Industry Affiliation and the Value of Portfolio Choice

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Overview

- In the presence of persistent inter-industry wage differentials (see, e.g., Dickens and Katz (1987), Krueger and Summers (1987, 1988), Katz and Summers (1989)), the value of portfolio choice varies across otherwise identical households employed in different industries.
- If human capital is nontradable, hedging demands for stocks vary with industry affiliation because the joint distribution of labor income (earnings) growth and aggregate stock return varies across industries.
- I solve a dynamic portfolio choice model with industry-specific labor income for 72 industries at the 3-digit classification level and investigate the impact of industry affiliation on the value of portfolio choice.

- I use certainty equivalent consumption to measure this value.
- I leave the DGP of earnings growth and stock return unspecified.
- From solving the model for all industries, I obtain the cross-sectional distribution of certainty equivalent consumption across industries.
- I analyze this distribution to answer three main research questions:

Q1. Do households in higher paid industries, i.e. those with a higher *level* of initial average earnings, benefit more from optimal portfolio choice than households in lower paid industries?

Q2. Which moments of earnings *growth* and comoments of earnings growth and stock return determine the value of portfolio choice?

Q3. Does cyclical variation in the risk of industry-specific earnings growth matter for the value of portfolio choice?

Literature on industry-specific hedging demands ($\Rightarrow$ Q2)

- Campbell, Cocco, Gomes, and Maenhout (2001) report variation in the *variance* of labor income shocks across 12 industries.
- Cocco, Gomes, and Maenhout (2005) derive life-cycle portfolio choice implications for 3 of these industries.
- Eiling (2013) documents variation in hedging demands across households working in 5 industries, which differ in the *covariance* structure between earnings growth and stock return.
- Eiling, de Jong, Laeven and Sperna Weiland (2019) find that hedging demands of households located in 9 industries vary with the investment horizon and are most significant at medium-term horizons.

Literature on inequality (Q1) and cyclical earnings risk (Q3)

- Does consumption inequality mirror income inequality?
  - Yes, e.g. Aguiar and Bils (2015), Attanasio and Pistaferri (2016).
  - Fagereng, Guiso, Malacrino, and Pistaferri (2016) show that the return on household wealth increases in the level of wealth.
- Does earnings risk vary over the business cycle?
  - Storesletten, Telmer, and Yaron (2004) find countercyclical variation in idiosyncratic labor income volatility. Guvenen, Ozkan, and Song (2014) document cyclical skewness in idiosyncratic earnings shocks.
  - Lynch and Tan (2011), Shen (2018), and Catherine (2020) explore portfolio choice implications for a given labor income DGP.

Main Findings

- Inequality in certainty equivalent consumption mirrors inequality in initial earnings across industries. Benhabib, Bisin, and Luo (2019): models that “focus on precautionary savings as an optimal response to stochastic earnings […] tend to produce tail indices of wealth close to the distribution of labor earnings which has been fed into the model.”
- Substantial heterogeneity in the value of portfolio choice is explained by variation in the covariance structure of earnings growth and stock return.
- Cyclical skewness in cumulative earnings growth is economically and statistically as important in explaining the value of portfolio choice as correlation between earnings growth and stock return.

Proposed measures of cyclical variation in earnings growth

- An industry with a (low) negative value of *coskewness* between earnings growth, G, and stock return, R, is likely to exhibit high earnings growth volatility during recessions.

$$Coskewness = \frac{E[(G - E[G])^2(R - E[R])]}{\sigma^2(G)\sigma(R)}$$

- An industry with a (high) positive value of *cokurtosis* is likely to exhibit negative skewness in earnings growth during recessions.

$$Cokurtosis = \frac{E[(G - E[G])^3(R - E[R])]}{\sigma^3(G)\sigma(R)}$$

Dynamic portfolio choice with consumption and labor income

- Households maximize time-0 conditionally expected power utility

$$\mathbb{E}_0 \left[\sum_{t=0}^{T} \delta^t \frac{C_t^{1-\gamma}}{1-\gamma} \right]$$

- subject to intertemporal budget constraint (where $G_{t+1} = L_{t+1}/L_t$)

$$X_{t+1} = (X_t - C_t)\, R_{t+1}^p + L_{t+1}$$

$$\Leftrightarrow \frac{X_{t+1}}{L_{t+1}} = G_{t+1}^{-1} \left(\frac{X_t}{L_t} - \frac{C_t}{L_t} \right) R_{t+1}^p + 1$$

$$\Leftrightarrow x_{t+1} = G_{t+1}^{-1} (x_t - c_t)\, R_{t+1}^p + 1$$

$$\Leftrightarrow x_{t+1} = G_{t+1}^{-1} x_t (1 - q_t)\, R_{t+1}^p + 1,$$

- Bellman equation (z_t: predictor of earnings growth and asset returns)

$$V_t\left(x_t, z_t\right) = \max_{c_t, w_t}\left\{\frac{c_t^{1-\gamma}}{1-\gamma} + \delta \mathbb{E}_t\left[G_{t+1}^{1-\gamma} V_{t+1}\left(x_{t+1}, z_{t+1}\right)\right]\right\}$$

- Euler equations for consumption and portfolio choice

$$\mathbb{E}_t\left[\delta\left(G_{t+1}\frac{x_{t+1}q_{t+1}}{x_t q_t}\right)^{-\gamma} R_{t+1}^{p} - 1\right] = 0$$

$$\mathbb{E}_t\left[\delta\left(G_{t+1}x_{t+1}q_{t+1}\right)^{-\gamma} R_{t+1}^{e}\right] = 0.$$

- Set of conditional moment restrictions (for given x_t; $\beta_t = (q_t, w_t)'$)

$$\mathbb{E}_t\left[\rho\left(y_{t+1}, \beta_t^0\right)\right] = \mathbb{E}\left[\rho\left(y_{t+1}, \beta_t^0\right) \mid z_t\right] = 0$$

Estimating parameterized policy functions by GMM

- Parameterize optimal control variables, β_t^0, as a function of polynomial terms, z_t^p, in the predictive variable z_t (see papers by Brandt et al.)

$$
\begin{aligned}
\beta_t^0 &= \Lambda\left(\Theta_t^0\left(x_t\right) z_t^p\right) \\
&= \Lambda\left(\operatorname{vec}\left(\Theta_t^0\left(x_t\right) z_t^p\right)\right) \\
&= \Lambda\left(\left(z_t^p \otimes I_2\right)' \operatorname{vec}\left(\Theta_t^0\left(x_t\right)\right)\right) \\
&= \Lambda\left(\left(z_t^p \otimes I_2\right)' \theta_t^0\right),
\end{aligned}
$$

- Note that we get different parameterizations for different candidate x_t.
- I propose to use cdf of the Logistic distribution, Λ, to enforce borrowing and short-sale constraints of typical households such that $0 \leq \beta_t^0 \leq 1$.

- Vector of unconditional moment functions implied by Euler equations

$$\psi\left(y_{t+1}, z_t, \theta_t\right) = \begin{pmatrix} \left(I_2 \otimes z_t^p\right) \rho\left(y_{t+1}, \beta_t\right) \\ \beta_t - \Lambda\left(\left(z_t^p \otimes I_2\right)' \theta_t\right) \end{pmatrix}$$

- This system is overidentified because the average Euler equations are not necessarily zero if borrowing and short-sale constraints are binding.
- Use GMM with identity weight matrix to estimate θ_t at rebalancing time $t = 0, \ldots, T-1$ from a sample of $s = 1, \ldots, S-1$ observations of y_{s+1}, z_s

$$\hat{\theta}_t = \underset{\theta_t}{\operatorname{argmin}} \left(\frac{1}{S-T} \sum_{s=t+1}^{S-(T-t)} \psi\left(y_{s+1}, z_s, \theta_t\right)\right)' \left(\frac{1}{S-T} \sum_{s=t+1}^{S-(T-t)} \psi\left(y_{s+1}, z_s, \theta_t\right)\right)$$

Estimated policy functions

- Repeat for every x_t in a given grid of cash-on-hand and obtain $\Theta_t(x_t)$.
- Make this relationship explicit by regressing $\Theta_t(x_t)$ on a polynomial in x_t

$$\theta_t = \text{vec}\left(\Theta_t\left(x_t\right)\right) = \Gamma_t x_t^p + \varepsilon_t.$$

- The policy functions are now functions of all polynomial terms in cash-on-hand and the predictor variable and all possible interactions of these terms

$$\hat{\beta}_t = \Lambda\left(\left(z_t^p \otimes I_2\right)' \hat{\Gamma}_t x_t^p\right)$$

- This extends the parameterization approach by Brandt and coauthors to a dynamic portfolio choice problem that is not homogeneous in wealth.

Certainty equivalent consumption

- Estimate the average value function at time 0

$$\widehat{V}_0 = \frac{1}{S-T} \sum_{s=1}^{S-T} \sum_{t=0}^{T} \delta^t \frac{\widehat{C}_{st}^{1-\gamma}}{1-\gamma}$$

- Certainty equivalent consumption (CEC) follows from solving

$$\sum_{t=0}^{T} \delta^t \frac{CEC^{1-\gamma}}{1-\gamma} = \widehat{V}_0$$

- Household is indifferent between receiving risk-free CEC or implementing the optimal strategies of consumption and portfolio choice.

Data sources

- Calculate industry-specific earnings growth from Current Employment Statistics (CES) data provided by the Bureau of Labor Statistics (BLS).
- Use “average weekly earnings of production and nonsupervisory employees” in 1982-84 dollars from January 1990 – December 2019.
- Available for 72 industries at 3-digit NAICS level (84% coverage).
- Monthly return on broad value-weighted stock market index from CRSP.
- Monthly return on 30-day T-bill from CRSP. Monthly inflation from CRSP.
- Use log dividend-price ratio as predictor variable (as in Campbell and Shiller (1988), Lynch and Tan (2011), Michaelides and Zhang (2017)).
- Sample includes three NBER recessions (important for cyclical variation).

Descriptive statistics and horizon effects

Table 2: Descriptive statistics of real earnings growth moments and its comoments with stock return

Correlation of earnings growth and stock return

	Mean	Std. dev.	Minimum	Maximum
1-month earnings growth and stock return	-0.0124	0.0471	-0.0865	0.0924
12-month earnings growth and stock return	0.0063	0.1717	-0.3436	0.3987
18-month earnings growth and stock return	0.0324	0.1670	-0.3718	0.4106
90-month earnings growth and stock return	0.2094	0.3619	-0.7231	0.7517

- I confirm strong horizon effects in the moments and comoments of cumulative earnings growth and stock return (see Eiling et al., 2019).
- The range of correlation increases dramatically with the horizon over which cumulative earnings growth and stock return are calculated.

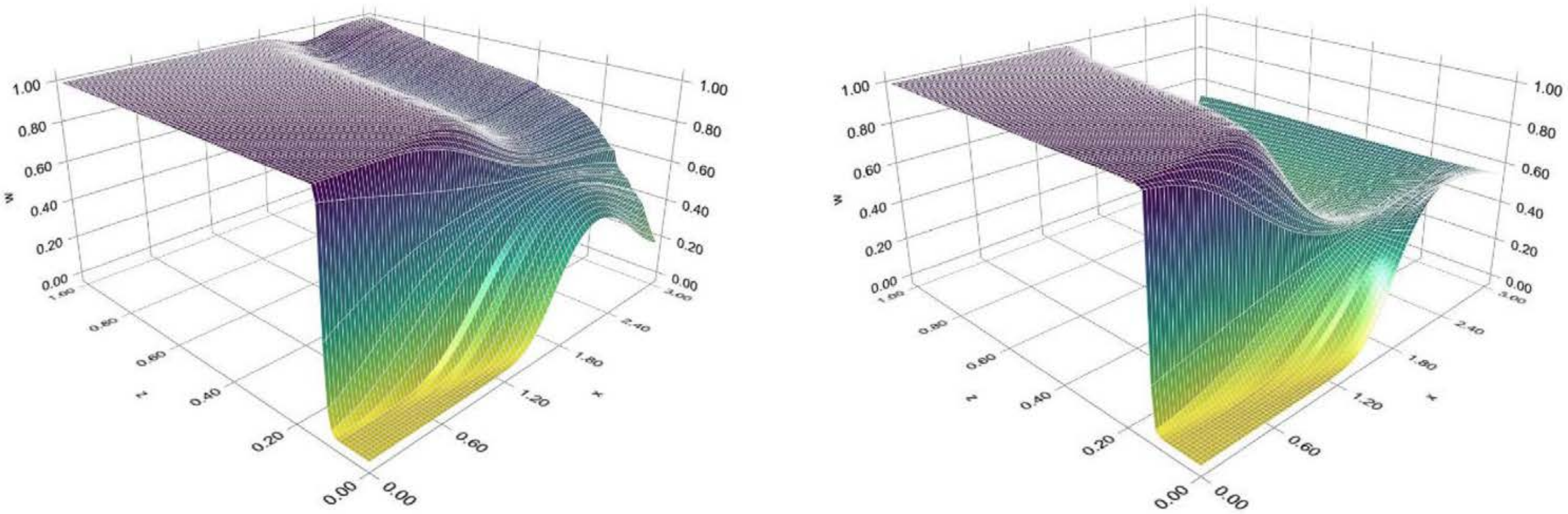
Baseline parameter choice

- Sample: $S = 360$ months. Use investment horizon of $T = 180$ months.
- Rebalancing occurs every 18 months (to save on computation time).
- Initial ratio of cash-on-hand to annual earnings: $x_0 = 1$.
- Comparative statics results for $T = 90$ and $x_0 = 2$ in the paper.
- Coefficients of risk aversion: $\gamma = 10$ or $\gamma = 5$.
- Subjective discount factor: $\delta = 0.97$.
- Third-order polynomial in cash-on-hand, x_t.
- Unconditional model ($m = 0$) and conditional models with linear ($m = 1$) and quadratic ($m = 2$) functions in the log dividend-price ratio are solved (Campbell, Chan, and Viceira (2003): policy functions are quadratic in z_t).

Estimated policy functions (for $m = 1$)

Figure 1: Policy functions for allocation to stocks for two selected industries and $\gamma = 10$

A. Petroleum and coal products $t = 1$ B. Securities and investments



Certainty equivalent consumption mirrors initial earnings

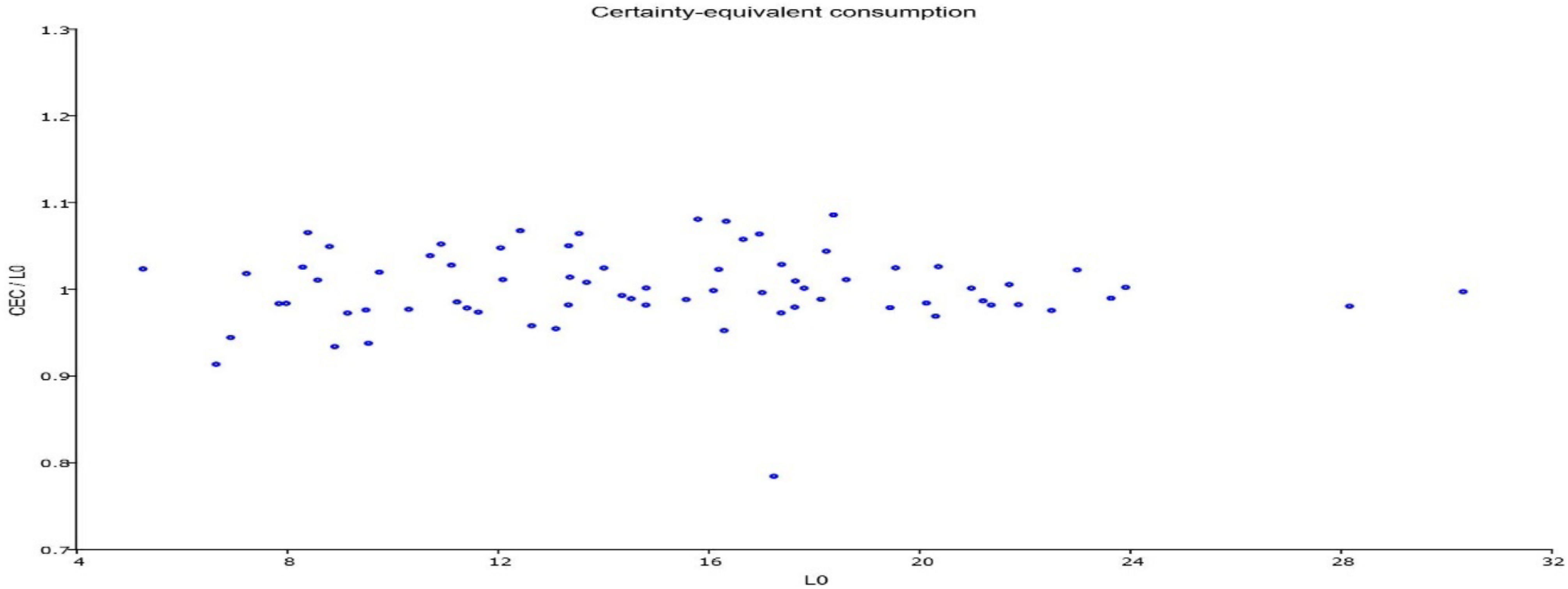
Table 4: Distribution of certainty equivalent consumption (CEC) by risk aversion: $T = 180$ & $x_0 = 1$

		$\gamma = 10$			$\gamma = 5$		
		$m = 0$	$m = 1$	$m = 2$	$m = 0$	$m = 1$	$m = 2$
	L_0	CEC	CEC	CEC	CEC	CEC	CEC
Mean	15.08	15.08	15.10	15.10	15.37	15.41	15.40
Std. dev.	5.29	5.28	5.31	5.29	5.38	5.40	5.39
Max	30.32	30.14	30.24	30.24	30.65	30.75	30.74
Q90	21.67	21.39	21.44	21.42	21.88	21.94	21.92
Q50	14.81	14.44	14.47	14.47	14.81	14.85	14.84
Q10	8.40	8.51	8.52	8.55	8.74	8.76	8.76
Min	5.26	5.38	5.38	5.38	5.45	5.46	5.45
Q90/Q10	2.58	2.51	2.52	2.51	2.50	2.50	2.50
Q90/Q50	1.46	1.48	1.48	1.48	1.48	1.48	1.48
Q50/Q10	1.76	1.70	1.70	1.69	1.70	1.70	1.69
Gini	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Mean($1[CEC(m) > CEC(m-1)]$)			0.88	0.19		0.99	0.14

Certainty equivalent consumption relative to initial earnings

Figure 5: Scaled certainty-equivalent consumption (CEC/L_0) by initial earnings (L_0) for $\gamma = 10$

A. Investment horizon $T = 180$ months and initial cash-on-hand $x_0 = X_0/L_0 = 1$



Winners and losers

- As evidenced by the Gini coefficients, inequality in certainty equivalent consumption tracks inequality in initial earnings. The industry with highest average earnings (*Petroleum and coal products*) also obtains highest CEC.
- There remains substantial variation in CEC that is unrelated to the level of initial earnings. Households in higher paid industries do not benefit more from portfolio choice than those in lower paid industries (and vice versa).
- Per unit of initial earnings, households in the *Securities and investments* industry (Wall Street) benefit most from portfolio choice. Households in the *Motion picture and sound recording* industry (Hollywood) benefit least.
- What explains this variation in scaled certainty equivalent consumption?

Table 7: Cross-sectional regressions of scaled certainty equivalent consumption (CEC/L_0) on moments and comoments of cumulative real earnings growth for $T = 180$ and $x_0 = 1$

A. Relative risk aversion: $\gamma = 10$

All X variables are standardized.

	18-month cumulative moments			90-month cumulative moments		
Comoment:	Correlation	Coskewness	Cokurtosis	Correlation	Coskewness	Cokurtosis
Intercept	1.0014	1.0014	1.0014	1.0014	1.0014	1.0014
	(365.60)	(354.71)	(361.52)	(562.18)	(535.20)	(595.02)
Mean	0.0341	0.0354	0.0344	0.0360	0.0390	0.0352
	(11.23)	(11.50)	(11.22)	(16.15)	(19.32)	(17.14)
Variance	-0.0290	-0.0288	-0.0289	-0.0286	-0.0289	-0.0288
	(-9.48)	(-9.06)	(-9.35)	(-14.68)	(-14.13)	(-15.66)
Skewness	0.0020	0.0017	0.0021	-0.0028	-0.0017	-0.0027
	(0.68)	(0.56)	(0.69)	(-1.08)	(-0.62)	(-1.09)
Kurtosis	0.0019	-0.0003	0.0013	-0.0022	-0.0026	-0.0013
	(0.63)	(-0.11)	(0.45)	(-0.83)	(-0.91)	(-0.49)
Comoment	-0.0063	-0.0014	-0.0050	-0.0058	-0.0014	-0.0079
	(-2.09)	(-0.47)	(-1.67)	(-2.72)	(-0.74)	(-4.03)
R^2	0.7490	0.7330	0.7430	0.8940	0.8830	0.9050

B. Relative risk aversion: $\gamma = 5$

	18-month cumulative moments			90-month cumulative moments		
Comoment:	Correlation	Coskewness	Cokurtosis	Correlation	Coskewness	Cokurtosis
Intercept	1.0219	1.0219	1.0219	1.0219	1.0219	1.0219
	(397.01)	(377.74)	(390.86)	(670.96)	(597.91)	(679.32)
Mean	0.0369	0.0384	0.0372	0.0381	0.0423	0.0383
	(12.92)	(13.01)	(12.83)	(19.97)	(22.95)	(20.87)
Variance	-0.0133	-0.0129	-0.0132	-0.0154	-0.0158	-0.0157
	(-4.64)	(-4.25)	(-4.53)	(-9.25)	(-8.45)	(-9.54)
Skewness	0.0013	0.0009	0.0014	-0.0016	-0.0008	-0.0012
	(0.46)	(0.30)	(0.48)	(-0.71)	(-0.32)	(-0.55)
Kurtosis	0.0004	-0.0024	-0.0002	-0.0016	-0.0022	-0.0008
	(0.14)	(-0.88)	(-0.06)	(-0.71)	(-0.87)	(-0.36)
Comoment	-0.0079	-0.0026	-0.0067	-0.0076	0.0009	-0.0077
	(-2.80)	(-0.93)	(-2.36)	(-4.18)	(0.50)	(-4.42)
R^2	0.7620	0.7370	0.7540	0.9170	0.8950	0.9190

- Over long horizons, cokurtosis is as important as correlation.

Conclusions

- Inequality in certainty equivalent consumption tracks earnings inequality.
- Accounting for the trivial effect that CEC increases with the level of initial earnings, there remains substantial heterogeneity in certainty equivalent consumption across households in different industries.
- First and second moments of industry-specific earnings growth explain much of this heterogeneity.
- Correlation and cokurtosis between cumulative earnings growth and stock return are equally important in explaining the value of portfolio choice.
- Calibration exercises should focus on matching long-term moments.
- Implications for pension asset allocation in industry-level pension funds.