Is Households' Consumption Decision-Making Reference-Dependent? *

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ABSTRACT

This paper presents evidence that households' consumption decision-making is reference-dependent. We propose a model wherein households use their desired target as an initial reference point to establish their rational consumption reference point. Assuming diminishing sensitivity to the disparity between these two reference points, the model predicts opposing movements of consumption reference points among households. This prediction leads us to discover that lower and upper consumption growth rates react oppositely to observed macroeconomic changes but similarly to unanticipated ones. This finding challenges the existing consumption-based risk analysis paradigm, shedding light on the fundamental cause and solution to asset pricing puzzles.

Key words: Consumption Reference Point, Consumption-Based Risk Analysis, Diminishing Sensitivity, Asset Pricing Puzzles

JEL Codes: D12, D91, E21, E71, G12, G41.

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1. Introduction

Kahneman and Tversky's (1979) prospect theory suggests that individuals' preferences are reference-dependent, evaluating monetary outcomes relative to a reference point. The foundational concept of reference dependence is a cornerstone of behavioral economics and has found extensive applications across various economic areas, including finance, insurance, marketing, auctions, labor economics, public economics, etc.

This paper investigates whether households' consumption decision-making is reference-dependent. Traditionally, reference-dependent preferences have predominantly pertained to monetary payoffs, such as prices, wealth, wages, tax payments, insurance deductibles, transaction costs, and investment returns, rather than consumption. Some models do incorporate reference-dependent preferences in the context of consumption. Notable examples include the work of Constantinides (1990), Campbell and Cochrane (1999), and Kőszegi and Rabin (2006, 2007, 2009). However, prevailing mainstream economic models evaluate consumption at its absolute level despite encountering numerous challenges in their application. A more widespread application of consumption-based models with reference dependence may require strong evidence from micro-level consumption data for this preference and its potential to address a wide range of significant economic questions.

We establish supporting empirical evidence for reference-dependent consumption decision-making by demonstrating that our proposed model with reference-dependent preferences outperforms traditional models in explaining the cross-quantile consumption-behavior heterogeneity identified from households' consumption growth data. Our empirical findings pose a challenge to classical economic theories and reveal the fundamental cause of many long-standing consumption-based asset pricing anomalies, such as the equity premium puzzle (see Mehra and Prescott 1985), risk-

free rate puzzle (see Weil 1989), equity volatility puzzle (see Shiller 1981; LeRoy and Porter 1981; Grossman and Shiller 1981), etc. Our findings highlight the inadequacy of existing solutions to these puzzles and support reference dependence as a foundational component of consumption-based risk analysis.

We investigate cross-quantile heterogeneity in consumption behavior by analyzing household consumption growth data from a macroeconomic perspective. We calculate the τ-th unconditional quantile of the growth rates of total consumption expenditures from period t to t+1, denoted by $Q_{y,t+1}(\tau)$, on a period-by-period basis using quarterly data from the Consumption Expenditure Survey (CEX). Our findings reveal that the correlation between $Q_{y,t+1}(\tau_1)$ and $Q_{y,t+1}(\tau_2)$, where $\tau_2 = 1-\tau_1$, decreases as the distance between the two quantile indices τ_1 and τ_2 increases. For example, in our sample, the correlation between $Q_{y,t+1}(0.55)$ and $Q_{y,t+1}(0.45)$ is 0.9466 with a standard deviation of 0.0084. In contrast, the correlation between $Q_{y,t+1}(0.75)$ and $Q_{y,t+1}(0.25)$ is only 0.2972 (standard deviation = 0.0979), and the correlation between $Q_{y,t+1}(0.95)$ and $Q_{y,t+1}(0.05)$ is -0.3240 (standard deviation = 0.1057). Refer to Table 2 for correlations across additional pairs of quantile indices. This trend, where correlation shifts from positive to negative, suggests that certain consumer behaviors are opposite when consumption is relatively low compared to when it is relatively high.

The contrasting behaviors become more apparent when we project $Q_{y,t+1}(\tau)$ onto macroeconomic factors representing the state of the economy. Let F_{t+1} represent the factors and $\lambda_\tau' F_{t+1}$ denote the projection, where λ_τ represents a vector of factor loadings. Figure 1 presents the curves for $\lambda_{0.95}' F_{t+1}$ and $\lambda_{0.05}' F_{t+1}$, with the dashed lines indicating NBER recessions. Two salient patterns emerge. First, the two curves tend to move in opposite directions over time. Specifically, when the curve of $\lambda_{0.95}' F_{t+1}$ rises, the curve of $\lambda_{0.05}' F_{t+1}$ generally falls, and vice versa. The estimated correlation between $\lambda_{0.95}' F_{t+1}$ and $\lambda_{0.05}' F_{t+1}$ is -0.9330, indicating a

strong inverse relationship. Therefore, households' consumption behaviors in response to changes in macroeconomic conditions are opposite when their consumption growth is low compared to when it is high. Second, $\lambda'_{0.95}F_{t+1}$ is procyclic while $\lambda'_{0.05}F_{t+1}$ is countercyclic. Surprisingly, the low quantiles of consumption growth increase in reaction to recessions but decrease in reaction to booms.

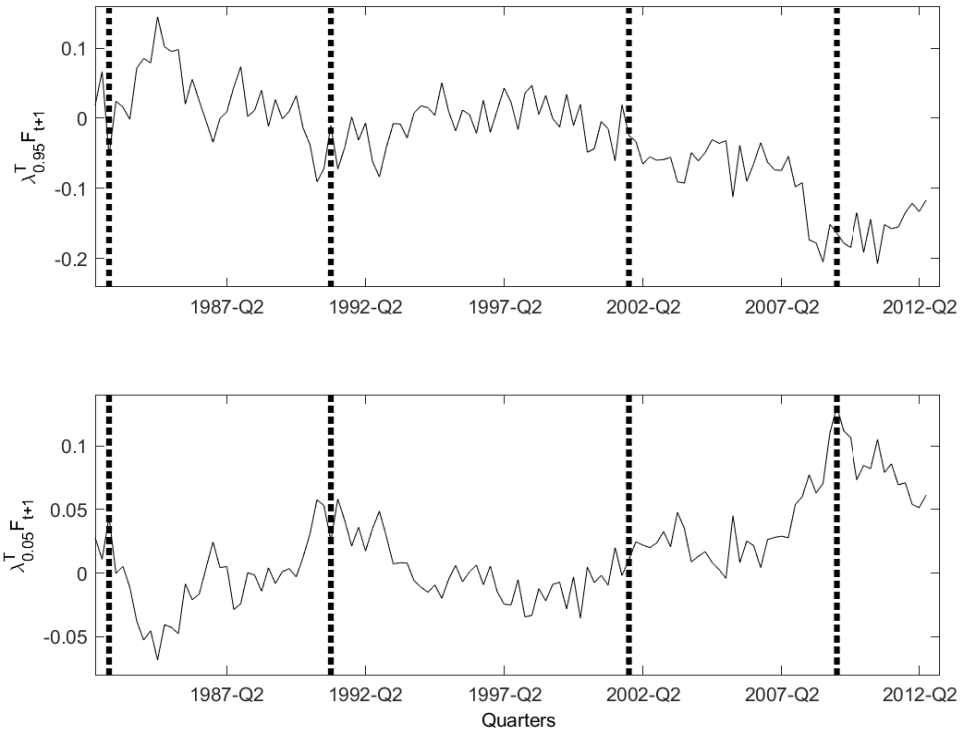


Figure 1.— The curves of $\lambda'_{0.05}F_{t+1}$ and $\lambda'_{0.95}F_{t+1}$ represent the projections of $Q_{y,t+1}(0.05)$ and $Q_{y,t+1}(0.95)$, respectively. The consumption measure used is households' total consumption expenditures. The correlation between the two projection series, $\lambda'_{0.05}F_{t+1}$ and $\lambda'_{0.95}F_{t+1}$, is -0.9330. Roughly speaking, when the curve of $\lambda'_{0.05}F_{t+1}$ goes up, the curve of $\lambda'_{0.95}F_{t+1}$ goes down, and vice versa. The dashed lines indicate NBER recessions.

The findings in Figure 1 challenge traditional economic theories. First, traditional theories are unable to account for the cross-quantile consumption-behavior heterogeneity. This heterogeneity is entirely different from cross-household heterogeneity, and the latter cannot, even if helpful, fully address the former. In the fol-

lowing, our empirical analysis shows that cross-quantile heterogeneity also exists in various subgroups of households. Consequently, we believe the cross-quantile heterogeneity may apply to most individual households. Second, the consumption behaviors at low consumption growth contradict the predictions of traditional theories.

To explain the opposing behaviors, we model the process of households' consumption planning. Unlike standard theories that assess consumption in absolute terms, we posit that households formulate for their short-term future a rational consumption target that serves as a reference point for evaluating their consumption under uncertainty. Apart from deriving utility from consumption, they derive utility from the difference between their established target and an exogenously determined desired target. When the difference is positive, we refer to it as a target gain; otherwise, we call it a target loss. We assume households demonstrate a diminishing sensitivity to the target gain/loss. Specifically, the utility function of the consumption target is concave when the target exceeds the desired target and convex when it falls below the desired target. Hence, this function exhibits an S-shaped curve.

The adoption of an S-shaped curve draws inspiration from the goal literature, with seminal works such as Hull (1932 and 1934), Locke (1968), and Locke and Latham (1990), which suggest that goals can significantly enhance efforts and performance. Building on this foundation, Heath et al. (1999) suggest that goals can function as reference points and that the empirical findings in the goal literature align with Kahneman and Tversky's (1979) S-shaped value function. In contrast to Kahneman and Tversky (1979), we use the S-shaped value function to model the choice of consumption targets under certainty while employing concave value functions to evaluate contingent consumption under uncertainty.

Our model is testable and predicts that lower and higher consumption growth rates react oppositely to observed macroeconomic fluctuations but similarly to unan-

ticipated changes in macroeconomic conditions. Let $c_{i,t}$ denote the consumption and $T_{i,t}$ the consumption target (reference point for the period t+1) of the i-th household. Note that the consumption growth can be decomposed into

$$\ln(c_{i,t+1}/c_{i,t}) = \ln(T_{i,t}/c_{i,t}) + \ln(c_{i,t+1}/T_{i,t}). \tag{1}$$

Our analysis indicates that the S-shaped value function for consumption targets can lead to opposing movements of upper and lower quantiles of $\ln(T_{i,t}/c_{i,t})$ in response to observed changes in economic conditions of periods up to t. Conversely, the concave value function for contingent consumption results in similar movements of upper and lower quantiles of $\ln(c_{i,t+1}/T_{i,t})$ in reaction to unanticipated (by households in the period t) economic changes of the period t+1. Therefore, to identify the cross-quantile opposing behaviors of $\ln(T_{i,t}/c_{i,t})$, it is necessary to control for the cross-quantile similar behaviors of $\ln(c_{i,t+1}/T_{i,t})$, and vice versa.

We devise a quantile regression model incorporating observed and unobserved macroeconomic factors to identify two distinct behaviors latent in the data on consumption growth rates. The dependent variable in the model is the consumption growth, $\ln(c_{i,t+1}/c_{i,t})$. The primary explanatory variables consist of the principal components of hundreds of macroeconomic variables representing the state of the economy in period t. These principal components can capture the behaviors of $\ln(T_{i,t}/c_{i,t})$ in association with observed macroeconomic changes. We control for the behaviors of $\ln(c_{i,t+1}/T_{i,t})$ in association with unanticipated macroeconomic changes by including the forecasting errors of the principal components in period t+1 and the unobserved common macroeconomic factors into the quantile regression model. The model can transform into an asymptotically equivalent mean regression model, allowing us to handle the unobserved factors. The estimation results are consistent with the predictions of our theoretical model.

Our model for the consumption planning process and our empirical findings have significant implications for understanding consumption-based asset pricing. Economists widely acknowledge that consumption-based asset pricing models (C-CAPM) often perform unsatisfactorily in empirical studies, and the fundamental issue in C-CAPMs lies in the low correlation between consumption growth and asset returns (see, e.g., Cochrane and Hansen 1992; Campbell and Cochrane 1999; Mehra and Prescott 2003; Campbell 2003; Albuquerque et al. 2016). Our analysis indicates that the low correlation arises from the opposing movements of consumption targets, which may be the fundamental cause of consumption-based asset pricing puzzles. Furthermore, our model is promising to solve the puzzles. First, in our model, the critical element for asset pricing is not absolute consumption but relative consumption, i.e., the difference between consumption and the consumption target. Our empirical findings suggest that this relative consumption may be more sensitive to asset returns than consumption growth is. Second, our model can extend to incorporate many existing mechanisms proposed to solve asset pricing puzzles, such as loss aversion (e.g., Benartzi and Thaler 1995; Barberis et al. 2001), ambiguity aversion (e.g., Ju and Miao 2012), and rare disasters (e.g., Rietz 1988; Barro 2006), because the consumption utility function in our asset pricing equations is concave rather than S-shaped.

Lastly, this paper contributes to the literature on reference dependence by showing how households choose or adjust their consumption reference points. The successful application of the prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1992) hinges closely on an accurate specification of the reference point. Researchers have explored various types of reference points, encompassing decision makers' current positions (e.g., Kahneman and Tversky 1979; Samuelson and Zeckhauser 1988), aspirations (e.g., Payne et al. 1980; Diecidue and Van De Ven 2008), social comparisons (e.g., Linde and Sonnemans 2012; Roels and Su

2014; Lou et al. 2021), and expectations (e.g., Bell 1985; Loomes and Sugden 1986; Gul 1991; Shalev 2000; Kőszegi and Rabin 2006, 2007, 2009; Abeler et al. 2011). Diverging from this literature, we introduce households' consumption planning processes to model the endogenously determined reference points. In this process, households refine their reference point from an initial desired consumption target to a rational target. Our empirical evidence regarding the opposing movement of consumption reference points offers new insights into the application of reference-dependent preferences. Of course, how households formulate their desired targets warrants further investigation in future research.

2. The Economic Model

This section introduces a model that simulates the process of consumption planning wherein households set short-run consumption targets or reference points and engage in a tradeoff between short-term and long-term futures. The model focuses on the short-term consumption behaviors.

2.1. Model Setup

Assume that households take the following process to plan consumption for their short-term future. They start with an initial desired consumption target, which may not be rational and is often influenced by individual aspirations, environmental factors, and economic prospects, among other factors. They refine their consumption target to achieve an optimal one by considering budget constraints and utility maximization. Concurrently, they formulate their contingent plans for the short-term future, using the established target as the reference point for utility evaluation. The core element in the planning process is the consumption target.

We designate t as the current period, t+1 as the short-term future, and $t+2, t+3, \ldots$ as the periods in the long-term future. Let $D_{i,t}$ represent the initial desired consumption target of household i in period t for the short-term period t+1. For simplicity, we assume that the time-series process $D_{i,t}$ is exogenously determined. Let $T_{i,t}$ denote the endogenously determined consumption target by the household in period t for the period $t+1$.

The desired consumption target, $D_{i,t}$, influences the choice of the optimal target, $T_{i,t}$. We introduce reference-dependent preference to model the decision of $T_{i,t}$. Let us denote

$$v(T_{i,t} - D_{i,t}) \tag{2}$$

as household i's utility derived from the target gains/losses $T_{i,t} - D_{i,t}$. In evaluating the chosen target $T_{i,t}$, the desired target, $D_{i,t}$, acts as a goal or reference point. We assume that households exhibit diminishing sensitivity to target differences, implying that $v(d)$ is concave when $d > 0$ and convex when $d < 0$. Consequently, the function v is S-shaped.

The specification in (2) follows from the goal-gradient hypothesis proposed by Hull (1932 and 1934). According to this hypothesis, animals and humans expend more effort as they approach their goals. Heath et al. (1999) propose that Kahneman and Tversky's (1979) S-shaped value function is well-suited to model this behavior. In the context of (2), the S-shaped curve implies that the marginal utility of $T_{i,t}$ increases as $T_{i,t}$ rises towards $D_{i,t}$.

Let $c_{i,t+1}$ denote the household's contingent consumption in period t+1 and

$$E_{i,t}\left[u(c_{i,t+1} - T_{i,t})\right] \tag{3}$$

be the expected utility, where $E_{i,t}$ is the expectation operator based on the house-

hold's information in period t and u is a concave utility function of the consumption gain/loss, $c_{i,t+1} - T_{i,t}$. Here, $T_{i,t}$ is the reference point for assessing the consumption under uncertainty. The concavity of u implies that households are risk-averse towards consumption risks.

The specification in (3) follows the literature on reference-dependent preferences, which suggests that individuals evaluate payoffs or consumption relative to a reference point. See, for example, Kahneman and Tversky (1979), Tversky and Kahneman (1992), and Kőszegi and Rabin (2006, 2007, 2009). In contrast to the literature, we apply a concave rather than an S-shaped value function to evaluate contingent consumption under uncertainty.

Assume that households do the short-term consumption planning on a period-by-period basis. In period t, household i chooses consumption $c_{i,t}$ for the current period, sets the short-term rational consumption target $T_{i,t}$, and makes the contingent consumption plans for period t+1. But, it makes no consumption plans for periods beyond t+1. Instead, the household accumulates wealth $w_{i,t+1}$ to finance the consumption expenditures in the long-term future. Household i's objective function in period t is

$$u(c_{i,t} - T_{i,t-1}) + v(T_{i,t} - D_{i,t}) + \beta E_{i,t}\left[u(c_{i,t+1} - T_{i,t}) + \phi(w_{i,t+1})\right] \tag{4}$$

where β is the subjective time discount factor, $T_{i,t-1}$ is the consumption target formulated in period t-1 for period t, and ϕ is a concave function of wealth. The households make a tradeoff among their current consumption, consumption target, short-term future consumption, and accumulated wealth for the long-term future.

The assumption of short-sighted planning can result in dynamic inconsistency, wherein households' consumption deviates from their plans. Our model acknowledges this issue. The first term, $u(c_{i,t} - T_{i,t-1})$ in (4) enables households to adapt

their consumption, $c_{i,t}$, to a new level that is different from their contingent consumption planned in the previous period.

Households can invest in two financial securities: risk-free government bonds and risky stocks. Denote their return rates from period t-1 to t as R^f_{t-1} and R_t respectively. Let $b_{i,t}$ and $a_{i,t}$ represent the investment amounts of household i in bonds and stocks, respectively. Its budget constraints in period t and t+1 are

$$c_{i,t} + a_{i,t} + b_{i,t} = a_{i,t-1}R_t + b_{i,t-1}R^f_{t-1} + Y_{i,t}, \tag{5}$$

$$c_{i,t+1} + w_{i,t+1} = a_{i,t}R_{t+1} + b_{i,t}R^f_t + Y_{i,t+1}, \tag{6}$$

respectively, where $Y_{i,t}$ denotes household i's other incomes, such as earnings from labor during period t.

2.2. Necessary Conditions

We begin by examining decision-making in period t+1. The Lagrange objective function is

$$\mathcal{L}_1 = u(c_{i,t+1} - T_{i,t}) + \phi(w_{i,t+1}) + \lambda_{i,t+1}\left(a_{i,t}R_{t+1} + b_{i,t}R^f_t + Y_{i,t+1} - c_{i,t+1} - w_{i,t+1}\right), \tag{7}$$

where $\lambda_{i,t+1}$ is the Lagrange multiplier. Taking the first-order derivative with respect to $c_{i,t+1}$ and $w_{i,t+1}$ yields

$$u'(c_{i,t+1} - T_{i,t}) - \lambda_{i,t+1} = 0,$$

and

$$\phi'(w_{i,t+1}) - \lambda_{i,t+1} = 0,$$

respectively. Combining these two equations, we obtain

$$u'(c_{i,t+1} - T_{i,t}) = \phi'(w_{i,t+1}), \tag{8}$$

which indicates that given the consumption target $T_{i,t}$ and for each uncertain state, household *i* equalizes the marginal utility of short-term consumption (gain/loss) and the marginal value of wealth for the long-term future.

Now, let's consider the decision-making in period t. The Lagrangian is

$$\begin{aligned}\mathcal{L} &= u(c_{i,t} - T_{i,t-1}) + v(T_{i,t} - D_{i,t}) + \lambda_{i,t}\left[a_{i,t-1}R_t + b_{i,t-1}R_{t-1}^f + Y_{i,t} - c_{i,t} - a_{i,t} - b_{i,t}\right] \\ &+ \beta E_{i,t}\left[u(c_{i,t+1} - T_{i,t}) + \phi(w_{i,t+1}) + \lambda_{i,t+1}\left(a_{i,t}R_{t+1} + b_{i,t}R_t^f + Y_{i,t+1} - c_{i,t+1} - w_{i,t+1}\right)\right],\end{aligned}$$

where λ_{it} is a Lagrangian multiplier for the period-t budget constraint. The first order derivative with respect to $T_{i,t}$ leads to the optimality condition for the consumption target

$$v'(T_{i,t} - D_{i,t}) = \beta E_{i,t}\left[u'(c_{i,t+1} - T_{i,t})\right]. \tag{9}$$

Combining Equations (8) and (9) yields

$$v'(T_{i,t} - D_{i,t}) = \beta E_{i,t}\phi'(w_{i,t+1}). \tag{10}$$

Equations (9) and (10) indicate that a household establishes a rational consumption target by a delicate tradeoff between target gain/loss, $T_{i,t} - D_{i,t}$ and the consumption gains/losses, $c_{i,t+1} - T_{i,t}$, for short-term future (or wealth, $w_{i,t+1}$, saved for the long-term future).

The S-shaped value function for the target gains/losses may lead to opposing movements of consumption targets among households. Consider a scenario where the economy in period t switches from a good state to a bad one. If a household's

good-state target $T_{i,t}$ lies within the convex segment of the function v and the household adheres to this target and the associated contingent consumption plans even when the state becomes bad, the wealth $w_{i,t+1}$ decreases, leading to an increase in its marginal value. Thus, $v'(T_{i,t} - D_{i,t}) < \beta E_{i,t}\phi'(w_{i,t+1})$ and it is necessary to readjust the consumption target to achieve the optimum for the new state. As the marginal value of v is increasing in $T_{i,t}$ when $T_{i,t} < D_{i,t}$, the household opts to increase its consumption target for the new state. The economic interpretation of this action is that the household prefers to achieve more of its desired target sooner because postponing it would be costly. Similarly, we infer that the convex segment of the function v could (not necessarily) result in a decrease in the consumption target $T_{i,t}$ when the economic state in period t switches from bad to good.[1] These counterintuitive predictions are consistent with the goal-gradient hypothesis. Conversely, should a household's target $T_{i,t}$ before the change in the economic state in period t lie within the concave segment of the function v, the anticipated changes in the target align with our intuitive expectations. In such a scenario, the consumption target for period t+1 decreases if the economic conditions deteriorate during period t, and is more likely to increase with improvements in the economic state.

The concavity in the functions of u and ϕ suggests that the consumption gain/loss $c_{i,t+1} - T_{i,t}$ of all households moves in the same direction in response to changes in the economy states of period t+1. Specifically, according to Equation (8), as the economic conditions in period t+1 improve, both $c_{i,t+1} - T_{i,t}$ and $w_{i,t+1}$ rise, and conversely, they decline when the economic states deteriorate. Unlike consumption targets, their movement directions in response to state changes are independent of their status quo.

Furthermore, from the optimality conditions for $c_{i,t}$, $a_{i,t}$, and $b_{i,t}$, we obtain the

[1] If the economic state undergoes a dramatic shift, the consumption target in this scenario may increase to a level above the desired target.

asset pricing equations for stocks and bonds:

$$E_{i,t}\left[\beta\frac{u'(c_{i,t+1}-T_{i,t})}{u'(c_{i,t}-T_{i,t-1})}R_{t+1}\right]=1, \tag{11}$$

and

$$E_{i,t}\left[\beta\frac{u'(c_{i,t+1}-T_{i,t})}{u'(c_{i,t}-T_{i,t-1})}R_t^f\right]=1. \tag{12}$$

In contrast to the conventional C-CAPMs in existing literature, both the consumption and its target in our model play a pivotal role in asset pricing. The opposite adjustments in consumption targets across households will introduce novel insights into consumption-based risk analysis. Section 6 discusses the implications of our model for resolving consumption-based asset pricing puzzles. In the following, we first provide empirical evidence for our economic model.

3. An Empirical Model

3.1. Identification

The core prediction of our economic model is that the consumption targets above the desired target and those below may exhibit opposite responses to the changes in the state of the economy. Nevertheless, a researcher generally lacks access to information regarding both the desired and rational consumption targets. Consequently, testing or identifying this prediction becomes inherently challenging.

A more meaningful and testable prediction is that the ratio $T_{i,t}/c_{i,t}$ may exhibit divergent behaviors at its upper and lower quantiles. For the moment, we assume that $T_{i,t}$ is known to an econometrician while considering $D_{i,t}$ as an unknown variable. When $T_{i,t}/c_{i,t}$ is at the lower quantile of its distribution, it is highly likely that $T_{i,t}$ is small and $T_{i,t}$ is below $D_{i,t}$. When the state of the economy in period t changes

from a good state to a bad state, the above analysis has indicated that the household may increase its consumption target $T_{i,t}$. Simultaneously, $c_{i,t}$ decreases. To see the latter, we combine Equations (9) and (12) to obtain

$$v'(T_{i,t} - D_{i,t})R_t^f = u'(c_{i,t} - T_{i,t-1}). \tag{13}$$

Equation (13) implies that when v is convex and u is concave, a marginal increase of $T_{i,t}$ leads to a fall in $c_{i,t}$, increasing the ratio $T_{i,t}/c_{i,t}$. When $T_{i,t}/c_{i,t}$ is at the upper quantile of its distribution, the movement direction of $T_{i,t}/c_{i,t}$ in responses to the changes in economy states is theoretically unclear. In this case, the consumption target $T_{i,t}$ is more likely in the concave section of the function v, and the transition from a good to a bad economy state may decrease both the target $T_{i,t}$ and the consumption $c_{i,t}$ (see Equation (13)). Thus, the change of the ratio $T_{i,t}/c_{i,t}$ is undetermined, and its movement direction is an empirical issue. However, if the target $T_{i,t}$ is more sensitive to the fluctuations of the economy state than the consumption $c_{i,t}$, the upper quantiles of $T_{i,t}/c_{i,t}$ in this case will move down.

Conducting a quantile analysis of the observed consumption growth can identify the opposing movements of $T_{i,t}/c_{i,t}$ without knowing the desired targets if such movements indeed exist. For illustration, we assume that $\ln(T_{i,t}/c_{i,t})$ and $\ln(c_{i,t+1}/T_{i,t})$ follow a joint normal distribution:

$$\begin{pmatrix} \ln(T_{i,t}/c_{i,t}) \\ \ln(c_{i,t+1}/T_{i,t}) \end{pmatrix} \sim N\left[\begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix} \right].$$

Here, μ_1, μ_2, σ_1, σ_2, and ρ denote the unconditional means, standard deviations, and their correlation, respectively. Then, conditioning on the observed $\ln(c_{i,t+1}/c_{i,t})$,

$\ln(T_{i,t}/c_{i,t})$ follows a normal distribution with the mean

$$E\left[\ln\frac{T_{i,t}}{c_{i,t}}\middle|\ln\frac{c_{i,t+1}}{c_{i,t}}\right]=\mu_1+\frac{\sigma_1^2+\rho\sigma_1\sigma_2}{\sigma_1^2+2\rho\sigma_1\sigma_2+\sigma_2^2}\left[\ln\frac{c_{i,t+1}}{c_{i,t}}-\mu_1-\mu_2\right]. \tag{14}$$

When $\rho > -\sigma_1/\sigma_2$, the slope coefficient in Equation (14) is positive, thus the conditional mean is monotonically increasing in $\ln(c_{i,t+1}/c_{i,t})$. Under this condition, high (resp. low) quantiles of $\ln(c_{i,t+1}/c_{i,t})$ are associated more with high (resp. low) quantiles of $\ln(T_{i,t}/c_{i,t})$ than with the low (resp. high) quantiles of $\ln(T_{i,t}/c_{i,t})$. Conversely, when $\rho < -\sigma_1/\sigma_2$, the association reverses. Therefore, as long as $\rho \neq -\sigma_1/\sigma_2$, we may observe that the extreme upper quantiles of consumption growth, $c_{i,t+1}/c_{i,t}$, move in a direction opposite to that of the extreme lower quantiles in response to the fluctuations in the state of the economy in period t.

Moreover, to identify the cross-quantile behaviors of $T_{i,t}/c_{i,t}$ accurately, it is imperative to control for the behaviors of $c_{i,t+1}/T_{i,t}$. Our theoretical model predicts that the upper and lower quantiles of $c_{i,t+1}/T_{i,t}$ move in the same direction in reaction to a change in the economic state. Neglecting to control for its behaviors may hinder us from finding the behavioral discrepancy of $T_{i,t}/c_{i,t}$ at its upper and lower quantiles. Likewise, controlling for the behaviors of $T_{i,t}/c_{i,t}$ is necessary when identifying the similar behaviors of $c_{i,t+1}/T_{i,t}$ across its quantiles.

3.2. Econometric Model Specification

Consider a quantile regression represented by the following equation:

$$\begin{aligned} y_{i,t+1} &= \delta_\tau+\lambda_\tau^{'}F_t+\alpha_\tau^{\prime}H_{t+1}+\gamma_\tau^{'}U_{t+1}+\varepsilon_{i,t+1}^{\tau} \\ &\quad \tau\in(0,1),\quad t=1,...,T-1,\quad i\in S_t=\{1,\ldots,N_t\}. \end{aligned} \tag{15}$$

Here, $y_{i,t+1} = \ln(c_{i,t+1}/c_{i,t})$ denotes the logarithm of the i^{th} individual's growth rate of consumption (or consumption expenditures) from t to t+1; F_t is a vector of constructed macro factors representing the state of the economy in period t; H_{t+1} is the forecasting errors of F_{t+1}, offering a partial control for the unforeseen information in period t about the state of the economy in period t+1. U_{t+1} is a vector of unobserved remaining common factors; S_t indicates the set of surveyed individuals in period t; N_t is the sample size for period t; and the conditional τ^{th} quantile of $\varepsilon^{\tau}_{i,t+1}$, given F_t, H_{t+1}, and U_{t+1}, is zero.

As $y_{i,t+1}$ can be decomposed into $\ln(T_{i,t}/c_{i,t})$ and $\ln(c_{i,t+1}/T_{i,t})$, Equation (15) models these two components separately. The model uses the variations of F_t to examine the behaviors of $\ln(T_{i,t}/c_{i,t})$ in response to observed macroeconomic changes. In practice, we specify F_t using the principal components of hundreds of macroeconomic time series. In our empirical analysis, we use the dataset contributed by McCracken and Ng (2020). Its first several principal factors contain substantial information about the state of the US economy. The factor loading λ_τ can capture the cross-quantile heterogeneity in households' choices of $T_{i,t}/c_{i,t}$. H_{t+1} and U_{t+1} in Equation (15) represent all the common macro factors that are relevant to $c_{i,t+1}/c_{i,t}$ and orthogonal to F_t. Here, we assume that U_{t+1} is orthogonal to F_t and H_{t+1}. We employ H_{t+1} and U_{t+1} to model the behaviors of $\ln(c_{i,t+1}/T_{i,t})$ in response to unforeseen economics changes. While U_{t+1} can perform this role without H_{t+1}, the inclusion of H_{t+1} helps enhance the precision of estimating λ_τ. In addition, incorporating U_{t+1} into the model (15) is essential because H_{t+1} possesses only limited unforeseen macroeconomic information.

3.3. Model Estimation

The primary challenge in estimating the model in Equation (15) stems from the unobservability of U_{t+1}. When U_{t+1} is observable, the check-function approach (see Koenker and Bassett 1978) identifies the model in Equation (15) using the condition that the conditional τ-th quantile of $\varepsilon^{\tau}_{i,t+1}$ given F_t, H_{t+1}, and U_{t+1} is zero. However, when U_{t+1} is unobservable, the estimation based on the check-function approach without U_{t+1} may be biased, notwithstanding our assumption that the variables in U_{t+1} are orthogonal to F_t and H_{t+1}. This is because the conditional τ-th quantile of $\varepsilon^{\tau}_{i,t+1}$, given F_t and H_{t+1}, is typically not equal to the the conditional τ-th quantile of $\varepsilon^{\tau}_{i,t+1}$, given F_t, H_{t+1}, and U_{t+1}, even when U_{t+1} is orthogonal to the included explanatory variables.

We have confirmed the biases through simulations. The findings indicate that detecting cross-quantile heterogeneity in responses to observed macroeconomic changes becomes more challenging when omitted factors exert uniform effects across various quantiles of the dependent variable. For additional information, please refer to Web Appendix A.

To tackle the challenge of unobserved factors in the quantile regression, we propose a novel estimation approach that relies on two identification restrictions: the conditional quantile condition applied to the residuals at the individual level and the conditional moment condition applied to the unobserved factors. By integrating these two conditions, our method provides a more comprehensive and accurate estimation of the quantile regression parameters.

Following Chen, Ju, and Li (2023), we transform the quantile regression model in Equation (15) into a mean regression model. This transformation is possible because all the regressors are macro variables. This unique characteristic allows us to conduct a quantile analysis period by period. Let $Q_{y,t}(\tau)$ be the unconditional τ^{th}

quantile of the population y_{it} in period t. For a fixed value of t, denote $\hat{Q}_{y,t}(\tau)$ the unconditional τ-th sample quantile of $\{y_{i,t}\}_{i=1}^{N_t}$ and compute it by the formula

$$\hat{Q}_{y,t}(\tau) = \hat{G}_{y,t}^{-1}(\tau),$$

where $\hat{G}_{y,t}(v) = N_t^{-1} \sum_{i=1}^{N_t} \mathbf{1}(y_{i,t} \leq v)$ is the empirical cumulative distribution function of $\{y_{i,t}\}_{i=1}^{N_t}$. Similarly, we compute the unconditional sample τ-th quantile of $\{\varepsilon_{\tau,it}\}_{i=1}^{N_t}$ and denote it $\hat{Q}_{\varepsilon,t}(\tau)$. Then from Equation (15), we obtain

$$\hat{Q}_{y,t+1}(\tau) \;=\; \delta_\tau + \lambda_\tau^{'} F_t + \alpha_\tau' H_{t+1} + \gamma_\tau^{'} U_{t+1} + \hat{Q}_{\varepsilon,t+1}(\tau), \quad \tau \in (0,1), \quad t = 1,...,T-1. \tag{16}$$

The model in Equation (16) is a time series regression because all the variables depend only on t, not i. $\hat{Q}_{\varepsilon,t+1}(\tau)$ converges to $Q_{\varepsilon,t+1}(\tau)$ at a rate of $N_{t+1}^{-1/2}$, where $Q_{\varepsilon,t+1}(\tau)$ is the unconditional τ^{th} quantile of the population $\varepsilon_{i,t+1}^{\tau}$ in period $t+1$. From the identification restriction (i.e., the conditional quantile condition) imposed on the individual-level residuals $\varepsilon_{i,t+1}^{\tau}$, we have $Q_{\varepsilon,t+1}(\tau) = 0$. Hence, $\hat{Q}_{\varepsilon,t+1}(\tau)$ converges to zero at a rate of $N_{t+1}^{-1/2}$. In our application, the sample size N_t is sufficiently large for all periods. Thus, $\hat{Q}_{\varepsilon,t+1}(\tau)$ is a negligible term in Equation (16).

The model in Equation (16) can be written as

$$\hat{Q}_{y,t+1}(\tau) \;=\; \Delta_\tau + \lambda_\tau^{'} F_t + \alpha_\tau' H_{t+1} + V_{t+1}^{\tau}, \quad \tau \in (0,1), \quad t = 1,...,T-1, \tag{17}$$

where V_{t+1}^{τ} is the demeaned value of $\gamma_\tau^{'} U_{t+1} + \hat{Q}_{\varepsilon,t+1}(\tau)$. As $\hat{Q}_{\varepsilon,t+1}(\tau)$ is negligible and U_{t+1} is assumed to be orthogonal to F_t and H_{t+1}, we can estimate the model in Equation (17) using the simple least-squares method. In Web Appendix A, simulations show that the least-squares method performs remarkably well. It corrects

for the biases produced by the standard check-function approach. The success of this simple method can be attributed to its proper utilization of the two identification conditions. In contrast, the check-function approach ignores the conditional moment condition and misapplies the conditional quantile restriction, leading to inferior results.

The mean-regression model in Equation (17) is robust against model misspecification. If the factor loadings in (15) are individual-specific, i.e., dependent on i, the model in (17) is generally not asymptotically equivalent to (15). In this case, we interpret the parameters in (17) as the projection coefficients of $\hat{Q}_{y,t+1}(\tau)$ onto F_t and H_{t+1}. Despite this discrepancy, these parameters remain valuable for characterizing how macroeconomic factors influence the τ-th quantile of consumption growth of all households.

3.4. Demonstration of Model Predictions

Let us denote

$$\mathbb{F}_t^\tau = \lambda_\tau' F_t \tag{18}$$

and

$$\mathbb{R}_t^\tau = \alpha_\tau' H_{t+1} + \gamma_\tau' U_{t+1} \tag{19}$$

the components of the τ^{th} quantile of consumption growth, $Q_{y,t+1}(\tau)$, explained by F_t and the remaining common macro factors, respectively. $\mathbb{F}^\tau = \{\mathbb{F}_t^\tau;\, t = 1,\ldots,T-1\}$ and $\mathbb{R}^\tau = \{\mathbb{R}_t^\tau;\, t = 1,\ldots,T-1\}$ form two time series. For any two quantile indexes τ_1 and τ_2, we compute the correlation between $\mathbb{F}_t^{\tau_1}$ and $\mathbb{F}_t^{\tau_2}$, denoted as $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$ and the correlation between $\mathbb{R}^{\tau_1}$ and $\mathbb{R}^{\tau_2}$, denoted as $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$.

Based on the correlation, $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$, we define a term called big bang/crunch.

Definition 1. (Big bang/crunch) For two quantile indices, τ_1 (< 0.5) and τ_2 (> 0.5),

if the correlation $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$ is negative, we say that the aggregate effects of the macro factors in the vector F_t on consumption growth, $c_{i,t+1}/c_{i,t}$, exhibit a big bang/crunch between τ_1 and τ_2.

The big bang/crunch refers to a situation where the time series $\mathbb{F}_t^{\tau_1}$ at a lower quantile τ_1 (< 0.5) and $\mathbb{F}_t^{\tau_2}$ at an upper quantile τ_2 (> 0.5) tend to move in opposite directions. It means that when $\mathbb{F}_t^{\tau_1}$ decreases, $\mathbb{F}_t^{\tau_2}$ is more likely to increase, resulting in a big bang as the mass of the consumption-growth distribution moving towards two ends. Conversely, when $\mathbb{F}_t^{\tau_1}$ increases, $\mathbb{F}_t^{\tau_2}$ is more likely to decrease, leading to a big crunch as the mass at the two ends of the consumption-growth distribution moves towards the median.

Similarly, we can extend the big bang/crunch concept to the remaining macro factors such as H_{t+1} and U_{t+1}. However, if F_t fully or largely encapsulates the information used in period t to plan consumption in period t+1, we do not anticipate witnessing the big bang/crunch associated with these factors. This is because these factors influence $c_{i,t+1}/T_{i,t}$ rather than $T_{i,t}/c_{i,t}$. In such instances, our theory predicts that $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$ should exhibit a positive sign for all τ_1 and τ_2. If F_t captures limited information about the state of the economy regarding $T_{i,t}/c_{i,t}$, $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$ can be small or negative for some τ_1 and τ_2.

Moreover, we underscore that the big bang/crunch may not always be discernible through our aggregate-level quantile analysis. The S-shaped utility function for the consumption targets implies that households may have two possible directions to adjust their consumption targets in response to changes in economic states. For instance, to diminish the marginal utility of the targets, a household with a status-quo target lower than its desired target might opt to reduce its target when the current economic state improves. Nevertheless, in the event of a drastic state change, the household may substantially increase its consumption target. In such

instances, the phenomenon of the big bang/crunch may be hard to identify.

4. Data and Consumption Characteristics

We utilize the CEX data published by the US Bureau of Labor Statistics (BLS) to compute micro-consumption growth rates. The CEX provides a broad measure of household consumption expenditures, comprising hundreds of expense items that represent roughly 95% of total household expenditure. The survey was first launched in 1980:Q1 and has since accumulated data for hundreds of quarters.

The CEX employs a rotating methodology wherein each household participates in the survey for five consecutive quarters. The first quarter serves as a training phase, and data is only collected from the second through fifth quarters. To ensure a representative sample, a stratification criterion designated by the U.S. Census is used to randomly select new households each quarter, replacing 20% of the sample that completed its final interview in the previous quarter. Therefore, the CEX is an overlapping short-panel study. The survey comprises approximately 5,000 U.S. households each quarter, representing the civilian noninstitutional population.

We follow Sabelhaus and Harris's procedure[2] to classify the various items of consumption expenditure, which are denoted by "UCC codes," into 52 distinct categories. As UCC codes are subject to changes in the CEX over time, we extend Sabelhaus and Harris's UCC codes under each category to reflect the changes after 2003. We aggregate monthly expenditures by categories and adjust them to real terms using the Consumer Price Indexes (CPI)-All Urban Consumers, which are provided by the BLS. Finally, we aggregate the real expenditures for each category into quarterly data.

We have defined two types of consumption measures based on these expendi-

[2]Refer to the link https://www.nber.org/research/data/consumer-expenditure-survey-extracts.

ture categories. Our primary measure involves quarterly spending on nondurable goods and services, a measure widely used in economic analysis. For the detailed categories of this measure, we refer readers to Aguiar and Hurst (2013, pp. 446–447). Our second measure encompasses total consumption expenditures, including spending on nondurable goods and services, education, health, durable goods, and more. Growth rates for each consumption measure are calculated based on consumption over two consecutive quarters.

The final samples are subject to several standard selection criteria. If any detailed expenditure at the UCC level is top-coded, we drop the record. Additionally, following Attanasio and Weber (1995), Vissing-Jøgensen (2002), and Brav, Constantinides, and Geczy (2002), we eliminate the consumption data for the years 1980 and 1981 from our samples due to questionable quality. We also exclude outliers by removing the top 1% and bottom 1% of consumption growth rates in each quarter subsample. Ultimately, the final data set comprises 121 quarters, with the sample period spanning from 1982:Q2 to 2012:Q3 (excluding 1985:Q4).[3] On average, there are around 2,500 observations in a single quarter.

Tables 1 and 2 report the correlation between $\hat{Q}_{y,t}(\tau_1)$ and $\hat{Q}_{y,t}(\tau_2)$ for the consumption measure of nondurable goods and services and the measure of total expenditures, respectively. Here, $\hat{Q}_{y,t}(\tau)$ is the unconditional τ-th quantile of the growth rate of consumption from period t-1 to t, and $\tau_1 = 0.05, 0.10, \ldots, 0.45$ and $\tau_2 = 0.95, 0.90, \ldots, 0.55$. For all low quantile indexes τ_1 and all top quantile indexes τ_2, the correlations displayed in Table 1 are positive-valued and statistically significant. Moreover, when we increase the distance between τ_1 and τ_2 by fixing one of them and changing the other, the reported correlation between $\hat{Q}_{y,t}(\tau_1)$ and $\hat{Q}_{y,t}(\tau_2)$

[3]The data from 1982:Q1 is of questionable quality and has therefore been excluded from the samples. Additionally, the BLS changed its household identification numbering system in 1986, rendering households in 1985:Q4 and 1986:Q1 unmatchable.

decreases. This pattern is evident in both tables. Interestingly, from Table 2, we find significantly negative correlations when τ_1 is 0.05 or 0.1 and τ_2 is greater or equal to 0.80. The patterns in Tables 1 and 2 suggest that some underlying mechanisms are at work.

Table 1

Estimation of $corr[\hat{Q}_{y,t}(\tau_1), \hat{Q}_{y,t}(\tau_2))]$ for Nondurable Goods and Services

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
τ_1 =0.05	0.2049 (0.1044)	0.2632 (0.1079)	0.3079 (0.1065)	0.3399 (0.1019)	0.3689 (0.1010)	0.3889 (0.0991)	0.4326 (0.0956)	0.4621 (0.0903)	0.5103 (0.0831)
τ_1 =0.10	0.2638 (0.1028)	0.3245 (0.1074)	0.3714 (0.1038)	0.4081 (0.1009)	0.4392 (0.1008)	0.4720 (0.0971)	0.5104 (0.0921)	0.5390 (0.0861)	0.5905 (0.0780)
τ_1 =0.15	0.3360 (0.0940)	0.4024 (0.0996)	0.4549 (0.0958)	0.4927 (0.0921)	0.5247 (0.0924)	0.5591 (0.0887)	0.5969 (0.0832)	0.6323 (0.0767)	0.6793 (0.0680)
τ_1 =0.20	0.3880 (0.0820)	0.4699 (0.0860)	0.5254 (0.0809)	0.5632 (0.0780)	0.5959 (0.0770)	0.6295 (0.0733)	0.6675 (0.0670)	0.7032 (0.0604)	0.7511 (0.0519)
τ_1 =0.25	0.4659 (0.0669)	0.5576 (0.0703)	0.6112 (0.0656)	0.6476 (0.0621)	0.6779 (0.0603)	0.7086 (0.0566)	0.7457 (0.0505)	0.7820 (0.0437)	0.8225 (0.0368)
τ_1 =0.30	0.5217 (0.0563)	0.6149 (0.0589)	0.6667 (0.0538)	0.7024 (0.0504)	0.7305 (0.0486)	0.7584 (0.0457)	0.7893 (0.0401)	0.8240 (0.0344)	0.8607 (0.0280)
τ_1 =0.35	0.5788 (0.0494)	0.6683 (0.0496)	0.7224 (0.0433)	0.7559 (0.0396)	0.7831 (0.0377)	0.8078 (0.0353)	0.8368 (0.0301)	0.8709 (0.0249)	0.9022 (0.0191)
τ_1 =0.40	0.6496 (0.0366)	0.7382 (0.0334)	0.7921 (0.0283)	0.8228 (0.0250)	0.8482 (0.0235)	0.8711 (0.0218)	0.8947 (0.0180)	0.9234 (0.0143)	0.9479 (0.0099)
τ_1 =0.45	0.6955 (0.0321)	0.7812 (0.0257)	0.8356 (0.0201)	0.8642 (0.0172)	0.8849 (0.0155)	0.9069 (0.0138)	0.9273 (0.0108)	0.9523 (0.0079)	0.9705 (0.0049)

Notes. $\hat{Q}_{y,t}(\tau)$ represents the unconditional τ-th quantile of the distribution of consumption growth between periods t-1 and t. The consumption measure used to compute individual-level growth, $y_{i,t}$, is the quarterly expenditure of a household on nondurable goods and services. We designate τ_1 ($\tau_1 < 0.5$) and τ_2 ($\tau_2 > 0.5$) as the low and high quantiles indices, respectively. The standard errors of the estimates are indicated in parentheses.

We utilize the dataset and codes contributed by McCracken and Ng (2020) to derive common macro factors. The dataset comprises 248 quarterly series, which we initially render stationary through logarithmic transformation, differencing, or a combination of both methods. After removing outliers, we identify common factors using an approach based on principal component analysis. We determine the optimal number of common factors by applying the information criteria formulated by Bai and Ng (2002), resulting in seven such factors.

Table 2
Estimation of corr$[\hat{Q}_{y,t}(\tau_1), \hat{Q}_{y,t}(\tau_2))]$ for Total Expenditures

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
τ_1 =0.05	-0.3240 (0.1057)	-0.3436 (0.1006)	-0.3265 (0.1003)	-0.2946 (0.1003)	-0.2699 (0.0991)	-0.2505 (0.1012)	-0.2232 (0.0977)	-0.1851 (0.0935)	-0.1154 (0.0903)
τ_1 =0.10	-0.2549 (0.1150)	-0.2816 (0.1094)	-0.2552 (0.1098)	-0.2128 (0.1090)	-0.1821 (0.1099)	-0.1553 (0.1110)	-0.1012 (0.1073)	-0.0465 (0.1034)	0.0441 (0.1002)
τ_1 =0.15	-0.1417 (0.1192)	-0.1568 (0.1146)	-0.1164 (0.1160)	-0.0637 (0.1146)	-0.0246 (0.1146)	0.0076 (0.1141)	0.0755 (0.1095)	0.1411 (0.1049)	0.2355 (0.0989)
τ_1 =0.20	-0.0435 (0.1110)	-0.0422 (0.1095)	0.0034 (0.1108)	0.0638 (0.1098)	0.1164 (0.1105)	0.1509 (0.1097)	0.2236 (0.1044)	0.2879 (0.0987)	0.3808 (0.0911)
τ_1 =0.25	0.1065 (0.1000)	0.1276 (0.0990)	0.1803 (0.1001)	0.2425 (0.0980)	0.2972 (0.0979)	0.3349 (0.0954)	0.4084 (0.0891)	0.4691 (0.0823)	0.5533 (0.0732)
τ_1 =0.30	0.2337 (0.0823)	0.2812 (0.0830)	0.3374 (0.0833)	0.4014 (0.0802)	0.4554 (0.0795)	0.4933 (0.0768)	0.5627 (0.0701)	0.6174 (0.0630)	0.6920 (0.0541)
τ_1 =0.35	0.3704 (0.0624)	0.4363 (0.0624)	0.4930 (0.0610)	0.5552 (0.0571)	0.6086 (0.0553)	0.6455 (0.0531)	0.7063 (0.0462)	0.7537 (0.0398)	0.8139 (0.0321)
τ_1 =0.40	0.4636 (0.0465)	0.5499 (0.0455)	0.6021 (0.0435)	0.6594 (0.0398)	0.7109 (0.0374)	0.7483 (0.0350)	0.8020 (0.0290)	0.8425 (0.0240)	0.8907 (0.0177)
τ_1 =0.45	0.5619 (0.0367)	0.6577 (0.0333)	0.7058 (0.0303)	0.7603 (0.0266)	0.8053 (0.0239)	0.8366 (0.0225)	0.8802 (0.0173)	0.9107 (0.0129)	0.9466 (0.0084)

Notes. $\hat{Q}_{y,t}(\tau)$ represents the unconditional τ-th quantile of the distribution of consumption growth between periods t-1 and t. The consumption measure used to compute individual-level growth is the quarterly total expenditure of a household. We designate τ_1 ($\tau_1 < 0.5$) and τ_2 ($\tau_2 > 0.5$) as the low and high quantiles indices, respectively. The standard errors of the estimates are indicated in parentheses.

5. Estimation and Results

5.1. Estimation Procedure and Statistical Inference

First, for each quantile index $\tau = 0.05j$ ($j = 1, \ldots, 19$), we compute the unconditional τ^{th} quantile, $\hat{Q}_{y,t+1}(\tau)$, of the consumption growth rates period by period and form the sample

$$\mathbb{S} = \{\{\hat{Q}_{y,t+1}(0.05j), j = 1, \ldots, 19\}, F_t, H_{t+1}\}, \quad t = 1, \ldots, T-1.$$

Here, F_t encompasses the first seven principal components of McCracken and Ng's (2020) 248 macroeconomic time series, and H_{t+1} denotes the vectors of projection residuals of F_{t+1} onto F_t and the first four components of both F_{t-1} and F_{t-2}.

Second, we estimate the models in (17) using the sample $\mathbb{S}$ and the least-squares method. Denote by $(\hat{\lambda}_\tau, \hat{\alpha}_\tau)$ the resulting estimators of $(\lambda_\tau, \alpha_\tau)$. We estimate $\mathbb{F}_t^\tau$ in

Equation (18) and $\mathbb{R}^{\tau}_{t+1}$ in Equation (19) using $\hat{\lambda}'_{\tau}F_t$ and $\hat{\alpha}'_{\tau}H_{t+1}+\hat{\gamma}'_{\tau}U_{t+1}$, respectively. Subsequently, we estimate the correlations $corr(\mathbb{F}^{\tau_1}_t,\mathbb{F}^{\tau_2}_t)$ and $corr(\mathbb{R}^{\tau_1}_t,\mathbb{R}^{\tau_2}_t)$ for all combinations of (τ_1,τ_2) where $\tau_1 = 0.05,0.10,\ldots,0.45$ represents lower quantil indexes and $\tau_2 = 0.95,0.90,\ldots,0.55$ represents the upper ones.

To statistically infer the estimated correlations, we utilize the circular block method introduced by Politis and Romano (1992). It entails applying bootstrapped distributions of the estimators, which we compute through 2000 replications. Our focus is on the signs of the correlations. As a result, we calculate the p-value for a one-tailed test. Throughout the paper, the estimation and statistical inference rely on the assumption that the estimated F_t and H_{t+1} are observable. The use of estimated factors is a common practice in empirical applications. For instance, Ludvigson and Ng (2007, 2009) and Jurado, Ludvigson, and Ng (2015) have used estimated factors to study the risk-return relation, bond risk premia, and macroeconomic uncertainty, respectively.

5.2. Estimation Results

Table 3 reports the correlations, $corr(\mathbb{F}^{\tau_1}_t,\mathbb{F}^{\tau_1}_t)$, between the aggregate effect of common macro factors, $\mathbb{F}^{\tau_1}_t$, at a lower quantile ($\tau_1 = 0.05,0.10,\ldots,0.45$) and the aggregate effect, $\mathbb{F}^{\tau_2}_t$, at an upper quantile ($\tau_2 = 0.95,0.90,\ldots,0.55$). The standard errors of estimates and p-values of the sign significance tests are indicated in parentheses and square brackets, respectively.

Table 3
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for the Measure of Nondurable Goods and Services

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.6044	-0.5968	-0.5945	-0.5647	-0.5755	-0.5579	-0.5284	-0.5021	-0.4680
τ_1 =0.05	(0.2502)	(0.2579)	(0.2553)	(0.2587)	(0.2603)	(0.2659)	(0.2733)	(0.2798)	(0.2957)
	[0.0000]	[0.0000]	[0.0000]	[0.0005]	[0.0000]	[0.0020]	[0.0045]	[0.0195]	[0.0450]
	-0.5885	-0.5793	-0.5761	-0.5335	-0.5446	-0.5141	-0.4836	-0.4551	-0.4186
τ_1 =0.10	(0.2912)	(0.2982)	(0.2957)	(0.3014)	(0.3026)	(0.3092)	(0.3149)	(0.3196)	(0.3307)
	[0.0000]	[0.0020]	[0.0020]	[0.0105]	[0.0095]	[0.0270]	[0.0485]	[0.0695]	[0.1090]
	-0.4820	-0.4676	-0.4717	-0.4194	-0.4232	-0.3826	-0.3519	-0.3131	-0.2547
τ_1 =0.15	(0.3293)	(0.3350)	(0.3336)	(0.3402)	(0.3410)	(0.3477)	(0.3505)	(0.3525)	(0.3581)
	[0.0570]	[0.0765]	[0.0730]	[0.1125]	[0.1120]	[0.1475]	[0.1715]	[0.2020]	[0.2475]
	-0.3400	-0.3072	-0.3097	-0.2551	-0.2458	-0.2025	-0.1756	-0.1413	-0.0542
τ_1 =0.20	(0.3368)	(0.3401)	(0.3377)	(0.3439)	(0.3429)	(0.3491)	(0.3493)	(0.3498)	(0.3507)
	[0.1775]	[0.2030]	[0.1985]	[0.2425]	[0.2495]	[0.2895]	[0.3155]	[0.3420]	[0.4115]
	0.0219	0.0545	0.0461	0.1015	0.1135	0.1570	0.1834	0.2207	0.3076
τ_1 =0.25	(0.3180)	(0.3169)	(0.3132)	(0.3143)	(0.3112)	(0.3136)	(0.3106)	(0.3062)	(0.2989)
	[0.4915]	[0.4665]	[0.4725]	[0.4145]	[0.3980]	[0.3490]	[0.3175]	[0.2560]	[0.1405]
	0.3593	0.3883	0.3806	0.4286	0.4415	0.4760	0.4968	0.5323	0.6094
τ_1 =0.30	(0.2707)	(0.2642)	(0.2595)	(0.2561)	(0.2504)	(0.2502)	(0.2449)	(0.2359)	(0.2210)
	[0.0735]	[0.0445]	[0.0440]	[0.0175]	[0.0070]	[0.0010]	[0.0000]	[0.0000]	[0.0000]
	0.5926	0.6214	0.6164	0.6603	0.6711	0.7023	0.7179	0.7469	0.8071
τ_1 =0.35	(0.2179)	(0.2048)	(0.1984)	(0.1900)	(0.1826)	(0.1793)	(0.1716)	(0.1580)	(0.1373)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8342	0.8562	0.8498	0.8778	0.8874	0.9075	0.9150	0.9304	0.9635
τ_1 =0.40	(0.1331)	(0.1158)	(0.1108)	(0.0999)	(0.0916)	(0.0851)	(0.0768)	(0.0636)	(0.0438)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8965	0.9120	0.9088	0.9323	0.9364	0.9505	0.9581	0.9697	0.9857
τ_1 =0.45	(0.0967)	(0.0810)	(0.0757)	(0.0643)	(0.0577)	(0.0525)	(0.0439)	(0.0331)	(0.0200)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of the whole population that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

We observe the big bang/crunch. In the top-left region of Table 3 where τ_1 and τ_2 are widely apart, many of the estimated correlations are negative and statistically significant. For example, the estimate of $corr(\mathbb{F}_t^{0.05}, \mathbb{F}_t^{0.95})$ is -0.6044, with a standard error of 0.2502. The p-value for the one-sided test of the negative sign is less than 0.0001. Figure 2 portrays the big bang/crunch between $\tau_1 = 0.05$ and $\tau_2 = 0.95$. The top and bottom panels of the figure showcase the curves for $\hat{\lambda}_{0.95}^{'} F_t$ and $\hat{\lambda}_{0.05}^{'} F_t$, respectively. The pattern is evident: when the curve for $\hat{\lambda}_{0.05}^{'} F_t$ ascends, the curve for $\hat{\lambda}_{0.95}^{'} F_t$ roughly descends, and vice versa.

The observed big bang/crunch links closely to business cycles. In Figure 2, the

dashed lines indicate NBER recessions. Over the span from one severe recession to the next, the economy typically undergoes a sequence of a big crunch, a big bang, and another big crunch. This pattern is less evident for the 2001 recession. It could be due to the fact that this recession is the mildest one in the postwar period, as documented by Nordhaus (2002).

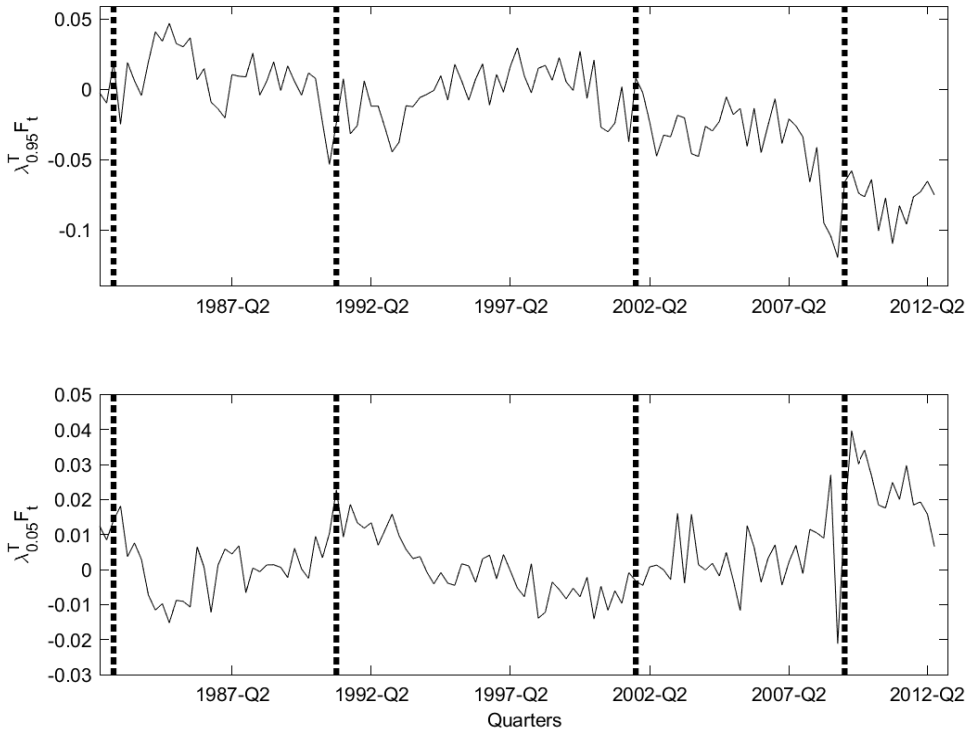


Figure 2.— The curves of $\hat{\lambda}'_{0.05}F_t$ and $\hat{\lambda}'_{0.95}F_t$ computed using the consumption measure of nondurable goods and services. This figure shows the big bang/crunch between quantile indexes $\tau_1 = 0.05$ and $\tau_2 = 0.95$. Here, $\hat{\lambda}'_{\tau}F_t$ denotes the estimated aggregate effects explained by common macro factors F_t for the τ^{th} quantile consumption growth rates. The sample used is the whole population. The correlation between the two series, $\hat{\lambda}'_{0.05}F_t$ and $\hat{\lambda}'_{0.95}F_t$, is -0.6044. Roughly speaking, when the curve of $\hat{\lambda}'_{0.05}F_t$ goes up, the curve of $\hat{\lambda}'_{0.95}F_t$ goes down, and vice versa. The dashed lines indicate NBER recessions.

Table 4
Estimation of corr($\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2}$) for the Measure of Nondurable Goods and Services

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	0.4759	0.5435	0.5899	0.6058	0.6420	0.6457	0.6620	0.6659	0.6917
τ_1 =0.05	(0.0665)	(0.0624)	(0.0659)	(0.0640)	(0.0574)	(0.0572)	(0.0560)	(0.0552)	(0.0525)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.5292	0.5970	0.6432	0.6630	0.7007	0.7181	0.7275	0.7301	0.7596
τ_1 =0.10	(0.0644)	(0.0569)	(0.0578)	(0.0558)	(0.0507)	(0.0483)	(0.0485)	(0.0494)	(0.0447)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.5710	0.6446	0.6997	0.7209	0.7572	0.7763	0.7865	0.7975	0.8213
τ_1 =0.15	(0.0614)	(0.0533)	(0.0500)	(0.0454)	(0.0417)	(0.0378)	(0.0380)	(0.0391)	(0.0343)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.5776	0.6698	0.7301	0.7532	0.7886	0.8080	0.8217	0.8357	0.8615
τ_1 =0.20	(0.0627)	(0.0537)	(0.0484)	(0.0422)	(0.0376)	(0.0336)	(0.0315)	(0.0314)	(0.0259)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.6150	0.7212	0.7802	0.8036	0.8357	0.8533	0.8684	0.8849	0.9052
τ_1 =0.25	(0.0565)	(0.0473)	(0.0412)	(0.0350)	(0.0294)	(0.0262)	(0.0228)	(0.0213)	(0.0176)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.6421	0.7507	0.8081	0.8320	0.8612	0.8771	0.8875	0.9045	0.9225
τ_1 =0.30	(0.0517)	(0.0419)	(0.0353)	(0.0286)	(0.0229)	(0.0213)	(0.0191)	(0.0172)	(0.0141)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.6632	0.7679	0.8297	0.8518	0.8807	0.8942	0.9062	0.9260	0.9418
τ_1 =0.35	(0.0507)	(0.0388)	(0.0304)	(0.0243)	(0.0183)	(0.0169)	(0.0148)	(0.0126)	(0.0103)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.6781	0.7854	0.8504	0.8736	0.9012	0.9163	0.9279	0.9474	0.9618
τ_1 =0.40	(0.0501)	(0.0366)	(0.0284)	(0.0228)	(0.0173)	(0.0155)	(0.0125)	(0.0102)	(0.0082)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.6982	0.8058	0.8733	0.8958	0.9193	0.9360	0.9461	0.9646	0.9761
τ_1 =0.45	(0.0476)	(0.0325)	(0.0230)	(0.0188)	(0.0137)	(0.0112)	(0.0086)	(0.0061)	(0.0046)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{R}_t^{\tau}$, (i.e., $\alpha_\tau' H_{t+1} + \gamma_\tau' U_{t+1}$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of the whole population that can be attributed to macroeconomic factors other than F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table 4 presents the estimated correlations, $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$, between the aggregate effect of the macro factors other than F_t at a lower quantile, τ_1, and that at an upper quantile, τ_2. For all combinations of $\tau_1 = 0.05, 0.10, \ldots, 0.45$ and $\tau_2 = 0.95, 0.90, \ldots, 0.55$, the estimated $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$ is positive and statistically significant. All the p-values for the one-sided test of their signs are less than 0.0001. Furthermore, for all τ_1 and τ_2, the estimated $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$ in Table 4 is greater than the corresponding estimate of $corr[\hat{Q}_{y,t}(\tau_1), \hat{Q}_{y,t}(\tau_2))]$ in Table 1. For example, the correlation between the unconditional 0.05 quantile of consumption growth and its 0.95 counterpart is merely 0.2049. By removing the subcomponents driven by the

principal components, F_t, the correlation $corr(\mathbb{R}_t^{0.05}, \mathbb{R}_t^{0.95})$ becomes 0.4795.

Table 5
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) using Total Consumption Expenditures

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.9101	-0.8639	-0.8485	-0.8245	-0.8280	-0.8291	-0.8218	-0.8172	-0.7811
τ_1 =0.05	(0.1172)	(0.1278)	(0.1329)	(0.1348)	(0.1356)	(0.1401)	(0.1459)	(0.1496)	(0.1680)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.9192	-0.9086	-0.9038	-0.8804	-0.8828	-0.8832	-0.8699	-0.8554	-0.8100
τ_1 =0.10	(0.1032)	(0.1019)	(0.1046)	(0.1090)	(0.1120)	(0.1169)	(0.1269)	(0.1379)	(0.1632)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.8945	-0.9033	-0.9021	-0.8785	-0.8801	-0.8803	-0.8633	-0.8444	-0.7966
τ_1 =0.15	(0.1248)	(0.1205)	(0.1228)	(0.1304)	(0.1351)	(0.1396)	(0.1520)	(0.1670)	(0.1936)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.8421	-0.8531	-0.8541	-0.8239	-0.8221	-0.8232	-0.7999	-0.7741	-0.7181
τ_1 =0.20	(0.1598)	(0.1555)	(0.1574)	(0.1664)	(0.1721)	(0.1760)	(0.1893)	(0.2047)	(0.2295)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.7532	-0.7617	-0.7640	-0.7283	-0.7245	-0.7266	-0.6949	-0.6619	-0.5986
τ_1 =0.25	(0.2067)	(0.2048)	(0.2073)	(0.2162)	(0.2220)	(0.2258)	(0.2388)	(0.2536)	(0.2742)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0010]
	-0.6046	-0.6111	-0.6127	-0.5688	-0.5655	-0.5679	-0.5318	-0.4946	-0.4215
τ_1 =0.30	(0.2607)	(0.2613)	(0.2638)	(0.2696)	(0.2738)	(0.2767)	(0.2846)	(0.2943)	(0.3077)
	[0.0000]	[0.0000]	[0.0000]	[0.0015]	[0.0020]	[0.0025]	[0.0145]	[0.0370]	[0.0870]
	-0.1475	-0.1597	-0.1672	-0.1156	-0.1093	-0.1110	-0.0692	-0.0245	0.0559
τ_1 =0.35	(0.3080)	(0.3104)	(0.3112)	(0.3098)	(0.3100)	(0.3107)	(0.3094)	(0.3099)	(0.3076)
	[0.3160]	[0.3145]	[0.3040]	[0.3500]	[0.3545]	[0.3525]	[0.3885]	[0.4260]	[0.4840]
	0.4217	0.4206	0.4108	0.4589	0.4683	0.4661	0.5013	0.5413	0.6082
τ_1 =0.40	(0.2568)	(0.2605)	(0.2591)	(0.2503)	(0.2449)	(0.2425)	(0.2323)	(0.2231)	(0.2046)
	[0.0210]	[0.0240]	[0.0250]	[0.0065]	[0.0035]	[0.0015]	[0.0000]	[0.0000]	[0.0000]
	0.7758	0.7850	0.7784	0.8120	0.8181	0.8164	0.8361	0.8599	0.9003
τ_1 =0.45	(0.1605)	(0.1583)	(0.1546)	(0.1406)	(0.1327)	(0.1283)	(0.1139)	(0.1001)	(0.0752)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household total expenditure) of the whole population that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table 6
Estimation of corr($\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2}$) using Total Consumption Expenditures

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	0.0879	0.0278	0.0443	0.0450	0.0629	0.0664	0.0549	0.0632	0.1025
τ_1 =0.05	(0.0792)	(0.0824)	(0.0813)	(0.0830)	(0.0839)	(0.0871)	(0.0870)	(0.0861)	(0.0852)
	[0.1340]	[0.3730]	[0.2970]	[0.2970]	[0.2325]	[0.2200]	[0.2610]	[0.2275]	[0.1120]
	0.2499	0.2075	0.2439	0.2497	0.2699	0.2782	0.2880	0.3030	0.3562
τ_1 =0.10	(0.0865)	(0.0877)	(0.0817)	(0.0805)	(0.0807)	(0.0827)	(0.0849)	(0.0854)	(0.0845)
	[0.0005]	[0.0080]	[0.0000]	[0.0005]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.3792	0.3763	0.4361	0.4521	0.4800	0.4915	0.5119	0.5341	0.5850
τ_1 =0.15	(0.0830)	(0.0822)	(0.0715)	(0.0685)	(0.0601)	(0.0604)	(0.0614)	(0.0611)	(0.0558)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.4058	0.4297	0.4956	0.5228	0.5681	0.5838	0.6101	0.6307	0.6800
τ_1 =0.20	(0.0763)	(0.0767)	(0.0654)	(0.0633)	(0.0521)	(0.0528)	(0.0527)	(0.0511)	(0.0451)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.4867	0.5371	0.6100	0.6392	0.6852	0.7049	0.7316	0.7490	0.7900
τ_1 =0.25	(0.0705)	(0.0698)	(0.0566)	(0.0554)	(0.0438)	(0.0415)	(0.0400)	(0.0374)	(0.0314)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.5254	0.6095	0.6844	0.7183	0.7633	0.7839	0.8097	0.8248	0.8600
τ_1 =0.30	(0.0623)	(0.0598)	(0.0477)	(0.0446)	(0.0339)	(0.0313)	(0.0295)	(0.0274)	(0.0217)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.5540	0.6611	0.7373	0.7744	0.8204	0.8430	0.8665	0.8807	0.9091
τ_1 =0.35	(0.0597)	(0.0537)	(0.0412)	(0.0375)	(0.0275)	(0.0245)	(0.0210)	(0.0190)	(0.0140)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.5640	0.6956	0.7664	0.8029	0.8495	0.8771	0.9006	0.9148	0.9390
τ_1 =0.40	(0.0579)	(0.0497)	(0.0378)	(0.0340)	(0.0245)	(0.0203)	(0.0170)	(0.0142)	(0.0097)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.6009	0.7445	0.8108	0.8500	0.8919	0.9153	0.9356	0.9461	0.9656
τ_1 =0.45	(0.0543)	(0.0422)	(0.0308)	(0.0266)	(0.0180)	(0.0149)	(0.0117)	(0.0090)	(0.0053)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{R}_t^{\tau}$, (i.e., $\alpha_{\tau}^{'} H_{t+1} + \gamma_{\tau}^{'} U_{t+1}$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household total expenditure) of the whole population that can be attributed to macroeconomic factors other than F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Tables 5 and 6 provide estimates of $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$ and $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$, respectively, for total consumption expenditures. Table 5 reveals an even more pronounced big bang/crunch phenomenon than observed in Table 3 for the measure of nondurable goods and services. When τ_1 ranges from 0.05 to 0.3 and τ_2 from 0.60 to 0.95, the correlation $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$ is consistently negative and statistically significant. Remarkably, these correlations exhibit substantial magnitudes. For instance, the correlation $corr(\mathbb{F}_t^{0.05}, \mathbb{F}_t^{0.95})$ is -0.9101, with a standard deviation of merely 0.1172. Figure 3 illustrates the curves of $\hat{\lambda}_{0.05}^{'} F_t$ and $\hat{\lambda}_{0.95}^{'} F_t$. Compared to Figure 2, Figure 3 displays an even more evident pattern. In this figure, the bottom

(resp. top) curve for $\hat{\lambda}'_{0.05}F_t$ (resp. $\hat{\lambda}'_{0.95}F_t$) is at a relatively high (resp. low) level during three severe NBER recessions. The estimated correlations, $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$, reported in Table 6 are positive for all combinations of $\tau_1 = 0.05, 0.10, \ldots, 0.45$ and $\tau_2 = 0.95, 0.90, \ldots, 0.55$. They are greater than their corresponding counterparts, $corr[\hat{Q}_{y,t}(\tau_1), \hat{Q}_{y,t}(\tau_2))]$, as presented in Table 2.

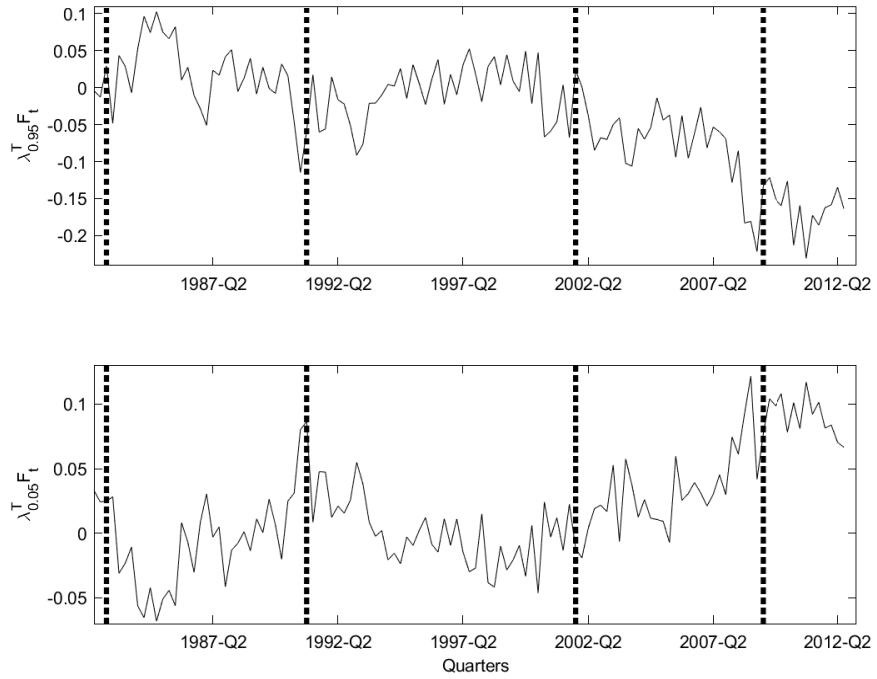


Figure 3.— The curves of $\hat{\lambda}'_{0.05}F_t$ and $\hat{\lambda}'_{0.95}F_t$ computed using the consumption measure of total expenditure. This figure shows the big bang/crunch between quantile indexes $\tau_1 = 0.05$ and $\tau_2 = 0.95$. Here, $\hat{\lambda}'_{\tau}F_t$ denotes the estimated aggregate effects explained by common macro factors F_t for the τ^{th} quantile consumption growth rates. The sample used is the whole population. The correlation between the two series, $\hat{\lambda}'_{0.05}F_t$ and $\hat{\lambda}'_{0.95}F_t$, is -0.9101. Roughly speaking, when the curve of $\hat{\lambda}'_{0.05}F_t$ goes up, the curve of $\hat{\lambda}'_{0.95}F_t$ goes down, and vie versa. The big bang/crunch is much more salient than reported for the consumption measure of nondurable goods and services. The dashed lines indicate NBER recessions.

In summary, our empirical results are consistent with the predictions of our economic model. Lower and higher consumption growth rates react oppositely to observed economic fluctuations but similarly to unanticipated economic changes.

5.3. Analysis by Groups

We examine the cross-quantile heterogeneity in consumption behaviors among different subgroups of households. We focus on three main age groups, namely young households (with household heads aged 30 or younger), prime-age households (with heads aged above 30 but not exceeding 60), and old households (with heads aged over 60). Additionally, we analyze the consumption behavior of stockholders. We define stockholders as the households that engaged in stock market investments during the survey period.

In the Web Appendix, Tables B.1, B.2, and B.3 present the estimated $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$ for young households, prime-age households, and old households, respectively. The consumption measures used are expenditures on nondurable goods and services. We observe a big bang/crunch between the upper and lower quantiles of the consumption growth from all these three groups. Tables B.5, B.6, and B.7 report the estimated $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$ for consumption measures of household overall expenditure. The observed big bang/crunch is even more salient.

For the group of stockholders, the computed $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$ using the consumption measure of non-durable goods and services, as depicted in Table B.4, does not reveal a pronounced big bang/crunch phenomenon. However, a conspicuous big bang/crunch appears in Table B.8 which displays the estimated $corr(\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2})$ based on the consumption measure of household total expenditure.

5.4. Alternative Model Specifications

We investigate the significance of the big bang/crunch using the following three alternative model specifications.

$$y_{i,t+1} = \delta_\tau + \lambda_\tau^{'} F_{t-1} + \alpha_\tau^{\prime} H_{t+1} + \gamma_\tau^{'} U_{t+1} + \varepsilon_{i,t+1}^{\tau} \tag{20}$$

$$y_{i,t+1} = \delta_\tau + \lambda_\tau^{'} F_{t-2} + \alpha_\tau' H_{t+1} + \gamma_\tau^{'} U_{t+1} + \varepsilon_{i,t+1}^{\tau} \tag{21}$$

$$y_{i,t+1} = \delta_\tau + \lambda_\tau^{'} F_{t+1} + \gamma_\tau^{'} U_{t+1} + \varepsilon_{i,t+1}^{\tau} \tag{22}$$

Models (20) and (21) deviate from Model (15) by replacing F_t with F_{t-1} and F_{t-2}, respectively. In the Web Appendix, tables C.1 and C.2 report the estimated $cov(\lambda_{\tau_1}^{'} F_{t-1}, \lambda_{\tau_2}^{'} F_{t-1})$ and $cov(\lambda_{\tau_1}^{'} F_{t-2}, \lambda_{\tau_2}^{'} F_{t-2})$, respectively, for a lower quantile τ_1 and an upper quantile τ_2. Both tables reveal a substantial big bang/crunch, indicating that the changes of economic states in multiple lagged periods also lead to opposing movements of consumption targets. Thus, F_t in Model (15) fails to capture all the information households utilize to establish their consumption targets. If we could control for all this information, the big bang/crunch produced by Model (15) may be even more salient, and the estimated positive correlation $corr(\mathbb{R}_t^{\tau_1}, \mathbb{R}_t^{\tau_2})$ could be larger.

Model (22) differs from Model (15) by substituting F_t with F_{t+1}. The factors in F_{t+1} contain information pertaining not only to the state of the economy in period t+1 but also in period t and prior periods. Consequently, $\lambda_\tau^{'} F_{t+1}$ captures the aggregate effects of F_{t+1} on $\ln(T_{i,t}/c_{i,t})$ and $\ln(c_{i,t+1}/T_{i,t})$. Table C.3 provides the estimated $cov(\lambda_{\tau_1}^{'} F_{t+1}, \lambda_{\tau_2}^{'} F_{t+1})$ between a lower quantile τ_1 and an upper quantile τ_2. The noticeable big bang/crunch in Table C.3 indicates a significant impact of F_{t+1} on $\ln(T_{i,t}/c_{i,t})$ compared to its effect on $\ln(c_{i,t+1}/T_{i,t})$.

6. Implications for Consumption-Based Asset Pricing

Our empirical findings suggest that households' actual consumption behaviors differ significantly from those assumed in traditional models. Consequently, these findings and our theoretical model could offer novel insights into various consumption-based studies, especially those concerning risk analysis. This paper concentrates

specifically on consumption-based asset pricing.

The C-CAPMs, pioneered by Merton (1971, 1973), Rubinstein (1976), Lucas (1978), and Breeden (1979), are widely regarded as pivotal in enhancing our understanding of the interplay between economic fundamentals and financial markets. However, when confronted with financial data, C-CAPMs perform poorly, leaving economists baffled by various pricing anomalies such as the equity premium puzzle (see Mehra and Prescott 1985), risk-free rate puzzle (see Weil 1989), equity volatility puzzle (see Shiller 1981; LeRoy and Porter 1981; Grossman and Shiller 1981), etc. These puzzles reveal a substantial gap in our understanding of the economy.

After nearly four decades of research, economists have reached a consensus that the primary challenge for C-CAPMs is the low correlation between consumption growth and asset returns (see, e.g., Cochrane and Hansen 1992; Campbell and Cochrane 1999; Mehra and Prescott 2003; Campbell 2003; Albuquerque et al. 2016). To illustrate this point, we discuss the equity premium puzzle, the most significant among all the consumption-based asset pricing anomalies (see, e.g., Campbell 2003). Consider an economy with representative agents whose utility function exhibits constant relative risk aversion. The conditional equity premium is expressed as

$$E_t(R_{t+1} - R_t^f) = \frac{-cov_t[(c_{t+1}/c_t)^{-\gamma}, R_{t+1}]}{E_t(c_{t+1}/c_t)^{-\gamma}}, \tag{23}$$

where γ ($\gamma > 0$) denotes the degree of relative risk aversion, c_t is the consumption of a representative agent, and R_{t+1} and R_t^f are equity return rates and risk-free return rates, respectively. Equation (23) indicates that the risk premium comes from investors' risk aversion and a positive correlation between consumption growth and the risk-return rates. However, this correlation in the real world is remarkably low, necessitating an implausibly high degree of risk aversion to justify the substantial equity premium witnessed in stock markets.

The C-CAPMs aiming to solve the equity premium puzzle often take as given the low correlation between consumption growth and asset returns and explore alternative mechanisms to account for the observed high equity premium. These mechanisms include but are not limited to, habit formation (e.g., Constantinides 1990; Campbell and Cochrane 1999), long-run risks (e.g., Bansal and Yaron 2004), rare disasters (e.g., Rietz 1988; Barro 2006), loss aversion (e.g., Benartzi and Thaler 1995; Barberis et al. 2001), ambiguity aversion (e.g., Ju and Miao 2012), and disappointment aversion (e.g., Delikouras 2017). The overarching idea is that during economic downturns, some mechanisms significantly elevate the marginal utility of consumption and/or the accompanying marginal value of certain kinds, even though aggregate consumption does not experience a substantial decline. There has been limited research that directly addresses the low correlation issue, especially from a data perspective.

Our theoretical model and empirical findings present a novel avenue for advancing the study of consumption-based asset pricing by directly examining the perplexing low correlation issue. Equations (11) and (12) of our model indicate that the choice of reference points matters for consumption-based risk analysis. As the economy in period t+1 transitions from a favorable state to an unfavorable one, the model predicts that $\ln(c_{i,t+1}/T_{i,t})$ decreases. However, the reference point $T_{i,t}$ may have increased significantly due to households' consumption targeting behaviors in response to changes in the economic state in period t. Consequently, the consumption growth, $\ln(c_{i,t+1}/c_{i,t})$, representing the sum of $\ln(T_{i,t}/c_{i,t})$ and $\ln(c_{i,t+1}/T_{i,t})$, may increase, contradicting the predictions of existing models. If the seemingly abnormal consumption movements substantially cancel out the "normal" ones, the correlation between consumption growth and asset returns can be small. Therefore, the abnormal movements of low-quantile consumption growth may be the key to understanding consumption-based asset pricing puzzles.

Modeling households' reference-dependent consumption planning behaviors holds considerable promise in solving asset pricing puzzles. First, our empirical findings indicate that the consumption targeting behaviors can elucidate the abnormal movements observed in low-quantile consumption growth. Second, controlling for the opposing movements of consumption targets among households can result in a higher equity premium because our empirical findings suggest that the relative consumption, i.e., the difference between consumption and the targets, may be more sensitive to fluctuations in stock returns. Third, future researchers can enhance our model's performance in explaining financial markets by incorporating existing mechanisms such as loss aversion (e.g., Benartzi and Thaler 1995; Barberis et al. 2001), ambiguity aversion (e.g., Ju and Miao 2012), and rare disasters (e.g., Rietz 1988; Barro 2006). This enhancement is possible because the consumption value function in our model is concave rather than S-shaped, making it compatible with these existing mechanisms.

To fully resolve asset pricing puzzles, it is imperative to distinguish the opposing movements of consumption growth found in our empirical investigation. The utilization of quantile analysis in our study has enabled the revelation of evidence substantiating these opposing movements. However, the aggregate-level estimation falls short of precisely quantifying the extent of these so-called abnormal movements. Fortunately, our evidence suggests that the proportion of abnormal movements is potentially substantial. The larger the number is, the more relevant our model is for resolving asset pricing puzzles.

7. Conclusion

This paper presents supporting evidence that households' consumption decision-making is reference-dependent. We find that the lower and upper quantiles of

households' consumption growth rates respond oppositely to observed macroeconomic changes but similarly to unanticipated ones. This finding supports our reference-dependent model, which somehow differs from prospect theory. In our model, the value function for contingent consumption is concave, while the value function for assessing the choice of a reference point is S-shaped. This model provides novel insights into consumption-based risk analysis and contributes to resolving many asset pricing puzzles.

REFERENCES

Abeler, Johannes, Armin Falk, Lorenz Goette, and David Huffman. 2011. "Reference Points and Effort Provision." *American Economic Review*, 101(2): 470-492.

Aguiar, Mark, and Erik Hurst. 2013. "Deconstructing Life Cycle Expenditure." *Journal of Political Economy*, 121(3), 437-92.

Albuquerque, Rui, Martin S. Eichenbaum, Victor Xi Luo, and Sergio Rebelo. 2016. "Valuation Risk and Asset Pricing." *Journal of Finance*, 71(6): 2861-904.

Attanasio, Orazio P., and Guglielmo Weber. 1995. "Is Consumption Growth Consistent with Intertemporal Optimization? Evidence from the Consumer Expenditure Survey." *Journal of Political Economy*, 103(6): 1121-57.

Bai, Jushan, and Serena Ng. 2002. "Determining the Number of Factors in Approximate Factor Models." *Econometrica*, 70(1): 191-221.

Bansal, Ravi, and Amir Yaron. 2004. "Risks for the Long Run: A Potential Resolution of Asset Pricing Puzzles." *Journal of Finance*, 59(4): 1481-509.

Barberis, Nicholas, Ming Huang, and Tano Santos. 2001. "Prospect Theory and Asset Prices." *Quarterly Journal of Economics*, 116(1): 1-53.

Barro, Rober J. 2006. "Rare Disasters and Asset Markets in the Twentieth Century." *Quarterly Journal of Economics*, 121(3): 823-66.

Benartzi Shiomo, and Richard H. Thaler. 1995. "Myopic Loss Aversion and the Equity Premium Puzzle." *Quarterly Journal of Economics*, 110(1): 73-92.

Brav, Alon, George M. Constantinides, and Christopher C. Geczy. 2002. "Asset Pricing with Heterogeneous Consumers and Limited Participation: Empirical Evidence." *Journal of Political Economy*, 110(4): 793-824.

Breeden, D. T. 1979. "An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities." *Journal of Financial Economics*, 7(3): 265-96.

Campbell, J. Y. 2003. "Consumption-Based Asset Pricing." In: Constantinides, G. M., Harris, M., Stulz, R. (Ed.), *Handbook of the Economics of Finance,* North Holland, Amsterdam, vol. 1, Part B, pp. 803-87.

Campbell, John. Y., and John H. Cochrane. 1999. "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior." *Journal of Political Economy*, 107(2): 205-51.

Chen, Xiaohong, Gaosheng Ju, and Qi Li. 2023. "A Simple Quantile Regression Model Linking Micro Outcomes to Macro Covariates." Unpublished working paper.

Cochrane, John H., and Hansen, Lars. P. 1992. "Asset Pricing Explorations for Macroeconomics." In: Blanchard, O., Fischer, S. (Ed.), NBER Macroeconomics Annual. MIT Press, Cambridge, Mass, vol. 7., pp. 115-165.

Constantinides, George M. 1990. "Habit Formation: a Resolution of the Equity Premium Puzzle." *Journal of Political Economy*, 98(3): 519-43.

Delikouras, S. 2017. "Where's the kink? Disappointment Events in Consumption Growth and Equilibrium Asset Prices." *Review of Financial Studies*, 30(8): 2851-89.

Diecidue, Enrico, and Jeroen Van De Ven. (2008). "Aspiration Level, Probability of Success and Failure, and Expected Utility." *International Economic Review*, 49(2): 683-700.

Grossman, Sanford J., and Robert J. Shiller. 1981. "The Determinants of the Variability of Stock Market Prices." *American Economic Review*, 71(2): 222-27.

Ju, Nengjiu, and Jianyun Miao. 2012. "Ambiguity, Learning, and Asset Returns." *Econometrica*, 80(2): 559-91.

Jurado, Kyle, Sydney C. Ludvigson, and Serena Ng. 2015. "Measuring Uncertainty." *American Economic Review*, 105(3): 1177-216.

Kahneman, Daniel, and Amos Tversky. 1979. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica*, 47(2): 263-91.

Koenker, Roger, ; Gilbert Bassett. 1978. "Regression quantiles." *Econometrica*, 46(1): 33-50.

Kőszegi, Botond, and Matthew Rabin. 2006. "A Model of Reference-Dependent Preferences." *Quarterly Journal of Economics*, 121(4): 1133-65.

Kőszegi, Botond, and Matthew Rabin. 2007. "Reference-Dependent Risk Attitudes." *American Economic Review*, 97(4): 1047-73.

Kőszegi, Botond, and Matthew Rabin. 2009. Reference-dependent consumption plans. *American Economic Review*, 99 (3), 909-936.

LeRoy, Stephen F., and Richard D. Porter. 1981. "The Present Value Relation: Tests Based on Implied Variance Bounds." *Econometrica*, 49(3), 555-74.

Linde, Jona, and Joep Sonnemans. 2012. "Social Comparison and Risky Choices." *Journal of Risk and Uncertainty*, 44: 45-72.

Locke, Edwin A. 1968. "Toward a Theory of Task Performance and Incentives." *Organizational Behavior and Human Performance*, 3: 157-189.

Locke, Edwin A., and Gary P. Latham. 1990. A theory of goal setting and task performance. Englewood Cliffs, NJ: Prentice Hall International.

Lou, Youcheng, Moris S. Strub, Duan Li, and Shouyang Wang. 2021. "The Impact of a Reference Point Determined by Social Comparison on Wealth Growth and Inequality." *Journal of Economic Dynamics and Control*, 127: 104-20.

Lucas Jr., Robert E. 1978. "Asset Prices in an Exchange Economy." *Econometrica*, 46(6): 1429-1445.

Ludvigson, Syndey C., and Serena Ng. 2007. "The Empirical Risk-Return Relation: a Factor Analysis Approach." *Journal of Financial Economics*, 83(1): 171-222.

Ludvigson, Syndey C., and Serena Ng. 2009. "Macro Factors in Bond Risk Premia." *Review of Financial Studies*, 22(12): 5027-67.

McCracken, Michael W., and Serena Ng. 2020. "FRED-QD: A Quarterly Database for Macroeconomic Research." Unpublished working paper 2020-005B. Federal Reserve Bank of St. Louis. https://doi.org/10.20955/wp.2020.005.

Mehra, Rajnish, and Edward C. Prescott. 1985. "The Equity Premium: a Puzzle." *Journal of Monetary Economics*, 15(2): 145-61.

Mehra, Rajnish, and Edward C. Prescott. 2003. "The Equity Premium in Retrospect." In: Constantinides, G. M., Harris, M., Stulz, R. (Ed.), Handbook of the Economics of Finance. North Holland, Amsterdam, pp. 889-938.

Merton, Robert C. 1971. "Optimum Consumption and Portfolio Rules in a Continuous-Time Model." *Journal of Economic Theory*, 3(4): 373-413.

Merton, Robert C. 1973. "An Intertemporal Capital Asset Pricing Model," *Econometrica*, 41(5): 867-87.

Nordhaus, William D. 2002. "The Mildest Recession: Output, Profits, and Stock Prices as the U.S. Emerges from the 2001 Recession." NBER working paper #8938.

Payne, John W., Dan J. Laughhunn, and Roy Crum. 1980. "Translation of Gambles and Aspiration Level Effects in Risky Choice Behavior." *Manage-*

ment Science, 26(10), 1039-60.

Politis, Dimitris N., and Joseph P. Romano. 1992. "A Circular Block-Resampling Procedure for Stationary Data." In: Lepage, R., Billard, L. (Ed.), Exploring the Limits of Bootstrap. John Wiley, New York, pp. 263-70.

Rietz, Thomas A. 1988. "The Equity Risk Premium: A Solution." *Journal of Monetary Economics*, 22(1): 117-31.

Roels, Guillaume, and Xuanming. (2014). "Optimal Design of Social Comparison Effects: Setting Reference Groups and Reference Points." *Management Science*, 60(3), 606-27.

Rubinstein, Mark. 1976. "The Valuation of Uncertain Income Streams and the Pricing of Options," *Bell Journal of Economics*, 7(2): 407-25.

Shiller, Robert. 1981. "Do Stock Prices Move Too Much to Be Justified by Subsequent Changes in Dividends?" *American Economic Review*, 71(3), 421-36.

Tversky, Amos, and Daniel Kahneman. 1992. "Advances in Prospect Theory: Cumulative Representation of Uncertainty." *Journal of Risk and Uncertainty*, 5: 297-323.

Vissing-Jørgensen, A. 2002. "Limited Asset Market Participation and the Elasticity of Intertemporal Substitution." *Journal of Political Economy*, 110(4): 825-53.

Weil, Philippe. 1989. "The Equity Premium Puzzle and the Risk-Free Rate Puzzle." *Journal of Monetary Economics*, 24(3): 401-21.

For Online Publication
Appendices for "Is Households' Consumption Decision-Making Reference-Dependent?

This online supplemental material consists of three parts. Appendix A demonstrates by simulations that the check-function estimation is biased when model specification omits some macro factors and that the least-squares method provides a more accurate estimate. Tables in Appendix B present the empirical results for four household subgroups. Additionally, we report the estimation results for three alternative model specifications in Appendix C.

Appendix A. Two Methods in Estimating Model (15)

In this section, we show through simulations that the least-squares estimator of Model (17) serves as a good estimator of Model (15), even when the latter omits certain (unrelated) macro factors. Additionally, we reveal that the standard check-function estimation is biased when subjected to this misspecification.

Without loss of generality, we examine a quantile regression model with two regressors. We consider a panel data setup in which the individual-level residuals can be (weakly) serially correlated.

Let θ_{it} be a random variable following the standard uniform distribution $U(0,1)$. Specify the θ_{it}^{th} quantile of y_{it} conditional on x_t and z_t as $\delta_0(\theta_{it}) + x_t\delta_1(\theta_{it}) + z_t\delta_2(\theta_{it})$, where $\delta_0(\theta_{it}) = -1 + 2\theta_{it}$, $\delta_1(\theta_{it}) = -5 + 10\theta_{it}$, $\delta_2(\theta_{it}) = 25$, $x_t = 3 + 0.25x_{t-1} + 0.5\zeta_t, \zeta_t \sim N(0,1)$, and $z_t = 3 + 0.25z_{t-1} + 0.5\xi_t, \xi_t \sim N(0,1)$. Here, ζ_t and ξ_t are two independent process. Hence, x_t and z_t are also independent. The quantile regression model is

$$y_{it} = \delta_0(\theta_{it}) + x_t\delta_1(\theta_{it}) + z_t\delta_2(\theta_{it}), \qquad \theta_{it} \sim U(0,1), \quad i = 1,\ldots,N; \;\; t = 1,\ldots,T. \tag{A.1}$$

In our specification, x_t has heterogeneous effects on different quantiles of y_{it}, whereas the effects of z_t are homogeneous across quantiles.

Model (A.1) is an equivalent representation of the quantile regression model

$$y_{it} = \delta_{0,\tau} + x_t\delta_{1,\tau} + z_t\delta_{2,\tau} + \varepsilon_{it}, \qquad \tau \in (0,1), \quad i = 1,\ldots,N; \;\; t = 1,\ldots,T. \tag{A.2}$$

Model (A.2) is similar to Model (15) in form, except for their differing numbers of explanatory variables. Here, $\delta_{0,\tau} = \delta_0(\theta_{it})$ and $\delta_{1,\tau} = \delta_1(\theta_{it})$ whenever $\theta_{it} = \tau$. In model (A.2), the residual ε_{it} is equal to zero when y_{it} is the τ^{th} conditional quantile of y_{it} given x_t and z_t. Therefore, the τ^{th} quantile of ε_{it} conditional on x_t and z_t is zero.

We allow the quantile residuals ε_{it} to be serially correlated. As

$$\varepsilon_{it} = \delta_0(\theta_{it}) + x_t\delta_1(\theta_{it}) - [\delta_{0,\tau} + x_t\delta_{1,\tau}],$$

we introduce the serial correlation by letting θ_{it} be serially correlated. Specify that θ_{i1} follows a standard uniform distribution $U(0,1)$, and for $t = 2,\ldots,T$,

$$\theta_{it} \sim \begin{cases} U(0.5,1), & \text{if } \theta_{it-1} < 0.5; \\ U(0,0.5), & \text{if } \theta_{it-1} \geq 0.5. \end{cases}$$

The procedure for generating data is straightforward. First, we randomly draw values for ζ_t, ξ_t and θ_{it} from their respective distributions. Next, we generate values for x_t and z_t based on their respective autoregressive processes. Finally, we compute the values of y_{it} by applying Equation (A.1).

Suppose that z_t is not observable and researchers are interested in estimating $\delta_{1,\tau}$. The check-function approach estimates the quantile regression model

$$y_{it} = \delta_{0,\tau} + x_t\delta_{1,\tau} + \upsilon_{it}, \qquad \tau \in (0,1), \quad i = 1,\ldots,N; \;\; t = 1,\ldots,T,$$

with an incorrect identification restriction that the conditional τ-th quantile of υ_{it} give x_t is zero. The least-square method estimates the transformed mean regression model

$$\hat{Q}_{y,t}(\tau) = \Delta_{0,\tau} + x_t\delta_{1,\tau} + V_t, \tau \in (0,1), \quad t = 1,\ldots,T, \tag{A.3}$$

where V_t is the demeaned value of $z_t\delta_{2,\tau} + \hat{Q}_{\varepsilon,t}(\tau)$, and $\hat{Q}_{y,t}(\tau)$ and $\hat{Q}_{\varepsilon,t}(\tau)$ are the period-t unconditional τ-th sample quantiles of $\hat{Q}_{y,t}(\tau)$ and $\hat{Q}_{\varepsilon,t}(\tau)$, respectively.

We consider twelve cases of sample sizes by combining $N = 300, 600, 1200, 2400$ and $T = 50, 100, 200$. For each case, we conduct $R = 250$ replications. To evaluate the performance of the estimation, we calculate their biases and mean squared

errors (MSE) using the following formulas:

$$BIAS(\hat{\delta}_{1,\tau}) = \frac{1}{R}\sum_{r=1}^{R}[\hat{\delta}_{1,\tau} - \delta_{1,\tau}], \qquad MSE(\hat{\delta}_{1,\tau}) = \frac{1}{R}\sum_{r=1}^{R}[\hat{\delta}_{1,\tau} - \delta_{,\tau}]^2.$$

Tables A.1–A.3 report the simulation results for the check-function approach. As expected, the estimation of $\delta_{1,\tau}$ exhibits a significant bias. The bias does not display a trend of reduction as N or T doubles or quadruples. In our data-generating process (DGP), there is a significant difference across quantiles. Specifically, the actual values of $\delta_{1,\tau}$ at low quantiles ($\delta < 0.5$) are negative, while those at top quanitles ($\delta > 0.5$) are positive. The omission of z_t in the check-function approach leads to an upward (downward) bias for low-quantile (resp. top-quantile) regression coefficients. Thus, for our DGP, the biases diminish the differences in the estimation of $\delta_{1,\tau}$ across different quantiles.

Tables A.4–A.6 report the simulation results for the least-squares method. The estimation biases are close to zero. The magnitudes of the biases and MSEs are much smaller than the counterparts in Tables A.1–A.3. The MSEs reduce roughly about one-half when T doubles and about one quarter when T quadruples. However, when N doubles or quadruples, the MSEs see no significant changes. Therefore, the convergence rate of the least-squares estimator is $T^{-1/2}$; when N is large relative to T, $\hat{Q}_{\varepsilon,t}(\tau)$ is negligible and hence can be neglected in the mean-regression analysis.

Table A.1
Simulation Results of the Check-Function Estimation (T=50)

		N=300		N=600		N=1200		N=2400	
$\tau =$	$\delta_{1,\tau}$	BIAS	MSE	BIAS	MSE	BIAS	MSE	BIAS	MSE
0.05	-4.5	1.3322	39.0714	1.3519	28.7350	1.2357	25.2130	0.7996	27.8070
0.10	-4.0	1.4675	29.8123	1.2868	21.0183	1.2779	21.2199	0.7993	22.9922
0.15	-3.5	1.3301	25.6693	1.1567	17.7587	1.2073	19.2479	0.7097	20.0644
0.20	-3.0	1.1723	23.0119	0.9957	16.4323	1.1032	17.8015	0.5568	18.5010
0.25	-2.5	1.0367	21.0926	0.8719	15.9886	0.9370	16.7985	0.4249	17.7523
0.30	-2.0	0.9050	19.9097	0.7346	15.6944	0.7629	16.3006	0.2914	17.2535
0.35	-1.5	0.7413	18.9851	0.5935	15.4351	0.6106	15.8940	0.1506	17.0923
0.40	-1.0	0.5883	18.4169	0.4502	15.3543	0.4357	15.5323	0.0005	16.9337
0.45	-0.5	0.4556	18.0185	0.3099	15.3556	0.2586	15.2434	-0.1517	16.9759
0.50	0.0	0.2913	17.6170	0.1653	15.5099	0.0809	15.0769	-0.3002	17.2804
0.55	0.5	0.1254	17.7396	0.0130	15.7417	-0.0545	15.0432	-0.4506	17.7369
0.60	1.0	0.0036	17.9571	-0.1470	15.9427	-0.2052	15.2044	-0.6103	18.2698
0.65	1.5	-0.1278	18.2011	-0.2989	16.4624	-0.3502	15.5751	-0.7785	18.8758
0.70	2.0	-0.2691	18.4970	-0.4317	17.1474	-0.5068	16.3530	-0.9413	19.6826
0.75	2.5	-0.4323	19.1315	-0.5644	17.9997	-0.6571	17.3490	-1.0740	20.4487
0.80	3.0	-0.5772	19.8283	-0.7025	19.3586	-0.8031	18.4351	-1.2243	21.3452
0.85	3.5	-0.7213	21.4680	-0.8239	21.4316	-0.9608	19.9428	-1.3168	22.4829
0.90	4.0	-0.8755	24.2938	-0.8641	24.4588	-1.0765	22.5773	-1.4549	25.3613
0.95	4.5	-0.9500	30.2791	-0.8447	31.8099	-1.0204	28.2981	-1.5734	31.8856

Notes: $\delta_{1,\tau}$ is the true value of the parameter of the quantile regression indexed by τ ($\tau = k \cdot 0.05, k = 1, \ldots, 19$). The bias and mean squared errors are computed based on 250 replications.

Table A.2
Simulation Results of the Check-Function Estimation (T=100)

		N=300		N=600		N=1200		N=2400	
$\tau =$	$\delta_{1,\tau}$	BIAS	MSE	BIAS	MSE	BIAS	MSE	BIAS	MSE
0.05	-4.5	1.9489	18.3004	1.1067	13.7709	0.9761	13.7929	1.3487	16.2084
0.10	-4.0	1.8147	14.2347	1.0627	10.6075	1.0136	11.7255	1.3526	12.8559
0.15	-3.5	1.5918	12.0590	0.9648	9.2744	0.9345	10.4650	1.2526	11.3089
0.20	-3.0	1.3785	10.5380	0.8469	8.3999	0.8268	9.4719	1.1048	10.1448
0.25	-2.5	1.1779	9.5206	0.7054	7.7922	0.6771	8.7933	0.9311	9.3387
0.30	-2.0	0.9937	8.9368	0.5408	7.3021	0.5097	8.3949	0.7604	8.7752
0.35	-1.5	0.8190	8.4962	0.3707	6.9970	0.3360	8.1045	0.6124	8.4486
0.40	-1.0	0.6291	8.0996	0.2062	6.8010	0.1603	7.8792	0.4703	8.2526
0.45	-0.5	0.4433	7.8575	0.0437	6.7635	-0.0169	7.8252	0.3327	8.1626
0.50	0.0	0.2638	7.6984	-0.1177	6.7723	-0.1815	7.9250	0.1885	8.1136
0.55	0.5	0.0784	7.6192	-0.2723	6.8420	-0.3352	8.0939	0.0456	8.1015
0.60	1.0	-0.0965	7.7416	-0.4176	7.0697	-0.4913	8.3826	-0.1055	8.1650
0.65	1.5	-0.2636	8.0041	-0.5662	7.3669	-0.6549	8.7506	-0.2610	8.3468
0.70	2.0	-0.4454	8.3156	-0.7201	7.7228	-0.8208	9.1256	-0.4171	8.6822
0.75	2.5	-0.6487	8.8851	-0.8916	8.2504	-0.9997	9.6378	-0.5752	9.2823
0.80	3.0	-0.8658	9.6974	-1.0794	9.0319	-1.1844	10.3713	-0.7290	10.1099
0.85	3.5	-1.0640	10.7879	-1.2666	10.1638	-1.3817	11.6206	-0.8896	11.3346
0.90	4.0	-1.2051	12.4672	-1.4365	12.0311	-1.5992	13.5159	-1.0730	13.2671
0.95	4.5	-1.3041	16.3575	-1.5737	15.8084	-1.7786	18.3306	-1.0949	17.3735

Notes: $\delta_{1,\tau}$ is the true value of the parameter of the quantile regression indexed by τ ($\tau = k \cdot 0.05, k = 1, \ldots, 19$). The bias and mean squared errors are computed based on 250 replications.

Table A.3
Simulation Results of the Check-Function Estimation (T=200)

		N=300		N=600		N=1200		N=2400	
$\tau =$	$\delta_{1,\tau}$	BIAS	MSE	BIAS	MSE	BIAS	MSE	BIAS	MSE
0.05	-4.5	0.9761	8.4269	1.2453	8.2001	1.3113	8.5218	1.3692	9.3531
0.10	-4.0	1.0119	6.5914	1.1037	6.2594	1.2373	6.6473	1.3256	7.6723
0.15	-3.5	0.9255	5.8696	0.9408	5.2867	1.1048	5.5832	1.1622	6.5021
0.20	-3.0	0.7941	5.3492	0.7849	4.6987	0.9552	4.7909	0.9829	5.6479
0.25	-2.5	0.6383	4.9422	0.6097	4.1984	0.7977	4.2310	0.7992	5.0431
0.30	-2.0	0.4884	4.6442	0.4517	3.8106	0.6244	3.7974	0.6171	4.5931
0.35	-1.5	0.3315	4.3855	0.2978	3.5363	0.4531	3.5108	0.4387	4.2551
0.40	-1.0	0.1900	4.2258	0.1451	3.3708	0.2793	3.3175	0.2716	4.0381
0.45	-0.5	0.0360	4.1363	-0.0054	3.2908	0.1166	3.2139	0.1140	3.9241
0.50	0.0	-0.1228	4.1553	-0.1606	3.2997	-0.0395	3.1735	-0.0446	3.9083
0.55	0.5	-0.2678	4.1706	-0.3067	3.3487	-0.1970	3.2074	-0.2018	3.9547
0.60	1.0	-0.4250	4.3023	-0.4625	3.4522	-0.3483	3.2998	-0.3618	4.0528
0.65	1.5	-0.5736	4.4733	-0.6182	3.6072	-0.5080	3.4507	-0.5304	4.2409
0.70	2.0	-0.7396	4.7706	-0.7809	3.8287	-0.6687	3.6758	-0.7099	4.5153
0.75	2.5	-0.8889	5.0616	-0.9403	4.1360	-0.8258	4.0269	-0.8880	4.8822
0.80	3.0	-1.0439	5.4754	-1.1129	4.6132	-0.9736	4.5314	-1.0710	5.3999
0.85	3.5	-1.1983	5.9745	-1.2908	5.2198	-1.1285	5.2390	-1.2491	6.0539
0.90	4.0	-1.2956	6.6501	-1.4156	6.1187	-1.2776	6.4716	-1.4179	7.0589
0.95	4.5	-1.3336	7.5986	-1.4410	8.1149	-1.3488	8.5943	-1.5023	8.8761

Notes: $\delta_{1,\tau}$ is the true value of the parameter of the quantile regression indexed by τ ($\tau = k \cdot 0.05, k = 1, \ldots, 19$). The bias and mean squared errors are computed based on 250 replications.

Table A.4
Simulation Results of the Least-Squares Estimation (T=50)

		N=300		N=600		N=1200		N=2400	
$\tau =$	$\delta_{1,\tau}$	BIAS	MSE	BIAS	MSE	BIAS	MSE	BIAS	MSE
0.05	-4.5	0.2601	17.7766	0.1890	14.7397	0.1220	14.1351	-0.3443	16.7513
0.10	-4.0	0.2575	17.8141	0.1984	14.7704	0.1188	14.1815	-0.3466	16.7960
0.15	-3.5	0.2668	17.9155	0.1903	14.7875	0.1106	14.1783	-0.3500	16.8231
0.20	-3.0	0.2567	17.9588	0.1800	14.6860	0.1107	14.1578	-0.3564	16.7929
0.25	-2.5	0.2488	17.9545	0.1754	14.6943	0.1141	14.1589	-0.3576	16.8086
0.30	-2.0	0.2744	17.8902	0.1769	14.7891	0.1213	14.1499	-0.3535	16.7829
0.35	-1.5	0.2662	17.8082	0.1818	14.7625	0.1250	14.1513	-0.3580	16.7765
0.40	-1.0	0.2491	17.8428	0.1863	14.7369	0.1227	14.1506	-0.3583	16.7764
0.45	-0.5	0.2576	17.9104	0.1788	14.7282	0.1206	14.1905	-0.3627	16.8054
0.50	0.0	0.2651	17.8052	0.1725	14.7936	0.1262	14.1843	-0.3577	16.8124
0.55	0.5	0.2665	17.7343	0.1636	14.7897	0.1253	14.2256	-0.3596	16.7789
0.60	1.0	0.2620	17.7414	0.1564	14.7842	0.1159	14.2041	-0.3596	16.8163
0.65	1.5	0.2684	17.6837	0.1509	14.8613	0.1105	14.1981	-0.3583	16.7892
0.70	2.0	0.2614	17.7149	0.1540	14.8775	0.1114	14.1472	-0.3574	16.7605
0.75	2.5	0.2637	17.6806	0.1676	14.8397	0.1075	14.1551	-0.3547	16.7414
0.80	3.0	0.2564	17.7194	0.1658	14.7591	0.1062	14.1948	-0.3519	16.7445
0.85	3.5	0.2498	17.6915	0.1658	14.7190	0.1025	14.1628	-0.3490	16.7300
0.90	4.0	0.2510	17.6500	0.1701	14.6654	0.1031	14.1736	-0.3473	16.7536
0.95	4.5	0.2408	17.5934	0.1740	14.6791	0.1150	14.1651	-0.3510	16.7344

Notes: $\delta_{1,\tau}$ is the true value of the parameter of the quantile regression indexed by τ ($\tau = k \cdot 0.05, k = 1, \ldots, 19$). The bias and mean squared errors are computed based on 250 replications.

Table A.5
Simulation Results of the Least-Squares Estimation (T=100)

		N=300		N=600		N=1200		N=2400	
$\tau =$	$\delta_{1,\tau}$	BIAS	MSE	BIAS	MSE	BIAS	MSE	BIAS	MSE
0.05	-4.5	0.2949	7.7670	-0.1290	6.8730	-0.2252	7.7502	0.1470	8.1383
0.10	-4.0	0.2937	7.8342	-0.1264	6.8677	-0.2223	7.7580	0.1474	8.1433
0.15	-3.5	0.2984	7.8406	-0.1207	6.8828	-0.2287	7.7523	0.1478	8.1396
0.20	-3.0	0.2826	7.8196	-0.1184	6.8813	-0.2327	7.7460	0.1475	8.1354
0.25	-2.5	0.2790	7.8202	-0.1283	6.9015	-0.2299	7.7325	0.1478	8.0945
0.30	-2.0	0.2794	7.8292	-0.1196	6.8622	-0.2328	7.7371	0.1471	8.0838
0.35	-1.5	0.2829	7.8166	-0.1194	6.8820	-0.2360	7.7629	0.1470	8.0844
0.40	-1.0	0.2796	7.8139	-0.1280	6.8851	-0.2368	7.7843	0.1450	8.1165
0.45	-0.5	0.2824	7.8718	-0.1219	6.8840	-0.2386	7.8160	0.1440	8.0985
0.50	0.0	0.2717	7.8570	-0.1177	6.9071	-0.2434	7.8265	0.1430	8.0999
0.55	0.5	0.2745	7.8379	-0.1196	6.8872	-0.2389	7.8204	0.1486	8.1078
0.60	1.0	0.2595	7.8011	-0.1225	6.8961	-0.2406	7.8332	0.1491	8.0982
0.65	1.5	0.2506	7.7557	-0.1258	6.8852	-0.2426	7.8379	0.1519	8.0929
0.70	2.0	0.2484	7.7505	-0.1328	6.8762	-0.2327	7.8287	0.1493	8.1038
0.75	2.5	0.2400	7.7476	-0.1440	6.8680	-0.2285	7.7929	0.1496	8.1045
0.80	3.0	0.2344	7.6793	-0.1439	6.8616	-0.2329	7.7882	0.1497	8.1366
0.85	3.5	0.2368	7.6832	-0.1468	6.8379	-0.2315	7.7821	0.1485	8.1353
0.90	4.0	0.2485	7.6566	-0.1507	6.8303	-0.2315	7.7601	0.1460	8.1346
0.95	4.5	0.2544	7.7217	-0.1521	6.8271	-0.2329	7.7782	0.1465	8.1455

Notes: $\delta_{1,\tau}$ is the true value of the parameter of the quantile regression indexed by τ ($\tau = k \cdot 0.05, k = 1, \ldots, 19$). The bias and mean squared errors are computed based on 250 replications.

Table A.6
Simulation Results of the Least-Squares Estimation (T=200)

		N=300		N=600		N=1200		N=2400	
$\tau =$	$\delta_{1,\tau}$	BIAS	MSE	BIAS	MSE	BIAS	MSE	BIAS	MSE
0.05	-4.5	-0.1090	3.8712	-0.1232	3.1509	-0.0184	3.1069	-0.0318	3.8362
0.10	-4.0	-0.1139	3.8951	-0.1233	3.1617	-0.0225	3.1149	-0.0295	3.8415
0.15	-3.5	-0.1235	3.9227	-0.1248	3.1925	-0.0187	3.1170	-0.0312	3.8305
0.20	-3.0	-0.1229	3.9240	-0.1260	3.1709	-0.0209	3.1227	-0.0290	3.8345
0.25	-2.5	-0.1241	3.9226	-0.1323	3.1904	-0.0175	3.1324	-0.0313	3.8322
0.30	-2.0	-0.1302	3.9223	-0.1325	3.1928	-0.0168	3.1249	-0.0341	3.8331
0.35	-1.5	-0.1299	3.9322	-0.1356	3.1893	-0.0175	3.1221	-0.0344	3.8237
0.40	-1.0	-0.1226	3.9363	-0.1324	3.1872	-0.0206	3.1132	-0.0338	3.8175
0.45	-0.5	-0.1222	3.9281	-0.1358	3.1780	-0.0223	3.1197	-0.0332	3.8222
0.50	0.0	-0.1292	3.9086	-0.1409	3.1705	-0.0245	3.1193	-0.0328	3.8226
0.55	0.5	-0.1305	3.9094	-0.1407	3.1855	-0.0263	3.1148	-0.0318	3.8229
0.60	1.0	-0.1345	3.9286	-0.1433	3.2093	-0.0245	3.1116	-0.0310	3.8271
0.65	1.5	-0.1403	3.9343	-0.1440	3.2081	-0.0228	3.1185	-0.0288	3.8242
0.70	2.0	-0.1366	3.9142	-0.1372	3.1908	-0.0222	3.1072	-0.0298	3.8239
0.75	2.5	-0.1341	3.9205	-0.1326	3.1946	-0.0182	3.1127	-0.0321	3.8209
0.80	3.0	-0.1319	3.9204	-0.1334	3.1956	-0.0184	3.0989	-0.0365	3.8326
0.85	3.5	-0.1320	3.9340	-0.1365	3.2071	-0.0163	3.1012	-0.0379	3.8262
0.90	4.0	-0.1311	3.8933	-0.1366	3.1900	-0.0194	3.1082	-0.0350	3.8231
0.95	4.5	-0.1352	3.8664	-0.1370	3.1754	-0.0209	3.1006	-0.0333	3.8302

Notes: $\delta_{1,\tau}$ is the true value of the parameter of the quantile regression indexed by τ ($\tau = k \cdot 0.05, k = 1, \ldots, 19$). The bias and mean squared errors are computed based on 250 replications.

Appendix B. Estimation Results for Subgroups

Table B.1
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for Young Households using the Measure of Nondurable Goods and Services

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.6999	-0.7432	-0.6726	-0.6029	-0.5949	-0.6470	-0.6645	-0.7013	-0.6748
τ_1 =0.05	(0.2583)	(0.2536)	(0.2619)	(0.2737)	(0.2619)	(0.2673)	(0.2686)	(0.2829)	(0.2994)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0005]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.6043	-0.6828	-0.6186	-0.5402	-0.5721	-0.6021	-0.6169	-0.6210	-0.5785
τ_1 =0.10	(0.2927)	(0.2867)	(0.2894)	(0.2986)	(0.2891)	(0.2905)	(0.2903)	(0.3099)	(0.3198)
	[0.0005]	[0.0000]	[0.0000]	[0.0180]	[0.0020]	[0.0015]	[0.0015]	[0.0040]	[0.0245]
	-0.5578	-0.6589	-0.5905	-0.5464	-0.5905	-0.6044	-0.6285	-0.6112	-0.5427
τ_1 =0.15	(0.2737)	(0.2746)	(0.2766)	(0.2856)	(0.2762)	(0.2756)	(0.2816)	(0.3012)	(0.3148)
	[0.0015]	[0.0000]	[0.0010]	[0.0070]	[0.0010]	[0.0010]	[0.0000]	[0.0035]	[0.0350]
	-0.6209	-0.7086	-0.6306	-0.6104	-0.6377	-0.6490	-0.6675	-0.6636	-0.5698
τ_1 =0.20	(0.2843)	(0.2805)	(0.2860)	(0.2867)	(0.2757)	(0.2804)	(0.2902)	(0.3078)	(0.3268)
	[0.0000]	[0.0000]	[0.0000]	[0.0010]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0265]
	-0.4756	-0.5695	-0.4951	-0.5203	-0.5504	-0.5444	-0.5803	-0.5516	-0.4432
τ_1 =0.25	(0.3331)	(0.3275)	(0.3351)	(0.3305)	(0.3172)	(0.3223)	(0.3306)	(0.3465)	(0.3628)
	[0.0675]	[0.0230]	[0.0530]	[0.0425]	[0.0280]	[0.0325]	[0.0235]	[0.0430]	[0.1225]
	-0.0978	-0.1581	-0.0973	-0.1029	-0.1583	-0.1246	-0.1518	-0.1112	0.0267
τ_1 =0.30	(0.3148)	(0.3054)	(0.3195)	(0.3279)	(0.3147)	(0.3112)	(0.3194)	(0.3270)	(0.3272)
	[0.3775]	[0.3080]	[0.3815]	[0.3705]	[0.3110]	[0.3460]	[0.3230]	[0.3615]	[0.5175]
	0.1542	0.1912	0.1895	0.1894	0.1271	0.1940	0.1815	0.2345	0.3717
τ_1 =0.35	(0.3015)	(0.2801)	(0.2912)	(0.2989)	(0.2861)	(0.2804)	(0.2836)	(0.2866)	(0.2730)
	[0.3350]	[0.2720]	[0.2880]	[0.2905]	[0.3625]	[0.2700]	[0.2960]	[0.2205]	[0.0440]
	0.7446	0.8016	0.7826	0.7660	0.7274	0.7864	0.7795	0.8165	0.8888
τ_1 =0.40	(0.2280)	(0.1899)	(0.1961)	(0.2050)	(0.1977)	(0.1815)	(0.1768)	(0.1642)	(0.1336)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8295	0.8851	0.8599	0.8585	0.8193	0.8730	0.8764	0.9058	0.9555
τ_1 =0.45	(0.1876)	(0.1473)	(0.1554)	(0.1482)	(0.1431)	(0.1200)	(0.1115)	(0.0967)	(0.0675)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of the young households that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table B.2
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for Prime-Aged Households using the Measure of Nondurable Goods and Services

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.4949	-0.4932	-0.4804	-0.4338	-0.4610	-0.4252	-0.3729	-0.3430	-0.2905
τ_1 =0.05	(0.2769)	(0.2822)	(0.2814)	(0.2847)	(0.2853)	(0.2925)	(0.2959)	(0.2957)	(0.2990)
	[0.0160]	[0.0180]	[0.0250]	[0.0515]	[0.0375]	[0.0615]	[0.1080]	[0.1355]	[0.1790]
	-0.3914	-0.3881	-0.3602	-0.3141	-0.3443	-0.3106	-0.2578	-0.2399	-0.1842
τ_1 =0.10	(0.3008)	(0.3026)	(0.3034)	(0.3036)	(0.3039)	(0.3102)	(0.3089)	(0.3068)	(0.3020)
	[0.0780]	[0.0845]	[0.1080]	[0.1530]	[0.1285]	[0.1625]	[0.2185]	[0.2320]	[0.2820]
	-0.2843	-0.2712	-0.2428	-0.1841	-0.2079	-0.1713	-0.1129	-0.0837	-0.0145
τ_1 =0.15	(0.3341)	(0.3331)	(0.3342)	(0.3345)	(0.3374)	(0.3448)	(0.3380)	(0.3338)	(0.3214)
	[0.2075]	[0.2215]	[0.2510]	[0.3040]	[0.2885]	[0.3220]	[0.3775]	[0.4045]	[0.4635]
	-0.0227	-0.0058	0.0207	0.1000	0.0894	0.1446	0.1939	0.2325	0.2964
τ_1 =0.20	(0.3324)	(0.3256)	(0.3250)	(0.3236)	(0.3268)	(0.3314)	(0.3207)	(0.3115)	(0.2951)
	[0.4750]	[0.4820]	[0.4945]	[0.4060]	[0.4195]	[0.3600]	[0.3080]	[0.2530]	[0.1590]
	0.1598	0.1750	0.2050	0.2742	0.2626	0.3101	0.3534	0.3937	0.4486
τ_1 =0.25	(0.3142)	(0.3070)	(0.3022)	(0.2987)	(0.3000)	(0.3037)	(0.2927)	(0.2815)	(0.2649)
	[0.3230]	[0.3030]	[0.2585]	[0.1835]	[0.1905]	[0.1530]	[0.0950]	[0.0325]	[0.0000]
	0.4113	0.4282	0.4624	0.5267	0.5204	0.5627	0.5959	0.6291	0.6751
τ_1 =0.30	(0.2733)	(0.2602)	(0.2513)	(0.2437)	(0.2433)	(0.2450)	(0.2318)	(0.2182)	(0.1978)
	[0.0465]	[0.0220]	[0.0065]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.6753	0.6870	0.7057	0.7575	0.7515	0.7852	0.8106	0.8376	0.8642
τ_1 =0.35	(0.2142)	(0.1960)	(0.1853)	(0.1719)	(0.1701)	(0.1677)	(0.1519)	(0.1344)	(0.1135)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8152	0.8257	0.8422	0.8825	0.8798	0.9048	0.9217	0.9383	0.9544
τ_1 =0.40	(0.1591)	(0.1368)	(0.1258)	(0.1089)	(0.1059)	(0.1005)	(0.0852)	(0.0693)	(0.0518)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8888	0.8971	0.9060	0.9372	0.9325	0.9489	0.9640	0.9743	0.9830
τ_1 =0.45	(0.1185)	(0.0985)	(0.0896)	(0.0727)	(0.0706)	(0.0658)	(0.0518)	(0.0386)	(0.0256)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of the prime-aged households that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table B.3
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for Old Households using the Measure of Nondurable Goods and Services

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.5862	-0.5681	-0.5882	-0.5676	-0.5543	-0.5328	-0.4876	-0.4734	-0.4025
τ_1 =0.05	(0.2892)	(0.3057)	(0.3109)	(0.2980)	(0.2972)	(0.3019)	(0.3049)	(0.3087)	(0.3157)
	[0.0010]	[0.0045]	[0.0055]	[0.0080]	[0.0090]	[0.0195]	[0.0475]	[0.0625]	[0.1070]
	-0.5732	-0.5267	-0.5547	-0.5264	-0.5205	-0.4729	-0.4296	-0.4063	-0.3095
τ_1 =0.10	(0.3026)	(0.3199)	(0.3214)	(0.3058)	(0.3050)	(0.3073)	(0.3110)	(0.3147)	(0.3215)
	[0.0050]	[0.0280]	[0.0205]	[0.0250]	[0.0270]	[0.0590]	[0.0860]	[0.1005]	[0.1815]
	-0.4960	-0.4472	-0.4747	-0.4264	-0.4320	-0.3629	-0.3211	-0.2987	-0.1874
τ_1 =0.15	(0.3151)	(0.3344)	(0.3348)	(0.3248)	(0.3219)	(0.3229)	(0.3219)	(0.3234)	(0.3266)
	[0.0440]	[0.0900]	[0.0750]	[0.0945]	[0.0960]	[0.1495]	[0.1785]	[0.2000]	[0.2890]
	-0.3033	-0.2213	-0.2458	-0.2176	-0.2183	-0.1565	-0.1216	-0.0927	0.0093
τ_1 =0.20	(0.3199)	(0.3352)	(0.3366)	(0.3257)	(0.3245)	(0.3212)	(0.3199)	(0.3206)	(0.3200)
	[0.1785]	[0.2750]	[0.2480]	[0.2640]	[0.2605]	[0.3165]	[0.3515]	[0.3750]	[0.5235]
	0.0495	0.1318	0.1055	0.1270	0.1183	0.1845	0.2152	0.2408	0.3377
τ_1 =0.25	(0.3128)	(0.3186)	(0.3215)	(0.3099)	(0.3108)	(0.2989)	(0.2920)	(0.2889)	(0.2808)
	[0.4720]	[0.3700]	[0.4095]	[0.3750]	[0.3845]	[0.2985]	[0.2520]	[0.2130]	[0.0805]
	0.2792	0.3523	0.2995	0.2978	0.2944	0.3496	0.3785	0.4033	0.5089
τ_1 =0.30	(0.2972)	(0.2966)	(0.2995)	(0.2908)	(0.2913)	(0.2805)	(0.2732)	(0.2697)	(0.2503)
	[0.1770]	[0.0900]	[0.1495]	[0.1380]	[0.1475]	[0.0660]	[0.0325]	[0.0140]	[0.0000]
	0.6400	0.6957	0.6553	0.6413	0.6323	0.6707	0.6884	0.7008	0.7757
τ_1 =0.35	(0.2142)	(0.2069)	(0.2105)	(0.2070)	(0.2097)	(0.1948)	(0.1831)	(0.1790)	(0.1560)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.7612	0.8153	0.7801	0.7645	0.7608	0.7875	0.7989	0.8103	0.8634
τ_1 =0.40	(0.1528)	(0.1393)	(0.1423)	(0.1402)	(0.1418)	(0.1276)	(0.1164)	(0.1125)	(0.0919)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8589	0.9044	0.8833	0.8811	0.8759	0.8998	0.9101	0.9166	0.9514
τ_1 =0.45	(0.1124)	(0.0954)	(0.0942)	(0.0943)	(0.0991)	(0.0844)	(0.0719)	(0.0664)	(0.0465)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of the old households that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table B.4
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for Stockholders using the Measure of Nondurable Goods and Services

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	0.6883	0.6573	0.5701	0.6149	0.5598	0.5573	0.5623	0.6503	0.7307
τ_1 =0.05	(0.2721)	(0.2669)	(0.2726)	(0.2769)	(0.2827)	(0.2856)	(0.2875)	(0.2825)	(0.2730)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.7481	0.7526	0.7006	0.7392	0.6887	0.6854	0.7005	0.7654	0.8145
τ_1 =0.10	(0.2739)	(0.2687)	(0.2654)	(0.2664)	(0.2704)	(0.2645)	(0.2597)	(0.2509)	(0.2394)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.6220	0.6062	0.5122	0.5613	0.5153	0.5067	0.5236	0.5955	0.6749
τ_1 =0.15	(0.2233)	(0.2244)	(0.2366)	(0.2410)	(0.2383)	(0.2387)	(0.2394)	(0.2343)	(0.2136)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.5995	0.5733	0.4699	0.5161	0.4581	0.4528	0.4718	0.5585	0.6436
τ_1 =0.20	(0.2819)	(0.2779)	(0.2830)	(0.2827)	(0.2818)	(0.2763)	(0.2752)	(0.2636)	(0.2484)
	[0.0000]	[0.0000]	[0.0090]	[0.0000]	[0.0140]	[0.0145]	[0.0050]	[0.0000]	[0.0000]
	0.7654	0.7394	0.6603	0.7082	0.6645	0.6626	0.6682	0.7539	0.8134
τ_1 =0.25	(0.2512)	(0.2515)	(0.2553)	(0.2420)	(0.2399)	(0.2370)	(0.2407)	(0.2197)	(0.2086)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8841	0.8636	0.8050	0.8292	0.7894	0.7816	0.7934	0.8567	0.9063
τ_1 =0.30	(0.1823)	(0.1776)	(0.1822)	(0.1702)	(0.1643)	(0.1606)	(0.1605)	(0.1422)	(0.1253)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.9148	0.9049	0.8760	0.8911	0.8616	0.8508	0.8605	0.9088	0.9390
τ_1 =0.35	(0.1400)	(0.1269)	(0.1252)	(0.1159)	(0.1093)	(0.1081)	(0.1083)	(0.0933)	(0.0822)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.9224	0.9230	0.9144	0.9185	0.8916	0.8843	0.8945	0.9281	0.9395
τ_1 =0.40	(0.1112)	(0.0938)	(0.0917)	(0.0763)	(0.0733)	(0.0682)	(0.0664)	(0.0556)	(0.0506)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.9578	0.9604	0.9447	0.9518	0.9292	0.9218	0.9323	0.9597	0.9731
τ_1 =0.45	(0.0821)	(0.0699)	(0.0713)	(0.0561)	(0.0548)	(0.0482)	(0.0414)	(0.0311)	(0.0231)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of stockholders that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table B.5
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for Young Households using the Measure of Total Expenditure

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.8829	-0.8052	-0.7507	-0.7008	-0.7162	-0.7077	-0.7116	-0.6882	-0.6912
τ_1 =0.05	(0.2159)	(0.2590)	(0.2657)	(0.2575)	(0.2545)	(0.2609)	(0.2722)	(0.2795)	(0.2870)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.8440	-0.8046	-0.7784	-0.7459	-0.7403	-0.7221	-0.7136	-0.6643	-0.6126
τ_1 =0.10	(0.1977)	(0.2330)	(0.2409)	(0.2310)	(0.2331)	(0.2425)	(0.2585)	(0.2729)	(0.2849)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.8393	-0.8129	-0.8162	-0.7841	-0.7616	-0.7555	-0.7558	-0.7067	-0.6296
τ_1 =0.15	(0.2054)	(0.2443)	(0.2405)	(0.2338)	(0.2275)	(0.2323)	(0.2507)	(0.2715)	(0.2905)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.7245	-0.7399	-0.7510	-0.7393	-0.7113	-0.6823	-0.6642	-0.5872	-0.4825
τ_1 =0.20	(0.2384)	(0.2644)	(0.2564)	(0.2482)	(0.2387)	(0.2439)	(0.2651)	(0.2847)	(0.3080)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0035]	[0.0460]
	-0.7526	-0.7836	-0.7788	-0.7809	-0.7723	-0.7338	-0.7051	-0.6257	-0.5407
τ_1 =0.25	(0.2476)	(0.2697)	(0.2669)	(0.2596)	(0.2504)	(0.2565)	(0.2756)	(0.2938)	(0.3153)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0020]	[0.0340]
	-0.6165	-0.6829	-0.6800	-0.7059	-0.7040	-0.6523	-0.6092	-0.5193	-0.4319
τ_1 =0.30	(0.2539)	(0.2680)	(0.2699)	(0.2638)	(0.2555)	(0.2637)	(0.2798)	(0.2934)	(0.3099)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0005]	[0.0310]	[0.0865]
	-0.3050	-0.4150	-0.4189	-0.4396	-0.4629	-0.3902	-0.3463	-0.2333	-0.1092
τ_1 =0.35	(0.2750)	(0.2847)	(0.2889)	(0.2916)	(0.2842)	(0.2868)	(0.2951)	(0.2974)	(0.3025)
	[0.1355]	[0.0770]	[0.0765]	[0.0600]	[0.0485]	[0.0960]	[0.1315]	[0.2200]	[0.3380]
	0.3270	0.2585	0.2320	0.2311	0.2394	0.3043	0.3322	0.4386	0.5807
τ_1 =0.40	(0.2847)	(0.2889)	(0.2973)	(0.2974)	(0.2854)	(0.2757)	(0.2746)	(0.2590)	(0.2362)
	[0.1245]	[0.1930]	[0.2390]	[0.2435]	[0.2175]	[0.1240]	[0.0885]	[0.0055]	[0.0000]
	0.6283	0.5644	0.5410	0.5320	0.5205	0.5716	0.5964	0.6725	0.7946
τ_1 =0.45	(0.2291)	(0.2372)	(0.2371)	(0.2353)	(0.2193)	(0.2046)	(0.1945)	(0.1740)	(0.1407)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly total household expenditure) of the young households that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table B.6
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for Prime-Aged Households using the Total Expenditures

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.8956	-0.8234	-0.8194	-0.7894	-0.7871	-0.7920	-0.7731	-0.7179	-0.6419
τ_1 =0.05	(0.1418)	(0.1544)	(0.1577)	(0.1584)	(0.1658)	(0.1649)	(0.1689)	(0.1812)	(0.2018)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.9220	-0.8940	-0.8911	-0.8710	-0.8732	-0.8765	-0.8577	-0.8104	-0.7439
τ_1 =0.10	(0.1240)	(0.1246)	(0.1272)	(0.1319)	(0.1389)	(0.1409)	(0.1502)	(0.1688)	(0.1969)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.8782	-0.8629	-0.8669	-0.8449	-0.8511	-0.8518	-0.8322	-0.7786	-0.7059
τ_1 =0.15	(0.1520)	(0.1477)	(0.1486)	(0.1555)	(0.1624)	(0.1673)	(0.1777)	(0.1979)	(0.2251)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.8301	-0.8063	-0.8122	-0.7857	-0.7913	-0.7929	-0.7704	-0.7102	-0.6253
τ_1 =0.20	(0.1876)	(0.1876)	(0.1884)	(0.1962)	(0.2023)	(0.2071)	(0.2165)	(0.2343)	(0.2580)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.7269	-0.6850	-0.6839	-0.6489	-0.6543	-0.6592	-0.6293	-0.5590	-0.4584
τ_1 =0.25	(0.2280)	(0.2297)	(0.2317)	(0.2390)	(0.2446)	(0.2491)	(0.2570)	(0.2697)	(0.2851)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0055]	[0.0420]
	-0.5983	-0.5457	-0.5401	-0.5007	-0.5061	-0.5123	-0.4764	-0.3990	-0.2897
τ_1 =0.30	(0.2808)	(0.2837)	(0.2824)	(0.2867)	(0.2898)	(0.2936)	(0.2974)	(0.3031)	(0.3070)
	[0.0005]	[0.0040]	[0.0065]	[0.0205]	[0.0210]	[0.0215]	[0.0420]	[0.1050]	[0.1885]
	-0.1495	-0.0949	-0.0970	-0.0584	-0.0667	-0.0669	-0.0276	0.0581	0.1652
τ_1 =0.35	(0.3045)	(0.3026)	(0.2963)	(0.2949)	(0.2950)	(0.2971)	(0.2929)	(0.2872)	(0.2735)
	[0.3115]	[0.3675]	[0.3660]	[0.4040]	[0.4025]	[0.3970]	[0.4430]	[0.4600]	[0.3165]
	0.3549	0.4184	0.4301	0.4700	0.4641	0.4578	0.4947	0.5624	0.6519
τ_1 =0.40	(0.2648)	(0.2635)	(0.2522)	(0.2453)	(0.2409)	(0.2387)	(0.2266)	(0.2103)	(0.1804)
	[0.0740]	[0.0245]	[0.0130]	[0.0015]	[0.0015]	[0.0015]	[0.0000]	[0.0000]	[0.0000]
	0.7153	0.7768	0.7809	0.8099	0.8056	0.8034	0.8249	0.8688	0.9189
τ_1 =0.45	(0.1863)	(0.1771)	(0.1634)	(0.1507)	(0.1434)	(0.1385)	(0.1230)	(0.1021)	(0.0698)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly total household expenditure) of the prime-aged households that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table B.7
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for Old Households using the Measure of Total Expenditures

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.9418	-0.9055	-0.8888	-0.8940	-0.8848	-0.8848	-0.9110	-0.9365	-0.9453
τ_1 =0.05	(0.0987)	(0.0979)	(0.0973)	(0.0942)	(0.0974)	(0.0974)	(0.0980)	(0.1028)	(0.1186)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.9450	-0.9489	-0.9307	-0.9121	-0.9081	-0.8812	-0.9139	-0.9182	-0.9048
τ_1 =0.10	(0.0952)	(0.0886)	(0.0933)	(0.0961)	(0.0985)	(0.1094)	(0.1044)	(0.1086)	(0.1292)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.9179	-0.9436	-0.9273	-0.9137	-0.9114	-0.8754	-0.8939	-0.8936	-0.8541
τ_1 =0.15	(0.1123)	(0.0982)	(0.1047)	(0.1102)	(0.1139)	(0.1255)	(0.1265)	(0.1391)	(0.1723)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.8168	-0.8648	-0.8562	-0.8265	-0.8184	-0.7658	-0.7696	-0.7621	-0.6936
τ_1 =0.20	(0.1647)	(0.1455)	(0.1509)	(0.1596)	(0.1630)	(0.1730)	(0.1815)	(0.1964)	(0.2357)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	-0.7329	-0.7961	-0.7827	-0.7385	-0.7324	-0.6691	-0.6777	-0.6717	-0.5953
τ_1 =0.25	(0.2108)	(0.1963)	(0.2038)	(0.2137)	(0.2165)	(0.2264)	(0.2309)	(0.2429)	(0.2734)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0005]
	-0.5804	-0.6577	-0.6353	-0.5765	-0.5647	-0.4934	-0.4997	-0.5057	-0.4165
τ_1 =0.30	(0.2813)	(0.2745)	(0.2827)	(0.2903)	(0.2910)	(0.2979)	(0.2958)	(0.3032)	(0.3156)
	[0.0035]	[0.0000]	[0.0000]	[0.0040]	[0.0085]	[0.0365]	[0.0335]	[0.0390]	[0.1025]
	0.0355	-0.0707	-0.0300	0.0499	0.0593	0.1382	0.1233	0.1105	0.1977
τ_1 =0.35	(0.3054)	(0.3106)	(0.3177)	(0.3167)	(0.3109)	(0.3060)	(0.3006)	(0.3020)	(0.2895)
	[0.4785]	[0.4025]	[0.4520]	[0.4630]	[0.4580]	[0.3615]	[0.3770]	[0.3890]	[0.2665]
	0.3784	0.2915	0.3232	0.4009	0.4136	0.4900	0.4738	0.4696	0.5414
τ_1 =0.40	(0.2795)	(0.2876)	(0.2922)	(0.2830)	(0.2755)	(0.2653)	(0.2602)	(0.2525)	(0.2329)
	[0.0620]	[0.1455]	[0.1215]	[0.0505]	[0.0340]	[0.0020]	[0.0025]	[0.0010]	[0.0000]
	0.7755	0.7205	0.7386	0.7969	0.8098	0.8518	0.8498	0.8430	0.8809
τ_1 =0.45	(0.1694)	(0.1795)	(0.1790)	(0.1628)	(0.1538)	(0.1399)	(0.1315)	(0.1214)	(0.0974)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly total household expenditure) of the old households that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table B.8
Estimation of corr($\mathbb{F}_t^{\tau_1}, \mathbb{F}_t^{\tau_2}$) for Stockholders using the Measure of Total Expenditures

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.6981	-0.5786	-0.5324	-0.5363	-0.5411	-0.5058	-0.4837	-0.5268	-0.4253
τ_1 =0.05	(0.1687)	(0.2031)	(0.2236)	(0.2231)	(0.2189)	(0.2270)	(0.2256)	(0.2294)	(0.2286)
	[0.0000]	[0.0000]	[0.0005]	[0.0000]	[0.0000]	[0.0020]	[0.0030]	[0.0015]	[0.0205]
	-0.4733	-0.3967	-0.3343	-0.3720	-0.4174	-0.3777	-0.3655	-0.4199	-0.3520
τ_1 =0.10	(0.2451)	(0.2572)	(0.2722)	(0.2668)	(0.2686)	(0.2787)	(0.2772)	(0.2820)	(0.2829)
	[0.0155]	[0.0585]	[0.1160]	[0.0830]	[0.0585]	[0.0925]	[0.0990]	[0.0655]	[0.1130]
	-0.4677	-0.5273	-0.4603	-0.5137	-0.5467	-0.5435	-0.5091	-0.5205	-0.4773
τ_1 =0.15	(0.2542)	(0.2500)	(0.2631)	(0.2573)	(0.2638)	(0.2681)	(0.2735)	(0.2840)	(0.2846)
	[0.0070]	[0.0005]	[0.0155]	[0.0040]	[0.0015]	[0.0030]	[0.0110]	[0.0135]	[0.0365]
	-0.3276	-0.3720	-0.3101	-0.3778	-0.3954	-0.3766	-0.3290	-0.3452	-0.2876
τ_1 =0.20	(0.2973)	(0.2926)	(0.3065)	(0.2993)	(0.3049)	(0.3064)	(0.3083)	(0.3081)	(0.3047)
	[0.1395]	[0.1030]	[0.1640]	[0.1085]	[0.1065]	[0.1190]	[0.1610]	[0.1515]	[0.1900]
	-0.0441	-0.0997	-0.0238	-0.0925	-0.0945	-0.0950	-0.0341	-0.0382	0.0136
τ_1 =0.25	(0.3014)	(0.2997)	(0.3041)	(0.3016)	(0.3063)	(0.3091)	(0.3073)	(0.3039)	(0.2984)
	[0.4355]	[0.3690]	[0.4505]	[0.3690]	[0.3670]	[0.3580]	[0.4155]	[0.4140]	[0.5305]
	0.3142	0.2560	0.3213	0.2555	0.2649	0.2644	0.3256	0.3403	0.3802
τ_1 =0.30	(0.2876)	(0.2867)	(0.2837)	(0.2836)	(0.2845)	(0.2819)	(0.2768)	(0.2648)	(0.2578)
	[0.1340]	[0.1975]	[0.1145]	[0.1900]	[0.1775]	[0.1705]	[0.0800]	[0.0550]	[0.0150]
	0.6358	0.6114	0.6583	0.6090	0.6326	0.6396	0.6961	0.7104	0.7511
τ_1 =0.35	(0.2397)	(0.2366)	(0.2288)	(0.2298)	(0.2233)	(0.2151)	(0.2037)	(0.1859)	(0.1721)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8145	0.8005	0.8403	0.8044	0.8175	0.8203	0.8598	0.8668	0.8876
τ_1 =0.40	(0.1849)	(0.1771)	(0.1626)	(0.1646)	(0.1563)	(0.1453)	(0.1312)	(0.1172)	(0.1032)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8887	0.8962	0.9263	0.9050	0.9087	0.9191	0.9451	0.9386	0.9593
τ_1 =0.45	(0.1334)	(0.1193)	(0.1003)	(0.1009)	(0.0955)	(0.0792)	(0.0671)	(0.0584)	(0.0417)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}_t^{\tau}$, (i.e., $\lambda_{\tau}^{'} F_t$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly total household expenditure) of the stockholders that can be attributed to common macroeconomic factors F_t. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Appendix C. Estimation Results for Alternative Specifications

Table C.1
Estimation of corr($\mathbb{F}^{\tau_1}_{t-1}, \mathbb{F}^{\tau_2}_{t-1}$) using Model (20)

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.5100	-0.4885	-0.4630	-0.4493	-0.4420	-0.4326	-0.3788	-0.3289	-0.2813
τ_1 =0.05	(0.2914)	(0.2943)	(0.2953)	(0.3006)	(0.3063)	(0.3129)	(0.3210)	(0.3291)	(0.3380)
	[0.0130]	[0.0255]	[0.0435]	[0.0590]	[0.0645]	[0.0785]	[0.1280]	[0.1695]	[0.2285]
	-0.3917	-0.3755	-0.3586	-0.3353	-0.3161	-0.2988	-0.2433	-0.1858	-0.1234
τ_1 =0.10	(0.3225)	(0.3247)	(0.3248)	(0.3306)	(0.3370)	(0.3424)	(0.3472)	(0.3523)	(0.3559)
	[0.1145]	[0.1335]	[0.1480]	[0.1730]	[0.1895]	[0.2025]	[0.2525]	[0.3030]	[0.3605]
	-0.2835	-0.2763	-0.2734	-0.2445	-0.2129	-0.1896	-0.1388	-0.0793	-0.0044
τ_1 =0.15	(0.3376)	(0.3388)	(0.3393)	(0.3445)	(0.3512)	(0.3548)	(0.3573)	(0.3602)	(0.3590)
	[0.2115]	[0.2215]	[0.2235]	[0.2425]	[0.2700]	[0.2935]	[0.3345]	[0.3860]	[0.4490]
	-0.1298	-0.1275	-0.1279	-0.0991	-0.0613	-0.0376	0.0103	0.0696	0.1489
τ_1 =0.20	(0.3283)	(0.3287)	(0.3285)	(0.3336)	(0.3397)	(0.3427)	(0.3426)	(0.3432)	(0.3396)
	[0.3375]	[0.3390]	[0.3380]	[0.3650]	[0.3975]	[0.4225]	[0.5370]	[0.4765]	[0.3860]
	0.1375	0.1361	0.1358	0.1652	0.2057	0.2305	0.2744	0.3309	0.4083
τ_1 =0.25	(0.2952)	(0.2944)	(0.2932)	(0.2957)	(0.3001)	(0.2999)	(0.2970)	(0.2934)	(0.2854)
	[0.3460]	[0.3485]	[0.3450]	[0.3100]	[0.2630]	[0.2310]	[0.1640]	[0.0855]	[0.0105]
	0.3715	0.3694	0.3698	0.3968	0.4367	0.4553	0.4939	0.5444	0.6106
τ_1 =0.30	(0.2378)	(0.2342)	(0.2314)	(0.2319)	(0.2332)	(0.2322)	(0.2261)	(0.2172)	(0.2056)
	[0.0210]	[0.0220]	[0.0205]	[0.0070]	[0.0015]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.5322	0.5314	0.5336	0.5592	0.5932	0.6104	0.6462	0.6906	0.7459
τ_1 =0.35	(0.2034)	(0.1963)	(0.1899)	(0.1881)	(0.1880)	(0.1855)	(0.1764)	(0.1629)	(0.1492)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.7654	0.7636	0.7670	0.7860	0.8128	0.8257	0.8497	0.8794	0.9165
τ_1 =0.40	(0.1269)	(0.1163)	(0.1077)	(0.1028)	(0.0978)	(0.0909)	(0.0810)	(0.0649)	(0.0486)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8520	0.8503	0.8523	0.8715	0.8909	0.9028	0.9216	0.9434	0.9668
τ_1 =0.45	(0.0983)	(0.0862)	(0.0779)	(0.0704)	(0.0644)	(0.0571)	(0.0468)	(0.0324)	(0.0204)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}^{\tau}_{t-1}$, (i.e., $\lambda^{'}_{\tau} F_{t-1}$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of the whole population that is attributed to common macroeconomic factors F_{t-1}. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table C.2
Estimation of corr($\mathbb{F}^{\tau_1}_{t-2}, \mathbb{F}^{\tau_2}_{t-2}$) using Model (21)

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.5622	-0.5358	-0.5397	-0.4591	-0.4530	-0.4176	-0.3809	-0.3199	-0.2108
τ_1 =0.05	(0.2671)	(0.2700)	(0.2792)	(0.2918)	(0.2987)	(0.3084)	(0.3222)	(0.3295)	(0.3296)
	[0.0000]	[0.0015]	[0.0025]	[0.0245]	[0.0330]	[0.0705]	[0.1105]	[0.1755]	[0.2780]
	-0.4986	-0.4672	-0.4730	-0.3843	-0.3688	-0.3227	-0.2843	-0.2227	-0.1051
τ_1 =0.10	(0.2802)	(0.2845)	(0.2948)	(0.3084)	(0.3139)	(0.3222)	(0.3349)	(0.3418)	(0.3392)
	[0.0105]	[0.0240]	[0.0295]	[0.0930]	[0.1120]	[0.1685]	[0.2095]	[0.2780]	[0.3800]
	-0.4374	-0.4062	-0.4166	-0.3275	-0.3061	-0.2575	-0.2181	-0.1574	-0.0341
τ_1 =0.15	(0.2770)	(0.2825)	(0.2932)	(0.3063)	(0.3127)	(0.3220)	(0.3337)	(0.3399)	(0.3350)
	[0.0345]	[0.0525]	[0.0570]	[0.1470]	[0.1775]	[0.2320]	[0.2780]	[0.3340]	[0.4515]
	-0.3040	-0.2685	-0.2816	-0.1867	-0.1552	-0.0977	-0.0580	-0.0004	0.1268
τ_1 =0.20	(0.2738)	(0.2802)	(0.2901)	(0.3017)	(0.3078)	(0.3135)	(0.3222)	(0.3250)	(0.3148)
	[0.1405]	[0.1810]	[0.1785]	[0.2845]	[0.3190]	[0.3850]	[0.4305]	[0.4865]	[0.3765]
	-0.1605	-0.1248	-0.1379	-0.0421	-0.0077	0.0497	0.0891	0.1460	0.2728
τ_1 =0.25	(0.2737)	(0.2789)	(0.2870)	(0.2938)	(0.2978)	(0.3002)	(0.3062)	(0.3045)	(0.2890)
	[0.2855]	[0.3270]	[0.3185]	[0.4320]	[0.4775]	[0.4550]	[0.4135]	[0.3545]	[0.1830]
	0.0116	0.0483	0.0315	0.1275	0.1691	0.2292	0.2660	0.3129	0.4347
τ_1 =0.30	(0.2575)	(0.2594)	(0.2650)	(0.2673)	(0.2688)	(0.2677)	(0.2698)	(0.2643)	(0.2445)
	[0.5160]	[0.4610]	[0.4870]	[0.3460]	[0.2810]	[0.2005]	[0.1590]	[0.0850]	[0.0000]
	0.2224	0.2612	0.2426	0.3360	0.3741	0.4336	0.4680	0.5089	0.6123
τ_1 =0.35	(0.2427)	(0.2390)	(0.2413)	(0.2362)	(0.2343)	(0.2282)	(0.2256)	(0.2138)	(0.1894)
	[0.1725]	[0.1180]	[0.1430]	[0.0385]	[0.0195]	[0.0010]	[0.0000]	[0.0000]	[0.0000]
	0.6003	0.6329	0.6195	0.6896	0.7222	0.7674	0.7909	0.8162	0.8787
τ_1 =0.40	(0.1729)	(0.1604)	(0.1592)	(0.1451)	(0.1372)	(0.1251)	(0.1186)	(0.1046)	(0.0783)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.7529	0.7775	0.7647	0.8241	0.8474	0.8802	0.8975	0.9154	0.9577
τ_1 =0.45	(0.1374)	(0.1236)	(0.1191)	(0.1019)	(0.0925)	(0.0810)	(0.0717)	(0.0569)	(0.0359)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}^{\tau}_{t-2}$, (i.e., $\lambda'_{\tau} F_{t-2}$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of the whole population that is attributed to common macroeconomic factors F_{t-2}. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.

Table C.3
Estimation of corr($\mathbb{F}^{\tau_1}_{t+1}, \mathbb{F}^{\tau_2}_{t+1}$) using Model (22)

	$\tau_2 = 0.95$	$\tau_2 = 0.90$	$\tau_2 = 0.85$	$\tau_2 = 0.80$	$\tau_2 = 0.75$	$\tau_2 = 0.70$	$\tau_2 = 0.65$	$\tau_2 = 0.60$	$\tau_2 = 0.55$
	-0.5235	-0.5396	-0.5217	-0.4822	-0.5027	-0.4811	-0.4405	-0.4125	-0.3888
τ_1 =0.05	(0.2935)	(0.2934)	(0.2974)	(0.3027)	(0.3018)	(0.3014)	(0.3065)	(0.3056)	(0.3115)
	[0.0100]	[0.0070]	[0.0110]	[0.0280]	[0.0195]	[0.0280]	[0.0545]	[0.0760]	[0.1055]
	-0.4002	-0.4112	-0.4022	-0.3558	-0.3721	-0.3500	-0.3038	-0.2771	-0.2512
τ_1 =0.10	(0.2881)	(0.2917)	(0.2894)	(0.2949)	(0.2964)	(0.2957)	(0.2995)	(0.2960)	(0.2978)
	[0.0630]	[0.0625]	[0.0695]	[0.1080]	[0.0970]	[0.1120]	[0.1585]	[0.1855]	[0.2100]
	-0.2148	-0.2278	-0.2160	-0.1631	-0.1772	-0.1516	-0.1036	-0.0790	-0.0442
τ_1 =0.15	(0.3176)	(0.3209)	(0.3179)	(0.3207)	(0.3237)	(0.3196)	(0.3205)	(0.3134)	(0.3109)
	[0.2575]	[0.2515]	[0.2620]	[0.3125]	[0.2975]	[0.3220]	[0.3695]	[0.3980]	[0.4295]
	0.0662	0.0434	0.0703	0.1237	0.1120	0.1337	0.1790	0.1953	0.2546
τ_1 =0.20	(0.3263)	(0.3274)	(0.3243)	(0.3239)	(0.3255)	(0.3201)	(0.3182)	(0.3095)	(0.3012)
	[0.4280]	[0.4555]	[0.4295]	[0.3720]	[0.3880]	[0.3655]	[0.3135]	[0.2925]	[0.2105]
	0.5243	0.5050	0.5291	0.5743	0.5644	0.5835	0.6187	0.6312	0.6701
τ_1 =0.25	(0.2599)	(0.2577)	(0.2553)	(0.2493)	(0.2486)	(0.2413)	(0.2354)	(0.2246)	(0.2146)
	[0.0030]	[0.0035]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.7136	0.7029	0.7150	0.7540	0.7499	0.7642	0.7936	0.8012	0.8256
τ_1 =0.30	(0.2009)	(0.1966)	(0.1936)	(0.1851)	(0.1837)	(0.1769)	(0.1698)	(0.1594)	(0.1475)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.8411	0.8330	0.8397	0.8687	0.8623	0.8729	0.8968	0.9059	0.9226
τ_1 =0.35	(0.1389)	(0.1309)	(0.1276)	(0.1178)	(0.1152)	(0.1092)	(0.1020)	(0.0913)	(0.0800)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.9387	0.9335	0.9377	0.9560	0.9537	0.9597	0.9725	0.9751	0.9864
τ_1 =0.40	(0.0791)	(0.0688)	(0.0659)	(0.0554)	(0.0518)	(0.0467)	(0.0406)	(0.0333)	(0.0240)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
	0.9563	0.9495	0.9563	0.9707	0.9658	0.9721	0.9820	0.9863	0.9925
τ_1 =0.45	(0.0550)	(0.0465)	(0.0426)	(0.0337)	(0.0315)	(0.0272)	(0.0224)	(0.0162)	(0.0095)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]

Notes. The term $\mathbb{F}^{\tau}_{t+1}$, (i.e., $\lambda'_{\tau} F_{t+1}$) represents the portion of the τ^{th} quantile of consumption growth rates $c_{i,t+1}/c_{i,t}$ (measured by quarterly household expenditure on non-durable goods and services) of the whole population that is attributed to common macroeconomic factors F_{t+1}. The standard errors and p-values of the estimated correlations are indicated in parentheses and brackets, respectively.