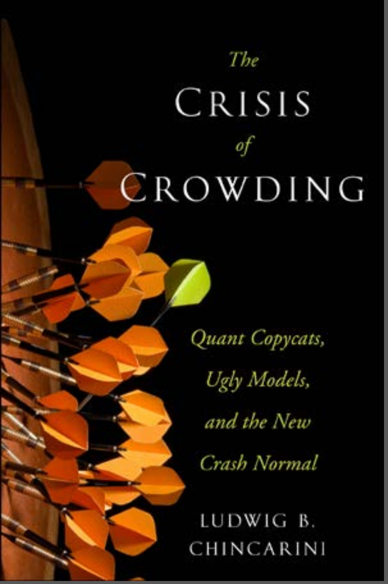

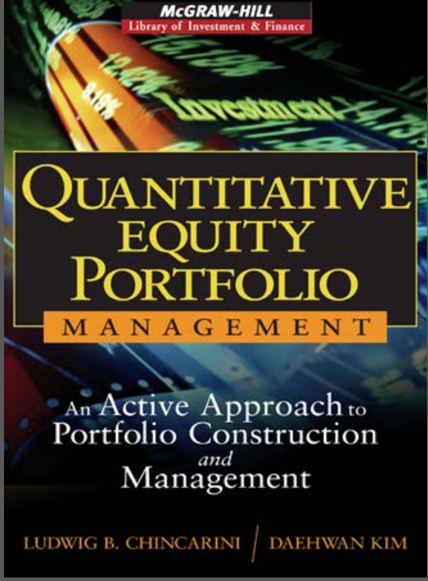

The Life Cycle of Beta

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- Thank you for coming. Thanks Janusz Brzeszczynski for chairing and organizing this session and for discussing the paper.

Structure of Presentation

- Summary of Research
- Motivation
- Techniques to Measure Beta over Age
- Disentangling the Effects
- Conclusion & Discussion

I. Summary

- We find the beta of a company changes over the life-cycle of company (i.e. as the company ages) and this could be due to several reasons including an increase in information about a company.

- Accounting for the age of a company may be important when using beta as a measure of a company's risk in the future.

II. A Brief History of Beta

- After the CAPM was invented in 1964, there have been numerous tests of whether beta is useful at explaining asset returns (in particular stock returns).
- Stylized Facts:
  1. Measured beta regresses towards 1 in future periods.
  2. Large portfolios have more stable betas than small portfolios.
  3. Beta can't explain the excess returns of small-cap and value stocks
  4. Empirical SML is flatter than theory predicts (Black et al)

II. A Brief History of Beta

Why might beta be mis-measured?

- Companies are dynamically changing and risk-premia change (Keim and Stambaugh(1986), Breen, Glosten, and Jagannathan (1989), Fama and French (1989), Chen (1991), Ferson and Harvey (1991), Jagannathan and Wang (1996).
- New companies might have low information and hence large estimation risk of beta (Clark and Thompson (1991)).
- Divergence of stock opinion by analysts leads to abnormal returns – could be a proxy for uncertainty (Anderson et al (2005), Diether et al. (2002), Doukas et al. (2006), Qu et al. (2003)).

III. Estimated Beta

- Measured beta will be biased when there is a time-varying component related to specific information on a stock.

$$\hat{\beta}_i = \beta_i + \frac{\widehat{\text{Cov}}(r_{m,t}, \gamma_i z_{i,t} r_{m,t} + \epsilon_t)}{\widehat{\text{Var}}(r_{m,t})} = \beta_i + \gamma_i \frac{\widehat{\text{Cov}}(r_{m,t}, z_{i,t} r_{m,t})}{\widehat{\text{Var}}(r_{m,t})} + \frac{\widehat{\text{Cov}}(r_{m,t}, \epsilon_t)}{\widehat{\text{Var}}(r_{m,t})} \to \beta_i + \gamma_i \frac{\widehat{\text{Cov}}(r_{m,t}, z_{i,t} r_{m,t})}{\widehat{\text{Var}}(r_{m,t})} \quad (3)$$

where

$$\text{Cov}(r_{m,t}, z_{i,t} r_{m,t}) = \text{Cov}(r_{m,t}^2, z_{i,t}) - E[r_m]\text{Cov}(r_{m,t}, z_{i,t}).$$

We believe that z could change over the life of a company. If z represented the uncertainty with a company's business, might naturally decline with age because new companies might be involved in new productive activities that are better understood with time.

III. Estimated Beta

- Even if this is true, one might argue that one can diversify away this uncertainty in portfolios of stocks.

- There is actually disagreement on whether this is possible or not.

- Information/Uncertainty diversifiable: Banz (1981), Reinganum and Smith (1983), Easley and O'Hara (2004)

- Not Diversifiable: Handa and Linn (1993), Lambert et al. (2007), Barry and Brown (1985)

IV. Contribution of Our Research

- Age matters in computing beta of a company.
- We show that the decline in beta is not limited to the first year after IPO. Thus, extend the work of Clarkson and Thompson (1990)
- We explain the decline in beta and attempt to understand the drivers of it.

V. The Life Cycle of Beta

- Our conjecture is that the age of a company matters for estimating beta.

Why?

1. Less uncertainty about the company – more information.
2. Company's fundamentals could change in a systemic way as they age.

Implications:

1. Firms measuring cost of capital using beta should adjust for age.
2. Performance of IPOs should be adjusted for age.

VI. Data

1. CRSP Data – obtain US traded total stock returns.
2. IBES Data – obtain number of analysts following a stock, consensus earnings and realized earnings for each stock.
3. Compustat – obtain fundamental stock data (e.g. size, price-to-book, and leverage)

Time Period: We study companies from July 1963 to June 2012.

VI. Data: Summary Statistics

Table 3: Summary Statstics

variables	no obs	mean	std	min	median	max
beta	140618	1.40	1.67	-35.26	1.28	43.14
s.e. beta	140618	1.34	0.94	0.04	1.11	25.63
illiquidity	126442	4.99	26.49	0.00	0.35	4545.56
size	140618	11.18	1.89	5.12	11.02	19.95
b2m	123669	0.82	1.29	0.00	0.58	208.36
leverage	123276	4.06	255.69	0.99	1.84	87702.50
earnings yield	131706	-0.02	0.77	-113.68	0.04	48.50
num of analysts	65459	3.66	4.38	0.00	2.08	39.33
dispersion	49544			0.00	0.07	
dispersion (rel to price)	49552	17.03	1706.65	0.00	0.00	343781.09
public info	13057	0.01	0.02	0.00	0.00	0.70
private info	13057	0.01	0.04	0.00	0.00	1.74

VII. Methodology: The Basics

- To measure the “age” of a company, we consider its birth year as the year it enters the CRSP database.
- We study all stocks from 1964 to 2011.
- We group stocks into age cohorts. Thus, a stock that entered CRSP between July 1, 1970 and June 30, 1971 is part of the 1970 cohort.
- We create 23 age-cohort portfolios (Age 0 to Age 22) in any given year. We then compute the subsequent 1-year return for each cohort using equal-weighted as well as market-cap weighted portfolios.

VII. Methodology: The Basics

Table 1: Age Distribution of Companies I

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11
1964	51	739	44	42	43	25	24	27	16	17	6	20
1965	52	118	710	43	41	43	26	24	24	16	16	6
1966	58	108	111	680	41	39	39	25	24	23	16	15
1967	53	98	103	104	639	38	37	38	24	23	22	14
1968	74	105	93	94	94	593	37	34	34	23	23	21
1969	71	139	100	86	92	89	558	36	32	31	23	23

Table 2: Age Distribution of Companies II

Year	Age 12	13	14	15	16	17	18	19	20	21	22
1964	13	26	19	16	28	38	35	24	18	1	9
1965	19	13	26	20	16	28	37	34	25	17	1
1966	6	19	13	26	20	16	27	37	33	22	17
1967	15	6	18	11	24	19	15	27	36	33	22
1968	14	13	6	16	11	24	18	14	22	33	30
1969	19	13	13	6	16	10	24	18	13	21	31

VIII.Methodology: Computing Beta

- For each company in each age-cohort, we compute the beta of each individual company with the following regression (Dimson approach):

$$r_t = \alpha + \beta_1(\tilde{r}_{M,t}) + \beta_2(\tilde{r}_{M,t-1}) + \beta_3(\tilde{r}_{M,t-2} + \tilde{r}_{M,t-3} + \tilde{r}_{M,t-4})/3 + \varepsilon_t$$

where r-tilde is the weekly return of the stock minus the weekly risk-free rate and r(m)-tilde is the weekly CRSP market return minus the risk-free rate. The returns are computed weekly from July 1 of year t-1 to June 30 of year t. Out beta is beta1+beta2+beta3.

- The age-cohort portfolio beta is the equal-weighted or market-cap weighted average of all stocks in the portfolio as of July 1 depending on what type of portfolio we are using.

VIII.Methodology: Others

- We then construct various measures to study the relationship between age and beta.
- These will be described along with our results.

IX. Results: Beta Declines with Age

- We run several types of regressions to analyze the relationship between age and beta using the following formula:

$$\beta_{t,a} = \gamma_0 + \gamma_1 a_t + \epsilon_{t,a}$$

- Gamma(1) represents the relationship between the age of a portfolio of companies and it's average beta.
- We estimate this relationship in three ways:

  1. Pooled. All of the year returns for all age portfolios for the entire period are used to estimate the regression. [No time - time taken care of in FM.]
  2. Fama-MacBeth. Each year the cross-sectional regression is run, parameters estimated, and then the average of parameters averaged over all years.
  3. Between Estimator. Average data across years, then run cross-sectional regression.

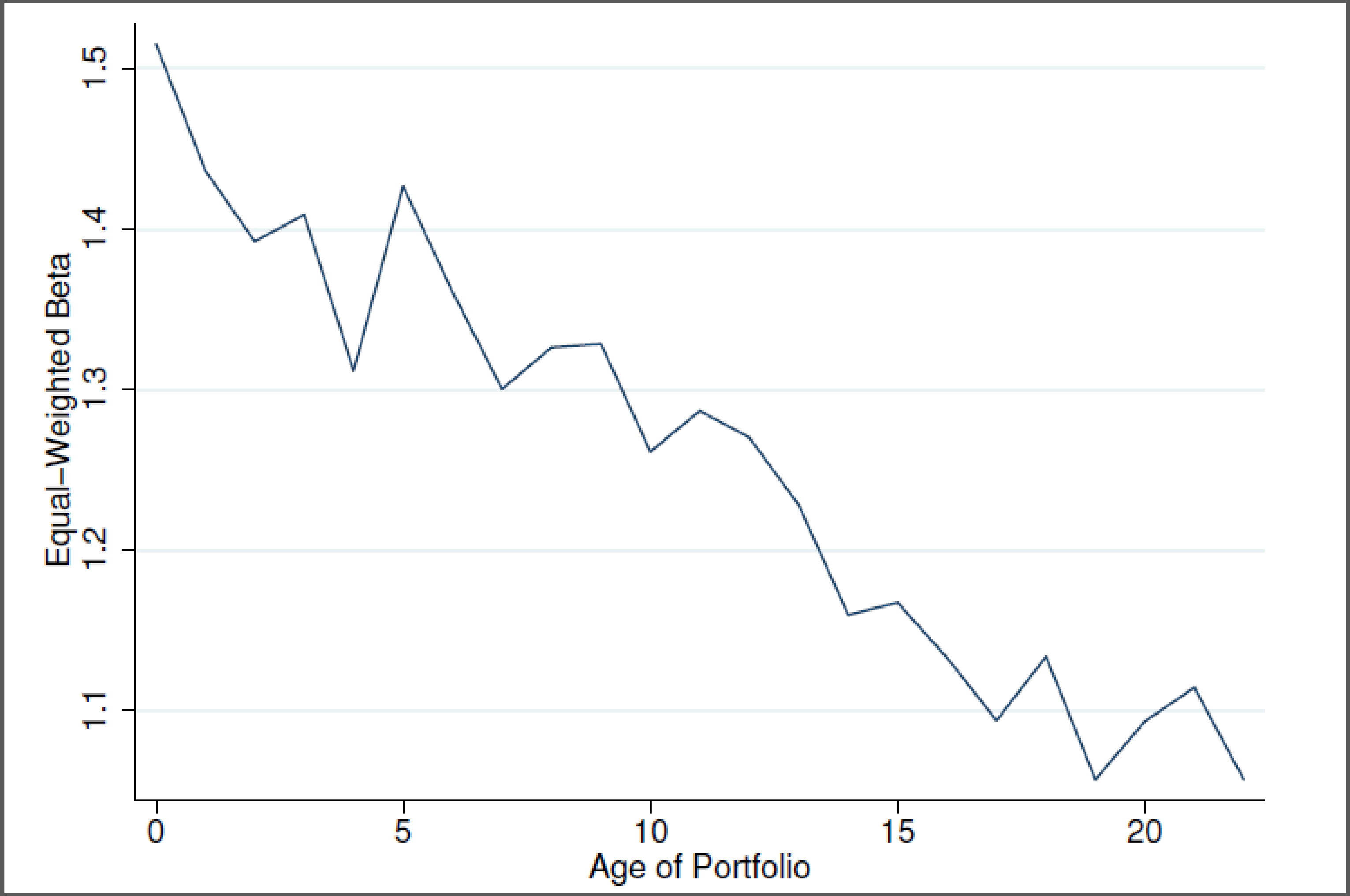
VI. Results: Beta Declines with Age

- In all estimations, average beta declines with age.
- Point estimate about -0.019. Thus, every 10 years of life, beta declines by 0.20 points. For a company with beta = 1.40 initially, this amounts to a 14% decline.

Table 4: Regressions of Beta and Age

Dependent Variable: $\beta_{t,a}$	Pooled	Fama-MacBeth	Between
$\hat{\gamma}_1$	-0.0192	-0.0192	-0.0192
	(-11.74)	(-6.75)	(-16.87)
$\hat{\gamma}_0$	1.47	1.47	1.47
	(69.97)	(27.68)	(100.48)

VI. Results: Beta Declines with Age



VI. Results: Info. Grows with Age

- Why might beta decline over age?
- One idea is that information about a company increases and uncertainty declines.
- Two measures of uncertainty:
  1. The standard error of beta estimates.
  2. Cross-sectional variation in beta amongst stocks.
- Three measures of amount of information.
  1. Number of analysts following a stock.
  2. Dispersion of analyst forecast of earnings [stdev(e)/abs(mean(e))]
  3. Dispersion of analyst forecast of earnings [stdev(e)/mean(price))]

VI. Results: Info. Grows with Age

- We run several types of regressions to analyze the relationship between age and information/uncertainty using the following formula:

$$X_{t,a} = \eta_0 + \eta_1 a_t + \epsilon_{t,a}$$

- X(t,a) represents one of the information/uncertainty variables for each age portfolio and a(t) represents the age of the corresponding portfolio.

- We estimate this relationship using pooled, Fama-MacBeth, and Between Estimator regressions, however we only show the results for pooled (the others are the same qualitatively).

VI. Results: Info. Grows with Age

Table 2: Regressions of Proxies of Information and Uncertainty on Age

	Uncertainty Measures		Information Measures		
	Std. Error Beta	Variance in Beta	Analysts	Dispersion 1	Dispersion 2
$\hat{\eta}_1$	-0.0221	-0.0268	0.2284	-0.0086	-0.0002
	(-14.88)	(-10.51)	(-9.27)	(-5.46)	(-4.20)
$\hat{\eta}_0$	1.09	1.63	7.74	0.28	0.01
	(56.98)	(49.77)	(24.41)	(13.63)	(18.59)

VI. Results: Proxies and Beta

- Regressions of proxies on beta show a significant relationship.

Table 3: Regressions of Proxies of Information and Uncertainty on Beta

	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$
Analysts	-0.0034				
	(-.9303)				
Dispersion 1		0.1340			
		(2.3064)			
Dispersion 2			0.6294		
			(.2592)		
Std. Error Beta				0.1828	
				(5.4109)	
Variance in Beta					0.0877
					(4.3112)
Intercept	1.2851	1.2257	1.2456	1.1055	1.1428
	(31.39)	(62.88)	(51.15)	(35.93)	(38.74)
$\bar{R}^2$	0.0012	0.0077	0.0001	0.0259	0.0166

VI. Results: Proxies and Beta

- Higher uncertainty is associated with higher betas for the group.

- Higher information is associated with lower betas for group (e.g. higher dispersion → less information → higher beta)

VI. Results: Fundamentals and Beta

- It could be that the fundamentals of a company are changing over time that are directly affecting the beta estimates (Beaver et al. (1970) and Shapovalova and Subbotin (2009))

- Thus, we examine the relationship between some basic fundamentals and beta.

VI. Results: Fundamentals and Beta

- Size of a company increases with age.
- BM of a company increases with age.
- Leverage decreases with age.

Table 7: Regressions of Fundamentals on Age

	Size	BM	Leverage
a_t	0.0636	0.0027	-0.0196
	(16.5856)	(2.5136)	(-2.0882)
Intercept	10.8162	0.5223	2.7922
	(219.4302)	(38.0678)	(23.1858)
$\bar{R}^2$	0.1998	0.0057	0.0039

VI. Results: Fundamentals and Beta

- Only size explains declining beta, leverage and BM do not.

Table 6: Regressions of Fundamentals on Beta

	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$
Size	-0.0535		
	(-4.4459)		
BM		-0.0379	
		(-.7797)	
Leverage			0.0033
			(.6013)
Intercept	1.8714	1.2759	1.2463
	(13.4517)	(43.7159)	(68.0080)
$\bar{R}^2$	0.0176	0.0006	0.0003

VI. Results: Untangling

- Size explains declining beta, but so do uncertainty and information. Can we untangle the web?

Table 7: Regressions of Information, Uncertainty and Size on Beta

	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$
Analysts	-0.0007				
	(-.1680)				
Dispersion 1		0.1270			
		(2.1761)			
Dispersion 2			-0.9965		
			(-.3733)		
Std. Error Beta				0.1658	
				(4.8788)	
Variance in Beta					0.0923
					(4.5675)
Size	-0.0297	-0.0274	-0.0361	-0.0466	-0.0595
	(-1.1072)	(-1.2205)	(-1.4614)	(-3.4126)	(-4.3961)
Intercept	1.6384	1.5779	1.7191	1.6582	1.8246
	(5.0934)	(5.4562)	(5.2904)	(10.0609)	(11.5597)
$\bar{R}^2$	0.0031	0.0099	0.0032	0.0362	0.0336

VI. Results: Untangling

- When Size and Information are considered, size effect disappears.

- When Size and Uncertainty considered, size still relevant.

- **Question**: How does age play into all of this?

VI. Results: Untangling

- With age, size importance diminishes and has wrong sign.
- Uncertainty also disappears
- Age remains important.

Table 8: Regressions of Information, Uncertainty, Size, and Age on Beta

	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$	$\beta_{t,a}$
Analysts	0.0016				
	(.3900)				
Dispersion 1		0.0535			
		(.9313)			
Dispersion 2			0.0533		
			(.0207)		
Std. Error Beta				0.0397	
				(1.1316)	
Variance in Beta					0.0269
					(1.3131)
Size	0.0508	0.0559	0.0562	0.0071	0.0039
	(1.8046)	(2.2559)	(2.0844)	(.5004)	(.2671)
a_t	-0.0199	-0.0194	-0.0199	-0.0199	-0.0199
	(-7.2655)	(-6.9658)	(-7.2460)	(-9.7339)	(-9.9178)
Intercept	0.8034	0.7390	0.7497	1.3619	1.3972
	(2.4294)	(2.4276)	(2.2005)	(8.4534)	(8.8828)
$\bar{R}^2$	0.0750	0.0760	0.0748	0.1128	0.1132

VI. Results: Untangling

- When explaining the declining beta of companies, the order of importance is 1. Age 2. Size 3. Information.

- Maybe age and size proxy for information?

VII. Robustness

1. Does it matter whether we run difference regressions? No.
2. Does it matter whether we include an illiquidity measure? No.
3. Does it matter what type of information it is (public vs private)? No.
4. The measurement of beta changes as leverage changes, does unlevered beta depend on age too? No.

VIII. Conclusion / Discussion

1. Age matters for beta. There is a lifecycle of beta.

2. We plan to do out-of-sample hedging performance on age adjusted beta.

3. We also plan to do CAPM testing with age-adjusted beta.

Thank you

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