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Consumption, Income Changes, and Heterogeneity: Evidence from Two Fiscal Stimulus Programs[†]

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Almost half of American families did not adjust their consumption following receipt of the 2001 or 2008 tax rebates. Another 20 percent, with low income and more likely to rent, spent a small but significant amount. Households with large spending propensity held high levels of mortgage debt. The heterogeneity is concentrated in a few nondurable categories and a handful of "new vehicle" purchases. The cumulated predictions of the heterogeneous response model tend to be smaller and more accurate than their homogeneous response model counterparts, offering new insights on the evaluation of the two fiscal stimulus programs. (*JEL* D12, D91, E21, E32, E62)

> *"When a full analysis of heterogeneity in responses was made* [in microeconometric investigations], *a variety of candidate averages emerged to describe the 'average' person, and the long-standing edifice of the representative consumer was shown to lack empirical support."*
>
> — James J. Heckman (2001, p. 674)

> *"We may expect to see that integrating individual coefficients* [from models of heterogeneous responses] *yields roughly mean effect as estimated by the associated least-squares coefficient. One should be cautious, however, about this interpretation in very heterogeneous situations."*
>
> — Roger Koenker (2005, p. 302)

In the aftermath of the recent financial crisis, governments around the world have sought to support the economy through unprecedented fiscal interventions. Considerable uncertainty (and disagreement among economists) exists, however, around the impact of these policies. At the heart of this uncertainty lays the recognition that the effects of fiscal policies on the aggregate economy cannot be fully understood without explicit consideration of distributional dynamics. This important insight feeds into a growing macroeconomic literature which explicitly recognizes that consumers and entrepreneurs are inherently different in their access to

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financial markets, life-cycle positions, patience, risk propensity, earning ability, and other individual characteristics.

Significant research efforts surveyed by Heathcote, Storesletten, and Violante (2009) have forcefully made the case for the quantitative relevance of heterogeneous behaviour in terms of both social welfare and macroeconomic outcomes. Storesletten, Telmer, and Yaron (2001), for instance, find that if some households are liquidity constrained the cross-sectional welfare costs of aggregate fluctuations can be substantially larger than the calculations á la Lucas (1987), which are based on complete markets and the representative agent paradigm. Closer to our work, Heathcote (2005) shows that temporary lump-sum tax cuts that would be neutral in a representative agent framework with complete markets may have large real effects in a model with heterogenous agents and borrowing constraints, even though approximate aggregation à la Krusell and Smith, Jr. (1998) holds.

A number of important macroeconomic implications of heterogeneous responses to shocks and stabilization policies have been recently investigated in the theoretical literature (Ragot 2010, Kaplan and Violante forthcoming, and Huntley and Michelangeli 2014). Yet, their relevance towards measuring the impact of fiscal policy on aggregate expenditure has been overlooked in the data. Stimulated by the quotes from Heckman and Koenker above, we try to fill this important gap in the literature by revisiting the consumption response to the 2001 and 2008 economic stimulus payments. We are interested in quantifying the extent to which the estimates of the impact from the homogeneous response model may be inaccurate relative to their heterogeneous model counterparts. Unlike earlier studies, we allow the propensity to spend out of the rebate to vary across household groups, which are determined within the estimation method, using quantile regressions.

Our analysis on Consumer Expenditure survey (CEX) data leads to four main findings. First, during both fiscal interventions, a share of American families between 40 percent and 50 percent spent a rebate amount that is not statistically different from zero. For another 20 percent, the spending propensity was significantly above one half, with the remaining families somewhere in between. Second, the spending was concentrated in "gas, motor fuel, public transportation," "health," "apparel," and a few "new vehicle" purchases. Third, for both stimulus programs, the largest propensity to consume out of the tax rebate tends to be found for households with both high levels of mortgage debt and high levels of income. This is also the group characterized by the largest extent of heterogeneity in the consumption responses to the stimulus payments. Fourth, when aggregated over the entire consumption change distribution, the propensity to spend out of the tax rebate predicted by the heterogeneous response model tends to be smaller and more accurate than the estimates implied by the homogeneous model.

A vast empirical literature surveyed by Jappelli and Pistaferri (2010) has used exogenous variation in household income data to test for the permanent income hypothesis. Parker (1999); Souleles (1999); Shapiro and Slemrod (2003 and 2009); Krueger and Perri (2006 and 2010); Hamilton (2008); Broda and Parker (forthcoming); Cloyne and Surico (2013); and Jappelli and Pistaferri (forthcoming); among many others, have documented a positive association between income shocks and nondurable expenditure. Significant comovements between government spending,

output and consumption are also found at a higher level of aggregation by Acconcia, Corsetti, and Simonelli (2011), Petev, Pistaferri, and Saporta-Eksten (forthcoming) and De Giorgi and Gambetti (2011).

Our work is most closely related to the influential studies by Parker et al. (2013) and Johnson, Parker, and Souleles (2006), who evaluate the impact of the 2001 and 2008 economic stimulus payments by exploiting the randomized timing of disbursement. Their main result is that American families spent cumulatively about two-thirds of the tax rebates. To study heterogeneity in the propensity to consume out of the stimulus payments, the authors consider an *exogenous* split of the sample into high-, middle-, and low-income households: their estimates suggest that there are no statistical differences in the spending propensity between these income groups. Based on an estimation method which allows us to group households according to some unobserved characteristics, we find that accounting for heterogeneity in the response to the tax rebates is both statistically and economically important for an accurate evaluation of the effect of the 2001 and 2008 fiscal interventions on US consumption.

The paper is organized as follows. Section I introduces the two empirical models. The first model restricts the responses of consumption to the tax rebate to be the same across households. The second model allows for slope heterogeneity. Section II reports our main findings by confronting the effects estimated by the homogeneous and heterogeneous response models. In Section III, we interpret our results in terms of the income and mortgage debt distributions. In Section IV, we show that the direct contribution of the 2001 and the 2008 economic stimulus payments to the performance of the US economy tends to be more precisely estimated and smaller than the effect predicted by the homogeneous response model. Section V concludes. In the Appendix, we show Monte Carlo evidence that quantile regressions are capable of recovering the true impact of the fiscal stimulus when artificial data are generated by a homogeneous response model as well as further robustness checks on restricted samples of the CEX data.

I. Empirical Framework

In this section, we lay out the empirical models that will be used in Section II to quantify the consumption responses to the income tax rebates. Following earlier contributions, the first model restricts the expenditure reaction to the economic stimulus payments to be constant across households. The second model relaxes the constancy assumption by allowing for slope heterogeneity across households at different points of the distribution of consumption change conditional on covariates.

A. *The Homogeneous Response Model*

A long standing tradition in the empirical literature (surveyed by Jappelli and Pistaferri 2010) has proposed alternative strategies to correlate exogenous variation in income to personal expenditure in an effort to quantify any departure from the permanent income hypothesis. In a typical formulation, the process of consumption growth has been modeled as function of time effects, individual controls and the

variable meant to identify exogenous changes in income (see for instance Zeldes 1989 and Lusardi 1996). Within this class of empirical models, Johnson, Parker, and Souleles (2006) and Parker et al. (2013) propose the following specification:

$$\Delta C_{it+1} = \sum_s \beta_{0s} \times M_s + \beta_1' X_{it} + \beta_2 R_{it+1} + u_{it+1}, \tag{1}$$

where ΔC is the first difference of consumption expenditure of household i in quarter t. The letter M denotes a complete set of indicator variables for every month s in the sample and it is meant to absorb seasonal variation in consumption as well as the impact of common factors such as aggregate shocks. Control variables are stacked in the matrix X and they include age, changes in the number of family members and, in our specification, squared age and changes in the squared number of family members. As argued by Attanasio and Weber (1993 and 1995) and Fernandez-Villaverde and Krueger (2007) a nonlinear formulation for demographics helps to control for differences in consumption driven by household-specific preferences. The key variable in specification (1) is R, which represents the amount of the rebate received by each household. Finally, u denotes unobserved shocks to consumption that are assumed to be drawn from an i.i.d. normal distribution.

As the mailing of the rebate was randomized according to the penultimate digit of the Social Security number of the tax filer, its arrival is independent from individual characteristics and therefore the coefficient β_2 can be interpreted as measuring the causal effect of the rebate on expenditure. Note, however, that the specification (1) assumes implicitly that the parametric assumptions behind the linear regression model hold and, thus, the least squares (LS) estimate of β_2 represents an accurate measure of the *average treatment effect* of the rebate on expenditure across all households in the samples.

Note that to interpret $\beta_2 = 0$ as a test of the permanent income hypothesis one has also to rely on the rebate arrival being preannounced. This implies that any resulting wealth effect should have arisen at the same time across households and thus it would be absorbed by the month fixed-effects. Furthermore, to the extent that the time dummies capture the marginal propensity to consume out of the *news* of the tax rebate, then β_2 can be interpreted as the marginal propensity to consume out of the *arrival* of the tax rebate.

While the randomized timing of the rebate receipt is uncorrelated to individual characteristics, the amount of the rebate is possibly not. To address this concern, Johnson, Parker, and Souleles (2006) and Parker et al. (2013) present also a set of estimates for equation (1) based on two stage least squares (TSLS) using as an instrument for R_{it+1} the indicator function $I(R_{it+1} > 0)$, which takes value of one in the period when the rebate was received. The authors report that the LS estimates and the TSLS estimates are sufficiently close that the Hausman test fails to reject the null of exogenous variation in the magnitude of the tax rebate across households.

B. *The Heterogeneous Response Model*

Several theoretical contributions have derived the conditions under which the aggregate implications of heterogeneous agent models may differ significantly from

the predictions of representative agent models. In an important theoretical work, Heathcote (2005) builds a heterogenous agent model with borrowing constraints to show that temporary changes in the timing of taxes can have large real effects. Kaplan and Violante (forthcoming) show that transaction costs and heterogeneity in illiquid asset holding trigger heterogeneity in the decision to consume out of additional transitory income. Differences in the degree of impatience and elasticity of intertemporal substitution may also be associated with differences in the expenditure response to a temporary tax cut.

To explore in the data the heterogeneity highlighted by the theory, we propose to use Quantile Regression (QR), which are designed to estimate unobserved heterogeneity models. To develop intuition for the way quantile regressions work and why they can be useful in our context, note that LS estimator is the solution to the problem of minimizing a sum of squared residuals. It is well-known, however, that LS estimates are not robust to outliers, leading one to prefer Least Absolute Deviations (LAD) as summary statistics whenever, for instance, fat tails are a concern (Koenker 2005).

As much as the solution to the problem of minimizing a sum of *squared* residuals yields an estimate of the mean of a distribution (subject to the important qualification noted in our introductory epigraphs from Heckman and Koenker), the solution to the problem of minimizing a sum of *absolute* residuals yields an estimate of the median. This is an estimate of the median because the symmetry of the piecewise linear absolute penalty function ensures that there are the same number of positive and negative residuals.

Quantile regressions generalize the principle behind LAD to *asymmetric* piecewise linear absolute penalty function. The asymmetry is introduced by a tilting term which weights differently the absolute residuals associated with different parts of the distribution of interest. By varying the tilting term, and therefore the weights in the penalty function, quantile regressions yield a family of slopes across the conditional distribution of the latent variable, which in the present context can be used to assess the extent of heterogeneity in the consumption response to the economic stimulus payments.

In our application, the outcome variable is expenditure change. This is treated as potentially latent because, given a received tax rebate and other variables at both individual and macro levels, the observed outcome for each household is only one of the possible realizations in the admissible space of outcomes. The quantiles of the potential outcome distributions conditional on covariates are denoted by:

$$Q_{\Delta C_{it+1}|R_{it+1},X_{it},M_s}(\tau) \quad \text{with} \quad \tau \in (0,1) \tag{2}$$

and the effect of the treatment, here the tax rebate R_{it+1}, on different points of the marginal distribution of the potential outcome is defined as:

$$QTE_\tau = \frac{\partial Q_{\Delta C_{it+1}|R_{it+1},X_{it},M_s}(\tau)}{\partial R}. \tag{3}$$

The quantile treatment model can then be written as:

$$\Delta C_{it+1} = q(R_{it+1}, X_{it}, M_s, \lambda_{it+1}) \quad \text{with} \quad \lambda_{it+1}|R_{it+1}, X_{it}, M_s \sim U(0,1), \tag{4}$$

where $q(R, X, M, \tau)$ is the conditional τ-th quantile of ΔC_{it+1} given $R = R_{it+1}$, $X = X_{it}$ and $M = M_s$. The term λ_{it+1} captures the unobserved heterogeneity across the households i having the same observed characteristics X_{it} and "treatment" R_{it+1}. This is referred to as the rank variable as λ_{it+1} determines the relative ranking of individuals in terms of potential outcomes. For each $\tau \in (0, 1)$, we specify a linear conditional quantile model of the form:

$$(5) \quad q(R_{it+1}, X_{it}, M_s, \tau) = Q_{\Delta C_{it+1}|\cdot}(\tau) = \sum_s \alpha_{0s}(\tau) \times M_s + \alpha_1(\tau)' X_{it} + \alpha_2(\tau) R_{it+1},$$

where the parameters $\{\alpha_2(\tau), \tau \in (0, 1)\}$ are the objects of main interest.

To the extent that the variation in the refunds is exogenous, the quantile treatment effect $\alpha_2(\tau)$ measures the causal effect of the tax rebate on consumption change, holding the unobserved characteristics driving heterogeneity fixed at $\lambda_{it+1} = \tau$.[1] Then, the methods outlined in Koenker and Bassett (1978) can be used to estimate quantile effects on the basis of the following conditional moment restrictions:

$$\mathbb{P}[\Delta C \leq q(R, X, M, \tau) | R, X, M] = \mathbb{P}[\lambda \leq \tau | R, X, M] = \tau$$

for each $\tau \in (0, 1)$. In Appendix A, we show that the QR estimates of (5) recover the true spending propensity β_2 when the data are simulated using the homogeneous response model (1) and a sample size similar to those in the CEX data.

Following Chernozhukov and Hansen (2006), we compute a measure of exogeneity for the amount of the rebate R_{t+1} that is the quantile regression analogous of the Hausman statistics for least squares. Applied to the estimates on food, strictly nondurable, nondurable and total consumption expenditure, using the indicator function $I(R_{it+1} > 0)$ as instrument for R_{it+1}, we cannot reject the null hypothesis of exogeneity on either 2001 or 2008 data.[2] On the basis of these results, we focus below on the QR estimates of the model described in (5).

II. Quantifying Consumption Heterogeneity

In this section, we present evidence of significant heterogeneity in the household expenditure responses to the 2001 and 2008 income tax refunds by contrasting results for the homogeneous specification (1) and the heterogeneous model (5). Furthermore, we assess the extent of heterogeneity across different expenditure categories among nondurable and durable goods and services. The main result is that the evidence of heterogeneous behaviour is pervasive, in a way that it is significantly missed by the homogeneous response model.

A. *The Expenditure Response to the Tax Rebates*

The data originate from CEX questionnaires which, shortly after the passage of the 2001 Tax Act and the 2008 Economic Stimulus Act, were augmented with questions

[1] The time effects are allowed to vary across quantiles so as to absorb unobserved heterogeneity in ΔC.
[2] The instrumental variable QR estimates tend to be close but less accurate than the QR estimates.

about the timing and the amount of each rebate check. Details on the design and distribution of these two fiscal stimulus programs can be found in Johnson, Parker, and Souleles (2006) and Parker et al. (2013).

The 2008 data have been constructed following Parker et al. (2013).[3] The nondurable expenditure data for 2001 are available at the link http://www.e-aer.org/data/dec06/20040878_data.zip associated with Johnson, Parker, and Souleles (2006). For the sake of comparability with the 2008 payments, we have complemented the 2001 Johnson, Parker, and Souleles' dataset with the durable expenditure figures in the CEX using the CEX interview identifiers.

Throughout the empirical analysis, we focus on direct responses from the CEX (as opposed to an imputation procedure). The rationale for this choice is two-fold. First, direct responses have been used extensively in earlier attempts to quantify the effects of the 2001 and 2008 tax rebates, including Johnson, Parker, and Souleles (2006) and Parker et al. (2013), and we want to ensure that any possible difference in our results is not driven by the use of a different version of the CEX data. Second, while Aguiar and Bils (2011) show that the *trends* in consumption inequality using an imputation procedure can be different from the *trends* based on direct responses, Attanasio, Hurst, and Pistaferri (2012) advocate that categories of large durable goods such as vehicle purchases are less prone to nonclassical measurement errors. Interestingly, our analysis, which covers periods of roughly *five quarters*, reveals that "new vehicle purchases" is not only the category associated with the largest extent of heterogeneity but also a main driver of the average treatment effect estimated using total household expenditure.

The dashed lines on the left (right) column of Figure 1 echo Parker et al.'s (2013) estimates and 95 percent confidence intervals fitting the specification (1) with least squares on 2008 (2001) data. Solid lines, in contrast, refer to the QR estimates of the heterogeneous response specification (5), with the surrounding light shaded areas representing 95 percent confidence intervals for 2008 (2001). In each panel, the horizontal axis indexes the τ*–th* quantile of the conditional distribution of consumption change while the vertical axis reports the impact of the tax rebate associated with each quantile. In the rows of Figure 1, we consider four widely used aggregated measures of expenditure: *food*, *strictly nondurable*, which following Lusardi (1996) excludes "apparel," "health," and "reading" from nondurable expenditure, *nondurable* and *total*, which includes both nondurable and durable expenditure.

A few results from Figure 1 are worth noticing. First, there is strong evidence in favor of heterogeneity with the effect implied by the homogeneous model overestimating (underestimating) significantly the household expenditure responses to the tax rebate at the lower (upper) end of the conditional consumption change distribution relative to the QR estimates.[4] Second, in either sample and for each

[3] The sources for these data are http://dx.doi.org/10.3886/ICPSR25623.v1 (2007 CEX data), http://dx.doi.org/10.3886/ICPSR26725.v1 (2008 CEX data) and http://dx.doi.org/10.3886/ICPSR29884.v2 (2009 CEX data). We thank the Economic and Social Data Service (ESDS) and Inter-university Consortium for Political and Social Research (ICPSR) for granting us with access to the files at the links above.

[4] Following Koenker and Machado (1999), we compute a measure of goodness-of-fit, which is the quantile regression analogous of the R^2 statistics for least squares. Applied to the QR estimates for nondurable expenditure, the measures of goodness-of-fit in percent are: 1.37 [1.34] ($\tau = 0.05$), 0.99 [1.19] ($\tau = 0.10$), 0.77 [1.01] ($\tau = 0.15$), 0.80 [0.87] ($\tau = 0.20$), 0.82 [0.80] ($\tau = 0.25$), 0.78 [0.68] ($\tau = 0.30$), 0.77 [0.54] ($\tau = 0.35$), 0.74 [0.37]

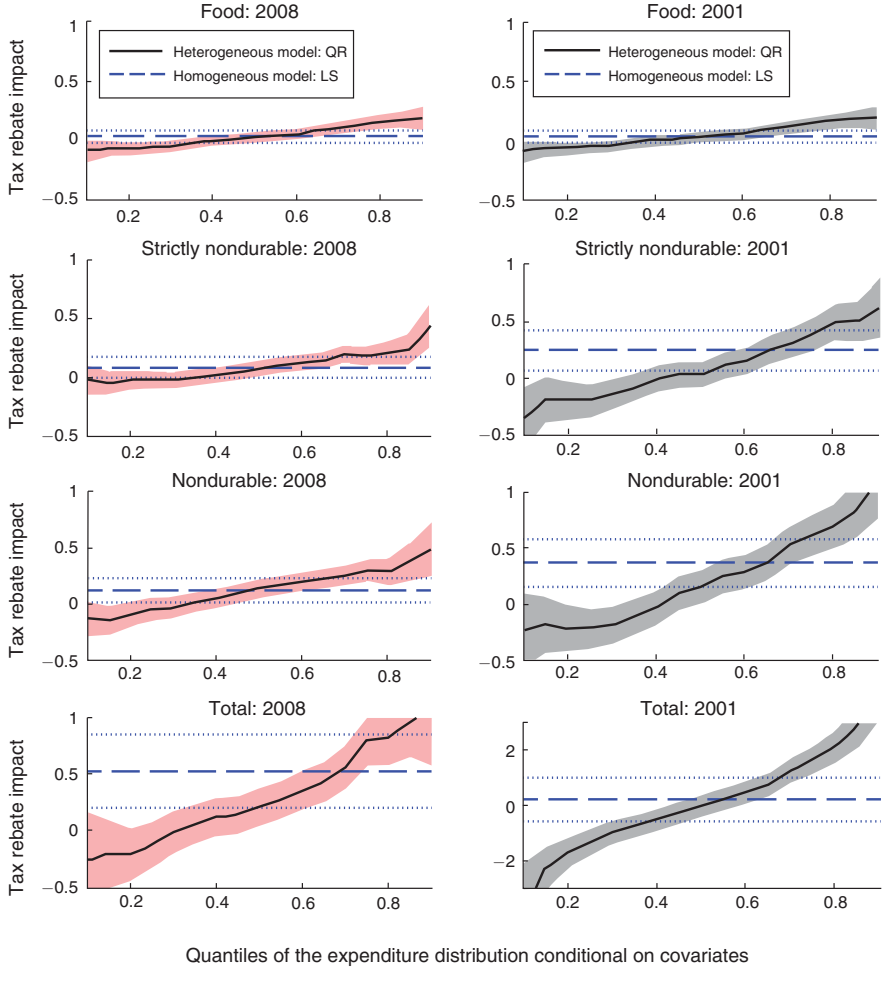

FIGURE 1

Notes: The figure shows the coefficient on tax rebate from regressions of consumption change on tax rebate, age, squared age, change in the number of kids and the number of adults, change in their square values and monthly dummies. In the left [right] column, QR (LS) estimates in light (dark) [light (dark)] refer to quantile (least squares) regressions for the 2008 [2001] data. Shaded areas (dotted lines) are 95 percent confidence intervals obtained using heteroscedasticity robust standard errors. Estimates are reported for $\tau \in [0.1, 0.9]$ at 0.05 unit intervals. The rows refer to specifications in which the dependent variable is food, strictly nondurable, nondurable, and total consumption change, respectively. Sample: $N = 17{,}718$ [$N = 13{,}066$].

specification, we reject the null hypothesis of homogeneous responses. Furthermore, going down the rows of Figure 1, the extent of heterogeneity appears increasing with the degree of "durability" of the good and services in each expenditure group. Third, the evidence of heterogeneous responses seems relatively stronger for the

$(\tau = 0.40)$, 0.73 [0.32] $(\tau = 0.45)$, 0.71 [0.30] $(\tau = 0.50)$, 0.72 [0.35] $(\tau = 0.55)$, 0.75 [0.46] $(\tau = 0.60)$, 0.77 [0.58] $(\tau = 0.65)$, 0.81 [0.72] $(\tau = 0.70)$, 0.88 [0.84] $(\tau = 0.75)$, 0.97 [0.99] $(\tau = 0.80)$, 1.02 [1.09] $(\tau = 0.85)$, 1.21 [1.48] $(\tau = 0.90)$ and 1.65 [2.11] $(\tau = 0.95)$ for the 2008 [2001] data. The R^2 statistics in percent associated with the corresponding OLS estimates is 1.23 [0.64]. Similar results are obtained for total expenditure.

2001 payments. Fourth, for a fraction of American households between 40 percent and 50 percent, the change in expenditure in each sample/column is not statistically different from zero, independent of the level of aggregation in the different rows (with the exception of total expenditure in 2001). Fifth, the conditional distributions of total expenditure change are associated with the least accurate and most extreme estimates: in the next section, we will present evidence suggesting that these outcomes are probably driven by a small number of outliers in the "new vehicle" purchase category.

To test formally the null hypothesis of homogeneity in the response of American households to the two economic stimulus payments programs, we follow the martingale approach proposed by Khmaladze (1982) and Koenker and Xiao (2002). This is based on the idea that the impact of a covariate in a homogeneous response model is a pure location shift, thereby making the coefficients constant across quantiles. The statistics of this test for 2008 (2001) are 2.56 (3.04), 2.59 (3.24), 2.37 (3.05), and 3.30 (2.65) for total, nondurable, strictly nondurable, and food expenditure respectively. As the empirical critical values at the 5 percent level is 1.99 (Koenker 2005, Appendix B), we can reject the null hypothesis of homogenous response across American households.

To assess the extent to which our results may be capturing any structural difference between receivers and nonreceivers of the economic stimulus payments, we estimate equations (1) and (5) on restricted samples that include only households who received a payment in any reference quarter, thereby exploiting variation in both the timing and the amount of the rebate. Figure 7 in Appendix B reveals that the findings of heterogenous responses in Figure 1 are not overturned by this restriction. We obtain similar results by restricting the sample further to only households who received a payment in a specific reference quarter, thereby exploiting only variation in the rebate amount.

In summary, the aggregated measures of nondurable and total consumption expenditure point towards significant heterogeneity in the responses of American households to income tax rebates. In particular, the distribution of the consumption change effects appears bimodal with a large share of households characterized by a marginal propensity to consume close to zero and another significant mass with a marginal propensity to consume close or above 0.5. While this bimodality is consistent with the predictions of the theory in Kaplan and Violante (forthcoming), a more direct test of the mechanism they propose involves looking at income and mortgage debt across the consumption change distribution. This is done in Section III where we aim at identifying the characteristics that make a household more likely to spend the tax rebate. Before that, we explore heterogeneity across expenditure categories.

B. *The Response across Expenditure Categories*

In Figure 2, we present QR and LS estimates for the sub-components of personal consumption expenditure associated with the largest extent of heterogeneity. The categories "gas, motor fuel, public transportation," "health," and "apparel" ("entertainment" and "transportation") represent about 35 percent (40 percent) of nondurable (durable) spending in each sample.

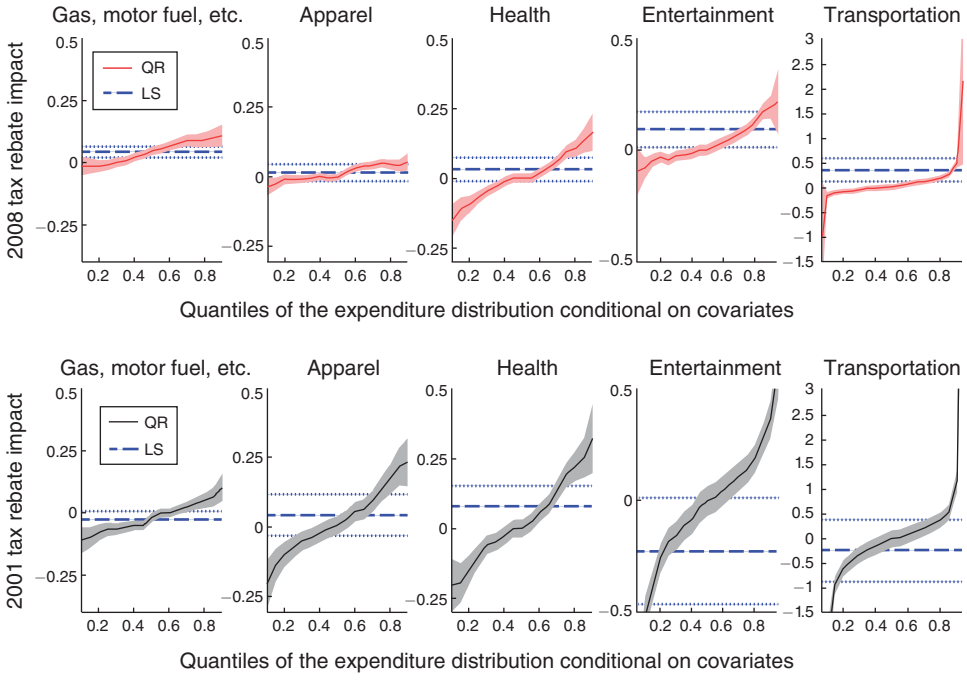

FIGURE 2

Notes: The figure shows the coefficient on tax rebate from regressions of consumption change on tax rebate, age, squared age, change in the number of kids and the number of adults, change in their square values and monthly dummies. In the top [bottom] row, QR (LS) estimates in light (dark) [light (dark)] refer to quantile (least squares) regressions for the 2008 [2001] data. Shaded areas (dotted lines) are 95 percent confidence intervals obtained using heteroscedasticity robust standard errors. Estimates are reported for $\tau \in [0.1, 0.9]$ at 0.05 unit intervals. Each columns refer to a specification in which the dependent variable is a different subcomponent of household expenditure. Sample: $N = 17{,}718$ [$N = 13{,}006$].

In all panels, the evidence against a homogeneous response is strong on the basis of the Khmaladze test. In contrast, we find little evidence of heterogeneity in "utilities, household operations" and "housing" (not reported), which represent about 25 percent and 50 percent of nondurable and durable consumption, respectively. The LS estimates are rarely significant with the nondurable sub-component "gas, motor fuel, public transportation" and the durable subcomponent "transportation" in 2008 being two prominent exceptions, consistent with Petev, Pistaferri, and Saporta (2011).

A feature of the disaggregated 2001 results is that the tails of the conditional distributions are associated with coefficients on tax rebates, which are large in absolute value. While this might reflect measurement errors, especially in durable consumption (as suggested by Parker et al. 2013, in their footnote 15), we note that the negative estimates in these categories do not prevent the responses of the aggregated nondurable expenditure to the stimulus payments in 2001 to be statistically indistinguishable from zero at the left of the conditional distribution in Figure 1.[5] Furthermore, Kaplan,

[5]The finding of heterogeneity is robust to constrain $\alpha_2(\tau) \in [0, 1] \; \forall \; \tau \in (0, 1)$ in equation (5). In particular, the marginal propensities to change total expenditure in 2001 remain at zero for the bottom 55 percent of the conditional distribution, increase monotonically afterwards and become one for the top 30 percent. On the other hand, the estimates for all other expenditure categories in Figure 1 are virtually unaffected.

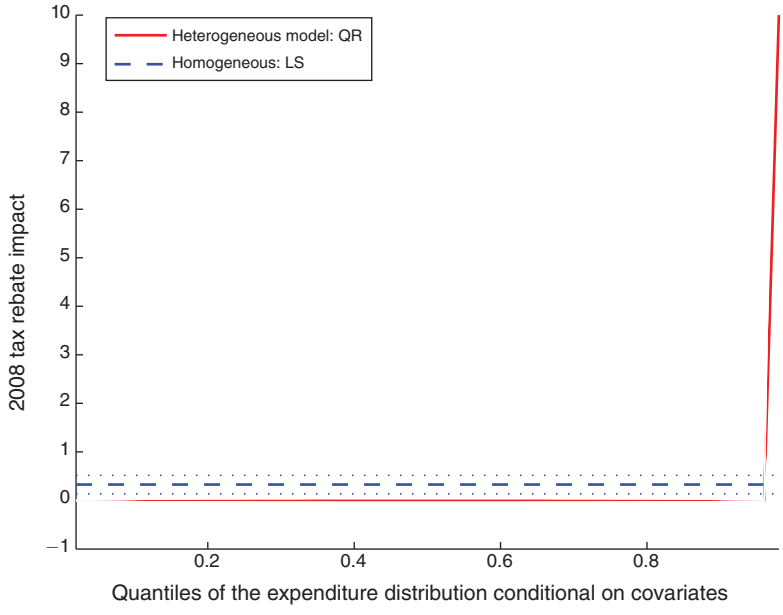

FIGURE 3

Notes: The figure shows the coefficient on tax rebate from regressions of consumption change on tax rebate, age, squared age, change in the number of kids and the number of adults, change in their square values and monthly dummies. QR (LS) estimates in light (dark) refer to quantile (least squares) regressions for the 2008 data. Shaded areas (dotted lines) are 95 percent confidence intervals obtained using heteroscedasticity robust standard errors. Estimates are reported for $\tau \in [0.02, 0.98]$ at 0.02 unit intervals. The dependent variable is the durable expenditure subcomponent denoted "new vehicle" purchases. Sample: $N = 17{,}718$.

and Violante (forthcoming) show that low transaction costs on illiquid assets provide an incentive to anticipate the portfolio adjustment decision in a way that can generate negative marginal propensities to consume for a fraction of the population.

The last column of Figure 2 on "transportation" (and to a lesser extent "entertainment") sheds light on the results on aggregated data reported in the previous section: the tails of the conditional distributions of total expenditure change in the last row of Figure 1 appear to be driven by inaccurate and extreme estimates at the tails of the conditional distributions of these durable categories. Within the latter, we find that the sub-component "new vehicle" purchases, which represents about one-fourth of "transportation" expenditure, accounts for the lion share of the tails in the total expenditure change conditional distribution of Figure 1. These patterns are exemplified in Figure 3, which displays as red shaded areas the QR estimates for "new vehicle" purchases in 2008, a category which has been often cited to exemplify the significant effect of the fiscal stimulus.

Two results are worth noting in Figure 3. First, the tails of the distributions amount to less than 1 percent of the full sample: there are only 63 (40) households—out of 17,718 observations—for which the arrival of the tax rebate coincided with (followed) the purchase of a new vehicle. For those individuals, the average change in the "new vehicle" purchase category was about $23,000 against the backdrop of an average tax rebate of around $1,100. Second, the estimates of the homogeneous

response model (reported as dark lines) show a significant spending propensity of 0.33 for this sub-category. But excluding "new vehicle" purchases from total expenditure makes the estimated spending propensity from the homogeneous response model fall from 0.58 to 0.20, with a standard error of 0.13.[6]

In summary, the results on the disaggregated categories provide important qualifications to the finding of heterogeneity in the previous section using aggregated measures. In particular, the responses of a few sub-components of nondurable expenditure to the economic stimulus payments in 2001 are typically larger and more heterogeneous than the responses of the same categories in 2008. Interestingly, the model in Kaplan and Violante (forthcoming) predicts that the marginal propensity to consume should be small (large) whenever the size of the tax rebate is large (small) relative to the transaction costs on illiquid assets: the 2008 tax rebate was, on average, about twice as large as the 2001 rebate. Furthermore, the heterogeneity in the response of total expenditure in 2008 seems driven by a handful of "new vehicle" purchases.

III. What Drives the Heterogeneous Responses?

Two sets of influential contributions to the empirical literature on consumption and tax rebates report conflicting results on the observed characteristics associated with the heterogeneous responses to the 2001 and 2008 economic stimulus payments.

Based on the Michigan survey, Sahm, Shapiro, and Slemrod (2010) and Shapiro and Slemrod (2003 and 2009) document that the highest share of "mostly spending" (out of the rebate) respondents is recorded among the households with the highest income in the sample. Based on the CEX and an exogenous split in three income groups, in contrast, Johnson, Parker, and Souleles (2006) and Parker et al. (2013) argue that the low-income households exhibit the largest propensity to consume, though the large standard errors associated with each group prevent their estimates to be significantly different from each other.

In this section, we show that applying the heterogeneous response model to the CEX data, we are able to reconcile the seemingly conflicting results from earlier contributions in a way that (i) makes the estimates based on the CEX consistent with the findings from the Michigan survey and (ii) explains the income group-specific point estimates and large standard errors in Johnson, Parker, and Souleles (2006) and Parker et al. (2013). For the sake of exposition, we focus on the distributions of nondurable expenditure in 2001 and total expenditure in 2008 as these were the main focus of Johnson, Parker, and Souleles (2006) and Parker et al. (2013), but the results in this section extend beyond these distributions.

The empirical literature emphasizes that some observed characteristics such as income, debt, and liquid wealth are likely to bear some correlation with the unobserved characteristics that may trigger a violation of the permanent income hypothesis. Accordingly, the rows of Figure 4 report respectively the median value

[6] As for 2001, only 502 households—out of 13,006—purchased a new vehicle in either the same quarter or the quarter before the arrival of the tax rebate. Excluding "new vehicle" purchases from total expenditure in 2001, however, produces only a modest difference in the spending propensity estimated with LS, possibly because the average response of new vehicle purchases in 2001 is not statistically different from zero.

FIGURE 4

Notes: Median values for income, home ownership rate for households *without* mortgage, home ownership rate for households *with* mortgage and principal outstanding balance on mortgage by rank-score quantile of the conditional distribution of the 2008 total [2001 nondurable] expenditure in the left [right] column. For each quantile τ, we include households for which $[y - X\alpha(\tau)] \leq 0$ and $[y - X\alpha(\tau - 0.05)] > 0$. Sample size $N = 15{,}035$ $[N = 10{,}863]$ for income, $N = 17{,}504$ $[N = 13{,}013]$ for home ownership and $N = 8{,}135$ $[5{,}798]$ for mortgage debt.

of income, the home ownership rate for households *without* mortgage, the home ownership rate for households *with* mortgage and the median value of primary outstanding balance on mortgage debt for each quantile of the conditional distribution of consumption estimated in the previous sections.

Three findings are worth emphasizing. First, during both 2008 (in the left column) and 2001 (in the right column), income, home ownership rate for households with mortgage and mortgage debt tend to have higher values at the tails. Bearing in

mind the evidence of Section II, this implies that households with a high propensity to spend at the right tail are more likely to have higher income and higher debt.[7] Second, the groups of households with lower income and more likely to rent are concentrated in the 45 to 65 percentiles. According to the QR estimates of Figure 1, these households spend a fraction of the rebate between 10 percent and 40 percent. Third, in both samples no discernable pattern emerges across the quantiles of the second row of Figure 4 on the home ownership rates for households without mortgage. The contrast between the statistics in the second row and the statistics in the last two rows accords well with the view that debt is correlated with some unobserved characteristics driving a violation of the permanent income hypothesis.

To provide formal evidence on the significant link between income, home ownership rate, debt and heterogeneity in the propensity to consume, we perform a battery of probit regressions for each quantile of the conditional expenditure change distribution using either income, home ownership rate without mortgage, home ownership rate with mortgage, mortgage debt or liquid wealth as explanatory variable.[8]

The findings of the probit regressions, available upon request, corroborate the prima facie evidence reported in Figure 4. Having higher income, higher mortgage debt or higher liquidity makes it more likely to belong to either the top or the bottom 15 percentiles. As for the central part of the distribution, the estimated coefficients switch sign, implying that renting or having lower income and lower liquidity increase the probability to be among the families who spent a small but significant amount of the rebate. On the other hand, the estimated coefficients on home ownership rate without mortgage are rarely significant and display no systematic pattern across quantiles.

The results in this section can also provide a rationale for two findings in Johnson, Parker, and Souleles (2006) and Parker et al. (2013). First, they find that households in the low-income group tend to spend the largest fraction of the 2001 and 2008 rebates. Second, they report that the estimates for the high-income group are not statistically different from those for the low- and middle-income groups.

According to the first row of Figure 4, the *exogenous* split adopted in earlier contributions pools together (into a high-income group) observations at the extremes of the conditional expenditure change distribution. But the estimates in Figure 1 show that the households at the bottom end and the top end of this distribution are respectively characterized by the lowest and the largest propensity to spend.

Altogether, the findings of this section suggest that an exogenous split into high/middle/low income groups is likely to lead to (i) large LS standard errors and (ii) an estimated spending propensity for the high-income group so close to the propensity for the other groups that one cannot reject the null of homogeneous responses.

In contrast, the Khmaladze test of Section II and the QR estimates in Figure 1 are based on groups of families which are determined within the estimation method. The evidence from the heterogeneous response model reveals that, in fact, the spending propensity of a sizable fraction of high income/high debt households is significantly

[7] The U-shaped result is robust to using liquid assets, though the number of observations with a valid entry for this financial variable is about 50 percent smaller than the full sample.

[8] For each quantile τ, the dependent variable takes value of 1 if $[y - X\alpha(\tau)] \leq 0$ and $[y - X\alpha(\tau - 0.05)] > 0$.

larger than the spending propensity of low income/renting families, consistent with the findings from the Michigan survey in Shapiro and Slemrod (2003 and 2009).

It is interesting to note that the nonmonotonic relationship between income and mortgage debt, on the one hand, and marginal propensity to consume, on the other hand, is consistent with the theoretical predictions in Kaplan and Violante (forthcoming). According to their model, in the US population a significant share of households with high income and high mortgage debt behave as hand-to-mouth because of the transaction costs to access their illiquid wealth. At the same time, however, another significant fraction of high income/high debt families hold sufficient liquidity to overcome the transaction costs and therefore not to adjust consumption following an income shock like the tax rebate.

IV. The Direct Contribution to Aggregate Expenditure

In the previous section, we have documented strong evidence of heterogeneous responses to the 2001 and 2008 tax rebates. In this section, we ask whether relaxing the assumptions behind the homogeneous response model affects the estimated direct contribution of the fiscal stimulus to aggregate consumption. It is useful to remind at this point that, by the very nature of the (micro) data, the calculations presented below abstract from general equilibrium effects. While this suggests that the aggregate impact of the policy interventions may differ from the direct contribution estimated using CEX data, our goal is to compare the estimates from the heterogenous response model in this paper with the estimates from the homogeneous response model in earlier studies, which also abstract from general equilibrium effects.

To measure the overall effect of the economic stimulus payments, we follow Johnson, Parker, and Souleles (2006) and augment our model specifications with the lagged value of the tax rebate, R_t. Then, we cumulate the two coefficients on the tax rebate amount and bootstrap the standard errors using the method described in Koenker (2005, section 3.9). Figure 5 reports the results of this exercise in the form of the distribution of the cumulative fraction of the tax rebate spent in the two quarters since its receipt. The left (right) column reports in light the findings for 2008 (2001) based on the heterogeneous response model. The effect implied by the homogeneous model is depicted in dark. The top (bottom) row refers to nondurable (total) expenditure.

The analysis in Johnson, Parker, and Souleles (2006) and Parker et al. (2013) as well as the subsequent literature has focused on the impact of the stimulus payments on nondurable spending in 2001 (top right panel) and total spending in 2008 (bottom left). Interestingly, these are also the two cases of Figure 5 in which the estimates implied by the heterogeneous response model are significantly smaller than the point estimates from the homogeneous model. More specifically, the blue distributions implied by the LS estimates are centered at 0.58 for total consumption in 2008 and 0.68 for nondurable consumption in 2001. In contrast, the corresponding red and grey distributions implied by the QR procedure are centered at 0.16 and 0.43 respectively.

The differences between the two sets of estimates are economically significant. According to the heterogeneous response model, the impact on total expenditure in

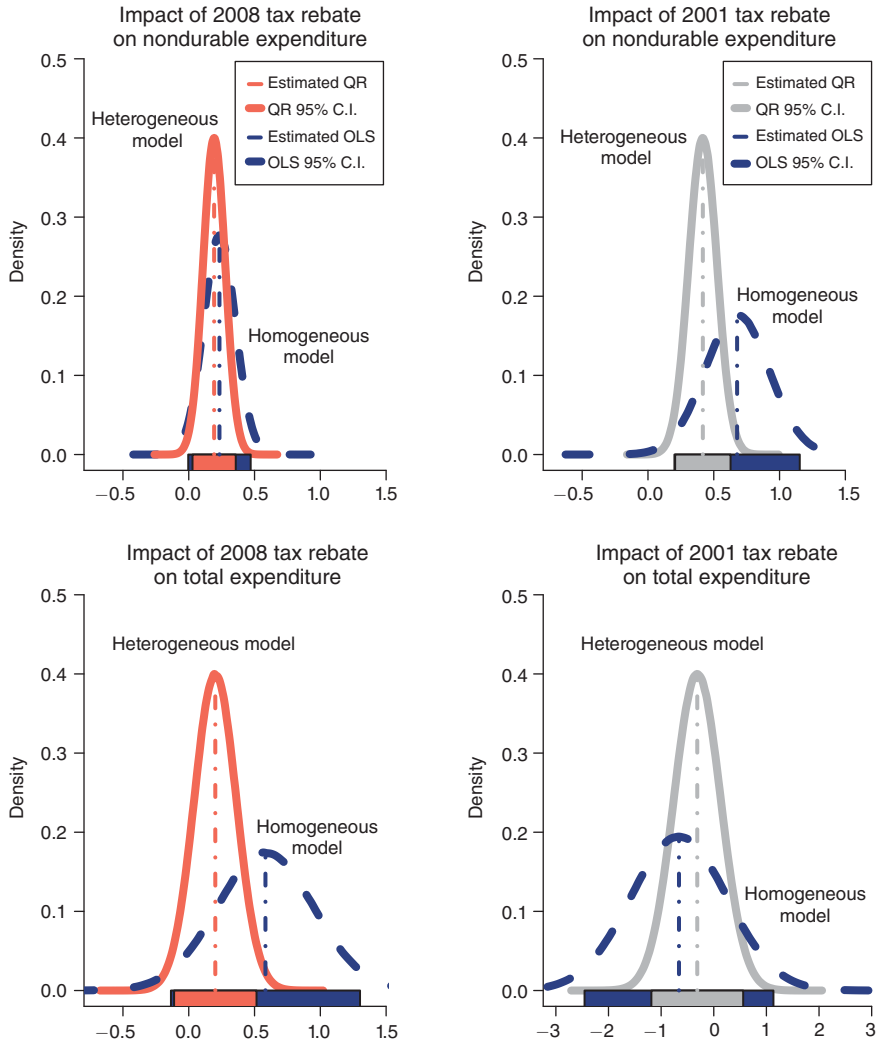

FIGURE 5

Notes: The figure shows the distribution of the cumulative fraction of the tax rebate spent in the two quarters following its receipt from regressions of consumption change on tax rebate, lagged tax rebate, age, squared age, change in the number of kids and the number of adults, change in their square values and monthly dummies. In the left [right] column, QR (LS) estimates in light (dark) [light (dark)] refer to quantile (least squares) regressions for the 2008 [2001] data. To compute the effect associated with the QR estimates, we integrate under the distribution of the estimated heterogeneous responses. Since all our estimated quantiles are equally spaced, this considers the average of the estimated effects across quantiles. The standard errors are calculated via bootstrapping (Koenker 2005, p. 302). Horizontal bars refer to 95 percent confidence intervals. The top (bottom) row refers to nondurable (total) expenditure.

2008 (nondurable expenditure in 2001) was about \$40 (\$10) billions smaller than the predictions of the homogeneous response model. This comes against a backdrop of \$96 (\$38) billions of total disbursement in 2008 (2001). Viewed through the lens of the heterogeneous response model, the *absolute* effects of the two economic stimulus payment programs on the US economy were surprisingly similar in size, corresponding respectively to a boost of about 17 billions of 2008 US dollars and 15 billions of 2001 US dollars.

Table 1—OLS Estimates of the Cumulated ESP Direct Contribution

	Unrestricted	1 percent trimming	5 percent trimming
2008 nondurable goods	0.23	0.28	0.18
	(0.12)	(0.09)	(0.07)
2008 total expenditure	0.58	0.18	0.12
	(0.37)	(0.29)	(0.20)
2001 nondurable goods	0.68	0.37	0.27
	(0.24)	(0.18)	(0.14)
2001 total expenditure	−0.66	−0.27	−0.15
	(0.92)	(0.73)	(0.50)

Notes: Standard errors in parentheses. OLS: ordinary least squares. EPS: economic stimulus payments. 1 percent (5 percent) trimming refers to excluding the highest 0.5 percent (2.5 percent) and the lowest 0.5 percent (2.5 percent) of the dependent variable.

As for the impact on nondurable expenditure in 2008 (top left panel in Figure 5) and total expenditure in 2001 (bottom right panel), the two models generate similar predictions, thereby providing two instances in which the inference drawn upon the estimates of the homogeneous response model is not compromised. Despite the similar impact of the fiscal stimulus on nondurable consumption in 2008, however, it should be noted that only the estimate of 0.20 implied by the heterogeneous response model is significantly different from zero, with a standard error of 0.05.[9]

An alternative way (relative to quantile regressions) to appreciate the impact of the heterogeneity at the tails of the conditional distribution of consumption change is to estimate a linear model of the type shown in (1) using OLS on a restricted sample which excludes the most extreme observations. While the choice of a specific cut-off is necessary arbitrary, we experiment with either 1 percent or 5 percent trimming at both the top (either 0.5 percent or 2.5 percent) and the bottom (either 0.5 percent or 2.5 percent) of the expenditure change distribution. Table 1 reports results for both total consumption and nondurable goods consumption.

A finding that stands out from this exercise is that, with the exception of the 2008 nondurable expenditure, a 1 percent trimming is sufficient for the cumulated effect of the economic stimulus payment on consumption to decrease dramatically. While the changes are not statistically significant due to the large standard errors, by removing a few outliers in the second column of Table 1 the estimated response becomes smaller than one-third of the point estimate based on the unrestricted sample for total expenditure in 2008, it looses more than 40 percent for 2001 nondurable expenditure, and it changes by about 0.4 for total consumption in 2001. These sizable differences are magnified by excluding observations in the top/bottom 2.5 percent of the conditional distribution in the last column. Under this cut-off for the removal of further possible outliers, the cumulated responses become even smaller,

[9] It is interesting to note the extent to which the extreme observations at the left tail of the conditional distribution for total expenditure change in 2001 tilt the OLS estimates towards a large negative propensity to consume of -0.7. In contrast, the QR estimates, which by design are robust to outliers, predict a point estimate of -0.2. Restricting the impact of the tax rebate to be between zero and one in each quantile produces an overall propensity to change total expenditure in 2001 of 0.3, which is still statistically insignificant. For all other expenditure in Figure 5, the restrictions on $\alpha_2(\tau)$ have no material impact.

always below 0.3, with the response of nondurable expenditure still retaining statistical significance under both fiscal stimulus programs.

It is interesting to note that the point estimates based on the restricted samples in Table 1 appear close to the QR estimates reported in Figure 5, but they tend to differ from the OLS estimates on the unrestricted sample in the first column, thereby providing yet another example of the extent to which OLS can be very sensitive to outliers. Furthermore, it is hard to know ex ante what specific cut-off makes robust the inference drawn upon OLS over the restricted sample.[10] This contrasts with quantile regressions which retain all observations while allowing for robust and accurate inference.[11]

As for statistical significance, the estimates of the heterogeneous model in Figure 5 are more accurate than their homogeneous model counterparts with confidence bands for the latter are about twice as large as the confidence bands of the former. Fat tails in finite samples can not only result in sizable deviations of the OLS coefficient estimates from their true values (Mikosch and de Vries 2013), but can also account for the difference in accuracy between the estimates of the homogeneous and heterogeneous response models. To investigate the extent of fat tails in the distribution of the error terms in equation (1), we run the tests of Kurtosis proposed by Anscombe and Glynn (1983) and Bonett and Seier (2002). The Kurtosis measure for the total (nondurable) expenditure distribution in 2008 (2001) is 44 (94), as opposed to 3 in a Gaussian distribution. The statistics for both tests overwhelmingly reject the null hypothesis of normality at the 1 percent significance level.

V. Conclusions

This paper has studied the response of the US economy to the 2001 and 2008 income tax rebates using an empirical model in which the propensity to spend is allowed, but not required, to vary across a large sample of American households. A number of results appear robust across the two stimulus programs.

The consumption responses to the tax rebates is highly heterogeneous, with 40 percent to 50 percent of households spending an amount not statistically different from zero. Another 20 percent consume significantly more than half of the rebate, with the remaining families somewhere in between. The heterogeneity is concentrated in "gas, motor fuel, public transportation," "health," "apparel," and a handful of observations in "new vehicle."

The impact of the stimuli appears statistically significant (but economically limited) for nondurable consumption expenditure. In contrast, the propensity to spend on total expenditure tends to be statistically indistinguishable from zero. The

[10] This point is reminiscent of Hamilton (2008) who shows that the effect of the 2001 tax rebates estimated by Johnson, Parker, and Souleles (2006) is not robust to slightly different trimmings of their data.

[11] As a further sensitivity analysis, we have also estimated a linear model with OLS over the unrestricted sample using the log difference of consumption (as opposed to consumption change) and the formula for the semi-elasticity to map the estimated coefficient into a marginal propensity to spend. Under this specification, the average effects are 0.22 (with standard error of 0.23) for the 2008 total expenditure and 0.43 (with standard error of 0.18) for the 2001 nondurable expenditure. Silva and Tenreyro (2006), however, warn against estimating a log-linear specification with OLS. As in Section IIB we also consider the OLS for the 2008 total expenditure without including new vehicle purchases. Under this specification, the estimated cumulated ESP direct contribution is 0.12 (with a standard error of 0.29).

households who spend most of the fiscal payment typically hold a mortgage and have higher income whereas renters with lower income tend to spend between 10 and 40 *cents* for each dollar of rebate.

The differences between the estimates of the heterogeneous model and the estimates of the homogeneous model are economically significant. According to the heterogeneous response model, the stimulus payments boosted GDP and Personal Consumption Expenditure, PCE, in 2008H1 (2001H2) by about 0.4 percent (0.6 percent) and 0.6 percent (0.9 percent) respectively. These figures should be compared to an increase of about 1.5 percent for GDP (1.0 percent) and 2.1 percent (1.5 percent) for PCE predicted by the homogeneous response model.

Our findings suggest that heterogeneity is more than a theoretical curiosity or a mere refinement of the estimated average effect for studying distributional dynamics. Applied to the 2001 and 2008 US economic stimulus payments, we have shown that a heterogeneous response model can provide a significantly different evaluation of the impact of large public programs on the aggregate economy *as well as* on the different groups of society.

Appendix A: Monte Carlo Simulations

In this Appendix, we use a Monte Carlo experiment to show that the QR estimator does not capture artificial heterogeneity. To do this, we generate data using a sample similar to the 2001 CEX data and forcing the consumption response to the tax rebate to be homogenous across households. More specifically, we simulate data for $N = 13{,}000$ observations according to the following rules:

- a third of the population receive no tax rebate, a third receive \$300 in tax rebate and the remaining third receive \$600 in tax rebate.
- the spending propensity β_2 is fixed at 0.37 for the entire population.
- the exogenous shocks to consumption change are drawn from a normal distribution with zero mean and variance such that the R^2 from the least square estimation is about 0.6 percent, as in the data.

Based on these three assumptions, we generate artificial data on consumption change and then estimate the spending propensity out the stimulus payments using either quantile regression or least squares. We generate 10,000 artificial samples (of size $N = 13{,}000$) and report means of the QR and LS estimates across these 10,000 repetitions. The results in Figure 1A shows that the QR model does correctly capture the homogeneity of spending propensity that we have imposed in the data generating process. Finally, we have also confirmed that the Monte Carlo evidence reported in this Appendix is robust to using nonnormally distributed disturbances as well as stimulus payments of a larger amount.

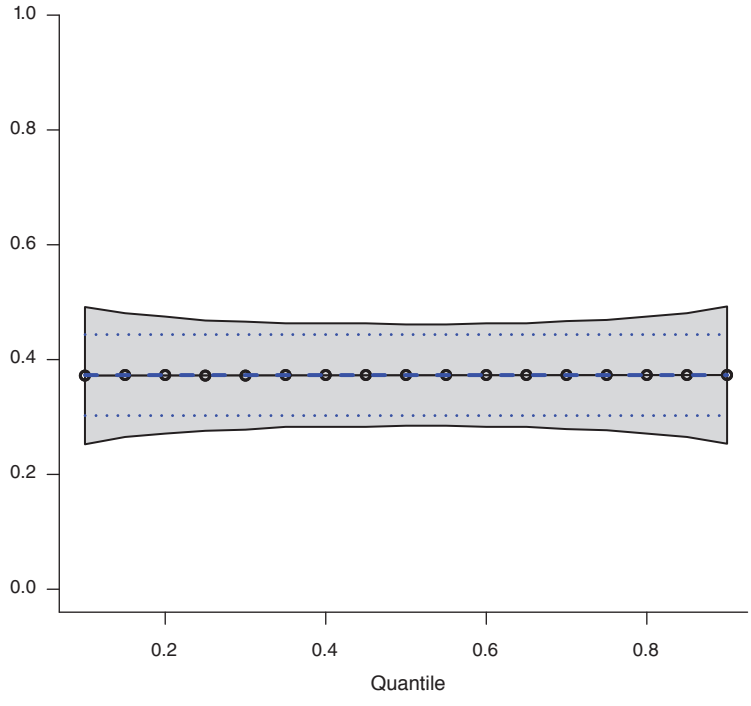

FIGURE 1A

Notes: QR and LS estimates over data generated under the assumption of a fixed spending propensity $\beta_2 = 0.37$ across all quantiles, using a sample of 13,000 observations. Results based on averages over 10,000 repetitions. Solid line with black circles (dashed line) and gray area (dotted line) refer to QR (LS) estimates and 95 percent confidence intervals.

Appendix B: Restricted Sample of Tax Rebate Receivers

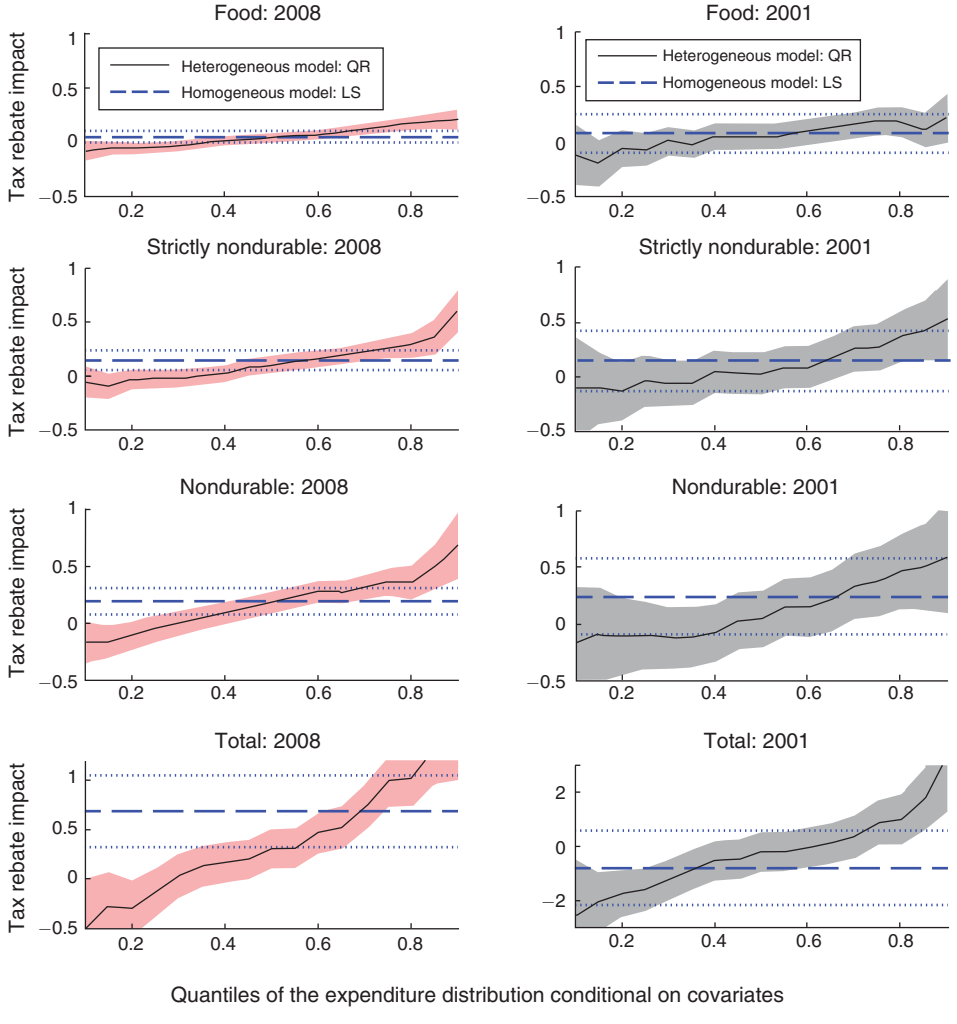

Figure 1B

Notes: See notes to Figure 1. Sample restricted to tax rebate receivers only: $N = 11{,}340$ [$N = 4{,}739$].

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