Population and Asset Pricing

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Background and Motivation

- Hansen and Singleton (1982, 1983), Mankiw and Shapiro (1986), and Breeden, Gibbons, and Litzenberger (1989) almost fail to find support for the CCAPM.

- There are a lot of papers proposing ways to improve the traditional CCAPM.

Background and Motivation

- Most empirical studies in the literature employ the growth of consumption per capita as a pricing factor and share a common assumption that the volatility of consumption per capita can capture that of aggregate consumption.
- ➔ We posit that previous empirical studies of the CCAPM have neglected an important explanatory variable, *i.e.*, population change.

Background and Motivation

- Our presumption is also motivated by a strand of the literature which shows that the population affects stock market returns (see, for example, Goyal (2004), Ang and Maddaloni (2005) and DellaVigna and Pollet (2007))

The Main Focus of the paper

- Population risk is an important factor by introduction of population factor into the traditional CCAPM and then improving the model performance.

The CCAPM Literature

- Improve the performance of traditional CCAPM by using multiperiod growth rates

1. Parker and Julliard (2005) find that the covariance between an asset's return during a quarter and cumulative consumption growth over the several following quarters, which they refer to as ultimate consumption risk, explains the cross-section of stock returns very well.

The CCAPM Literature

2. Jagannathan and Wang (2007) find that when consumption betas of stocks are computed using year-over-year consumption growth based on the fourth quarter, the CCAPM performs as well as the Fama and French (1993) three-factor model. Since, for the CCAPM to hold at any given time point, investors must make their consumption and investment decisions simultaneously at that time point, they suspect it is more likely to happen during the fourth quarter.

The CCAPM Literature

- Improve the performance of traditional CCAPM by using different consumption goods

1. Ait-Sahalis, Parker, and Yogo (2004) use novel data on the consumption of luxury goods and find that the consumption of luxuries covaries significantly more with stock returns than does aggregate consumption.
2. Yogo (2006) finds that durable consumption in conjunction with nondurable consumption can explain the cross-section of stock returns.

Population Risk and the Cross-Section of Asset Returns

- The traditional CCAPM can be implemented by using the intertemporal optimality condition:

$$E\left[R_{i,t+1}M_{t+1}\right]=0 \qquad (1)$$

where M_{t+1} is the pricing kernel;

$R_{i,t+1}$ is the excess return on asset i from date t to t+1.

Population Risk and the Cross-Section of Asset Returns

- The pricing kernels for the traditional CCAPM can be given by

$$M_{t+1} = \beta_0 + \beta_1 \cdot cg_{t+1} \tag{2}$$

or

$$M_{t+1} = \beta_0 + \beta_1 \cdot Cg_{t+1}. \tag{3}$$

where cg_{t+1} is the growth of consumption per capita;
Cg_{t+1} is the growth of aggregate consumption.

Population Risk and the Cross-Section of Asset Returns

- After rewriting equation (1) in the more common covariance form and putting equation (2) or (3) into it, we can obtain the unconditional version of the CCAPM:

$$E\left(R_{i,t+1}\right) = -\frac{\operatorname{cov}\left(M_{t+1}, R_{i,t+1}\right)}{E\left(M_{t+1}\right)} = -\frac{\beta_1 \operatorname{cov}\left(cg_{t+1}, R_{i,t+1}\right)}{E\left(M_{t+1}\right)} = \lambda\beta_1$$

or

$$E\left(R_{i,t+1}\right) = -\frac{\operatorname{cov}\left(M_{t+1}, R_{i,t+1}\right)}{E\left(M_{t+1}\right)} = -\frac{\beta_1 \operatorname{cov}\left(Cg_{t+1}, R_{i,t+1}\right)}{E\left(M_{t+1}\right)} = \lambda\beta_1.$$

Population Risk and the Cross-Section of Asset Returns

- Actually, the aggregate consumption can be represented as

$$C_t = N_t \cdot \theta_t$$

, where

θ_t is the consumption per capita at time t;

N_t is the aggregate population at time t.

Population Risk and the Cross-Section of Asset Returns

- We simply assume that the pricing kernel depends in a linear way on the two factors, namely, consumption and population:

$$M_{t+1} = b + b_\theta \cdot cg_{t+1} + b_N \cdot pd_{t+1}, \qquad (6)$$

where the growth of consumption per capita can be given by $cg_{t+1} = (\theta_{t+1}/\theta_t) - 1$; the decline of aggregate population by $pd_{t+1} = 1 - (N_{t+1}/N_t)$.

Population Risk and the Cross-Section of Asset Returns

- Why we use the decline of population??

It shrinks the consumption market, so the market may treat population change as a risk when the population declines.

One usually measures population growth as $pg_{t+1} = (N_{t+1}/N_t) - 1$. Population decline works in a reverse, so it can be defined by $pg_{t+1} = -pd_{t+1}$. Thus, we specify it as $pd_{t+1} = 1 - (N_{t+1}/N_t)$.

Population Risk and the Cross-Section of Asset Returns

- We follow Parker and Julliard (2005) to test how long-term risk can explain the stock returns very well and replace equation (6) by

$$M_{t+1} = b^s + b^s_\theta \cdot cg_{t+1+s} + b^s_N \cdot pd_{t+1+s},$$

where

$$cg_{t+1+s} = \left(\theta_{t+1+s}/\theta_t\right) - 1$$

$$pd_{t+1+s} = 1 - \left(N_{t+1+s}/N_t\right)$$

Population Risk and the Cross-Section of Asset Returns

- In our empirical study, we also work with an unconditional version, referred to as the population-based CCAPM (the P-CCAPM):

$$E\left(R_{i,t+1}\right) = \lambda_{\theta}^{S}\beta_{\theta}^{S} + \lambda_{N}^{S}\beta_{N}^{S}, \qquad (*)$$

Population Risk and the Cross-Section of Asset Returns

- We examine the specification in equations (*) by applying the two-stage regression method of Fama-MacBeth (1973):

1st Stage: estimate consumption and population betas;

2nd Stage: estimate the market risk prices for the consumption and population factors.

- We would like to set the return horizon as a calendar year and present our results under a different s. Moreover, we also consider Q4-Q4 data.

The Data

- Consumption data: 1950 to 2005 from NIPA tables available from the Bureau of Economic Analysis.

Panel A: (s+1)-year Per capita Consumption Growth (Annual-Annual)(%)										
	Nondurables and Services					Durables, Nondurables and Services				
s	0	1	2	3	4	0	1	2	3	4
Mean	2.21	4.48	6.80	9.19	11.68	3.05	6.26	9.58	12.99	16.52
SD	1.19	1.98	2.56	3.05	3.45	1.85	3.06	3.99	4.74	5.42
Min	-1.31	0.39	1.73	3.20	6.58	-0.72	-0.31	0.61	3.98	6.19
Max	4.24	8.26	12.57	15.57	19.46	6.13	12.27	17.90	22.35	26.63
Panel B: (s+1)-year Per capita Consumption Growth (Q4-Q4)(%)										
	Nondurables and Services					Durables, Nondurables and Services				
s	0	1	2	3	4	0	1	2	3	4
Mean	2.23	4.51	6.81	9.22	11.70	3.06	6.31	9.59	13.02	16.54
SD	1.41	2.24	2.69	3.14	3.58	2.14	3.30	4.12	4.82	5.53
Min	-1.42	-1.01	1.12	3.80	6.11	-2.46	-0.62	0.96	4.07	5.12
Max	5.26	9.97	12.24	15.16	19.82	8.22	14.04	17.58	21.50	27.13

The Data

- Population data: the quarterly number of the aggregate population from NIPA Table 2.1.

Table 2
Summary Statistics for Population Decline

	Annual-Annual					Q4-Q4				
s	0	1	2	3	4	0	1	2	3	4
Mean	-1.22	-2.46	-3.71	-4.97	-6.24	-1.22	-2.45	-3.69	-4.94	-6.20
SD	0.31	0.62	0.92	1.21	1.50	0.31	0.61	0.91	1.20	1.49
Min	-2.05	-3.77	-5.51	-7.40	-9.33	-2.05	-3.75	-5.48	-7.33	-9.27
Max	-0.88	-1.78	-2.71	-3.63	-4.58	-0.88	-1.78	-2.71	-3.63	-4.57

The Data

- Asset return data: use the returns on 25 book-to-market and size-sorted portfolios, values for Fama and French (1993) three factor (market, SMB, HML) for the period 1951 to 2005 available from Kenneth French's web site.

Table 3
Average Annual Excess Returns

	Low		Book-to-Market		High
			Panel A: 1951-2005 (%)		
Small	7.97	14.69	14.74	17.07	20.61
	5.67	10.03	13.35	13.76	15.06
Size	6.72	10.74	10.87	13.48	14.29
	7.79	8.74	11.69	12.21	13.03
Big	6.88	8.20	9.35	9.52	10.83

Empirical Findings— PCCAPM, CCAPM and FF Model

	constant	cg_{t+1}	pd_{t+1}	Rm-Rf	SMB	HML	R^2 (adj R^2)
Panel A: CCAPM and PCCAPM (Nondurables and Services)							
Annual	12.03 (16.41)***	1.05 (1.91)*					0.14 (0.10)
- Annual	14.59 (24.80)***	0.50 (1.50)	0.51 (6.53)***				0.71 (0.68)
Q4-Q4	-1.15 (-0.73)	2.31 (8.25)***					0.75 (0.74)
	4.59 (1.70)	1.48 (3.50)***	0.24 (2.49)**				0.80 (0.79)
Panel B: CCAPM and PCCAPM (Durables, Nondurables and Services)							
Annual	13.82 (10.57)***	1.47 (2.07)**					0.16 (0.12)
- Annual	15.49 (18.88)***	0.75 (1.70)	0.51 (6.54)***				0.71 (0.69)
Q4-Q4	1.52 (1.27)	3.56 (8.69)***					0.77 (0.76)
	5.96 (2.81)**	2.36 (3.84)***	0.22 (2.44)**				0.82 (0.80)
Panel C: Fama-French Model							
-	10.15 (2.76)**			-4.81 (-1.20)	3.92 (2.51)**	8.80 (4.64)***	0.79 (0.76)

Not significant

Significant

Similar comparisons also apply for the case of durables, nondurables and services.

The performance of model improves a lot.

Empirical Findings— PCCAPM, CCAPM and FF Model

	constant	cg_{t+1}	pd_{t+1}	Rm-Rf	SMB	HML	R^2 (adj R^2)
Panel A: CCAPM and PCCAPM (Nondurables and Services)							
Annual	12.03	1.05					0.14
	(16.41)***	(1.91)*					(0.10)
-	14.59	0.50	0.51	**Positive**			0.71
Annual	(24.80)***	(1.50)	(6.53)***				(0.68)
Q4-Q4	-1.15	2.31					0.75
	(-0.73)	(8.25)***					(0.74)
	4.59	1.48	0.24				0.80
	(1.70)	(3.50)***	(2.49)**				(0.79)
Panel B: CCAPM and PCCAPM (Durables, Nondurables and Services)							
Annual	13.82	1.47					0.16
	(10.57)***	(2.07)**					(0.12)
-	15.49	0.75	0.51				0.71
Annual	(18.88)***	(1.70)	(6.54)***				(0.69)
Q4-Q4	1.52	3.56					0.77
	(1.27)	(8.69)***					(0.76)
	5.96	2.36	0.22				0.82
	(2.81)**	(3.84)***	(2.44)**				(0.80)
Panel C: Fama-French Model							
-	10.15			-4.81	3.92	8.80	0.79
	(2.76)**			(-1.20)	(2.51)**	(4.64)***	(0.76)

Consumption v.s. Population

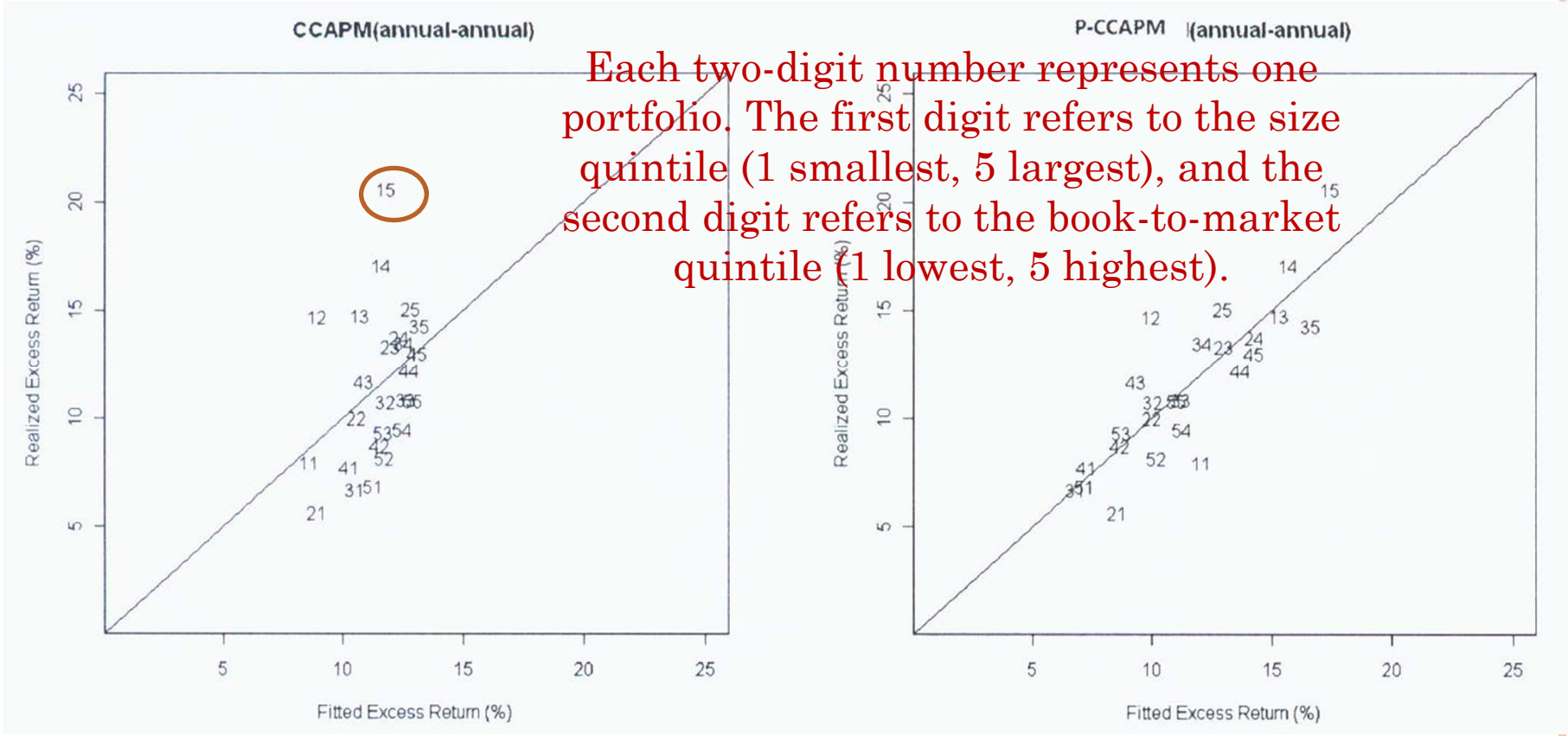
- Consumption risk

The market requires less expected excess returns on the firms that can be exposed to less consumption risk in the bad times when people cut down their consumption, i.e., the firms with lower consumption betas.

- Population risk

Similarly, the market is also willing to pay more to buy firms that provide better insurance against population risk, i.e., lower volatility with the population decline.

Empirical Findings— PCCAPM, CCAPM and FF Model



Each two-digit number represents one portfolio. The first digit refers to the size quintile (1 smallest, 5 largest), and the second digit refers to the book-to-market quintile (1 lowest, 5 highest).

The points in the PCCAPM are roughly distributed around the 45-degree line. The PCCAMP provides a better fit than CCAPM.

Empirical Findings— PCCAPM, CCAPM and FF Model

	constant	cg_{t+1}	pd_{t+1}	Rm-Rf	SMB	HML	R^2 (adj R^2)
Panel A: CCAPM and PCCAPM (Nondurables and Services)							
Annual	12.03 (16.41)***	1.05 (1.91)*					0.14 (0.10)
- Annual	14.59 (24.80)***	0.50 (1.50)	0.51 (6.53)***				0.71 (0.68)
Q4-Q4	-1.15 (-0.73)	2.31 (8.25)***					0.75 (0.74)
	4.59 (1.70)	1.48 (3.50)***	0.24 (2.49)**				0.80 (0.79)
Panel B: CCAPM and PCCAPM (Durables, Nondurables and Services)							
Annual	13.82 (10.57)***	1.47 (2.07)**					0.16 (0.12)
- Annual	15.49 (18.88)***	0.75 (1.70)	0.51 (6.54)***				0.71 (0.69)
Q4-Q4	1.52 (1.27)	3.56 (8.69)***					0.77 (0.76)
	5.96 (2.81)**	2.36 (3.84)***	0.22 (2.44)**				0.82 (0.80)
Panel C: Fama-French Model							
-	10.15 (2.76)**			-4.81 (-1.20)	3.92 (2.51)**	8.80 (4.64)***	0.79 (0.76)

The PCCAPM worse than FF.

The PCCAPM with Q4 effect better than FF.

Empirical Findings— PCCAPM, CCAPM and FF Model

	constant	cg_{t+1}	pd_{t+1}	Rm-Rf	SMB	HML	R^2 (adj R^2)
Panel A: CCAPM and PCCAPM (Nondurables and Services)							
Annual	12.03 (16.41)***	1.05 (1.91)*					0.14 (0.10)
- Annual	14.59 (24.80)***	0.50 (1.50)	0.51 (6.53)***				0.71 (0.68)
Q4-Q4	-1.15 (-0.73)	2.31 (8.25)***					0.75 (0.74)
	4.59 (1.70)	1.48 (3.50)***	0.24 (2.49)**				0.80 (0.79)
Panel B: CCAPM and PCCAPM (Durables, Nondurables and Services)							
Annual	13.82 (10.57)***	1.47 (2.07)**					0.16 (0.12)
- Annual	15.49 (18.88)***	0.75 (1.70)	0.51 (6.54)***				0.71 (0.69)
Q4-Q4	1.52 (1.27)	3.56 (8.69)***					0.77 (0.76)
	5.96 (2.81)**	2.36 (3.84)***	0.22 (2.44)**				0.82 (0.80)
Panel C: Fama-French Model							
-	10.15 (2.76)**			-4.81 (-1.20)	3.92 (2.51)**	8.80 (4.64)***	0.79 (0.76)

RRA

28

16

32

21

decrease

The lower risk price corresponds to a lower coefficient of relative risk aversion, and so the equity premium is less of a puzzle when including the population factor.

Empirical Findings— The Effect of Ultimate Risk

Panel A: Nondurables and Services

	CCAPM			PCCAPM			
s	constant	cg_{t+1+s}	R^2 (adj R^2)	constant	cg_{t+1+s}	pd_{t+1+s}	R^2 (adj R^2)
0	12.03 (16.41)***	1.05 (1.91)*	0.14 (0.10)	14.59 (24.80)***	0.50 (1.50)	0.51 (6.53)***	0.71 (0.68)
1	1.31 (1.04)	3.55 (8.52) ***	0.76 (0.75)	5.51 (2.19)**	2.42 (3.37)***	0.38 (1.89)*	0.79 (0.77)
2	6.94 (10.36)***	4.03 (8.07)***	0.74 (0.73)	10.00 (8.38)***	2.67 (4.22)***	0.66 (2.94)***	0.81 (0.80)
3	8.10 (14.00)***	4.44 (6.39)***	0.64 (0.62)	12.00 (8.84)***	2.62 (3.12)***	1.13 (3.08)***	0.75 (0.73)
4	10.19 (23.89)***	5.74 (6.74)***	0.66 (0.65)	12.46 (12.83)***	3.82 (3.56)***	1.16 (2.54)**	0.74 (0.72)

1. Similar results also apply for the case of durables, nondurables and services.
2. Even with Q4 and Ultimate risk effects together, we still yield significant coefficients of population factor.

Empirical Findings—The Robustness

Table 12
Other Portfolios

Panel A: Nondurables and Services

	CCAPM			PCCAPM			
	Constant	cg_{t+1}	R^2 (adj R^2)	Constant	cg_{t+1}	pd_{t+1}	R^2 (adj R^2)
18 Size Portfolios	-2.51	2.49	0.81	10.69	0.66	0.48	0.96
	(-1.57)	(8.18)***	(0.79)	(5.80)***	(2.43)**	(7.80)***	(0.96)
18 B/M Portfolios	-3.39	2.99	0.96	7.33	1.27	0.36	0.99
	(-4.01)***	(20.01)***	(0.96)	(3.26)***	(3.50)***	(4.91)***	(0.98)
19 E/P Portfolios	-4.90	-2.62	0.30	-10.10	-4.00	0.53	0.36
	(-0.73)	(-2.71)**	(0.26)	(-1.26)	(-2.61)**	(1.16)	(0.27)
19 CE/P Portfolios	4.54	-1.29	0.20	-18.89	-5.84	1.01	0.50
	(1.01)	(-2.04)*	(0.15)	(-2.28)**	(-3.80)***	(3.14)***	(0.44)
17 Industry Portfolios	14.70	-0.50	0.24	14.03	-0.48	-0.14	0.30
	(11.39)***	(-2.19)**	(0.19)	(9.88)***	(-2.11)*	(-1.10)	(0.20)

Conclusion

- Population risk is an important factor based on the improved performance of the model, e.g., the R2 increase from .14 to .71 when adding the population factor to the CCAPM, and the significant coefficient.
- The market treats population change as a risk when the population declines.

Conclusion

- The price of consumption risk is decreased by the introduction of population risk. Our finding can at least partially mitigate the so-called "equity premium puzzle."

Thank you for your attention!!