Expanding our cybersecurity factors to global markets

November 2019

Research Signals

Cybersecurity risks are increasingly important, not only for the financial impact from the interruption of internal business processes, but additionally in light of punitive damages from regulations such as the General Data Protection Regulation in Europe which applies to all enterprises that collect the personal data of individuals under its jurisdiction, regardless of location. Recent high profile cyber attacks this year include that of **German industrial firms** BASF, Siemens and Henkel in July, along with **Airbus** and **Visma** which were targeted by hackers as reported in February. Given the pervasiveness of cyber risks, we partnered with BitSight Technologies in early 2018 to introduce factors derived from their Security Ratings that quantify cybersecurity risks to enhance stock selection and portfolio risk management. We now introduce expanded coverage of the factors for our global universes and report our findings.

- BitSight captures company-specific cybersecurity risk through a proprietary process, providing quantifiable Security Ratings which have identified a relatively weak trend in cybersecurity performance overall globally, though with improvement in Europe since the new regulatory environment has been in place
- We find BitSight Security Ratings are predictive of data breach events, and such events on average have a negative impact on excess stock price returns over the first 10 days from when a breach is identified, including -58 bps and -149 bps in Developed Europe and Emerging Markets, respectively, with persistence out to 60 days
- Our research suggests BitSight Ratings are unique signals from ESG factors and a combined strategy proved effective in most regions with an improvement in 1-month decile spreads over the stand-alone ESG factor ranging from 8 bps in Developed Europe to 45 bps in Latin America

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Introduction

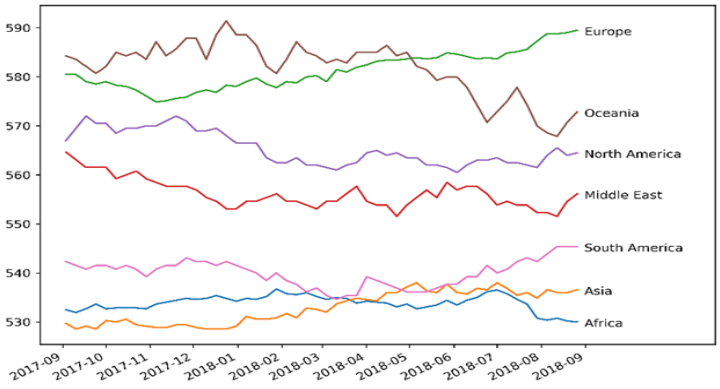
In February 2018, we **introduced** a set of cybersecurity factors designed to assess cyber risk in companies' ecosystems using critical cybersecurity intelligence on organizations. Data breaches can cause significant damage to companies' finances and brand reputation resulting in revenue loss and customer churn, according to a recent **study** of 113 afflicted companies, ultimately impacting the stock price with an average decline of 5% the day a breach was disclosed. Corbet and Gurdgiev's (2017) investigation of 819 observed incidents of cybercrime further confirms increased stock price volatility particularly for cyber events in the form of hacking, larger data breaches and smaller market capitalization firms, while Rosati et al. (2017) found increased bid-ask spreads and trading volume the day of 74 sampled data breach announcements.

In May 2018, the General Data Protection Regulation (**GDPR**) went into effect in Europe, with EU regulators taking aim at how companies protect personal information and disclose breaches, and how they are penalized for breaches. The intention of the GDPR is to protect citizens from privacy and data breaches by harmonizing data privacy laws across Europe and reshaping the way companies approach data privacy. The regulation's broad territorial scope means the regulation is applicable in any case where data on EU citizens is collected, whether or not the company is based in the EU.

Since the regulation has been in place, BitSight has found that cybersecurity performance in Europe has **improved**, while remaining weak overall globally (Figure 1). In the US, the state of California has taken the first steps toward a similar national regulation, a concept fully **supported** by Apple CEO Time Cook, with the approval of the **California Consumer Privacy Act of 2018**, scheduled for enforcement in 2020.

Figure 1

Cybersecurity performance by continent



Source: BitSight Technologies

The ubiquity of cyber risks and the current regulatory environment expose the need for a sophisticated measurement of cyber risk. In 2011 BitSight Technologies pioneered the security ratings market, providing Security Ratings that are objective, verifiable and actionable on tens of thousands of companies worldwide. The normalized systematic measurements quantify a company's security performance to produce daily security ratings ranging from 250 to 900, with a higher rating indicating better security performance.

The remainder of this report describes our research of the BitSight security ratings and our cybersecurity factor suite. We begin by reviewing the dataset used in the study and our proprietary factors derived from the data. Next, we demonstrate the ability of BitSight Ratings to predict data breach events and the impact of such events on stock returns. We then turn to the performance characteristics and correlation of BitSight Ratings to traditional factors. We also walk through case studies

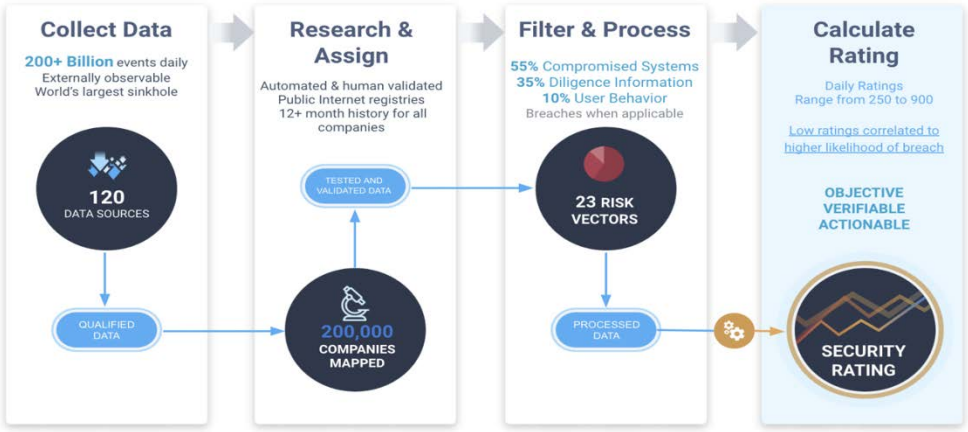
where BitSight data identified cybersecurity risk prior to breach events. Finally, we introduce an application for cybersecurity factors in conjunction with an ESG strategy.

BitSight data

BitSight analyzes existing security incidents and practices and applies sophisticated algorithms to produce the Security Ratings (Figure 2).

Figure 2

How BitSight Security Ratings are calculated



Source: BitSight Technologies

More specifically, BitSight collects externally available internet data on security performance gathered from over 120 sources looking for malicious activity, social chatter, vulnerabilities and configuration diligence across the globe. With this data, BitSight produces daily Security Ratings by using a proprietary algorithm based on the following four dimensions:

- Compromised systems – captures risk from devices that are infected with malware and includes botnet, spam, malware server, potentially exploited applications and unsolicited communications
- Diligence – gauges efforts to reduce risk, including patching cadence, open ports and application security
- User behavior – assesses the behavior of users at the company, specifically file sharing
- Data breaches – measures actual data breach occurrences and is included when applicable

The final rating is a weighted average of these four main classes of data, with compromised systems representing the greatest weight. (See the academic **research paper** for detailed analysis of security risk assessment.) BitSight suggests Ratings from 250-639 indicate Basic cybersecurity risk mitigation, Ratings 640-739 indicate Intermediate mitigation, and 740-900 shows Advanced mitigation. BitSight Ratings are typically used to help organizations manage their own security performance, mitigate third party risk, underwrite cyber insurance policies, conduct M&A due diligence and assess aggregate risk. The use of the BitSight Ratings for stock selection and portfolio management is a novel application.

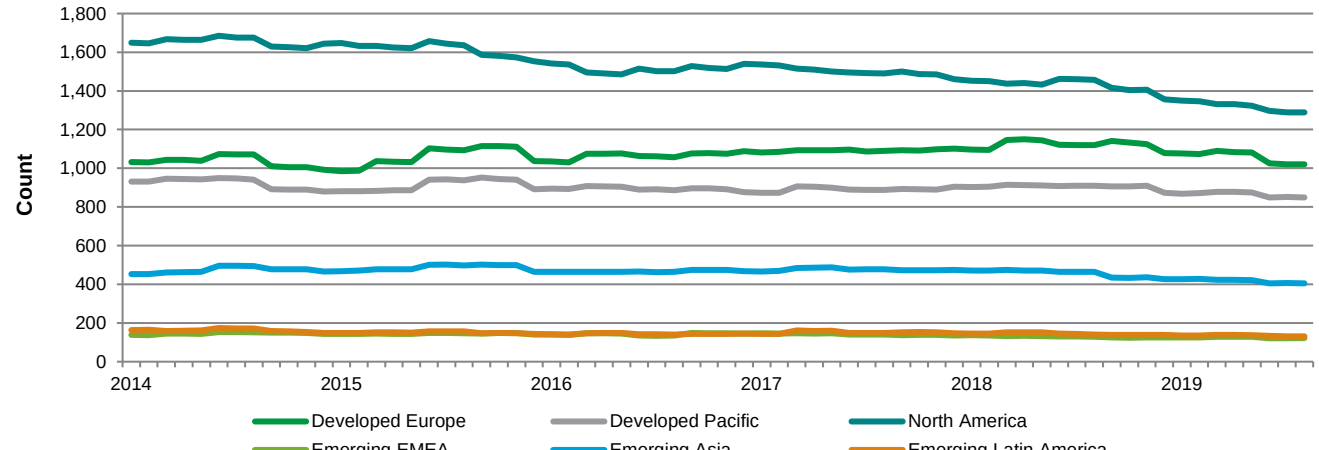
Factor introduction and descriptive statistics

Research Signals introduced a total of 35 factors in our Cybersecurity suite including the key BitSight Rating, 18 scores from the BitSight risk vectors, and 16 derived factors measuring changes and volatility in ratings, z-scores, industry and sector positioning and impact of data breaches (see the Appendix for the full list of factors and their definitions). The data can in turn be easily plugged into existing processes allowing for individual stock and portfolio assessment of cybersecurity risk based on a normalized systematic measure.

We have mapped the data from BitSight to an expanded set of stock identifiers from several regional universes[1] outside the US. Coverage begins in January 2014 and has averaged over 4,200 names, standing at 3,817 names as of September 2019. By region (Figure 3), North America[2] has the broadest coverage averaging 1517 names, capturing 90% of the universe at the most recent observation (Table 1), followed by Developed Europe (1074) and Developed Pacific (901), representing 72% and 41% of the underlying universes, respectively. As anticipated, emerging markets coverage is lower than their corresponding regional developed markets.

Figure 3

BitSight Rating coverage



Source: IHS Markit

Table 1

BitSight Rating coverage, Sep 2019

Region	Coverage	Percentage coverage
Developed Europe	1074	72%
Developed Pacific	901	41%
North America	1517	90%
Emerging EMEA	139	32%
Emerging Asia	466	25%
Emerging Latin America	149	47%

Source: IHS Markit

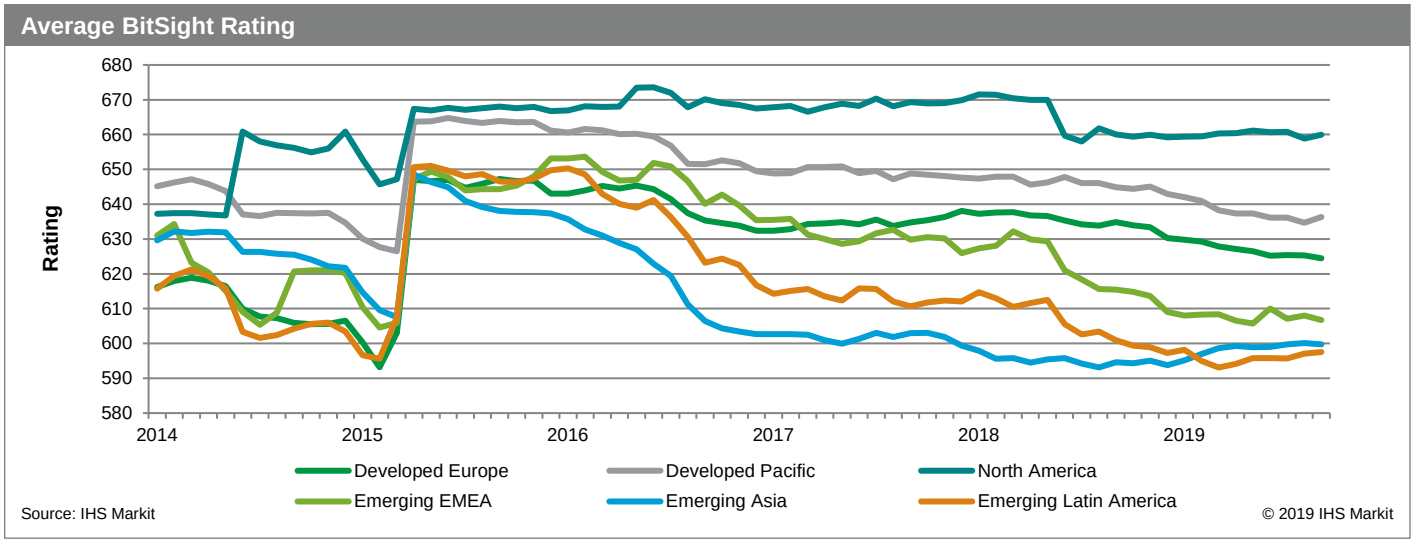
Over time, the average Rating (Figure 4) tended to be the highest in North America, ranging between 637 and 674 over this period and now residing at 660. Not surprisingly, emerging market ratings are the weakest on average. We also draw attention to Developed Europe and Emerging EMEA average Ratings, and compare and contrast our results with that cited

[1] Our global universe covers 95% of cumulative market cap for each member country subject to minimum market cap of USD 250 Mn and 100 Mn for developed and emerging markets, respectively

[2] North America coverage is lower than that cited in our original publication given that our global universe covers 95% of cumulative market cap for each member country, as opposed to the US Total Cap universe which covers 98%

by BitSight Technologies (see Figure 1 above), particularly since May 2018 when the GDPR took effect. Based on our results, we do not see a clear impact of GDPR on Developed Europe, and actually see the average Rating noticeably drop for Emerging EMEA, though the averages we report are higher. However, since we are looking at universes of fairly large, publicly traded companies, GDPR may not have had as much of an impact on their cybersecurity practices as cybersecurity was of key focus well before GDPR, while smaller private companies were perhaps more reactionary to the new regulation.

Figure 4

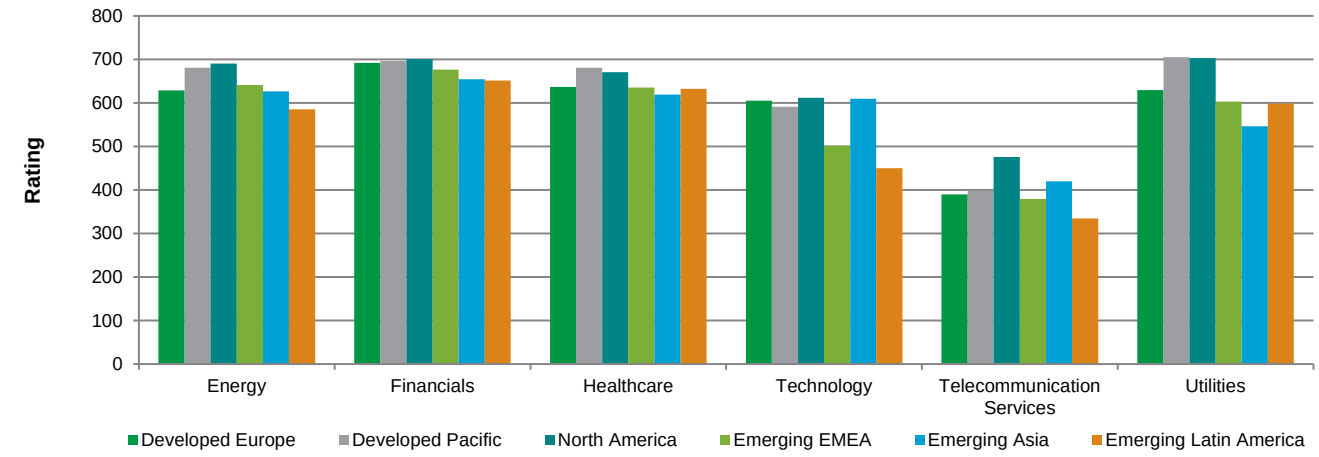


Taking a closer look at the distribution of BitSight Ratings across sectors and industries, we find interesting variations between groups (see Tables A1 and A2, respectively, in the Appendix for a complete list of average Ratings). Highlighting a few sectors of interest (Figure 5), we see that Financials scored the highest in general across each region, with Banks and Financial Services – Diversified among the stronger industry subgroups, indicative of the constituents' position as having the most to lose, and is in line with our observations from the US dataset. On the other hand, Technology and Telecommunication Services have been the weakest sectors for most regions. We note that many companies in these two sectors are considered service providers, meaning they are companies that handle or deliver services for other companies, such as web hosting, certificate signing, cloud infrastructure services or email hosting. The nature of this business can lead to lower security ratings since the service providers are exposed to the activities of their customers. These observations indicate an industry adjustment may be warranted, which we address in our factor calculations. One notable difference across regions at the sector level is Utilities' strong score for North America and Developed Pacific, while representing one of the weaker sectors in emerging markets.

At the industry level, some interesting observations include relatively higher scores in Developed Europe for Retailers (660) along with Semiconductors (650) in the poorly scoring Technology sector, while Hotels & Entertainment Services (583) and Media & Publishing (551) resided at the opposite extreme. In Developed Pacific, Real Estate (720) and Food & Drug Retailing (705) sat opposite Aerospace & Defense (600) and Automobiles & Auto Parts (588) on the spectrum of scores. In North America, the top scoring industry on average is Renewable Energy (774), while poorly scoring industries include Hotels & Entertainment (616) and Media & Publishing (587). In emerging markets, Retailers attained respectable ratings, scoring above average in EMEA (673), Asia (662) and Latin America (633).

Figure 5

BitSight Rating sector averages, Jan 2014 - Sep 2019

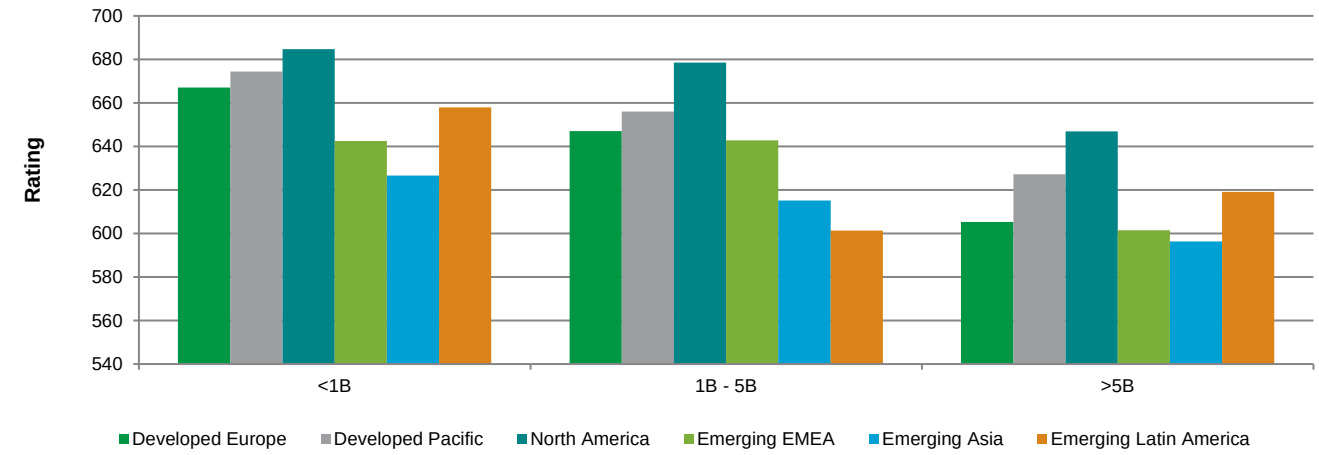


Source: IHS Markit

Lastly, we evaluate BitSight Ratings (Figure 6) across company size (in US dollars), from small caps (<1B) to large caps (>5B). Large caps consistently have lower Ratings, averaging 605 for example in Developed Europe since January 2014, compared with 667 for the smallest cap names. The next largest spread is associated with Developed Pacific, with average scores of 674 for the smallest cohort of stocks compared with 627 for the larger cap group. Overall, Ratings tend to move inversely with market cap, indicating higher vulnerabilities as companies grow in size.

Figure 6

BitSight Rating market cap averages, Jan 2014 - Sep 2019



Source: IHS Markit

Data breach prediction

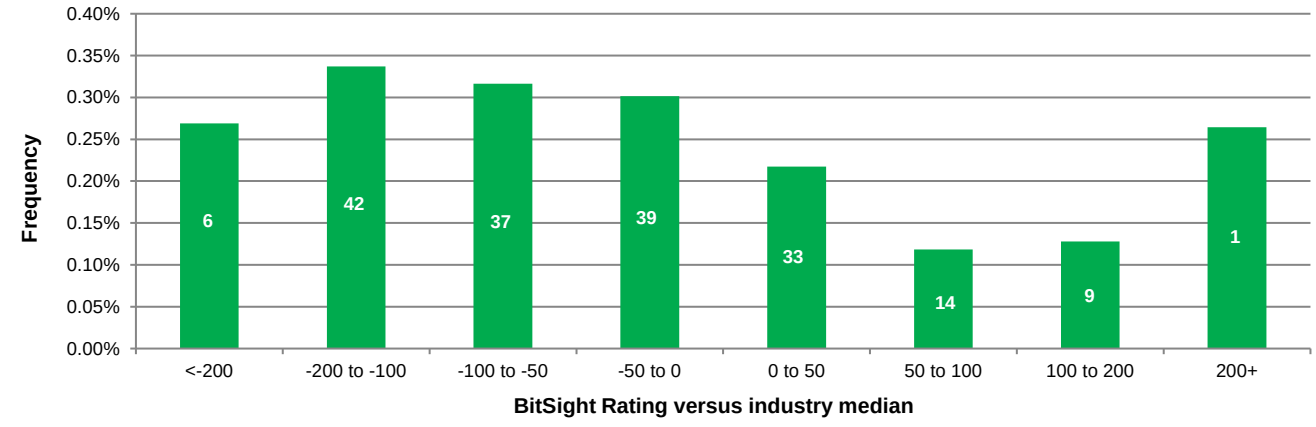
We now present results based on the predictability of BitSight Ratings. Two aspects are considered, namely the prediction of breach events and the implication for stock prices. Beginning with breach prediction, we compute the frequency of data breaches based on firms' BitSight Ratings relative to the industry median (Figures 7 - 10) for stocks in our investible universe. Given the low number of breaches in Emerging Markets, we combine the three relevant regions for more meaningful statistics for this analysis. We also report the number of breaches on the charts to add more insight into the frequency percentages.

Based on our independent results, we find that, while breaches are rare overall (see Figures A1 – A4 in the Appendix for the number of breaches by quarter), firms with the weakest scores tend to be the most likely to experience a data breach within the following month. In Developed Europe, a breach frequency of 0.27% was found in the <-200 group, alongside an elevated level of 0.34% in the -200 to -100 range. (We remark that only one breach was recorded in the 200+ group, but resulted in a frequency of 0.26% due to the limited number of observations.)

The average frequency for the remaining groups registering below the industry median is 0.37% compared with 0.18% in the 0 to 200 range, while no breaches were recorded in the 200+ group. These findings corroborate BitSight's research on the ability of the BitSight Rating to predict data breaches on public and private companies. North America shows the most consistent relationship between BitSight Rating and breach frequency, and we remark that the region has the highest number of data breaches to analyze, perhaps reflecting the lack of transparency in disclosure present in other regions.

Figure 7

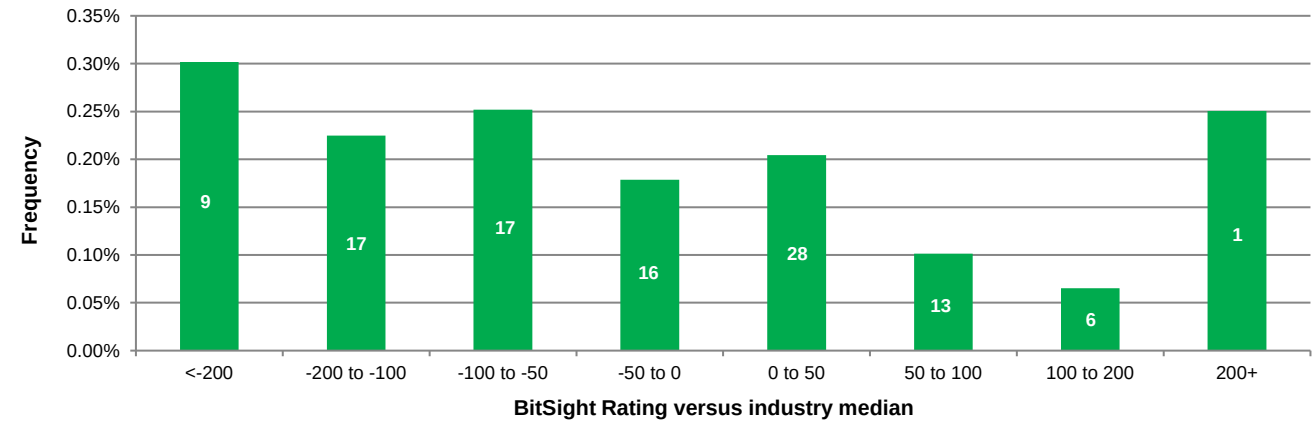
Developed Europe data breach frequency for industry-relative BitSight Ratings, Jan 2014 - Jul 2019



Source: IHS Markit

Figure 8

Developed Pacific data breach frequency for industry-relative BitSight Ratings, Jan 2014 - Jul 2019



Source: IHS Markit

Figure 9

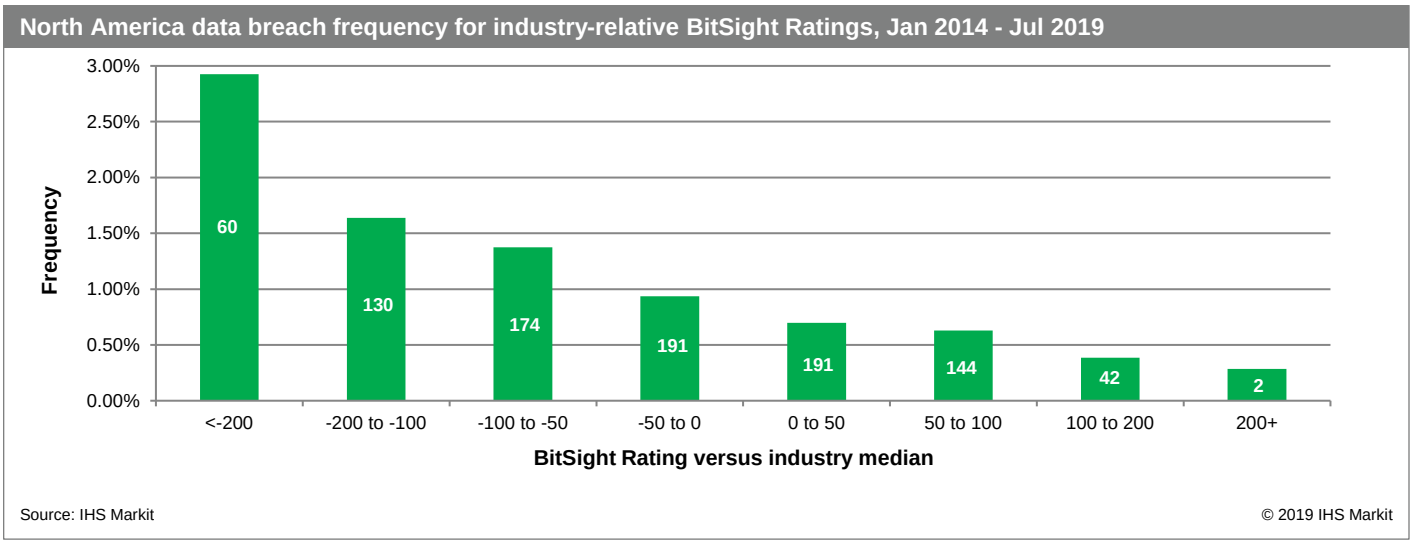
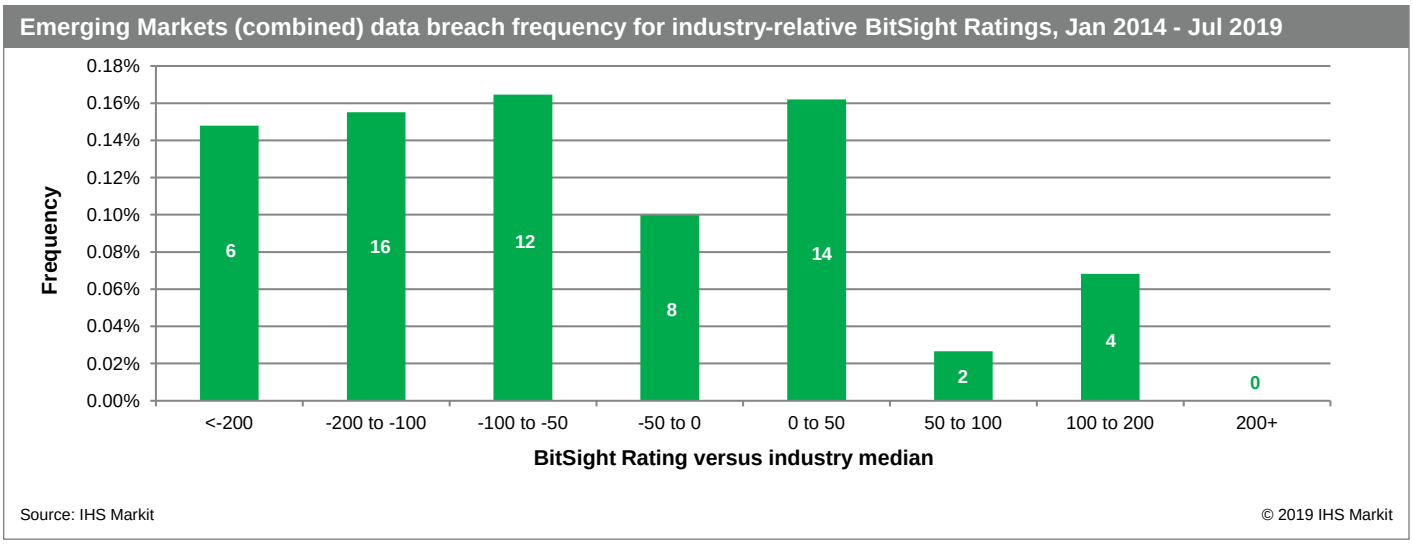


Figure 10



Turning to stock price movement around the time of data breaches, we perform an event study of the occurrences that took place during our analysis period. First, we narrow our analysis to 575 breaches across the regions where the information about the data breach was made public and captured by BitSight within 90 days of the breach occurring to filter out stale data breach announcements. We report average BitSight Ratings and average Rating versus the industry median for these breaches, along with excess returns (relative to the SPDR S&P 500 ETF) over various horizons starting from the day the breach was added to the database (Table 2). Results are broken out by severity level, where 0 severity indicates a breach occurred but 0 records were lost, 1 indicates 1-10 records were lost, 2 indicates between 11 and 100,000 records were lost, and 3 is the most severe, meaning that >100,000 records were affected by the data breach.

As expected, stock prices in general tend to underperform following the date that a data breach is known to the market. However, we find stock returns do not react the same to data breach events in different markets, and varying severity levels may have distinct reactions (albeit with small sample sizes in many cases). In Developed Europe, we find that stock prices tend to decline over the first three to five days following the breach and continue to decrease out to 40-days after the event before plateauing at the 60-day mark.

Developed Pacific shows weaker results overall. Immediate responses to the overall set of breaches was not negative (3-day: 0.12%); however, returns turned negative out to 10-days, with the largest declines associated with the severity

classification of 1 (66 bps). We observe negative returns out to 20-days in the market, with returns mean reverting over the 40-day period on average.

Not surprisingly, North America shows results closest to what we observed in the US report. The returns tend to decline over the first 10 days subsequent to a data breach, and then revert up. Excess returns for the lowest severity breaches remain positive over each horizon, while the weakest returns are associated with the severity classifications 1 and 3.

Lastly, Emerging Markets experienced the largest drawdowns across all breaches at the 3-day (-0.88%) out to 10-day (-1.49%) period, with more extreme results for the severe occurrences, though we remark that only 2 observations are included at this level. On average, excess returns are -2.17% at the 40-day time horizon.

Table 2

Data breach occurrences and excess returns, Jan 2014 – Jul2019

	Severity	Count	Average BitSight Rating	Average distance from industry median	Average 3-day excess return (%)	Average 5-day excess return (%)	Average 10-day excess return (%)	Average 20-day excess return (%)	Average 40-day excess return (%)	Average 60-day excess return (%)
Developed Europe	All	120	579	-59	-0.32	-0.27	-0.58	-1.45	-2.95	-2.82
	0	46	574	-71	-0.35	-0.35	-1.50	-2.63	-3.82	-4.79
	1	27	559	-64	-0.74	-0.90	-0.76	-0.69	-0.47	1.64
	2	35	607	-45	0.51	0.70	1.37	-0.14	-3.67	-3.51
	3	12	562	-42	-1.63	-1.37	-2.36	-2.44	-3.04	-3.27
Developed Pacific	All	83	573	-57	0.12	-0.02	-0.26	-1.00	0.48	0.98
	0	27	574	-60	-0.48	-0.36	-0.61	-1.86	-1.22	-0.37
	1	23	560	-72	0.23	-0.16	-0.66	-0.80	2.86	3.17
	2	23	601	-39	1.01	0.49	0.41	-0.67	0.13	0.82
	3	10	539	-59	-0.53	0.04	0.07	0.09	0.43	-0.08
North America	All	322	582	-52	-0.13	-0.35	-0.16	-0.09	-0.41	-0.22
	0	111	551	-91	0.25	0.11	0.39	0.77	1.12	0.86
	1	80	614	-20	-0.31	-0.72	-1.17	-1.94	-2.40	-2.02
	2	107	589	-38	-0.16	-0.30	0.33	0.50	-0.92	-0.18
	3	24	581	-35	-1.16	-1.39	-1.48	-0.55	1.40	0.67
Emerging Markets (combined)	All	50	570	-75	-0.88	-1.26	-1.49	-0.88	-2.17	-2.12
	0	11	555	-100	-2.04	-2.52	-3.14	-3.21	-2.95	-4.78
	1	16	579	-77	-0.18	-0.02	-0.22	1.52	2.46	0.79
	2	21	575	-59	-0.62	-1.01	-1.03	-1.89	-5.38	-3.10
	3	2	530	-95	-2.92	-6.97	-7.41	3.40	-1.27	-0.55

Source: IHS Markit

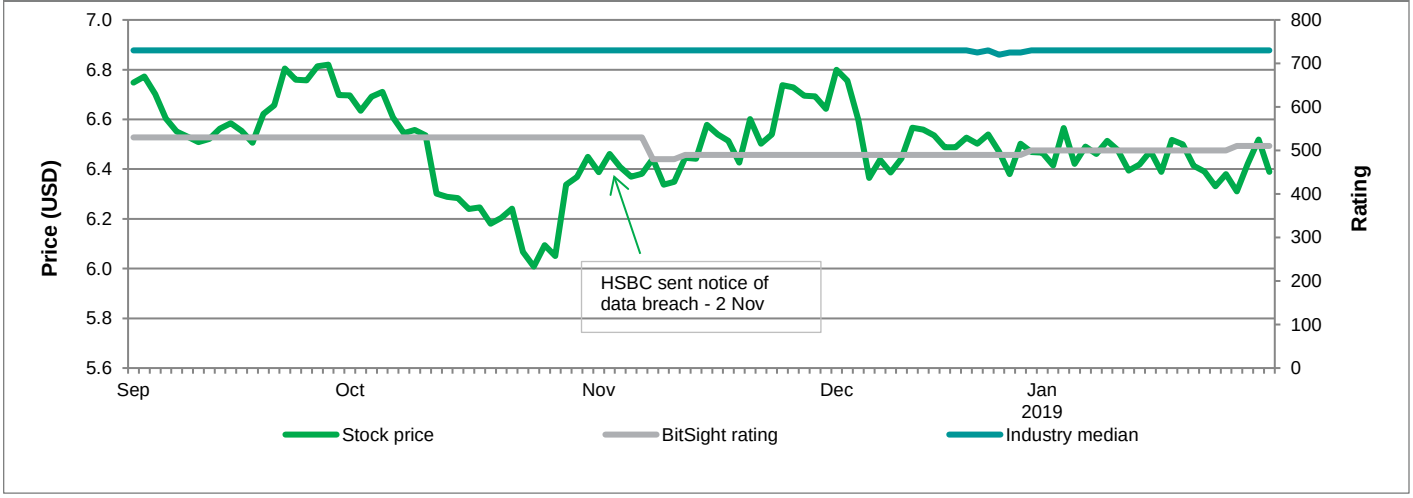
Next, we provide a couple of case studies demonstrating application of the BitSight Rating including HSBC and Huazhu Hotels.

HSBC

On 2 November 2018, HSBC, Europe's biggest bank by assets, sent a **notice of data breach** to US customers, stating that a number of accounts were hacked between 4 and 14 October (Figure 11). The breach was expected to have the potential to expose sensitive financial information in customer bank accounts including personal user details, account numbers and balances, transaction history and payee account information. Hackers accessed the accounts by "credential stuffing", in which passwords are used from data breaches of previously breached systems with the hopes that customers used the same password on other systems. The company's BitSight Rating has regularly resided below the industry median and has suffered more severe breaches in 2016. Prior to the breach, the stock price was recovering from a near term bottom, but stalled for several weeks subsequent to the event.

Figure 11

HSBC stock price reaction to BitSight Rating

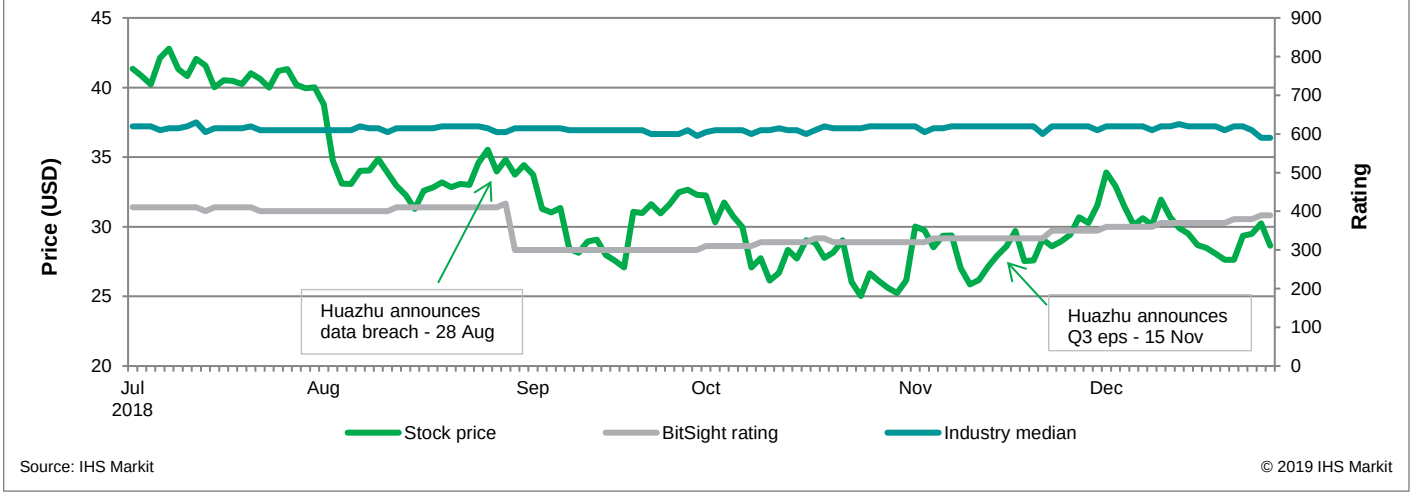


Huazhu Hotels

On 28 August 2018, Huazhu Hotels (Figure 12), among the world's largest hotel groups, released an official statement regarding an investigation into a Chinese dark web forum post selling **hacked personal data** of 130 million hotel guests. The BitSight rating, already 200 points below the industry median, reacted to the initial data breach by dropping a further 100 points, and the stock price tumbled nearly 20% in the three-week period subsequent to the downgrade, and never fully recovered even after an upbeat quarterly earnings announcement and positive growth outlook.

Figure 12

Huazhu Hotels stock price and BitSight Rating



Source: IHS Markit

Factor performance and correlation

Next we turn to factor attribution, beginning with analysis of factor performance. We report the spread between top and bottom rated stocks for the key underlying BitSight Rating factor along with Industry Relative BitSight Rating given our previous findings (Table 3). For developed markets we report decile spreads and for emerging markets we report quintile spreads given the more limited universe sizes. Various holding periods are considered including 1-, 3-, 6- and 12-month horizons from January 2014 through September 2019 on both a cross sectional and sector neutral basis.

Table 3

Factor quantile return spread performance (%), Jan 2014 – Sep 2019

Universe	Factor	Ranking	1-month	3-month	6-month	12-month
Developed Europe	BitSight Rating	Cross sectional	-0.14	-0.27	-0.68	-0.05
		Sector neutral	-0.14	-0.19	-0.48	-0.06
	Industry Relative BitSight Rating	Cross sectional	-0.14	-0.21	-0.40	-0.62
		Sector neutral	-0.13	-0.26	-0.52	-0.08
Developed Pacific	BitSight Rating	Cross sectional	0.16	0.60	1.19	3.59
		Sector neutral	0.34	0.94	1.79	4.19
	Industry Relative BitSight Rating	Cross sectional	0.43	0.97	2.15	5.30
		Sector neutral	0.37	1.04	1.76	3.98
North America	BitSight Rating	Cross sectional	-0.20	-0.57	-1.35	-2.60
		Sector neutral	-0.21	-0.43	-0.74	-1.36
	Industry Relative BitSight Rating	Cross sectional	-0.23	-0.57	-1.26	-2.74
		Sector neutral	-0.11	-0.21	-0.55	-1.61
Emerging EMEA	BitSight Rating	Cross sectional	-0.07	-0.26	0.22	0.14
		Sector neutral	0.02	0.21	0.39	-0.04
	Industry Relative BitSight Rating	Cross sectional	0.12	0.90	1.51	1.35
		Sector neutral	0.05	0.56	1.02	0.69
Emerging Asia	BitSight Rating	Cross sectional	0.22	0.78	1.87	5.04
		Sector neutral	0.28	0.69	1.46	4.30
	Industry Relative BitSight Rating	Cross sectional	0.21	0.75	1.49	3.78
		Sector neutral	0.35	0.80	1.42	4.01
Emerging Latin America	BitSight Rating	Cross sectional	0.11	0.26	0.12	0.02
		Sector neutral	-0.15	-0.33	-0.16	-0.82
	Industry Relative BitSight Rating	Cross sectional	0.04	-0.20	-0.34	-0.94
		Sector neutral	0.09	-0.25	-0.23	-0.20

Source: IHS Markit

Factor performance for both factors across the various holding periods tended to be inconsistent over time resulting in relatively flat spreads. Average spreads for most regions tended to reside slightly below zero; however, Developed Pacific and Emerging Asia saw positive spreads of relatively higher magnitude over our analysis period. For 1-month holding periods, the average cross sectional spread for Developed Pacific (Emerging Asia) was 0.16% (0.22%) for BitSight Rating compared with 0.43% (0.21%) based on industry relative construction, and spreads came in at 3.59% (5.04%) and 5.30% (3.78%), respectively, at the 12-month horizon. As one might expect, while cybersecurity is an important risk to measure, these findings suggest that it is not a standalone driver of stock returns on a cross-sectional basis.

Beyond absolute performance, we also look for diversifying features offered from BitSight Rating relative to other alpha factors. For this perspective, we use factors from our Consolidated Factor library, offering broad representation across styles. Analysis is based on two aspects of factor correlation, including Information Coefficient (IC) correlation for 1-month holding periods and average factor rank correlations (see Tables A4 and A5, respectively, in the Appendix).

In Developed Europe, the highest BitSight Rating IC correlation is associated with Natural Logarithm of Market Capitalization (0.78), which also has a relatively high rank correlation (0.18), not surprising given our previous attribution results. Similar outcomes were seen for North America for both IC (0.57) and rank (0.21) correlations. In Developed Pacific, BitSight Ratings had strong co-movement with low risk strategies of 24-Month Value at Risk (0.43) and 60-Month Beta (0.42) and the reverse with high growth captured by 2-Year Ahead EPS Growth (-0.43). High magnitude IC correlations in emerging markets were also realized with Average Monthly Trading Volume-to-Market Cap in EMEA (0.56) and the reverse direction in Latin America (-0.60) along with 24-Month Value at Risk (0.77) and 2-Year Ahead EPS Growth (-0.59).

Rank correlations were, in general, more muted than that seen for ICs. However, factors of interest with notable rank correlations beyond the aforementioned Natural Logarithm of Market Capitalization include positive correlations with 60-Month Beta and Book-to-Market in developed markets and negative correlations with TTM EBITDA-to-Enterprise Value and Inventory Turnover Ratio in emerging markets. The factor correlation results indicate that cybersecurity ratings contain differentiated information not present in traditional factors, suggesting the factors may be additive to existing stock selection models.

Factor interaction with ESG

Cybersecurity risk management can be considered another form of governance, where strong cybersecurity practices by management teams can protect shareholders from adverse events described in the prior section. With that in mind, we examine the interaction of BitSight Ratings with Environmental, Social, and Corporate Governance, or ESG, factors. First, we confirm that the BitSight Rating is a unique signal from ESG given the low rank correlations with the **Integrated ESG Rating** along with the Economic, Environmental, Corporate Governance and Social pillar scores across the six regions (Table 4).

Table 4

BitSight Rating average rank correlations, Jan 2014 – Sep 2019

Factor	Developed Europe	Developed Pacific	North America	Emerging EMEA	Emerging Asia	Emerging Latin America
Integrated ESG Rating	-0.19	-0.10	-0.22	0.00	-0.09	0.08
Economic Rating	-0.15	-0.06	-0.13	-0.05	-0.09	0.05
Environmental Rating	-0.15	-0.11	-0.26	0.06	-0.09	0.09
Corporate Governance Rating	-0.13	-0.05	-0.15	-0.08	-0.05	0.09
Social Rating	-0.15	-0.10	-0.22	0.01	-0.12	0.04

Source: IHS Markit

Given these results, we developed an application to explore the use of the BitSight Rating as a missing component of governance within an ESG strategy. We begin by applying an 80% weight to percentile ranks of the Integrated ESG Rating and a 20% weight to the Distance from Industry Median BitSight Rating. The composite scores are then reranked and split into deciles. To test the efficacy of the methodology, we compute 1- and 3-month decile excess returns and report the average decile spread (D1-D10) and decile 1 excess return over the analysis period (Table 5).

Overall, we find promising results from our combined strategy, particularly for 1-month holding periods. In developed markets, the largest improvement between the combined ESG and BitSight strategy and the base ESG factor was seen in Developed Pacific with a 1-month decile spread of 0.22% compared with 0.00% for the base factor. Likewise in Developed Europe, the BitSight score provided an enhancement to the ESG strategy with an 8 bps improvement in 1-month spreads, while results were less favorable in North America where the BitSight factors saw the weakest regional performance (see Table 3 above).

In emerging markets, the addition of the BitSight factor with the Integrated ESG Rating proved to be a more effective strategy. Emerging Latin America saw the largest increase in 1-month decile spread of 75 bps, followed by Emerging EMEA (35 bps) and then Emerging Asia (28 bps). The results also held up to 3-month holding periods, suggesting encouraging results for application in buy-and-hold strategies.

For long-only portfolio managers, we find somewhat weaker results, with positive spreads in 1-month excess returns between the combined strategy and base factor associated with Emerging Latin America (45 bps), Emerging EMEA (23 bps) and Developed Europe (8 bps). However, given the stronger decile spread results, long-only strategies can still benefit by avoiding decile 10 names from the combined BitSight and ESG factors.

Table 5

ESG and BitSight combination performance (%), Jan 2014 – Sep 2019

		Decile spread		Decile 1 excess return	
Region	**Model**	**1-month**	**3-month**	**1-month**	**3-month**
Developed Europe	ESG+BitSight	0.07	-0.14	0.09	0.05
	ESG Integrated Rating	-0.01	0.11	0.01	0.03
Developed Pacific	ESG+BitSight	0.22	0.24	-0.18	-0.61
	ESG Integrated Rating	0.00	-0.03	-0.02	-0.01
North America	ESG+BitSight	-0.25	-0.73	0.09	0.35
	ESG Integrated Rating	0.09	0.34	0.17	0.39
Emerging EMEA	ESG+BitSight	1.09	3.07	0.59	1.55
	ESG Integrated Rating	0.74	1.81	0.36	0.93
Emerging Asia	ESG+BitSight	0.27	0.71	-0.13	-0.27
	ESG Integrated Rating	-0.01	-0.24	0.04	0.09
Emerging Latin America	ESG+BitSight	1.60	3.83	0.47	0.87
	ESG Integrated Rating	0.85	3.40	0.02	0.57

Source: IHS Markit

Conclusion

BitSight offers independent third-party monitoring of company cybersecurity risk using a systematic approach to produce a daily Security Rating. Based on this underlying score, in early 2018 we introduced 16 derived factors in addition to 19 factors passed through directly from BitSight, mapped across our US Total Cap universe (3,000+ names). We have now expanded our coverage to global markets, covering an additional 2,500+ stocks, allowing the stock-specific data to easily plug into existing processes to assess individual stocks and portfolios with a normalized systematic measure of cybersecurity risk.

BitSight Ratings range from 250 to 900, with a higher rating indicating better security performance, and average between 593 and 674 in developed markets from January 2014 through January 2018, with lower average across emerging markets. Financials have consistently scored the highest, with Banks the strongest industry subgroup, while Technology and Telecommunication Services have been the weakest sectors over time. Ratings also tend to move inversely with market cap.

While BitSight Technologies had an independent third party confirm the Ratings predictability of breaches, we conducted our own analysis showing that BitSight Ratings are predictive of data breach events. Though breaches are rare overall, firms with the weakest scores relative to the industry median (<-200) tend to be the most likely to experience a data breach as demonstrated by a frequency of 0.30% (2.93%) in Developed Pacific (North America) and, combined with the average frequency for the remaining groups registering below the industry median, exceeding the combined frequency of those above the median.

Data breach events are also found to typically lead to negative returns relative to the market, particularly in the first 10 days after the event, before subsequently reverting up more immediately in North America, while other markets took longer to mean revert, as observed after 20-days in Developed Pacific and out to 60-days in Developed Europe and Emerging Markets. The largest drawdowns 10 days from when a breach was identified were associated with Emerging Markets (-1.49%) and Developed Europe (-0.58%), with persistence out to 60 days (-2.12% and -2.82%, respectively). HSBC and Huazhu Hotels are two case studies that further exemplify the results.

In terms of factor performance, BitSight Rating results across various holding periods tended to be inconsistent over time resulting in relatively flat decile spreads. However, the factor offers a unique signal relative to rankings of other alpha

factors and diversification relative to factors such as 2-Year Ahead EPS Growth in Developed Pacific and 1-yr Growth in TTM Free Cash Flow in Emerging EMEA.

Lastly, we analyze interactions of BitSight Ratings with ESG factors to explore the use of the BitSight Rating as a missing component of governance within an ESG strategy. Empirical results from our methodology of giving some weight to the Distance from Industry Median BitSight Rating factor in the ESG stock selection process suggest that the BitSight Rating is an effective overlay in most regions with the exception of North America. Improvements in 1-month decile spreads between the combined model and stand-alone ESG factor ranged from 8 bps in Developed Europe to 45 bps in Latin America, while long-only managers also saw positive spreads in excess returns between the two strategies in Emerging Latin America (45 bps), Emerging EMEA (23 bps) and Developed Europe (8 bps).

Appendix

Cybersecurity factor suite

BitSight factors

- BitSight Rating – calculated using a proprietary algorithm that analyzes and classifies externally observable data, with scores ranging from 250 to 900, where higher ratings indicate more effective company implementation of good security practices
- Botnet Risk – a unified network of machines that are performing coordinated actions based on instructions received from the malware's creators
- Malware Server Risk – a machine hosting a website that injects malicious code into a visitor's browser, often resulting in the installation of new malware on that visitor's computer
- Potentially Exploited Software Risk – a machine running a potentially unwanted application which leaves the system vulnerable to adware, spyware, and remote access tools
- Spam Propagation Risk – machines compromised with malware that causes them to send large volumes of unwanted email
- Unexpected Communications Risk – any host that is observed trying to contact a service on another host that is not expected or supported
- Domain Keys Identified Mail (DKIM) Risk – a protocol designed to prevent unauthorized servers from sending email on behalf of a company's domain
- Sender Policy Framework (SPF) Risk – a DNS (Domain Name System) record identifying which mail servers are permitted to send email on behalf of a domain, preventing spammers from sending emails with forged "From:" addresses
- TLS/SSL Configuration – records indicating that servers have properly configured security protocol libraries and support strong encryption standards when making encrypted connections to other machines
- TLS/SSL Certificates – records verifying the authenticity of your company servers to your associates, clients, and guests, and which serve as the basis for establishing cryptographic trust
- DNSSEC Records – a protocol that uses public key encryption to authenticate DNS servers
- Open Ports – ports that are exposed to the public internet, which are evaluated to determine whether or not unnecessary access points exist

- Application Security – HTTP header configurations that inform how to receive and respond to web requests in a manner that prevents malicious behavior such as man-in-the-middle and cross-site scripting attacks
- User Behavior – examines activities that may introduce malicious software onto a corporate network, for example, by downloading a compromised file
- Patching Cadence – the speed at which a company resolves publicly disclosed vulnerabilities, which are bugs in software or device firmware that can be used to gain unauthorized access to systems and data
- Insecure Systems – shows which endpoints inside an organization are communicating with an unintended destination. The software in these endpoints have been tampered with or misconfigured, and end up communicating with a remote server that, if captured, may allow attackers to inject code, breach the organization, or extract sensitive data.
- Desktop Software – desktop software are laptops, servers, and other non-tablet, non-phone computers in a company's network which access the internet. If there are unsupported desktop software in an organization's network, there is a greater risk of system failure (vendor devices are not being maintained), disruption of business continuity, and attackers may be able to use unpatched vulnerabilities to gain system access.
- Mobile Software – mobile software are smartphones and tablets in a company's network which access the internet. If there are unsupported mobile software in an organization's network, there is a greater risk of system failure (vendor devices are not being maintained), disruption of business continuity, and attackers may be able to use unpatched vulnerabilities to gain system access.
- Server Software – this risk type can be used to create a rich picture about the software used by an organization. It helps track security holes created by server software that is no longer supported by its original developers or has become out-of-date (deprecated).

Research Signals derived factors

- 1-Week Change in BitSight Rating – change in BitSight Rating over the past 1 week
- 1-Month Change in BitSight Rating – change in BitSight Rating over the past 1 month
- 3-Month Change in BitSight Rating – change in BitSight Rating over the past 3 Months
- 12-Week Volatility in BitSight Rating – standard deviation of the BitSight Rating over the past 12 weeks
- BitSight Rating 8-week Z-score – z-score of the BitSight Rating over the past 8 weeks, calculated as the current rating of a company minus the average rating for the past 8 weeks, divided by the standard deviation over the past 8 weeks (if standard deviation is 0, the z-score is 0)
- BitSight Rating 12-week Z-score – z-score of the BitSight Rating over the past 12 weeks, calculated as the current rating of a company minus the average rating for the past 12 weeks, divided by the standard deviation over the past 12 weeks (if standard deviation is 0, the z-score is 0)
- BitSight Rating 26-week Z-score – z-score of the BitSight Rating over the past 26 weeks, calculated as the current rating of a company minus the average rating for the past 26 weeks, divided by the standard deviation over the past 26 weeks (if standard deviation is 0, the z-score is 0)
- BitSight Rating 52-week Z-score – z-score of the BitSight Rating over the past 52 weeks, calculated as the current rating of a company minus the average rating for the past 52 weeks, divided by the standard deviation over the past 52 weeks (if standard deviation is 0, the z-score is 0)

- Distance from Industry Median BitSight Rating – difference between the company's current BitSight Rating and the median BitSight Rating for the industry
- Industry Relative BitSight Rating – difference between the company's current BitSight Rating and the average BitSight Rating for the industry, scaled by the standard deviation of the industry's BitSight Ratings
- Distance from Sector Median BitSight Rating – difference between the company's current BitSight Rating and the median BitSight Rating for the sector
- Sector-Relative BitSight Rating – difference between the company's current BitSight Rating and the average BitSight Rating for the sector, scaled by the standard deviation of the sector's BitSight Ratings
- Compromised Systems Score – score penalizing companies with poor observed compromised systems risk. It is calculated as the minimum of the risk scores in the diligence category, which includes Botnet Risk, Malware Server Risk, Potentially Exploited Software Risk, Spam Propagation Risk, and Unexpected Communications Risk.
- Diligence Score – score penalizing companies with poor observed cybersecurity diligence. It is calculated as the minimum of the risk scores in the diligence category, which includes Sender Policy Framework (SPF) Risk , Domain Keys Identified Mail (DKIM) Risk, TLS/SSL Certificates, TSL/SSL Configuration, Open Ports, Application Security, and Patching Cadence.
- Data Breach Impact – score penalizing companies with data breaches within the past 1 year. More recent and severe data breaches have greater negative impact on this score.
- Data Breach Relevance – score penalizing companies with data breaches within the past 1 year. More recent data breaches have greater impact on this score.

Tables and figures

Table A1

Average BitSight Rating by sector, Jan 2014 – Sep 2019

Sector	Developed Europe	Developed Pacific	North America	Emerging EMEA	Emerging Asia	Emerging Latin America
Basic Materials	634	675	677	612	615	631
Cyclical Goods & Services	611	632	634	664	630	610
Energy	629	681	691	641	626	586
Financials	692	697	701	677	654	651
Healthcare	637	681	670	635	619	632
Industrials	620	630	655	631	607	639
Non-Cyclical Goods & Services	636	673	658	683	623	641
Technology	605	591	612	502	610	450
Telecommunication Services	390	398	476	380	420	335
Utilities	630	705	703	603	546	598

Source: IHS Markit

Table A2

Average BitSight Rating by industry, Jan 2014 – Sep 2019

Industry group	Developed Europe	Developed Pacific	North America	Emerging EMEA	Emerging Asia	Emerging Latin America
Basic Materials						
Containers & Packaging	634	675	666	624	NA	623
Paper & Forest Products	638	629	670	646	694	667
Chemicals	636	660	670	499	635	517
Construction Materials	624	704	689	562	631	631
Metal & Mining	634	689	688	628	579	638
Cyclical Goods & Services						
Automobiles & Auto Parts	610	588	628	695	629	NA
Homebuilding & Household Goods	648	639	668	576	669	615
Textiles & Apparel	630	634	669	NA	667	614
Hotels & Entertainment Services	583	642	616	708	593	602
Media & Publishing	551	648	587	493	586	483
Retailers	660	647	659	673	662	633
Energy						
Coal	NA	753	649	NA	703	NA
Energy Related Equipment & Services	629	646	655	NA	725	625
Oil & Gas	628	683	703	641	615	575
Renewable Energy	656	NA	774	NA	NA	NA
Financials						
Banks	693	709	719	683	661	657
Financial Services - Diversified	707	721	691	634	635	701
Holding Companies	537	NA	NA	NA	NA	NA
Insurance	682	682	700	674	686	586
Collective Investments	729	697	681	NA	NA	NA
Real Estate	680	683	681	671	607	555
Real Estate Operations	NA	NA	664	NA	NA	NA
Healthcare						
Biotechnology & Pharmaceuticals	636	690	686	619	623	646
Healthcare Equipment & Supplies	636	681	652	NA	664	NA
Healthcare Providers & Services	658	622	665	770	584	539

Source: IHS Markit

Table A3

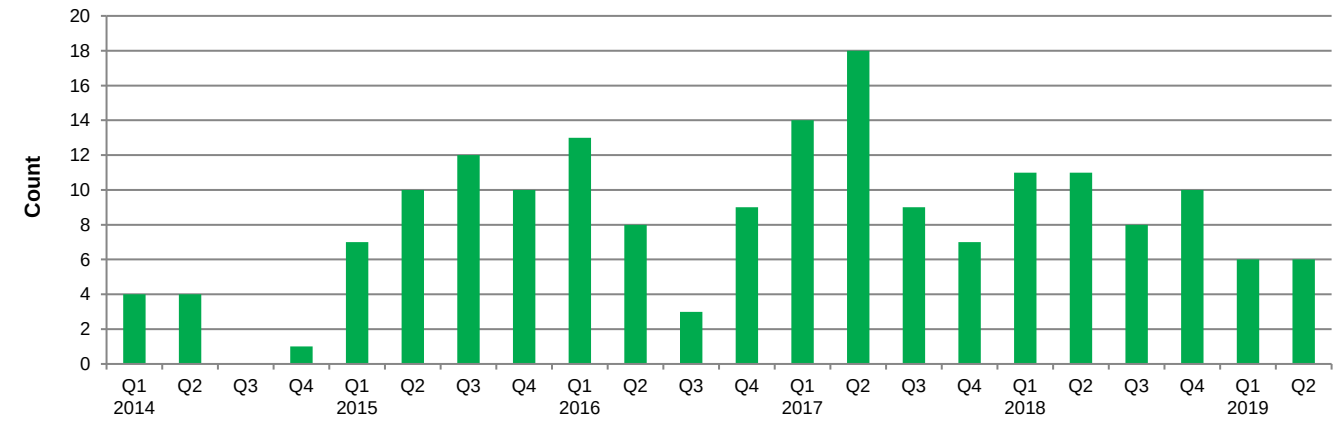
Average BitSight Rating by industry, Jan 2014 – Sep 2019 (continued)

Industry group	Developed Europe	Developed Pacific	North America	Emerging EMEA	Emerging Asia	Emerging Latin America
Industrials						
Industrial Conglomerates	667	578	631	588	591	566
Aerospace & Defense	625	600	639	740	NA	NA
Industrial Machinery & Equipment	613	623	650	634	603	614
Commercial Services & Supplies	604	689	655	NA	657	545
Construction, Engineering & Materials	627	610	659	617	617	687
Diversified Trading & Distributing	638	612	663	NA	480	NA
Air Freight & Courier Services	574	611	598	NA	636	691
Airline Services	597	670	663	675	587	684
Marine Services	639	623	716	NA	646	NA
Rails & Roads Transportation	646	654	666	NA	721	575
Non-Cyclical Goods & Services						
Beverages	602	712	662	718	578	643
Food & Tobacco	646	667	669	663	642	624
Food & Drug Retailing	646	705	663	720	NA	759
Personal & Household Products & Services	646	639	634	NA	566	687
Technology						
Software & IT Services	602	596	620	493	599	450
Communications Equipment	549	655	578	548	610	NA
Computers & Office Equipment	608	536	581	NA	560	NA
Electronic Equipment & Parts	642	608	NA	NA	NA	NA
Semiconductors	650	593	616	NA	668	NA
Telecommunications Services						
Telecommunications Services	390	398	476	380	420	335
Utilities						
Electric Utilities	634	732	700	603	561	593
Gas Utilities	673	686	713	NA	712	601
Utilities - Multiline	596	648	701	NA	353	NA
Utilities - Water & Others	713	501	720	NA	473	634

Source: IHS Markit

Figure A1

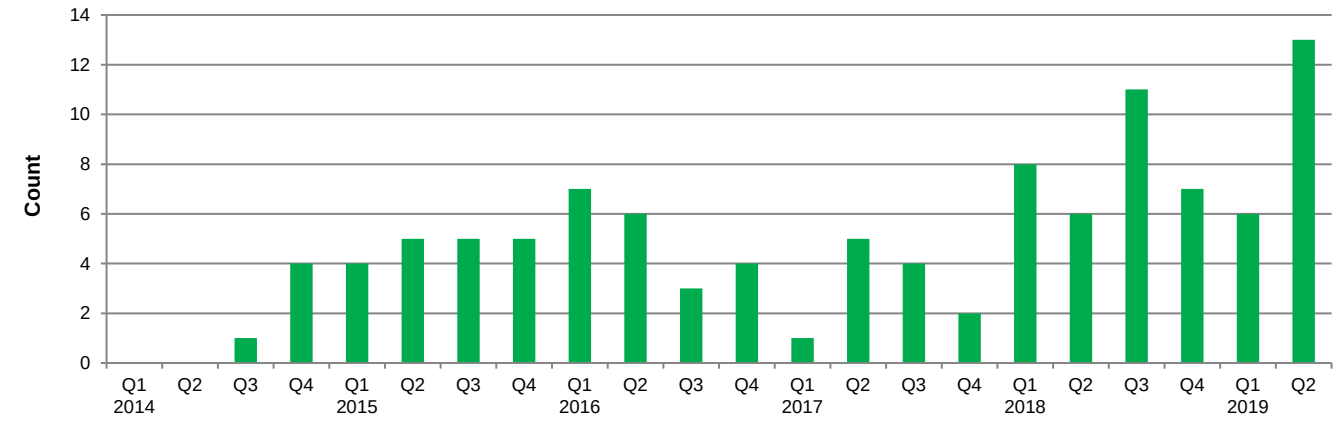
Developed Europe data breach occurrences



Source: IHS Markit

Figure A2

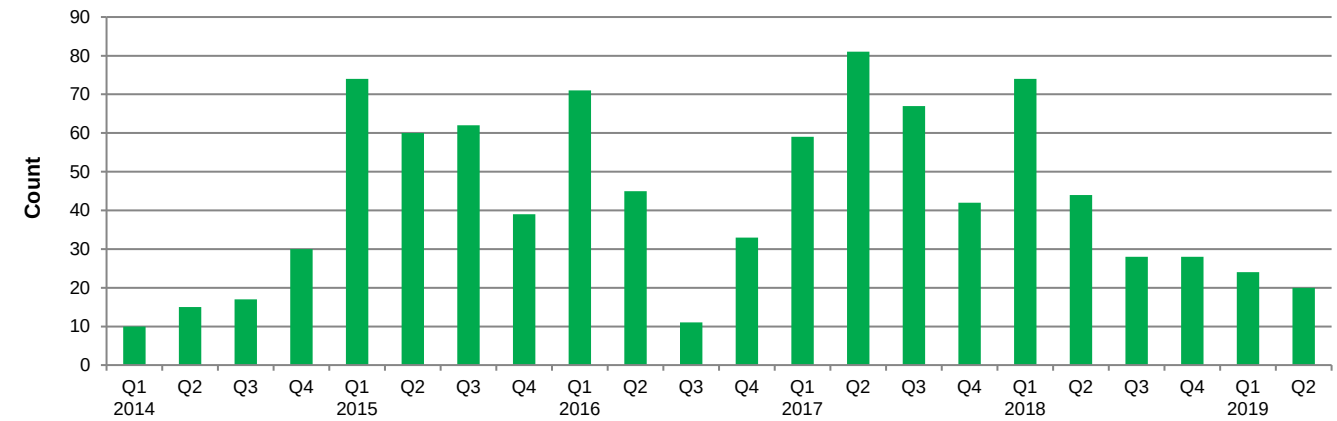
Developed Pacific data breach occurrences



Source: IHS Markit

Figure A3

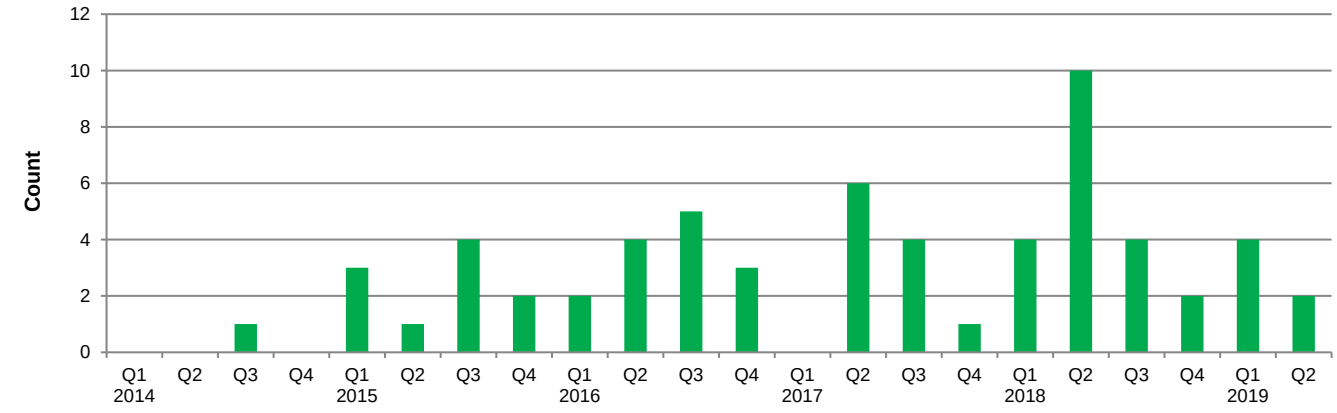
North America data breach occurrences



Source: IHS Markit

Figure A4

Emerging Markets (combined) data breach occurrences



Source: IHS Markit

Table A4

BitSight Rating 1-month IC correlations, Jan 2014 – Sep 2019

Factor	Developed Europe	Developed Pacific	North America	Emerging EMEA	Emerging Asia	Emerging Latin America
Altman Z Score	-0.49	-0.18	0.19	0.14	-0.04	-0.51
Asset Quality Index	0.11	-0.08	0.31	0.01	-0.10	0.22
60-Month Beta	0.19	0.42	0.03	-0.28	-0.26	0.70
Book-to-Market	-0.09	-0.20	0.45	0.06	0.04	-0.44
Change in TTM COGS vs. Inventory Level	-0.27	0.00	-0.27	0.08	-0.18	0.08
Industry Relative TTM Dividend Yield	-0.23	0.27	0.08	-0.26	-0.15	0.12
Total Debt to Total Assets	-0.48	-0.01	-0.18	0.24	-0.06	-0.26
TTM EBITDA-to-Enterprise Value	-0.24	-0.26	-0.12	-0.31	0.02	-0.45
Industry Relative Leading 4-QTRs EPS to Price	0.01	-0.29	-0.28	-0.15	0.05	-0.46
Forward 12-M EPS-to-Enterprise Value	0.12	-0.29	-0.18	-0.39	0.02	-0.33
3-M Revision in FY2 EPS Forecasts	0.24	0.00	0.00	-0.25	-0.05	-0.26
2-Year Ahead EPS Growth	-0.06	-0.43	0.04	0.29	0.25	-0.59
Fixed Assets Turnover Ratio	0.17	-0.15	-0.29	0.32	0.06	-0.23
5-day Industry Relative Return	0.00	-0.10	-0.16	0.10	-0.03	0.02
Inventory Turnover Ratio	-0.02	0.34	0.15	-0.12	-0.19	0.26
Natural Logarithm of Market Capitalization (USD)	0.78	0.22	0.57	0.10	0.09	0.08
Average Monthly Trading Volume-to-Market Cap	0.09	0.16	0.19	0.56	0.07	-0.60
Net Operating Asset Turnover	-0.16	-0.17	-0.59	-0.08	0.00	-0.05
Operating Leverage	-0.12	-0.22	0.19	-0.03	0.04	0.09
1-yr Growth in TTM Free Cash Flow	0.03	0.16	-0.38	-0.46	0.03	0.26
Rational Decay Alpha	0.17	0.01	0.03	0.06	-0.04	0.27
Reinvestment Rate	0.33	-0.19	-0.43	0.23	0.04	0.20
Industry-adjusted 12-month Relative Price Strength	0.17	0.17	0.09	-0.18	-0.11	-0.01
Change in TTM Sales vs. Accounts Receivable	0.11	-0.23	0.00	0.10	0.03	-0.10
Real Earnings Surprise	0.25	0.27	-0.12	0.01	0.06	-0.11
TTM Free Cash Flow-to-Enterprise Value	-0.09	0.02	-0.25	-0.32	-0.11	-0.07
24-Month Value at Risk	0.11	0.43	-0.05	-0.28	-0.13	0.77
Working Capital Accruals	0.07	-0.41	-0.08	0.24	0.08	-0.40
Change in Accruals to Assets	0.05	0.07	0.09	-0.29	-0.11	-0.06

Source: IHS Markit

Table A5

BitSight Rating average rank correlations, Jan 2014 – Sep 2019

Factor	Developed Europe	Developed Pacific	North America	Emerging EMEA	Emerging Asia	Emerging Latin America
Altman Z Score	-0.18	-0.09	-0.06	-0.13	-0.07	-0.22
Asset Quality Index	0.03	0.00	0.02	0.01	0.05	0.10
60-Month Beta	0.02	0.06	0.09	-0.04	-0.09	0.11
Book-to-Market	0.10	0.07	0.13	0.00	0.05	-0.08
Change in TTM COGS vs. Inventory Level	0.00	-0.02	-0.08	0.04	0.00	0.06
Industry Relative TTM Dividend Yield	-0.05	-0.01	-0.06	-0.10	-0.09	0.00
Total Debt to Total Assets	-0.16	-0.08	-0.12	-0.17	-0.07	-0.14
TTM EBITDA-to-Enterprise Value	-0.12	-0.09	-0.10	-0.24	-0.14	-0.18
Industry Relative Leading 4-QTRs EPS to Price	-0.08	0.01	-0.13	0.00	-0.03	-0.14
Forward 12-M EPS-to-Enterprise Value	-0.03	-0.04	-0.08	0.05	0.00	0.01
3-M Revision in FY2 EPS Forecasts	0.02	0.03	0.01	-0.02	0.01	-0.02
2-Year Ahead EPS Growth	-0.03	-0.08	-0.05	0.07	0.07	-0.06
Fixed Assets Turnover Ratio	0.07	-0.03	-0.11	0.19	0.09	0.08
5-day Industry Relative Return	-0.01	0.00	-0.01	-0.02	0.00	-0.02
Inventory Turnover Ratio	-0.15	-0.08	-0.05	-0.30	-0.17	-0.16
Natural Logarithm of Market Capitalization (USD)	0.18	0.14	0.21	0.05	0.09	0.03
Average Monthly Trading Volume-to-Market Cap	-0.05	0.06	0.08	-0.05	0.07	-0.14
Net Operating Asset Turnover	-0.13	-0.12	-0.22	-0.05	-0.15	-0.09
Operating Leverage	0.01	-0.02	0.01	-0.06	-0.02	-0.01
1-yr Growth in TTM Free Cash Flow	-0.04	-0.03	-0.04	0.02	-0.04	0.02
Rational Decay Alpha	0.02	0.01	0.00	0.01	0.03	0.06
Reinvestment Rate	0.01	-0.01	-0.09	0.09	0.02	0.07
Industry-adjusted 12-month Relative Price Strength	0.02	0.00	0.01	-0.01	0.02	0.06
Change in TTM Sales vs. Accounts Receivable	0.01	-0.01	0.01	0.07	0.01	0.00
Real Earnings Surprise	0.00	0.03	-0.02	0.03	0.02	0.05
TTM Free Cash Flow-to-Enterprise Value	-0.06	-0.03	-0.11	0.04	-0.03	0.01
24-Month Value at Risk	0.00	-0.03	-0.02	-0.01	-0.05	0.07
Working Capital Accruals	0.02	-0.01	0.00	-0.09	0.04	-0.02
Change in Accruals to Assets	0.01	0.01	0.00	0.02	0.02	0.03

Source: IHS Markit

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