

**MOODY'S**

# Cyber security and its effects on financial risk

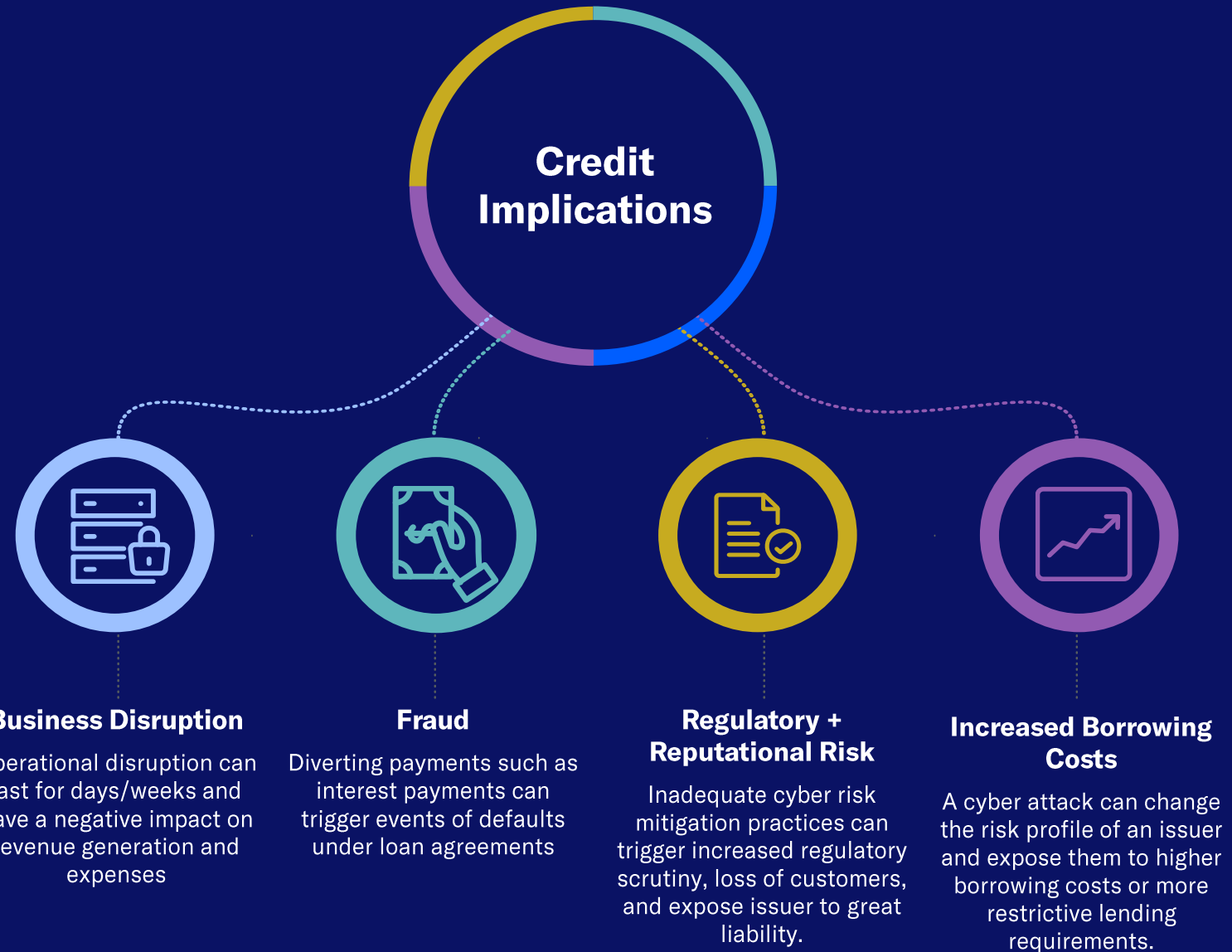
Alejandra Caro Rincon

Associate Director, Predictive Analytics

# Introduction

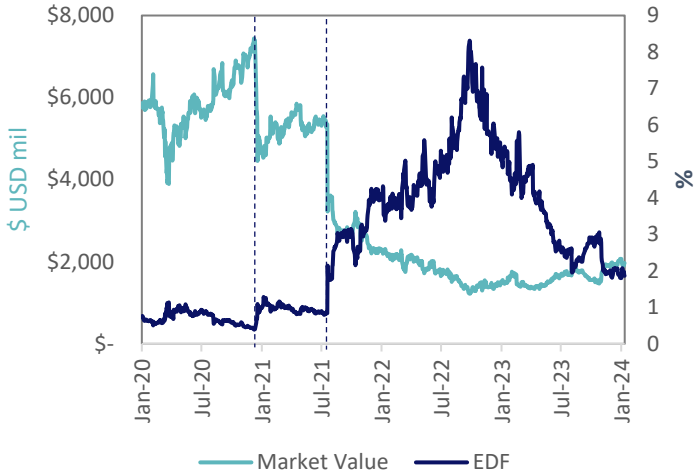
## Channels for cyber to impact credit impact

- Cyber risk is an operational risk that can have knock on effects on other risks.
- Assessing the impact of a cyber event is challenging as it doesn't always result in immediate material consequences.
- Additional factors with indirect financial implications are crucial in assessing how a cybersecurity event can directly affect credit standing.

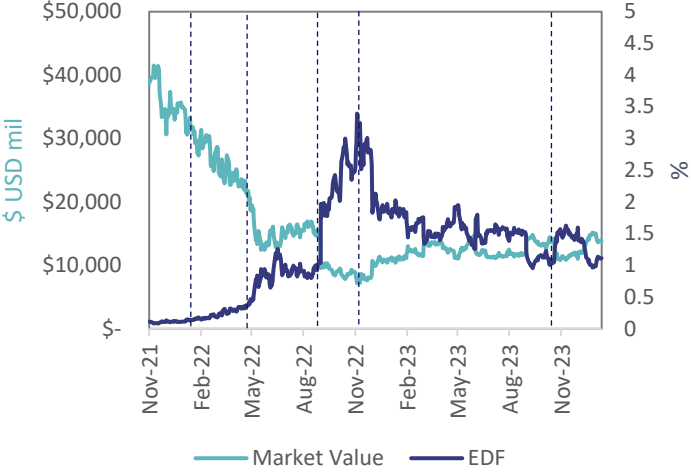


# Cyber shockwaves: Impact on credit quality

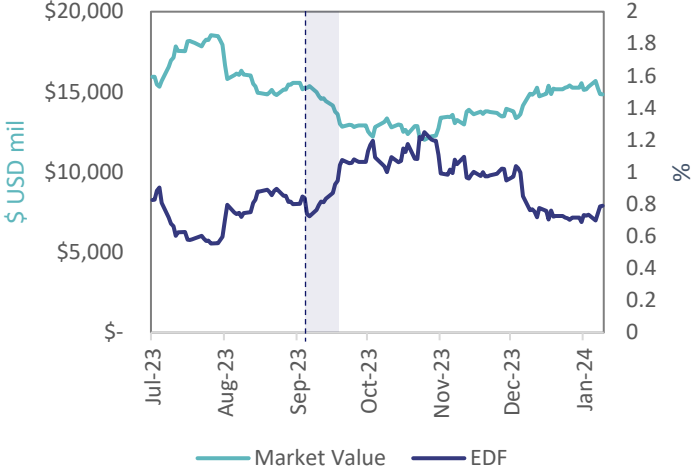
## Solarwinds



## Okta



## MGM



In December 2020, a significant cybersecurity breach involving SolarWinds's software was uncovered.

After filing form 8-K on December 14, 2020, the stock price lost 25% over the next few days and approximately **35%** by the end of the month.

In the same amount of time the PD went from from 0.39% to 0.98%.

The breaches in 2022 and 2023 exposed vulnerabilities in Okta's major clients, impacting market capitalization and credit quality immediately.

Within four months of 2022, Okta lost 40% of its market value and saw its probability of default triple.

By the end of the year the implied forward looking credit rating migrated from shifting from low to substantial risk.

A cyber attack crippled MGM's casino and hospitality operations for 10 days, during that time MGM's value slumped 14% and its forward-looking probability of default increased by 40%. Going from 0.76 to 1.75

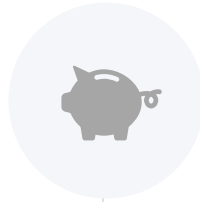
# From monitoring to risk management

## A dual risk model approach



### Probability of Cyber Event

What is the firm's probability of observing a cyber event based on their sector, size and score



### Expected Loss

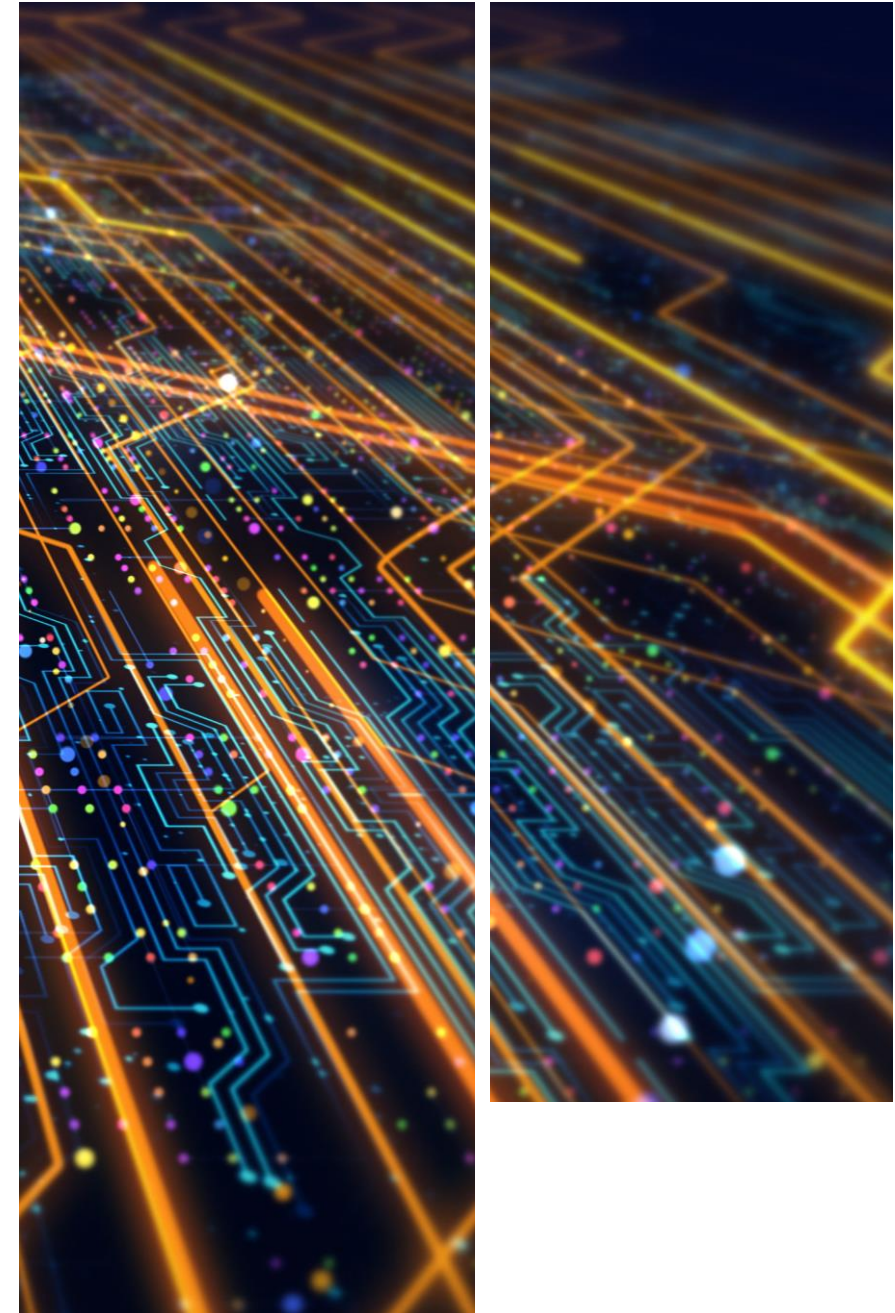
For a given event, what is the best reasonable estimate loss from a cyber event

$$P(\text{Event}) \times \text{Loss Given Event} = \text{Expected Loss}$$



### Loss Given Event

If a firm does have an event, what would the loss severity be given risk mitigants.

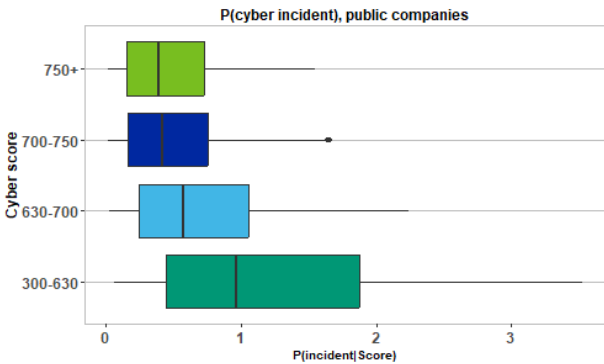


# Probability of a cyber event

## Takeaways from modeling exercise

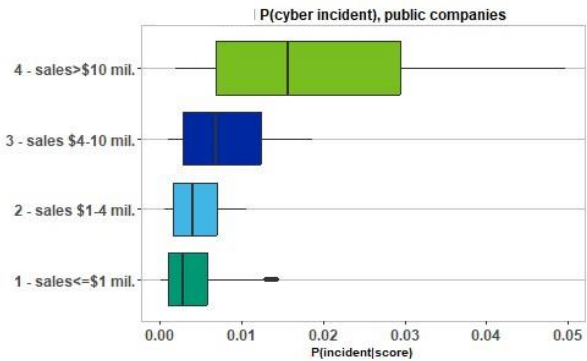
### ★★☆ Cyber security practices matter

Companies with good cyber ratings have a lower probability of a cyber event.



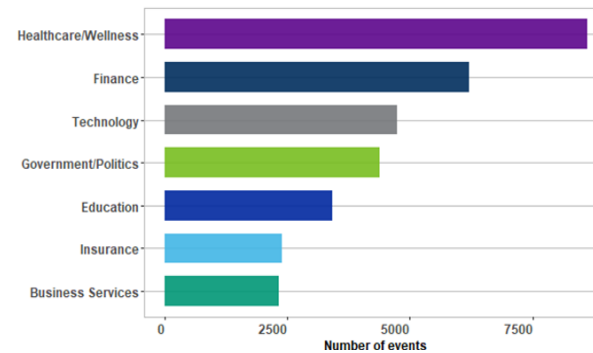
### Company size is a good predictor of a cyber event

Larger companies are more likely to be attacked



### Information relevance varies across sectors

Probability varies across industries (some sectors are more likely to get impacted than others)



### Geography matters

Controlling by country captures different regulatory frameworks.



# Loss Given Event

## Assessing the impact on market value after a cyber event

Event study approach (based on seminal paper by Campbell, Lo, MacKinlay, 1997)



Answer questions about how markets perceive and respond to **new information** (ESG controversies, earnings call, new strategy, cyber event, news).



The **Efficient Market Hypothesis** is a foundational assumption. Stock prices should adjust rapidly to new information.



Assume that market participants assess the impact of events on a firm's **expected** future profits.

These assumptions imply that the **expected returns** can be modelled  **$h$**  periods ahead.

### Key concepts

**Expected returns:** using single factor model based on a firm's beta to market.

$$R_{it} = \alpha_{it} + \beta_{it}MKT_t + \varepsilon_{it}$$

**Abnormal returns** is the difference between observed and expected returns.

$$AR_{i,t+h} = R_{i,t+h} - (\hat{\alpha}_{it} + \hat{\beta}_{it}MKT_{t+h})$$

**Cumulative abnormal returns** aggregate abnormal returns over an event window.

$$CAR_{i,t+2} = AR_{it} + AR_{i,t+1} + AR_{i,t+2} + \dots$$

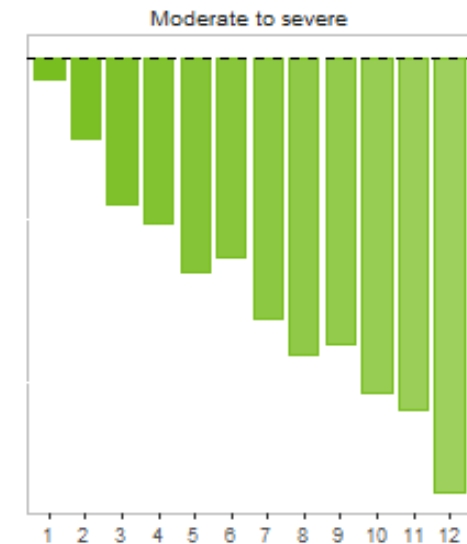
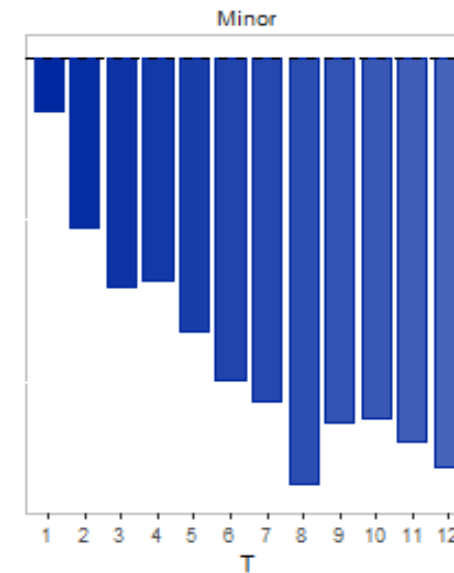
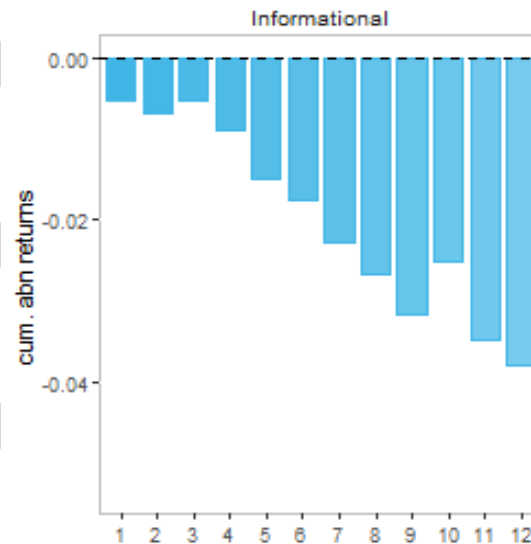
**Test:** are abnormal returns statistically different from zero? If so, the difference is the **impact** of the event

# Impact on market value given a cyber event

- We find the cumulative abnormal returns n months after events reported.
- Ran a statistical test to validate our findings
- Found that cumulative abnormal return are negative and statistically significant.
- Present average losses in terms of returns not levels.

**Average cumulative abnormal returns up to 12 months post cyber event by severity**

Event type	N	mean	t
<b>1 - month after incident</b>			
Informational	1,395	-0.54 %	-5.12089
Minor	680	-0.674%	-3.11278
Moderate to severe	1,308	-0.28 %	-2.48496
<b>2 - month after incident</b>			
Informational	1,377	-0.678 %	-4.48888
Minor	669	-2.084 %	-6.7019
Moderate to severe	1,292	-0.999 %	-6.20012
<b>12- months after incident</b>			
Informational	1,247	-3.796 %	-9.28625
Minor	610	-5.041 %	-6.0334
Moderate to severe	1,163	-5.352 %	-12.2115



# Connecting event analysis to credit risk

**Objective:** Observe how credit quality changes in the event of a cyber attack.

Structural model based on the Black-Scholes option pricing. Suggests that a company's equity is a call option on the asset value. Probability of Default (PD) is driven by three key elements:

## Assets

Market value of assets: inferred from market capitalization

## Liabilities

Default point: Threshold for asset value

## Volatility

Uncertainty of future cashflows.

- From the abnormal returns described in the event study, we obtain **observed** and **expected** market value.
- Each have an associated **observed** and **expected** PD.
- The difference is the impact on credit risk.

- The Probability of Default at time t is defined as:

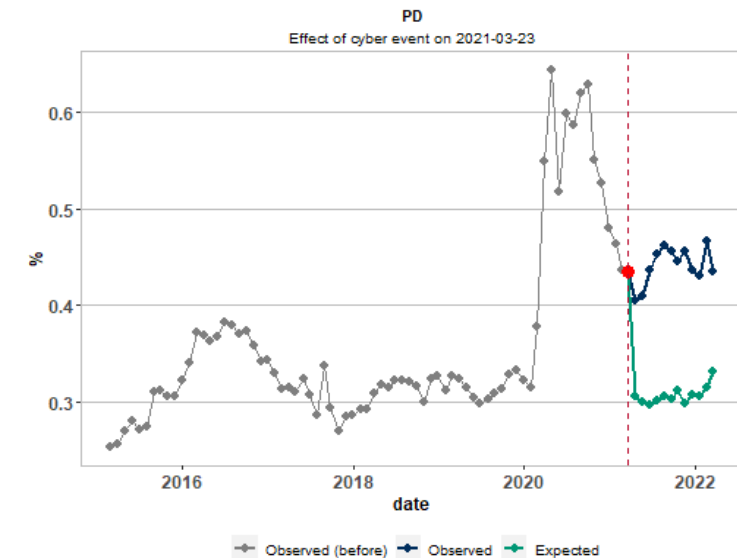
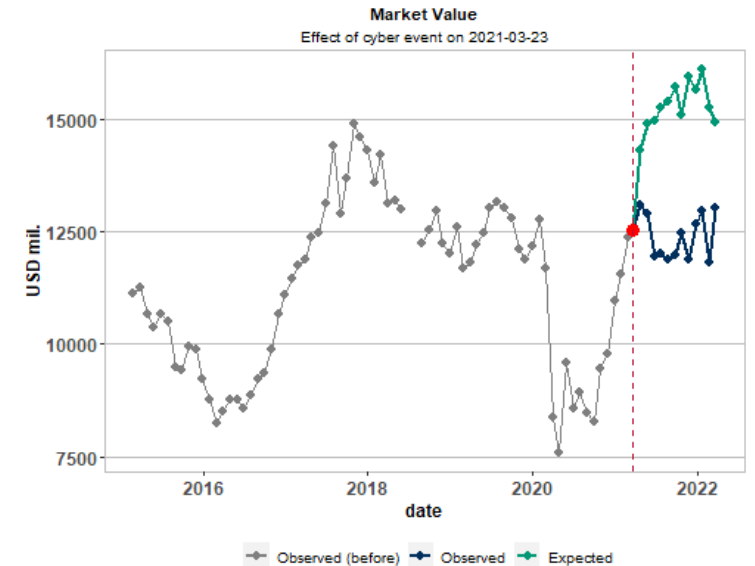
$$PD_t = Pr[A_t \leq D] = Pr[\ln(A_t) \leq \ln(D)]$$

- Market Asset value (A) is unobservable, but we infer it as follows:

$$Asset = Equity + Liabilities - Default\ risk\ premium$$

- Use the volatility of the assets and find the PD using the calibrated function:

$$PD_t = M \left[ -\frac{\log\left(\frac{A_0}{D}\right) + \left(\mu_A - \frac{1}{2}\sigma_A^2\right)t}{\sigma_A} \right]$$





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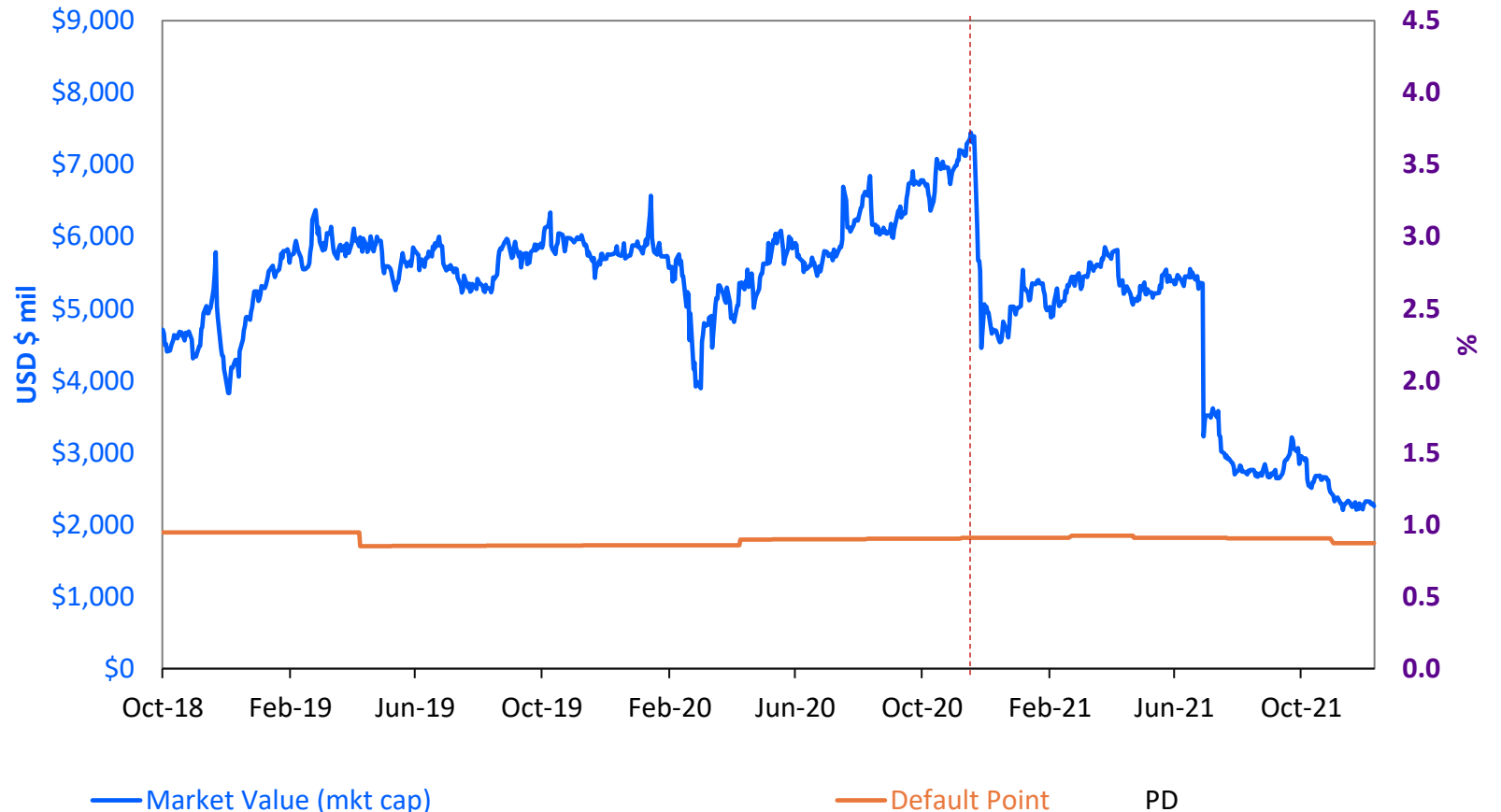
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## Solarwinds



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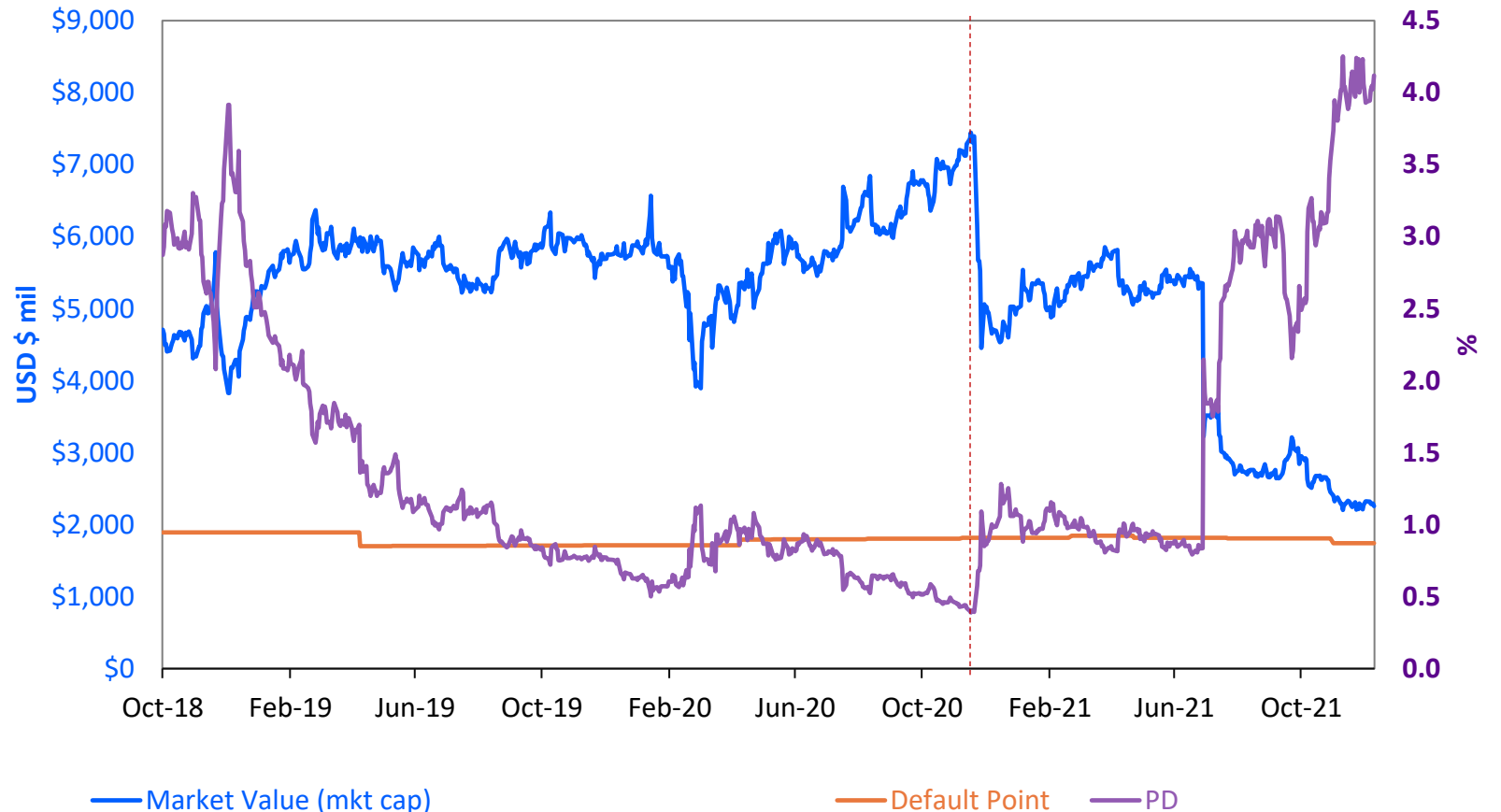
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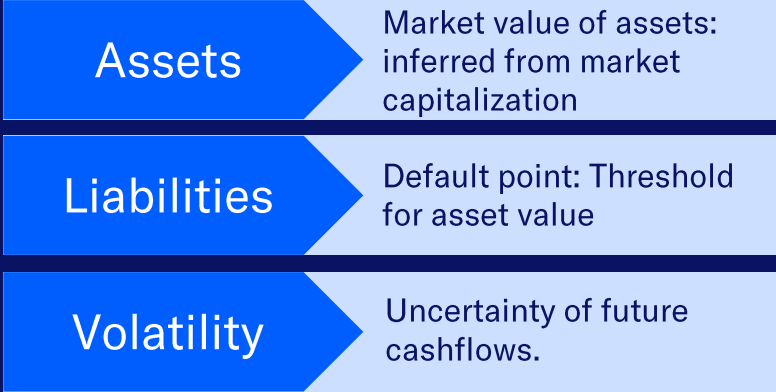


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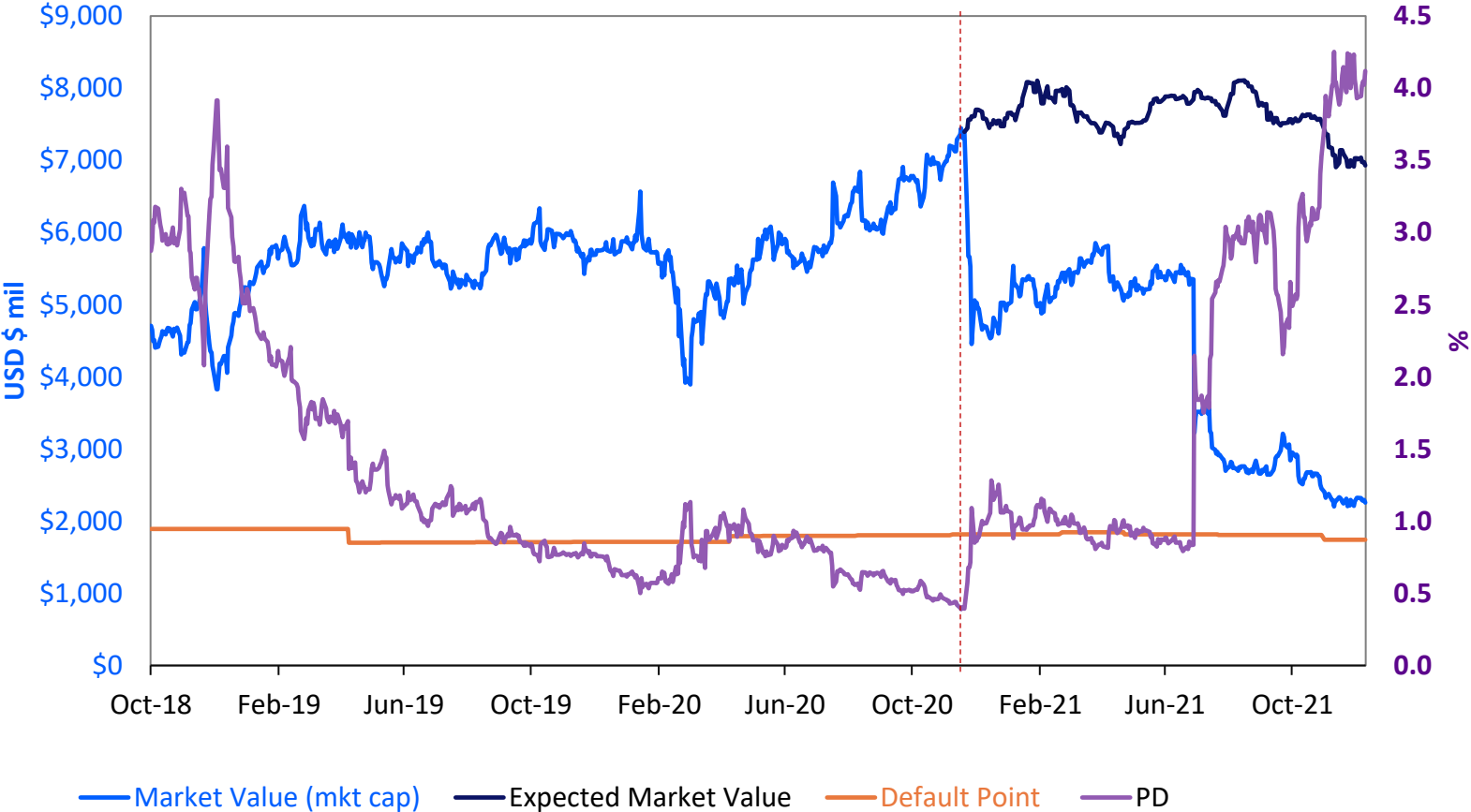
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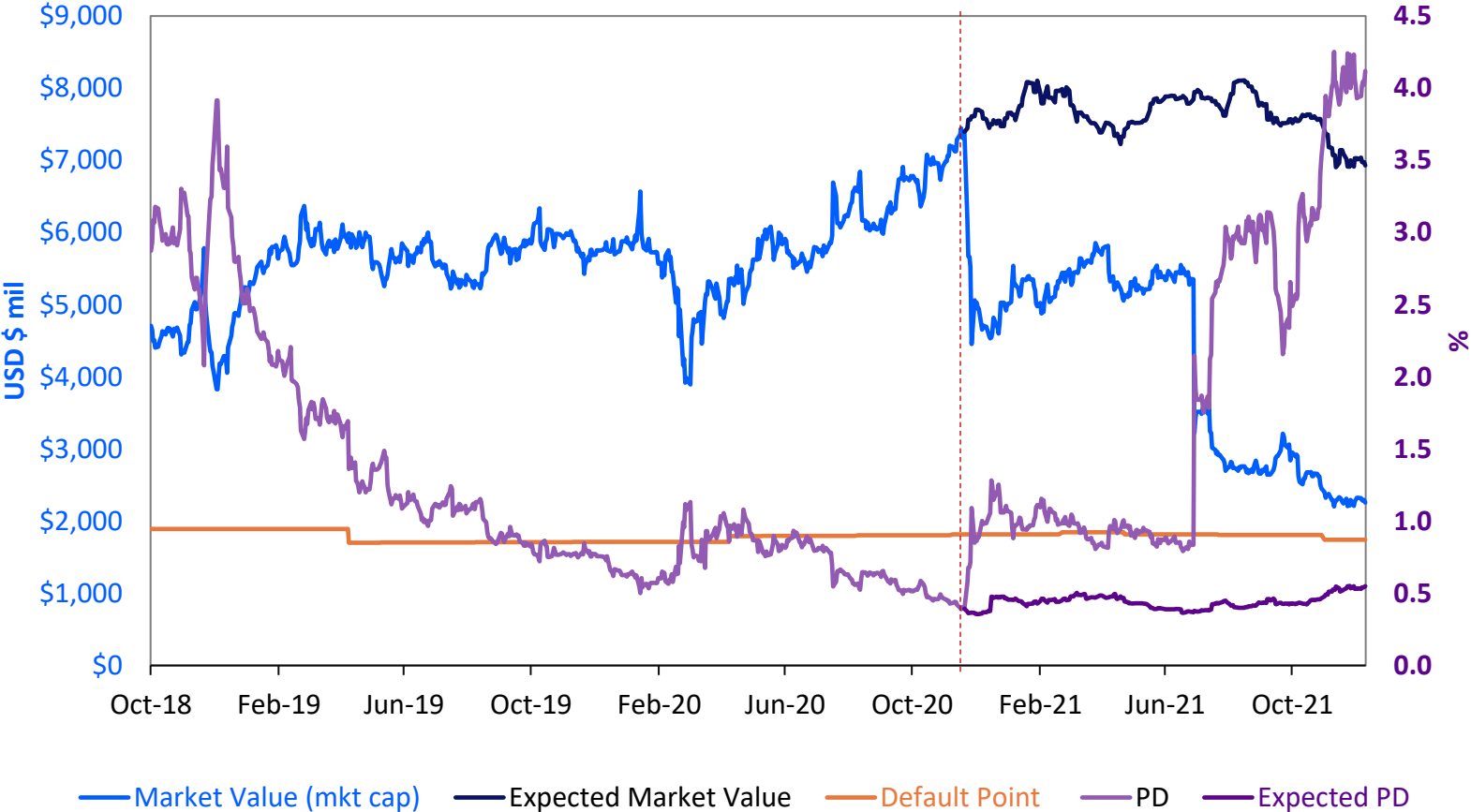
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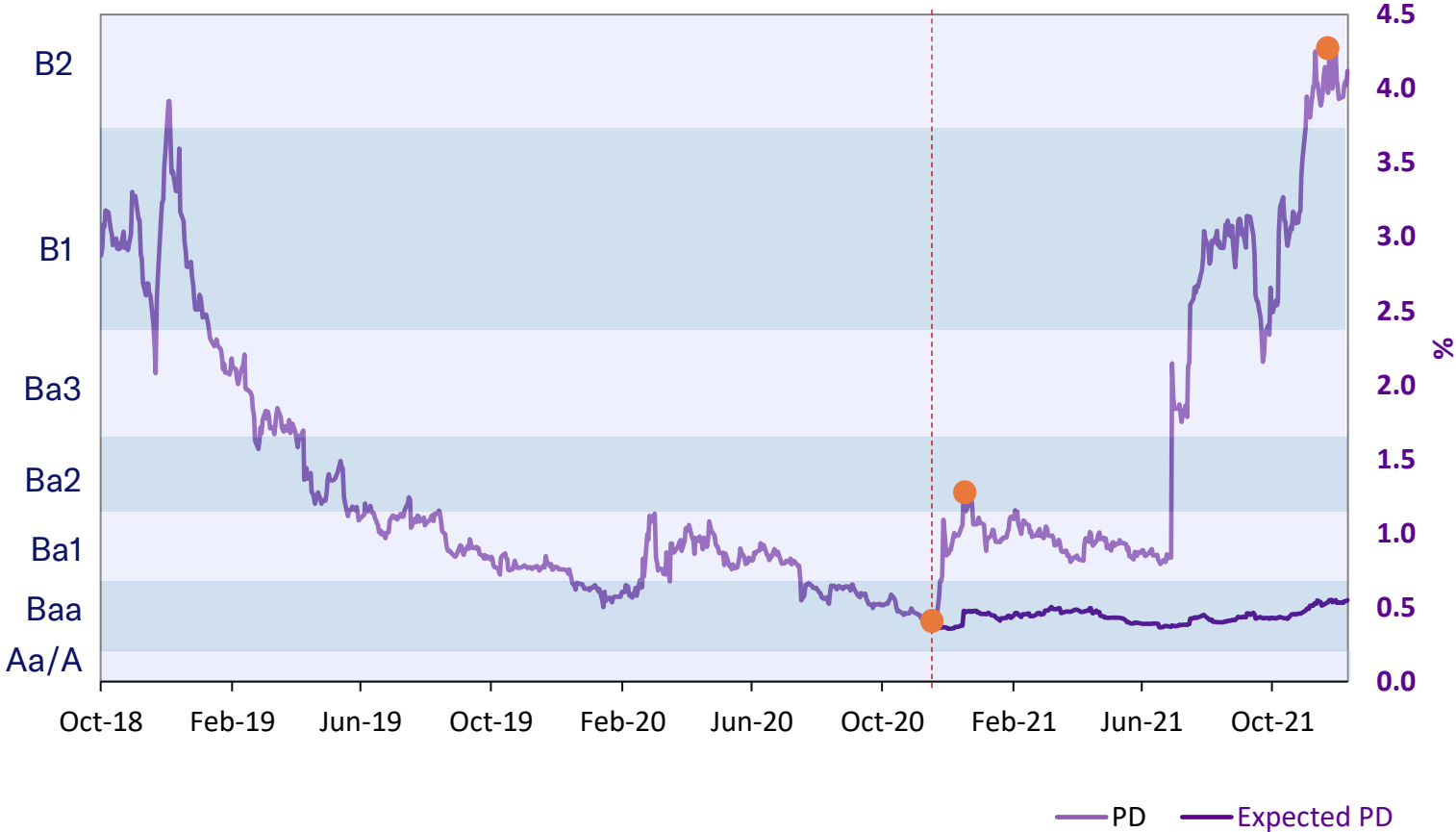
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# Connecting event analysis to credit risk

Moody's Implied ratings:

Static Rating Mapping Cutoffs		
Notch	Static Rating	1-yr Cutoff
1	Aaa	0.02%
2	Aa1	0.03%
3	Aa2	0.05%
4	Aa3	0.09%
5	A1	0.14%
6	A2	0.18%
7	A3	0.22%
8	Baa1	0.28%
9	Baa2	0.43%
10	Baa3	0.66%
11	Ba1	1.10%
12	Ba2	1.65%
13	Ba3	2.48%
14	B1	3.71%
15	B2	5.57%
16	B3	8.35%
17	Caa/C	100.00%

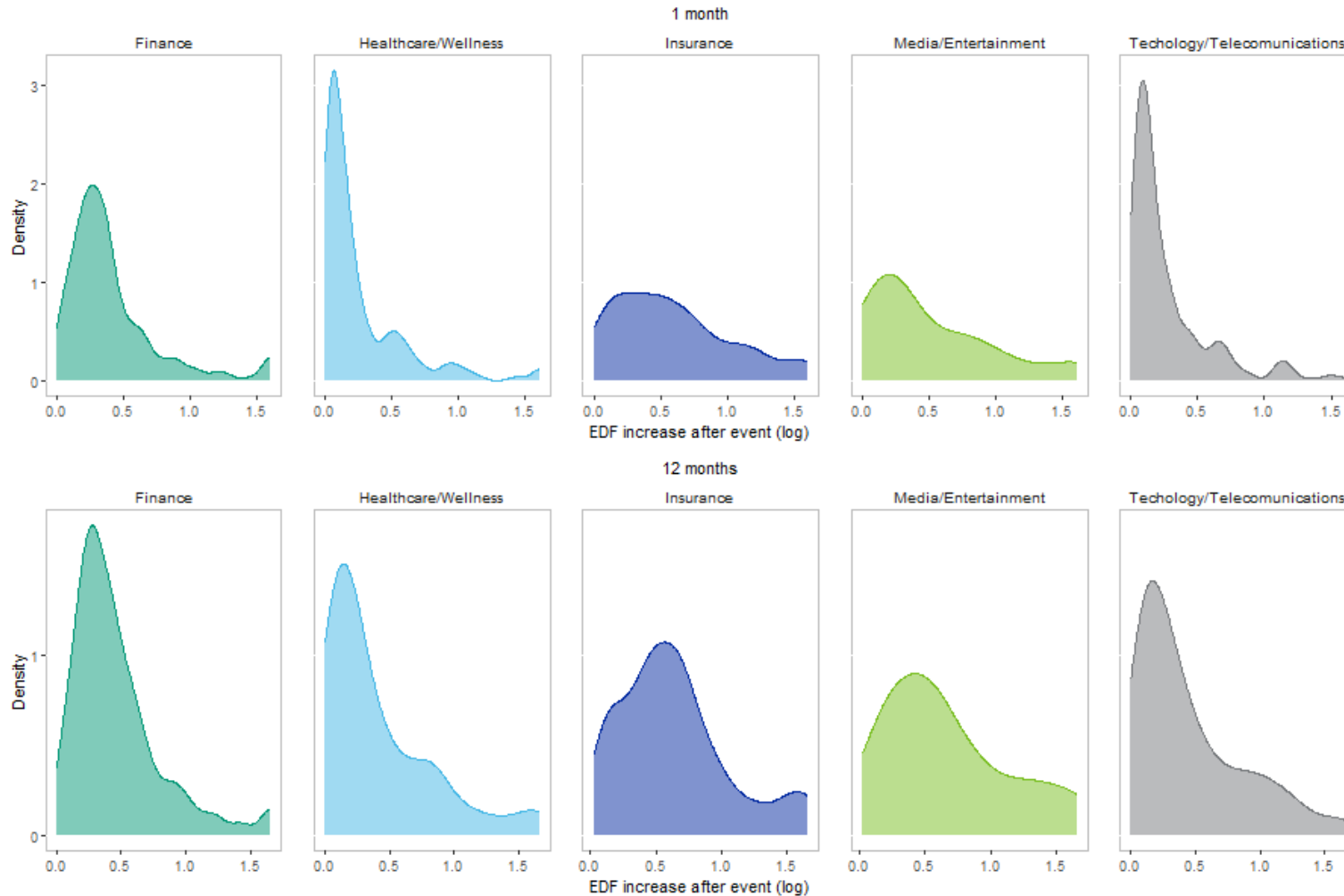
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# Connecting market return to credit risk

## Expected vs observed PD after cyber event



- Credit impact varies across industries.
- Sectors observing the largest number of attacks (finance, healthcare and technology) have the lowest increase in PD.
- There is an element of persistence over time, as PD changes increases over time.

# Takeaways

## Cyber scores matter

- Cyber hygiene score is predictive of the probability of an attack.
- Its impact varies across sectors

## Data challenges

- Under reporting diminishes the models' quality

## Cyber remains an underpriced area of risk

- There is a challenge associated to measuring cyber risk, and an opportunity to be included in healthy risk management framework

## Financial effect of cyber events tend to be persistent

- Not all cyber events have a material impact.
- On average, those that do, have a persistent event over time.



Thank you

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