

Moneyball for Startups

Tauhid Zaman

Joint Work with David Scott Hunter



Picking Winners

IPO:
\$2.5 B
100x

Nutanix



Virtualization
Previous Experience
38 Years Old
Masters

stiQRd SEED



Mobile Apps
Previous Experience
8 Previous Companies
PhD

Checkd.In SEED



Big Data/Advertising
Previous Experience
"Top" School
26 Years Old

Sanuthera SEED



Medical Devices
No Previous Experience
MD
Professor

IMRSV SEED



Computer Vision
"Top" School
PhD
28 Years Old

Venture Capital Investments

- The average early-stage VC investment produces a return of 31%
- Yet, most VC firms lose money on these investments
 - 80-90% of early-stage startups do not achieve an exit
 - **5-10% achieve exits with returns of 10-20X**
 - **1% achieve exits with returns greater than 100X**

Venture Capital Investments

- How do they make these investment decisions?



Quantitative Approach

- Scholars
 - Most academic studies have focused on what factors are correlated with startup success
 - No academic study has considered a fully quantitative approach to VC investment

Quantitative Approach

- Dollars

- Some VCs have developed analytical tools to assist in the investment decision-making process



CORRELATION
VENTURES

Google™
ventures 




Our Contribution

1. New **data** on startups
2. New **model** for startup success (based on random walks)
3. **Analytics based portfolio construction method (“Moneyball”)**

Data

crunchbase

Linked 


 PitchBook[®]
Better Data. Better Decisions.

Data

- **Crunchbase** (from 1981 to 2016, public user)
 - 83,000 startup companies
 - 48,000 investors
 - 147,000 investment rounds
 - 558,000 employees

Larry Page

Overview | Timeline | Contributors



Overview UPDATE

Primary Role
CEO & Founder @ [Alphabet](#)

Investments
5 Investments in 4 Companies

Gender: Male
Location: San Francisco
Social: [f](#) [in](#)

Person Details UPDATE

Larry Page, the Chief Executive Officer of Alphabet and one of Google's founders, has served as a member of Alphabet's board of directors since October 2015.

He has served as a member of Google's board of directors since its inception in September 1998, and as ...

[See More](#)

Recent Timeline Activity (6,849)


June 18, 2017

Asian Age - [The 'Google It' generation](#)

ALL TIMELINE ACTIVITY


Jobs (6) UPDATE

Current



CEO & Founder
Alphabet
Aug 10, 2015 - Current (almost 2 years)

Google



[ADD TO LIST](#)

TOP CONTRIBUTORS

[ADD TO THIS PROFILE](#)

[CONTRIBUTE](#)

Funding Rounds (4) - \$36.1M UPDATE

Date	Amount / Round	Valuation	Lead Investor	Investors
Jun, 2000	\$10M / Undisclosed	–	Yahoo	1
Jun, 1999	\$25M / Series A	–	Kleiner Perkins Caufield & Byers Sequoia Capital	8
Nov, 1998	\$1M / Angel	–	–	4
Aug, 1998	\$100k / Angel	–	Andreas Bechtolsheim	1

Investors (13)

Investor	Round(s)	Partner(s)
Andreas Bechtolsheim	Angel (Lead)	–
Angel Investors LP	Angel	–
Arnold Schwarzenegger	Series A	–
David Cheriton	Angel	–
Henry Kissinger	Series A	–
Jeff Bezos	Angel	–
Kleiner Perkins Caufield & Byers	Series A (Lead)	Al Gore John Doerr
Ram Shriram	Angel	–
Sequoia Capital	Series A (Lead)	John Doerr Michael Moritz
Shaquille O'Neal	Series A	–
Signatures Capital	Series A	Bobby Yazdani
Tiger Woods	Series A	–
Yahoo	Undisclosed (Lead)	–

Data

- **Pitchbook** (Privately maintained)
 - 774,000 companies
 - Investing rounds information
 - Valuation at these rounds

Illumio

Profile News Similar Companies Public Comps Signals LinkedIn Last Updated: 06-Jun-2017

Follow Add to List Download Print Share Feedback

Deal History (4)

#	Deal Type	Date	Amount	Raised to Date	Pre-Val	Post-Val	Status	Stage
4.	Later Stage VC (Series D)	20-Apr-2017	\$125.00M		\$1.06B	\$1.18B ^E	Completed	Generating Revenue
3.	Later Stage VC (Series C)	14-Apr-2015					Completed	Generating Revenue
2.	Early Stage VC (Series B)	18-Sep-2013					Completed	Startup
1.	Early Stage VC (Series A)	08-Feb-2013					Completed	Startup

^E Estimated

Cap Table History (as of 20-Apr-2017)

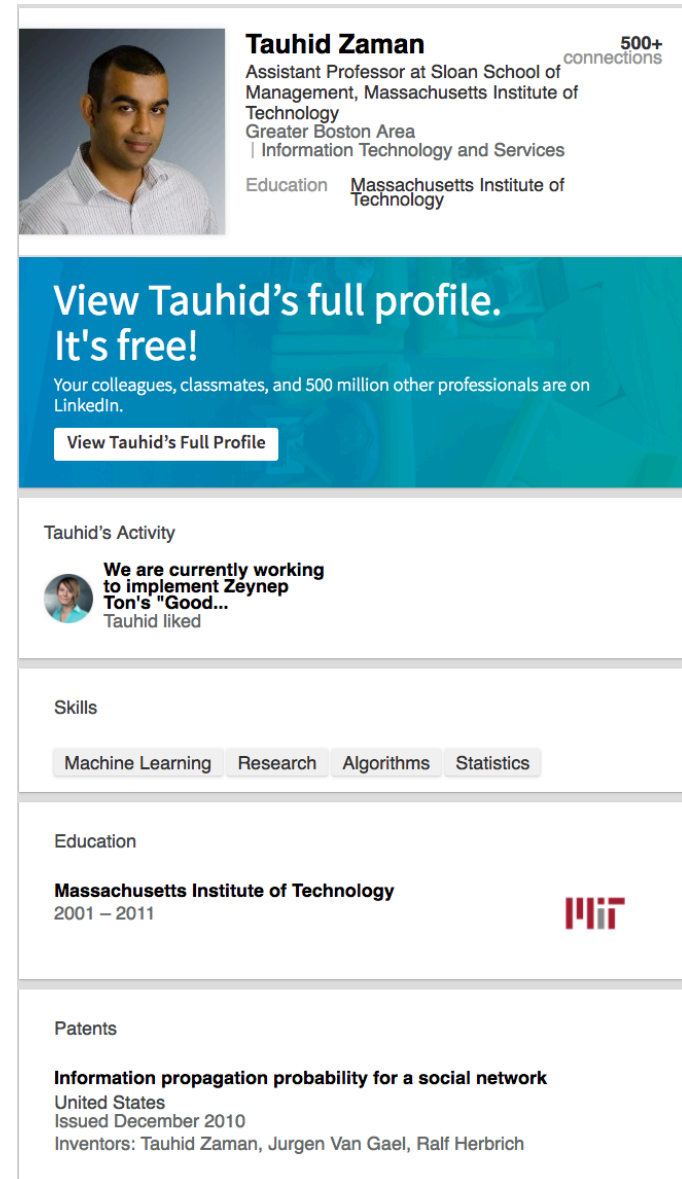
Stock	# of Shares Authorized	Par Value	Dividend Rate (%)	Original Issue Price	Liquidation	Liquidation Pref. Multiple	Conversion Price	% Owned
Series D								
Series C								
Series B								
Series A								

Contents

- Timeline
- General Information
- Top 5 Similar Companies
- Signals
- Executives (10)
- Board Members (8)
- Deal History (4)
 - 4. Series D 2017 Completed
 - 3. Series C 2015 Completed
 - 2. Series B 2013 Completed
 - 1. Series A 2013 Completed
- Investors (17)
- Service Providers

Data

- **LinkedIn**
 - 200,000 employees
 - Employment history
 - Education




Tauhid Zaman 500+ connections
Assistant Professor at Sloan School of Management, Massachusetts Institute of Technology
Greater Boston Area
| Information Technology and Services

Education **Massachusetts Institute of Technology**

View Tauhid's full profile. It's free!
Your colleagues, classmates, and 500 million other professionals are on LinkedIn.
[View Tauhid's Full Profile](#)


Tauhid's Activity

 **We are currently working to implement Zeynep Ton's "Good..."**
Tauhid liked

Skills

Machine Learning Research Algorithms Statistics

Education

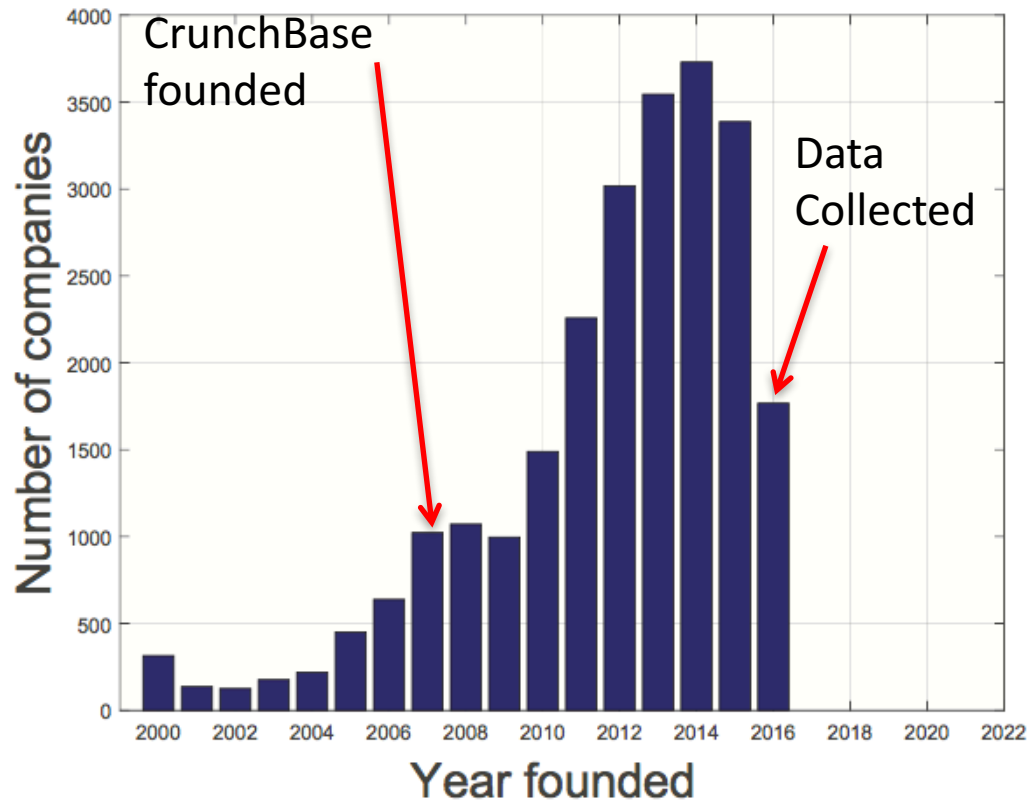
Massachusetts Institute of Technology
2001 – 2011 

Patents

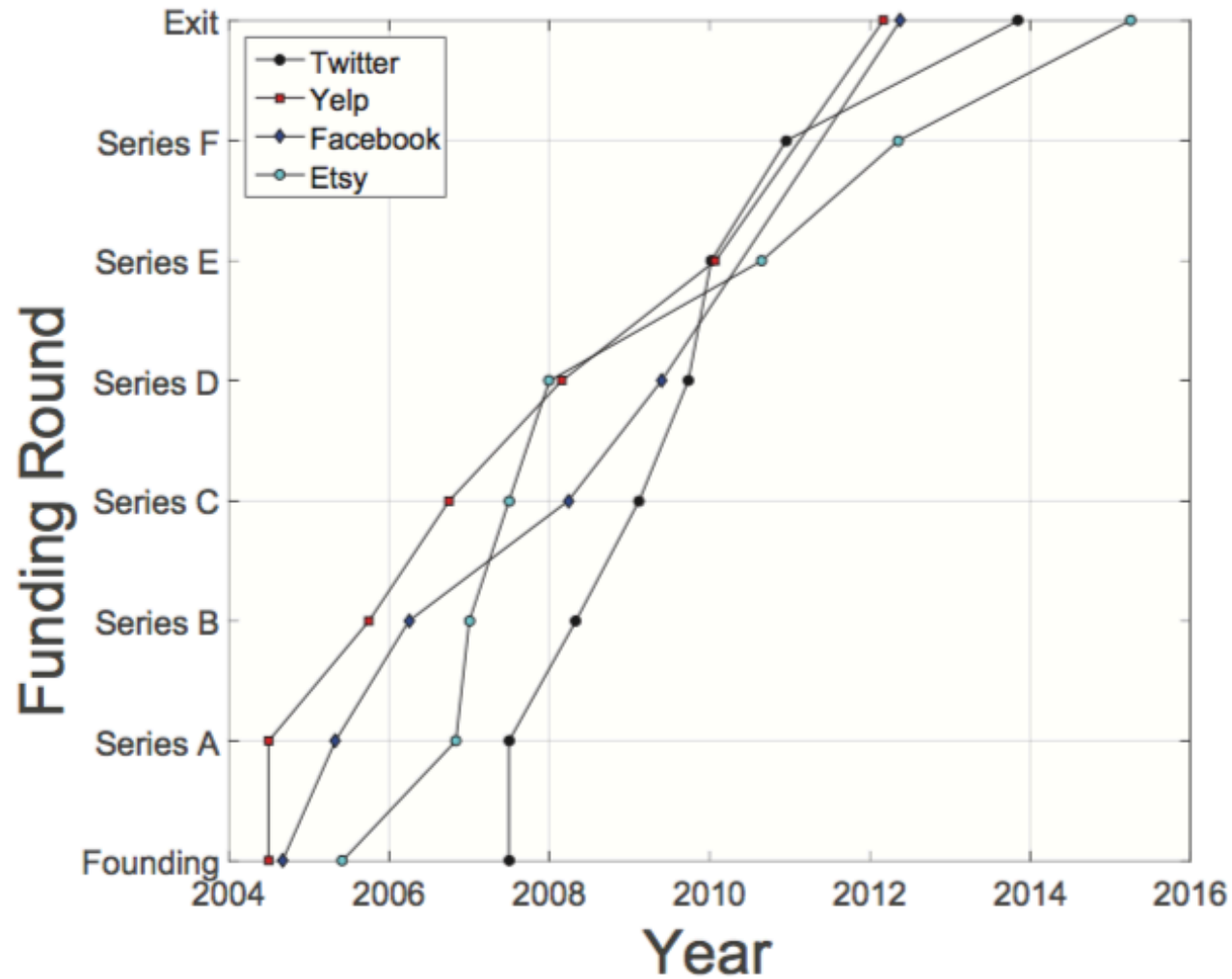
Information propagation probability for a social network
United States
Issued December 2010
Inventors: Tauhid Zaman, Jurgen Van Gael, Ralf Herbrich

Dataset for Analysis

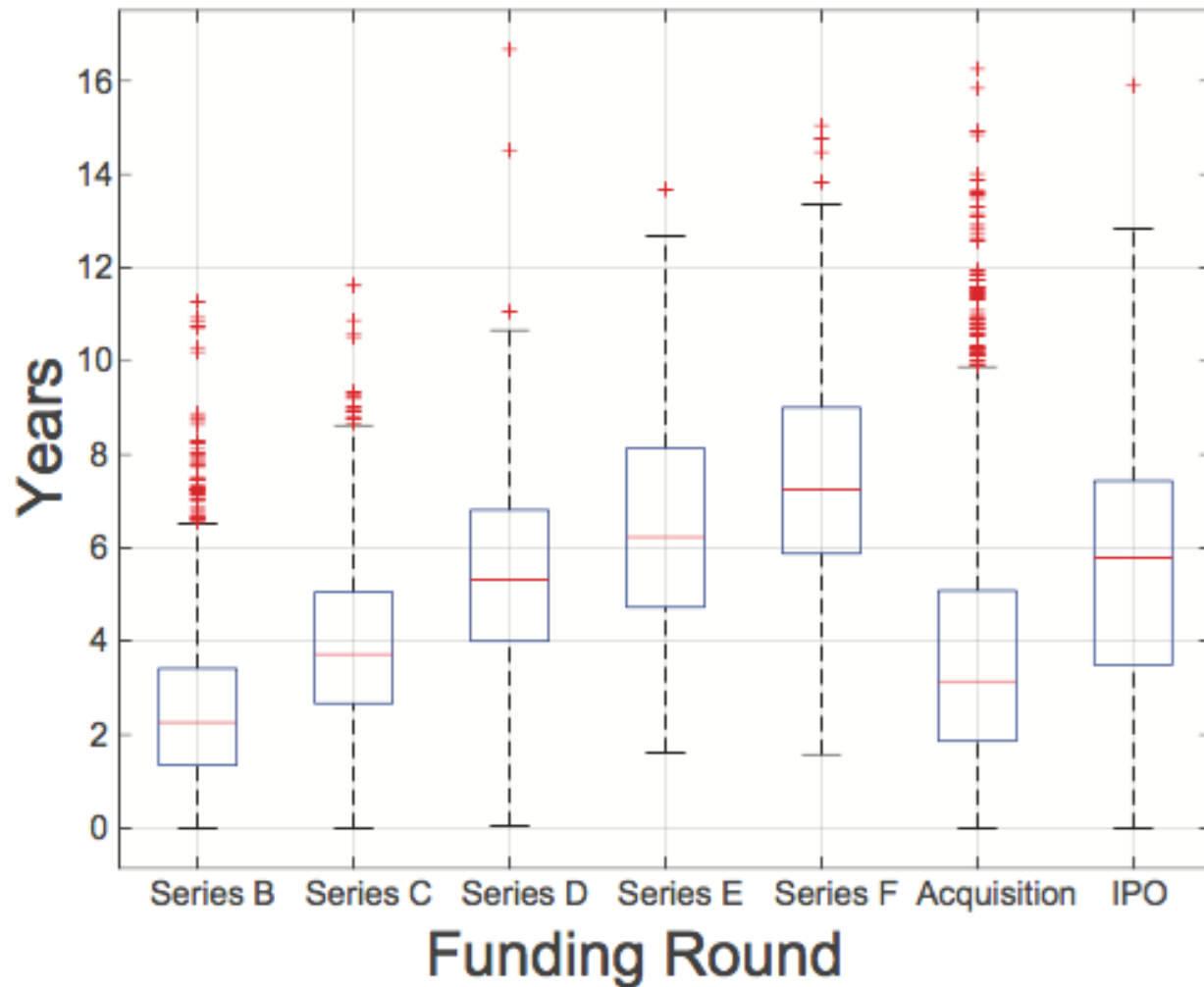
- US companies founded after 2000
- 24,000 companies



Funding Rounds Data

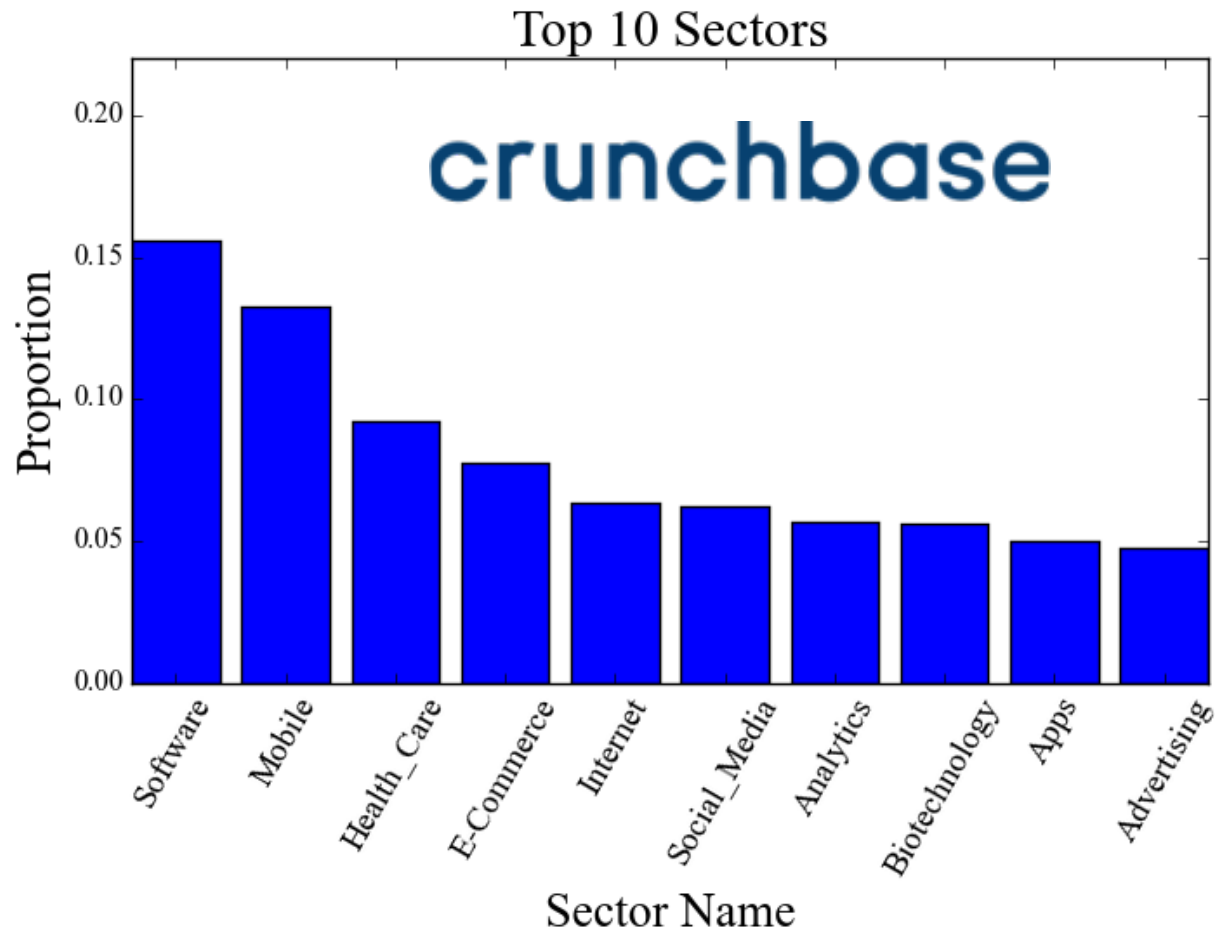


Time of Maximum Funding Round



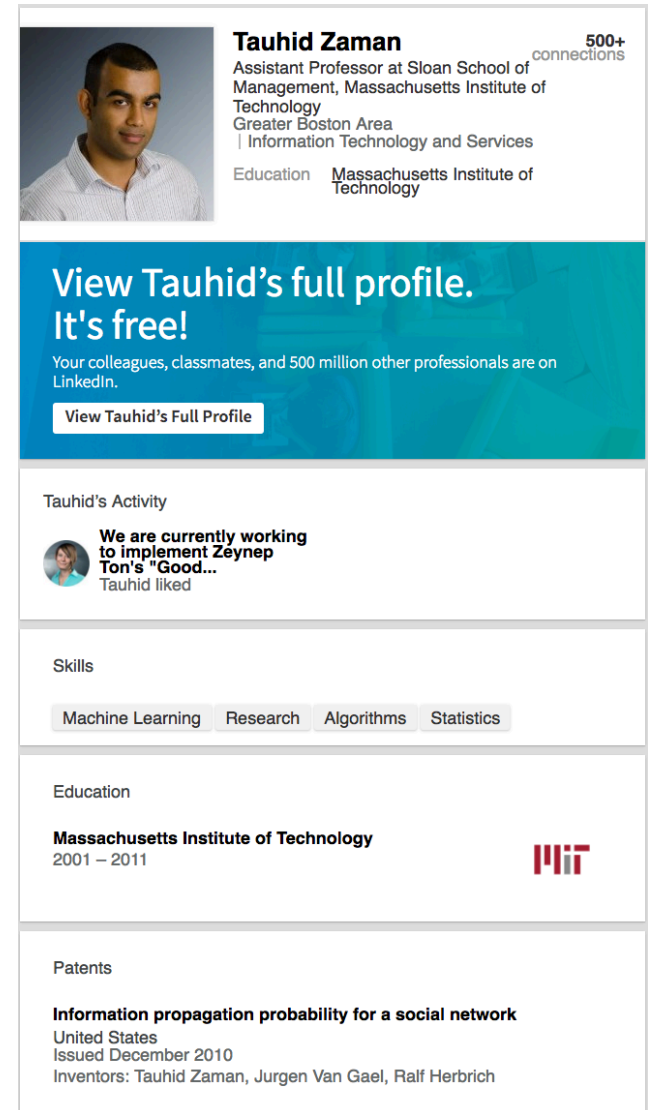
Sector Data

- 59 sector indicators



Leadership Data

- Using Crunchbase:
 - **Previous startup experience** for the founders, employees, and advisors
- Using LinkedIn:
 - **Previous startup experience**
 - Education
 - Academic major
 - Age of the founders




Tauhid Zaman 500+ connections
Assistant Professor at Sloan School of Management, Massachusetts Institute of Technology
Greater Boston Area
| Information Technology and Services

Education **Massachusetts Institute of Technology**

View Tauhid's full profile.
It's free!
Your colleagues, classmates, and 500 million other professionals are on LinkedIn.
[View Tauhid's Full Profile](#)


Tauhid's Activity

 **We are currently working to implement Zeynep Ton's "Good..."**
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Skills

Machine Learning Research Algorithms Statistics

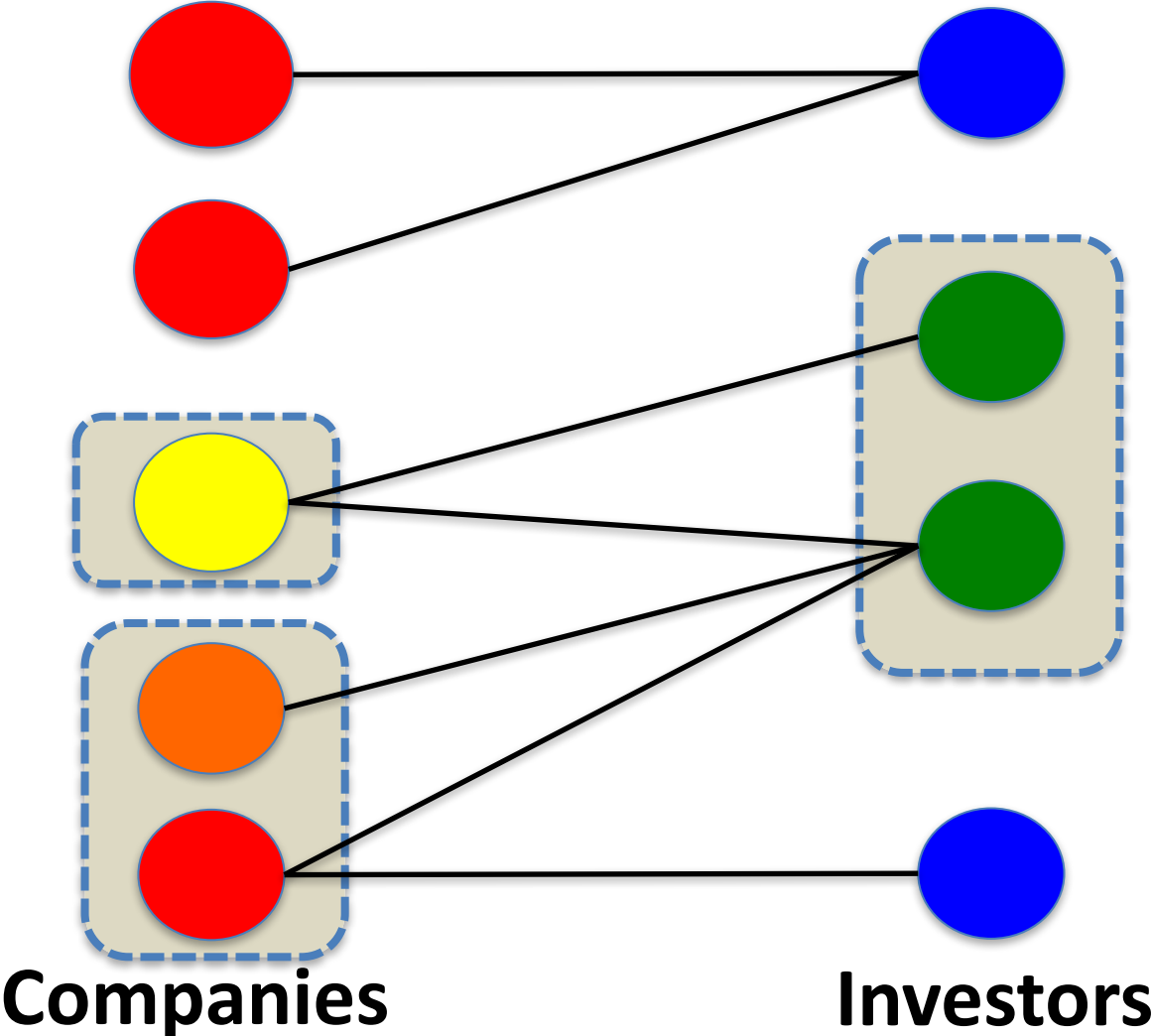
Education

Massachusetts Institute of Technology
2001 – 2011 

Patents

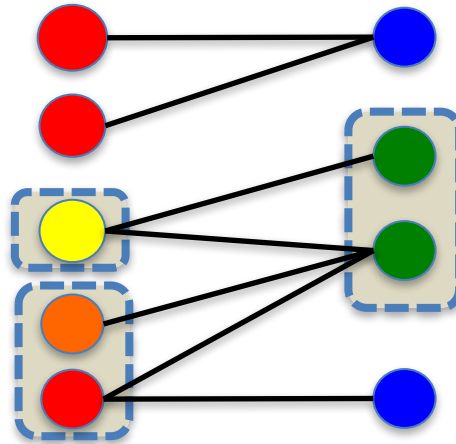
Information propagation probability for a social network
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Investor Data



Investor Data

- Network features
 - *investor neighborhood size*
 - *investor IPO/acquisition fraction*



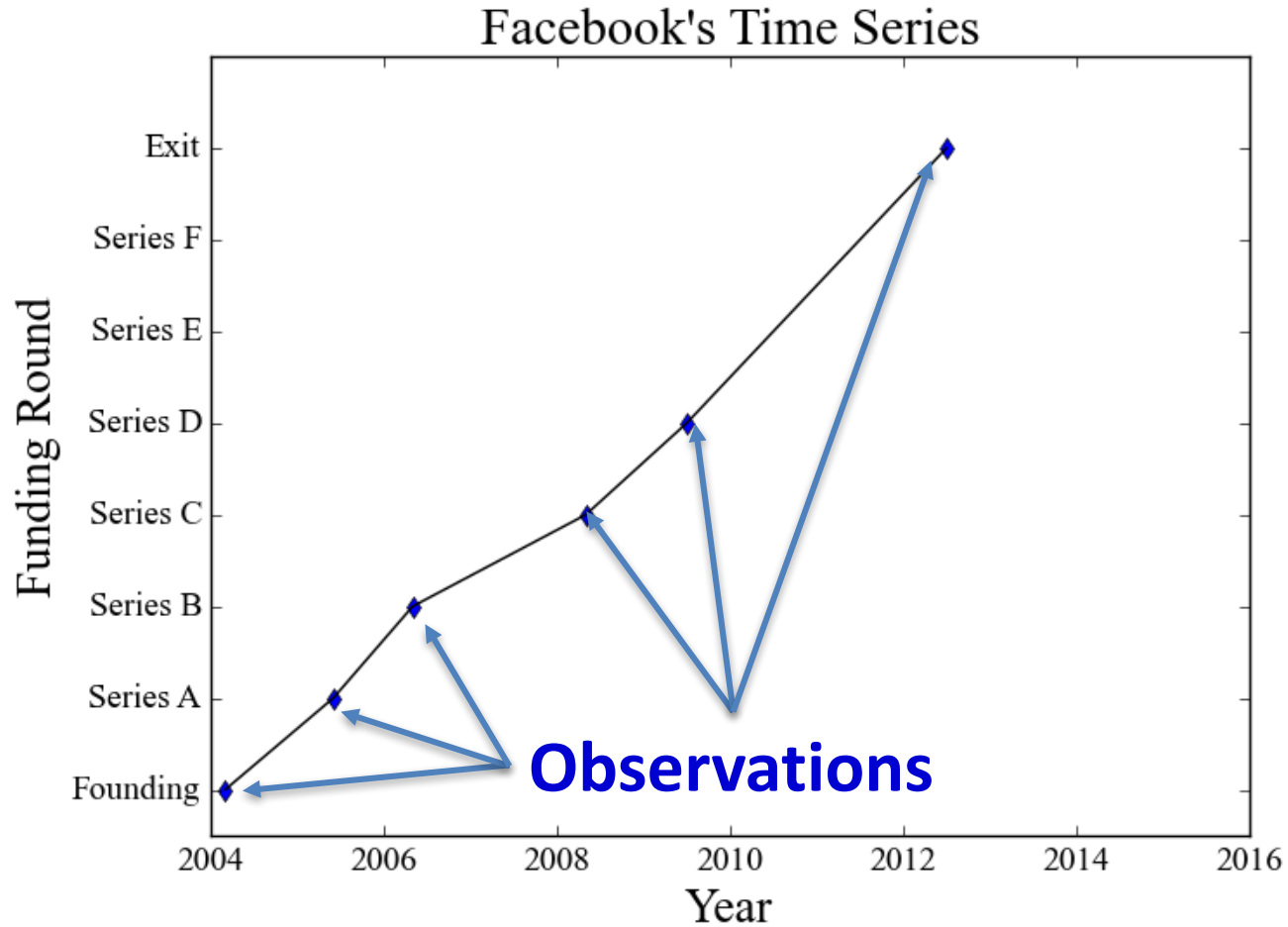
- Dynamic company-investor networks
 - Each edge has a time stamp

No Cheating Condition

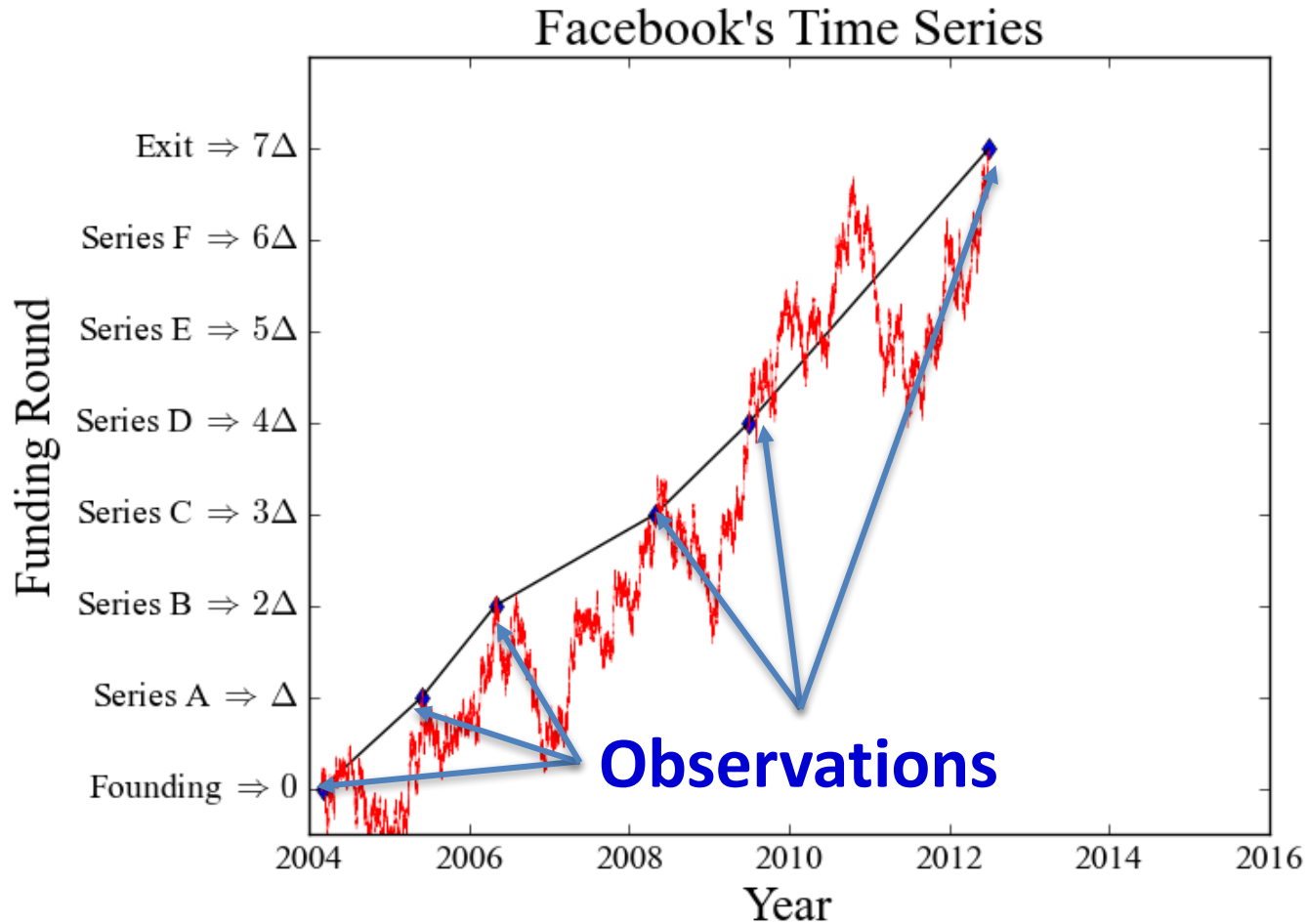
- **Funding round data**
- **Sector data**
- **Investor network data**
- **Leadership data**

Could you have known this information when deciding to invest in the company?

Random Walk Model

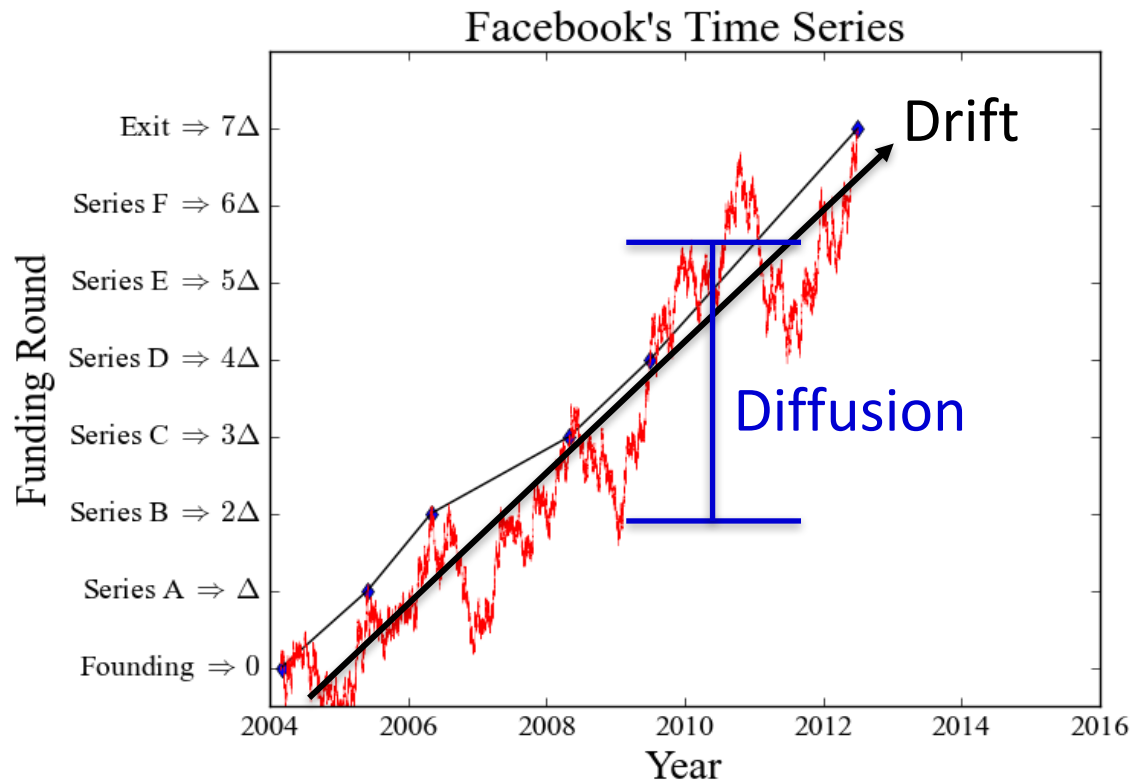


Random Walk Model

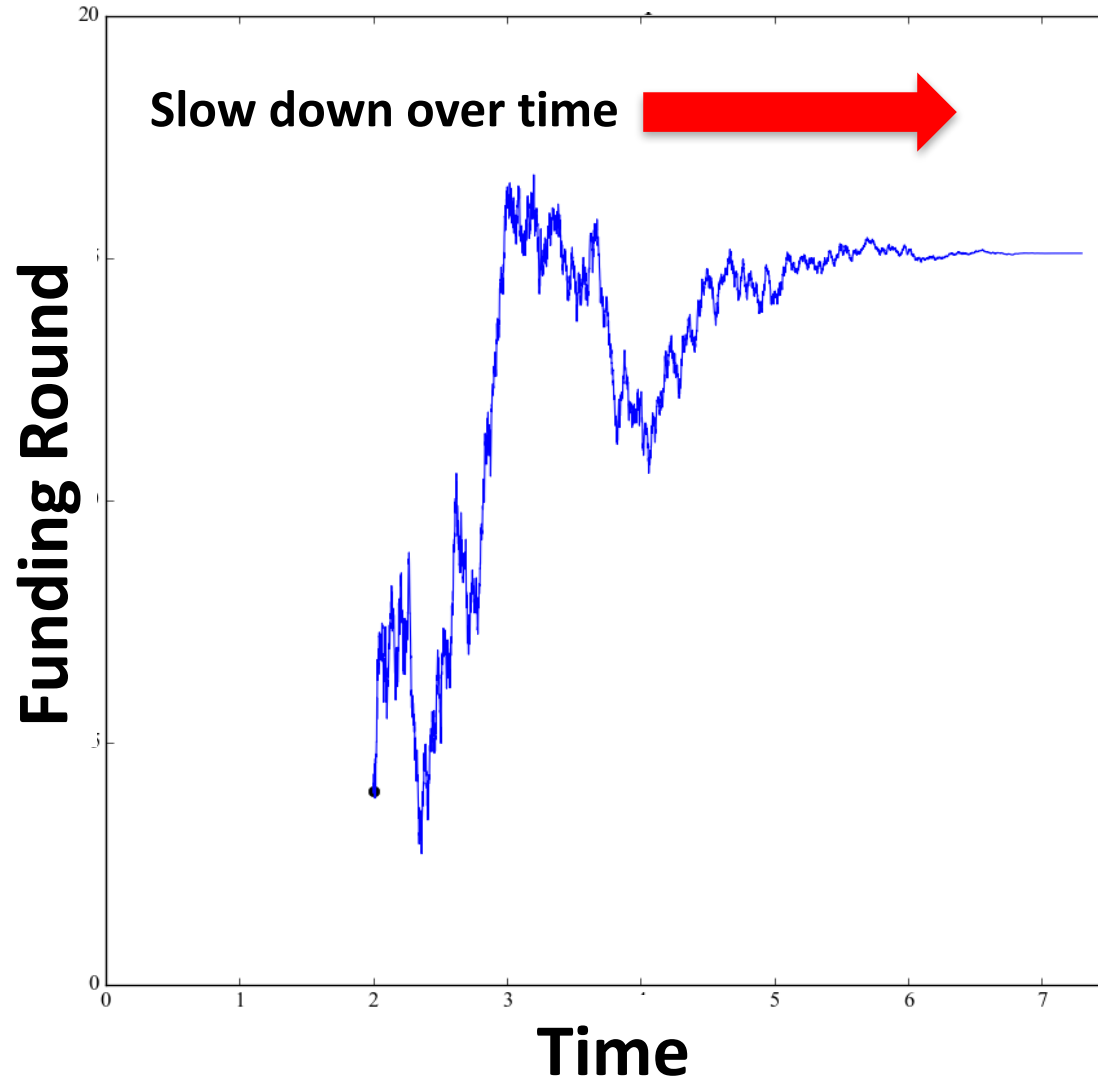


Random Walk Drift and Diffusion

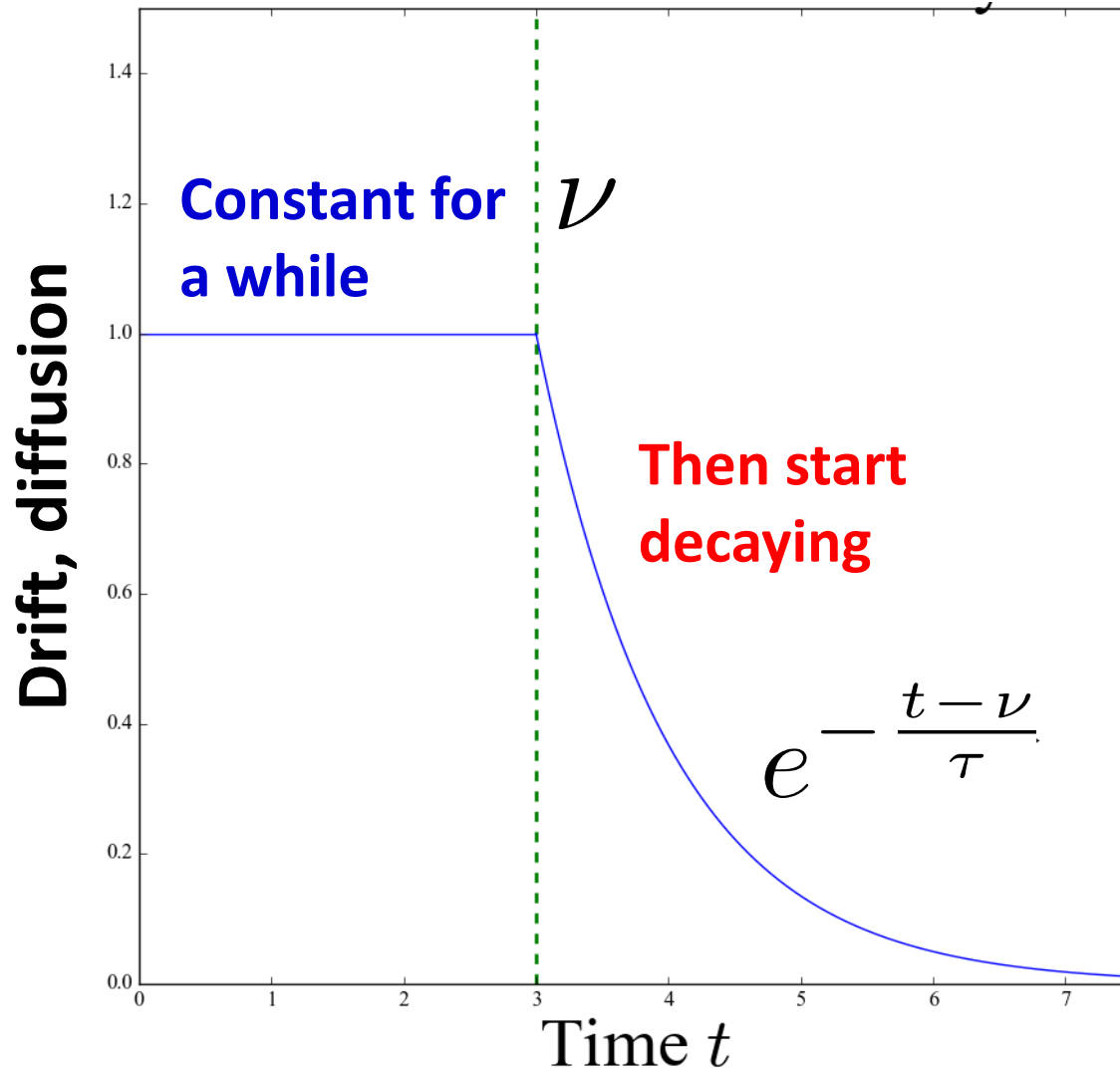
- Drift – avg. rate of increase of random walk
- Diffusion – how erratic the random walk is



Modeling Drift and Diffusion



Temporal Behavior of Drift and Diffusion



Modeling Drift and Diffusion

- For a company i that is founded in year y with feature vector \mathbf{x}_i we have:

$$\text{Drift: } \mu_i = \beta_y^T \mathbf{x}_i$$

$$\text{Diffusion: } \sigma_i = \gamma^T \mathbf{x}_i$$

- Time varying strength of drift features:

$$\beta_{i,y+1} = \beta_{i,y} + \epsilon$$

$$\epsilon = \text{noise}$$

Building Portfolios

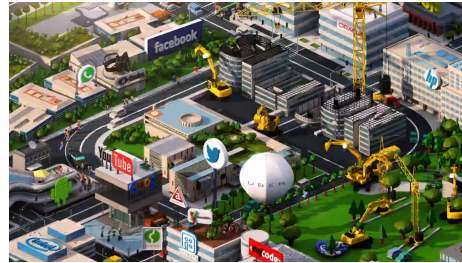
- Given a predictive model, how can we select companies?
 - If **at least one company exits**, we make a huge profit. Otherwise, we lose money.
 - Let E_i correspond to the event that company i **Exits**.

$$\max_{\mathcal{S} \subseteq [m], |\mathcal{S}|=k} \mathbf{P} \left(\bigcup_{i \in \mathcal{S}} E_i \right)$$

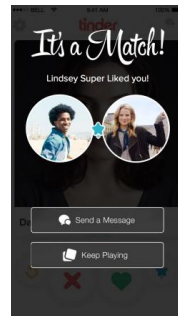
“Picking Winners” Portfolio

Picking Winners

- Venture capital



- Romance

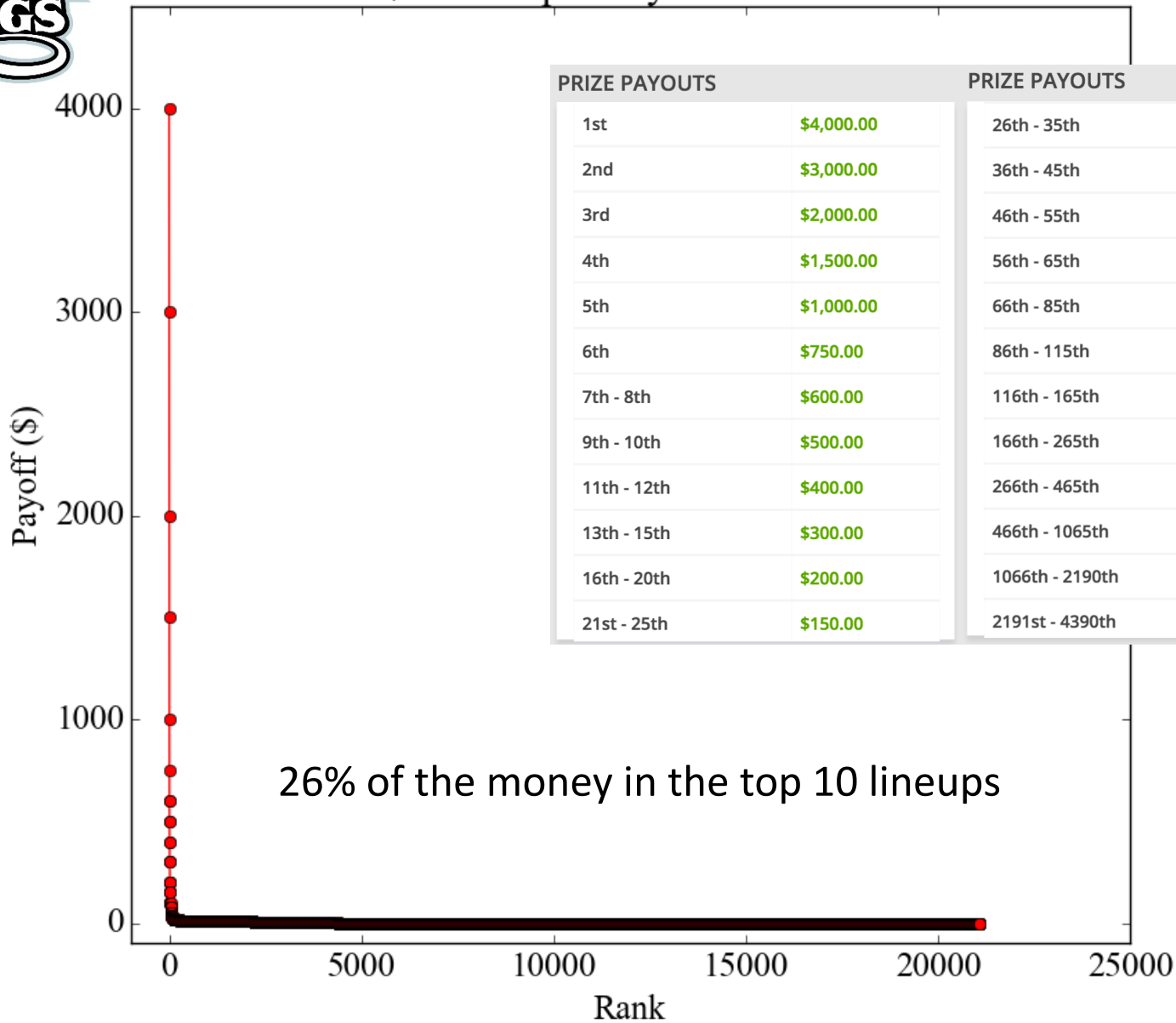


- Fantasy sports





\$55K Sniper Payoff Structure



PRIZE PAYOUTS		PRIZE PAYOUTS	
1st	\$4,000.00	26th - 35th	\$100.00
2nd	\$3,000.00	36th - 45th	\$75.00
3rd	\$2,000.00	46th - 55th	\$50.00
4th	\$1,500.00	56th - 65th	\$40.00
5th	\$1,000.00	66th - 85th	\$30.00
6th	\$750.00	86th - 115th	\$25.00
7th - 8th	\$600.00	116th - 165th	\$20.00
9th - 10th	\$500.00	166th - 265th	\$15.00
11th - 12th	\$400.00	266th - 465th	\$12.00
13th - 15th	\$300.00	466th - 1065th	\$10.00
16th - 20th	\$200.00	1066th - 2190th	\$8.00
21st - 25th	\$150.00	2191st - 4390th	\$6.00

Were we able to win?

NHL \$2K Sniper [\$2,000 Guaranteed]

Rank	Player	Score	Prize
1st	zlisto	54.50	\$150.00
3rd	zlisto	51.50	\$90.00
9th	zlisto	49.50	\$30.00
23rd	zlisto	46.00	\$18.75
28th	zlisto	45.50	\$15.00
28th	zlisto	45.50	\$15.00

November 15, 2015

NHL \$40K Sniper [\$40,000 Guaranteed]

Rank	Player	Score	Prize
2nd	zlisto	61.30	\$2,000.00
21st	zlisto	57.30	\$50.00
21st	zlisto	57.30	\$50.00
40th	zlisto	56.10	\$40.00
42nd	zlisto	55.70	\$40.00
81st	zlisto	54.10	\$0.00

November 16, 2015

NHL \$80K Tuesday Special [\$80,000 Guaranteed]

Rank	Player	Score	Prize
3rd	zlisto	54.60	\$3,000.00
6th	zlisto	52.80	\$1,000.00
7th	zlisto	52.30	\$800.00
10th	zlisto	50.60	\$600.00
11th	zlisto	50.30	\$500.00
15th	zlisto	50.10	\$0.00

November 17, 2015

NHL \$45K Sniper [\$45,000 Guaranteed]

Rank	Player	Score	Prize
1st	zlisto	52.60	\$3,000.00
8th	zlisto	49.60	\$275.00
57th	zlisto	45.60	\$50.00
57th	zlisto	45.60	\$50.00
83rd	zlisto	44.60	\$40.00
83rd	zlisto	44.60	\$40.00

November 23, 2015

200 lineups



Tauhid Zaman –
Former MIT student,
Compulsive gambler



Scott Hunter –
Current MIT student





Jason Robbins –
CEO DraftKings

Policy Change



200 lineups -> 100 lineups

Performance in Baseball

1st	 zlisto \$50,000.00	232.20 PIR 0
2nd	 geotico \$10,000.00	228.05 PIR 0
3rd	 woppen1 \$5,000.00	227.50 PIR 0
4th	 eggjockey \$3,000.00	218.25 PIR 0



Liked by [mel.a.chen](#), [sirtedb](#) and 9 others

[zlisto](#) Still a Draft God. [#dkmafia](#)

[View all 2 comments](#)

[kevincturner](#) Which sport???

Performance in Football

MY CONTESTS

● LIVE ● UPCOMING ● HISTORY

History Contests: 1

History Entries: 51

History Lineups: 0

CREATE A CONTEST »

ENTRIES

View Last 30 Days

nil



Download Entry History

Contest Name	Place	\$ Won	FPTS	Completed	Total Prizes	Top Prize	Places Paid
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	23	\$3,000	219.12	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	391	\$300	202.22	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	1123	\$150	193.62	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	1414	\$150	191.42	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	1887	\$125	188.82	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	1918	\$125	188.62	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	3889	\$75	182.02	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	3889	\$75	182.02	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	4681	\$60	180.32	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	5906	\$60	177.92	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	6829	\$50	176.32	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	7216	\$50	175.72	09/19/2016	\$5,000,000	\$1,000,000	81475
NFL \$5M Fantasy Football Millionaire [\$1M to \$5M] RESULTS »	7216	\$50	175.72	09/19/2016	\$5,000,000	\$1,000,000	81475

Fantasy Sports to Venture Capital

- Colleagues and reviewers wanted us to apply our “picking winners” technique to something more “business oriented”
- ***“We don’t play games at Sloan!”***
- So we were “forced” to apply it to venture capital

Back to Startups

- Given a predictive model, how can we select companies?

$$\max_{\mathcal{S} \subseteq [m], |\mathcal{S}|=k} \mathbf{P} \left(\bigcup_{i \in \mathcal{S}} E_i \right)$$

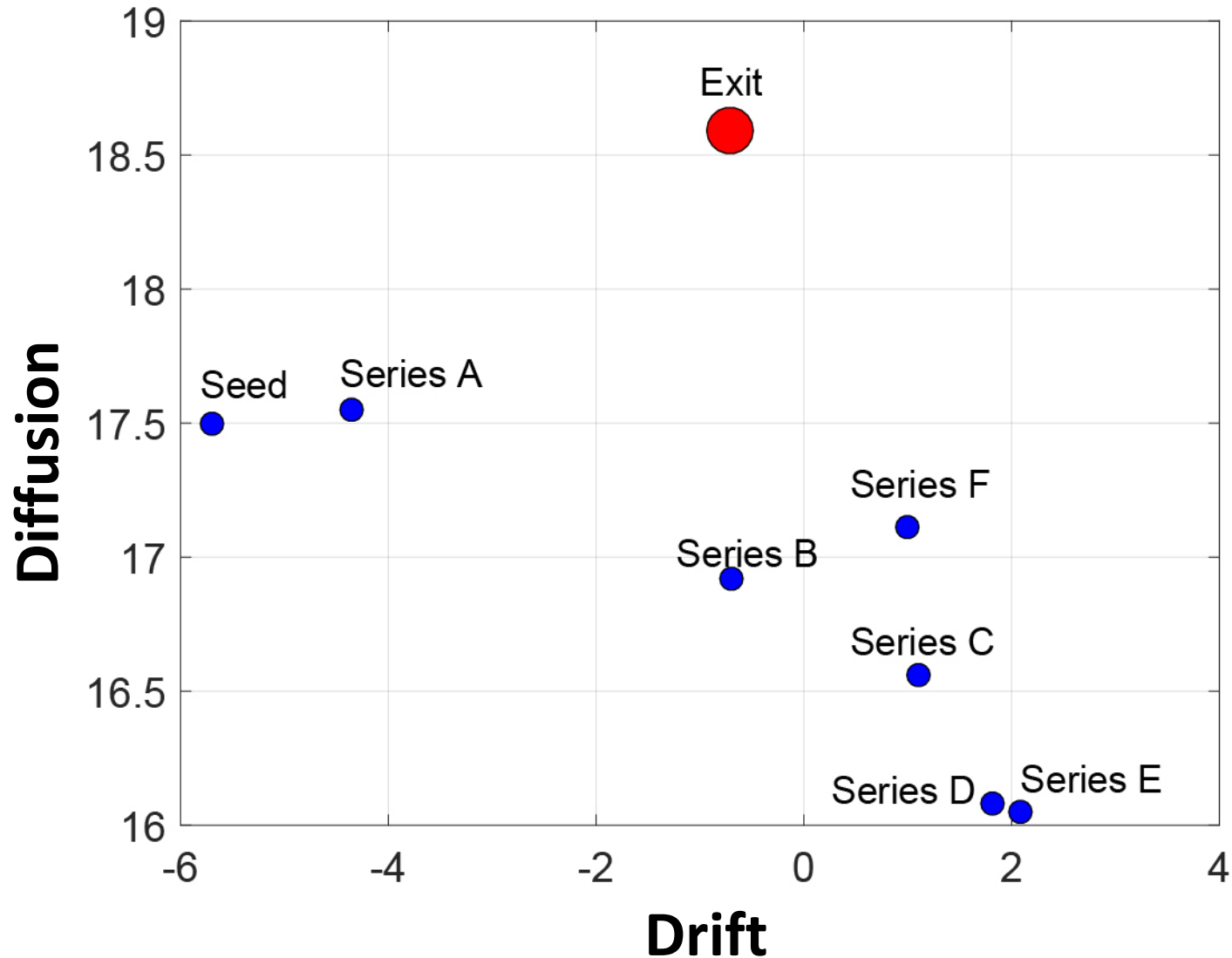
“Picking winners” portfolio

Building the Picking Winners Portfolio

- Choose observation date t_{obs}
- Estimate model using data before t_{obs}
- For companies founded the year after t_{obs} solve

$$\max_{\mathcal{S} \subseteq [m], |\mathcal{S}|=k} \mathbf{P} \left(\bigcup_{i \in \mathcal{S}} E_i \right)$$

Drift and Diffusion by Funding Round



Non-Sector Parameter Values

Drift

Non-sector feature	β_{2010}
Executive acquisition	0.80
Executive IPO	0.80
Advisory IPO	0.26
Leadership age	0.25
Maximum acquisition fraction	0.24

Diffusion

Non-sector feature	γ
Job IPO	3.31
Previous founder	3.22
Job acquisition	2.88
Top school	2.45
Maximum acquisition fraction	2.43

Sector Parameter Values

Drift

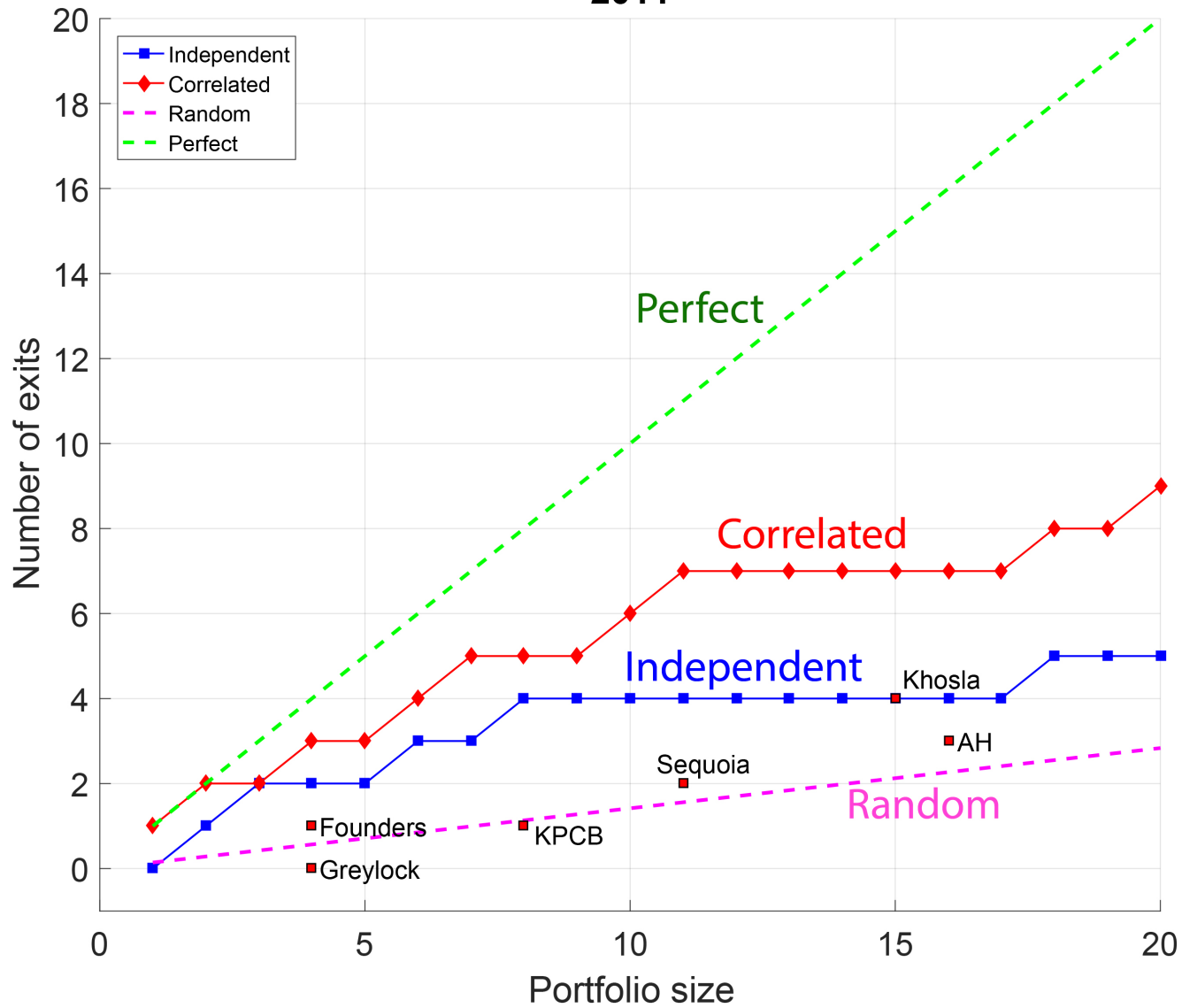
Sector feature	β_{2010}
E-learning	0.18
Ride sharing	0.14
Open source	0.13
Cloud computing	0.12
Bioinformatics	0.10

Diffusion


Sector feature	γ
Social media	4.88
Messaging	3.47
Social network	3.46
Apps	2.47
Cloud computing	1.94

Performance

2011



2011 Picking Winners Portfolio

2011 Company	Maximum funding round
SHIFT	Acquired
Jibbigo	Acquired
Sequent	Series B
Nutanix 	IPO
PowerInbox	Series A
Friend.ly	Acquired
Jybe	Acquired
MediaRoost	Seed
CloudTalk	Series A

Papers and Code

Picking Winners:

A Framework For Venture Capital Investment

<https://arxiv.org/abs/1706.04229>

Picking Winners Using Integer Programming

<https://arxiv.org/abs/1604.01455>

DraftKings baseball code

<https://github.com/zlisto/dailyfantasybaseball>

Thank You!