Income Versus Consumption Inequality: The Role of Time-Varying Higher Moments*

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October 3, 2016

Abstract

We propose an approach to explore the link between income and consumption inequality that incorporates time-varying skewness of the income process in a tractable fashion. We find evidence of no insurance with respect to persistent income shocks, contrary to prior studies that document the existence of partial insurance with respect to such shocks. This difference can potentially be attributed to the omission of time-varying higher moments of income from the analyses in prior studies – a phenomenon for which there is ample recent empirical evidence. We find evidence of almost full insurance of transitory income shocks. Our results suggest that consumption inequality tracks income inequality much more closely than commonly believed.

Keywords: Income inequality, consumption inequality, permanent income shocks, transitory income shocks, partial insurance, time-varying skewness.

JEL Classification Codes: D12, D31, D91, E21

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*I benefited from helpful comments from Richard Blundell, George Constantinides, Christian Julliard, Chris Telmer, and seminar participants at University College London, ESSFM 2016 at Gerzensee, and the NBER Summer Institute 2016. All errors and omissions are my own.

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I Introduction

An extant literature studies the link between income inequality and consumption inequality, i.e. the extent to which household-level idiosyncratic income shocks are transmitted to consumption. This link depends on both the evolution of the income distribution across households and over time as well as the degree of insurance that exists with respect to the income shocks. Among other things, the extent of insurance is critical in determining the welfare effects of shifts in the income distribution. The complete markets hypothesis assumes that full consumption insurance exists against idiosyncratic income shocks. This hypothesis is strongly rejected in micro data (see e.g., Cochrane (1991), Attanasio and Davis (1996), and Brav, Constantinides, and Geczy (2002)). However, the extent of insurance that exists against income shocks remains a largely open question (see e.g., Deaton and Paxson (1994) and Hayashi, Altonji, and Kotlikoff (1996)). In an influential study, Blundell, Pistaferri, and Preston (2008) - hereafter referred to as BPP - highlighted the importance of incorporating income shocks of different durabilities, along with the existence of different degrees of insurance with respect to these shocks in studies of income versus consumption inequality. BPP conclude that only partial insurance exists with respect to very persistent income shocks, while transitory income shocks are almost fully insurable. They use these findings to argue that income and consumption inequality diverged over the latter half of the 1980s. A similar conclusion is shared by several other papers in the literature.[1]

BPPs estimates of the consumption insurance parameters are obtained to match the time series of the variances of the cross-sectional distribution of household income and consumption growth and their covariation, without regard to the higher-order moments of the distribution. Recent research has highlighted the pivotal role played by higher moments, in particular the skewness, of the cross-sectional distribution of household income and consumption growth in explaining several observed phenomena in macroeconomics and finance. Guvenen, Ozkan, and Song (2014), employing a very large and confidential dataset from the U.S. Social Security Administration, showed that, while the cross-sectional variance of household income growth is mostly flat over the business cycle, the cross-sectional third central moment (a commonly used measure of skewness) is strongly countercyclical, becoming significantly more negative during recessions. Busch, Domeij, Guvenen, and Madera (2015) show that countercyclical left skewness in the cross-sectional distribution of income growth is also a feature of countries like Germany and Sweden whose labor markets are quite different

[1] See e.g., Blundell and Preston (1998), Krueger and Perri (2006), and Heathcote, Perri, and Violante (2010).

from that in the US. Constantinides and Ghosh (2016) show that countercyclical left skewness is not just a feature of the income distribution, but that it is also observed in household consumption data. They build a dynamic equilibrium model, that features incomplete markets and heterogeneous households, with countercyclical left skewness in the cross-sectional distribution of household consumption growth, and show that time-varying skewness plays a central role in explaining several seemingly puzzling aspects of asset market data. These recent findings suggest that studies of income versus consumption inequality should also incorporate in the analysis time-varying higher moments of the income distribution. For instance, estimating the insurance parameters with respect to persistent and transitory income shocks to match solely the second moments of the cross-sectional distribution of income and consumption growth rates may produce biased results.

This paper investigates the link between income and consumption inequality and estimates the insurance parameters using a framework that incorporates time-variation in the higher-order moments of the income distribution. Following BPP, we model household income as being driven by a permanent and a transitory shock. But, differently from BPP, we propose a dynamic model for the evolution of the permanent shock that incorporates higher-order moments in the process in a tractable fashion. In particular, the permanent component of the income process is modeled as an exponential function of a Poisson mixture of normals random variable. The time-varying intensity of the Poisson process induces time-variation in the variance and higher-moments of the permanent component. This specification can generate countercyclical left skewness in the cross-sectional distribution of income and consumption growth, consistent with the findings in Guvenen, Ozkan, and Song (2014) and Constantinides and Ghosh (2016). Moreover, Constantinides and Ghosh (2016) showed that this specification of the persistent shocks, embedded as the endowment process in an equilibrium pure exchange economy, provides an explanation of several observed aspects of stock markets. The transitory component of the income process is modeled as a white noise process with potentially time-varying higher-order moments. For the transmission of the income shocks to consumption, we allow for different degrees of insurance with respect to the permanent and transitory shocks. To summarize, our specification resembles that in BPP with the point of departure being the incorporation of higher-order dynamics in the permanent and transitory components of income shocks.

We estimate the model using the generalized method of moments approach using panel data on income and nondurables consumption. We show that when the insurance parameters are estimated to match only the second moments of the cross-sectional distribution of household income and consumption growth, the estimates are similar to those in BPP. In particular, partial insurance exists with respect to the permanent income shocks, with the point estimate of the insurance parameter being about 0.54, close to the BPP point estimate of 0.64. The transitory shocks are fully insurable, with the point estimate of the insurance parameter being 0.00 - once again very close to the BPP point estimate of 0.05. At these parameter estimates, the model-implied time series of the cross-sectional second moments of income and consumption growth match well their sample counterparts However, the time series of the model-implied cross-sectional third moments of income and consumption growth provide a poor fit to their data counterparts. In particular, the model implies essentially flat time series for the third moments of income and consumption growth rates, in stark contrast to the patterns observed in the data.

The above results change significantly when the model parameters are estimated to simultaneously match the second *and* third moments of income and consumption growth. The insurance parameter with respect to the transitory shocks remains virtually unchanged at 0.00. But, the insurance parameter with respect to the permanent shocks is estimated to be 0.997 - statistically and economically larger than the 0.54 point estimate obtained in the absence of the third moments in the estimation and is statistically indistinguishable from one. Therefore, we cannot reject the hypothesis that no insurance exists with respect to permanent shocks to income. Importantly, at the new parameter estimates, the model matches well the time series of both the second and third moments of income and consumption growth rates. Our results suggest that consumption inequality tracks income inequality much more closely than what has been argued in earlier literature and highlights the role of time-varying higher-order moments of the income process in reaching this conclusion.

What drives our results? The intuition behind our result can be summarized by the following two observations. First, both the permanent and transitory shocks contribute substantially to the overall cross-sectional variance of income growth. However, the permanent component alone drives the variation in the third moment of income growth – the joint hypothesis that the third moment of the transitory income shocks is zero in all the time periods cannot be rejected at conventional significance levels. Since the transitory shocks can be more effectively insured than the more persistent shocks, this suggests that the correlation between the third moments of income and consumption growth should be higher than the correlation between their variances – an implication that is supported by the data. Second, the magnitude of the skewness in consumption growth is very similar to that in income growth. Now, the third moment of consumption growth depends on the third moments of the permanent and transitory shocks to income growth, the shocks to consumption unrelated to those in income (e.g., taste shocks), and the measurement error. The hypotheses that the measurement error in consumption has constant third moment cannot be rejected. Therefore, measurement error does not contribute to the third moment of consumption growth. Therefore, the only contribution to the third moment of consumption growth comes from the permanent income shock. And, since the magnitudes of the third moments of income and consumption growth are very similar in the data, this is only feasible with the insurance parameter with respect to the permanent shocks being close to 1. Since the estimate of the insurance parameter with respect to the persistent income shocks increases from 0.54 to 0.997 upon inclusion of the third moments in the estimation, how does the model continue to provide a good fit for the second moments of income and consumption growth? It does so by reducing slightly the contribution of the permanent shocks to the variance of income growth and, therefore, increasing a little the contribution of the transitory shock such that the overall variance of income and consumption growth remain largely unchanged.

Our paper provides empirical evidence consistent with Ai and Bhandari (2016) who show that workers would be uninsured against tail risks under a limited commitment optimal contract where capital owners provide insurance to workers against idiosyncratic fluctuations in their labor productivities but cannot commit to contracts that yield a negative net present value of dividends. Such tail risks are ruled out in existing studies of the link between income and consumption inequality, leading the estimate of the insurance parameter with respect to persistent income shocks to be biased in the direction of excessive insurance.

Our conclusions are similar to that in Aguir and Bils (2015) who, using an alternative measure of consumption expenditure based on a demand system, also argue that consumption inequality has closely tracked income inequality. These authors argue that the main reason for the difference between their results and the earlier literature is their newly constructed measure of consumption expenditure that is different from the traditional approach of directly summing household expenditures, and is robust to systematic trends in measurement error that may plague the traditional measure. Our conclusions, on the other hand, obtain even using the traditional measure of consumption expenditure, just by incorporating time-variation in the higher-order moments of the income distribution – a phenomenon for which there is ample recent empirical evidence.

Finally, our paper is related to Arellano, Blundell, and Bonhomme (2015) who study the transmission of income shocks to consumption in the presence of nonlinearities in the income process. Motivated by the observations that nonlinearities in the earnings process generally imply a consumption function that is a complex nonliner function of the income components and that linear aproximations to the equilibrium conditions may not be accurate in such settings, Arellano, Blundell, and Bonhomme (2015) model the optimal consumption rule as a nonlinear function of the persistent and transitory income shocks. By contrast, in this paper, we model the consumption function as linear in the persistent and transitory income shocks even in the presence of nonlinearities in the income process. This is motivated by the the evidence in Constantinides and Ghosh (2016) that such a specification for the household consumption process in conjunction with a carefully chosen specification of the persistent income shocks is consistent with the Euler equations of infinitely-lived households endowed with Kreps and Porteus (1978) recursive preferences. This paper presents evidence that this model for the evolution of the income distribution across households and over time along with the linear specification for the consumption function is consistent with several aspects of income and consumption data and can be used to address other phenomena in macroeconomics, labor economics, and finance.

The remainder of the paper is organized as follows. Section II describes our model for the evolution of the income process and the transmission of income shocks to consumption. Section III describes the identification of the model parameters. Section IV describes the data. The empirical results are presented in Section V. Section VI presents a nonparametric specification of the permanent income shocks and shows that our results are robust to the particular modeling choice for the persistent income shocks. Section VII provides the intuition behind our results. Section VIII concludes with suggestions for future research. The derivations are relegated to the Appendix.

II Model for the Income Process and Transmission of Income Shocks to Consumption

To investigate the link between income and consumption inequality, the two central ingredients are (1) the specification of the evolution of the income distribution, and (2) a framework for studying how income shocks are transmitted to consumption. In this section, we describe our modeling choices for these two ingredients.

We follow BPP and adopt a permanent-transitory model for the income process. In particular, the real (log) income of household i at time t, $\log(Y_{i,t})$, has a permanent component $P_{i,t}$ and a transitory component $\varepsilon_{i,t}$:

$$\log(Y_{i,t}) = z_{i,t}'\varphi_t + \log(P_{i,t}) + \varepsilon_{i,t} \tag{1}$$

In the above equation, $z_{i,t}$ denotes a set of income characteristics in the time-t information set of consumers (e.g., demographic, education, ethnic, and other variables). The parameter φ_t allows the effect of such characteristics to vary with calendar time.

Our point of departure from BPP lies in the specification of the permanent component $P_{i,t}$ in equation (1). Unlike BPP who assume that $P_{i,t}$ follows a random walk, we model it as an exponential function of a Poisson mixture of normals random variable:

$$P_{it} = \exp\left(\sum_{s=1}^{t}\left\{j_{i,s}^{1/2}\sigma\eta_{i,s} - j_{i,s}\frac{\sigma^2}{2} + \omega_s\frac{\sigma^2}{2}\right\}\right),$$

$$\eta_{it} \sim i.i.d.\ N(0,1),$$

$$\text{Prob}(j_{i,s}=n) = \frac{e^{-\omega_s}\omega_s^n}{n!}, \quad n = 0,1,2,.... \tag{2}$$

This particular specification of the permanent component has several attractive features. First, true to its definition, since P_{it} is determined by the sum of *all* past shocks, this component has a permanent impact on income. Second, note that each term in the exponent is normal, conditional on the Poisson variable j and its time-varying intensity ω. It is in this sense that the permanent component is described as an exponential function of a Poisson mixture of normals. As will be seen below, this specification generates higher-order moments of the income distribution in a tractable fashion. For this reason, such an exponential mixture structure is popular in other literatures, e.g. in trade and firm dynamics model, where it is also used to capture rich higher-order moments and thick-tailed distributions. Third, consistent with empirical evidence, the time-varying intensity of the Poisson process driving the persistent shocks induces time-variation in the variance and higher-order moments of the income process. In particular, it generates countercyclical left skewness in the cross-sectional distribution of household income and consumption growth, consistent with the evidence documented in Guvenen, Ozkan, and Song (2014) and Constantinides and Ghosh (2016), respectively. Fourth, Constantinides and Ghosh (2016) show that the above specification, when embedded as the endowment process in an equilibrium asset pricing model, plays a central role in matching several aspects of financial market data including the high observed level of the equity premium, the low risk free rate, the excess volatility of asset prices relative to subsequent changes in dividends, and the cross-sectional dispersion in average returns between different classes of financial assets. Finally, we assume a nonparametric specification of the permanent component in Section VI and show that the results remain virtually unchanged. This result affirms the generality of the specification in equation (2) and provides a modeling framework that can be used to address other questions in macro and labor economics.

The transitory shock to income, $\varepsilon_{i,t}$, in equation (1) is modeled as a white noise process.[2] We allow the variance as well as the higher-order moments of this component to be potentially

[2]It is straightforward to extend the analysis to an $MA(q)$ process.

time-varying. The permanent and transitory shocks are assumed to be orthogonal to each other.

Given the specifications for the permanent and transitory shocks, the unexplained (or idiosyncratic) income growth, $\Delta y_{i,t} \equiv \Delta\left(\log\left(Y_{i,t}\right) - z'_{i,t}\varphi_t\right)$, is given by

$$\Delta y_{i,t} = \left(j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right) + \varepsilon_{i,t} - \varepsilon_{i,t-1} \tag{3}$$

Therefore, the variance of the cross-sectional distribution of income growth is given by

$$E\left[\left(\Delta y_{i,t}\right)^2\right] = \left(\sigma^2 + \frac{\sigma^4}{4}\right)\omega_t + E\left(\varepsilon_{i,t}^2\right) + E\left(\varepsilon_{i,t-1}^2\right),$$

and the third central moment (skewness) is

$$E\left[\left(\Delta y_{i,t}\right)^3\right] = -\left(\frac{3}{2}\sigma^4 + \frac{1}{8}\sigma^6\right)\omega_t + E\left(\varepsilon_{i,t}^3\right) - E\left(\varepsilon_{i,t-1}^3\right).$$

Note that, the contributions to the variance and skewness of income growth arising from the permanent shocks are perfectly correlated to each other, i.e. periods of high variance of permanent income shocks coincide with periods of large negative skewness of these shocks. As we discuss in Section IV below, this feature of the model seems to be consistent with the data.

Having specified the dynamics of the income process, our framework for studying how income shocks are transmitted to consumption follows closely that in BPP. Specifically, we assume that the true (unobserved) consumption growth is given by

$$\Delta c_{i,t} = \phi_{i,t}\left(j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right) + \psi_{i,t}\varepsilon_{i,t} + \xi_{i,t}, \tag{4}$$

where $c_{i,t}$ denotes household i's (log) real consumption net of its predictable components at time t. In other words, the consumption growth depends on permanent shocks to income and transitory shocks to income. $\phi_{i,t}$ and $\psi_{i,t}$ denote, respectively, the extent of insurance that exists with respect to permanent and transitory income shocks. $\phi_{i,t} = \psi_{i,t} = 0$ implies full consumption insurance while $\phi_{i,t} = \psi_{i,t} = 1$ implies no consumption insurance. In addition to being affected by income shocks, consumption growth also depends on shocks unrelated to those in income ξ (e.g., taste shocks). The taste shock is assumed to have a constant variance as well as potentially non zero (albeit constant) higher moments.

Note that nonlinearities in the earnings process generally imply a consumption function that is a complex nonlinear function of the income components and recent research has highlighted that linear aproximations to the equilibrium conditions may not be accurate in such settings (see, e.g. Kaplan and Violante (2010)). For instance, Arellano, Blundell, and Bonhomme (2015), that studies the transmission of income shocks to consumption in the presence of nonlinearities in the income process, model the optimal consumption rule as a nonlinear function of the persistent and transitory income shocks. By contrast, in this paper, we model the consumption function as linear in the persistent and transitory income shocks even in the presence of nonlinearities in the income process. This is motivated by Constantinides and Ghosh (2016) who show that the above specification of the consumption growth process, with $\phi_{i,t} = 1$, $\psi_{i,t} = 0$, and $\xi_{i,t} = 0$ is consistent with the intertemporal consumption-savings choice problem of households. In particular, they build a dynamic equilibrium asset pricing model where Equation (4) (with the above restrictions) is specified as the consumption process of household i at time t in an endowment economy where households have identical recursive preferences (see e.g., Kreps and Porteus (1978), Epstein and Zin (1989)). The Poisson intensity ω_t of the persistent shocks is assumed to follow an autoregressive gamma process. The specification satisfies the consumption Euler equations of households for both the risk free rate as well as the return on a broad stock market index capturing risky investment opportunities available to households. The Constantinides and Ghosh (2016) model is a partial equilibrium model where the consumption process can be interpreted at the post-trade consumption allocation of household i at time t and no reference is made to the link between income and consumption. The current paper, on the other hand, attempts to provide the underpinnings of the consumption specification as resulting from an underlying income process subject to permanent and transitory shocks for which varying degrees of insurance exist. Rather than setting the insurance parameters $\phi_{i,t} = 1$ and $\psi_{i,t} = 0$, as in Constantinides and Ghosh (2016), we estimate them to match the joint distribution of household income and consumption growth. Our results, presented in Sections V and VI, suggest that no insurance exists against permanent income shocks, i.e. $\phi_{i,t} \approx 1$, and that full insurance exists against transitory income shocks, i.e $\psi_{i,t} \approx 0$. These results lend support to the consumption specification in Constantinides and Ghosh (2016) and the ensuing asset pricing implications.

In our empirical analysis, household-level consumption data is obtained by combining information in the Consumer Expenditure Survey (CEX) and Panel Survey of Income Dynamics (PSID) databases. Both datasets are survey-based and, therefore, may have considerable measurement error. We allow for measurement error in consumption by specifying that the measured (or observed) consumption, $c^*_{i,t}$, is the sum of the true consumption, $c_{i,t}$, and the measurement error, $u_{i,t}$:

$$c^*_{i,t} = c_{i,t} + u_{i,t},$$

Therefore, the measured consumption growth is given by

$$\Delta c^*_{i,t} = \phi_{i,t}\left(j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right) + \psi_{i,t}\varepsilon_{i,t} + \xi_{i,t} + \Delta u_{i,t} \quad (5)$$

We assume that the measurement error is *i.i.d.* with potentially time-varying variance and third moment. We also assume that the shocks $j_{i,t}$, $\eta_{i,t}$, $\varepsilon_{i,t}$, $\xi_{i,t}$, and $u_{i,t}$ are mutually independent. Note that, under these assumptions, measurement error induces serial correlation in observed consumption growth, $E\left[\Delta c^*_{i,t}\Delta c^*_{i,t+1}\right] = -E\left(u^2_{i,t}\right)$. The variance of the cross-sectional distribution of consumption growth is given by

$$E\left[\left(\Delta c^*_{i,t}\right)^2\right] = \phi_t^2\left(\sigma^2 + \frac{\sigma^4}{4}\right)\omega_t + \psi_t^2 E\left(\varepsilon^2_{i,t}\right) + E\left(\xi_i^2\right) + E\left(u^2_{i,t}\right) + E\left(u^2_{i,t-1}\right),$$

and the third central moment (skewness) is

$$E\left[\left(\Delta c^*_{i,t}\right)^3\right] = -\phi_t^3\left(\frac{3}{2}\sigma^4 + \frac{1}{8}\sigma^6\right)\omega_t + \psi_t^3 E\left(\varepsilon^3_{i,t}\right) + E\left(\xi_i^3\right) + E\left(u^3_{i,t}\right) - E\left(u^3_{i,t-1}\right).$$

Therefore, the moments of observed consumption growth reflect the contributions from the permanent and transitory income shocks, the degrees of insurance with respect to these shocks, as well as the taste shock and measurement error in observed consumption.

III Identification of Insurance and Other Model Parameters

Our specification of the joint dynamics of the income and consumption growth processes imposes restrictions on their second and higher-order moments that can be used to identify the insurance and other model parameters. Consistent with empirical evidence, we allow for non-stationarity in the distributions of most of the shocks. In particular, the specification of the permanent income shocks in equation (2) implies that the cross-sectional variance and third moment of the permanent shocks are time-varying. We also allow the cross-sectional variance and third moment of the transitory shocks, $E\left(\varepsilon^2_{i,t}\right)$ and $E\left(\varepsilon^3_{i,t}\right)$, to be time-varying. The shocks to consumption unrelated to those in income are assumed to have a stationary distribution, i.e. have constant variance and third moment, i.e. $E\left(\xi^2_{i,t}\right) = E\left(\xi^2_i\right)$ and $E\left(\xi^3_{i,t}\right) = E\left(\xi^3_i\right)$ for all t[3]. BPPs imputation procedure for nondurables consumption

[3] It is straightforward to allow for non-stationarity in the distribution of the ξ shocks.

induces non-stationarity in the measurement error for imputed nondurables consumption. We, therefore, allow the cross-sectional variance, $E\left(u_{i,t}^2\right)$, and third moment, $E\left(u_{i,t}^3\right)$, of the measurement error in consumption to vary with time. Finally, consistent with the evidence in BPP, we set the insurance parameters ϕ and ψ to be constant over the sample. Therefore, the full set of parameters to be estimated consists of the parameters of the income process $\{\omega_s\}_{s=1}^T$, σ, $\left\{E\left(\varepsilon_{i,t}^2\right)\right\}_{s=1}^T$, and $\left\{E\left(\varepsilon_{i,t}^3\right)\right\}_{s=1}^T$; the constant variance and third moment of the shocks to consumption unrelated to those in income, $E\left(\xi_i^2\right)$ and $E\left(\xi_i^3\right)$, respectively; the variance and third moment of the measurement error in consumption, $\left\{E\left(u_{i,t}^2\right)\right\}_{s=1}^T$, and $\left\{E\left(u_{i,t}^3\right)\right\}_{s=1}^T$, respectively; and the insurance parameters ϕ and ψ.

We now describe how these parameters can be identified using T years of income and consumption growth data. Detailed derivations are provided in Appendix A. In particular, for a given time period $t = 1, 2, ..., T-1$, the variance of the transitory shock can be identified using

$$E\left[\Delta y_{i,t}\Delta y_{i,t+1}\right] = -E\left(\varepsilon_{i,t}^2\right); \tag{6}$$

the third moment of the transitory shock is identified from

$$E\left[\left(\Delta y_{i,t}\right)^2\Delta y_{i,t+1}\right] = -E\left(\varepsilon_{i,t}^3\right); \tag{7}$$

the insurance parameter with respect to the transitory shocks can be identified from the equation

$$E\left[\Delta c_{i,t}^*\Delta y_{i,t+1}\right] = -\psi E\left(\varepsilon_{i,t}^2\right); \tag{8}$$

the variance of the measurement error is identified from the equation

$$E\left[\Delta c_{i,t}^*\Delta c_{i,t+1}^*\right] = -E\left(u_{i,t}^2\right); \tag{9}$$

and the third moment of the measurement error is identified from

$$E\left[\left(\Delta c_{i,t}^*\right)^2\Delta c_{i,t+1}^*\right] = -E\left(u_{i,t}^3\right). \tag{10}$$

For $t = 2, ..., T-1$, the parameters σ and ω_t can be identified from the equations:

$$E\left[\Delta y_{i,t}\left(\Delta y_{i,t-1} + \Delta y_{i,t} + \Delta y_{i,t+1}\right)\right] = \left(\sigma^2 + \frac{\sigma^4}{4}\right)\omega_t, \tag{11}$$

$$E\left[\left(\Delta y_{i,t}\right)^2\left(\Delta y_{i,t-1} + \Delta y_{i,t} + \Delta y_{i,t+1}\right)\right] = -\left(\frac{3}{2}\sigma^4 + \frac{1}{8}\sigma^6\right)\omega_t; \tag{12}$$

the insurance parameter with respect to the permanent shocks can be identified from the equation

$$E\left[\Delta c_{i,t}^{*}\left(\Delta y_{i,t-1}+\Delta y_{i,t}+\Delta y_{i,t+1}\right)\right]=\phi\left(\sigma^{2}+\frac{\sigma^{4}}{4}\right)\omega_{t}; \tag{13}$$

the variance of the shocks to consumption unrelated to those in income is identified using

$$E\left[\Delta c_{i,t}^{*}\left(\Delta c_{i,t-1}^{*}+\Delta c_{i,t}^{*}+\Delta c_{i,t+1}^{*}\right)\right]=\phi^{2}\left(\sigma^{2}+\frac{\sigma^{4}}{4}\right)\omega_{t}+\psi^{2}E\left(\varepsilon_{i,t}^{2}\right)+E\left(\xi_{i}^{2}\right); \tag{14}$$

and, finally, the third central moment of the shocks to consumption unrelated to those in income is identified from the equation

$$E\left[\left(\Delta c_{i,t}^{*}\right)^{2}\left(\Delta c_{i,t-1}^{*}+\Delta c_{i,t}^{*}+\Delta c_{i,t+1}^{*}\right)\right]=-\phi^{3}\left(\frac{3}{2}\sigma^{4}+\frac{1}{8}\sigma^{6}\right)\omega_{t}+\psi^{3}E\left(\varepsilon_{i,t}^{3}\right)+E\left(\xi_{i}^{3}\right), \tag{15}$$

Therefore, the parameters can be estimated using the standard GMM approach and the model specification can be tested using the overidentifying restrictions.

IV Data

We use panel data on income and consumption. As is evident from equations (6)-(15), panel data is required to investigate the link between the evolution of income and consumption inequality and to estimate the insurance parameters with respect to the permanent and transitory income shocks. In particular, panel data is necessary to separately identify the time-varying moments of the persistent and transitory income shocks and the degree of insurance that exists with respect to these shocks. The Panel Survey of Income Dynamics (PSID) has panel data on income and consumption expenditures for a representative sample of U.S. households since 1968. However, for the most part of the sample, the PSID only collected consumption expenditures on food items. It has been argued that food expenditure is a noisy estimate of the total nondurables consumption expenditure. Moreover, over time, it represents a declining fraction of the total consumption expenditure. Therefore, using food consumption as a proxy for the total consumption expenditure may produce misleading results. The Consumer Expenditure Survey (CEX), on the other hand, attempts to account for an estimated 95% of all household expenditures in each consumption category from a highly disaggregated list of consumption goods and services. However, the CEX database lacks the panel dimension – it consists of repeated cross sections of data whereby each household is interviewed for only 4 regular quarters[4] after which a newly chosen household replaces it.

BPP propose an approach to imputing total nondurables consumption in the PSID by combining information from the PSID and CEX databases. Our construction of the total consumption expenditure follows closely that in BPP and serves as the measure of consumption expenditures in our empirical analysis. As in BPP, our measure of income is net family income, defined as the sum of labor income (earned by the head and the spouse) and transfers (such as welfare payments) minus taxes paid. We also investigate the role of taxes and transfers and family labor supply in providing insurance against income shocks by using alternative definitions of income such as labor earnings and male labor earnings. Our sample is annual spanning the period 1980-1992. The sample coincides with that in BPP and, as highlighted in BPP, corresponds to the period over which the most pronounced changes in income inequality occurred in the US. We briefly describe the imputation procedure for total consumption in Section IV.1 and refer the reader to BPP for a more detailed description. Readers familiar with the BPP imputation procedure can skip Section IV.1 without loss of continuity. Section IV.2 presents summary statistics from the cross-sectional distributions of income and (imputed) consumption growth.

IV.1 Imputation of Nondurables Consumption in the PSID

Our baseline sample consists of all the PSID households with continuously married couples with the male, aged 30 to 65, being the primary wage earner. Households are eliminated from our sample in the events of a change in the primary wage earner or a change in the spouse of the primary wage earner. Therefore, our analysis focuses on income risk, and not on divorce, widowhood, or other household breaking up factors. This sample selection procedure is replicated in the CEX database to the extent possible. Finally, we focus on the group of households in the PSID that are representative of the U.S. population, eliminating the supplementary low-income subsample (SEO) of households.

The following demand equation for food is specified for any household i at time t:

$$f_{i,t} = W_{i,t}'\mu + p_t'\gamma + \beta\left(D_{i,t}\right)c_{i,t} + e_{i,t},$$

where f is the log of real food expenditure, defined as the sum of annual expenditures on food at home and food away from home; c is the log of nondurables consumption expenditure,

[4]Each household is interviewed for 5 quarters, the first of which is regarded as a training quarter and not used in empirical analyses.

defined as the sum of food, alcohol, tobacco, and expenditures on other nondurable goods, such as services, heating, fuel, public and private transport (including gasoline), personal care, and semidurables, defined as clothing and footwear; W contains a set of demographic variables, including dummy variables for the number of children, level of education, geographic location, birth cohort, and ethnicity, as well as the age, square of age, and family size; p contains relative prices of food, transport, fuel and utilities, and alcohol and tobacco; and e captures unobserved heterogeneity in the demand for food and measurement error in food expenditure. The budget elasticity $\beta(.)$ – the fraction of food expenditure in total nondurables consumption expenditure – is allowed to vary with time and with observable household characteristics D. Note that data on f, W, and p are available in both the PSID and CEX databases, while total nondurable consumption c is available in the CEX database alone.

The above equation is estimated using CEX data pooled from 1980-1992. An instrumental variables approach is used in the estimation to accommodate potential measurement error in total nondurables consumption. We use two instruments for total consumption – the average of the hourly wage of the husband and the average of the hourly wage of the wife, where the averages are computed by cohort, year, and education in both cases. Under the assumption that food demand is monotonic, the above demand equation can be inverted to obtain a measure of nondurable consumption c for families in the PSID using the available data on their food expenditure. The panel data on income are readily obtained from the PSID. The income and imputed nondurables consumption are converted to real using the Consumer Price Index. Since CEX data is available only since 1980, we construct an unbalanced PSID panel using data from 1978 to 1992.

Next, we compute income and consumption net of their respective predictable components by regressing the real income and real imputed nondurables consumption on year and year-of-birth dummies, and dummies for education, race, family size, number of children, region of residence, employment status, residence in a large city, presence of outside dependents in the family, and the presence of income recipients other than the husband and wife. The dummies for education, race, employment status, region, and residence in large city are interacted with the year dummies to allow the effect of these characteristics to vary over time. The residuals from these regressions are our empirical counterparts to unexplained or idiosyncratic income and consumption. The first difference of these residuals constitute unexplained income growth and consumption growth.

IV.2 Summary Statistics of Income and (Imputed) Nondurables Consumption in the PSID

Table 1 reports summary statistics from the cross-sectional distribution of income growth each year for the 1980-1992 sample. Column 1 shows the variance of the cross-sectional distribution. The column reveals a substantial increase in the variance over the first half of the eighties – the variance increased by 39% from 8.3% in 1980 to 11.5% in 1985. The variance stabilizes in the post 1985 period and even decreases slightly. Column 2 shows that the first-order autocovariance of the cross-sectional distribution of income growth is negative in all years and statistically significant in every year. Note that the model in Section II implies that the income growth has a negative first-order autocovariance induced by the transitory shock, and this is supported by the data. Column 3 shows that the second-order autocovariance of income growth is at least an order of magnitude smaller than the first-order autocovariance in all but two of the years and is generally statistically and economically small. This aspect of the data motivates our white noise specification for the transitory income shock.

Column 4 presents the third moment of the cross-sectional distribution of income growth - a commonly used measure of the skewness of the distribution. The third moment is negative in more than two-thirds of the sample period with its average being $-.016$. Moreover, the point estimates of the third moment are often economically large – for instance, the third moment is -0.10 in 1985 which implies a coefficient of skewness of -2.68 (compared to 0 for a Gaussian distribution), and the third moment is -0.04 in 1990 which implies a coefficient of skewness of -1.41. Note that most of the estimates are not statistically significant, mostly because of the small size of the cross-section and the inherent difficulties in estimating higher moments using a small sample size. However, the more powerful joint test that the third moment is zero in all the time periods is strongly rejected with a p-value of 0.043. Moreover, the findings are consistent with those in Guvenen, Ozkan, and Song (2014) who use a much richer panel dataset comprised of all working males in the United States to document strongly countercyclical left skewness of the cross-sectional distribution of income growth. Finally, Column 5 reports the covariance between squared current income growth and one-period-ahead income growth. In the context of our model, this covariance equals, in absolute value, the third moment of the transitory income shock (see equation (7)). Column 5 shows that this covariance is not statistically significant in any of the periods. Even the more powerful joint test of the null hypothesis that this moment is zero in all periods has a p-value of 0.42 and, therefore, the null cannot be rejected at conventional significance levels. More importantly, in about half of the years, this moment is at least an order of magnitude smaller than the corresponding third moment of income growth. This observation suggests that, although there is strong evidence that the third moment of income growth is time-varying, the contribution of the transitory income shock to the third moment of income growth is quite small. This observation will play an important role in the interpretation of our results in Section V. Since there is some evidence of time-variation in the covariance between squared current income growth and one-period-ahead income growth based on the point estimates of this moment, we allow the third moment of the transitory income shock to be non-zero and time-varying in the estimation.

Table 2 reports summary statistics from the cross-sectional distribution of consumption growth. Column 1 shows that, just like the cross-sectional variance of income growth, the variance of consumption growth increases sharply over the 1980-1985 period. Subsequently the variance stabilizes at a lower level. Note that the variance of consumption growth is considerably higher than the variance of income growth (Table 1, Column 1), suggesting the presence of measurement error in measured consumption. In the context of the model, measurement error in the consumption level induces negative serial correlation in measured consumption growth. In fact, the first-order autocovariance of consumption growth equals the variance of the measurement error in absolute value. Indeed, Column 2 shows that the first-order autocovariance of consumption growth and, therefore, the variance of the measurement error is statistically and economically large. Column 3 shows that the second-order autocovariance of consumption growth statistically insignificant and economically small in all time periods. This is consistent with the *i.i.d.* specification of the measurement error in our model.

Column 4 presents the third moment of the cross-sectional distribution of consumption growth. As with the income growth, the estimated third moments are mostly statistically insignificant because of the small size of the cross-sectional sample. However, the more powerful joint test that the third moment is zero in all the time periods is rejected at the 10% level of significance. Moreover, the third moments are negative in about half of the sample and often economically large. For instance, the third moment is -0.18 in 1985 which implies a coefficient of skewness of -1.74, and the third moment is -0.05 in 1992 which implies a coefficient of skewness of -0.76. Finally, Column 5 reports the covariance between squared current consumption growth and one-period-ahead consumption growth that, in the context of our model, equals the third moment of the measurement error in absolute value (see equation (10)). Column 5 shows that this covariance is not statistically significant in any of the periods. Even the more powerful joint test of the null hypothesis that this moment is zero in all periods has a p-value of 0.51 and, therefore, the null cannot be rejected at conventional significance levels. Since there is some evidence of time-variation in the covariance between squared current consumption growth and one-period-ahead consumption growth based on the point estimates of this moment, we allow the third moment of the measurement to be non-zero and time-varying in the estimation.

One important point to note regarding Tables 1 and 2 is the following. Note that the cross-sectional variance of income growth rises sharply by almost 40% from 1980 to 1985. The cross-sectional variance of observed consumption growth also increases substantially, from 11.9% to 21.6%, over this period. However, not only do the variances of income and consumption growth increase over the first half of the eighties, but so do the skewness (measured by the third moment) of their cross-sectional distributions. The third moment of income growth decreases from 0.02 in 1980 to -0.10 in 1985 and that of consumption growth declines from -0.002 to -0.18 over 1980-1985. In fact, the year with the largest cross-sectional variance of income and consumption growth, namely 1985, is also the year with the highest negative cross-sectional skewness. A closer examination reveals that the high variance in this year is not because of a uniform expansion of the two tails of the cross-sectional distributions (as the definition of variance would suggest). Rather it is because of the sharp expansion of the left tail of the distributions when moving from 1980 to 1985 (in fact, the right tail.of the income distribution actually shrinks over this period while that for the consumption distribution increases very slightly). This is reflected in the large negative skewness in the distributions of income and consumption growth in 1985. Therefore, focusing on variance alone would lead one to conclude that households received larger negative *and* positive income and consumption shocks in 1985 compared to 1980. Using skewness in conjunction with the variance, on the other hand, reveals that while certain households received large negative income and consumption shocks in 1985, these were not accompanied by large positive shocks for certain other households.

Finally, Tables 1-2 reveal an important aspect of the distributions of income and consumption growth that helps interpret our main results in the next section. Note that consumption growth is determined by not only the income shocks, but also the shocks to consumption growth unrelated to income e.g., taste shock (the ξ shock in equation (5)) and the measurement error. Moreover, the extent to which income shocks impact consumption depends on the degree of insurance that exists with respect to such shocks. Thus, the variance of the cross-sectional distribution of consumption growth depends on the variances of the permanent and transitory income shocks, the insurance parameters with respect to these two types of income shocks, as well as the variances of the taste shock and the measurement error. Therefore, the strength of the association between the variance of income growth and the variance of consumption growth depends on the relative contributions of the permanent and transitory income shocks to the overall variance of income growth and the insurance parameters with respect to these shocks. For instance, suppose that the insurance parameter with respect to the permanent income shock $\phi = 1$ and the insurance parameter with respect to the transitory shock $\psi = 0$. In this scenario, the larger is the contribution of the permanent component to the overall variance of income growth, the stronger is the association between the variances of income and consumption growth since the permanent income shocks are entirely transmitted to consumption. On the other hand, if the transitory shock accounts for most of the variance of income growth, since these shocks can be insured against and are not transmitted to consumption, there is a mismatch between the variances of income and consumption growth. A similar argument holds for the third moments of income and consumption growth. Figure 1, Panel A plots the time series of the cross-sectional variances of income growth (red dashed line) and consumption growth (black solid line). The figure shows that while the variance of consumption growth does show a clear relation to the variance of income growth, the association is far from perfect. In fact, the correlation between the variances of income and consumption growth rates is only 0.44. This implies that, in the context of the above example, the transitory income shocks constitute a substantial fraction of the variance of income growth. The taste shock and measurement error, that are assumed to be independent of the income shocks, help explain the differences in the levels of the variances of income and consumption growth. Figure 1, Panel B plots the time series of the cross-sectional third moments of income growth (red dashed line) and consumption growth (black solid line). The graph suggests a much stronger relation between the third moments of income and consumption growth rates compared to that between their variances. Indeed, the correlation between the third moments of income and consumption growth rates is 0.71 – much higher than the correlation of 0.44 between their variances. In the context of the above example, this suggests that the permanent income shock accounts for most of the variation in the third moment of income growth. Moreover, the magnitudes of the third moments of income and consumption growth are very close to each other suggesting a high value of the insurance parameter ϕ with respect to these shocks. Our estimation results in Section V formalize these insights.

V Empirical Results

To investigate the link between the evolution of income and consumption inequality, the quantities of interest are the parameters driving the variances and third moments of the permanent and transitory income shocks and how they vary over time, as well as the insurance coefficients with respect to the permanent and transitory shocks. We estimate these parameters using the generalized method of moments approach described in Section III for a variety of different specifications.

We first present results when only the second moments of the cross-sectional distribution of household income and consumption growth are included in the estimation. In particular, the moments included consist of the cross-sectional variance of income growth growth, the first-order autocovariance of income growth, the variance and first-order autocovariance of consumption growth, the covariance between income and consumption growth, and the covariance between income and lagged consumption growth. Note that, under the model assumptions, the covariance between consumption and lagged income growth is zero. Accounting for the fact that the PSID did not collect data on food expenditure in 1987 and 1988, this gives a total of 68 moments. The total number of parameters to be estimated is 37 – the time-varying variances of the permanent income shocks $\left\{\left(\sigma^2 + \frac{\sigma^4}{4}\right)\omega_t\right\}_{t=1980}^{1991}$,[5] the time-varying variances of the transitory income shocks $\{E(\varepsilon_t^2)\}_{t=1979}^{1991}$, the variance of the taste shocks $E(\xi_t^2)$, the time-varying variances of the measurement error in consumption $\{E(u_t^2)\}_{t=1979-1985,\ 1990-1991}$, the insurance coefficient with respect to the permanent income shock ϕ, and the insurance coefficient with respect to the transitory shock ψ. This approach is similar in spirit to that in BPP in that it does not attempt to match the time-variation in the higher moments of the cross-sectional income and consumption growth distributions. We use a diagonal weighting matrix where the diagonal entries correspond to the inverse of the variances of the sample moments.[6]

The results are presented in Tables 4A and 4B. Columns 2 and 4 of Table 4A, that present the estimates of the permanent and transitory variances, respectively, show that, not surprisingly, the estimates are close to those obtained in BPP. Specifically, both the permanent and transitory shocks contribute substantially to the variance of annual income growth. For instance, in 1981, the permanent component accounts for 34.6% of the model-implied variance of income growth while the transitory component accounts for the remaining

[5] Note that, when only the second moments of income and consumption growth are included in the estimation, the parameters σ and ω of the permanent income shocks cannot be separately identified.

[6] We present our baseline results using this diagonal weighting matrix because of the well documented poor finite sample performance of the efficient weighting matrix and the observation that the poor performance is mostly the result of the off-diagonal terms. In additional unreported robustness tests, we repeated the estimation using both the efficient weighting matrix as well as the identity weighting matrix and obtained largely similar results. The results are available from the author upon request.

65.4%. The contribution of the permanent component increased from 9.9% in 1980 to 49.3% in 1983. Although the contribution of the permanent component declined slightly thereafter to 45.1% in 1984 and 40.6% in 1985, the sharp increase in the variance of income growth over 1980-1985 was due almost entirely to the increase in the variance of the permanent component over this period. This is evident from the observation that

$$\begin{aligned}\Delta Var\left(\Delta y_t\right) &\equiv Var\left(\Delta y_{1985}\right) - Var\left(\Delta y_{1980}\right) \\ &= \left(\sigma^2 + \frac{\sigma^4}{4}\right)\omega_{1985} - \left(\sigma^2 + \frac{\sigma^4}{4}\right)\omega_{1980} \\ &+ Var\left(\varepsilon_{1985}\right) + Var\left(\varepsilon_{1984}\right) - Var\left(\varepsilon_{1980}\right) - Var\left(\varepsilon_{1979}\right).\end{aligned}$$

Plugging in the parameter estimates from Table 4 into the above equation, the contribution of the permanent component to the overall increase in the variance of income growth is obtained as 84.9%. This is consistent with the findings in BPP and also Moffitt and Gottschalk (1995) that the sharp increase in the variance of income growth during the first half of the eighties – a nearly 40% increase – is largely the consequence of a strong growth in the permanent income shocks during this period.

The point estimate of the partial insurance parameter ϕ with respect to the permanent income shocks is 0.54, within the 95% confidence interval of the 0.64 estimate in BPP. In other words, we find evidence of partial consumption insurance with respect to persistent income shocks – a 1% change in income leads to only a .5% change in consumption. We find evidence of full insurance with respect to transitory income shocks - the point estimate of the insurance parameter ψ with respect to the transitory shocks is 0.00, once again within one standard error of the 0.05 estimate in BPP. Table 4B shows that the shock to consumption unrelated to income, i.e. the taste shock, has a variance of 0.012, that is small but statistically significant. The measurement error in consumption, on the other hand, has a large variance varying from 0.052 in 1979 to 0.10 in 1984. Therefore, a substantial part of the variance of consumption growth reflects the contribution of the measurement error.

Using the parameter estimates in Tables 4A and 4B, we compute the model-implied time series of the second and third moments of the cross-sectional distributions of household income and consumption growth.[7] Figure 2 shows that the model fits quite well the time

[7] The third moment of income growth is given by $E\left[\left(\Delta y_{i,t}\right)^3\right] = -\left(\frac{3}{2}\sigma^4 + \frac{1}{8}\sigma^6\right)\omega_t$. Note, that, σ and ω cannot be separately identified when only the second moments of income and consumption growth are included in the estimation. The estimation provides an estimate of the cross-sectional variance of income growth at time t as $E\left[\left(\Delta y_{i,t}\right)^2\right] = \left(\sigma^2 + \frac{1}{4}\sigma^4\right)\omega_t$. Using this estimate, we compute the cross-sectional third moment of income growth at time t as $E\left[\left(\Delta y_{i,t}\right)^3\right] = -E\left[\left(\Delta y_{i,t}\right)^2\right]$. Note that this estimates the third

series of the variances and first-order autocovariances of the income and consumption growth rates, and the covariance between the income and consumption growth rates. So far, the results are quite similar to those obtained in BPP. However, Figure 3 shows that these parameter estimates provide a poor fit to the time series of the third moments of income and consumption growth. In particular, the model implies an essentially flat time series for the third moment of household consumption growth, in stark contrast with the pattern observed in the data.

Next, we proceed to estimate the model parameters to match simultaneously the time series of the second and third moments of income and consumption growth, i.e., using the full set of moments described in Section III. This gives a total of 137 moment restrictions in 61 parameters. The results are reported in Columns 3 and 5 of Tables 4A and 4B.[8] Columns 3 and 5 of Tables 4A reveal that the results obtained from trying to simultaneously match the second and third moments of income and consumption growth seem similar in several respects to those obtained in Columns 2 and 4 from trying to solely match the second moments. Specifically, all of the increase in the variance of income growth in the first half of the 1980s was due to the permanent component – the permanent component accounted for 111.0% of the increase in the variance whereas the contribution of the transitory component was negative at -11.0%. Both the permanent and transitory shocks contribute significantly to the variance of annual income growth. Table 4B shows that all of the increase in the left skewness of income growth in the first half of the 1980s was due to the permanent component. With regard to the variance of consumption growth, the taste shock with a variance of 0.001 has a negligible contribution, while the measurement error has large variance varying from 0.054 in 1981 to 0.10 in 1984.

However, there are important differences in the results when the model parameters are estimated to simultaneously match the second and third moments of income and consumption growth compared to when the third moments are excluded from the estimation. In particular, the insurance parameter with respect to the permanent shocks is estimated to be 0.997 - statistically and economically larger than the 0.54 point estimate obtained in the absence of the third moments in the estimation. Therefore, we cannot reject the hypothesis

moment upto a positive constant scale factor equal to $\frac{\frac{3}{2}\sigma^4+\frac{1}{8}\sigma^6}{\sigma^2+\frac{1}{4}\sigma^4}$. Given the third moment of income growth, the third moment of consumption growth is obtained as $E\left[\left(\Delta c^*_{i,t}\right)^3\right] = \phi^3 E\left[\left(\Delta y_{i,t}\right)^3\right]$.

[8] Note that, when both the second and third moments of income and consumption growth are included in the estimation, the parameters σ and ω of the permanent income shocks can be separately identified and, therefore, estimated. Using the point estimates of the σ and ω parameters, the standard errors of the variances of the permanent income shocks are obtained using the Delta Method.

that *no insurance* exists with respect to permanent shocks to income. The estimate of the insurance parameter with respect to the transitory shocks, however, remains at 0.00 even when the third moments are included in the estimation suggesting that full insurance exists for transient income shocks. Note that, if some proportion of the income shock is anticipated by the households who then incorporate it into their consumption decision, this would lead to an underestimation of the partial insurance parameters. Therefore, in the case of availability of advance information, the true values of the parameters may be even higher than that estimated in the data. Figure 4 shows that, with the inclusion of the third-order moments in the estimation, the model-implied time series of the second moments of the cross-sectional distribution of income and consumption growth continue to line up closely with their respective sample counterparts as in Figure 2 where the estimation targets the second moments alone. But, Figure 5 shows that, when the third moments are included in the estimation, the model provides a good fit to the third moments of income and consumption growth rates as well – in stark contrast to the flat model-implied time series of the third moments of the growth rates when the second moments alone are used in the estimation of the model parameters.

Our results suggest that consumption inequality tracks income inequality much more closely than what has been argued in earlier literature and highlights the role of higher-order moments of the income process in reaching this conclusion.

VI A Nonparametric Specification of the Income Shocks

The model in Section II specifies an exponential mixture distribution for the persistent idiosyncratic income shocks. While this choice offers a fairly flexible specification of the income process and is commonly used in other literatures to capture rich higher-order moments in a tractable fashion and model fat-tailed distributions, it nonetheless raises the question as to whether our conclusions critically depend on the particular specification assumed. In this section, we offer a nonparametric specification of the permanent income shocks and investigate how this impacts the results of the previous section.

As in Section II, the idiosyncratic income process is subject to a permanent and a transitory shock. However, differently from the model in Section II, the permanent shock follows a martingale process:

$$P_{i,t} = P_{i,t-1} + \varsigma_{i,t},$$

where $\varsigma_{i,t}$ is independent across time. Note that this specification of the permanent component is similar to that in BPP, with the key difference being that we allow $\varsigma_{i,t}$ to not only have time-varying variance but also time-varying third moment. The specifications of the transitory income shock, the taste shock and measurement error in consumption are the same as in Section II.

The parameters to be estimated for this new model specification include the time-varying variances, $\{E(\varsigma_t^2)\}_{t=1}^T$, and third-order moments, $\{E(\varsigma_t^3)\}_{t=1}^T$, of the permanent income shocks; the time-varying variances, $\{E(\varepsilon_t^2)\}_{t=1}^T$, and third-order moments, $\{E(\varepsilon_t^3)\}_{t=1}^T$, of the transitory income shocks; the constant variance, $E(\xi^2)$, and third moment, $E(\xi^3)$, of the taste shock; the time-varying variances, $\{E(u_t^2)\}_{t=1}^T$, and third-order moments, $\{E(u_t^3)\}_{t=1}^T$, of the measurement error in consumption; and the insurance parameters ϕ and ψ with respect to the permanent and transitory income shocks, respectively. Appendix A.2 describes the identification of the parameters that are then estimated using a similar GMM approach.

The results are presented in Tables 5A and 5B. Columns 2 and 4 present the parameter estimates when only the second moments of income and consumption growth are included in the estimation. The table shows that all the parameter estimates are identical to those obtained for the more parametric model specification in Tables 4A and 4B. Note that this is to be expected since the third moments of the income and consumption processes are not included in the estimation and, therefore, the $\{\omega_t\}$ parameters – that simultaneously drive *all* the moments of the income distribution under the parametric model specification and is the only difference between the two models – are chosen to match only the time series of the variance without regard to the higher-order moments.

Columns 3 and 5 present the parameter estimates when both the second and third moments of income and consumption growth are included in the estimation. In this case, the exponential mixture distributional assumption for the permanent income shocks in the parametric model specification may be viewed as a restricted version of the martingale specification of the permanent shocks in the nonparametric model. This is because, in the former model, the $\{\omega_t\}$ parameters simultaneously drive not only the variance but *all* the moments of the income distribution. In fact, under the model assumptions, the second and third moments of the permanent shocks to income growth are both linear in ω and, therefore, perfectly correlated. The more nonparametric model, on the other hand, freely estimates the time-varying second and third moments of the permanent income shocks to match the data and, therefore, allows for the possibility that these moments are driven by different underlying state variables. The table shows that, once again, the parameter estimates are very similar to those obtained in Table 4A and 4B. In particular, the point estimate of the insurance parameter with respect to the permanent shocks is 1.00, very close to the 0.997

estimate obtained for the parametric model; the estimate of the insurance parameter with respect to the transitory shocks is 0.00, once again very close to the 0.00 estimate obtained for the parametric model, and the estimates of the variance of the permanent shocks suggest a strong increase in this component during the first half of the eighties.

Overall, the results suggest that our conclusions about the link between income and consumption inequality are robust to the particular specification of the permanent income shocks assumed. In fact, the particular specification seems broadly consistent with the data and offers a model for the evolution of the income distribution that can be used to address other phenomena in macroeconomics, labor economics, and finance.

VII What Drives the Results?

Sections V and VI show that the estimate of the insurance parameter with respect to the permanent income shocks doubles from 0.5 to 1.0 upon the inclusion of the third moments of income and consumption growth in the estimation. This result is robust to the choice of weighting matrix used in the GMM estimation. More importantly, it is robust to the particular modeling choice for the permanent income shocks in the sense that the parametric exponential mixture of normals specification gives precisely the same point estimate as a fully nonparametric specification of these shocks. The insurance parameter with respect to transitory income shocks, on the other hand, is estimated to be 0.0 with or without the inclusion of the third moments. This result is reminiscent of the permanent income hypothesis that asserts that intertemporal consumption smoothing is possible against transitory income shocks via borrowing and saving, but not against permanent shocks. The question naturally arises regarding what drives this stark difference in the estimates of the insurance parameter for the persistent shocks.

We focus on the nonparametric specification of the permanent income shocks in Section VI to illustrate the intuition behind our results. The crux of the intuition lies in the following two observations. First, both the permanent and transitory income shocks contribute significantly to the cross-sectional variance of income growth. For instance, when only the second moments of income and consumption growth are used in the estimation (Table 5, Rows 2 and 4), a Wald test strongly rejects the null hypothesis that the variance of the permanent shock is constant over time with a p-value of 0. The hypothesis that the variance of the transitory shock is constant over time is also strongly rejected with a p-value of 0. Moreover, both the permanent and transitory shocks contribute significantly to the overall income growth – the contribution of the permanent shock varies from 9.9% in 1980 to 49.3% in 1983, while that of the transitory component varies from 50.7% in 1983 to 90.1% in 1980. Similar results are obtained when both the second and third moments of income and consumption growth are included in the estimation (Table 5, Rows 3 and 5). On the other hand, the permanent component alone drives the third moment, i.e. skewness, of the cross-sectional distribution of income growth – the null hypothesis that the third moment of the permanent shock is constant over time is strongly rejected with a p-value of 0.016 whereas the hypothesis that the third moment of the transitory shock is constant over time has a p-value of 0.67 and cannot be rejected at conventional significance levels. Since the transitory shocks can be more effectively insured than the more persistent shocks, this suggests that the correlation between the third moments of income and consumption growth should be higher than the correlation between their variances – an implication that is supported by the data.

Second, not only is there a high correlation between the third moments of income and consumption growth rates, but the magnitudes of the third moment in consumption growth are also very similar to those in income growth. For instance, the third moment of income growth is the most negative in 1985 with a value of -0.10, and the corresponding third moment of consumption growth is -0.18. Now, the third moment of consumption growth is the sum of the third moments of the permanent shock to income, the transitory shock to income, the taste shock, and the first difference of the third moment of the measurement error. The transitory shock does not contribute to the third moment of consumption growth because we cannot reject the hypothesis that the third moment of this shock is constant over time and also because there exists almost full insurance against such shocks. We also cannot reject the hypothesis that the third moment of the measurement error is constant over time – the Wald test has a p-value of 0.52. Since the third moment of consumption growth depends on the difference in the third moments of the measurement error between the current and previous periods, we conclude that that measurement error in consumption cannot impact either its level or variation over time in a statistically significant way. Finally, the constant third moment of the taste shock is not statistically different from zero (the t statistic has a p-value of 0.11). Therefore, the third moment of consumption growth seems to be driven entirely by the permanent income shock, i.e. $E\left[\left(\Delta c^*_{i,t}\right)^3\right] \approx \phi^3 E\left[(\Delta y_{i,t})^3\right]$. And, since the magnitudes of the third moments of income and consumption growth are very similar in the data, this is only feasible with $\phi \approx 1$. If ϕ is substantially smaller than 1, for instance if $\phi = 0.5$ (the estimate obtained using only the second moments in the estimation), the model-implied third moments of observed consumption growth would be much smaller in magnitude than those on income growth. For instance, a third moment of -0.10 for income growth would imply a value of -0.016 for the third moment of consumption growth – an order of magnitude smaller than the -0.18 value observed in the data. To further assess the validity of the above intuition, we repeat our estimation of the parameters setting as constant the third moments of the transitory income shocks, taste shocks, and measurement error, which implies $E\left[\left(\Delta c_{i,t}^{*}\right)^{3}\right] \approx \phi^{3} E\left[\left(\Delta y_{i,t}\right)^{3}\right] + c$. Not surprisingly, we find that the parameter estimates and the model fit remain largely unchanged.[9]

Finally, the question arises that since the permanent insurance parameter doubles upon inclusion of the third moments of income and consumption growth in the estimation, how does the model continue to fit well the second moments of the growth rates? It does so by reducing slightly the contribution of the permanent shocks to the variance of income growth and, therefore, increasing a little the contribution of the transitory shock such that the overall variance of income growth remains largely unchanged. These required changes are sufficiently small that they also don't affect much the model fit for the first-order autocovariance of income and consumption growth.

VIII Conclusion and Extensions

In this paper, we propose a framework to investigate the link between income and consumption inequality that incorporates time-varying higher moments of the income distribution. Time-variation in the higher-order moments of the income process is an important aspect of the data that has been highlighted in a number of recent papers. Recent research has also shown that time-varying higher moments of the consumption distribution plays a central role in addressing several apparently puzzling aspects of financial market data. In this paper, we show that incorporating time-variation in the higher-order moments of income is critical in assessing the link between income and consumption inequality. Specifically, ignoring these higher moments leads to a downward bias in the estimate of the insurance parameter with respect to persistent income shocks and would lead one to conclude, erroneously, that consumption inequality does not closely track income inequality and, in particular, increases much less in response to a rise in the latter. Once time-variation in the higher moments of income are taken into account in the estimation, the estimate of the insurance parameter with respect to persistent income shocks is statistically and economically larger than the estimate obtained in the absence of the third moments in the estimation and is, in fact, numerically equal to one. Therefore, we cannot reject the hypothesis that no insurance exists with respect to permanent shocks to income. Our results suggest that consumption

[9] The results are available from the author upon request.

inequality tracks income inequality much more closely than what has been argued in earlier literature and highlights the role of time-varying higher-order moments of the income process in reaching this conclusion. Finally, we offer a model for the evolution of the income distribution across households and over time that is consistent with several aspects of the data and can be used to address other phenomena in macroeconomics, labor economics, and finance.

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A Appendix

A.1 Cross-Sectional Moments of Income and Consumption Growth

This section derives the moment restrictions enumerated in Section III.

1.

$$
\begin{aligned}
&E\left[\Delta y_{i,t}\left(\Delta y_{i,t-1}+\Delta y_{i,t}+\Delta y_{i,t+1}\right)\right]\\
&=E\left[\begin{array}{c}\left\{j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^2}{2}+\omega_t\frac{\sigma^2}{2}+\varepsilon_{i,t}-\varepsilon_{i,t-1}\right\}\\ \left\{\begin{array}{c} j_{i,t-1}^{1/2}\sigma\eta_{i,t-1}-j_{i,t-1}\frac{\sigma^2}{2}+\omega_{t-1}\frac{\sigma^2}{2}+\varepsilon_{i,t-1}-\varepsilon_{i,t-2}\\ +j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^2}{2}+\omega_t\frac{\sigma^2}{2}+\varepsilon_{i,t}-\varepsilon_{i,t-1}\\ +j_{i,t+1}^{1/2}\sigma\eta_{i,t+1}-j_{i,t+1}\frac{\sigma^2}{2}+\omega_{t+1}\frac{\sigma^2}{2}+\varepsilon_{i,t+1}-\varepsilon_{i,t}\end{array}\right\}\end{array}\right]\\
&=E\left[\begin{array}{c}\left\{j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^2}{2}+\omega_t\frac{\sigma^2}{2}+\varepsilon_{i,t}-\varepsilon_{i,t-1}\right\}\\ \left\{\begin{array}{c} j_{i,t-1}^{1/2}\sigma\eta_{i,t-1}-j_{i,t-1}\frac{\sigma^2}{2}+\omega_{t-1}\frac{\sigma^2}{2}+j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^2}{2}+\omega_t\frac{\sigma^2}{2}\\ +j_{i,t+1}^{1/2}\sigma\eta_{i,t+1}-j_{i,t+1}\frac{\sigma^2}{2}+\omega_{t+1}\frac{\sigma^2}{2}+\varepsilon_{i,t+1}-\varepsilon_{i,t-2}\end{array}\right\}\end{array}\right]\\
&=E\left[\left\{j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^2}{2}+\omega_t\frac{\sigma^2}{2}\right\}^2\right]\\
&=E\left[j_{i,t}\sigma^2\eta_{i,t}^2+j_{i,t}^2\frac{\sigma^4}{4}+\omega_t^2\frac{\sigma^4}{4}-j_{i,t}^{3/2}\sigma^3\eta_{i,t}+j_{i,t}^{1/2}\omega_t\sigma^3\eta_{i,t}-j_{i,t}\omega_t\frac{\sigma^4}{2}\right]\\
&=E\left[j_{i,t}\sigma^2\eta_{i,t}^2+j_{i,t}^2\frac{\sigma^4}{4}+\omega_t^2\frac{\sigma^4}{4}-j_{i,t}\omega_t\frac{\sigma^4}{2}\right]\\
&=\omega_t\sigma^2+\omega_t\left(1+\omega_t\right)\frac{\sigma^4}{4}+\omega_t^2\frac{\sigma^4}{4}-\omega_t^2\frac{\sigma^4}{2}\\
&=\left(\sigma^2+\frac{\sigma^4}{4}\right)\omega_t
\end{aligned}
$$

where the third equality follows from the observation that

$$E\left[\left(j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^2}{2}+\omega_t\frac{\sigma^2}{2}\right)\left(j_{i,s}^{1/2}\sigma\eta_{i,s}-j_{i,s}\frac{\sigma^2}{2}+\omega_s\frac{\sigma^2}{2}\right)\right]=0 \text{ for } t\neq s,$$

the assumption that $\varepsilon_{i,t}$ is serially uncorrelated, and the assumption that the shocks $\varepsilon_{i,t}$, $j_{i,t}$, and $\eta_{i,t}$ are mutually independent.

2.

$$
\begin{aligned}
E\left[\Delta y_{i,t}\Delta y_{i,t+1}\right]&=E\left[\begin{array}{c}\left\{j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^2}{2}+\omega_t\frac{\sigma^2}{2}+\varepsilon_{i,t}-\varepsilon_{i,t-1}\right\}\\ \left\{j_{i,t+1}^{1/2}\sigma\eta_{i,t+1}-j_{i,t+1}\frac{\sigma^2}{2}+\omega_{t+1}\frac{\sigma^2}{2}+\varepsilon_{i,t+1}-\varepsilon_{i,t}\right\}\end{array}\right]\\
&=E\left[\left(\varepsilon_{i,t}-\varepsilon_{i,t-1}\right)\left(\varepsilon_{i,t+1}-\varepsilon_{i,t}\right)\right]\\
&=-E\left(\varepsilon_{i,t}^2\right)
\end{aligned}
$$

3.

$$E\left[(\Delta y_{i,t})^3\right] = E\left[\left\{\left(j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right) + (\varepsilon_{i,t} - \varepsilon_{i,t-1})\right\}^3\right]$$
$$= E\left[\left(j_{i,t}^{1/2}\sigma\eta_{i,t} - (j_{i,t} - \omega_t)\frac{\sigma^2}{2}\right)^3\right] + E\left[(\varepsilon_{i,t} - \varepsilon_{i,t-1})^3\right]$$
$$= E\left[\begin{array}{c} j_{i,t}^{3/2}\sigma^3\eta_{i,t}^3 - 3j_{i,t}\sigma^2\eta_{i,t}^2(j_{i,t} - \omega_t)\frac{\sigma^2}{2} \\ +3j_{i,t}^{1/2}\sigma\eta_{i,t}(j_{i,t} - \omega_t)^2\frac{\sigma^4}{4} - (j_{i,t} - \omega_t)^3\frac{\sigma^6}{8} \end{array}\right]$$
$$+ E\left[\varepsilon_{i,t}^3\right] - E\left[\varepsilon_{i,t-1}^3\right]$$
$$= E\left[-3j_{i,t}\sigma^2\eta_{i,t}^2(j_{i,t} - \omega_t)\frac{\sigma^2}{2} - (j_{i,t} - \omega_t)^3\frac{\sigma^6}{8}\right] + E\left[\varepsilon_{i,t}^3\right] - E\left[\varepsilon_{i,t-1}^3\right]$$
$$= \left(-\frac{3}{2}\sigma^4 - \frac{1}{8}\sigma^6\right)\omega_t + E\left[\varepsilon_{i,t}^3\right] - E\left[\varepsilon_{i,t-1}^3\right]$$

4.

$$E\left[\Delta c_{i,t}^*\Delta c_{i,t+1}^*\right] = E\left[\begin{array}{c} \left\{\phi\left(j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right) + \psi\varepsilon_{i,t} + \xi_{i,t} + u_{i,t} - u_{i,t-1}\right\} \\ \left\{\phi\left(j_{i,t+1}^{1/2}\sigma\eta_{i,t+1} - j_{i,t+1}\frac{\sigma^2}{2} + \omega_{t+1}\frac{\sigma^2}{2}\right) + \psi\varepsilon_{i,t+1} + \xi_{i,t+1} + u_{i,t+1} - u_{i,t}\right\} \end{array}\right]$$
$$= E\left[(u_{i,t} - u_{i,t-1})(u_{i,t+1} - u_{i,t})\right]$$
$$= -E\left[u_{i,t}^3\right]$$

5.

$$E\left[\Delta c_{i,t}^*\Delta y_{i,t+1}\right] = E\left[\begin{array}{c} \left\{\phi\left(j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right) + \psi\varepsilon_{i,t} + \xi_{i,t} + u_{i,t} - u_{i,t-1}\right\} \\ \left\{\left(j_{i,t+1}^{1/2}\sigma\eta_{i,t+1} - j_{i,t+1}\frac{\sigma^2}{2} + \omega_{t+1}\frac{\sigma^2}{2}\right) + \varepsilon_{i,t+1} - \varepsilon_{i,t}\right\} \end{array}\right]$$
$$= -\psi\sigma_{\varepsilon,t}^2$$

6.

$$E\left[\Delta c_{i,t}^*(\Delta y_{i,t-1} + \Delta y_{i,t} + \Delta y_{i,t+1})\right]$$
$$= E\left[\begin{array}{c} \left\{\phi\left(j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right) + \psi\varepsilon_{i,t} + \xi_{i,t} + u_{i,t} - u_{i,t-1}\right\} \\ \left\{\begin{array}{c} j_{i,t-1}^{1/2}\sigma\eta_{i,t-1} - j_{i,t-1}\frac{\sigma^2}{2} + \omega_{t-1}\frac{\sigma^2}{2} + \varepsilon_{i,t-1} - \varepsilon_{i,t-2} \\ +j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2} + \varepsilon_{i,t} - \varepsilon_{i,t-1} \\ +j_{i,t+1}^{1/2}\sigma\eta_{i,t+1} - j_{i,t+1}\frac{\sigma^2}{2} + \omega_{t+1}\frac{\sigma^2}{2} + \varepsilon_{i,t+1} - \varepsilon_{i,t} \end{array}\right\} \end{array}\right]$$
$$= E\left[\phi\left\{j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right\}^2\right]$$
$$= \phi\left(\sigma^2 + \frac{\sigma^4}{4}\right)\omega_t$$

7.

$$
\begin{aligned}
&E\left[\Delta c_{i,t}^{*}\left(\Delta c_{i,t-1}^{*}+\Delta c_{i,t}^{*}+\Delta c_{i,t+1}^{*}\right)\right] \\
&=E\left[\begin{array}{c}
\left\{\phi\left(j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^{2}}{2}+\omega_{t}\frac{\sigma^{2}}{2}\right)+\psi\varepsilon_{i,t}+\xi_{i,t}+u_{i,t}-u_{i,t-1}\right\} \\
\left\{\begin{array}{c}
\left\{\phi\left(j_{i,t-1}^{1/2}\sigma\eta_{i,t-1}-j_{i,t-1}\frac{\sigma^{2}}{2}+\omega_{t-1}\frac{\sigma^{2}}{2}\right)+\psi\varepsilon_{i,t-1}+\xi_{i,t-1}+u_{i,t-1}-u_{i,t-2}\right\} \\
+\left\{\phi\left(j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^{2}}{2}+\omega_{t}\frac{\sigma^{2}}{2}\right)+\psi\varepsilon_{i,t}+\xi_{i,t}+u_{i,t}-u_{i,t-1}\right\} \\
+\left\{\phi\left(j_{i,t+1}^{1/2}\sigma\eta_{i,t+1}-j_{i,t+1}\frac{\sigma^{2}}{2}+\omega_{t+1}\frac{\sigma^{2}}{2}\right)+\psi\varepsilon_{i,t+1}+\xi_{i,t+1}+u_{i,t+1}-u_{i,t}\right\}
\end{array}\right\}
\end{array}\right] \\
&=E\left[\phi^{2}\left\{j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^{2}}{2}+\omega_{t}\frac{\sigma^{2}}{2}\right\}^{2}\right]+\psi^{2}E\left[\varepsilon_{i,t}^{2}\right]+E\left[\xi_{i}^{2}\right] \\
&=\phi\left(\sigma^{2}+\frac{\sigma^{4}}{4}\right)\omega_{t}+\psi^{2}E\left[\varepsilon_{i,t}^{2}\right]+E\left[\xi_{i}^{2}\right]
\end{aligned}
$$

8.

$$
\begin{aligned}
&E\left[\left(\Delta c_{i,t}^{*}\right)^{2}\left(\Delta c_{i,t-1}^{*}+\Delta c_{i,t}^{*}+\Delta c_{i,t+1}^{*}\right)\right] \\
&=E\left[\begin{array}{c}
\left\{\phi\left(j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^{2}}{2}+\omega_{t}\frac{\sigma^{2}}{2}\right)+\psi\varepsilon_{i,t}+\xi_{i,t}+u_{i,t}-u_{i,t-1}\right\}^{2} \\
\left\{\begin{array}{c}
\left\{\phi\left(j_{i,t-1}^{1/2}\sigma\eta_{i,t-1}-j_{i,t-1}\frac{\sigma^{2}}{2}+\omega_{t-1}\frac{\sigma^{2}}{2}\right)+\psi\varepsilon_{i,t-1}+\xi_{i,t-1}+u_{i,t-1}-u_{i,t-2}\right\} \\
+\left\{\phi\left(j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^{2}}{2}+\omega_{t}\frac{\sigma^{2}}{2}\right)+\psi\varepsilon_{i,t}+\xi_{i,t}+u_{i,t}-u_{i,t-1}\right\} \\
+\left\{\phi\left(j_{i,t+1}^{1/2}\sigma\eta_{i,t+1}-j_{i,t+1}\frac{\sigma^{2}}{2}+\omega_{t+1}\frac{\sigma^{2}}{2}\right)+\psi\varepsilon_{i,t+1}+\xi_{i,t+1}+u_{i,t+1}-u_{i,t}\right\}
\end{array}\right\}
\end{array}\right] \\
&=E\left[\phi^{3}\left\{j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^{2}}{2}+\omega_{t}\frac{\sigma^{2}}{2}\right\}^{3}\right]+\psi^{3}E\left(\varepsilon_{i,t}^{3}\right)+E\left(\xi_{i}^{3}\right) \\
&=\phi^{3}\left(-\frac{3}{2}\sigma^{4}-\frac{1}{8}\sigma^{6}\right)\omega_{t}+\psi^{3}E\left(\varepsilon_{i,t}^{3}\right)+E\left(\xi_{i}^{3}\right)
\end{aligned}
$$

9.

$$
\begin{aligned}
E\left[\left(\Delta y_{i,t}\right)^{2}\Delta y_{i,t+1}\right]&=E\left[\begin{array}{c}
\left\{\left(j_{i,t}^{1/2}\sigma\eta_{i,t}-j_{i,t}\frac{\sigma^{2}}{2}+\omega_{t}\frac{\sigma^{2}}{2}\right)+\left(\varepsilon_{i,t}-\varepsilon_{i,t-1}\right)\right\}^{2}\times \\
\left\{\left(j_{i,t+1}^{1/2}\sigma\eta_{i,t+1}-j_{i,t+1}\frac{\sigma^{2}}{2}+\omega_{t+1}\frac{\sigma^{2}}{2}\right)+\left(\varepsilon_{i,t+1}-\varepsilon_{i,t}\right)\right\}
\end{array}\right] \\
&=E\left[\left(\varepsilon_{i,t}-\varepsilon_{i,t-1}\right)^{2}\times\left(\varepsilon_{i,t+1}-\varepsilon_{i,t}\right)\right] \\
&=-E\left(\varepsilon_{i,t}^{3}\right)
\end{aligned}
$$

10.

$$
\begin{aligned}
& E\left[\left(\Delta c_{i,t}^{*}\right)^{2} \Delta c_{i,t+1}^{*}\right] \\
&= E\left[\begin{array}{c}
\left\{\phi\left(j_{i,t}^{1/2}\sigma\eta_{i,t} - j_{i,t}\frac{\sigma^2}{2} + \omega_t\frac{\sigma^2}{2}\right) + \psi\varepsilon_{i,t} + \xi_{i,t} + u_{i,t} - u_{i,t-1}\right\}^{2} \times \\
\left\{\phi\left(j_{i,t+1}^{1/2}\sigma\eta_{i,t+1} - j_{i,t+1}\frac{\sigma^2}{2} + \omega_{t+1}\frac{\sigma^2}{2}\right) + \psi\varepsilon_{i,t+1} + \xi_{i,t+1} + u_{i,t+1} - u_{i,t}\right\}
\end{array}\right] \\
&= E\left[\left(u_{i,t} - u_{i,t-1}\right)^{2} \times \left(u_{i,t+1} - u_{i,t}\right)\right] \\
&= -E\left(u_{i,t}^{3}\right)
\end{aligned}
$$

A.2 An Alternative (Nonparametric) Model Specification

These parameters can be identified as follows. For a given time period $t = 1, 2, ..., T-1$, the variance of the transitory shock can be identified using

$$
\begin{aligned}
E\left[\Delta y_{i,t}\Delta y_{i,t+1}\right] &= E\left[\left(\varsigma_{i,t} + \varepsilon_{i,t} - \varepsilon_{i,t-1}\right)\left(\varsigma_{i,t+1} + \varepsilon_{i,t+1} - \varepsilon_{i,t}\right)\right] \\
&= -E\left(\varepsilon_{i,t}^{2}\right);
\end{aligned}
$$

the third moment of the transitory shock is identified from

$$
\begin{aligned}
E\left[\left(\Delta y_{i,t}\right)^{2}\Delta y_{i,t+1}\right] &= E\left[\left(\varsigma_{i,t}^{2} + \varepsilon_{i,t}^{2} + \varepsilon_{i,t-1}^{2} + 2\varsigma_{i,t}\varepsilon_{i,t} - 2\varsigma_{i,t}\varepsilon_{i,t-1} - 2\varepsilon_{i,t}\varepsilon_{i,t-1}\right)\left(\varsigma_{i,t+1} + \varepsilon_{i,t+1} - \varepsilon_{i,t}\right)\right] \\
&= -E\left(\varepsilon_{i,t}^{3}\right);
\end{aligned}
$$

the insurance parameter with respect to the transitory shocks can be identified from the equation

$$
\begin{aligned}
E\left[\Delta c_{i,t}^{*}\Delta y_{i,t+1}\right] &= E\left[\left(\phi\varsigma_{i,t} + \psi\varepsilon_{i,t} + \xi_{i,t} + u_{i,t} - u_{i,t-1}\right)\left(\varsigma_{i,t+1} + \varepsilon_{i,t+1} - \varepsilon_{i,t}\right)\right] \\
&= -\psi E\left(\varepsilon_{i,t}^{2}\right);
\end{aligned}
$$

the variance of the measurement error is identified from the equation

$$
\begin{aligned}
E\left[\Delta c_{i,t}^{*}\Delta c_{i,t+1}^{*}\right] &= E\left[\left(\phi\varsigma_{i,t} + \psi\varepsilon_{i,t} + \xi_{i,t} + u_{i,t} - u_{i,t-1}\right)\left(\phi\varsigma_{i,t+1} + \psi\varepsilon_{i,t+1} + \xi_{i,t+1} + u_{i,t+1} - u_{i,t}\right)\right] \\
&= -E\left(u_{i,t}^{2}\right);
\end{aligned}
$$

and the third moment of the measurement error is identified from

$$
E\left[\left(\Delta c_{i,t}^{*}\right)^{2}\Delta c_{i,t+1}^{*}\right] = -E\left(u_{i,t}^{3}\right);
$$

For $t = 2, ..., T-1$, the variance and third moment of the persistent shock can be identified from the equations:

$$\begin{aligned}
&E\left[\Delta y_{i,t}\left(\Delta y_{i,t-1}+\Delta y_{i,t}+\Delta y_{i,t+1}\right)\right] \\
&= E\left[\{\varsigma_{i,t}+\varepsilon_{i,t}-\varepsilon_{i,t-1}\}\{\varsigma_{i,t-1}+\varepsilon_{i,t-1}-\varepsilon_{i,t-2}+\varsigma_{i,t}+\varepsilon_{i,t}-\varepsilon_{i,t-1}+\varsigma_{i,t+1}+\varepsilon_{i,t+1}-\varepsilon_{i,t}\}\right] \\
&= E\left[\{\varsigma_{i,t}+\varepsilon_{i,t}-\varepsilon_{i,t-1}\}\{\varsigma_{i,t-1}+\varsigma_{i,t}+\varsigma_{i,t+1}+\varepsilon_{i,t+1}-\varepsilon_{i,t-2}\}\right] \\
&= E\left[\varsigma_{i,t}^2\right],
\end{aligned}$$

and

$$\begin{aligned}
&E\left[\left(\Delta y_{i,t}\right)^2\left(\Delta y_{i,t-1}+\Delta y_{i,t}+\Delta y_{i,t+1}\right)\right] \\
&= E\left[\{\varsigma_{i,t}+\varepsilon_{i,t}-\varepsilon_{i,t-1}\}^2\{\varsigma_{i,t-1}+\varepsilon_{i,t-1}-\varepsilon_{i,t-2}+\varsigma_{i,t}+\varepsilon_{i,t}-\varepsilon_{i,t-1}+\varsigma_{i,t+1}+\varepsilon_{i,t+1}-\varepsilon_{i,t}\}\right] \\
&= E\left[\begin{array}{c}\{\varsigma_{i,t}^2+\varepsilon_{i,t}^2+\varepsilon_{i,t-1}^2+2\varsigma_{i,t}\varepsilon_{i,t}-2\varsigma_{i,t}\varepsilon_{i,t-1}-2\varepsilon_{i,t}\varepsilon_{i,t-1}\} \\ \{\varsigma_{i,t-1}+\varsigma_{i,t}+\varsigma_{i,t+1}+\varepsilon_{i,t+1}-\varepsilon_{i,t-2}\}\end{array}\right] \\
&= E\left[\varsigma_{i,t}^3\right];
\end{aligned}$$

the insurance parameter with respect to the permanent shocks can be identified from the equation

$$\begin{aligned}
E\left[\Delta c_{i,t}^*\left(\Delta y_{i,t-1}+\Delta y_{i,t}+\Delta y_{i,t+1}\right)\right] &= E\left[\begin{array}{c}\{\phi\varsigma_{i,t}+\psi\varepsilon_{i,t}+\xi_{i,t}+u_{i,t}-u_{i,t-1}\} \\ \{\varsigma_{i,t-1}+\varsigma_{i,t}+\varsigma_{i,t+1}+\varepsilon_{i,t+1}-\varepsilon_{i,t-2}\}\end{array}\right] \\
&= \phi E\left[\varsigma_{i,t}^2\right];
\end{aligned}$$

and the variance of the shocks to consumption unrelated to those in income is identified using

$$E\left[\Delta c_{i,t}^*\left(\Delta c_{i,t-1}^*+\Delta c_{i,t}^*+\Delta c_{i,t+1}^*\right)\right] = \phi^2 E\left[\varsigma_{i,t}^2\right]+\psi^2 E\left(\varepsilon_{i,t}^2\right)+E\left(\xi_i^2\right);$$

and, finally, the third central moment of the shocks to consumption unrelated to those in income is identified from the equation

$$E\left[\left(\Delta c_{i,t}^*\right)^2\left(\Delta c_{i,t-1}^*+\Delta c_{i,t}^*+\Delta c_{i,t+1}^*\right)\right] = -\phi^3 E\left[\varsigma_{i,t}^3\right]+\psi^3 E\left(\varepsilon_{i,t}^3\right)+E\left(\xi_i^3\right).$$

Table 1: Moments of Income Growth

Year	$\mathrm{Var}(\Delta y_t)$	$\mathrm{Cov}(\Delta y_t, \Delta y_{t+1})$	$\mathrm{Cov}(\Delta y_t, \Delta y_{t+2})$	$\mathrm{E}\left[(\Delta y_t)^3\right]$	$\mathrm{Cov}\left((\Delta y_t)^2, \Delta y_{t+1}\right)$
1980	.0825 (.0091)	−.0194 (.0034)	−.0020 (.0032)	.0204 (.0167)	.0002 (.0032)
1981	.0705 (.0074)	−.0223 (.0035)	−.0086 (.0038)	−.0270 (.0124)	.0022 (.0033)
1982	.0732 (.0055)	−.0218 (.0035)	−.0087 (.0027)	−.0065 (.0059)	.0029 (.0028)
1983	.0734 (.0055)	−.0187 (.0035)	−.0108 (.0045)	−.0019 (.0060)	−.0048 (.0025)
1984	.0807 (.0060)	−.0288 (.0038)	−.0048 (.0035)	−.0070 (.0066)	.0044 (.0031)
1985	.1147 (.0207)	−.0393 (.0084)	.0007 (.0040)	−.1043 (.0742)	.0227 (.0250)
1986	.1036 (.0087)	−.0357 (.0059)	−.0125 (.0042)	−.0127 (.0119)	−.00003 (.0067)
1987	.1073 (.0102)	−.0356 (.0055)	−.0011 (.0045)	−.0190 (.0172)	.0074 (.0062)
1988	.0884 (.0081)	−.0322 (.0049)	−.0004 (.0037)	.0125 (.0121)	−.0025 (.0054)
1989	.0808 (.0069)	−.0223 (.0073)	−.0067 (.0037)	.0031 (.0091)	−.0164 (.0112)
1990	.0942 (.0128)	−.0295 (.0062)	−.0064 (.0065)	−.0408 (.0316)	.0123 (.0089)
1991	.0885 (.0082)	−.0364 (.0054)	NA	−.0087 (.0113)	−.0013 (.0051)
1992	.1287 (.0107)	NA	NA	.0054 (.0146)	NA

The table presents the time series of the cross-sectional variance of income growth (Column 2), the first-order autocovariance (Column 3), the second-order autocovariance (Column 4), the third moment (Column 5), and the covariance between income growth and the square of its first lag (Column 6). Standard errors are in parentheses. Income denotes net family income (defined as the sum of the labor income of the head and spouse and transfers minus taxes paid) and is obtained from the PSID dataset over 1980-1992.

Table 2: Moments of Consumption Growth

Year	$\text{Var}(\Delta c_t)$	$\text{Cov}(\Delta c_t, \Delta c_{t+1})$	$\text{Cov}(\Delta c_t, \Delta c_{t+2})$	$\text{E}\left[(\Delta c_t)^3\right]$	$\text{Cov}\left((\Delta c_t)^2, \Delta c_{t+1}\right)$
1980	.1186 (.0096)	−.0597 (.0082)	.0030 (.0055)	−.0019 (.0144)	.0187 (.0116)
1981	.1278 (.0127)	−.0603 (.0089)	.0001 (.0046)	.0077 (.0255)	.0093 (.0176)
1982	.1379 (.0120)	−.0639 (.0094)	−.0024 (.0066)	−.0140 (.0222)	.0185 (.0144)
1983	.1595 (.0177)	−.0698 (.0111)	−.0075 (.0076)	.0045 (.0433)	.0041 (.0253)
1984	.1948 (.0198)	−.1088 (.0186)	−.0157 (.0103)	.0337 (.0465)	−.0618 (.0421)
1985	.2164 (.0287)	−.0910 (.0229)	NA	−.1751 (.1079)	.0859 (.0972)
1986	.1698 (.0226)	NA	NA	.0973 (.0846)	NA
1987	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA
1990	.1620 (.0217)	−.0562 (.0065)	.0022 (.0060)	.0016 (.0674)	.0075 (.0065)
1991	.1516 (.0134)	−.0776 (.0135)	NA	.0332 (.0250)	−.0289 (.0273)
1992	.1539 (.0175)	NA	NA	−.0459 (.0393)	NA

The table presents the time series of the cross-sectional variance of consumption growth (Column 2), the first-order autocovariance (Column 3), the second-order autocovariance (Column 4), the third moment (Column 5), and the covariance between consumption growth and the square of its first lag (Column 6). Standard errors are in parentheses. Consumption refers to the real personal consumption expenditure on nondurable goods and services and is imputed for the households in the PSID by combining information in the PSID and CEX datasets.

Table 3: Consumption-Income Growth Covariance Matrix

Year	Cov($\Delta c_t, \Delta y_y$)	Cov($\Delta y_{t+1}, \Delta c_t$)	Cov($\Delta y_t, \Delta c_{t+1}$)
1980	.0013 (.0040)	.0014 (.0038)	.0069 (.0037)
1981	.0119 (.0038)	−.0070 (.0034)	−.0039 (.0036)
1982	.0180 (.0038)	−.0062 (.0032)	−.0011 (.0041)
1983	.0221 (.0046)	−.0098 (.0053)	−.0064 (.0043)
1984	.0234 (.0056)	−.0035 (.0047)	−.0106 (.0055)
1985	.0233 (.0076)	−.0034 (.0054)	−.0069 (.0073)
1986	.0193 (.0053)	.0010 (.0055)	NA
1987	NA	NA	NA
1988	NA	NA	NA
1989	NA	NA	.0031 (.0046)
1990	.0054 (.0056)	.0036 (.0090)	.0021 (.0047)
1991	.0091 (.0055)	−.0024 (.0063)	−.0075 (.0056)
1992	.0053 (.0063)	NA	NA

The table presents the time series of the cross-sectional covariance between income growth and consumption growth (Column 2), the covariance between income growth and lagged consumption growth (Column 3), and the covariance between consumption growth and lagged income growth (Column 3). Standard errors are in parentheses.

Table 4A: Parameter Estimates, 1979-1992

	Only 2nd Moments	2nd + 3rd Moments	Only 2nd Moments	2nd + 3rd Moments
	Var of Permanent Shock= $\left(\sigma^2 + \frac{\sigma^4}{4}\right)\omega_t$		Var of Transitory Shock= $\sigma^2_{\varepsilon,t}$	
1979	–	–	.0370 (.0058)	.0387 (.0064)
1980	.0065 (.0046)	.0017 (.0106)	.0223 (.0035)	.0313 (.0044)
1981	.0236 (.0053)	.0173 (.0118)	.0224 (.0034)	.0224 (.0039)
1982	.0311 (.0045)	.0256 (.0185)	.0207 (.0034)	.0243 (.0045)
1983	.0370 (.0054)	.0271 (.0204)	.0173 (.0033)	.0219 (.0040)
1984	.0373 (.0053)	.0384 (.0283)	.0281 (.0037)	.0195 (.0087)
1985	.0452 (.0125)	.0655 (.0483)	.0381 (.0079)	.0439 (.0120)
1986	.0325 (.0071)	.0009 (.0230)	.0348 (.0058)	.0452 (.0081)
1987	.0369 (.0065)	.0297 (.0242)	.0356 (.0054)	.0378 (.0067)
1988	.0207 (.0056)	.0042 (.0086)	.0322 (.0049)	.0380 (.0064)
1989	.0214 (.0063)	.0096 (.0119)	.0273 (.0077)	.0314 (.0090)
1990	.0213 (.0072)	.0247 (.0238)	.0300 (.0063)	.0289 (.0071)
1991	.0193 (.0064)	.0192 (.0147)	.0445 (.0050)	.0494 (.0055)
1992	–	–		
	ϕ		ψ	
	.5433 (.0637)	.9968 (.3406)	2.2×10^{-15} (.0525)	.0002 (.0723)

The table presents parameter estimates when different sets of moments are included in the estimation. Columns 2 and 4 present results when only the second moments of income and consumption growth are included in the estimation. Column 2 presents estimates of the variances of the permanent income shocks and the insurance parameter with respect to the permanent shocks. Column 4 presents estimates of the variances of the transitory income shocks and the insurance parameter with respect to the transitory shocks. Standard errors are in parentheses. Columns 3 and 5 present analogous results when both the second and third moments of income and consumption growth are included in the estimation.

Table 4B: Parameter Estimates, 1979-1992

	Only 2nd Moments	2nd + 3rd Moments	Only 2nd Moments	2nd + 3rd Moments
	Third Moment of Permanent Shock=$\left(-\frac{3}{2}\sigma^4 - \frac{1}{8}\sigma^4\right)\omega_t$		Third Moment of Transitory Shock=$E\left(\varepsilon_{i,t}^3\right)$	
1979	–	–	–	.0010 (.0166)
1980	–	−.0013 (.0082)	–	.0104 (.0044)
1981	–	−.0135 (.0092)	–	.0010 (.0037)
1982	–	−.0200 (.0144)	–	.0010 (.0033)
1983	–	−.0212 (.0159)	–	.0050 (.0028)
1984	–	−.0300 (.0221)	–	.0189 (.0105)
1985	–	−.0512 (.0377)	–	.0010 (.0200)
1986	–	−.0007 (.0179)	–	.0010 (.0095)
1987	–	−.0231 (.0189)	–	.0010 (.0067)
1988	–	−.0032 (.0067)	–	.0078 (.0057)
1989	–	−.0075 (.0093)	–	.0184 (.0164)
1990	–	−.0193 (.0186)	–	.0010 (.0095)
1991	–	−.0150 (.0115)	–	.0021 (.0058)
1992	–	–	–	–
	Var of Taste Shock=$E\left(\xi^2\right)$		Third Moment of Taste Shock=$E\left(\xi^3\right)$	
	.0123 (.0040)	.0023 (.0074)	–	.0191 (.0261)

The table presents parameter estimates when different sets of moments are included in the estimation. Column 3 presents estimates of the third moment of the permanent income shocks, while Column 5 presents estimates of the third moment of the transitory income shocks. Standard errors are in parentheses. Note that the third moments of shocks can only be identified when both the second and third moments of income and consumption growth are included in the estimation.

Table 5A: Nonparametric Model Specification, 1979-1992

	Only 2nd Moments	2nd + 3rd Moments	Only 2nd Moments	2nd + 3rd Moments
	Var of Permanent Shock=$\sigma^2_{\varsigma,t}$		Var of Transitory Shock=$\sigma^2_{\varepsilon,t}$	
1979	–	–	.0370 (.0058)	.0363 (.0054)
1980	.0065 (.0046)	.0060 (.0028)	.0223 (.0035)	.0302 (.0041)
1981	.0236 (.0053)	.0132 (.0038)	.0224 (.0034)	.0261 (.0037)
1982	.0311 (.0045)	.0182 (.0049)	.0207 (.0034)	.0260 (.0040)
1983	.0370 (.0054)	.0244 (.0063)	.0173 (.0033)	.0215 (.0040)
1984	.0373 (.0053)	.0238 (.0065)	.0281 (.0037)	.0340 (.0048)
1985	.0452 (.0125)	.0306 (.0094)	.0381 (.0079)	.0463 (.0091)
1986	.0325 (.0071)	.0151 (.0058)	.0348 (.0058)	.0389 (.0063)
1987	.0369 (.0065)	.0328 (.0072)	.0356 (.0054)	.0356 (.0054)
1988	.0207 (.0056)	.0207 (.0056)	.0322 (.0049)	.0322 (.0049)
1989	.0214 (.0063)	.0168 (.0069)	.0273 (.0077)	.0319 (.0085)
1990	.0213 (.0072)	.0202 (.0059)	.0300 (.0063)	.0324 (.0062)
1991	.0193 (.0064)	.0088 (.0037)	.0445 (.0050)	.0539 (.0049)
1992	–	–		
	ϕ		ψ	
	.5433 (.0637)	1.00 (.2424)	2.2×10^{-15} (.0525)	1.0×10^{-13} (.0508)

The table presents parameter estimates for the nonparametric model specification when different sets of moments are included in the estimation. Columns 2 and 4 present results when only the second moments of income and consumption growth are included in the estimation. Column 2 presents estimates of the variances of the permanent income shocks and the insurance parameter with respect to the permanent shocks. Column 4 presents estimates of the variances of the transitory income shocks and the insurance parameter with respect to the transitory shocks. Standard errors are in parentheses. Columns 3 and 5 present analogous results when both the second and third moments of income and consumption growth are included in the estimation.

Table 5B: Nonparametric Model Specification, 1979-1992

	Only 2nd Moments	2nd + 3rd Moments	Only 2nd Moments	2nd + 3rd Moments
	Third Moment of Permanent Shock=$E\left(\varsigma_{i,t}^{3}\right)$		Third Moment of Transitory Shock=$E\left(\varepsilon_{i,t}^{3}\right)$	
1979	–	–	–	−.0134 (.0182)
1980	–	.0221 (.0187)	–	−.0066 (.0058)
1981	–	−.0352 (.0118)	–	−.0051 (.0032)
1982	–	−.0196 (.0087)	–	−.0046 (.0038)
1983	–	−.0270 (.0112)	–	.0034 (.0036)
1984	–	−.0295 (.0111)	–	.0117 (.0085)
1985	–	−.0723 (.0465)	–	−.0055 (.0214)
1986	–	.0340 (.0437)	–	−.0155 (.0138)
1987	–	−.0293 (.0167)	–	−.0053 (.0061)
1988	–	.0039 (.0084)	–	.0033 (.0051)
1989	–	−.0076 (.0155)	–	.0139 (.0199)
1990	–	−.0209 (.0423)	–	−.0101 (.0135)
1991	–	−.0301 (.0143)	–	.0042 (.0063)
1992	–	–	–	–
	Var of Taste Shock=$E\left(\xi^{2}\right)$		Third Moment of Taste Shock=$E\left(\xi^{3}\right)$	
	.0123 (.0040)	.0023 (.0074)	–	.0267 (.0222)

The table presents parameter estimates for the nonparametric model specification when different sets of moments are included in the estimation. Column 3 presents estimates of the third moment of the permanent income shocks, while Column 4 presents estimates of the third moment of the transitory income shocks. Standard errors are in parentheses. Note that the third moments can only be estimated when both the second and third moments of income and consumption growth are included in the estimation.

Table 6: Estimation Results for Low and High Wealth Households, 1979-1992

	Only 2nd Moments	2nd + 3rd Moments	Only 2nd Moments	2nd + 3rd Moments
	Low Wealth Households		High Wealth Households	
ϕ	.6836 (.1426)	1.00 (.3228)	.4747 (.0739)	.2548 (.0574)
ψ	.1128 (.0940)	.0000 (.1320)	.0000 (.0511)	.0217 (.0663)

The table presents estimates of the consumption insurance parameters for low-wealth and high-wealth households separately when different sets of moments are included in the estimation. Column 2 and 4 present estimates for the low-wealth and high-wealth households, respectively, when only the second moments of income and consumption growth are included in the estimation. Column 3 and 5 present estimates for the low-wealth and high-wealth households, respectively, when both the second and third moments of income and consumption growth are included in the estimation. Standard errors are in parentheses.

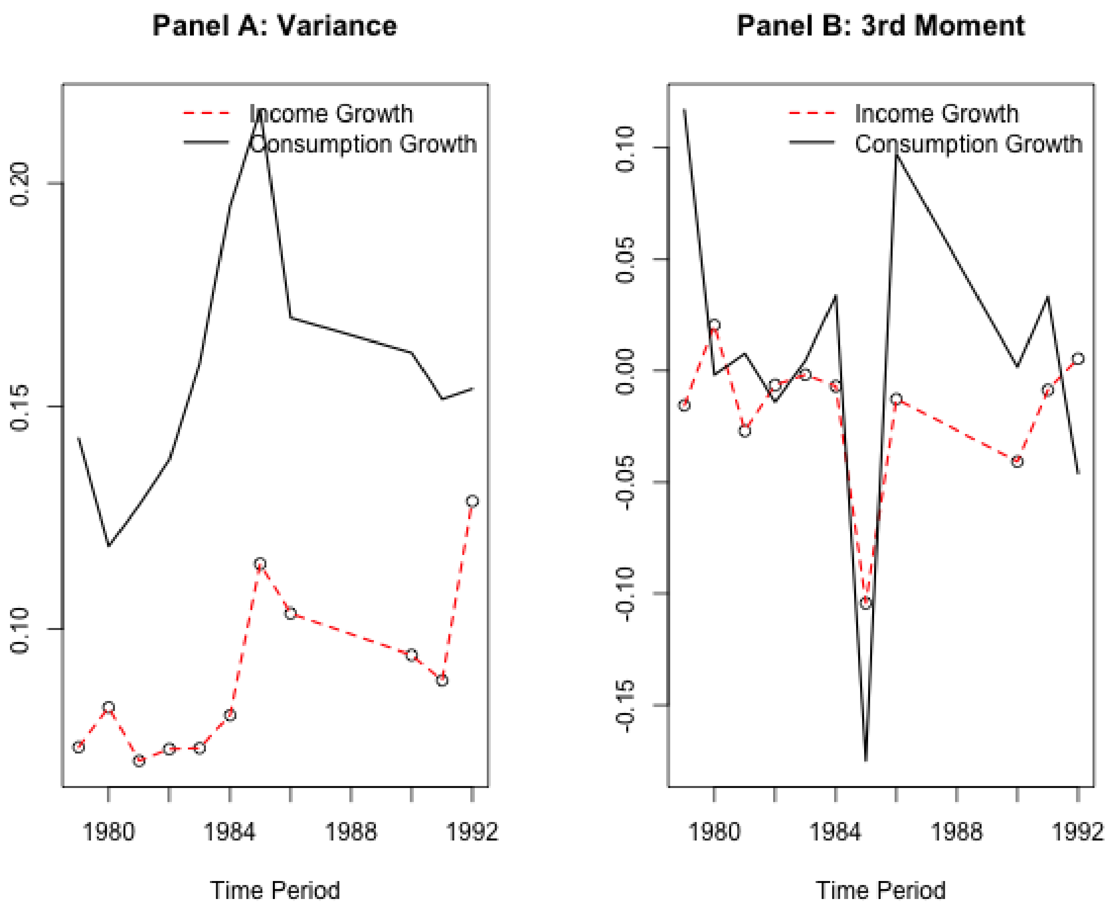

Figure 1: Panel A plots the time series of the cross-sectional variance of income growth (red-dashed line) and consumption growth (black solid line) using PSID data over 1980-1992. Panel B plots the time series of the cross-sectional third moment of income growth (red-dashed line) and consumption growth (black solid line).

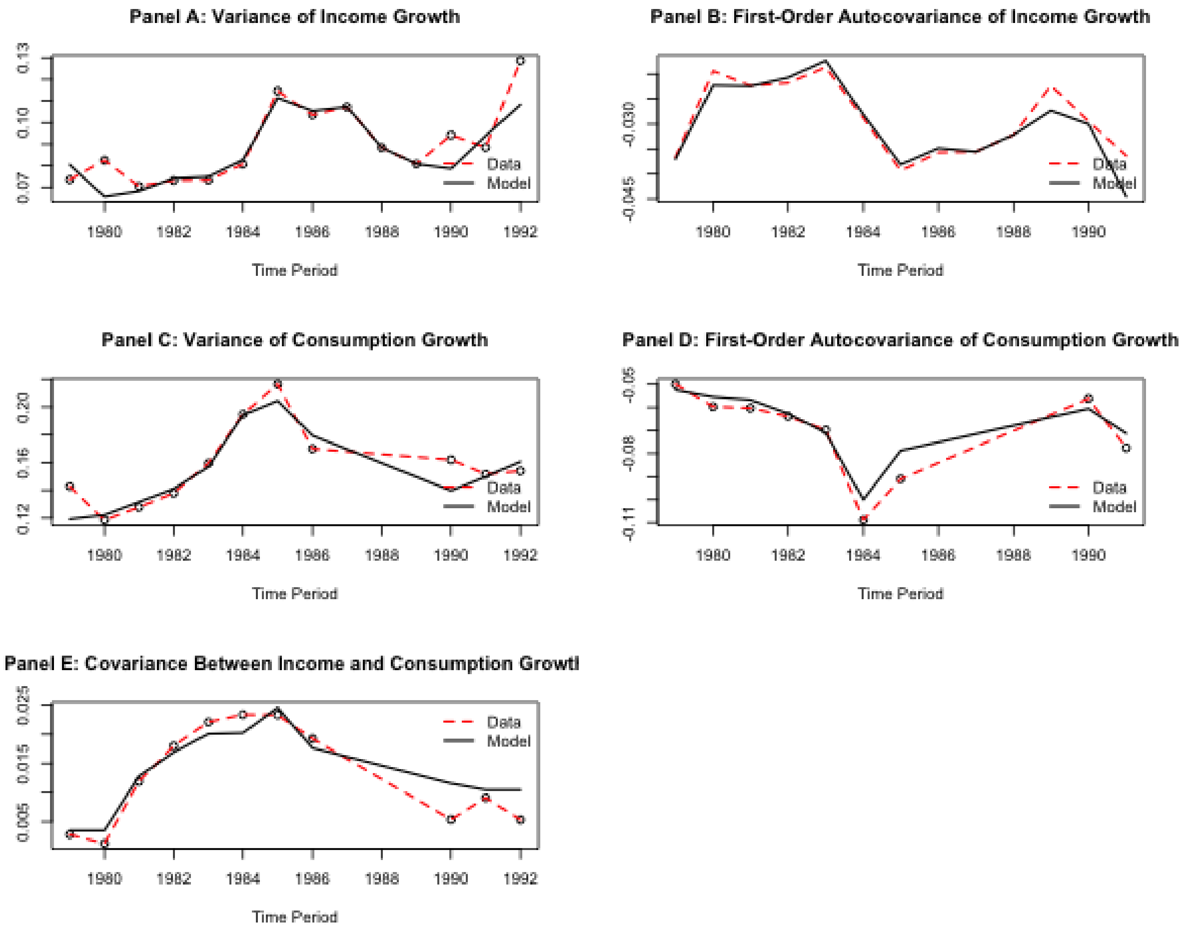

Figure 2: The time series of the cross-sectional variance of income growth (Panel A), the cross-sectional first-order autocovariance of income growth (Panel B), the cross-sectional variance of consumption growth (Panel C), the cross-sectional first-order autocovariance of consumption growth (Panel D), and the covariance of income and consumption growth (Panel E). In each panel, the black solid line plots the model-implied moments while the red dashed line plots the sample moments. Only the second moments of income and consumption growth are used in the estimation of the model parameters.

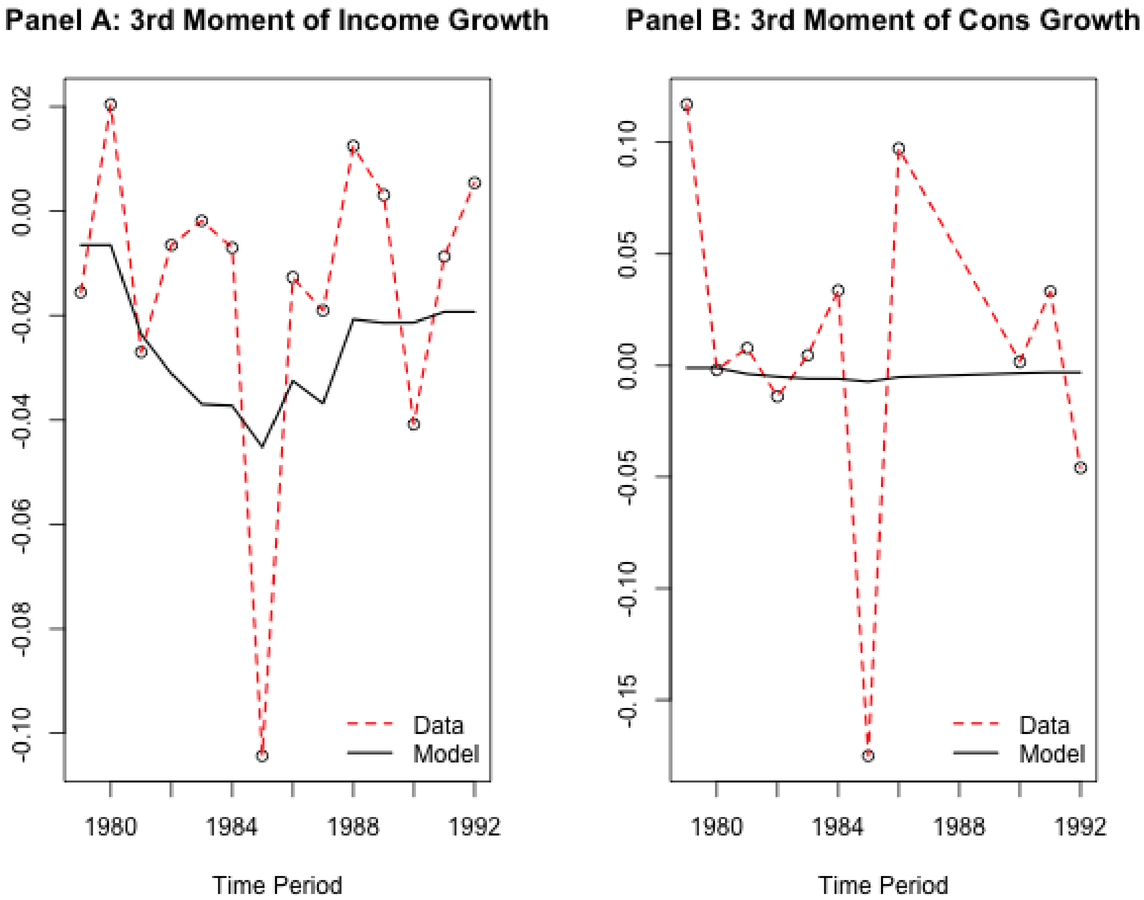

Figure 3: The time series of the cross-sectional third moment of income growth (Panel A) and the cross-sectional third moment of consumption growth (Panel B). In each panel, the black solid line plots the model-implied moments while the red dashed line plots the sample moments. Only the second moments of income and consumption growth are used in the estimation of the model parameters. Note that the third moments of income and consumption growth are identified upto a positive constant scale factor $\frac{\frac{3}{2}\sigma^4+\frac{1}{8}\sigma^6}{\sigma^2+\frac{1}{4}\sigma^4}$.

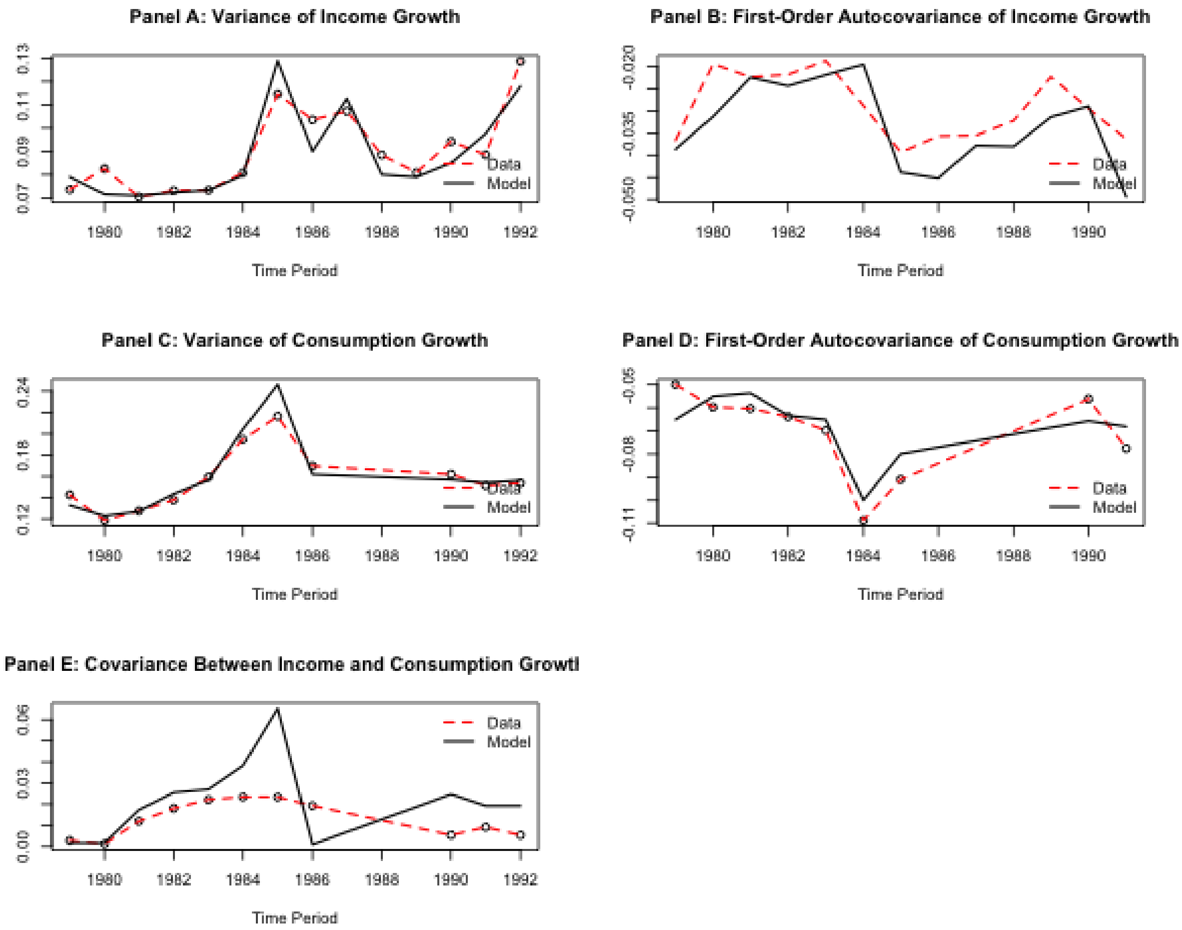

Figure 4: The time series of the cross-sectional variance of income growth (Panel A), the cross-sectional first-order autocovariance of income growth (Panel B), the cross-sectional variance of consumption growth (Panel C), the cross-sectional first-order autocovariance of consumption growth (Panel D), and the covariance of income and consumption growth (Panel E). In each panel, the black solid line plots the model-implied moments while the red dashed line plots the sample moments. Both the second and third moments of income and consumption growth are used in the estimation of the model parameters.

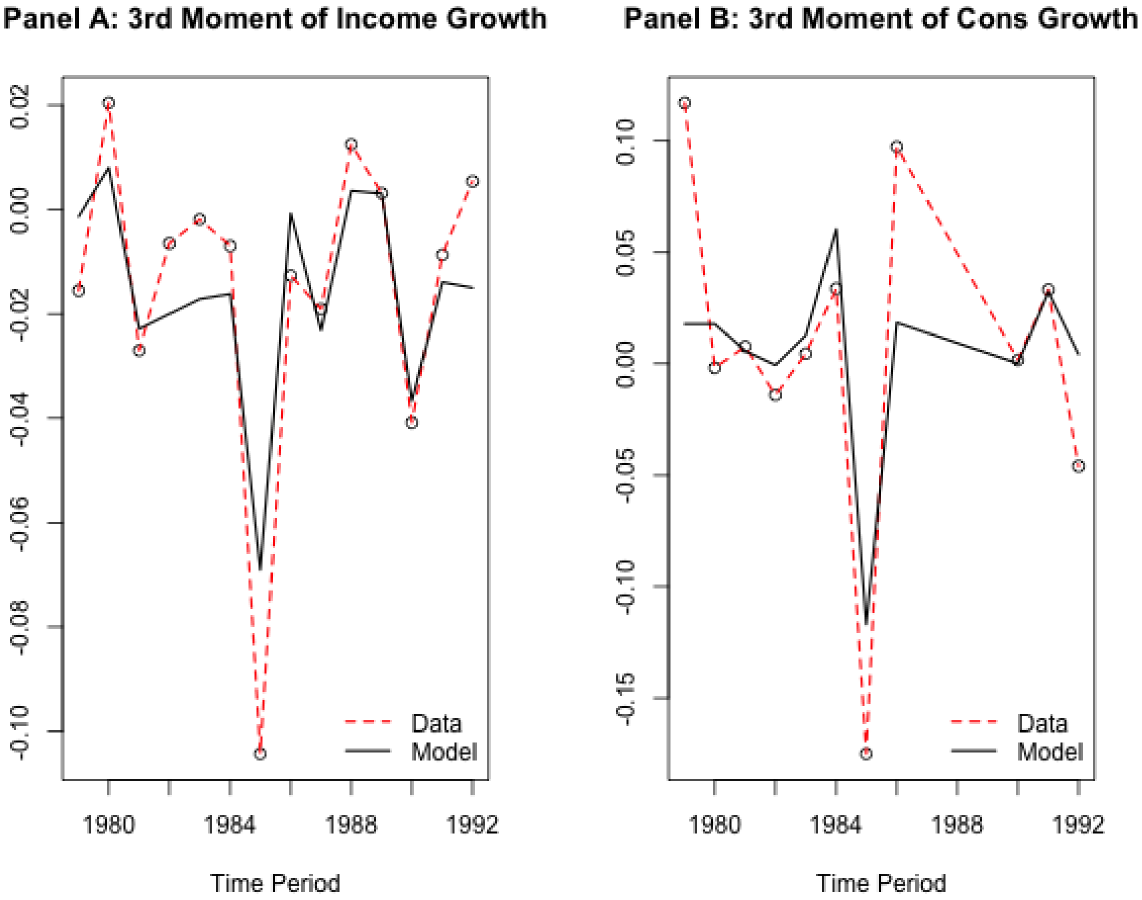

Figure 5: The time series of the cross-sectional third moment of income growth (Panel A) and the cross-sectional third moment of consumption growth (Panel B). In each panel, the black solid line plots the model-implied moments while the red dashed line plots the sample moments. Both the second and third moments of income and consumption growth are used in the estimation of the model parameters.