Countercyclical Risks and Portfolio Choice over the Life Cycle: Evidence and Theory

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Abstract

Using the Panel Study of Income Dynamics, I find that skewness in earnings growth affects the mean and skewness in consumption growth, and this effect is stronger for stockholders than nonstockholders. Moreover, I also find that stockholders subject to less negative skewness in earnings growth hold a higher share of their financial wealth in stocks. Using a life-cycle model incorpating business cycle variation in expected growth and skewness in earnings shocks, I investigate these relationships from an asset allocation perspective. During expansions (recessions), households consume more (less), and also invest a higher (lower) share of their wealth in the stock market, because of a higher (lower) expected future earnings growth rate. Negative skewness in the earnings process during recessions further reduces households' consumption and stock market exposure. The model shows how countercyclical skewness in earnings shocks leads to countercyclical skewness in consumption growth, while simultaneously matching quantitatively observed portfolio choice and wealth accumulation over the life cycle.

JEL Classification: D91, E21, G11.

Key Words: Countercyclical Skewness, Earnings Risk, Life-cycle Portfolio Choice, Countercyclical Risks.

1 Introduction

Using the Consumer Expenditure Survey (CEX), Constantinides and Ghosh (2017) find that skewness in consumption growth is countercyclical and, more importantly, drives asset prices[1]. Where might this countercyclical skewness in consumption growth come from? Given the recent work of Guvenen, Ozkan, and Song (2014), who find skewness in earnings shocks is strongly countercyclical, it is reasonable to raise the hypothesis that countercyclical skewness in individual earnings shocks leads to countercyclical skewness in consumption growth. I provide evidence on this question using the Panel Study of Income Dynamics (PSID).

Although my focus is on the third moment of consumption growth, it is also interesting to examine the sensitivity of the first moment of consumption growth. I therefore start by studying how consumption growth responds to changes in the skewness of earnings shocks and changes in the variance of earnings shocks, while controlling for a broad set of household characteristics. I find that changes in the skewness of earnings shocks are significantly positively correlated with consumption growth for stockholders but not for nonstockholders. Moreover, changes in the labor income variance seem to be consistently negatively correlated

[1] Considerable literature addresses the asset pricing implications of consumption risk, and provides plausible explanations to justify puzzling aspects of asset market data.Campbell and Cochrane (1999) formulate a model that explains a wide variety of asset pricing puzzles, by augmenting the standard power utility function with a time-varying external habit, that adapts nonlinearly to current and past average consumption in the economy. Rietz (1988) first brings in the potential for low-probability disasters to solve the asset pricing puzzles. Barro (2006) revisits Rietz's analysis and shows a large and sustained drop in consumption can explain the equity premium and related puzzles. Cogley (2002) and Brav, Constantinides, and Geczy (2002) find that assuming households are endowed with power utility, including higher moments, such as the standard deviation and skewness of the consumption growth distribution, reduces the size of the Euler equation errors for stock returns. Bansal and Yaron (2004) develop a long-run risks model for growth rates and consumption volatility that explains various asset market phenomena well. Parker and Julliard (2005) measure consumption risk by the covariance of an asset's return and consumption growth cumulated over many quarters following the return, and confirm that consumption risk is an important determinant of average returns across stocks

with consumption growth.

Next, I test the hypothesis that countercyclical skewness in consumption growth comes from countercyclical skewness in earnings shocks. I find changes in the skewness of earnings shocks are significantly positively correlated with changes in the skewness of consumption growth for all households. This is largely driven by the especially stronger correlation for stockholders and the rising rate of stock market participation over time. As for nonstockholders, this positive correlation is not statistically significant. Meanwhile, no significant correlation is found from changes in the variance of earnings shocks. Taken together, my findings suggest that countercyclicality could be transmitted from skewness in earnings shocks to skewness in consumption growth, and this effect is particularly stronger for stockholders.

What might drive this heterogeneity between stockholders and nonstockholders? I find that stockholders are relatively richer and spend more on unnecessary goods, such as dining at a nice restaurant. This expenditure on unnecessary goods is more responsive to earnings risk. Thus when stockholders are hit by negative earnings risk, they largely reduce their expenditure on unnecessary goods, which leads to stronger correlation for them.

Additionally, earnings shocks affect household portfolios (Guiso, Jappelli and Terlizzese (1996)). As the PSID dataset provides rich information on asset holdings, to make the best possible use of this dataset, I study the importance of skewness in earnings shocks on portfolio choice for stockholders as well. I find that changes in the skewness of earnings shocks are significantly positively correlated with changes in the proportion of risky assets. When more downward movements in earnings are more likely, households reduce their holdings of risky assets. This is consistent with the positive coefficients of changes in the skewness of earnings shocks. Moreover, the coefficients of changes in the variance of earnings shocks are significantly negative. A higher variance in earnings shocks discourages stockholders to invest in risky assets. I conclude that both skewness and variance in earnings shocks are not only statistically significant but also economically significant for risky asset shares.

Overall, the empirical evidence shows skewness in earnings shocks is an important determinant of consumption and skewness in consumption growth. Moreover, heterogeneity matters: the effect is statistically significant for stockholders, not for nonstockholders. As households get rich and are more likely to become stockholders, consumption may become more responsive to skewness in earnings shocks. For stockholders, increasing negative skewness in earnings shocks discourages them from holding risky assets. Skewness in earnings shocks seems to be an uninsurable earnings risk that many households face. It fluctuates over the business cycle and this fluctuation affects households' consumption and portfolio choice decisions.

This empirical evidence suggests a strong link between skewness in earnings shocks, consumption, skewness in consumption growth and portfolios. It is natural to ask if a model can capture all these empirical findings, and whether a theoretical mechanism behind these findings can be uncovered. A quantitative model where skewness in labor income process can be switched on and off allows me to study the causal relationship between skewness in consumption growth and skewness in labor income process more comprehensively.

I therefore build a life-cycle model, which allows for countercyclical earnings risk, to study the relationship among skewness in earnings shocks, consumption, skewness in consumption growth and portfolios. In order to be consistent with the findings of the labor income process in Guvenen, Ozkan and Song (2014), I not only consider business cycle variation in the third moment, but also in the first moment. In a recession, households expect a lower mean growth rate in their labor income and they also expect to draw labor income from a distribution that exhibits negative skewness. I use a mixture normal distribution to construct any desired higher moments in labor income shocks, and revisit the role of uninsurable labor income risk on consumption decisions and asset allocation over the life cycle and the business cycle.

Improving our understanding of how countercyclical earnings risk affects consumption decisions and portfolio choice over the life cycle and business cycle is not sufficient to generate a calibration that can match wealth accumulation and portfolio choice over the life cycle. To do so, I produce two variants of the model that can be calibrated to the 1989 Survey of Consumer Finances (SCF) data. In the first variant (benchmark 1) I show how preference heterogeneity among stockholders and non-stockholders can generate a reasonable fit. In the second variant, I show how a rare event can also generate similar implications. With these specifications I show that the model can do a reasonable job in matching the cross sectional wealth and portfolio choices observed in the 1989 SCF Survey.

Next, I investigate what the model would have predicted for the same regressions as those with the PSID data. This model provides evidence that is consistent with its empirical counterparts. First, given that the model has implications at the micro level, I run three regressions to test the predictions of the model. I start by examining how changes in the skewness of earnings shocks affect portfolio choice for stockholders. Both models generate significant positive effects of changes in the skewness of earnings shocks on changes in risky asset shares, and inclusion of rare events in the stock market amplifies this positive effect. Then I explore how changes in the skewness of earnings shocks affect consumption growth. I find that in both models, changes in the skewness of earnings shocks have positive effects on consumption growth, as expected, and statistically significant for all households, stockholders and nonstockholders. An increase in positive skewness in earnings shocks leads to a tiny effect on consumption.

Moreover, I study how changes in the skewness of consumption growth respond to changes in the skewness of earnings shocks. I find that the positive effect of skewness changes in earnings shocks on skewness in consumption growth appears for all households, stockholders and nonstockholders. This positive effect is significant in both benchmark models. For nonstockholders, the models predict much stronger effect than the data. This might be the result of stronger negative skewness in labor income process assumed in the model than the skewness in the data for nonstockholders. This model does not differentiate the labor income process between stockholders and nonstockholders.

Now, I turn to next questions: what would the model have contributed to the evolution of skewness in consumption growth from 1989 to 2013? Is the model capable of generating countercyclical skewness in consumption growth? In order to emphasize the importance of skewness in labor income on skewness in consumption growth, I first consider various specifications of the model, such as the model with normal permanent income shocks (log-normal earnings model) and the model with normal permanent income shocks and different expected growth rate between booms and recessions (log-normal earnings model with business cycle).

Then I introduce a dummy variable for boom, and study how skewness in consumption growth is correlated with this dummy variable. The larger the correlation, the stronger the countercyclicality. The log-normal earnings model does not generate countercyclicality at all with almost zero correlation, while the log-normal earnings model with business cycle seems to generate a positive but statistically weak correlation because of different expected growth rate in labor income process during booms and recessions. Benchmark 1 and benchmark 2 both generate extremely significant positive correlations for stockholders. Meanwhile, benchmark 1 also generates significant positive correlation for all households. Both models generate positive but insignificant correlations for nonstockholders. As a result, the model verifies the hypothesis that countercyclical skewness in earnings shocks leads to countercyclical skewness in consumption growth and is consistent with the empirical evidence in the PSID data.

This paper draws on several strands of the literature. First, it is motivated by the recent work of Constantinides and Ghosh (2017), who show that household consumption growth displays countercyclical negative skewness and study the implication of consumption risk on asset pricing using the Consumer Expenditure Survey (CEX) data base. I use a different micro-level data, the PSID data, and find the empirical link between skewness in earnings shocks, consumption, skewness in consumption growth and portfolios.

This paper also draws on a large recent literature on life cycle portfolio choice studies the role of non-diversifiable labor income risk on life-cycle consumption and portfolio choice. Research in this literature usually focuses on analysing labor income shocks that follow a log-normal distribution (Deaton (1991), Carroll (1997), Carroll and Samwick (1997), Cocco, Gomes, and Maenhout (2005), Gomes and Michaelides (2005), among other papers). In contrast to these models, my model allows higher moments in labor income shocks, and is able to generate similar results as the PSID dataset. Meanwhile, Galvez (2017) uses quantile regression to study earnings risk and its effect on stock market participation and portfolio choice. Catherine (2017) explores its effect on participation costs. More recent work from Chang, Hong and Karabarbounis (2018) has looked at age-dependent labor market uncertainty and obtained the results consistent with what I find. My work differs from their studies due to the investigation of earnings risk in the PSID dataset, the different model setup and the focus on heterogeneity between stockholders and nonstockholders.

Finally, this paper relates to the literature on the dynamics in individual earnings risk. Earlier research argue that idiosyncratic earnings risk has countercyclical variance (e.g., Storesletten, Telmer, and Yaron (2004)), and investigate the asset pricing implications of this kind of risk (e.g., Constantinides and Duffie (1996), Storesletten, Telmer, and Yaron (2007)). However, recent studies show that higher job displacement risk in recessions gives rise to countercyclical skewness of earnings shocks and the cost of job loss can be very large, especially when it happens during a recession (e.g., Krebs (2007), Davis and von Wachter (2011)). Moreover, Guvenen, Ozkan and Song (2014) document this countercyclical skewness in individual earnings risk using a very large data set from the US Social Security Administration. This paper links this countercyclical skewness in earnings shocks to the life-cycle consumption decision and portfolio choices, and displays the importance of this uninsured and unforeseen earnings risk.

The paper is organized as follows. Section 2 shows empirical evidence in micro-level data. Section 3 presents the model and Section 4 calibrates the parameters for the model with the 1989 SCF data. Section 5 compares the model's implication for consumption and portfolio choice relative to the log-normal earnings process. Section 6 conducts regression analysis with the model simulation and compares the results between model and data. The paper concludes with Section 7.

2 Empirical Evidence

Skewness in consumption growth is countercyclical, with a correlation 0.370 with NBER-dated recessions. What drives this countercyclical left-skewness in consumption growth? The answer to this question turns out to be central for understanding the asset pricing implication of consumption risk.

Unfortunately, there is limited literature on this question. One possible explanation for this countercyclical skewness in consumption growth is countercyclical labor income risk. Recent research, Guvenen, Ozkan and Song (2014), shows using large social security administration data that skewness in labor income shocks is countercyclical. This is an important, but untested, hypothesis. It is not clear how countercyclical skewness in earnings shocks affects consumption and skewness in consumption growth. Fortunately, in addition to comprehensive expenditure data, the PSID dataset also includes detailed information on labor income, asset holdings and demographic variables. With the use of these data, I provide some empirical evidence on how changes in the skewness of earnings shocks affect consumption growth and skewness in consumption growth. Moreover, to better explore the PSID dataset and understand the importance of earnings risk on portfolios, I also present empirical evidence on how changes in the skewness of earnings shocks affect portfolios.

I first examine how changes in the skewness of labor income risk affect consumption growth. Following Brunnermeier and Nagel (2008), I conduct regression analysis and control a broad set of household socioeconomic characteristics, as the heterogeneity can cause changes in consumption, which obscures the relationship between cross-sectional skewness in labor income shocks and consumption. Then in order to check whether there exists a link between skewness in labor income shocks and skewness in consumption growth, I regress changes in the skewness of consumption growth on changes in the skewness of earnings shocks. Additionally, I also investigate how portfolios respond to skewness in earnings shocks by regressing changes in the risky assets shares on changes in the skewness of earnings shocks.

2.1 Data

I use the mirco-level data, the Panel Study of Income Dynamics (PSID), to study how skewness in earnings shocks affects consumption, skewness in consumption growth and portfolios. The PSID is an annual survey from 1968 to 1997 and a biennial survey after 1997. Since 1999, more questions on consumption expenditure and many other domains have been added to the survey. The quality of the PSID has been greatly enhanced since 1999.

Additionally, another three distinct features make consumption data collected in the PSID of higher quality. First, the PSID allows respondents to report expenditures for different time periods, which is easier for them to recall. Second, the PSID offers the respondents unfolding brackets when they cannot recall the exact amount of expenditures. Third, the PSID collects expenditure data at a more aggregate level[2]. These features make the PSID a unique dataset to study household consumption expenditure.

Nevertheless, most of the literature on consumption expenditures use the CEX, which is a short panel data and the quality of its income, asset and consumption data has recently raised some worries. There is now mounting evidence showing the CEX has non-classical measurement problems that will likely hinder the extent to which definitive conclusions

[2]See also Andreski, Li, Samancioglu and Schoeni (2014) for the comparison between the PSID data with those in the Consumer Expenditure Survey (CE).

can be made about the extent to the effect of skewness in earnings shock[3]. Because of these measurement errors, the PSID is a better data source to study the dynamics of consumption.

Besides better consumption data, the PSID also contains a variety of other information, including labor market, risky asset holdings and demographic variables, such as age, education, household composition, household marital status. These detailed information enable me to explore not only consumption itself, but also the empirical link between labor income, consumption and portfolios.

2.2 Consumption and Earnings Risk

In this section, I conduct regression analysis to examine how consumption growth responds to changes in the cross-sectional skewness of labor income risk. I not only report results for all households, but also report results for two subgroups: stockholders and nonstockholders. It is worth exploring how results change for them, as heterogeneity between these two groups has been well documented in many studies. Attanasio, Banks, and Tanner (2002) and Vissing-Jørgensen (2002) show that differences in estimates of the EIS between stockholders and nonstockholders are large and statistically significant.

The PSID only collects detailed data on asset holdings in the years 1984, 1989, 1994, 1999, 2001, 2003, 2005, 2007 and 2009. Considering the missing food data in 1989 and more comprehensive consumption data since 1999, I only use data collected in 1999, 2001, 2003, 2005, 2007 and 2009.

[3]Garner and Maki (2004) document the fact that aggregate measures of expenditure from the CEX does a poor job at reproducing the level of expenditure in National Income and Product Accounts (NIPA). Blundell, Pistaferri, and Saporta-Eksten (2012) also argue that the PSID dataset is more valuable than the CEX data because it seems much better aligned with NIPA. Attanasio, Hurst, and Pistaferri (2013) worry about the fact that the large discrepancy between CEX aggregate consumption measures and the Personal Consumption Expenditures (PCE) aggregates has been increasing over time.

To estimate variance and skewness in the labor income process, I follow closely the estimation process described by Carroll and Samwick (1997) and Cocco, Gomes and Maenhout (2005), where I control for family-specific fixed effects including family size, marital status, age and a constant term.

The moments of earnings growth distribution are the same for all households each year. To increase the variability of skewness in earnings risk and variance in earnings risk, I exploit the region information in the dataset by calculating skewness in earnings risk and variance in earnings risk based on the region where the household lives. I consider four regions: Northeast, North Central, South and West. I would like to be able to consider the state where the household lives, but that would lead to a decrease in sample size and to an increase in measurement error.

The labor income shocks are defined as

$$\Delta y^*_{irt} = log(Y^*_{ir,t+2}) - log(Y^*_{irt}) \tag{1}$$

where Y^*_{irt} is given by

$$log(Y^*_{irt}) = log(Y_{irt}) - \hat{f}(t, Z_{irt}) \tag{2}$$

Hence, variance and skewness in the cross-sectional distribution of permanenet shocks can be expressed as follows:

$$var(\Delta y^*_{irt}) = 2 \times l_{var,rt} + 2 \times var(\varepsilon_{rt}) \tag{3}$$

$$skew(\Delta y^*_{irt}) = 2 \times l_{skew,rt} \tag{4}$$

where subscript r indicates the region where the household lives. I need cross-sectional variance and skewness, so constant variance and skewness over the time do not help the regression analysis. So I take $var(\varepsilon_t)$ as 0.1^2 from the model and estimate variance ($l_{var,rt}$) and skewness ($l_{skew,rt}$) in the permanent shocks u_t based on variance and skewness of Δy^*_{irt}.

I define the rest of variables as Brunnermeier and Nagel (2008) do. Liquid assets are defined as the sum of stocks and mutual funds plus riskless assets. Subtracting other debts from liquid assets yields liquid wealth. Financial wealth is defined as the sum of liquid wealth, home equity and equity in private business. I regress consumption growth ($\Delta_k c_t$) on changes in the skewness of earnings shocks ($\Delta_k l_{skew,t}$) conditional on the change of liquid asset (financial wealth) between $t-k$ and t ($\Delta_k w_t$), the cross-sectional variance in earnings shocks ($\Delta_k l_{var,t}$), preference shifters (q_{t-k}) and life-cycle controls ($\Delta_k h_t$) as follows:

$$\Delta_k c_{it} = \beta q_{i,t-k} + \gamma \Delta_k h_{it} + \psi \Delta_k w_{it} + \rho \Delta_k l_{skew,rt} + \kappa \Delta_k l_{var,rt} + \epsilon_{it} \tag{5}$$

where preference shifters are the variables related to the changes in the household between $t-k$ and t, and life-cycle controls include the variables related to the life cycle, background and financial situation of the household at $t-k$. Except skewness and variance, I omit region subscripts for the remaining variables to reduce clutter.

To be included in the sample, households can not have missing information on consumption or food consumption. I also delete households with zero consumption or zero food consumption. The log consumption is denoted as $c_t = log(C_t)$. Consumption growth is defined as $\Delta c_{t+1} = c_{t+1} - c_t$. If households with consumption growth rate $\Delta c_t < log(1/2)$ and $\Delta c_{t+1} > log(2)$, or if $\Delta c_t > log(2)$ and $\Delta c_{t+1} < log(1/2)$, or if $\Delta c_t > log(5)$, these households are deleted from the sample.

Household marital status is required to remain the same in two consecutive survey years and no assets move in or move out due to a family member moving into or out of a family unit. If a household head retires in the current survey year, I delete all the information about this household. I also exclude those households with too little wealth, for example: households with liquid wealth less than $10,000. Stock market participants are defined as those whose risky assets shares to be larger than zero. Sample weights are not considered, as Deaton (1997) shows it is inefficient to do so (also following Brunnermeier and Nagel (2008)).

Table 1 shows summary statistics for stockholders (Panel A) and nonstockholders (Panel B). Comparing consumption, liquid assets, financial wealth and income mean for stockholders and nonstockholders, it is obvious that stockholders have higher consumption, wealth and income on average. This is consistent with the large correlation of consumption and wealth, and the fact that wealth is known to be a strong predictor of participation in the stock markets (Attanasio and Browning (1995)). The distribution of consumption growth and income shocks has negative skewness and it is especially strong for stockholders. Therefore, it is important to split between stockholders and nonstockholders and perform regression analysis for these two groups.

I regress consumption growth on changes in the cross-sectional skewness of earnings shocks and condition on a set of variables, including changes in the cross-sectional variance of earnings shocks. Panel A of Table 2 presents the main results for all households, stockholders and nonstockholders. Column $1-3$ show the results with liquid assets and Column $4-6$ show the results with financial wealth.

The first row of Panel A shows that the point estimates for changes in the cross-sectional skewness of labor income shocks are positive for all households, stockholders and nonstockholders. These positive coefficients are consistent with the fact that when more downward movements in the labor income process are more likely, households would like to reduce their consumption. Especially for all households and stockholders, the slope coefficients are statistically significant. For all households, the coefficient is 0.102 with liquid assets and 0.106 with financial wealth. For stockholders, the coefficient is 0.165 with liquid assets and 0.141 with financial wealth, which imply that a one standard deviation increase in skewness of earnings risk is associated with a 14.12% increase in consumption with liquid assets and a 22.74% increase in consumption with financial wealth. Therefore, the estimated coefficients are not only statistically significant, but also economically significant.

As for changes in the variance of earnings risk, it is a different story. The second row of Panel A shows the point estimates for changes in the variance of earnings risk are all negative. With liquid assets, the coefficient of changes in the variance is statistically insignificant for stockholders. The coefficient -0.947 implies that a one standard deviation increase in skewness of earnings risk decrease consumption by 7.15% with liquid assets. With financial wealth, the point estimates are still insignificant for stockholders. The coefficient -0.930 suggests that a one standard deviation increase in variance of earnings risk is associated with a 9.60% decrease in consumption. Although the coefficients of variance are larger than those of skewness, they are neither statistically significant nor economically significant.

Overall, I conclude that no matter which definition of wealth is used, changes in the skewness of earnings risk are positively correlated with consumption growth and this correlation is statistically significant for stockholders and all households.

2.3 Consumption Risk and Earnings Risk

As I perform results not only for all households but also for stockholders and nonstockholders, before I conduct any test, I would like to check first if countercyclical skewness in consumption growth still exists even after the split between stockholders and nonstockholders. I therefore calculate the correlations between skewness in consumption growth and NBER-dated recession for stockholders and nonstockholders respectively. Correlation for stockholders is 0.301, and 0.248 for nonstockholders, which shows skewness in consumption growth is still countercyclical for different subgroups.

Now I turn to the test, examining if there exists a link between changes in the consumption risk and changes in the skewness of earnings risk. Figure 1 shows the scatter plot and best fit line between skewness in consumption growth and skewness in labor income shocks[4]. Most points lie within the third and the forth quadrant, suggesting skewness in consumption growth are mostly negative, which is consistent with the observations in Constantinides and Ghosh (2017). The pattern of dots slopes from lower left to upper right, and indicates a positive correlation between these two skewnesses.

Next, I conduct a similar regression as I do in the previous section, but use changes in

[4]Figure 1 also shows heterogeneity across different regions. See Online Appendix B for more discussion.

consumption risk as dependent variable, instead of consumption growth.

$$\Delta_k c_{skew,rt} = \beta q_{i,t-k} + \gamma \Delta_k h_{it} + \psi \Delta_k w_{it} + \rho \Delta_k l_{skew,rt} + \kappa \Delta_k l_{var,rt} + \epsilon_{it} \tag{6}$$

Panel B of Table 2 presents the regression results for all households, stockholders and nonstockholders. Column $1-3$ show the results with liquid assets. Column $4-6$ show the results with financial wealth. The first row of Panel B shows how changes in the consumption risk respond to changes in the skewness of earnings risk. The second row of Panel B shows how changes in consumption risk respond to changes in the variance of earnings risk. The regressions include all the preference shifters and life-cycle controls as mentioned.

My focus is on the coefficient for changes in the skewness of earnings risk. As Panel B first row shows, I find positive coefficients for all households and stockholders, with high statistical significance. In the second column of Panel B, the point estimate of 0.202 implies that a one standard deviation increase in skewness of earnings risk is associated with a 48.74% increase in consumption. In the first column of Panel B, the magnitude of the point estimate for all households is smaller than that for stockholders, but is different from zero at a high level of statistical significance. For nonstockholders, I don't find significant coefficients for changes in the skewness of earnings risk, although the slope coefficient remains positive. The second row of Panel B shows that variance in earnings risk has no significant effect on consumption risk for all three groups, and the point estimate of 0.207 implies that a one standard deviation increase in variance of earnings risk is associated with a 2.02% increase in consumption. I obtain similar results with financial wealth.

In summary, skewness in earning risk is positively correlated with skewness in consumption growth, and this correlation is economically and statistically significant for stockholders. As skewness in earnings risk is countercyclical documented by Guvenen, Ozkan and Song (2014), it may lead to countercyclical skewness in consumption growth through the positive correlation between skewness in earnings risk and consumption risk.

2.4 Explanation for Heterogeneity: Components of Consumption

Skewness in earnings shocks is positively correlated with consumption. Meanwhile, the correlation is statistically significant for stockholders, not nonstockholders. What drives this stronger correlation for stockholders? In this section, I test the most possible explanation and discuss another two explanations in Online Appendix D.

One possible explanation is that negative shocks to labor income process are more easily transmitted to consumption process for stockholders. As stockholders are wealthier than nonstockholders on average, they are more likely to consume unnecessary goods. When they are exposed to negative shocks to their labor income, they can choose to reduce their consumption on unnecessary goods and still maintain their consumption of necessary goods. On the other hand, under the extreme circumstance, when some poor households who consume only necessary goods face negative shocks to their labor income, they can not reduce their consumption any further as they almost keep their consumption as minimum as possible. Therefore, skewness in earnings shock has much more significant correlation for stockholders, less so for nonstockholders.

To test this explanation, I examine how components of consumption for stockholders differ from those for nonstockholders, and whether these differences help explain the stronger effect of skewness in earnings risk for stockholders. The PSID collects information regarding spending on food, housing, education, childcare and transportation. Although the consumption expenditure questions were further expanded in 2005 to include information on spending on trips, vacations and entertainment, to keep the consistency of the data, I still exclude them from the total consumption in 2005, 2007 and 2009.

Table 3 reports the estimation results for each component of consumption. Column $1-3$ show results with liquid assets, and Column $4-6$ show results with financial wealth. As the results with financial wealth are similar those with liquid assets, I discuss the results mainly with liquid assets to aviod repetition.

Table 3 shows that stockholders decrease their spending on food significantly than nonstockholders, when they experience negative earnings shocks. As the total amount spent on food includes the amount spent on food consumed at home and food consumed in restaurants. Dining at a nice restaurant can be unnecessary goods. Stockholders are relatively richer than nonstockholders, and more satiated in their consumption of necessary goods. Negative earnings shocks are reflected in the consumption of luxury goods, which is much more responsive than the consumption of necessary goods. Thus when stockholders are hit by negative earnings shock, they reduce the frequency of dining out, which leads to large reduction on food expenditure. Meanwhile, households display a high degree of risk aversion with respect to their consumption of necessary goods. Cutting down on these goods is costly in utlity terms. Nonstockholders mainly consume necessary goods, and therefore their food consumption does not significantly drop because of negative skewness in earnings risk.

The simliar principle also applies to childcare and education, as some components in childcare and education can be treated as unnecessary goods. They respond more vigorously to negative earnings shocks, which leads to stronger correlation between skewness in earnings risk and consumption for stockholders. For nonstockholders, the amount spent on childcare and education is not significantly correlated with skewness in earnings risk.

The amount spent on housing includes mortgage, rent, utility, home insurance and property tax. Renegotiating mortgage plan or moving home is time consuming, which suggests it is difficult to adjust housing expenditure instantly. This explains why housing expenditure does not respond to skewness in earnings risk significantly regardless of whether households are stockholders or nonstockholders.

Transportation expenditure is a different story. The estimated coefficients are significantly positive for both stockholders and nonstockholders, although the estimated coefficient is only weak significant for nonstockholders. Transportation expenditure is one of the largest expenses for households, the fourth largest category after healthcare, housing and food. Personal vehicles account for the vast majority of total transportation expenditures. Among personal vehicles, gasoline and motor oil, repair cost, parking and other vehicle expenses, except vehicle purchases, account for more than 60%. When households are hit by negative earnings shocks, they choose to use more public transportation and decrease their transportation expenditure. Hence, skewness in earnings risk is significantly positively correlated with transportation expenditure.

Table 4 presents the regression results for skewness in each component of consumption. Two findings in Table 4 are noteworthy. First, skewness in each component of consumption for stockholders is more highly correlated with skewness in earnings risk than is skewness in each component of consumption for nonstockholders. Second, skewness in each component of consumption is nearly uncorrelated with skewness in earnings risk for stockholders and nonstockholders. These findings strengthen the importance of skewness in earnings risk for consumption.

Overall, Table 3 and Table 4 can explain the stronger correlation between consumption and skewness in earnings risk for stockholders. Components of consumption that partially relate to expenditure on unnecessary goods respond more actively for stockholders than nonstockholders, which suggest stockholders are more easily to reduce their consumption on unnecessary goods to offset negative earnings shocks during recessions.

2.5 Portfolios and Earnings Risk

An early literature initiated by Guiso, Jappelli and Terlizzese (1996) empirically points out the temperance effect of labor income uncertainty on portfolios and I follow the same empirical strategy. More recently, Brunnermeier and Nagel (2008) investigate whether the share of wealth in stocks varies in response to wealth shocks (an implication of habit formation models). I use the similar approach as previous section, but investigate empirically whether a link exists between skewness in earnings risk and portfolios.

I calculate two risky asset shares: stocks and mutual funds divided by liquid assets (α_1) and as a second measure the sum of stocks, home equity and equity in a private business, divided by financial wealth (α_2). I regress the changes in risky assets shares on changes in the skewness in earnings shocks conditional on variance in earnings shocks and a broad set of household characteristics, such as changes of liquid asset between $t-k$ and t, preference shifters and life-cycle controls, as follows:

$$\Delta_k \alpha_{it} = \beta q_{i,t-k} + \gamma \Delta_k h_{it} + \psi \Delta_k w_{it} + \rho \Delta_k l_{skew,rt} + \kappa \Delta_k l_{var,rt} + \epsilon_{it} \tag{7}$$

Panel C of Table 2 reports the main results for $\Delta\alpha_1$ (Column $1-3$) and $\Delta\alpha_2$ (Column $4-6$). The table shows that the point estimates for two definitions of risky asset shares are positive and statistically significant. The coefficient of the skewness for $\Delta\alpha_1$ is 0.008 and that for $\Delta\alpha_2$ is 0.010. During the recession, when more downward movements in the labor income process are more likely (skewness becomes more negative), households would choose to reduce their holdings of risky asset, which is consistent with the positive coefficients of the change in skewness. For $\Delta\alpha_1$, the coefficient implies that one standard deviation increases in the negative skewness leads to risky asset share decreases 2%. Meanwhile, the coefficient for $\Delta\alpha_2$ implies that one standard deviation increases in the negative skewness leads to risky asset share decreases 2.5%.

No matter how risky asset share is defined, the coefficients of the variance are both negative as expected. For $\Delta\alpha_1$, the coefficient of the variance is -0.174, significantly different from 0. For $\Delta\alpha_2$, the coefficient of the variance is quite similar to that for $\Delta\alpha_1$. The estimate is of the same order of magnitude and significance. These results imply that the risky asset share of households with higher variance in labor process is much less than that of households with lower variance, other things being equal, which is consistent with Guiso, Jappelli and Terlizzese (1996).

These empirical findings show the background risk decreases households' willingness to bear other avoidable risks. When households face the negative shocks to the cross-sectional skewness, their uninsurable labor risk increases and they choose to reduce their holdings of risky assets. The regression analysis in this section confirms that the presence of negative skewness is crucial to the portfolio choice problem.

2.6 Summary of Empirical Results

So far, with the PSID data, I show that skewness in earnings shocks is positively correlated with consumption. Increasing negative skewness in earnings shocks leads households to reduce their consumption, as they all face more earnings risk. Self-insurance is not very effective in smoothing earnings shocks, so on average households respond quite strongly to skewness in earnings shocks. Skewness in earnings shocks also has positive correlation with skewness in consumption growth, which indicates countercyclical skewness in earnings shocks may generate countercyclical skewness in consumption growth.

Moreover, heterogeneity matters: the correlation is statistically significant for stockholders, not nonstockholders. This heterogeneity comes from that components of consumption that partially relate to expenditure on unnecessary goods respond more actively for stockholders than nonstockholders, when negative earnings risk happens. Hence, correlation is stronger for stockholders, less so for nonstockholders.

I also find skewness in earnings shocks is statistically positively correlated with risky asset shares for stockholders. The implicit risk-free asset holdings in the form of labor income lose importance as negative skewness in earnings shock increases. All else equal, when stockholders are exposed to more downward movement in their labor income process, they reduce their risky assets shares. Therefore, earnings risk crowds out risky assets holdings.

To sum up, skewness in earnings risk seems to be an uninsurable earnings risk that households face. It fluctuates over the business cycle and this fluctuation affects households' consumption and portfolio choice decision.

3 The Model

In the previous section, I find empirical link between skewness in earnings shocks, consumption, skewness in consumption growth and portfolios. In this section, I build a life-cycle model with business cycle variation in earnings risk to better understand these facts quantitatively.

3.1 Preferences

I solve an annual frequency model and follow households from age 20 until their death. Death happens by age 100 at the latest, but could happen earlier as households are faced with an age-specific survival rate. Households start working at age 20 and receive uncertain labor income exogenously. They retire at age 65.

Households have Epstein-Zin (1989) preferences defined recursively over consumption C_{it} and separating the elasticity of intertemporal substitution from the relative risk aversion,

$$V_{it} = \left\{(1-\beta)C_{it}^{1-1/\psi} + \beta(E_t(p_{t+1}V_{i,t+1}^{1-\gamma} + b(1-p_{t+1})X_{i,t+1}^{1-\gamma}))^{\frac{1-1/\psi}{1-\gamma}}\right\}^{\frac{1}{1-1/\psi}} \tag{8}$$

where β is the discount factor, b is the strength of bequest motive, γ is the coefficient of relative risk aversion and ψ is the elasticity of intertemporal substitution. p_{t+1} is the probability that the household is alive at date $t+1$ conditional on being alive at date t.

3.2 Labor Income Process

Households work for the first K (46) periods out of T (81) periods. During working period, household i's labor income at age t (Y_{it}) is given in logs ($y_{it} = logY_{it}$), by

$$y_{it} = v_{it} + \varepsilon_{it} \text{ for } t \leq K \tag{9}$$

where ε_{it} is temporary shock to labor income, which is normally distributed with mean $-\sigma_\varepsilon^2/2$, variance σ_ε^2, and the permanent component v_{it} is given by

$$v_{it} = f(t, Z_{it}) + v_{i,t-1} + u_{it} \tag{10}$$

where $f(t, Z_{it})$ is a deterministic function of age t and a vector of other individual characteristics Z_{it}, and u_{it} is permanent shock, uncorrelated with ε_{it}. For simplicity, income during retirement is assumed to be exogenous and deterministic. Income is specified as a constant fraction λ of permanent component of labor income in the last working period,

$$y_{it} = log(\lambda) + v_{iK} \text{ for } t > K \tag{11}$$

where $K = 46$, corresponding to the retirement age 65.

A key variation relative to the prior literature on life cycle portfolio choice is allowing countercyclical earnings risks. To be consistent with the empirical findings in Guvenen, Ozkan and Song (2014). I not only allow skewness depend on the business cycle, but also expected growth rates. In what follows subscript $s(t)$ indicates whether year t is a boom or recession. Countercyclical earnings risks and captured by assuming u_{it} is a mixture of normal distributions, so that conditional on the state of the economy $s(t)$ with probability p_1 the u_{it} draw is from one distribution and with probability $(1 - p_1)$ from a second distribution:

$$
u_{it} = \begin{cases} u_{it}^1 \sim N(\mu_{1s(t)}, \sigma_{1s(t)}^2) & \text{with prob. } p_1 \\ u_{it}^2 \sim N(\mu_{2s(t)}, \sigma_{2s(t)}^2) & \text{with prob. } 1 - p_1 \end{cases} \tag{12}
$$

One of the key contributions of the paper is to understand how these countercyclical earnings risks affect saving/consumption and portfolio choices. Therefore, I also report results from a model where the permanent income shock u_{it} is distributed as $N(-\sigma_u^2/2, \sigma_u^2)$, which is a common setting, for example, from Deaton (1991), Hubbard et. al. (1995), Carroll (1997), Carroll and Samwick (1997) and Gourinchas and Parker (2002) for consumption-saving problems and, for instance, Cocco, Gomes and Maenhout (2005), Gomes and Michaelides (2005), Polkovnichenko (2007), Guiso, Fagereng and Gottlieb (2017) for portfolio choice problems.

3.3 Financial Asset Returns

I assume there are only two assets in the market where households can invest, one riskless and one risky. The riskless asset has a constant gross return r_f, and the excess return of the risky asset is $\mu + r_f$. The gross return of the risky asset is r_{t+1} and given by

$$
r_{t+1} = r_f + \mu + \eta_{t+1} \tag{13}
$$

where η_{t+1} is the innovation to returns, and independently and identically distributed as $N(0, \sigma_\eta^2)$.

I also introduce a variant of this model that allows a rare disaster in the stock market.

In this case I change the stock return structure and households may lose τ_{tail} of their returns invested in the stock market with probability p_{tail} during recessions:

$$(14) \qquad r_{t+1} = \begin{cases} (1-\tau_{tail})(r_f + \mu + \eta_{t+1}) & \text{with prob. } p_{tail} \\ r_f + \mu + \eta_{t+1} & \text{with prob. } 1 - p_{tail} \end{cases}$$

I also allow for positive correlation between innovations to excess stock returns and permanent income shocks, $\rho_{u,\eta}$.

3.4 Wealth Accumulation

At each period t, households start with accumulated financial wealth W_t and receive labor income Y_t, which are available for consumption and saving. I denote it as cash on hand.

$$(15) \qquad X_{it} = W_{it} + Y_{it}$$

Households decide to consume C_t, allocate α_t share of wealth in risky assets and save the rest of cash on hand. Hence, the next period cash on hand can be re-written as

$$(16) \qquad X_{i,t+1} = (X_{it} - C_{it}) r^p_{i,t+1} + Y_{i,t+1}$$

where $r^p_{i,t+1}$ is the portfolio return and given by

$$(17) \qquad r^p_{i,t+1} = \alpha_{it} r_{t+1} + (1 - \alpha_{it}) r_f$$

Stocks are not allowed to be sold short and the allocation to stocks can not be levered up. Hence, the fraction of wealth invested in stocks cannot be negative or larger than one:

$$0 \leq \alpha_{it} \leq 1 \tag{18}$$

Borrowing against future income is not allowed as well. Hence, consumption can not exceed the contemporaneous cash on hand:

$$0 < C_{it} \leq X_{it} \tag{19}$$

3.5 Household Optimization Problem

Households face an optimization problem to maximize their lifetime recursive value function subject to liquidity constraints and three sources of uncertainty, the labor income shocks ϵ_{it} and u_{it} and the stock return shock η_t. This optimization problem can be stated as:

$$\max_{\{\alpha_{it}\}_{t=1}^{T}, \{C_{it}\}_{t=1}^{T}} E(V_0) \tag{20}$$

where V_0 is given by equation (8) and is subject to the constraints given by equations (9) to (19).

The state variables in this problem are time t, cash on hand X_{it}, the permanent component of labor income v_{it} and the business cycle indicator $s(t)$. At each time period t, depending on different states, households control their consumption $\{C_{it}^{*}\}_{t=1}^{T}$ and allocation on the stocks $\{\alpha_{it}^{*}\}_{t=1}^{T}$ to maximize the value function. Because of the unit-root process assumption for the labor income process, the state space can be reduced to two variables by standardizing the entire problem by the permanent component of labor income $e^{v_{it}}$, which is denoted by P_{it} for simplicity.

Let $x_{it} = \frac{X_{it}}{P_{it}}$ and $c_{it} = \frac{C_{it}}{P_{it}}$ be the normalized cash-on-hand and consumption, then the normalized value function can be given by

(21)

$$V_{it}(x_{it}, s(t)) = \max_{\{\alpha_{it}\}_{t=1}^{T}, \{C_{it}\}_{t=1}^{T}} \left\{ \begin{array}{c} (1-\beta)c_{it}^{1-\frac{1}{\psi}} + \beta(E_t((\frac{P_{i,t+1}}{P_{it}})^{1-\gamma} p_{t+1} V_{it+1}(x_{i,t+1}, s(t+1))^{1-\gamma} \\ +b(\frac{P_{i,t+1}}{P_{it}})^{1-\gamma}(1-p_{t+1})x_{i,t+1}^{1-\gamma}))^{\frac{1-1/\psi}{1-\gamma}} \end{array} \right\}^{\frac{1}{1-1/\psi}}$$

subject to

$$x_{i,t+1} = (x_{it} - c_{it}(x_{it}, s(t)))r_{i,t+1}^{p}\frac{P_{it}}{P_{i,t+1}} + e^{\varepsilon_{i,t+1}} \qquad \text{for } t \leq K \tag{22}$$

$$x_{i,t+1} = (x_{it} - c_{it}(x_{it}, s(t)))r_{i,t+1}^{p}\frac{P_{it}}{P_{i,t+1}} + \lambda \qquad \text{for } t > K \tag{23}$$

Appendix A presents the details of the numerical solution method and Appendix B details the approximation accuracy of continuous distributions of mixture normals. I follow the techniques implemented by Zoia (2009) and Faliva, Poti, and Zoia (2016) that allow the numerical approximation of mixture normal distributions without using too many grid points. An online appendix provides accuracy tests that justify this choice.

4 Baseline Calibration

4.1 Financial Asset Returns

Table 5 presents the benchmark parameters that I take from the relative literature. Panel A describes the choices for asset returns. The risk-free rate (r_f) is set to 2% per year and the mean return on stocks (μ) is equal to 4% per year, which is a common choice (for example, Campbell et. al. (2001) to reflect transaction costs). I set the correlation between innovations to stocks and permanent income shocks ($\rho_{u,\eta}$) to 0.15, consistent with the estimates in Campbell et al. (2001), while the correlation between innovations and transitory income shocks ($\rho_{\varepsilon,\eta}$) is zero, taken from Cocco et al. (2005). I also use a second specification of stock returns that follow Rietz (1988) and Barro (2006) and assume a rare disaster event in the stock market. Barro and Ursúa (2009) use a long-term data for 30 countries up to 2006 reveal stock market crashes and macroeconomics depression. Market crashes are defined as cumulative real returns of -25% or worse. During recessions, households who participate into stock market can experience around 2 to 3 market crashes over their life cycle and lose on average 55% of investments in the stock market. Hence, I set the probability of rare disaster is set to (p_{tail}) to 3% and the size of loss (τ_{tail}) to 55%. I recognize there is disagreement on this choice (see the discussion in Constantinides and Ghosh (2017)) but this framework allows me to explicitly compare the implications of a model with, to a model without, a rare stock market disaster event and compare the implications with the literature.

4.2 Labor Income Process

Panel B discusses the labor income process calibration. The replacement ratio during the retirement (λ) is set to 0.68 and the deterministic component of labor income process is set to be the same as that in Cocco, Gomes and Maenhout (2005). I use 0.1^2 for the transitory variance (σ_ϵ^2), which is similar to the one in Gourinchas and Parker (2002). For the permanent income shocks I rely on the estimates in Guvenen, Ozkan and Song (2014) who estimate a quantitative labor income model using a large and confidential US data set. The moments of permanent income shocks can be easily calculated based on these estimates and therefore the parameters with respect to the mixture normal distribution during expansions and recessions can be calibrated. I slightly deviate from the data in Guvenen, Ozkan and Song (2014) by assuming the same variance and kurtosis during expansions and recessions because I would like to isolate effects coming from changes in the mean and skewness of labor income shocks over the business cycle. I therefore fix the variance and kurtosis to be the same during expansions and recessions: the variance is 0.05 and the kurtosis is 3.0, both slightly lower than the Guvenen et. al. (2014) estimates. The probability of the mixture normal distribution ($p_1 = 0.49$) is the same as in Guvenen et. al. (2014). I then estimate the remaining eight moments to match the first four moments during expansions and the first four moments during recessions, yielding similar estimates to Guvenen et. al. (2014). The estimated moments imply a substantially higher mean growth in booms (20.7%) rather than in recessions (-17.3%) in one of the two normal distributions, and a negative mean growth in booms (-11.0%) rather than in recessions (16.2%) in the other normal distribution.

If the NBER peak of the previous expansion takes place in the first half of a given year, that year is classified as the first year of the new recession. If the peak is in the second half, the recession starts in the subsequent year. The ending date is defined as the next year after the start year of the expansion announced by the NBER, since the unemployment rate is a lagging variable and does not fall immediately after NBER troughs. According to this definition, recessions are 1991-1992, 2001-2002 and 2008-2010.

4.3 Preference and Bequest Motive

I calibrate the preference parameters and the bequest motive with the 1989 Survey of Consumer Finances (SCF) for the model with skewed permanent income shocks (benchmark 1) and the model with skewed permanent income shocks and rare events in stock market (benchmark 2). I assume stockholders have Epstein-Zin preferences and nonstockholders have simpler CRRA preferences.

I calibrate preference parameters to best match the average normalized wealth and average risky asset share for different age groups at different points in the life cycle. Specifically, for stockholders I calibrate the discount factor (β) to match the average normalized wealth during the working phase and the bequest motive (b) to match the average normalized wealth during retirement. The relative risk aversion coefficient (γ) determines the average risky asset share over the life cycle. For nonstockholders, I assume the discount factor (β) is the same as that of stockholders and calibrate the relative risk aversion coefficient (γ) to match the lower normalized wealth over working life and the bequest motive (b) to match the average normalized wealth during retirement.

Tables 6 shows the main findings for benchmark 1. For stockholders, the preference parameters are $\beta = 0.98$ and $\gamma = 6.8$, and the strength of the bequest motive is $b = 2.0$, which are within the range of existing empirical evidence and calibrations. Nonstockholders are less risk averse compared with stockholders, with the coefficient of risk aversion only 1.6 but I could instead have reduced the discount factor and kept the risk aversion the same without a large change in the intuition. Stockholders are wealthier and have a balanced portfolio between bonds and stocks.

Table 7 shows what happens in benchmark 2 (adding a small probability of big loss in stock market in recessions). Compared with benchmark 1, benchmark 2 generates a more moderate coefficient of risk aversion (relative risk aversion drops from 6.8 to 6.3). Wealth accumulation decreases slightly relative to the previous model at each stage of the life cycle. Nevertheless, the remaining parameters are not affected: the discount factor and bequest motive generate substantial wealth accumulation during the work phase and even higher wealth accumulation during retirement. As nonstockholders do not participate into the stock market, both models obtain the same values for the calibrated parameters.

4.4 Life-cycle Profiles

Figure 2 compares the life-cycle profiles of average normalized wealth and risky asset share implied by benchmark 1, benchmark 2 and the equivalent profiles in the data. Graph A shows mean normalized wealth accumulation over the life cycle for stockholders and shows that benchmark 1 and benchmark 2 match exactly the wealth accumulation during retirement. During working life, both models slightly overshoot normalized wealth accumulation in the data but overall, these models can generate predictions close to the data. Graph B compares the share of wealth in stocks and shows that the models are able to generate low share of wealth in stocks that can match the data even for younger ages. Graph C illustrates that both benchmark 1 and benchmark 2 match the wealth accumulation well for the nonstockholders.

5 Understanding Model Predictions

To better understand the implications of countercyclical earnings risk and rare events in the stock market compared with log-normal earnings model, I present results with the calibrated preference parameters and bequest motive from benchmark 1: the discount factor (β) is equal to 0.98, the coefficient of relative risk aversion (γ) is set to 6.8, the elasticity of intertemporal substitution (ψ) is 0.5 and the bequest motive (b) is 2.

5.1 Understanding Model: Policy Functions

In this section, I study the behavior of the normalized consumption functions. Figure 3 plots consumption policy functions at age 25, 55 and 75 for four models: the model with normal permanent income shocks (log-normal earnings model), the model with normal permanent income shocks and different expected growth rate during booms and recessions (log-normal model with business cycle), the model with skewed permanent income shocks (benchmark 1) and the model with skewed permanent income shocks and rare events in stock market (benchmark 2). The left graphs show consumption policy functions conditional on being in a boom and the right graphs show consumption policy functions conditional on being in a recession.

The following comments about these policy functions are worth making. First, during working phase (Graph A, B, D and E), differential expected earnings growth overall encourage households to consume more, because it generates an average higher expected growth rate compared with log-normal earnings model. As households expect to receive more labor income, they are more willing to consume more. Second, during working phase (Graph A, B, D and E), adding slightly positive skewness during booms leads to more consumption, while adding negative skewness during recessions leads to a tiny reduction in consumption. This is actually consistent with my empirical finding with the PSID in Section 2: skewness in earnings risk has positive effect on consumption. Third, adding the rare events in the stock market lower consumption, as households need to bear with more risk in stock returns. Last but not the least, during retirement (Graph C and F), households start receiving constant labor income and all earnings risks disappear. As a result, log-normal earnings model, log-normal earnings model with business cycle and benchmark 1 all share the same consumption level. However, risk in stock returns still exists because rare events could happen in the stock market anytime. Hence, benchmark 2 still keeps lower consumption.

Figure 4 plots consumption policy functions at age 25, 55, and 75 conditioning in a boom and conditioning in a recession. Looking at the left hand side graphs (A, B, C) reveals that adding negative skewness in the labor income process reduces consumption. Additionally, business cycles show three distinct effects. First, recessions encourage households to save more, leading to less consumption compared with booms. During recessions, households are faced with the slightly negative expected growth rate and negative cross-sectional skewness in the labor income process, both making human wealth riskier and less valuable. Households therefore tend to reduce their consumption relative to expansions. Second, for a given level of cash on hand, the business cycle effect has a stronger effect on the consumption of younger households relative to older households. Young households have a relatively higher human wealth to financial wealth ratio compared with older households, and thus they have more to lose and respond more vigorously. Third, during retirement, the business cycle effect disappears because households' income does not depend on the business cycle by assumption.

The right hand side graphs (Graph D, E and F) show that adding the rare disaster in the stock market (benchmark 2) lowers the consumption policy rule further. The distance between booms and recessions is much larger than before since a rare event might happen in recessions but not in expansions. As a result, the business cycle effect is still prominent during retirement as well.

Overall, policy functions show that differential expected earnings growth and positive skewness in labor income process raise the normalized consumption, while negative skewness in labor income process, business cycles and rare disaster in stock market lower the normalized consumption.

5.2 Understanding Model: Simulation Results

In this section, I discuss the implications of the model with respect to consumption, portfolio holdings and wealth accumulation over the life-cycle and business-cycle. I simulate the model for $10,000$ individuals to compute the mean consumption, mean risky asset shares and mean wealth holdings.

Figure 5 plots the life-cycle profile of mean wealth, share of wealth in stocks, and consumption with bequest motive, simulated from four models. First, I solve the standard life-cycle model with normal permanent income shocks and no differential expected growth in labor income between booms and recessions. I compare it with a model with normal permanent income shocks, but differential expected growth in labor income between booms and recessions. Overall, the model with differential mean has an average higher expected growth rate compared with the standard normal life-cycle model. Higher expected growth rate in labor income accumulates less wealth (Graph A) and increases the share of wealth in stocks (Graph B). In the beginning of the life cycle, all households start with similar wealth accumulation. Households with higher expected growth rate consume more because of their lower saving rates. When households approach their middle age, those with lower expected growth rate accumulate so much wealth that even with a higher saving rate, they are still able to consume more than households with higher expected growth rate (Graph C).

Next, I add the mixture normal specification to the model with differential expected growth in labor income during booms and recessions (benchmark 1), which can capture countercyclical left skewness in permanent shocks. This introduction of higher moment decreases the share of wealth in stocks to a large extent, but leads to only a very tiny reduction in mean wealth and mean consumption. The existence of higher moments in labor income process indicates the large downward movements are more likely, which makes labor income more uncertain and undermines the nature of income serving as riskless asset. Moreover, adding stock market crashes (benchmark 2) lowers mean wealth, the share of wealth in stocks, and mean consumption further. As stock becomes much riskier, households choose to consume less, save more and rebalance their portfolio toward cash.

Figure 6 reports the separate profiles, assuming all booms and recessions. Business cycle variation in earning risks comes from differential expected earnings growth during booms and recessions, and drop in skewness during recessions. Households save much less and invest more aggressively on stocks during booms and do the opposite during recessions. In the beginning of the life cycle, households are faced with similar initial wealth and consume more during booms. Around age 40, much more wealth accumulation during booms leads to more consumption even with higher saving rates. The difference in mean wealth, risky asset shares and consumption between boom and recession is nonnegligible, suggesting that business cycle variation has large impact on life-cycle profiles. The rare disaster in stock returns amplifies this business cycle effect over the life cycle.

6 Comparison between Model and Data

The model shows clear implications of countercyclical earnings risk on the consumption and portfolio choice decisions over the life cycle and the business cycle. In this section, I use the model to simulate labor income, risky assets shares and consumption starting from the initial distribution in 1989 and following through to 2013. The focus of my interest is on how countercyclical skewness in the labor income process affects the evolution of portfolios, consumption and consumption risk, and to explore to what extent models are able to generate the empirical findings in Section 2.

6.1 Simulation Method

For the cohorts in the sample of the 1989 SCF, I observe many of the state variables, such as age, wealth level and stock market participation status. Using this information and the calibration in the previous section, I simulate optimal stock holdings, labor income, consumption, and wealth accumulation for the repeated cross-sections of cohorts from 1989 to 2013, and calculate consumption risk over time.

In order to simulate labor income and consumption over time, I make certain assumptions when simulating the model forward from 1989 to 2013. There are two main sources of risk in the model: (i) aggregate stock returns, and (ii) idiosyncratic labor income shocks. When simulating forward, all stockholders are assumed to face the same realized annual equity return taken from the Center for Research in Security Prices (CRSP). Although the stock returns here are exogenous, I acknowledge the importance to endogenize stock returns in a production economic world to build general equilibrium model. I follow the advice in Heaton and Lucas (2000) who argue that matching complicated models in partial equilibrium is a first necessary step before endogeneizing stock returns. As for idiosyncratic labor income shocks, I simulate them from the model.

From 1989 to 2013, there are three NBER-dated recessions. In a similar spirit with realized stock returns, I assume that certain years in the annual simulation belong to an expansion and certain years in a recession based on the NBER dating methodology. Households know this information and make decisions conditional on the distributions they expect to face in those years. Households die at 100 and once they die, they are dropped from the simulation. New twenty-year old households enter the labor market every year and are randomly assigned an initial wealth based on the wealth distribution with head aged 20 or less from the 1989 SCF.

I need to take into account the fact that stock market participation has increased from around 30% in 1989 to around 50% in 2013. Moreover, the sampling weights of the SCF change over time. Therefore, starting from the initial wealth distribution in the data in 1989, I can use our two benchmark models to follow what would happen to the two different population groups (stockholders and non-stockholders). I use a zero-one indicator variable based on NBER-dated recessions to denote recessions and expansions. Given an initial wealth distribution, I can then track each group separately from 1989 onwards. I combine these two groups by the realized participation rate. As I do not assume population growth, I adjust the weights for each household in order to match the increasing participation rate. Two steps are taken. First, I match the participation rate. I fix the weights for the non-stockholders, and only adjust the weights for the stockholders by simply multiplying the ratio of the number of the stockholders I want to the actual number of the stockholders in our simulation. Although the participation rate is matched, the total population changes because of the adjusted weight. Next, I adjust both weights of the stockholders and the non-stockholders. I multiple both weights by the ratio of the population in 1989 to the population in our simulation to keep the population be the same from 1989 to 2013.

6.2 Portfolios and Consumption

I start by examining how risky asset shares respond to skewness in labor income process. Panel C of Table 8 shows the results for benchmark 1 (Column $1-3$) and benchmark 2 (Column $4-6$). Both models are able to capture significantly positive effect of changes in skewness in earnings shock on risky asset shares. The point estimates are 0.006 for benchmark 1 and 0.009 for benchmark 2, indicating that inclusion of rare events in stock market amplifies the effect of skewness in earnings shock on portfolios. Meanwhile, both models produce negative effect of variance in earnings shock, but not so significantly as the data indicates. This is largely because of the assumption made in the model: no business cycle variation exists in variance in earnings shock.

Next, to analyse how skewness in labor income process influences consumption, I conduct the similar regression as that in Section 2, where the same question is asked and answered with the PSID data. Considering the limited variables in the model, I regress consumption growth on changes in skewness in permanent income shock conditioning on life-cycle controls, such as age, age squared, labor income at $t-2k$ and the change in labor income between $t-2k$ and t, and the change in wealth between $t-2k$ and t.

Panel A of Table 8 presents the main results for benchmark 1 and benchmark 2. As the table shows, I find the positive coefficients for skewness in income shocks in both models, suggesting larger positive skewness in income shocks encourages households to consume more and do the opposite with larger negative skewness in earnings shocks. For stockholders, the point estimate is statistically significant. 10% growth in skewness in earnings shocks leads to an increase in consumption by 0.0051 in benchmark 1 and 0.0024 in benchmark 2. For all households and nonstockholders, the estimates in Panel A, Column 1 and 3 are also statistically significant, but again of tiny magnitude in both models. The inclusion of rare disasters in stock market (benchmark 2) dampens the effect of skewness in labor income shocks on consumption significantly for all households and stockholders: the magnitudes of the point estimates are almost half smaller than those in benchmark 1, but they are still significant from zero at a high level of statistical significance (Panel A, Column 4 and 5). As rare disasters in stock market only affect the participants in stock market, the coefficient for nonstockholders does not show any significant change between benchmark 1 and benchmark 2.

Overall, the results in Table 8 accord well with the results in Table 2. Although the magnitudes of the coefficients are lower than those in Table 2 on average, they are all significantly different from zero for all households and stockholders. For nonstockholders, consumption is not significantly affected by the skewness in labor income shocks with the data, while I still find strong positive relationship between consumption and skewness with the simulation. Looking at Panel A of Table 2 and Panel A of Table 8 together, I show the positive effect of skewness in labor income shocks on consumption and this effect is especially stronger for stockholders.

6.3 Consumption Risk

Using the model simulation, Panel B of Table 8 replicates the estimation in Panel B of Table 2 and clarifies the role of countercyclical left skewness in labor income shocks on skewness of consumption growth. Many of the patterns displayed in Panel B of Table 2 with the empirical data seem to also appear for the simulation.

Panel B of Table 8 shows that significant positive coefficients for skewness in labor income shocks in both models (benchmark 1 and benchmark 2). For stockholders, 10% growth in skewness in labor income leads to an increase in skewness in consumption growth by 0.0422 in benchmark 1, e.g., from 50% to 54.22% , and 0.0327 in benchmark 2, from 50% to 53.27%. Both are economically significant. For all households, the point estimate of 0.317 in benchmark 1 implies an increase in skewness in labor income shocks by 10% implies a roughly 3% percent increase in skewness in consumption growth. Similar effect is found in benchmark 2. For nonstockholders, the estimates are slightly negative, but significantly different from zero in both models.

Given that skewness in income shocks is countercyclical documented in Guvenen, Ozkan and Song (2014), the positive correlation between skewness in labor income process and skewness in consumption growth (Panel B of Table 2) may lead to countercyclical skewness in consumption growth. In order to better identify the causality of skewness in labor income process on skewness in consumption growth, I use the flexibility of my model to shut down skewness in labor income process and compare the consumption risk under four models: the standard normal model, the model with normal permanent shock but different expected growth rate during booms and recessions, the model with skewed permanent shock and different growth rate during booms and recessions (benchmark 1) and the model with rare events in stock market and skewed permanent shock (benchmark 2).

I introduce a dummy variable for the business cycle, taking the value of 1 if a year is a boom and a value of 0 if a year is a recession, and study how skewness in consumption growth and this dummy variable are correlated. The larger the correlation, the stronger the countercyclicality. Table 9 shows the correlations between skewness in consumption growth and business cycle for all households, stockholders and nonstockholders. Take a look at first column, I find the correlations are all insignificant different from zero among three groups under the model with normal income shock. No significant differences exists between stockholders and nonstockholders. With the addition of differential expected growth rate in labor income, the point estimates increase for all three groups, but still insignificant different from zero. If I switch on the countercyclical skewness in income shocks in the model (benchmark 1), the correlation between skewness in consumption growth and skewness in income shocks increases significantly for stockholders, while the correlation for nonstockholders does not change a lot. This huge gap between stockholders and nonstockholders shows the heterogeneity in consumption amplified by countercyclical skewness in income shocks. Inclusion of rare disaster in stock market to the model (benchmark 2) doesn't add significant effect on the estimates. Actually, it even lowers the estimate for stockholders. Considering the relatively large standard error, I can not conclude that the difference between benchmark 1 and benchmark 2 is significant, but evidently the addition of countercyclical skewness in income shocks results in significant strong correlation between left skewness in consumption growth and business cycle.

To visualize the variation of skewness in consumption growth over the business cycle better, I compare the model-simulated skewness in consumption growth and the model-simulated skewness in labor income shocks in Figure 7. Skewness in labor income shocks drops in the 1991, 2001 and 2008 recessions (Graph A), and generates drops in skewness in consumption growth in all three recessions for all households, stockholders and nonstockholders (benchmark 1 and benchmark 2). However, log-normal earnings model and log-normal earnings model with business cycle seem to generate almost flat skewness in consumption growth for nonstockholders and all households and a tiny wavy skewness in consumption growth for stockholders.

Summing up, my model implications are analogous to the empirical findings using data on consumption, wealth information and demographics from the PSID. Actually, by controlling skewness in labor income shocks in the model, the model reinforces the results I find with the data: (i) skewness in labor income shocks has significantly positive effect on risky asset shares; (ii) skewness in labor income shocks has positive effect on consumption; (iii) skewness in labor income shocks has positive effect on skewness in consumption growth, which implies countercyclical skewness in labor income shocks results in countercyclical skewness in consumption growth. The hypothesis raised in the beginning is tested and verified; (iv) heterogeneity matters: these effects are especially stronger for stockholders, less so for nonstockholders.

7 Conclusion

In this paper, I find empirical link between skewness in earnings shocks, portfolios, consumption and skewness in consumption growth. Decreasing skewness in earnings shocks is positively correlated with portfolio choice. All else equal, stockholders subject to less earnings risk hold more risky assets. Decreasing negative skewness in earnings shocks also stimulates consumption and reduces skewness in consumption growth. The effect is statistically significant for stockholders, not nonstockholders. As documented in Guvenen, Ozkan and Song (2014), skewness in labor income shocks is countercyclical. Taken together, countercyclical skewness in labor income shocks may lead to countercyclical skewness in consumption growth.

To verify these empirical results better, I build a life-cycle model, which allows business cycle variation in labor income shocks. Therefore, I make sure that the only channel to affect skewness in consumption growth is through labor income process. I find negative skewness in labor income shocks lowers households' consumption and reduces the share of wealth in stocks, which accords well with the empirical link between skewness in earnings shocks, consumption and risky asset shares in the data. Meanwhile, increases in this negative skewness in labor income shocks lead to increases in negative skewness in consumption growth. This positive effect of skewness in labor income shocks on skewness in consumption growth results in very strong correlation between skewness in consumption growth and dummy variable for boom. This evidence suggests that countercyclicality is transmitted from skewness in labor income shocks to skewness in consumption growth, which is consistent with its empirical counterpart from the PSID data and verifies the hypothesis raised in the beginning.

For future work, it might be helpful to distinguish the labor income process between stockholders and nonstockholders, and explore more about heterogeneity among different groups in stockholders and nonstockholders. Also a general equilibrium to endogenize stock returns can help us understand the theoretical mechanism behind these empirical findings more comprehensive.

A Appendix

A.1 Supplementary Data

A.1.1 Panel Study of Income Dynamics

The PSID is the longest longitudinal household survey. Started in 1968, the PSID was an annual survey through 1997 and a biennial survey afterward. Before 1999, only the limited information was collected on consumption expenditure. Food consumption was usually regarded as a replacement of total consumption, and after Skinner (1987), food consumption and rent was used to impute total consumption. Besides consumption expenditure in the PSID, PSID provides has quite rich information on household socioeconomic characteristics, labor market experiences, income, wealth, health status, and family structure.

Total consumption since 1999 are constructed as the sum of food, health care, housing, transportation, education and child care. Further in 2005, the PSID expanded again its questions on consumption expenditures. Three new categories are added to the survey: clothing and apparel, trips and vacations, and recreation and entertainment. Three new subgroups are also added to housing expenditure: telecommunication, home repair and maintenance, and household furnishings and equipment. In order to keep the concept of total consumption to be the same since 1999, I calculate total consumption without the addition of these new categories. Food consumption includes food consumed at home, food delivered and food away from home. Housing expenditure covers mortgage and loan payments, rent, property tax, insurance, utilities. Utilities sum up gas the electricity combined, water and sewer, and other utilities. Transportation includes vehicle loan payment, vehicle down payment, vehicle lease payment, insurance, other vehicle expenditures, repairs and maintenance, gasoline, parking and carpool, bus fares and train fares, taxicabs, and other transportation. Health care includes hospital and nursing home, doctor, prescription drugs, and insurance.

Total family labor income contains labor income of head and labor income of wife. Labor income is the sum of wages and salaries, bonuses, overtime, tips, commissions, professional practice or trade, market gardening, additional job income, and miscellaneous labor income. Riskless assets comprise cash (checking and savings accounts, money market funds, certificates of deposits, savings bonds, and treasury bills) plus bonds and life insurance (bonds, bond funds, cash value in a life insurance, valuable collection for investment purposes, and rights in a trust or estate). Risky liquid assets are defined as the amount reported in the PSID survey question asking for the combined value of shares of stock in publicly held corporations, mutual funds, and investment trusts.

A.1.2 SCF Data

The SCF has been conducted by the Federal Reserve Board every three years to provide detailed information on the finances of US households. The survey deliberately over-samples relatively wealthy households to produce more accurate statistics; in my analysis I then use the sampling weights provided by the SCF to obtain unbiased statistics for the US population. The SCF also handles the survey nonrespondents by using weighting adjustments. These weights are used to calculate the values reported in the tables and graphs. I use data from the 1989 to 2013 wave. Variables are constructed using the codebook and macro-variables definitions from the Federal Reserve website.

Wealth is made up of checking accounts, savings accounts, certificates of deposit, saving bonds, money market accounts, cash/call money accounts, trusts, life insurance, thrift plans, IRAs, future pensions, total directly held mutual funds, stocks, bonds, savings bonds, other managed assets and other financial assets. Household income refers to the household's cash income, before taxes, for the full calendar year preceding the survey. The components of income are the sum of wages and salaries, unemployment insurance, worker's compensation, Social Security income, other pension income, annuities, other disability or retirement programs. Wealth invested in the risky assets is the sum of directly held stock, stock mutual funds, and amounts of stock in retirement accounts. Stock market participants are those who have the full value of stocks greater than zero. Risky assets share is constructed as the ratio of wealth invested in the risky assets to wealth, which are defined above.

A.2 Numerical Solution

The model does not have an analytical solution but can be solved with backward induction numerically. The policy functions and value functions are functions of the state variables: time t, business cycle indicator $s(t)$, and cash on hand relative to the permanent labor income, which is continuous and thus needs to be discretized appropriately. In the last period, the policy functions are determined by the bequest motive and the value function corresponds to the bequest function. I use grid search to optimize the value function. I compute the value associated with each level of consumption and the share of wealth invested in stocks. Then I choose the level of consumption and the share of wealth invested in stocks achieving the maximum value, which are saved as the policy rules for the previous period. For every time t prior to T, and for each point in the state space, this procedure is iterated backwards.

To approximate the distributions of innovations to the permanent labor income shocks, I use numerical integrations. My density function for permanent income shock can be rewritten as a sum of Hermite polynomials with Gaussian Kernel so that I can use Gaussian quadrature points with some adjusted weights to approximate numerical integrations. For points that do not lie on state space grid, I evaluate the value function using a cubic spine interpolation. I use cubic spline interpolation for value function evaluation off the chosen grids. As for the transition matrix between expansion and recession, I assume the probability of current state staying the same in the next period is 0.75 and the probability of current state changing to the other state in the next period is 0.25. During recession, there is a small probability 3% to loss 55% of stock returns.

After the optimal policy rules are derived, I start simulating life-cycle profile for each household in 1989 SCF until 2013. Following the NBER dating methodology specified in the previous section, I have three recessions from the 1989 SCF to 2013 SCF: 1992, 2001 and 2010. To make the results comparable, I use the 1989 to 2013 waves for the U.S. Financial Accounts as well. All households face the same annual stock returns from CRSP and choose the income distribution based on the business cycle status. Once households die at age 100, they are dropped from the simulation. New twenty-year old households enter the labor market every year with initial wealth distribution of aged 20 or less from the 1989 SCF.

A.3 Continuous Distributions Approximation Experiments

I now provide experimentation with the orthogonal polynomials approximation method in Zoia (2009) and Faliva, Poti and Zoia (2016). To test the accuracy of the approximation method, I use two different methods. The first method is based on simulation. I simulate based on the discretization for a given number of gird points and then perform a Monte Carlo analysis to investigate how close the estimated parameters to the actual parameters

N	Mean	Variance	Skewness	Kurtosis	Avg. Distance
5	$-3.3043e-05$	0.0101	-0.0085	3.0044	$9.2008e-05$
10	$2.0576e-04$	0.0100	$-1.1483e-4$	2.9963	$1.4082e-05$
15	$-3.4842e-06$	0.0100	-0.0027	3.0018	$1.0594e-05$
20	$2.4127e-17$	0.0100	$-1.1044e-15$	3.0000	$8.1986e-06$

N	Mean	Variance	Skewness	Kurtosis
5	$2.0817e-17$	0.0100	$3.5128e-16$	3.0000
10	$-3.1113e-17$	0.0100	$3.0709e-16$	3.0000
15	$-5.5311e-17$	0.0100	$2.1441e-16$	3.0000
20	$-1.3772e-17$	0.0100	$-9.8642e-17$	3.0000

used to generate the discrete approximation. I generate 100000 simulation paths, and report the means, variance, skewness and kurtosis of each variable and the distance between the estimations and true values. The second method uses the nodes and weights used in the numerical solution to compute the first four moments of the variables. These values should be close to the simulations.

I test the orthogonal polynomials approximation method for three different situations: (i) a variable distributed normally, (ii) a variable distributed as a mixture of normal distribution with negative skewness and excess kurtosis, and (iii) two correlated variables.

Experiment 1: Assume a variable follows a normal distribution $N(0, 0.1)$. I report the first four moments of this variable and change the number of grid points (N) to check if the accuracy can be improved by increasing the number of grid points. The first four moments and the average distance by simulation are:

The first four moments computed using the numerical integration method are:

From these two tables, I can find that the orthogonal polynomials approximation method can produce accurate first four moments for the normal variable with only five grid points.

N	Mean	Variance	Skewness	Kurtosis	Avg. Distance
5	$2.9796e-04$	0.0100	-0.4944	4.9972	$3.9133e-05$
10	$-9.0775e-05$	0.0100	-0.4995	5.0047	$2.2194e-05$
15	$-4.6554e-05$	0.0100	-0.4996	4.9988	$1.5714e-06$
20	$-2.4788e-05$	0.0100	-0.5001	5.0001	$8.1986e-07$

N	Mean	Variance	Skewness	Kurtosis
5	$3.4694e-17$	0.0100	-0.5000	5.0000
10	$-4.8843e-17$	0.0100	-0.5000	5.0000
15	$-2.6057e-17$	0.0100	-0.5000	5.0000
20	$-2.3259e-17$	0.0100	-0.5000	5.0000

Increasing the number of gird points does not improve the accuracy too much. Considering the computation speed and accuracy, I use five grid points for the numerical approximation. Now, an interesting question is whether this orthogonal polynomials approximation method can also applied to the non-normal variables, which leads to the experiment 2.

Experiment 2: Assume a variable follows a mixture of normal distributions with mean 0, standard deviation 0.1, skewness -0.5 and kurtosis 5. I report the first four moments of this variable and change the number of grid points (N) to check if the accuracy can be improved by increasing the number of grid points. The first four moments and the average distance by simulation are:

The first four moments computed using the numerical integration method are:

From these two tables, I can find that the orthogonal polynomials approximation method can produce accurate first four moments for the variable with non-zero skewness and excess kurtosis with only five grid points. Increasing the number of gird points does not improve the accuracy too much. Considering the computation speed and accuracy, I use five grid points for the numerical approximation.

N	Correlation	Mean	Variance	Skewness	Kurtosis	Avg. Distance
5	0.1674	$-1.3310e-04$	0.0100	-0.0024	2.9907	$9.3236e-05$
		$-2.7394e-05$	0.0100	-0.4981	4.9951	$2.7826e-05$
10	0.1662	$5.1730e-05$	0.0100	-0.0036	3.0016	$1.5511e-05$
		$-1.8385e-05$	0.0100	-0.5015	5.0025	$1.3567e-05$
15	0.1571	$1.3257e-05$	0.0100	$6.4496e-04$	2.9979	$4.8294e-06$
		$1.6052e-05$	0.0100	-0.5005	5.0019	$6.3069e-06$
20	0.1533	$5.9415e-06$	0.0100	$-3.0275e-04$	3.0015	$2.2885e-06$
		$-1.7116e-06$	0.0100	-0.4998	4.9994	$3.1394e-06$

N	Correlation	Mean	Variance	Skewness	Kurtosis
5	0.1500	$2.7322e-17$	0.0100	$1.0192e-16$	3.0000
		$3.8164e-17$	0.0100	-0.5000	5.0000
10	0.1500	$-2.7566e-17$	0.0100	$3.2543e-16$	3.0000
		$-4.8843e-17$	0.0100	-0.5000	5.0000
15	0.1500	$-6.1494e-17$	0.0100	$3.7788e-16$	3.0000
		$-2.0095e-17$	0.0100	-0.5000	5.0000
20	0.1500	$2.4127e-17$	0.0100	$1.1044e-16$	3.0000
		$1.7961e-17$	0.0100	-0.5000	5.0000

Experiment 3: Assume there are two correlated variables with correlation 0.15: one (v_1) follows a normal distribution $N(0, 0.1)$, and the other one (v_2) follows a mixture of normal distributions with mean 0, standard deviation 0.1, skewness -0.5 and kurtosis 5. I report the correlation and the first four moments of each variable and change the number of grid points (N) to check if the accuracy can be improved by increasing the number of grid points. For each N, I report the correlation, the first four moments (v_1 on the first row and v_2 on the second row), and the average distance by simulation:

The correlation and the first four moments (v_1 on the first row and v_2 on the second row) computed using the numerical integration method are:

From these two tables, I can find that the orthogonal polynomials approximation method can produce accurate correlation and the first four moments for the correlateds with only five grid points. Increasing the number of gird points does not improve the accuracy too much. Considering the computation speed and accuracy, I use five grid points for the numerical approximation.

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Table 1

Summary Statistics

Table 1 presents summary statistics for the 1999-2009 sample ($k = 2$). C is consumption, and $\Delta_k c$ is consumption growth.c_{skew} and $\Delta_k c_{skew}$ are skewness in consumption growth, and the change in skewness. Liquid asset is defined as the sum of stocks and mutual funds plus riskless assets. Subtracting other debts from liquid assets yields liquid wealth. Financial wealth is defined as the sum of liquid wealth, home equity and equity in private business. Δ_k log liquid assets (financial wealth) is the change in liquid asset (financial wealth) between $t - k$ and t, α_1 is the sum of stocks and mutual funds held divided by liquid assets, α_2 is defined as the sum of stocks, home equity and equity in a private business, divided by financial wealth. Income is total family labor income, and Δ_k log income is the change in total family labor income. l_{var} and l_{skew} are the second and third moment in the permanent income shocks, and $\Delta_k l_{var}$ and $\Delta_k l_{skew}$ are the changes in variance and skewness. Panel A reports summary statistics for stockholders. Panel B reports summary statistics for nonstockholders.

Variable	Mean	Std.Dev.	Min	Max	Mean	Std.Dev.	Min	Max
	Panel A. Stockholders				*Panel B. Nonstockholders*			
C	32712	21483	2096	257577	32225	20857	920	206928
$\Delta_k c$	0.089	0.740	−2.960	1.583	0.058	0.776	−4.299	1.608
c_{skew}	−0.344	0.183	−0.536	−0.043	−0.128	0.346	−0.661	0.229
$\Delta_k c_{skew}$	0.045	0.270	−0.223	0.493	0.045	0.270	−0.223	0.493
Liquid assets	316097	948635	11155	6795220	251102	473567	10136	6304820
Δ_k log liquid assets	0.187	1.795	−5.228	5.577	−0.117	1.558	−7.583	6.828
α_1	0.579	0.320	0.015	1.000	NA			
$\Delta_k \alpha_1$	0.085	0.370	−0.939	0.956	NA			
Financial wealth	503121	1179555	36475	9715000	518835	8273985	16500	9100000
Δ_k log financial wealth	0.096	1.426	−6.477	6.718	−0.031	1.002	−6.477	4.935
α_2	0.815	0.229	0.021	1.000	NA			
$\Delta_k \alpha_2$	0.051	0.262	−0.966	0.938	NA			
Income	149050	126648	14216	1218500	140834	184366	1510	1083420
Δ_k log income	0.055	0.528	−2.616	2.670	−0.072	0.547	−1.982	3.456
l_{skew}	−0.660	0.927	−2.038	0.917	−0.109	0.550	−1.006	0.774
$\Delta_k l_{skew}$	0.108	1.221	−1.451	1.826	−0.355	0.630	−1.467	0.298
l_{var}	0.087	0.034	0.036	0.143	0.104	0.017	0.081	0.136
$\Delta_k l_{var}$	−0.017	0.069	−0134	0.057	0.001	0.033	−0.056	0.038

Table 2

Regressions on Changes in Skewness of Labor Income Shocks

Table 2 presents the results for the 1999-2009 sample ($k = 2$) with liquid assets (Column $1 - 3$) and financial wealth (Column $4 - 6$). Panel A shows how changes in the skewness of consumption growth ($\Delta_k c_{skew}$) responds to changes in the skewness of earnings shocks ($\Delta_k l_{skew}$) conditional on changes in the variance of earnings shocks ($\Delta_k l_{var}$) and a vector of the variables which may course common movements. Liquid asset is defined as the sum of stocks and mutual funds plus riskless assets. Subtracting other debts from liquid assets yields liquid wealth. Financial wealth is defined as the sum of liquid wealth, home equity and equity in private business. Regressions control for preference shifters and life-cycle controls (not reported). Preference shifters include changes in household characteristics. Life-cycle controls is related to the life cycle, background and financial situation of the household. Panel B reports the results with dependent variable, changes in skewness of consumption growth ($\Delta_k c_{skew}$). Panel C reports the results with dependent variable, changes in risky assets shares ($\Delta_k \alpha$). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Explanatory variable	All households	Stockholders	Nonstockholders	All households	Stockholders	Nonstockholders
	Column $1-3$: Liquid assets			*Column $4-6$: Financial Wealth*		
	Panel A. Dependent variable: Consumption growth($\Delta_k c$)					
$\Delta_k l_{skew}$	0.102***	0.165***	0.013	0.106***	0.141***	0.032
	(0.018)	(0.045)	(0.044)	(0.019)	(0.053)	(0.068)
$\Delta_k l_{var}$	−0.905	−0.947	−0.823	−0.917	−0.930	−0.819
	(0.934)	(0.833)	(0.831)	(0.995)	(0.826)	(0.791)
	Panel B. Dependent variable: Changes in skewness of consumption growth ($\Delta_k c_{skew}$)					
$\Delta_k l_{skew}$	0.040***	0.202***	0.007	0.048***	0.266***	0.009
	(0.004)	(0.012)	(0.011)	(0.003)	(0.013)	(0.015)
$\Delta_k l_{var}$	0.539	0.207	0.670	0.564	0.274	0.663*
	(0.589)	(0.431)	(0.542)	(0.632)	(0.365)	(0.430)
	Panel C. Dependent variable: Changes in risky assets shares ($\Delta_k \alpha$)					
$\Delta_k l_{skew}$		0.008***			0.010***	
		(0.004)			(0.002)	
$\Delta_k l_{var}$		−0.174***			−0.120**	
		(0.078)			(0.061)	

Table 3

Components of Consumption and Skewness in Labor Income Shocks

Table 3 presents for the 1999-2009 sample ($k = 2$) with liquid assets (Column $1-3$) and financial wealth (Column $4-6$), how growth in each component of consumption ($\Delta_k c$) responds to changes in the skewness of earnings shocks ($\Delta_k l_{skew}$) conditional on changes in the variance of earnings shocks ($\Delta_k l_{var}$) and a vector of the variables which may course common movements. Liquid asset is defined as the sum of stocks and mutual funds plus riskless assets. Subtracting other debts from liquid assets yields liquid wealth. Financial wealth is defined as the sum of liquid wealth, home equity and equity in private business. Regressions still constrol for preference shifters and life-cycle controls (not reported). Preference shifters include changes in household characteristics. Life-cycle controls is related to the life cycle, background and financial situation of the household. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Explanatory variable	All households	Stockholders	Nonstockholders	All households	Stockholders	Nonstockholders
	Column $1-3$: Liquid assets			*Column $4-6$: Financial Wealth*		
	Panel A. Dependent variable: Food					
$\Delta_k l_{skew}$	0.046^{***}	0.050^{***}	0.025	0.045^{***}	0.049^{**}	0.017
	(0.008)	(0.020)	(0.020)	(0.017)	(0.026)	(0.016)
$\Delta_k l_{var}$	−0.162	−0.188	−0.150	−0.075	−0.107	−0.095
	(0.166)	(0.520)	(0.394)	(0.136)	(0.291)	(0.310)
	Panel B. Dependent variable: Health					
$\Delta_k l_{skew}$	0.123^{***}	0.161^{***}	0.015	0.154^{***}	0.203^{***}	0.032
	(0.024)	(0.026)	(0.049)	(0.025)	(0.027)	(0.053)
$\Delta_k l_{var}$	−0.701	−0.876	−0.927	−0.833	−0.875	−0.914
	(0.549)	(0.629)	(0.923)	(0.591)	(0.578)	(0.731)
	Panel C. Dependent variable: Housing					
$\Delta_k l_{skew}$	0.014	0.024	0.021	0.014	0.028	0.026
	(0.028)	(0.022)	(0.031)	(0.031)	(0.035)	(0.0307)
$\Delta_k l_{var}$	−0.103	−0.724	−0.131	−0.142	−0.577	−0.144
	(0.162)	(0.316)	(0.211)	(0.137)	(0.287)	(0.356)

Table 3

Components of Consumption and Skewness in Labor Income Shocks

Table 3 presents for the 1999-2009 sample ($k = 2$) with liquid assets (Column $1 - 3$) and financial wealth (Column $4 - 6$), how growth in each component of consumption ($\Delta_k c$) responds to changes in the skewness of earnings shocks ($\Delta_k l_{skew}$) conditional on changes in the variance of earnings shocks ($\Delta_k l_{var}$) and a vector of the variables which may course common movements. Liquid asset is defined as the sum of stocks and mutual funds plus riskless assets. Subtracting other debts from liquid assets yields liquid wealth. Financial wealth is defined as the sum of liquid wealth, home equity and equity in private business. Regressions still constrol for preference shifters and life-cycle controls (not reported). Preference shifters include changes in household characteristics. Life-cycle controls is related to the life cycle, background and financial situation of the household. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Explanatory variable	All households	Stockholders	Nonstockholders	All households	Stockholders	Nonstockholders
	Column 1 − 3: Liquid assets			*Column 4 − 6: Financial Wealth*		
	Panel D. Dependent variable: Transport					
$\Delta_k l_{skew}$	0.051***	0.058**	0.044**	0.037***	0.032	0.038**∗*
	(0.016)	(0.028)	(0.024)	(0.015)	(0.026)	(0.022)
$\Delta_k l_{var}$	−0.517	−0.776	−0.832	−0.743	−0.792	−0.923
	(0.387)	(0.772)	(0.807)	(0.532)	(0.709)	(0.723)
	Panel E. Dependent variable: Childcare					
$\Delta_k l_{skew}$	0.078***	0.047**	0.029	0.070*	0.047**	0.036*
	(0.040)	(0.026)	(0.024)	(0.050)	(0.026)	(0.028)
$\Delta_k l_{var}$	−0.482	−0.282	−0.226	−0.834	−0.103	−0.312
	(0.299)	(0.265)	(0.553)	(0.453)	(0.683)	(0.544)
	Panel F. Dependent variable: Education					
$\Delta_k l_{skew}$	0.022	0.058***	0.018	0.021	0.030**	0.018
	(0.048)	(0.021)	(0.058)	(0.042)	(0.017)	(0.053)
$\Delta_k l_{var}$	−0.345	−0.228	−0.529	−0.275	−0.648	−0.283
	(0.306)	(0.242)	(0.519)	(0.678)	(0.706)	(0.925)

Table 4

Skewness in Components of Consumption Growth and Skewness in Labor Income Shocks

Table 4 presents for the 1999-2009 sample ($k = 2$) with liquid assets (Column $1-3$) and financial wealth (Column $4-6$), how changes in the skewness of each component of consumption ($\Delta_k c_{skew}$) responds to changes in the skewness of earnings shocks ($\Delta_k l_{skew}$) conditional on changes in the variance of earnings shocks ($\Delta_k l_{var}$) and a vector of the variables which may course common movements. Liquid asset is defined as the sum of stocks and mutual funds plus riskless assets. Subtracting other debts from liquid assets yields liquid wealth. Financial wealth is defined as the sum of liquid wealth, home equity and equity in private business. Regressions still constrol for preference shifters and life-cycle controls (not reported). Preference shifters include changes in household characteristics. Life-cycle controls is related to the life cycle, background and financial situation of the household. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Explanatory variable	All households	Stockholders	Nonstockholders	All households	Stockholders	Nonstockholders
	Column $1-3$: Liquid assets			*Column $4-6$: Financial Wealth*		
			Panel A. Dependent variable: Food			
$\Delta_k l_{skew}$	0.086***	0.356***	0.007	0.089***	0.351***	0.007
	(0.002)	(0.002)	(0.008)	(0.002)	(0.02)	(0.009)
$\Delta_k l_{var}$	0.412	0.162	0.456	0.375	0.254	0.359
	(0.593)	(0.266)	(0.723)	(0.522)	(0.210)	(0.839)
			Panel B. Dependent variable: Health			
$\Delta_k l_{skew}$	0.049***	0.486***	0.006	0.049***	0.511***	0.006
	(0.006)	(0.037)	(0.012)	(0.007)	(0.045)	(0.017)
$\Delta_k l_{var}$	0.783	0.206	0.652	0.794	0.131	0.695
	(0.592)	(0.208)	(0.535)	(0.529)	(0.183)	(0.568)
			Panel C. Dependent variable: Housing			
$\Delta_k l_{skew}$	0.004	0.570***	0.009	0.002	0.572***	0.009
	(0.022)	(0.028)	(0.011)	(0.016)	(0.021)	(0.012)
$\Delta_k l_{var}$	0.624	0.153	0.615	0.638	0.146	0.693
	(0.564)	(0.168)	(0.601)	(0.581)	(0.125)	(0.831)

Table 4

Skewness in Components of Consumption Growth and Skewness in Labor Income Shocks (Continued)

Table 4 presents for the 1999-2009 sample ($k = 2$) with liquid assets (Column $1 - 3$) and financial wealth (Column $4 - 6$), how changes in the skewness of each component of consumption ($\Delta_k c_{skew}$) responds to changes in the skewness of earnings shocks ($\Delta_k l_{skew}$) conditional on changes in the variance of earnings shocks ($\Delta_k l_{var}$) and a vector of the variables which may course common movements. Liquid asset is defined as the sum of stocks and mutual funds plus riskless assets. Subtracting other debts from liquid assets yields liquid wealth. Financial wealth is defined as the sum of liquid wealth, home equity and equity in private business. Regressions still constrol for preference shifters and life-cycle controls (not reported). Preference shifters include changes in household characteristics. Life-cycle controls is related to the life cycle, background and financial situation of the household. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Explanatory variable	All households	Stockholders	Nonstockholders	All households	Stockholders	Nonstockholders
	Column $1 - 3$*: Liquid assets*			*Column* $4 - 6$*: Financial Wealth*		
	Panel D. Dependent variable: Transport					
$\Delta_k l_{skew}$	0.032***	0.096***	0.007	0.034***	0.057***	0.007
	(0.007)	(0.016)	(0.008)	(0.006)	(0.018)	(0.010)
$\Delta_k l_{var}$	0.450	0.517	0.270	0.473	0.573	0.259
	(0.734)	(0.399)	(0.181)	(0.713)	(0.316)	(0.174)
	Panel E. Dependent variable: Childcare					
$\Delta_k l_{skew}$	0.062***	0.140***	0.009	0.063***	0.146***	0.010
	(0.008)	(0.023)	(0.008)	(0.008)	(0.028)	(0.009)
$\Delta_k l_{var}$	0.129	0.102	0.168	0.179	0.122	0.268
	(0.284)	(0.189)	(0.294)	(0.321)	(0.211)	(0.299)
	Panel F. Dependent variable: Education					
$\Delta_k l_{skew}$	0.022***	0.171***	0.004	0.028***	0.167***	0.006
	(0.010)	(0.030)	(0.0016)	(0.007)	(0.020)	(0.015)
$\Delta_k l_{var}$	0.127	0.167	0.173	0.108	0.172	0.135
	(0.251)	(0.135)	(0.143)	(0.272)	(0.150)	(0.113)

Table 5

Baseline Calibration Parameters

Table 5 reports calibration parameters for the baseline annual frequency life-cycle model. Panel A shows the parameters for stock returns. For stock returns, I consider two cases sequentially: stock returns without a rare disaster and stock returns with a rare disaster. The risk-free rate (r_f) and the mean return on stocks (μ) are common choices in Campbell et al. (2001). The parameters related to the rare disasters are calibrated by the empirical evidence in Barro and Ursúa (2009). Panel B shows the parameters for the labor income process. The replacement ratio (λ) is taken from Cocco, Gomes and Maenhout (2005) and the standard deviation of transitory shocks (ε) is set following Gourinchas and Parker (2002). The rest of income parameters are calculated based on the first four moments from Guvenen, Ozkan and Song (2014).

Description	Parmeter value
Panel A. Asset returns	
Risk-free rate (r_f)	0.02
Mean return on stocks (μ)	0.04
Standard deviation of stock return (σ_η)	0.157
Probability of big loss during recessions (p_{tail})	0.03
Big loss during recessions (τ_{tail})	0.55
Correlation between innovations and permanent shocks ($\rho_{u,\eta}$)	0.15
Panel B. Labor income process	
Replacement ratio (λ)	0.68
Standard deviation of transitory shocks (σ_ε)	0.1
Probability of mixture normal distribution (p_1)	0.49
Normal distribution 1 mean during booms (μ_{1b})	0.207
Normal distribution 2 mean during booms (μ_{2b})	−0.110
Normal distribution 1 standard deviation during booms (σ_{1b})	0.212
Normal distribution 2 standard deviation during booms (σ_{2b})	0.076
Normal distribution 1 mean during recessions (μ_{1r})	−0.173
Normal distribution 2 mean during recessions (μ_{2r})	0.162
Normal distribution 1 standard deviation during recessions (σ_{1r})	0.212
Normal distribution 2 standard deviation during recessions($\sigma_{2,r}$)	0.003

Table 6

Baseline Results

Table 6 presents the preference parameters of the model with skewed permanent shocks but without rare event (Benchmark 1) calibrated to 1989 Survey of Consumer Finances (SCF) and compares the data with the model for different age groups. Stockholders have Epstein-Zin preferences, while non-stockholders have CRRA preferences. I calibrate discount factor (β) to match average ratio of financial wealth to labor income during the working time, strength of bequest motive (b) to match average ratio of financial wealth to labor income during the retirement phase, coefficient of relative risk aversion (γ) to match the optimal risky asset shares, and elasticity of intertemporal substitution (ψ) is set at 0.5. For nonstockholders, discount factor (β) is the same as stockholders, coefficient of relative risk aversion (γ) matches average ratio of financial wealth to labor income during the working time and strength of bequest motive (b) matches the average ratio of financial wealth to labor income during the retirement phase.

Benchmark 1			Stockholders			Non-stockholders	
			Data	Model		Data	Model
Discount factor (β)	0.98	(mean W/Y work phase)			0.98		
		20 – 34	1.772	1.315		0.580	0.057
		35 – 44	1.907	3.289		0.577	0.578
		45 – 54	2.653	4.989		0.980	1.294
		55 – 64	5.078	6.933		1.471	2.095
Strength of bequest motive (b)	2.0	(mean W/Y retirement)			0.5		
		65 – 74	8.785	8.819		2.540	2.953
		75 – 64	9.934	10.002		3.805	3.539
Coefficient of relative risk aversion (γ)	6.8	(mean α)			1.6		
		20 – 34	0.300	0.403			
		35 – 44	0.322	0.293			
		45 – 54	0.286	0.248			
		55 – 64	0.262	0.211			
		65 – 74	0.340	0.326			
		75 – 100	0.324	0.315			
Elasticity of intertemporal substitution (ψ)	0.5				1/1.6		

Table 7

Baseline Results

Table 7 presents the preference parameters of the model with skewed permanent shocks and rare event (Benchmark 2) calibrated to 1989 Survey of Consumer Finances (SCF) and compares the data with the model for different age groups. Stockholders have Epstein-Zin preferences, while non-stockholders have CRRA preferences. I calibrate discount factor (β) to match average ratio of financial wealth to labor income during the working time, strength of bequest motive (b) to match average ratio of financial wealth to labor income during the retirement phase, coefficient of relative risk aversion (γ) to match the optimal risky asset shares, and elasticity of intertemporal substitution (ψ) is set at 0.5. For nonstockholders, discount factor (β) is the same as stockholders, coefficient of relative risk aversion (γ) matches average ratio of financial wealth to labor income during the working time and strength of bequest motive (b) matches the average ratio of financial wealth to labor income during the retirement phase.

Benchmark 2			Stockholders			Non-stockholders	
			Data	Model		Data	Model
Discount factor (β)	0.98	(mean W/Y work phase)			0.98		
		20 – 34	1.772	1.245		0.580	0.057
		35 – 44	1.907	3.078		0.577	0.578
		45 – 54	2.653	4.750		0.980	1.294
		55 – 64	5.078	6.485		1.471	2.095
Strength of bequest motive (b)	2.0	(mean W/Y retirement)			0.5		
		65 – 74	8.785	8.357		2.540	2.953
		75 – 64	9.934	8.832		3.805	3.539
Coefficient of relative risk aversion (γ)	6.3	(mean α)			1.6		
		20 – 34	0.300	0.416			
		35 – 44	0.322	0.307			
		45 – 54	0.286	0.245			
		55 – 64	0.262	0.219			
		65 – 74	0.340	0.304			
		75 – 100	0.324	0.279			
Elasticity of intertemporal substitution (ψ)	0.5				1/1.6		

Table 8

Regressions on Skewness in Labor Income Shocks (Model)

Table 8 presents for the 1999-2009 sample ($k = 2$) with benchmark 1 (Column $1-3$) and benchmark 2 (Column $4-6$), how changes in the skewness of consumption growth ($\Delta_k c_{skew}$) responds to changes in the skewness of earnings shocks ($\Delta_k l_{skew}$) conditional on changes in the variance of earnings shocks ($\Delta_k l_{var}$) and a vector of the variables which may course common movements. Liquid asset is defined as the sum of stocks and mutual funds plus riskless assets. Subtracting other debts from liquid assets yields liquid wealth. Financial wealth is defined as the sum of liquid wealth, home equity and equity in private business. Regressions control for life-cycle controls (not reported). Life-cycle controls is related to the life cycle, background and financial situation of the household. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Explanatory variable	All households	Stockholders	Nonstockholders	All households	Stockholders	Nonstockholders
	Column $1-3$: Benchmark 1			*Column $4-6$: Benchmark 2*		
	Panel A. Dependent variable: Consumption growth($\Delta_k c$)					
$\Delta_k l_{skew}$	0.025***	0.051***	0.011***	0.015***	0.024***	0.012***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
$\Delta_k l_{var}$	−0.138	−0.110	−0.095	−0.101	−0.098	−0.092
	(0.117)	(0.094)	(0.091)	(0.093)	(0.086)	(0.088)
	Panel B. Dependent variable: Skewness in consumption growth ($\Delta_k c_{skew}$)					
$\Delta_k l_{skew}$	0.317*	0.422***	0.014***	0.279***	0.327***	0.019***
	(0.018)	(0.016)	(0.001)	(0.017)	(0.016)	(0.001)
$\Delta_k l_{var}$	0.246	0.208	0.215	0.225	0.241	0.169
	(0.175)	(0.168)	(0.177)	(0.146)	(0.153)	(0.137)
	Panel C. Dependent variable: Risky assets shares ($\Delta_k \alpha$)					
$\Delta_k l_{skew}$		0.006***			0.009***	
		(0.001)			(0.001)	
$\Delta_k l_{var}$		−0.011			−0.012	
		(0.007)			−0.012	

Table 9

Skewness in Consumption Growth and Business Cycle

Table 9 presents the correlations between skewness in consumption growth and dummy variable for boom for all households, stockholders and nonstockholders. The standard errors are reported in parentheses below. The table shows the results for the model with normal permanent income shocks (Lognormal Earnings Model), the model with normal permanent shocks but different growth rate during booms and recessions (Lognormal Earnings Model with Business Cycle), the model with skewed permanent shocks (Benchmark 1) and the model with skewed permanent shocks and rare events in stock market (Benchmark 2). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Log-normal earnings model	Log-normal earnings model with business cycle	Benchmark 1	Benchmark 2
All households	0.023	0.287	0.345*	0.324
	(0.213)	(0.203)	(0.200)	(0.202)
Stockholders	0.030	0.312	0.756***	0.621***
	(0.213)	(0.199)	(0.140)	(0.167)
Nonstockholders	−0.003	0.269	0.307	0.291
	(0.213)	(0.205)	(0.206)	(0.204)

Figure 1

Skewness in Consumption Growth and Skewness in Labor Income Shocks

Figure 1 presents the scatter plot and the best fit line of the skewness in consumption growth and the skewness in labor income shocks.

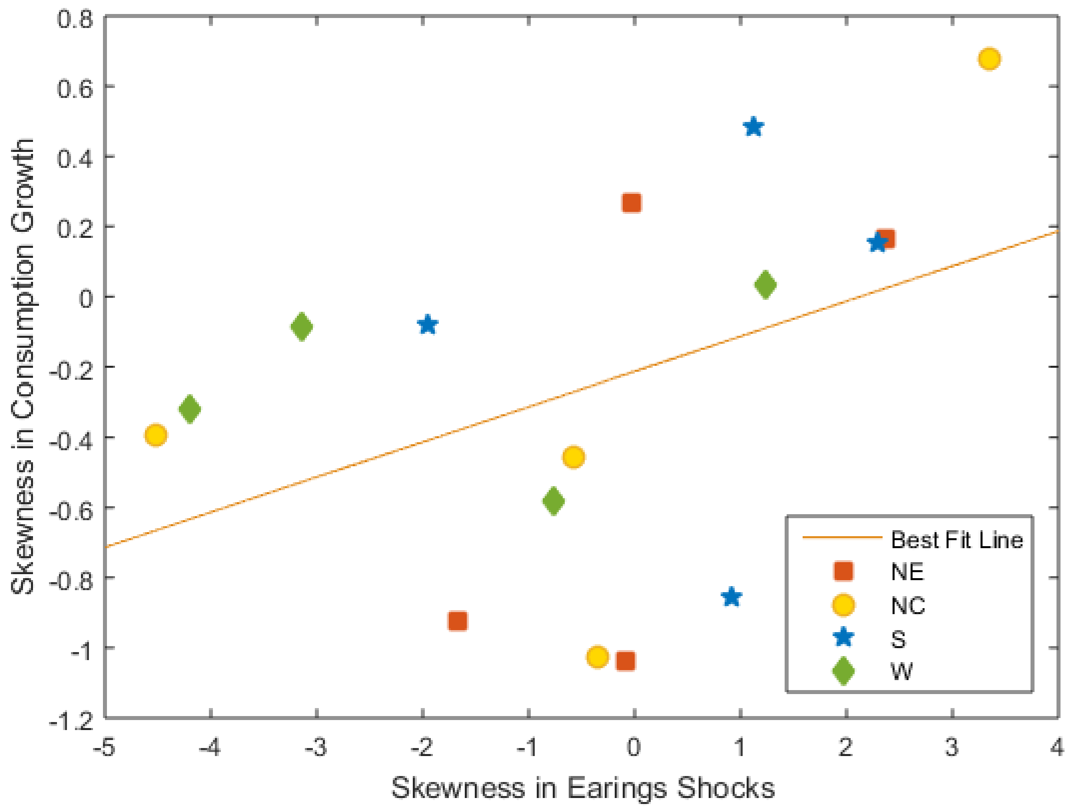

Figure 2

Life-cycle Profiles for Mean Wealth and Share of Wealth in Stocks

Figure 2 presents the mean wealth and mean share of wealth in stocks for different age groups. Graph A and B plot the life-cycle profile for stockholders and Graph C plots the life-cycle profile for nonstockholders.

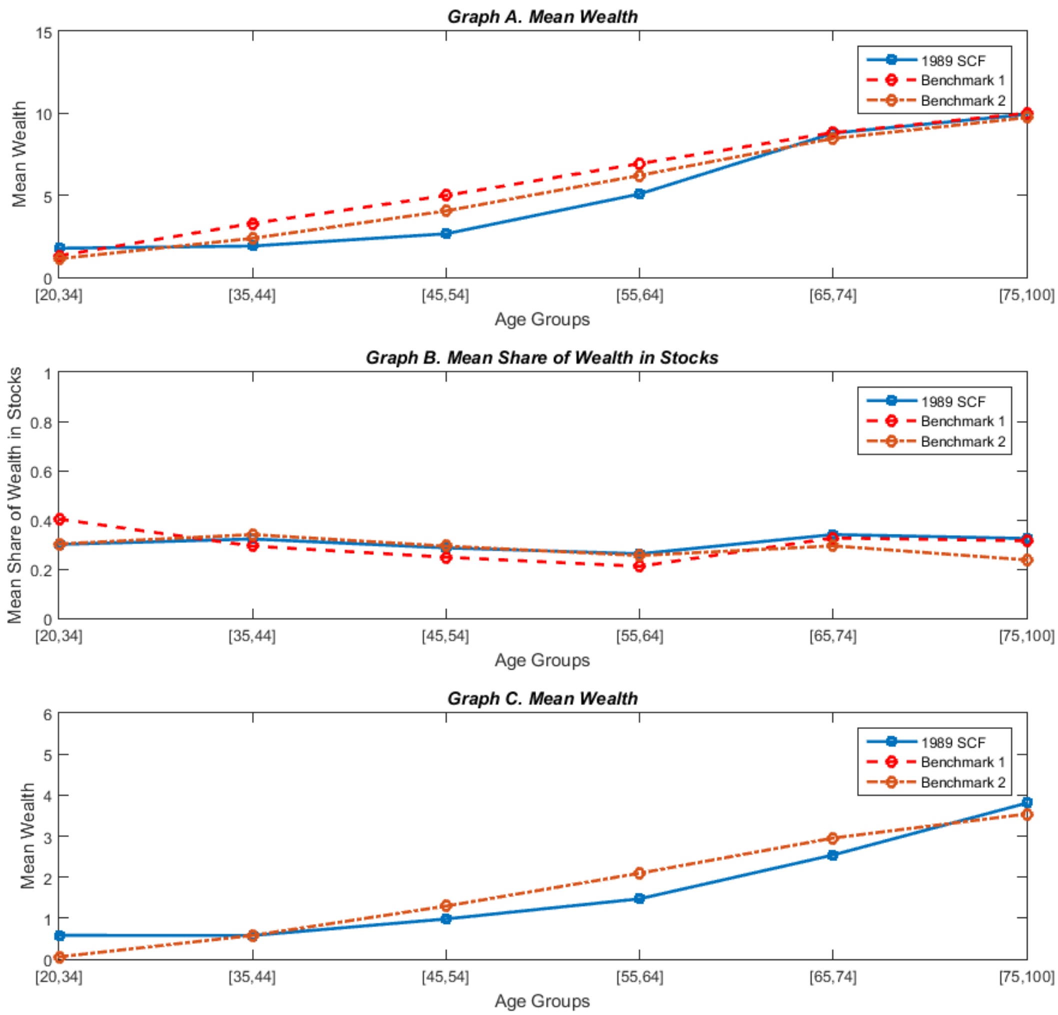

Figure 3

Consumption Policy Function

Figure 3 presents policy functions for consumption and provides comparison among different models.

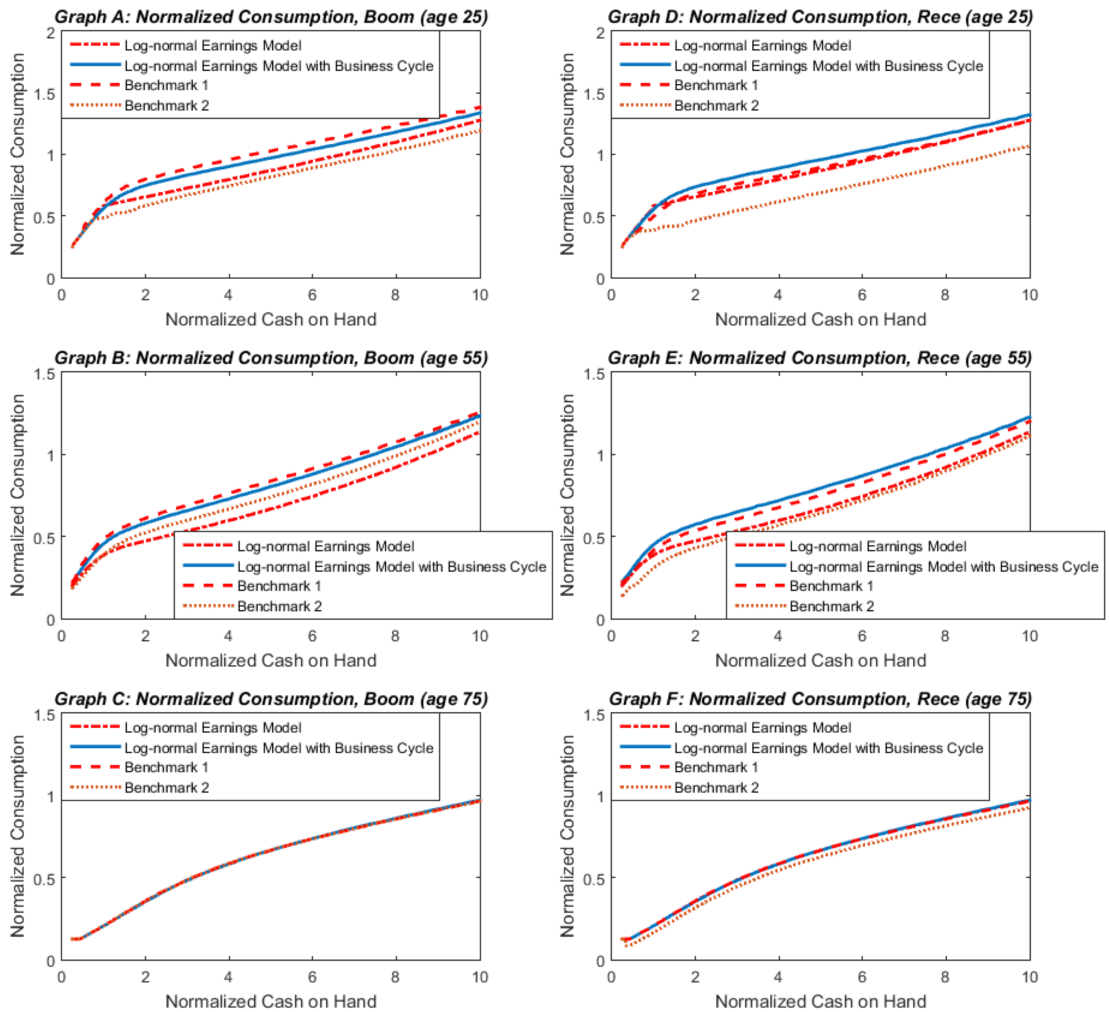

Figure 4

Consumption Policy Function

Figure 4 presents policy functions for consumption and provides comparison between booms and recessions.

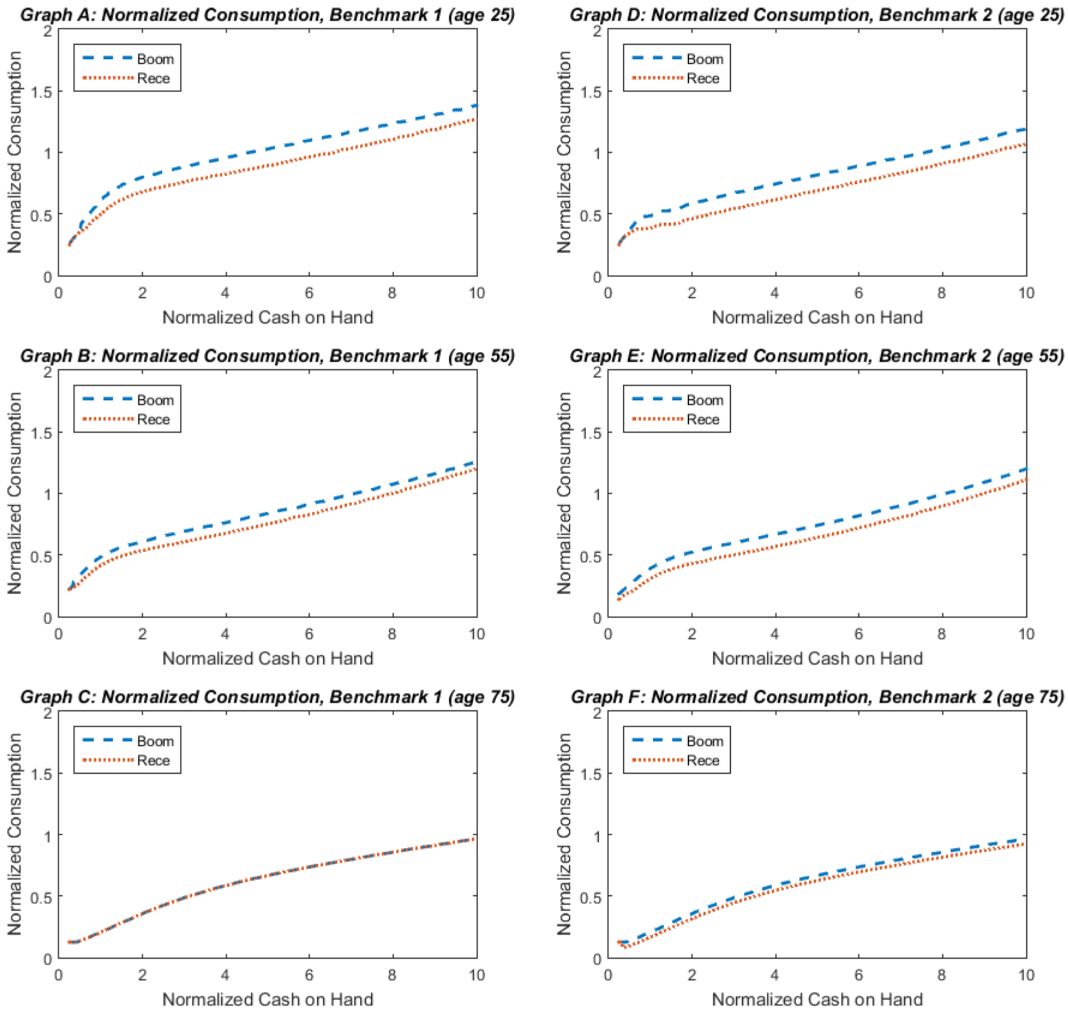

Figure 5

Life-Cycle Profile

Figure 5 presents the life-cycle profile comparison among the model with normal permanent income shocks (Log-normal Earnings Model), the model with normal permanent shocks but different growth rate during booms and recessions (Log-normal Earnings Model with Business Cycle), the model with skewed permanent shocks (Benchmark 1) and the model with skewed permanent shocks and rare events in stock market (Benchmark 2).

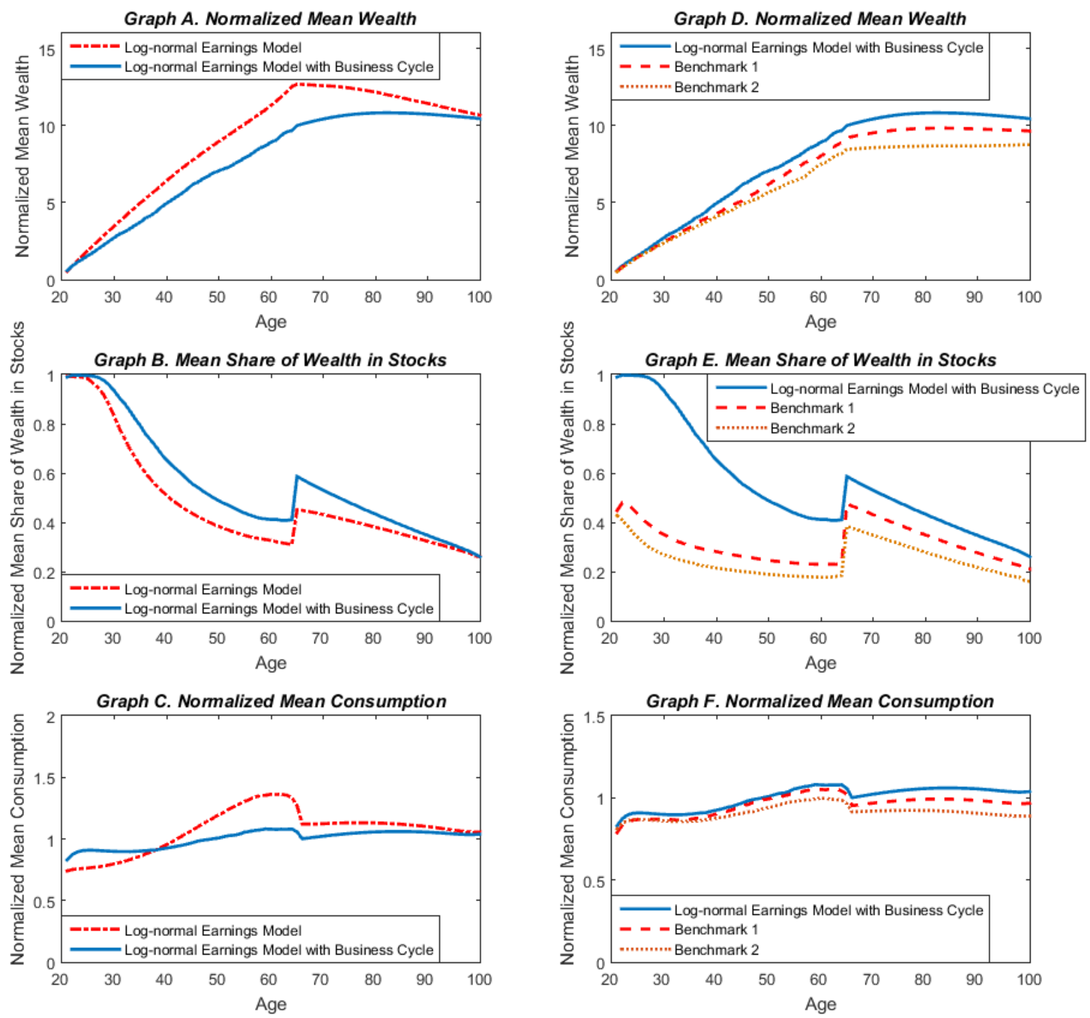

Figure 6

Business Cycle Variation in Life-Cycle Profile

Figure 6 presents the business cycle variation in life-cycle profiles. To show effect clearly, I assume a recession in all life cycle or a boom in all life cycle. The left graphs plot the model with skewed permanent shocks (Benchmark 1) under the circumstance of a boom in all life cycle, and the model with skewed permanent shocks (Benchmark 1) under the circumstance of a recession in all life cycle. The right graphs plot the model with skewed permanent shocks and rare events in stock market (Benchmark 2) under the circumstance of a boom in all life cycle, and the model with skewed permanent shocks and rare events in stock market (Benchmark 2) under the circumstance of a recession in all life cycle.

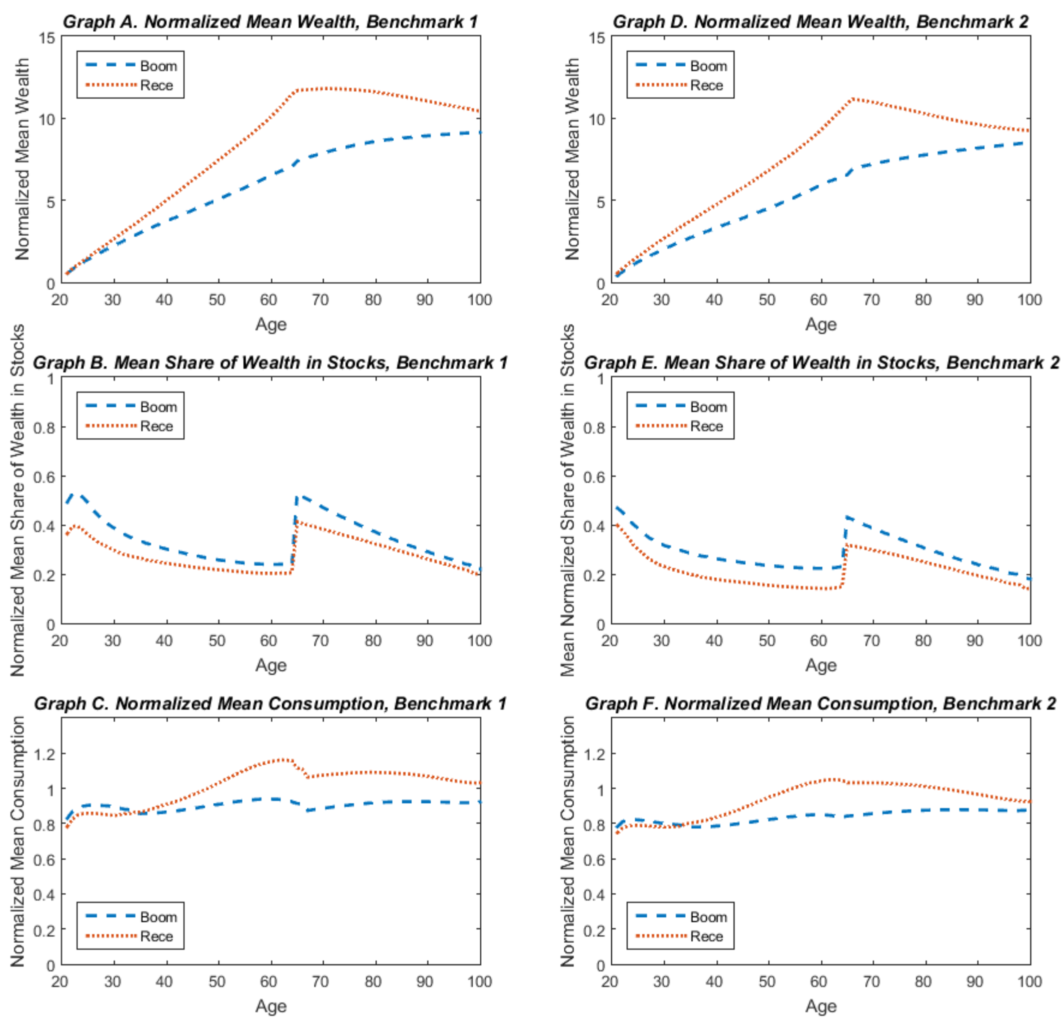

Figure 7

Skewness in Consumption Growth and Business Cycle

Figure 7 presents how skewness in consumption growth changes over the time. Grey shadow indicates that year is in a recession. Graph A shows skewness in labor income shocks from 1989 to 2013. Graph B, Graph C and Graph D show skewness in consumption growth for stockholders, nonstockholders and all households respectively.