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Creating structure from unstructured text data

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In this new series of publications, we lift the lid on the black box surrounding alternative datasets and describe the foundations required to analyze unstructured data starting with text-based signals.

In our view, text signals are not restricted to high frequency strategies. Indeed, our goal is to demonstrate the potential of text analysis for long-only, low turnover investors too.

Collecting publically-available Web data – in our first publication we consider the use case of text analysis for detecting corporate anti-competitive behavior, bribery/corruption issues, environmental pollution violations and product recalls.

Processing text – we describe a computational linguistics technique known as Named Entity Recognition to detect company mentions in text.

Social networks analysis – one application of Named Entity Recognition is a framework to infer 'hidden' connections between companies (both private and publically listed), and potentially 'hidden' stock risks.

Source: Deutsche Bank

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A letter to our readers

One of the defining characteristics of systematic factor-based strategies is the need to hold a large number of positions expressed as relatively low conviction views. Investment strategies rely upon good quality accounting and pricing data rather than an understanding of each company's business model.

By contrast, a fundamental portfolio manager will develop high conviction views formed partially from insights by meeting company management, listening to conference calls, and attending company site visits.

In our view, the exploitation of unstructured data can help bridge the gap between these two investment approaches, enabling investors to integrate fundamental insights (or proxies of) in an objective and consistent way.

Take, for example, a company plagued by regulatory violations and ongoing litigation risk. A systematic Value strategy may buy into the company on the basis of cheap multiples, with limited awareness of the regulatory overhang to identify if the stock is a potential value trap. Similarly, a low volatility strategy may buy into the company based on a one-dimensional view of historic stock volatility if these risks are not fully priced, while a Quality strategy may buy companies on the basis of earnings and balance sheet strength measures, with limited insights into management quality.

In this publication, we describe the steps required to process text data. In future publications, we'll extend our approach to consider a broader range of media sources, topics (both company-level and macro-related), and test whether unstructured datasets are predictive for risk-adjusted returns.

Regards,

Andy, Spyros, Khoi, Miguel, and the quant team

Deutsche Bank Quantitative Strategy

Introduction

To date, most of the hype surrounding big data[1,2] has focused on the Volume of data (such as in-memory cluster computing solutions), the Variety of data (ranging from credit card transactions, satellite images, sensor data to near real-time news processing), and the Velocity of the data (e.g. the potential of social media analysis to detect events at higher frequency than traditional media newswires).

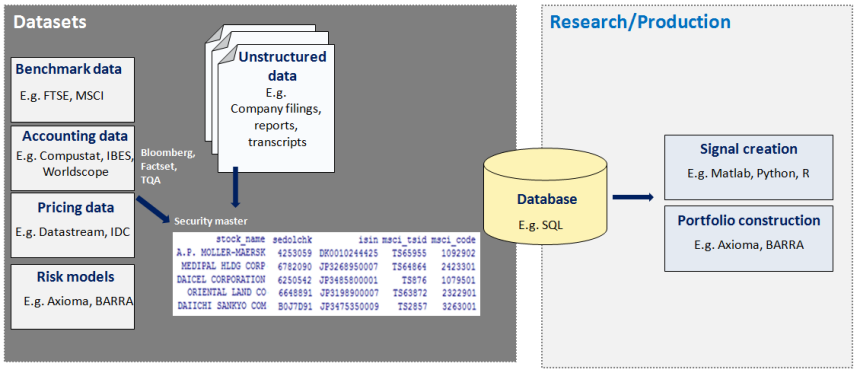
In our view, the fourth 'V' commonly associated with big data, namely Veracity, appears to be largely overlooked. Veracity broadly translates as can the data be trusted? To our mind, the speed of processing a dataset is of secondary importance if a portfolio manager doesn't understand the provenance of a signal.

Often, the proprietary nature of alternative datasets means that vendors are reluctant to open the black-box to provide any insights into how their datasets are collected. This only serves to make the concept of 'big data' even more elusive. In our view, an investor is unlikely to investigate the merits of an alternative dataset unless certain criteria are first fulfilled:

Question 1: Are security identifiers available to integrate datasets into existing investment processes?

As Figure 1 seeks to illustrate, systematic investors rely upon a fully-populated security master table to link datasets together.

Figure 1: Example infrastructure for a systematic investment process



Source: Factset, Deutsche Bank

[1] Big Data in Investment Management, G. Rohal et al., Deutsche Bank, 2016.
[2] Machine Learning in Finance, V.Zoonekynd et al., Deutsche Bank, 2016.

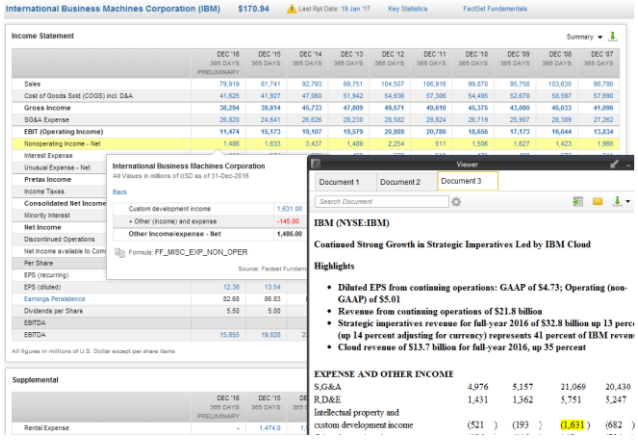
Ultimately, unstructured datasets are just one of many potential signals an investor may consider. All datasets eventually need to be structured so that they can be seamlessly integrated alongside traditional accounting and pricing data.

Question 2: What is the provenance of the data?

Many investors may be reluctant to integrate alternative data signals into their investment processes if the signals cannot be fully understood or explained. In the same way that an investor can click through a company's financial statements on Factset or Bloomberg to see where numbers appear in a firm's reported filings (see Figure 2), why should the provenance of alternative datasets be any different?

We hope that alternative data vendors start to address investors' needs for transparency. Take for instance, Ravenpack's newsflow archive (see Figure 3 for an overview). We are encouraged to see that the dataset now includes title and summary text, the source of the news article, whether the information is fact- versus opinion-based (fact-level tagging), and whether the news is forward or backward looking (temporal analysis). Greater transparency should broaden the appeal of such datasets to more traditional investors.

Figure 2: Example of data provenance in Factset



Source: Factset, Deutsche Bank

Figure 3: Evolution of Ravenpack's news dataset

	Release Date			
Attributes	**2011**	**2013**	**2014**	**2017**
Event coverage	330	1,200	2,064	6895
Historical archive	11+ Years	13+ Years	14+ Years	17+ Years
Named entity recognition:				
Entity coverage	28,000+	170,000+	175,000+	194,000+
Companies	✓	✓	✓	✓
Places		✓	✓	✓
Organizations		✓	✓	✓
Positions of authority			✓	✓
People				✓
Products				✓
Media sources:				
Premium Newswires	✓	✓	✓	✓
Regulatory & PR feeds		✓	✓	✓
Online publications		✓	✓	✓
Sentiment analysis:				
Event Sentiment Score	✓	✓	✓	✓
Fact-level tagging				✓
Temporal analysis				✓

Source: Ravenpack, Deutsche Bank

Question 3: What is the coverage of alternative datasets across stocks and over time?

This remains a concern for many of the alternative datasets we are starting to investigate. Given the novelty of datasets, we believe that some investors may be willing to comprise on the depth of time-series data if there is sufficient breadth of coverage to enable signals to be tested in the cross-section.

To our mind, it is unclear whether alternative datasets based upon app download statistics or mobile sensor data will ultimately have sufficient stock coverage for the design of scalable systematic investment strategies.

Text processing

In our view, the best way to understand the decisions alternative data vendors make in their signal construction process, and to assess the strengths and weaknesses of signals, is to recreate the signals from first principles.

Here, we discuss approaches to process publically-available text. We employ a computational linguistics algorithm to assess whether a given text is relevant for specific companies within an investment portfolio. We then tag companies names mentioned in the text with security identifiers, so that qualitative information can ultimately be transformed and integrated into a traditional financial database.

Information Retrieval

For researchers interested in text analysis, a natural starting point may be to retrieve publically-available regulatory filings. In the case of U.S. regulatory filings, we highlight a number of benefits. First, data are readily available and in a consistent format, see for example, the U.S. Securities and Exchange Commission's EDGAR (Electronic Data Gathering, Analysis, and Retrieval system) database. Second, texts are written in English, and language is relatively formal. This mitigates the need to process text with abbreviations, slang, spelling mistakes, and double negatives often observed in social media. Third, text analysis is simplified by circumventing the need to assess the credibility of the information (a potential concern for news and social media[3]). Finally, there is a growing body of academic literature in this domain, enabling researchers to empirically validate others' findings.

Figure 4 provides an example of a press release published by the SEC. The announcement includes a title and main body text, though notably no security identifiers. We also highlight that the press release is for a non-US company, illustrating both the global reach of U.S. regulators irrespective of a company's domicile, and their abilities to impose substantial fines (as a % of market cap).

[3] See, for example, Allcott, H., Gentzkow, M., (2017), Social Media and Fake News in the 2016 Election, NBER Working Paper No. 23089.

Figure 4: Example of a press release available on the SEC's website

Source: SEC, Deutsche Bank

In particular, we draw the reader's attention to the header and side banners which typically need to be stripped away in a pre-processing step before conducting text analysis. This is because the text in these banners may discuss topics that are substantially different from those in the main body text (potentially biasing signal creation and statistical inference).

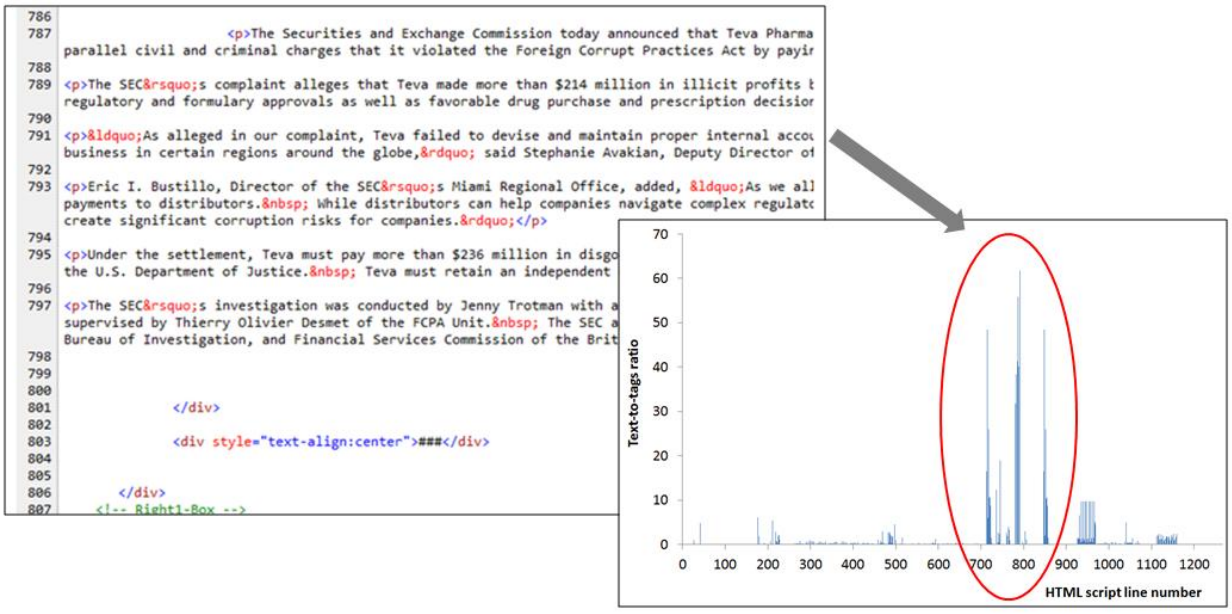
Perhaps a clearer-cut example of this bias is illustrated when applying text analysis techniques to brokers' research reports – in this report alone, almost one-quarter of the text consists of legal/compliance disclosures. The topics discussed in the disclosures are not reflective of the topics discussed in the rest of the text.

One way to extract the main body text from an online document is to simply search for pre-defined markers within the html file. For instance, in Figure 4, the main body text begins after the keyphrase 'FOR IMMEDIATE RELEASE'. In principle, a researcher could search for these tags to analyse the main content of the document rather than the banners. Unfortunately, searching for pre-defined markers does not offer a scalable solution. This is because websites use their own templates with different sets of tags, while templates can change over time. Consequently, hardcoded solutions are unlikely to remain robust.

An alternative approach is to employ a probabilistic solution to detect passages of text in a html file.

A relatively straight-forward approach is to compute the ratio of words written in an html file versus the words surrounded by html tags. This 'text-to-tags' ratio can be computed for every row of code written in the html file. The premise being that rows with a large proportion of text compared to html tags are more likely to contain meaningful content (as illustrated by rows 787-797 in Figure 5).

Figure 5: Example of a html file with the per line ratio of text-to-tags



Source: SEC, Deutsche Bank

Figure 5 illustrates several small clusters of text around the start and end of the html script. These clusters typically represent advertisements, side banners, copyright information and disclosures.

Assessing the relevance of publically available text

There are multiple ways to define relevance. For example, what are the topics discussed in the text, is the text 'new' news and is the information potentially material for stock risk/returns?

We'll return to the question of defining and assessing the materiality of news in a future publication. Here we consider relevance from an Information Retrieval perspective – is the text relevant for specific companies in an investment portfolio? At this stage, our goal is simply to tag security identifiers to a text so that qualitative information can be transformed into a quantitative output and integrated alongside traditional financial accounting and pricing data.

To assess whether a given text refers to specific stocks, we employ a computational linguistics algorithm known as Named Entity Recognition (NER). Many of these algorithms are readily available in Natural Language Processing (NLP) toolkits. The goal of NER algorithms is to locate and classify elements of text into predefined categories. Examples include the ability to identify a person's name, geographic locations, or in this case, company names (see Figure 6).

Locating these elements in text is a challenging task given that there are an infinite number of ways to represent the same name. For example, an article may refer to the company IBM by its popular name rather than by its official name, International Business Machines Inc., or by its Bloomberg/Reuters tickers.

Typically, the output of NER algorithms is a machine-readable JSON (JavaScript Object Notation) file, consisting of "name":"value" pairings (see Figure 7). In our example, named entities include The Securities and Exchange Commission (SEC) and Teva Pharmaceutical Industries Limited, as well as geographical locations.

Figure 6: Illustrative example of entities detected using a Named Entity Recognition algorithm

Entity	Type
Teva Pharmaceutical Industries Limited	Company
The Securities and Exchange Commission	Organization
FCPA	Organization
Foreign Corrupt Practices Act	FieldTerminology
Russia	Country
Ukraine	Country
Mexico	Country
Washington	City
D.C.	StateOrCounty

Source: IBM AlchemyLanguage, Deutsche Bank

Figure 7: Example of the JSON containing named entities

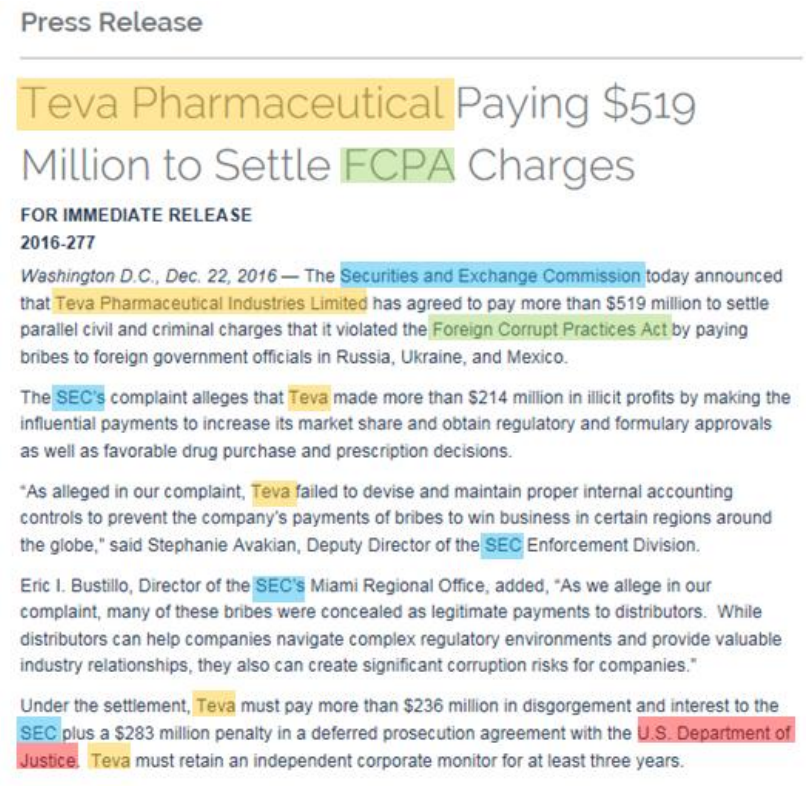

```
"count": "1",
      "text": "Teva Pharmaceutical Industries Limited"
    },
    {
      "type": "Company",
      "relevance": "0.599409",
      "sentiment": {
        "type": "neutral"
      },
      "emotions": {
        "anger": "0.202251",
        "disgust": "0.319806",
        "fear": "0.08498",
        "joy": "0.183728",
        "sadness": "0.296969"
      },
      "count": "1",
      "text": "Teva",
      "disambiguated": {
        "subType": [],
        "name": "Teva Pharmaceutical Industries",
        "website": "http://www.tevapharm.com/",
```


Source: IBM AlchemyLanguage, Deutsche Bank

Having extracted the named entities, we next need to distinguish between whether a company is the subject of the text or simply mentioned in passing (i.e. how relevant is the information). To assess this, one approach is to count the number of times each named entity appears in the text and to record its position (e.g. in the headline, first paragraph, etc.). The more frequently a named entity appears in a text and/or the more prevalent its position, the more likely it is to be the focus of the text.

In Figure 8, for example, Teva is most frequently mentioned entity – once in the title, once in the first paragraph, and a further four times throughout the rest of the text.

Figure 8: Example of Named Entity Recognition



Press Release

Teva Pharmaceutical Paying $519 Million to Settle FCPA Charges

FOR IMMEDIATE RELEASE
2016-277

Washington D.C., Dec. 22, 2016 — The Securities and Exchange Commission today announced that Teva Pharmaceutical Industries Limited has agreed to pay more than $519 million to settle parallel civil and criminal charges that it violated the Foreign Corrupt Practices Act by paying bribes to foreign government officials in Russia, Ukraine, and Mexico.

The SEC's complaint alleges that Teva made more than $214 million in illicit profits by making the influential payments to increase its market share and obtain regulatory and formulary approvals as well as favorable drug purchase and prescription decisions.

"As alleged in our complaint, Teva failed to devise and maintain proper internal accounting controls to prevent the company's payments of bribes to win business in certain regions around the globe," said Stephanie Avakian, Deputy Director of the SEC Enforcement Division.

Eric I. Bustillo, Director of the SEC's Miami Regional Office, added, "As we allege in our complaint, many of these bribes were concealed as legitimate payments to distributors. While distributors can help companies navigate complex regulatory environments and provide valuable industry relationships, they also can create significant corruption risks for companies."

Under the settlement, Teva must pay more than $236 million in disgorgement and interest to the SEC plus a $283 million penalty in a deferred prosecution agreement with the U.S. Department of Justice. Teva must retain an independent corporate monitor for at least three years.

Source: SEC, IBM AlchemyLanguage, Deutsche Bank

To retain information, it is also useful to tag metadata to note the associations between Teva and the other named non-listed entities (e.g. the SEC and U.S. Department of Justice). We consider this next.

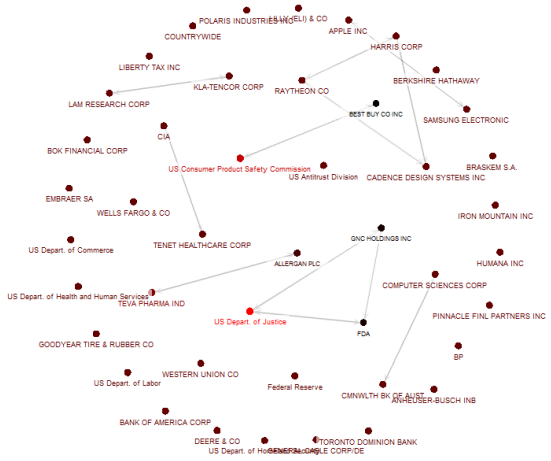
Mapping security identifiers

The third step to structuring text data is to tag security identifiers (e.g. SEDOLs). One approach is to design a string matching algorithm to compare the names detected using the NER algorithm with the company names listed in a financial database. The output of such algorithms is a probabilistic assessment of the accuracy of the SEDOL classification (please contact us for a discussion)[4].

One of the key advantages of text analysis is the ability to identify relationships between companies. In particular, social network analysis techniques have become increasingly popular as a framework for representing relationships between people, groups, in this case interconnected companies (both publically-listed and private companies). Figure 9 shows the results of a network analysis created from a co-occurrence matrix of the named entities associated with regulatory violations.

The approach not only helps visualize which companies are currently associated with regulatory issues but may be used to derive a quantitative score for stock selection strategies. To illustrate this, Figure 10 provides a screen of companies with media allegations of wrong-doing (bribery, corruption, fraud and product recalls), together with quantitative scores derived from a sentiment analysis.

Figure 9: Illustrative example of entities detected using a Named Entity Recognition algorithm



Source: Deutsche Bank

Figure 10: Recent corporate allegations published in media news

Date	Company	Title	Sentiment
20170223	ABB LTD	ABB Hit by Fraud at Unit in Korea Swiss firm alleges that treasurer of its subsidiary is behind	-0.09
20170223	ALTRIA GROUP INC	Altria Sees $50M $70M Hit from Smokeless Tobacco Recall market talk	-0.05
20170223	BOSTON SCIENTIFIC CORP	Boston Scientific recalls Lotus Valve heart devices	-0.04
20170223	CREDIT SUISSE GP	Credit Suisse Under Investigation Justice Department probing whether banks Israeli desk he	-0.01
20170223	CROWN RESORTS LIM	Casino Operator Crown Puts Big China Play on Hold Beijings graft crackdown and arrests of C	-0.03
20170223	MALAYSIA AIRPORT	MACC arrests MAHB senior GM for graft	-0.02
20170223	MAZDA MOTOR CORP	Mazda to recall 460000 cars globally for diesel engine defects	-0.09
20170223	PETROL BRASILEIROS	Brazil Graft Scandal Has Firms Bulking Up Compliance Ranks	-0.05
20170223	VALEANT PHARMACEUTICALS INTL	Former Valeant and Philidor execs plead not guilty in fraud scheme	-0.08
20170222	BRASKEM S.A.	Brazils Braskem Posts BRL2 64B Loss Due to Leniency Agreement	-0.11
20170222	WELLS FARGO & CO	Wells Fargo fires former LA regional president	-0.04
20170220	SAMSUNG ELECTRONIC	Samsung Heir Is Arrested Prosecutors accuse conglomerates de facto leader of bribery and c	-0.13
20170220	VOLKSWAGEN AG	Volkswagens boss accused of telling blatant lies over diesel emissions scandal	-0.14
20170219	BAYER MOTOREN WERK	BMW recalling 19000 i3 plug in hybrids for fire risk	-0.13
20170219	MORRISON(W)SUPRMKT	Morrisons pulls meat product and urges shoppers not to eat it after meningitis bug find	-0.06
20170217	AIRBUS GROUP SE	Austria Chases After Airbus Fraud Investigation of fighter jet deal flags over $1 billion in con	-0.11
20170217	BANK OF CHINA LTD	Bank of China to pay fine in Italy money laundering	-0.06
20170216	DEUTSCHE BOERSE AG	Insider dealing claim false Börse chief says	-0.06
20170216	DR REDDYS LABS	Dr Reddy's Aurobindo recall drugs in US	-0.04
20170216	ROYAL BK SCOT GRP	RBS accused of fraud and systematic forgery by customers and former employee	-0.06
20170216	TWENTY-FIRST CENTURY FOX INC	21st Century Fox Faces Probe Over Funds to Settle Sexual Harassment Claims	-0.05
20170214	DIAGEO	CORRUPTION Questions raised over Diageo	-0.03
20170214	ROLLS ROYCE HLDGS	Rolls Royce tumbles as bribery fine sparks record loss	-0.04

Source: Deutsche Bank

We will discuss ways to integrate such information into factor-based strategies in our forthcoming research.

[4] We achieve a precision of 97% (defined as the number of correctly classified SEDOLs in a documents divided by the total number of documents analyzed), using a relatively limited number of model features.

Final thoughts

In this publication we outline the steps required to transform qualitative information into quantitative scores.

We began with a discussion regarding the Veracity of unstructured data. Our working premise is that mainstream investors are only likely to integrate alternative data once they have confidence in the collection process and transparency in signal creation.

We conclude by highlighting the importance of a further three Vs associated with 'big data':

- Validity – Where do the data come from? Are the data truth or collective opinions? Are the data publicly available data or behavioral-based (i.e. inferred from consumers' web browsing and buying habits)? How can we evaluate the integrity of the signals (i.e. is there a look ahead bias in signal construction)?
- Viability – Can long-only stock selection portfolio managers use such signals? While the potential for satellite imagery and store-level credit card transaction data are interesting datasets, are they sufficiently scalable for stock selection?
- Value – How accretive are alternative data signals for risk-adjusted returns versus traditional factors? And can such signals be implemented in a low turnover way?

Appendix 1

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flows), increases in interest rates naturally lift the discount factors applied to the expected cash flows and thus cause a loss. The longer the maturity of a certain cash flow and the higher the move in the discount factor, the higher will be the loss. Upside surprises in inflation, fiscal funding needs, and FX depreciation rates are among the most common adverse macroeconomic shocks to receivers. But counterparty exposure, issuer creditworthiness, client segmentation, regulation (including changes in assets holding limits for different types of investors), changes in tax policies, currency convertibility (which may constrain currency conversion, repatriation of profits and/or the liquidation of positions), and settlement issues related to local clearing houses are also important risk factors to be considered. The sensitivity of fixed income instruments to macroeconomic shocks may be mitigated by indexing the contracted cash flows to inflation, to FX depreciation, or to specified interest rates – these are common in emerging markets. It is important to note that the index fixings may -- by construction -- lag or mis-measure the actual move in the underlying variables they are intended to track. The choice of the proper fixing (or metric) is particularly important in swaps markets, where floating coupon rates (i.e., coupons indexed to a typically short-dated interest rate reference index) are exchanged for fixed coupons. It is also important to acknowledge that funding in a currency that differs from the currency in which coupons are denominated carries FX risk. Naturally, options on swaps (swaptions) also bear the risks typical to options in addition to the risks related to rates movements.

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