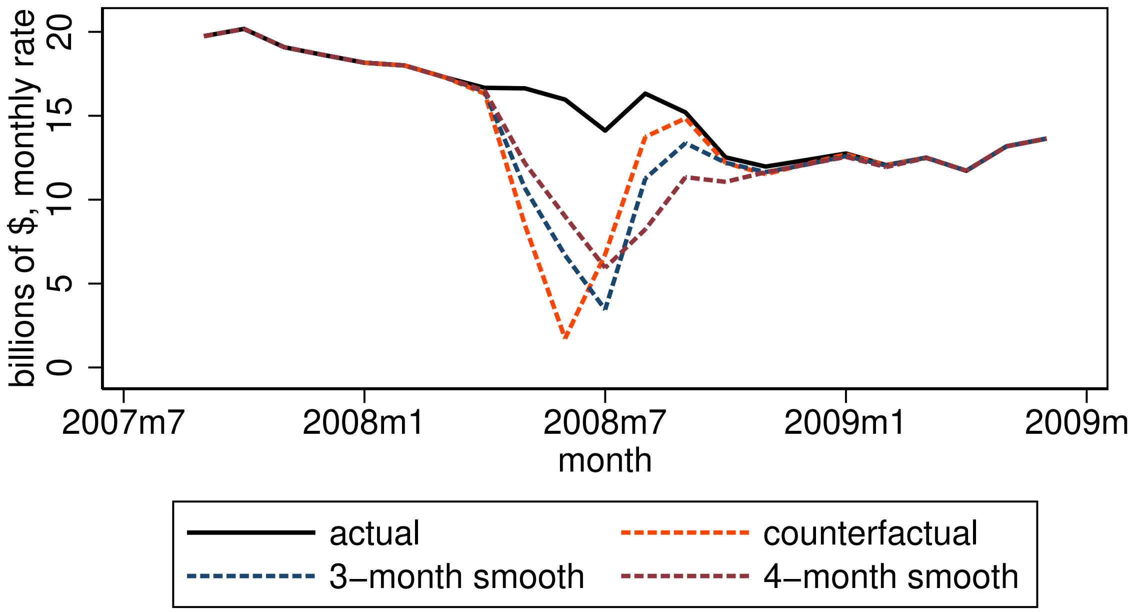
Table B.1. General Equilibrium Marginal Propensity to Consume: Model with Less Elastic Durable Demand

PCE		Motor vehicles		Nondurable goods	
micro	GE	micro	GE	micro	GE
0.34	0.15	0.31	0.14	0.03	0.0
0.52	0.34	0.4	0.22	0.12	0.12
0.86	1.49	0.43	0.55	0.43	0.94

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 Decomposing the OLS Estimates

We first apply Sun and Abraham (2020) to decompose the differences and differences coefficient (β_2 from 1) as a linear combination of cohort average treatment effects on the treated (CATT) from the period households receive the rebate and from other periods. Where the CATT from each period ($\gamma_{e,h}$) are estimated in the following saturated regression:

$$
\begin{aligned}
C_{i,t+1} - C_{i,t} = & \sum_s \beta_{0s} month_{s,i} + \beta_1' \mathbf{X}_{i,t} \\
& + \sum_e \gamma_{e,0} \left(I(ESP_{i,t+1}) \times I(t+1=e) \right) \\
& + \sum_{h \neq 0} \sum_e \gamma_{e,h} \left(I(ESP_{i,t+1+h}) \times I(t+1+h=e) \right) \\
& + \varepsilon_{i,t+1}.
\end{aligned} \tag{7}
$$

In the above expression, $\gamma_{e,0}$, represents the contemporaneous treatment effect for households that report receiving their rebate in interview e.[27] Each $\gamma_{e,h}$ represent separate CATT for different horizons around the treatment date. For example, if $h = 1$ then $\gamma_{e,h}$ would be the estimated impact of treatment on the period after receiving the rebate. We do not estimate separate effects for the never-treated units in each interview because these identify the interview-month fixed effects. Thus, the never-treated households are the excluded category, $\gamma_{e,\infty} = 0 \ \forall e$.

Sun and Abraham (2020) show that the OLS coefficient β_2 is a linear combination of these cohort-specific treatment effects $\gamma_{e,h}$:

$$\beta_2 = \sum_h \sum_e \omega_{e,h} \gamma_{e,h}$$

Where the weights $\omega_{e,h}$ are the coefficients in the following series of regressions:

$$\begin{aligned}\big(I(ESP_{i,t+1+h}) \times I(t+1+h=e)\big) = &\sum_s \tilde{\beta}_{0s} month_{s,i} + \tilde{\beta}_1' \mathbf{X}_{i,t} \\ &+ \omega_{e,h}\big(I(ESP_{i,t+1}) \times I(t+1=e)\big) + \varepsilon_{i,t+1}.\end{aligned}$$

The weights on the period the rebate is received sum to 1, $\sum_e \omega_{e,0} = 1$, while the weights on the other sum to -1, $\sum_e \sum_{\neq 0} \gamma_{e,h} = -1$. In each period, the treatment weights and the other period weights are symmetric i.e. $\omega_{e,0} = -\sum_{h \neq 0} \omega_{e,h}$. [28]

In the left panel of Figure **??** we plot the estimated weights ($\omega_{e,h}$), separately for each period. Where:

$$\begin{aligned}\text{Weight Treated} &= \omega_{e,0} \\ \text{Weight Not-yet Treated} &:= \omega_{e,h<0} = \omega_{e,\infty} + \sum_{h<0} \omega_{e,h} \\ \text{Weight Past Treated} &:= \omega_{e,h>0} = \sum_{h>0} \omega_{e,h}\end{aligned}$$

The treated weight each period is symmetric with the non-treated and past-treated weights: $\omega_{e,0} = -(\omega_{e,h<0} + \omega_{e,h>0})$. Since these weights are symmetric, in Figure 14 in the main text, we show only the per-period treatment weights in the upper-left panel.

27. In keeping with the notation in Sun and Abraham (2020), e could also represent the household's rebate cohort. This results in a similar decomposition, but Figure 14 would then represent treatment cohorts rather than interview dates. We find that the decomposition via interview date is more intuitive for our application.

28. The never treated units are included in the weights for the other periods.

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

	Dependent Variable: Change in Total Expenditures					
Specification:	Table 5, Column 1			Table 5, Column 4		
True MPC:	0.34	0.52	0.86	0.34	0.52	0.86
Rebate Coeff.	378.9	579.1	957.9	324.2	495.6	819.7
Implied MPC	0.40	0.61	1.01	0.34	0.52	0.86

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.

With our estimated weights ($\omega_{e,h}$) and CATT ($\gamma_{e,h}$) we can decompose the relative contribution of each period and horizon of treatment to the final OLS DID coefficient (β_2). We can also estimate average coefficients for past-treated, not-yet treated, and treated units in each period:

$$\text{Coefficient Treated} = \gamma_{e,0}$$

$$\text{Coefficient Not-yet Treated} := \gamma_{e,h<0} = \frac{\sum_{h<0} \omega_{e,h}\gamma_{e,h}}{\sum_{h<0} \omega_{e,h}}$$

$$\text{Coefficient Treated} - \text{Not Yet Treated} = \gamma_{e,0} - \frac{\omega_{e,h<0}\gamma_{e,h<0}}{\omega_{e,h<0} + \omega_{e,h>0}}$$

$$\text{Coefficient Past Treated} := \gamma_{e,h<0} = \frac{\sum_{h>0} \omega_{e,h}\gamma_{e,h}}{\sum_{h>0} \omega_{e,h}}$$

$$\text{Average Coefficient} := \gamma_e = \gamma_{e,0} - \frac{\omega_{e,h<0}\gamma_{e,h<0} + \omega_{e,h>0}\gamma_{e,h>0}}{\omega_{e,h<0} + \omega_{e,h>0}}$$

C.3 Model Regressions

In this section we simulate data from the model in section **??** 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 5 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.2. Rebate Coefficient MPC Estimates in Model: Rebate Only Sample

Dependent Variable: Change in Total Expenditures

Specification:	Table 5, Column 1			Table 5, Column 4		
True MPC:	0.34	0.52	0.86	0.34	0.52	0.86
Rebate Coeff.	483.4	738.8	1222.3	324.2	495.8	819.9
Implied MPC	0.51	0.78	1.29	0.34	0.52	0.86

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.4 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.[29]. Panel A column one 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 are 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.

29. 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.

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	33%	29%	37%	39%
Mar-Jun-Sep-Dec	33%	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 Effect		Heterogeneous Treatment Effect	
	(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 Effect		Heterogeneous Treatment Effect	
	(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	6.42
		(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.5 Estimated MPCs for Motor Vehicles and Parts and Other PCE

Table C.5. Household Motor Vehicle and Parts Spending Response to Rebate

Panel A: Full Sample

	Homogeneous Treatment Effect		Heterogeneous Treatment Effect	
	(1)	(2)	(3)	(4)
Rebate Indicator	234.38	215.83	207.21	308.41***
	(164.25)	(155.01)	(158.89)	(114.69)
Lag Rebate Indicator		−88.74	−56.35	129.58
		(172.87)	(141.99)	(94.72)
Lag Total Expenditure				0.02***
				(0.01)
Lag Motor Vehicle				−1.04***
				(0.01)
Implied 3-month MPC	0.25	0.23	0.22	0.33
Implied 6-month MPC		0.36	0.38	0.46
6-Month MPC S.E.		(0.34)	(0.36)	(0.17)
Income Decile FE	No	No	No	Yes
Observations	16,962	16,962	16,962	16,962

Panel B: Rebate Recipients Only

	Homogeneous Treatment Effect		Heterogeneous Treatment Effect	
	(1)	(2)	(3)	(4)
Rebate Indicator	146.21	0.60	438.05	286.72*
	(258.31)	(263.57)	(380.64)	(173.35)
Lag Rebate Indicator		−262.88	276.01	138.07
		(297.04)	(325.18)	(120.18)
Lag Total Expenditure				0.02***
				(0.01)
Lag Motor Vehicle				−1.04***
				(0.01)
Implied 3-month MPC	0.16	0.00	0.47	0.30
Implied 6-month MPC		-0.27	1.23	0.44
6-Month MPC S.E.		(0.71)	(1.07)	(0.24)
Income Decile FE	No	No	No	Yes
Observations	10,076	10,076	10,076	10,076

Notes: The dependent variable is the change in motor vehicles and parts expenditure. 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: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.6. Household Other Spending Response to Rebate

Panel A: Full Sample

	Homogeneous Treatment Effect		Heterogeneous Treatment Effect	
	(1)	(2)	(3)	(4)
Rebate Indicator	272.78*	249.25*	181.13	−20.28
	(148.70)	(146.92)	(150.85)	(145.54)
Lag Rebate Indicator		−112.55	−32.24	−181.36
		(145.95)	(145.91)	(133.82)
Lag Total Expenditure				−0.28***
				(0.03)
Lag Motor Vehicle				0.30***
				(0.03)
Implied 3-month MPC	0.29	0.26	0.19	-0.02
Implied 6-month MPC		0.40	0.35	-0.22
6-Month MPC S.E.		(0.35)	(0.36)	(0.32)
Income Decile FE	No	No	No	Yes
Observations	16,962	16,962	16,962	16,962

Panel B: Rebate Recipients Only

	Homogeneous Treatment Effect		Heterogeneous Treatment Effect	
	(1)	(2)	(3)	(4)
Rebate Indicator	664.85***	543.76**	195.94	68.29
	(211.41)	(238.28)	(393.64)	(460.16)
Lag Rebate Indicator		−218.62	−479.35*	−483.39
		(202.67)	(271.64)	(343.67)
Lag Total Expenditure				−0.32***
				(0.02)
Lag Motor Vehicle				0.33***
				(0.03)
Implied 3-month MPC	0.71	0.58	0.21	0.07
Implied 6-month MPC		0.90	-0.09	-0.38
6-Month MPC S.E.		(0.62)	(1.07)	(1.14)
Income Decile FE	No	No	No	Yes
Observations	10,076	10,076	10,076	10,076

Notes: The dependent variable is the change in PCE excluding motor vehicles and parts. 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: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C.7. 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.8. 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.9. Contemporaneous Household PCE Response to Rebate: BJS Method

	Full Sample		Rebate Only Sample	
	(1)	(2)	(3)	(4)
Rebate Indicator	330.9	215.4	946.3	384.8
	(224.4)	(195.9)	(668.2)	(558.1)
Lag Total Expenditure		-0.25^{***}		-0.31^{***}
		(0.039)		(0.050)
Lag Motor Vehicle		-0.75^{***}		-0.71^{***}
		(0.045)		(0.055)
Implied MPC	0.35	0.23	0.99	0.40
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: $^{*}\, p < 0.1$, $^{**}\, p < 0.05$, $^{***}\, p < 0.01$.