



# 15.482 Healthcare Finance

## Spring 2017

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Unit 9, Part 1: Risk and Return in the  
Biopharma Industry

# Unit Outline

- Risk and Return in the Biopharma Industries, 1930-2015
- Estimating Clinical Success Rates
- Predicting Phase Transitions and Approvals
- Patient-Centered Clinical Trials

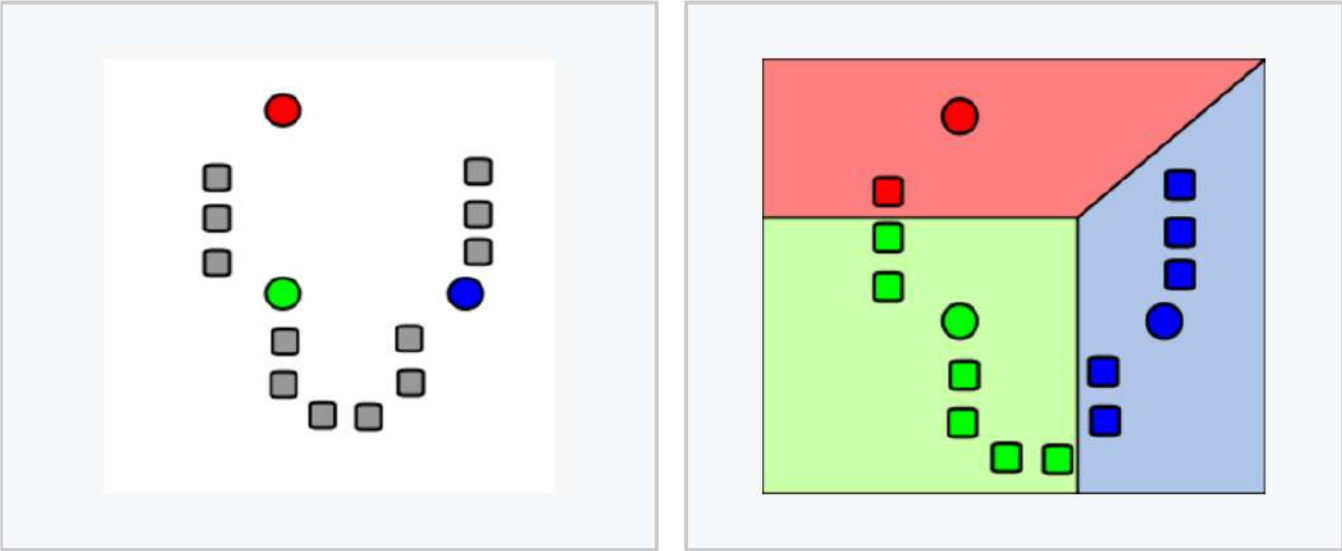
# **Financial Risk and Return in the Biotech and Pharmaceutical Industries from 1930 to 2015**

Richard T. Thakor, Nicholas Anaya, Yuwei Zhang,  
Christian Vilanilam, and Andrew W. Lo (2017)

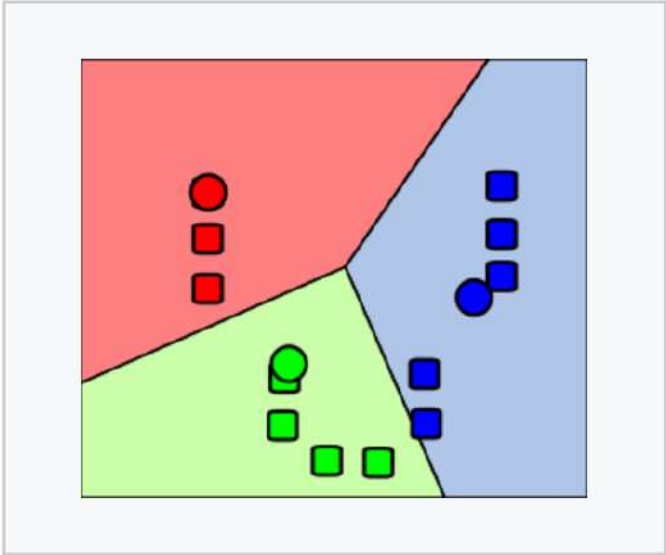
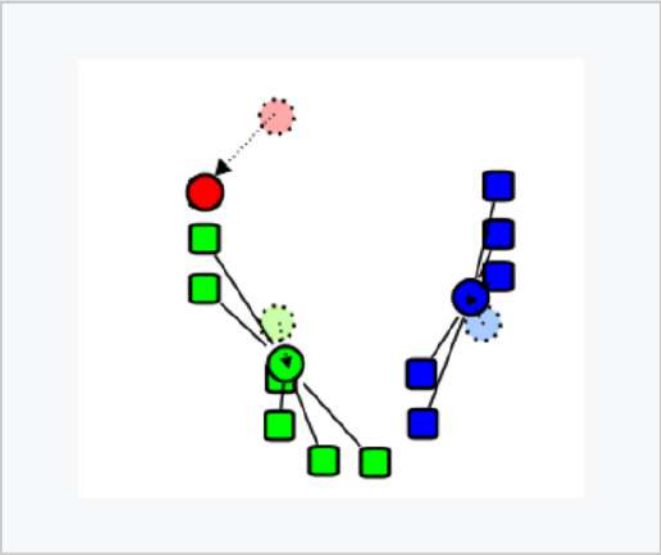
# Stock Market Data on All Biopharma Firms

- January 1930 to December 2015
- All publicly traded biotech and pharma companies (current and defunct): 965 firms after filtering
- Classification into industry using NAICS or GICS
- Neither is perfect; both rarely change over time
- We propose more refined classification: pharma, specialty pharma, early biotech, late biotech, other

# k-Means Classification



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1. Number of Employees
2. Intangible Assets
3. Revenues
4. Research and Development Expenses
5. Stock Returns
6. Standard deviation of returns
7. Value of Total Assets
8. Cash Holdings
9. Amount of Debt
10. Amount of Dividends Paid
11. Earnings Before Interest and Taxes (EBIT)
12. Property, Plant, and Equipment (PPE)
13. Sales
14. Months since Initial Public Offering (IPO)
15. Number of Products in Pipeline
16. Number of Products on Market
17. Number of Patents
18. Whether Company has Marketing Expenses
19. Whether Company has FDA Approvals
20. Whether Company has Manufacturing
21. Type of Product (Drug, Device, Diagnostic, Other)

# k-Means Classification

- Seed companies for Pharma:
  - Johnson & Johnson, Pfizer Inc., Genentech Inc., Merck and Co., Pfizer Inc., Amgen Inc., and Wyeth.
- Seed companies for Specialty Pharma:
  - Forest Laboratories, Valeant Pharmaceuticals, Gilead Sciences Inc., Jazz Pharmaceuticals PLC, Pacira Pharmaceuticals Inc., Salix Pharmaceuticals LTD, and Shire PLC



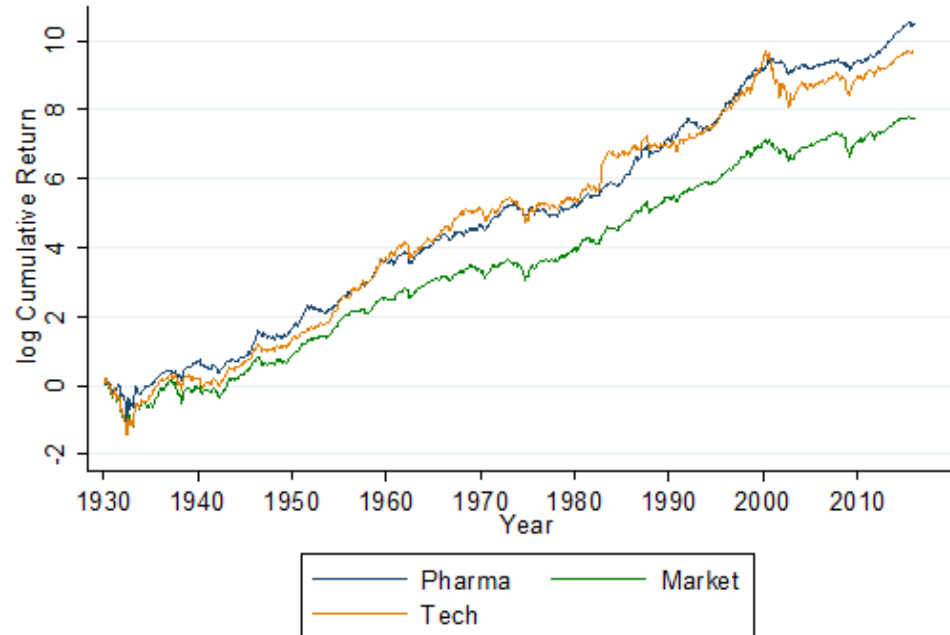
# **k-Means Classification**

- Seed companies for Early Biotech:
  - Accentia Biopharmaceuticals, Conatus Pharmaceuticals Inc., Diacrin Inc., Kindred Biosciences Inc., Opexa Therapeutics Inc., Sarepta Therapeutics Inc., Sophiris Bio Inc., and Sorrento Therapeutics Inc.
- Seed companies for Late Biotech:
  - Cor Therapeutics Inc., Dendreon Corp., Discovery Laboratories Inc., and Human Genome Sciences Inc.

# ***k*-Means Classification**

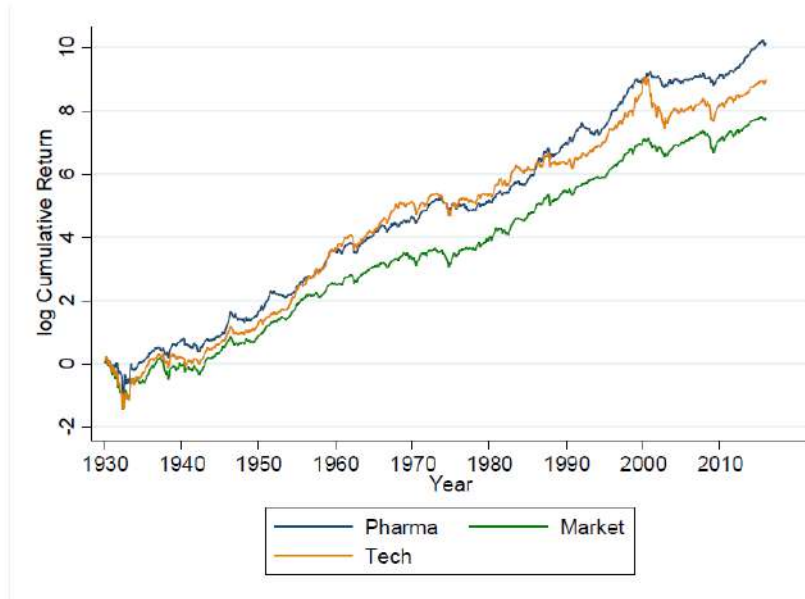
- Other:
  - Diagnostics-related companies (e.g., imaging), diagnostics toolkits, assays, etc., devices companies that do a significant portion of business in laboratory equipment design, medical instruments, and manufacturing

# Cumulative Returns of Biopharma

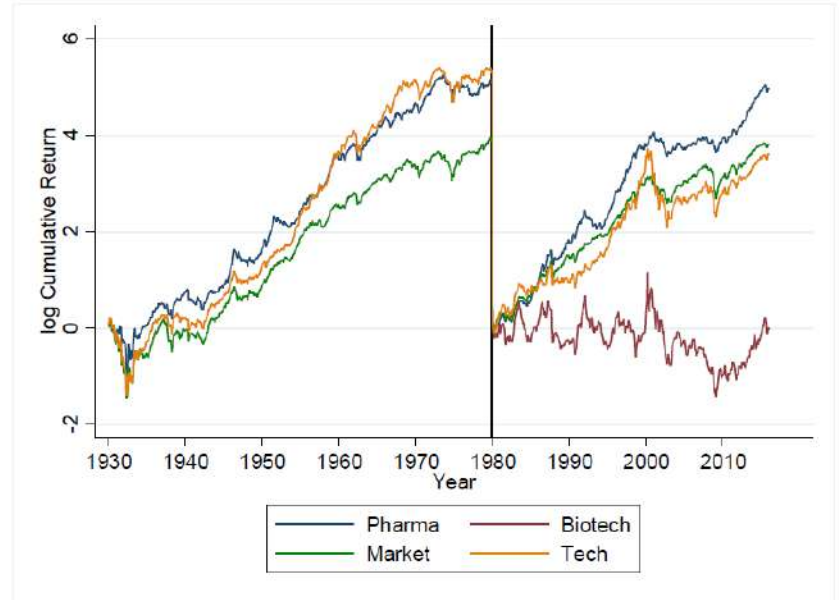


# Cumulative Returns of Biopharma

Panel A: Continuous Sample from 1930-2015, excluding Biotech



Panel B: Sample from 1930-1980 and 1980-2015, including Biotech

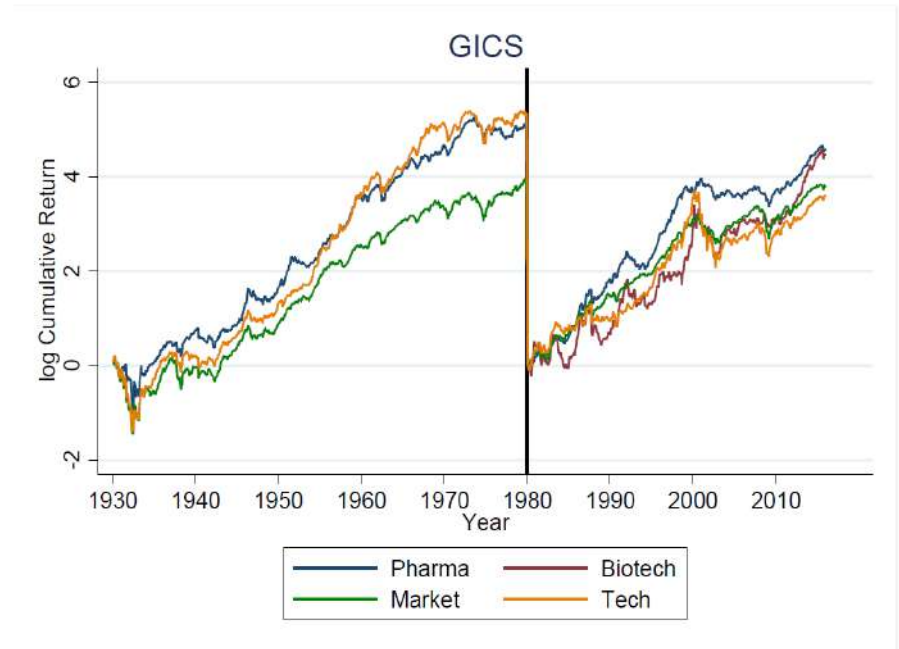
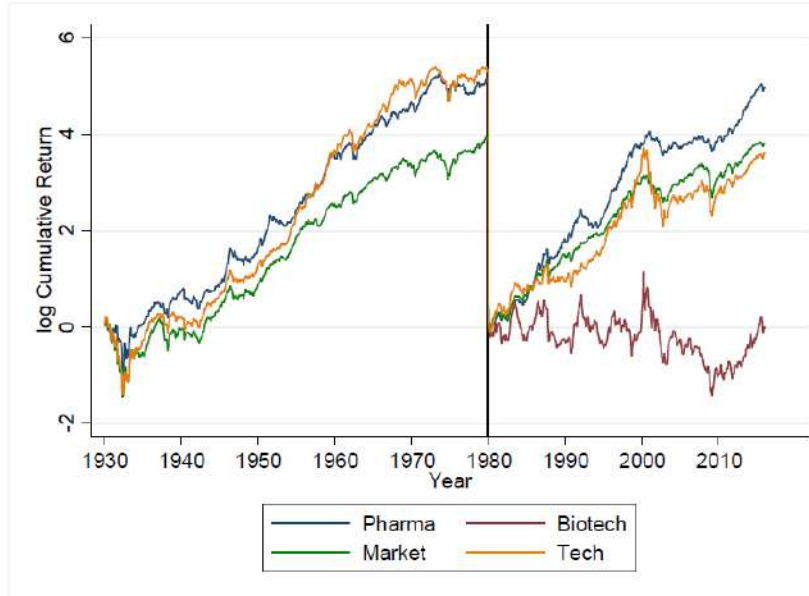


# Cumulative Returns of Biopharma

- Results depend on how these 11 companies are classified:
  - Amgen, Gilead, Robins (A.H.), Searle (G.D.), Sepracor, Dura, PDL, Taro, Valeant, Syntex, and Mylan

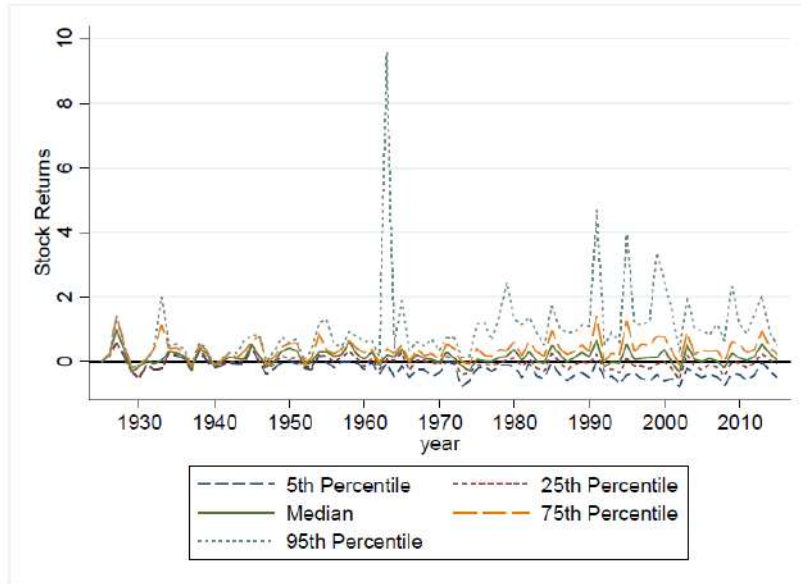
# Cumulative Returns of Biopharma

Panel B: Sample from 1930-1980 and 1980-2015, including Biotech

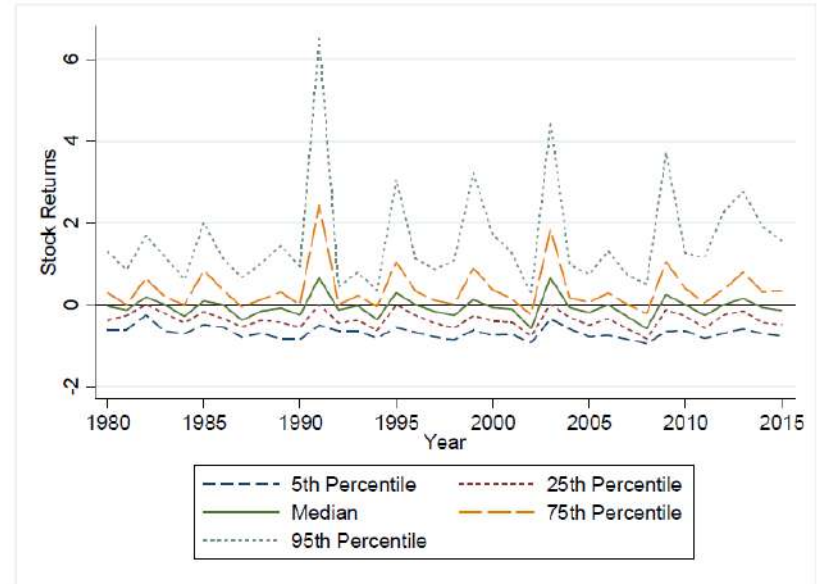


# Annual Returns of Biopharma

Panel A: Pharma Annual Returns

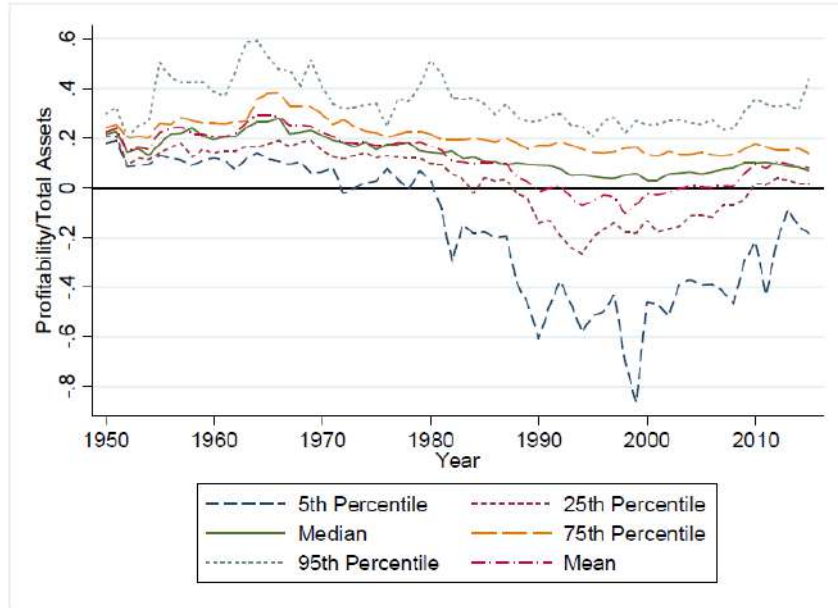


Panel B: Biotech Annual Returns

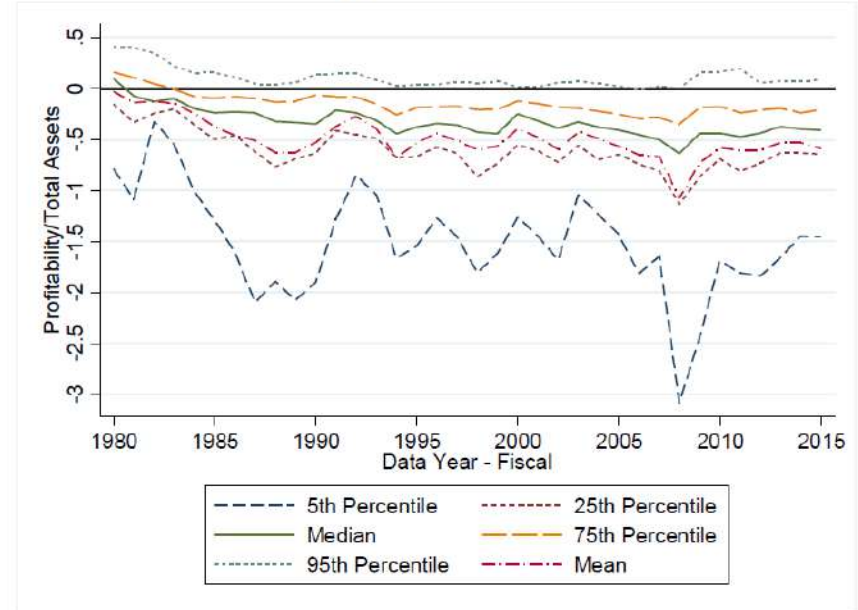


# Profitability

Panel A: Pharma Profitability

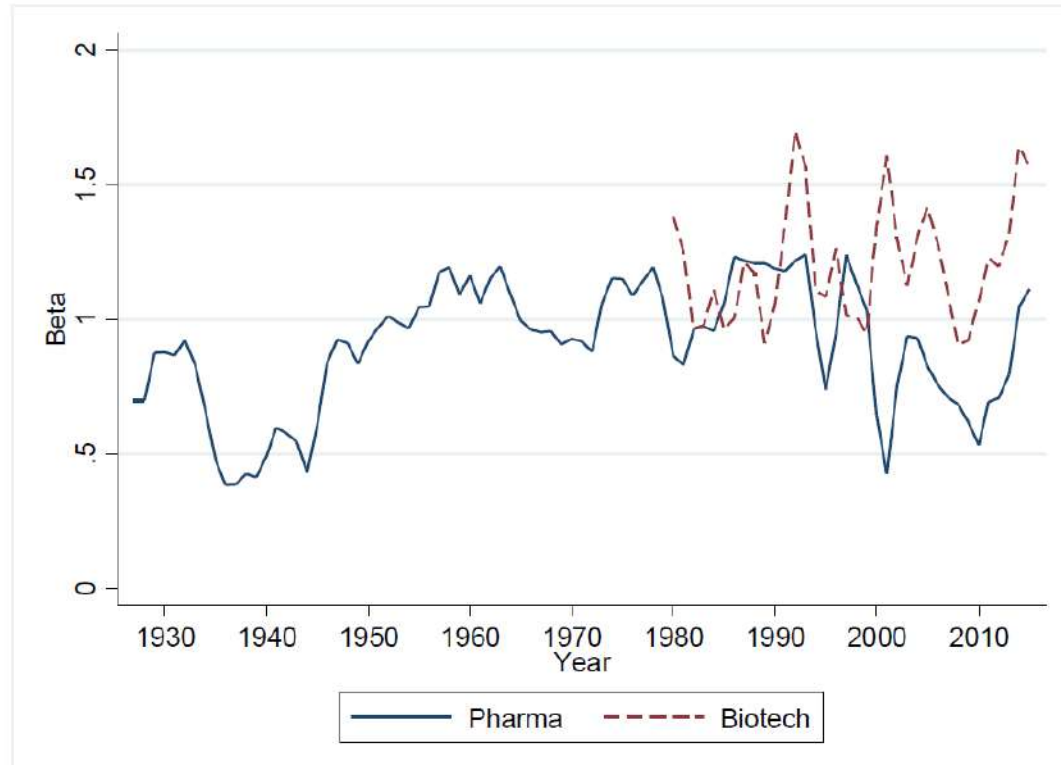


Panel B: Biotech Profitability

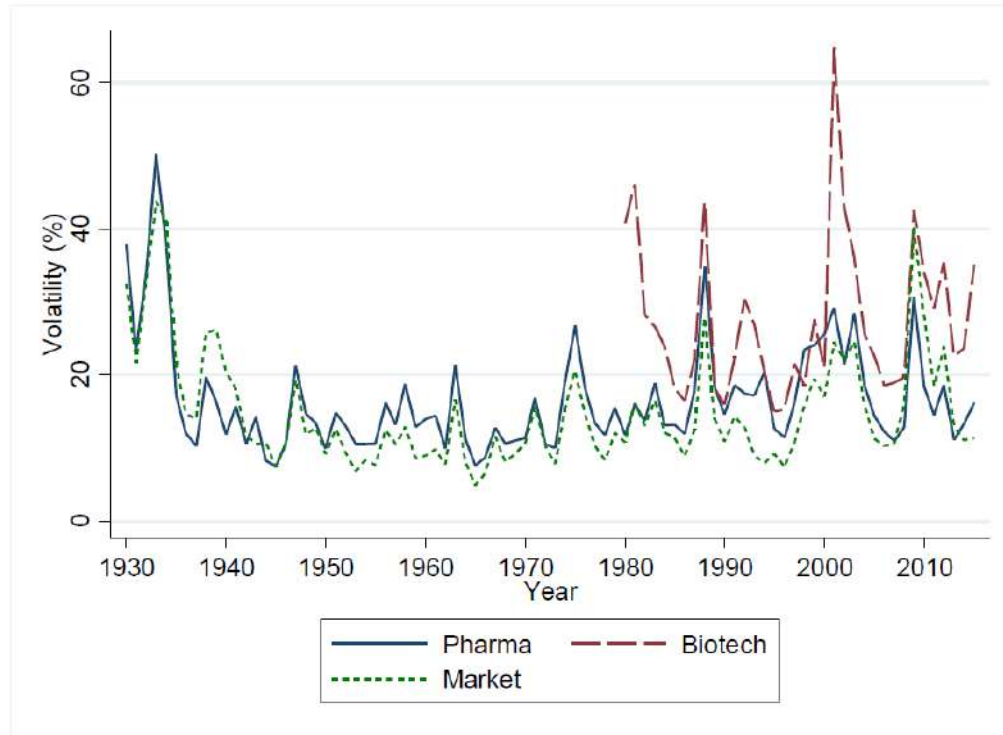




# CAPM Betas

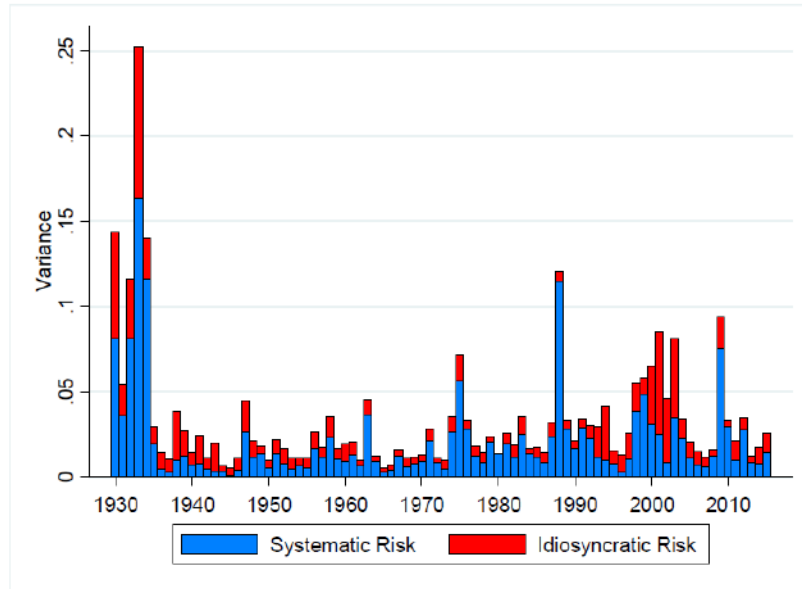


# Biopharma Volatility

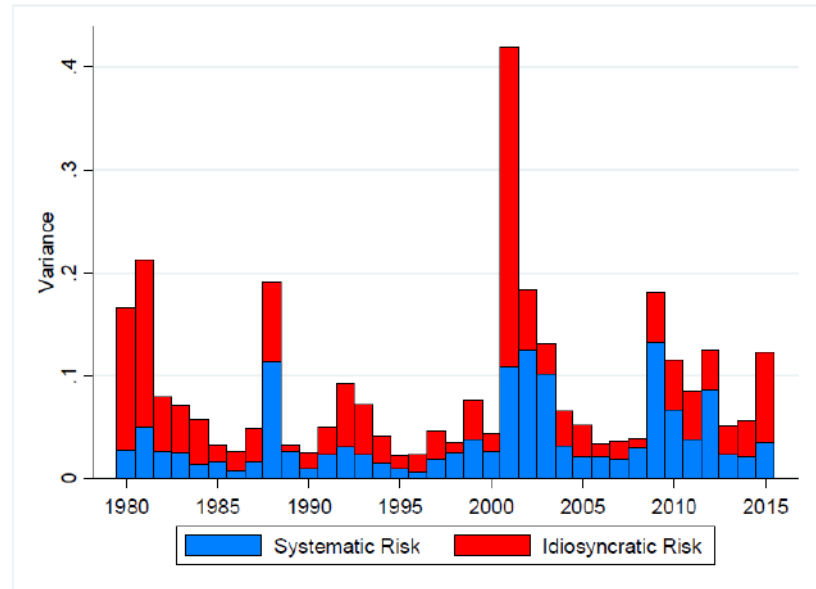


# Biopharma Variance Decomposition

Panel A: Pharma Variance Decomposition



Panel B: Biotech Variance Decomposition



# Biopharma Performance

Time Period	Annualized Mean Returns				Annualized Volatilities				Sharpe Ratios			
	Market	Tech	Pharma	Biotech	Market	Tech	Pharma	Biotech	Market	Tech	Pharma	Biotech
1930-1934	-10%	-5%	2%	-	0.33	0.37	0.34	-	-0.05	0.06	0.23	-
1935-1939	10%	11%	15%	-	0.21	0.18	0.14	-	0.51	0.56	0.86	-
1940-1944	9%	9%	2%	-	0.12	0.11	0.12	-	0.58	0.61	0.17	-
1945-1949	11%	14%	17%	-	0.13	0.14	0.15	-	0.71	0.84	0.88	-
1950-1954	22%	23%	17%	-	0.09	0.11	0.12	-	1.70	1.44	0.89	-
1955-1959	15%	30%	26%	-	0.11	0.15	0.15	-	1.10	1.53	1.43	-
1960-1964	10%	10%	11%	-	0.10	0.17	0.14	-	0.61	0.43	0.52	-
1965-1969	6%	23%	12%	-	0.09	0.16	0.11	-	0.18	1.03	0.53	-
1970-1974	-4%	-9%	4%	-	0.15	0.22	0.18	-	-0.48	-0.66	0.03	-
1975-1979	18%	14%	6%	-	0.11	0.16	0.14	-	0.73	0.45	0.04	-
1980-1984	14%	16%	13%	-6%	0.14	0.20	0.15	0.30	0.26	0.33	0.17	-0.28
1985-1989	18%	4%	28%	1%	0.16	0.21	0.21	0.26	0.69	0.00	1.01	-0.03
1990-1994	9%	15%	10%	-4%	0.11	0.18	0.17	0.24	0.36	0.62	0.34	-0.06
1995-1999	27%	46%	34%	16%	0.15	0.26	0.21	0.21	1.39	1.40	1.48	0.48
2000-2004	-1%	-16%	0%	-10%	0.20	0.40	0.23	0.41	-0.15	-0.31	-0.08	0.04
2005-2009	2%	3%	4%	-14%	0.24	0.25	0.18	0.28	0.02	0.11	0.12	-0.46
2010-2015	11%	13%	19%	17%	0.16	0.18	0.16	0.31	0.87	0.82	1.44	0.68
1980-2015	11%	10%	15%	0%	0.17	0.25	0.19	0.29	0.47	0.35	0.66	0.06
1930-1979	8%	11%	11%	-	0.17	0.19	0.17	-	0.36	0.48	0.47	-
1930-2015	9%	11%	13%	-	0.17	0.22	0.18	-	0.40	0.42	0.53	-

# Biopharma Performance

Time Period	Pharma	Biotech	Tech
1930-1934	0.104		0.067
1935-1939	0.091 *		0.032
1940-1944	-0.023		0.028
1945-1949	0.069 *		0.043
1950-1954	-0.034		0.046
1955-1959	0.086 **		0.134 ***
1960-1964	0.013		-0.017
1965-1969	0.060 *		0.158 ***
1970-1974	0.105 ***		-0.020
1975-1979	-0.109 ***		-0.045
1980-1984	-0.004	-0.153	0.013
1985-1989	0.065 *	-0.144 **	-0.134 ***
1990-1994	0.013	-0.101	0.055
1995-1999	0.052	-0.068	0.074
2000-2004	0.015	-0.021	-0.081
2005-2009	0.017	-0.139 **	0.017
2010-2015	0.091 **	0.046	0.008
1980-2015	0.051 **	-0.084 **	-0.010
1930-1979	0.039 **		0.036 **
1930-2015	0.044 ***		0.018