Quantifying the Impact of Impact Investing

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1 Overview

2 Characterizing Excess Returns

3 Impact Portfolio Construction

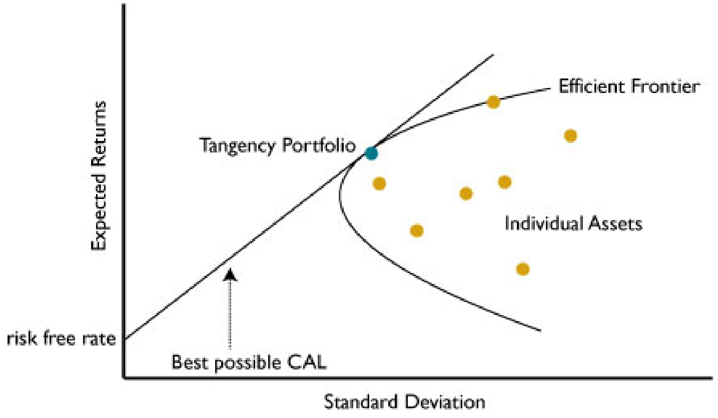
4 Empirical Applications

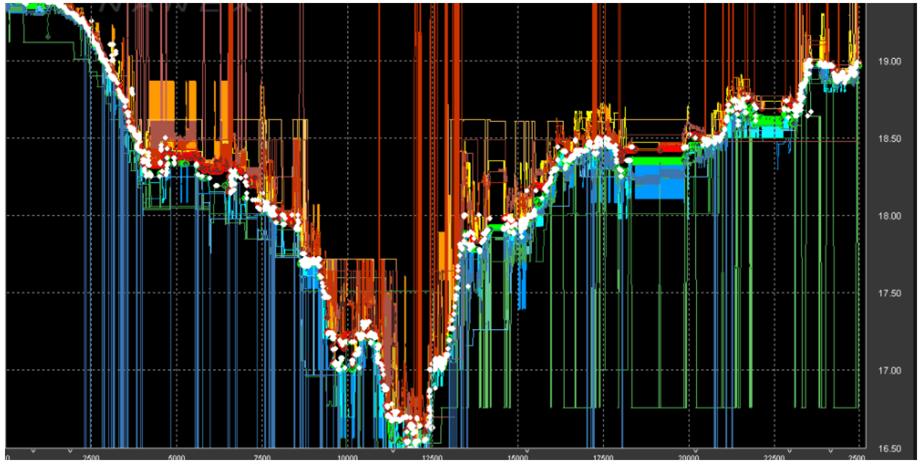
Paper is available on SSRN: abstract_id=3944367

The Evolving Investment Landscape

- ❑ From Warrant Buffet to Jim Simons
  - Modern Portfolio Theory (Markowitz)
  - Alpha Beta and Factor Models (Sharpe, Fama)
  - Derivatives (Black-Scholes-Merton)
  - Automation (Quant trading, HFT)

- ❑ All of them focus on the **Monetary Outcome** of an investment





What Is Impact Investing?

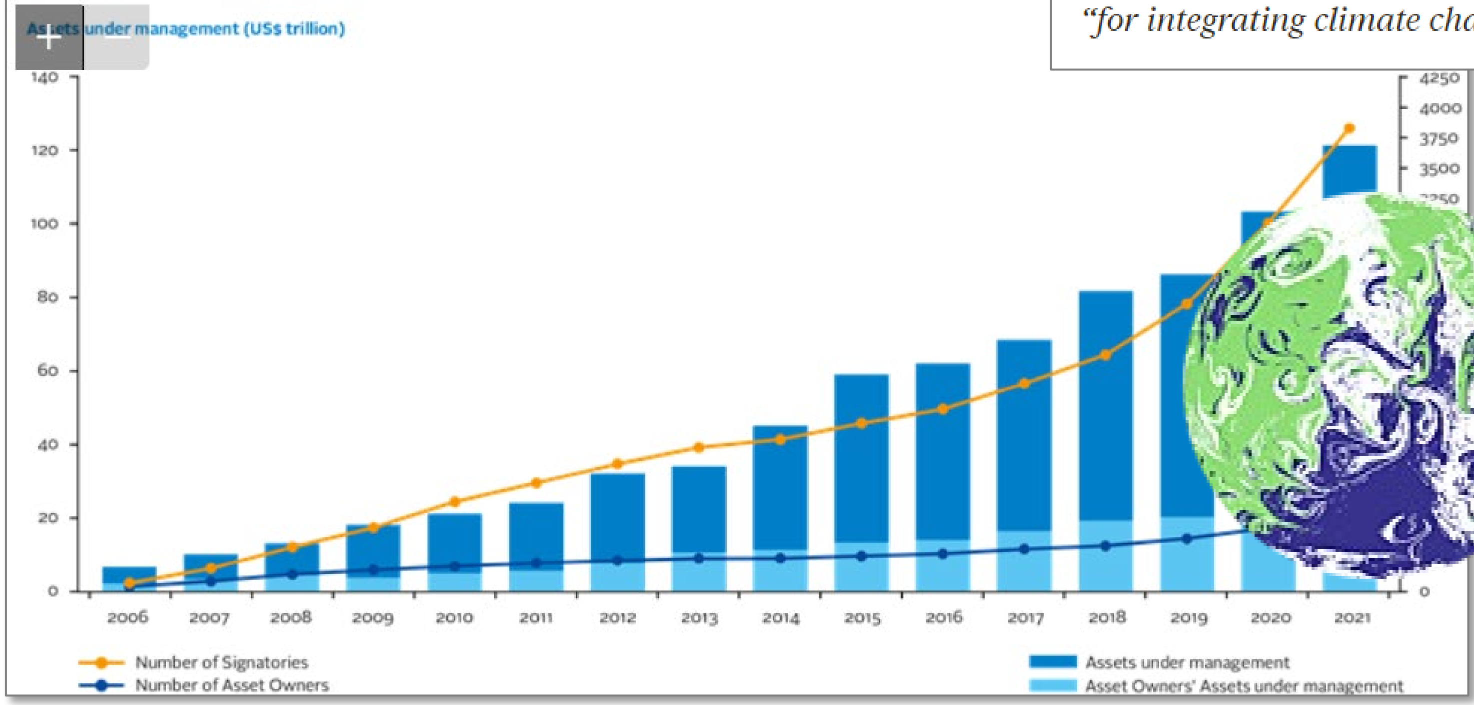
- **Impact Investing**: investing for purposes **other than** solely to maximize risk-adjusted returns

- Maximize risk-adjusted returns, subject to **constraints** that **supports certain social priorities and agendas**
  - Socially Responsible Investing (SRI)
  - Environmental, Social, and Governance (ESG)
  - Fossil fuels, tobacco, “sin stocks”
  - Biotech and rare disease drugs

Who Cares?

- **Principle 1**: We will incorporate ESG issues into investment analysis and decision-making processes.

PRI growth 2006-2021



KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

8 October 2018

The Royal Swedish Academy of Sciences has decided to award the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2018 to

William D. Nordhaus
Yale University, New Haven, USA

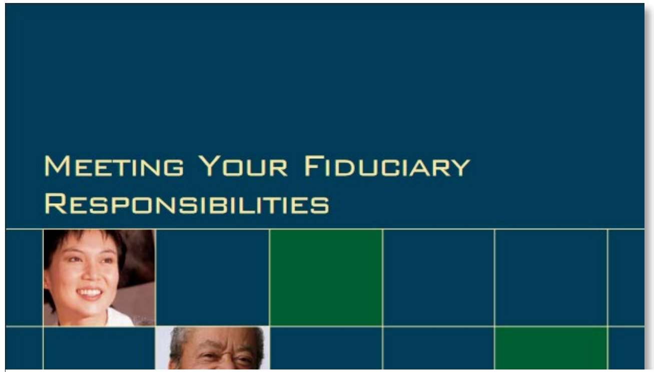
"for integrating climate change into long-run macroeconomic analysis"

UN CLIMATE CHANGE CONFERENCE UK 2021
IN PARTNERSHIP WITH ITALY

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

MIT LFE

What About Fiduciary Duty?



WHAT IS THE SIGNIFICANCE OF BEING A FIDUCIARY?

Fiduciaries have important responsibilities and are subject to standards of conduct because they act on behalf of participants in a retirement plan and their beneficiaries. These responsibilities include:

- Acting solely in the interest of plan participants and their beneficiaries and with the exclusive purpose of providing benefits to them;
- Carrying out their duties prudently;
- Following the plan documents (unless inconsistent with ERISA);
- Diversifying plan investments; and
- Paying only reasonable plan expenses.

The duty to act prudently is one of a fiduciary's central responsibilities under ERISA. It requires expertise in a variety of areas, such as investments. Lacking that expertise, a fiduciary will want to hire someone with that professional knowledge to carry out the investment and other functions. Prudence focuses on the *process* for making fiduciary decisions. Therefore, it is wise to document decisions and the basis for those decisions. For instance, in hiring any plan service provider, a fiduciary may want to survey a number of potential providers, asking for the same information and providing the same requirements. By doing so, a fiduciary can document the process and make a meaningful comparison and selection.

- ❑ Does impact investing meet this test?
- ❑ Does impact investing necessarily mean lower risk-adjusted returns?
- ❑ **Framework?**

How To Evaluate Impact Investing?

- Given a portfolio $W \equiv \sum_{i=1}^{N} \omega_i R_i$, traditional mean-variance optimization:

$$\max_{\{\omega_1,\ldots,\omega_N \in \Omega\}} E[U(W)]$$

- Consider any arbitrary subset $S \subseteq \{1,\ldots,N\}$, and portfolios formed on the subset: $W^c \equiv \sum_{i \in S} \omega_i^c R_i$.

- Then:

$$\max_{\{\omega_1,\ldots,\omega_N \in \Omega\}} E[U(W)] \geq \max_{\{\omega_i^c \in \Omega^c :\, i \in S\}} E[U(W^c)]$$

  - Constrained optimization
  - Worse risk-adjusted returns?

How To Evaluate Impact Investing?

- ❑ Consider two examples

BABA	Alibaba Group Holding ...
GOOG	Alphabet Inc Class C
AMZN	Amazon.com, Inc.
AAPL	Apple Inc
F	Ford Motor Company
MANU	Manchester United PLC
FB	Meta Platforms Inc

Exclude stocks that start with the letter "F"

Buy stocks that Jim Simons will buy next month

- ❑ Key: whether the subset S contains any information?
- ❑ i.e. Are constraints **independent** of returns?

This Paper

- A **systematic framework** to quantify the (financial) impact of impact investing.
  - Main statistical tool: **Induced order statistics**
  - Also called **concomitants** of the order statistic
  - First applied to financial data by Lo and MacKinlay (1990) in a different context

- How to apply it optimally? Treynor-Black portfolios

- Empirical demonstration in 4 examples
  - Venture Philanthropy
  - ESG
  - Sin Stocks
  - “Meme” stocks (e.g. Gamestop)

- Related Literature

The Framework

Basic linear multi-factor model: N securities with returns R_{it}

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}(\Lambda_{1t} - R_{ft}) + \cdots + \beta_{iK}(\Lambda_{Kt} - R_{ft}) + \epsilon_{it}$$

such that $E[\epsilon_{it}|\Lambda_{kt}] = 0$, for $k = 1, \ldots, K$

- R_{ft}: risk free rate
- Λ_{kt}: k-th factor return
- α_i: excess return
- β_{ik}: factor betas
- ϵ_{it}: idiosyncratic risk

- Consistent with CAPM, ICAPM, APT, FF iff $\alpha_i = 0$.
- Prop 1: If $\alpha_i = 0$, impact investing can only make investors worse off financially.

- Suppose for simplicity that $\boldsymbol{\alpha_i \sim N(0, \sigma_\alpha^2)}$

The Framework

- Impact factor used to construct portfolios: $\mathbf{X} = [X_1, X_2, \ldots, X_N]^T$

- **Impact Portfolio**: any portfolio $S(\mathbf{X})$ formed as a function of the impact factor, **X**.
  - Selecting top n securities based on **X**
  - Overweight top securities based on **X**

- N stocks: $\begin{pmatrix} X_1 \\ \alpha_1 \end{pmatrix}, \quad \begin{pmatrix} X_2 \\ \alpha_2 \end{pmatrix}, \quad \ldots, \quad \begin{pmatrix} X_N \\ \alpha_N \end{pmatrix}$

- Re-order the bivariate vector: $\begin{pmatrix} X_{1:N} \\ \alpha_{[1:N]} \end{pmatrix}, \begin{pmatrix} X_{2:N} \\ \alpha_{[2:N]} \end{pmatrix}, \ldots, \begin{pmatrix} X_{N:N} \\ \alpha_{[N:N]} \end{pmatrix}$

- Order statistics: $X_{1:N} < X_{2:N} < \ldots < X_{N:N}$
- **Induced order statistics**: $\alpha_{[1:N]}, \alpha_{[2:N]}, \ldots, \alpha_{[N:N]}$

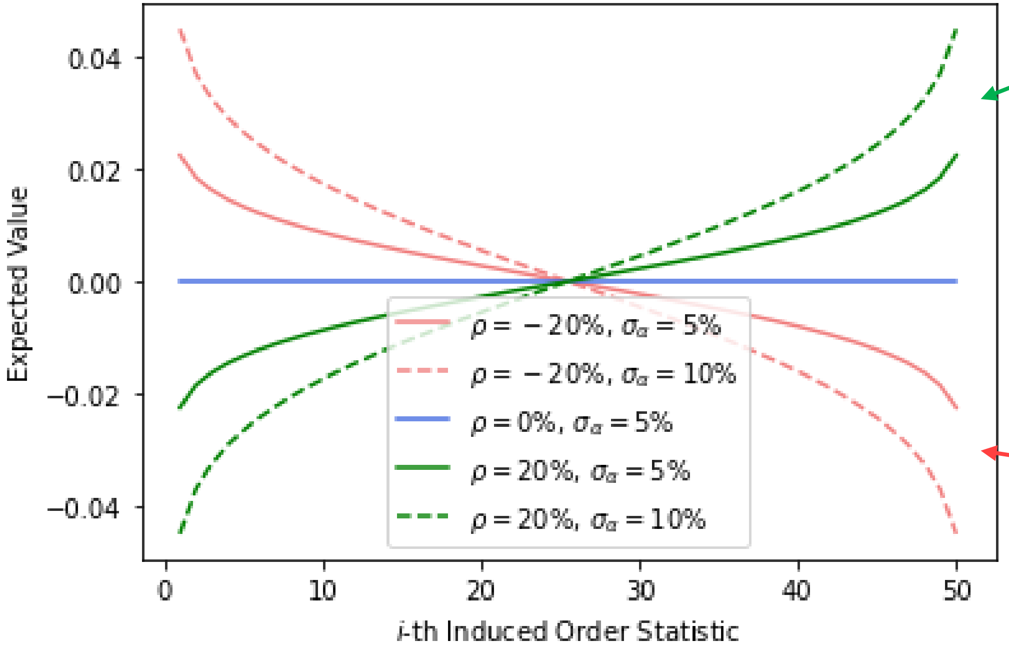
Goal: Quantify Alpha

Characterizing Alpha

Expected Value of Induced Order Statistics (Prop 2)

- Suppose we have: $(X_1, \alpha_1), \ldots, (X_N, \alpha_N) \overset{\text{IID}}{\sim} N\left(\begin{bmatrix} \mu_x \\ \mu_\alpha \end{bmatrix}, \begin{bmatrix} \sigma_x^2 & \rho\sigma_x\sigma_\alpha \\ \rho\sigma_x\sigma_\alpha & \sigma_\alpha^2 \end{bmatrix} \right)$
- Suppose W.L.O.G. that $\mu_x = \mu_\alpha = 0$ and $\sigma_x = 1$, then:

$$\boldsymbol{\mu_i \equiv E\left[\alpha_{[i:N]}\right] = \rho\sigma_\alpha E[X_{i:N}]}$$



X and α positively correlated

X and α negatively correlated

Characterizing Alpha

Sketch of Proof

- Because $(X_i, \alpha_i)^T$, $i = 1, 2, \ldots, N$, are IID jointly normal, we can write:

$$\alpha_i = \mu_\alpha + \rho \frac{\sigma_\alpha}{\sigma_x}(X_i - \mu_X) + \epsilon_i$$

  where X_i and ϵ_i are mutually independent.
- Ordering on X_i we have

$$\alpha_{[i:N]} = \mu_\alpha + \rho \frac{\sigma_\alpha}{\sigma_x}(X_{i:N} - \mu_x) + \epsilon_{[i]}$$

- In view of the independence of X_i and ϵ_i, $X_{[i:N]}$ and $\epsilon_{[i]}$ are also independent. In particular, for expected value we have:

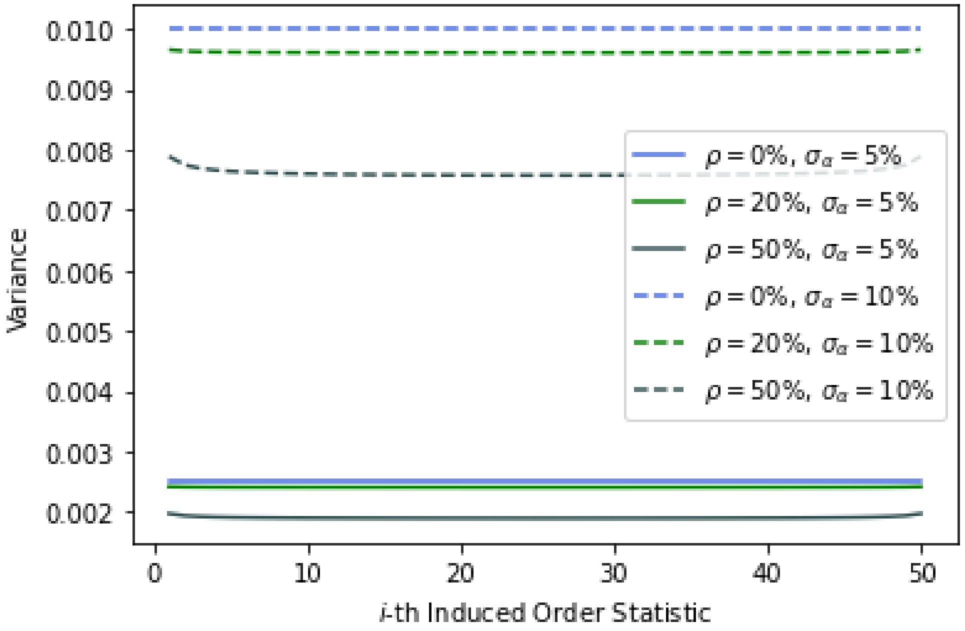
$$E\left[\alpha_{[i:N]}\right] = \mu_\alpha + \rho\sigma_\alpha E\left[\frac{X_{i:N} - \mu_x}{\sigma_x}\right] = \rho\sigma_\alpha E[Y_{i:N}]$$

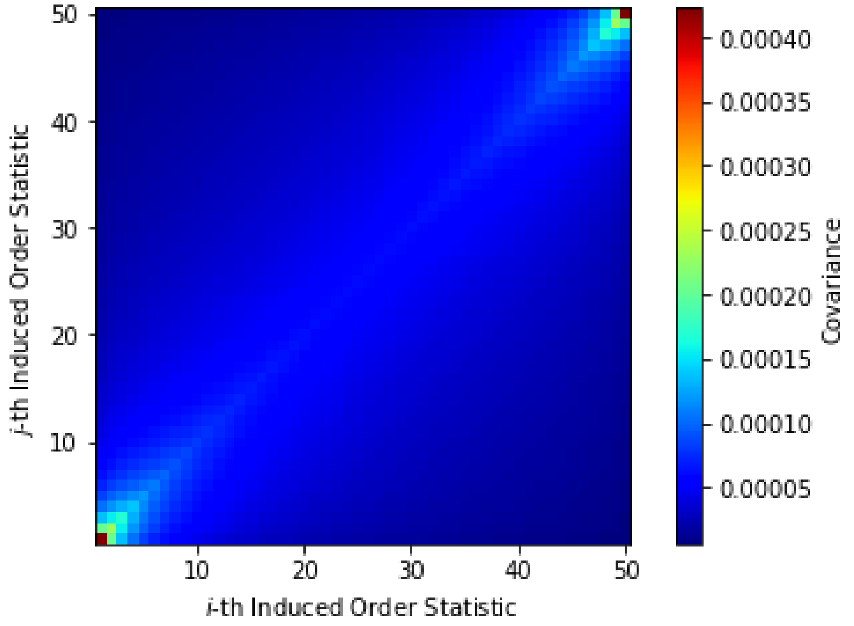
Characterizing Alpha

Variance and Covariances of Induced Order Statistics

$$\sigma_i^2 \equiv \text{Var}\left(\alpha_{[i:N]}\right) = \sigma_\alpha^2 \left(1 - \rho^2 + \rho^2 \text{Var}\left(\frac{X_{i:N} - \mu_x}{\sigma_x}\right)\right) = \sigma_\alpha^2 \left(1 - \rho^2 + \rho^2 \text{Var}\left(Y_{i:N}\right)\right).$$

$$\sigma_{ij} \equiv \text{Cov}\left(\alpha_{[i:N]}, \alpha_{[j:N]}\right) = \sigma_\alpha^2 \rho^2 \text{Cov}\left(\frac{X_{i:N} - \mu_x}{\sigma_x}, \frac{X_{j:N} - \mu_x}{\sigma_x}\right) = \sigma_\alpha^2 \rho^2 \text{Cov}\left(Y_{i:N}, Y_{j:N}\right).$$





Comparison with Conventional Order Statistics

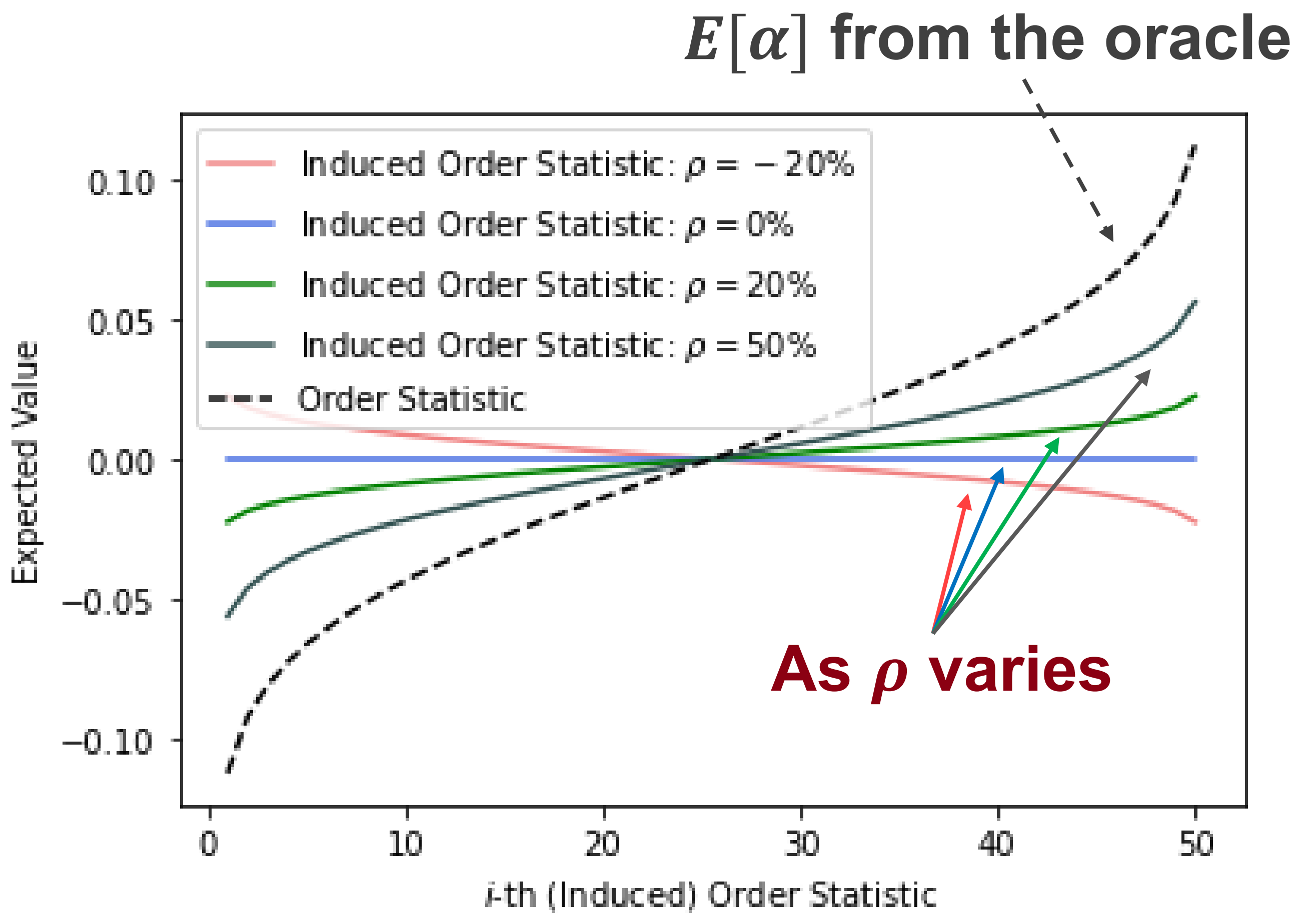
Imagine we have an **omniscient oracle** that ranks securities by **unobserved alpha**

$$\mu_i \equiv E[\alpha_{[i:N]}] = \rho E[\alpha_{i:N}]$$

$$\mathrm{Var}(\alpha_{[i:N]}) - \sigma_\alpha^2 = \rho^2[\mathrm{Var}(\alpha_{i:N}) - \sigma_\alpha^2]$$

$$\mathrm{Cov}(\alpha_{[i:N]}, \alpha_{[j:N]}) = \rho^2 \mathrm{Cov}(\alpha_{i:N}, \alpha_{j:N})$$

- (Prop 4) Induced order statistics is just a discounted version of the corresponding alpha from the omniscient oracle, where **the discount is just ρ**.



Characterizing Alpha: Asymptotics

Asymptotic distribution when $N \to \infty$ (Prop 5-6)

- Assuming $(X_i, \alpha_i)^T$, $i = 1, 2, \ldots, N$, are IID, for any sequence $1 < i_1 < \cdots < i_n < N$ such that, as $N \to \infty$, $i_k/N \to \xi_k \in (0,1)$ for $k = 1, \ldots, n$, we have:

$$\lim_{N\to\infty} P\left(\alpha_{[i_1:N]} < a_1, \cdots, \alpha_{[i_n:N]} < a_n\right) = \prod_{k=1}^{n} P(\alpha_k < a_k | F_x(X_k) = \xi_k)$$

where $F_x(\cdot)$ is the marginal CDF of X_i.

- Moreover, when $(X_i, \alpha_i)^T$ are jointly normal,

$$\mu(\xi_k) \equiv \rho(\sigma_\alpha/\sigma_x)[F_x^{-1}(\xi_k) - \mu_x] = \rho\sigma_\alpha\Phi^{-1}(\xi_k)$$
$$\sigma^2(\xi_k) \equiv \sigma_\alpha^2(1 - \rho^2)$$

- **Expected value** depends on ρ, σ_α^2, and the inverse CDF of "order"
- **Variance is a constant** across all orders
- **Mutually independent**

Interpreting Alpha as Omitted Factors

$\alpha_i \neq 0$ can be interpreted as omitted factors (Prop 7):

$$R_{it} - R_{ft} = \alpha_i + \underbrace{\beta_{i1}(\Lambda_{1t} - R_{ft})}_{\text{Observed}} + \underbrace{\cdots + \beta_{iK}(\Lambda_{Kt} - R_{ft})}_{\text{Omitted Factors}} + \epsilon_{it}$$

λ_i

- No arbitrage or inefficiencies assumed
- Impact PMs provide investors with exposure to novel factor risk premia

- We generalize our results by introducing dependence ***across*** (X_i, λ_i)

$$E[\lambda_{[i:N]}] = \rho_{adj}\sigma_\lambda E[X_{i:N}]$$

- $\rho_{adj} \equiv (\rho_{x,\lambda} - \tilde{\rho}_{x,\lambda})/(1 - \rho_x)$
- $\rho_{x,\lambda} \equiv Corr(X_i, \lambda_i),\ \ \tilde{\rho}_{x,\lambda} \equiv Corr(X_i, \lambda_j),\ \ \rho_x \equiv Corr(X_i, X_j)$

1 Overview

2 Characterizing Excess Returns

3 **Impact Portfolio Construction**

4 Empirical Applications

Quantifying Impact

With these results, we can quantify any impact portfolio (Prop 8)

$$\mathrm{E}[\alpha_p] = \sum_{i=1}^{n} \omega_i \mathrm{E}[\alpha_{[i:N]}] \quad , \quad \mathrm{Var}[\alpha_p] = \sum_{i=1}^{n}\sum_{j=1}^{n} \omega_i \omega_j \mathrm{Cov}\left[\alpha_{[i:N]}, \alpha_{[j:N]}\right]$$

- The standard tools apply
  - Sharpe, Sortino, information ratios
  - Performance attribution
  - Risk management, etc.

- Equal weighted Portfolios provide a way to estimate ρ and $\sigma_\alpha{}^2$.

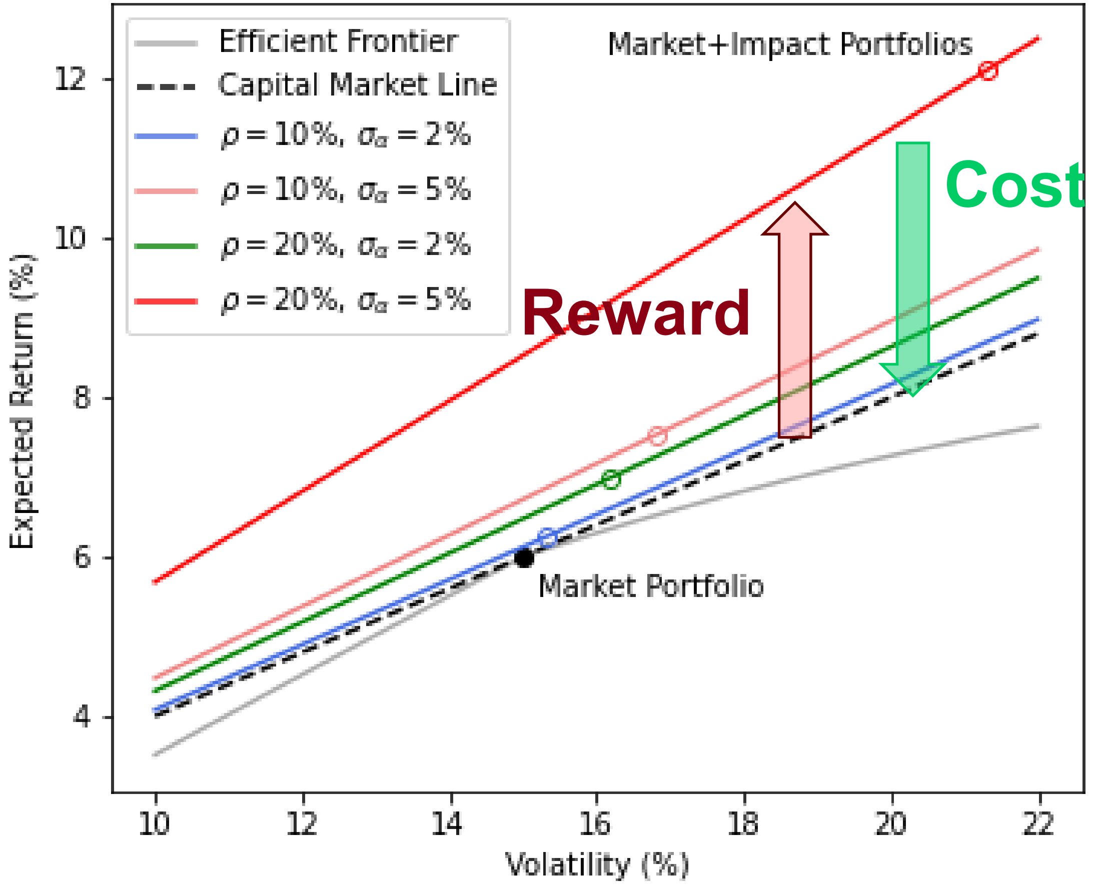
$$E[\tilde{\alpha}] = \frac{1}{n_0}\sum_{i\in S}\mu_i = \frac{\rho\sigma_\alpha}{n_0}\sum_{i\in S} E[Y_{i:N}]$$

Optimizing Impact

- Treynor-Black show how to construct **super-efficient portfolios** (Prop 9):

$$\omega_i^* \propto \frac{\mathrm{E}[\alpha_{[i:N]}]}{\sigma_i^2 + \sigma(\epsilon_i)^2}$$

- Optimal asset allocation with a passive index portfolio (Prop 10)
- A natural definition of the **financial reward / cost of impact investing**
- As we vary the desired level of impact, this corresponds to the "ESG-efficient frontier" of Pedersen et al (2021) in an explicit way.



Impact Portfolio Alpha

Combining Impact portfolio with Passive portfolios

$$\omega_A = \frac{\frac{\alpha_A}{\sigma(\epsilon_A)^2}}{\frac{E[R_m]-R_f}{\sigma_m^2}}$$

Correlation ρ	Weight ω_A Bottom	2^{nd}	9^{th}	Top	Expected Excess Return α_A Bottom	2^{nd}	9^{th}	Top
$\sigma_\alpha = 1\%$								
30% ($R^2 = 9\%$)	-0.66	-0.39	0.39	0.66	-0.6%	-0.3%	0.3%	0.6%
10% ($R^2 = 1\%$)	-0.22	-0.13	0.13	0.22	-0.2%	-0.1%	0.1%	0.2%
−10% ($R^2 = 1\%$)	0.22	0.13	-0.13	-0.22	0.2%	0.1%	-0.1%	-0.2%
−30% ($R^2 = 9\%$)	0.66	0.39	-0.39	-0.66	0.6%	0.3%	-0.3%	-0.6%
$\sigma_\alpha = 2\%$								
30% ($R^2 = 9\%$)	-1.31	-0.78	0.78	1.31	-1.1%	-0.6%	0.6%	1.1%
10% ($R^2 = 1\%$)	-0.44	-0.26	0.26	0.44	-0.4%	-0.2%	0.2%	0.4%
−10% ($R^2 = 1\%$)	0.44	0.26	-0.26	-0.44	0.4%	0.2%	-0.2%	-0.4%
−30% ($R^2 = 9\%$)	1.31	0.78	-0.78	-1.31	1.1%	0.6%	-0.6%	-1.1%
$\sigma_\alpha = 5\%$								
30% ($R^2 = 9\%$)	-3.23	-1.93	1.93	3.23	-2.8%	-1.6%	1.6%	2.8%
10% ($R^2 = 1\%$)	-1.08	-0.64	0.64	1.08	-0.9%	-0.5%	0.5%	0.9%
−10% ($R^2 = 1\%$)	1.08	0.64	-0.64	-1.08	0.9%	0.5%	-0.5%	-0.9%
−30% ($R^2 = 9\%$)	3.23	1.93	-1.93	-3.23	2.8%	1.6%	-1.6%	-2.8%

$E[R_m] - R_f = 6\%$
$\sigma_m = 15\%$

Even small correlations lead to meaningful alpha

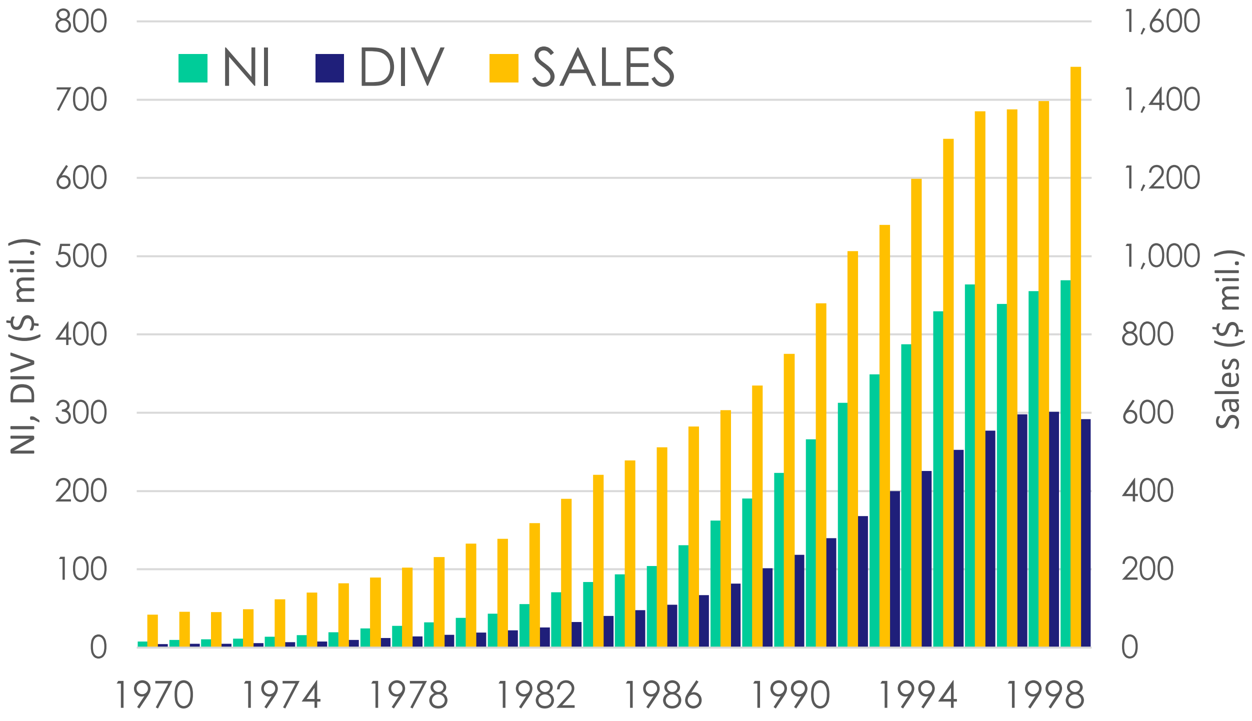
Four Impact Investments

- ❑ Sin stocks
- ❑ ESG
- ❑ Venture philanthropy
- ❑ "Meme" stocks (e.g. Gamestop)

Divesting Sin Stocks

- Sin stocks: stocks from companies involved in unethical or immoral activities.
  - Examples: alcohol, tobacco, gambling, sex-related industries, and firearms.

- U.S. Tobacco as of Dec 1998 (HBS Case study 9-200-069)



- Very successful
- 36 consecutive years of earnings increases
- 27 consecutive years of dividend increases
- Uninterrupted dividends since 1912

Divesting Sin Stocks

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- U.S. Tobacco as of Dec 1998 (HBS Case study 9-200-069)

	UST	Phillip Morris	North Atlantic	RJR Nabisco	Standard Commercial	DiMon	Universal	Average (other)
Gross Profit Margin	80.1%	41.7%	65.4%	46.2%	12.3%	9.7%	14.3%	31.6%
Net Margin	32.9%	10.3%	1.1%	3.5%	2.4%	1.8%	3.0%	3.7%
ROE	103.4%	49.3%	N/A	8.4%	12.5%	22.5%	25.6%	23.7%
ROA	53.8%	13.2%	40.0%	2.4%	2.7%	3.4%	6.5%	11.4%
Debt/Book Capitalization	17.6%	47.5%	90.0%	54.4%	71.9%	72.3%	59.4%	65.9%
Debt/Market Capitalization	1.5%	10.1%	N/A	49.8%	69.3%	67.4%	38.7%	47.1%
EBIT Interest Coverage		11.2	1.3	2.5	3.3	2.6	3.5	4.1
Credit Rating		A	B+	BBB-	BB-	BB+	A-	

Divesting Sin Stocks

- Sin stocks: stocks from companies involved in unethical or immoral activities.
  - Examples: alcohol, tobacco, gambling, sex-related industries, and firearms.
- **Correlation(Sin Stocks, Alpha)**: 10-27%.
- **Financial Cost** of Divesting Sin Stocks: 1-3% per annum.

Impact Portfolio	Weight of Impact Portfolio ω_A	Expected Excess Return: Impact Portfolio α_A	Expected Excess Return: Combined with Passive Portfolio $\omega_A \alpha_A$
Panel A: Hong and Kacperczyk (2009)			
Implied correlation $\rho = 27\%$ ($R^2 = 7.2\%$) assuming $\sigma_\alpha = 5\%$.			
Top Half	8.58	1.7%	14.4%
Top Decile	3.78	2.5%	9.35%
Top 2%	1.04	3.3%	3.4%
Panel B: Blitz and Fabozzi (2017)			
Implied correlation $\rho = 10\%$ ($R^2 = 1.1\%$) assuming $\sigma_\alpha = 5\%$.			
Top Half	3.30	0.6%	2.1%
Top Decile	1.45	1.0%	1.4%
Top 2%	0.40	1.3%	0.5%

Controlling for market, size, value, and momentum.

Controlling additionally for two Fama-French quality factors (profitability and investment).

ESG Investing

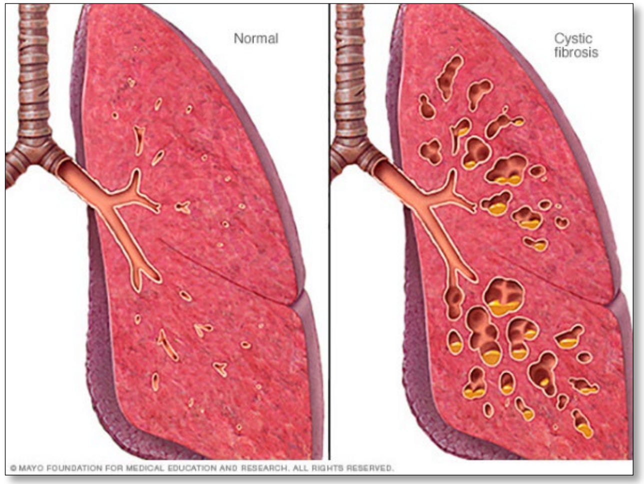
- **Correlation ranges** from -2% to 22% in these examples, implying **financial reward or cost** of ESG investing, in various forms.
- Depends on specific metric, asset class, region, time period, etc.
- Disclose the correlations, especially when they are negative.

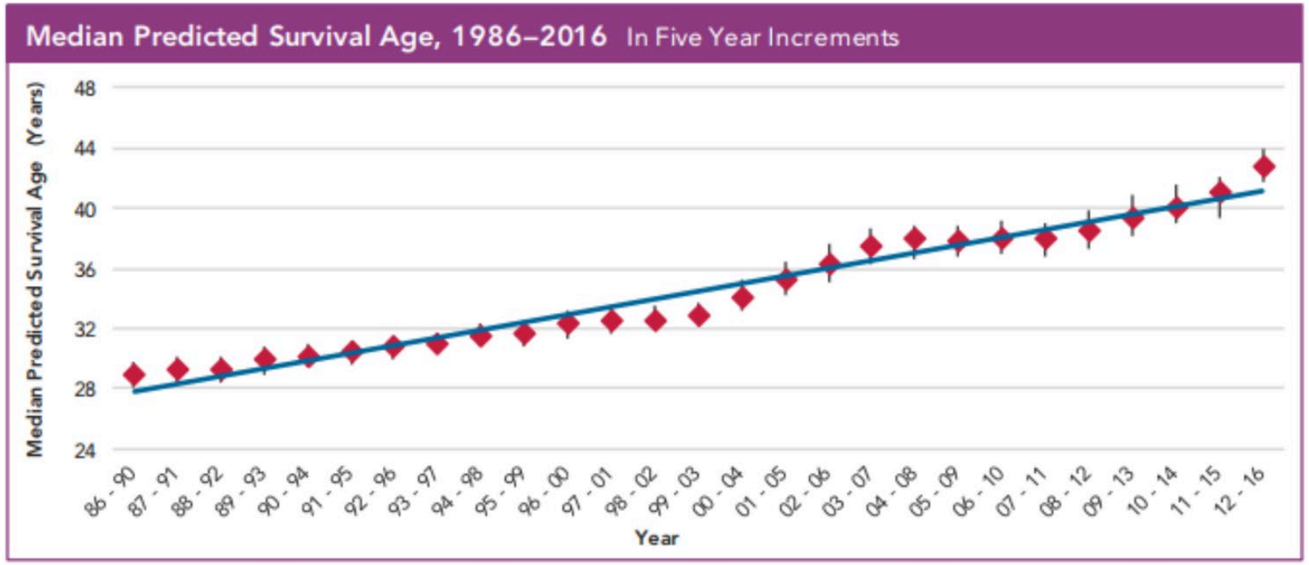
Impact Portfolio	Weight of Impact Portfolio ω_A	Expected Excess Return Impact Portfolio α_A	Expected Excess Return Combined with Passive Portfolio $\omega_A \alpha_A$
Panel A: MSCI (2021)			
Implied correlation $\rho = 1.6\%$ ($R^2 = 0.0\%$) assuming $\sigma_\alpha = 5\%$.			
Top Half	0.11	0.10%	0.01%
Top Decile	0.05	0.15%	0.00%
Top 2%	0.01	0.20%	0.00%
Panel B: Baker et al. (2021)			
Implied correlation $\rho = -2.0\%$ ($R^2 = 0.04\%$) assuming $\sigma_\alpha = 1\%$.			
Top Half	-1.06	-0.02%	-0.03%
Top Decile	-0.47	-0.04%	-0.02%
Top 2%	-0.13	-0.05%	-0.00%
Panel C: Bansal, Wu, and Yaron (2021) ("good times")			
Implied correlation $\rho = 22\%$ ($R^2 = 4.7\%$) assuming $\sigma_\alpha = 5\%$.			
Top Half	2.69	1.35%	3.64%
Top Decile	1.19	1.99%	2.37%
Top 2%	0.33	2.65%	0.88%
Panel D: Bansal, Wu, and Yaron (2021) ("bad times")			
Implied correlation $\rho = -0.2\%$ ($R^2 = 0.0\%$) assuming $\sigma_\alpha = 5\%$.			
Top Half	-0.02	-0.01%	-0.00%
Top Decile	-0.01	-0.02%	-0.00%
Top 2%	-0.00	-0.02%	-0.00%

Cystic Fibrosis Foundation

Venture Philanthropy: non-profit organizations combined with venture capital practices

- ❑ A case study of the Cystic Fibrosis (CF) Foundation (Kim and Lo 2019)
- ❑ Rare genetic disease
- ❑ Progressive, multi-system disease; respiratory failure causes death
- ❑ Life expectancy of 28 years in 1986



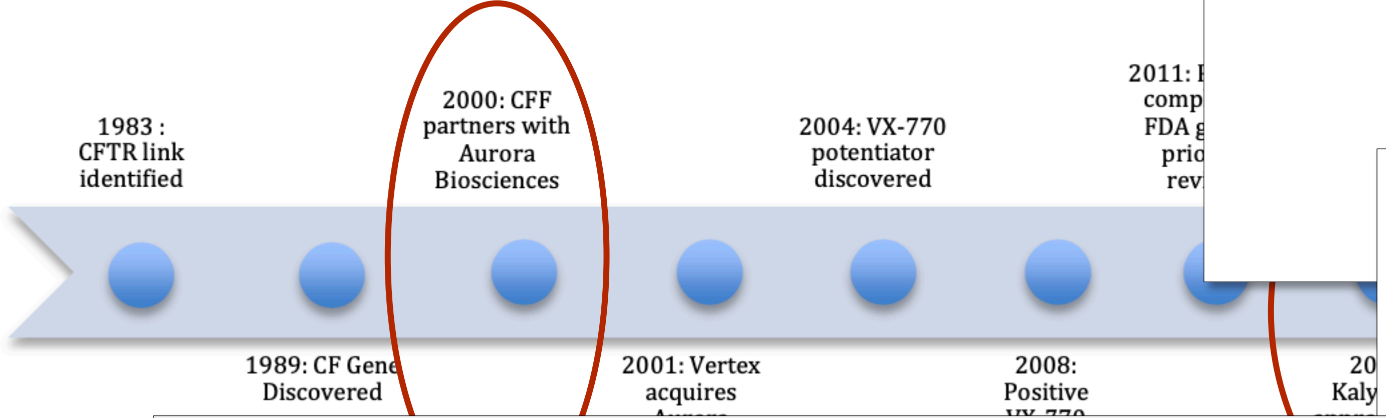


**Using the currently recommended method for calculating median predicted survival.*

Figure 1. Median Predicted Survival Age of CF Patients over Time.
Source: Cystic Fibrosis Foundation's 2016 Patient Registry Annual Data Report

Cystic Fibrosis Foundation

$150 million investment from 1998 to 2005



THE WALL STREET JOURNAL.

Nov 19, 2014

BUSINESS

Cystic Fibrosis Foundation Sells Drug's Rights for $3.3 Billion

ROYALTY PHARMA

Nov 2, 2020

ROYALTY PHARMA ACQUIRES ADDITIONAL ROYALTY INTEREST FROM THE CYSTIC FIBROSIS FOUNDATION

"The mission of the Cystic Fibrosis Foundation is to cure cystic fibrosis and to provide all people with the disease the opportunity to lead full, productive lives by funding research and drug development, promoting individualized treatment and ensuring access to high-quality, specialized care."

- Com
- Impl

Then… Why Don't People Invest?

Conclusion

- "Not all impact investments are created equal": A new framework to **quantify and manage the financial impact of impact investing**
- Know your ρ, and disclose it to investors
- How to optimally exploit impact alpha
- More broadly applicable to any characteristics correlated with returns
- Comments welcome: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3944367

Doing Well by Doing Good

- **Finance does not have to be a zero-sum game!**

Thank you!