How News and Its Context Drive Risk and Returns Around the World

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Machine Learning in Finance Workshop 2017
Outline of talk

• Introduction
• Text measures defined
• Empirical observations
• Empirical results
• Out-of-sample testing
• Conclusion
Introduction

• Automated processing of natural language allows:
  ✓ Practitioners to monitor information in real time
  ✓ Researcher to systematically study how markets react to information

• Econometrician’s information set

• Prior work has (mostly) focused on short-term responses of individual US stocks to news

• Do news forecast longer horizon, country level outcomes?
  ✓ We construct news measures that seem to do so
  ✓ We think we’re the first to focus on this question
How to measure country level news?

• News measures:
  • Sentiment
  • Frequency
  • Unusualness
  • News topics

• We are particularly interested in news topics:
  • What are country level news topics?
  • Does importance of news differ by topic?
  • Do topics differ from EM to DM?
  • How do topics evolve over time?

• In this paper, we scratch the surface...
Do news forecast country level outcomes?

• We look at four variables at the country level
  • Next month’s return -- $return$
  • Next 12-month returns -- $return^{12}$
  • Next month’s realized volatility -- $\sigma$
  • Next 12-month maximum drawdown -- $\text{drawdown}$

• Look at stock market indexes
  • Returns measured in US$ terms – from perspective of a US-based investor

• Analyze responses separately for emerging market (EM) and developed market (DM) countries
Some answers, many questions...

**Answers**

- Short term country-level responses appear different than single name responses
- EM is different from DM
- Topics matter
- Evidence of out-of-sample predictive ability
- Evidence of regime shifts in coefficients
- Our approach compares favorably to *a priori* approaches, like Baker, Bloom and Davis’ *economic policy uncertainty*

**Questions**

- Why do effects of sentiment depend on topic?
- Do stock index returns cause news?
- Why are EMs different from DMs?
- How much of predictability is from currency effect?
- Is the effect causal? Is it under-reaction? Limited attention? Will it change?
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* Text measures defined

**Data:**
- Thomson-Reuters digital news archive from 1996—2015
- 5mm EM and 12mm DM articles
- 52 countries, 28 DM and 24 EM (country list)

**Text measures:**
- **artcount** – number of articles per country per month
- **entropy** – “unusualness” of an article $j$ (Glasserman and Mamaysky 2016)
  \[ H_j = - \sum_{i \in \{4-grams\}} p_i \log m_i \]
  - E.g. “Order imbalance of 10,000 shares” vs “Order imbalance of 2,000,000 shares”
- **sentiment** – the difference of positive and negative words divided by total words in article $j$:
  \[ s_j = \frac{POS_j - NEG_j}{a_j} \]
  - Word sentiment comes from Loughran – McDonald dictionary (examples)
Topic detection

**Intuition:** Find groups of words that tend to co-occur together in articles

**Details:**

- **1242 econ words**
  - Start w/ 237 words from index of Beim and Calomiris (2001) and find other words, bigrams and trigrams from EM corpus based on cosine similarity
  - *Examples: barriers, currency, parliament, macroeconomist, World Bank, and soybean*

- We have 2 document term matrixes:
  - EM: 5mm articles x 1,240 words
  - DM: 12mm articles x 1,242 words
  - Compute cosine similarity matrixes (1,242 x 1,242)
  - Then do community detection (using Louvain method for modularity maximization)
  - Our topics are mutually exclusive (not necessary)
5 Topics for EM

Wordcloud

Mkt # words (mm) = 113.80
percent
market
expect
investor
central
bank
exchange
money
announced
interest
rate
interest
sector
quarter
growth
profit
trade
stock
share
bank

Govt # words (mm) = 76.58
elect
country
consist
interest
taxation
public
support
fight
war
put
run
pass
voter
problem
free
general
state

Corp # words (mm) = 58.77
compani
rate
invest
debt
infrastructure
regulate
execute
interest
rate
company
bank

Comms # words (mm) = 58.90
price
buy
oil
bid
soybean
product
refine
export
import
mkt

Macro # words (mm) = 15.98
pct
board
account
tax

5 topics
Topic similarity
5 Topics for DM

Mkt # words (mm) = 236.23

Govt # words (mm) = 111.02

Corp # words (mm) = 131.95

Comms # words (mm) = 26.86

Credit # words (mm) = 139.63

5 topics

Topic similarity
### Sample articles in each topic for emerging markets

<table>
<thead>
<tr>
<th>Topic</th>
<th>Date</th>
<th>Sent</th>
<th>Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkt</td>
<td>1997-11-06</td>
<td>-0.22</td>
<td>Elbit Ltd&lt;ELBT3.TA&gt;,&lt;ELBTF.O&gt; Q3 loss $0.11 per share</td>
</tr>
<tr>
<td>Mkt</td>
<td>1996-02-16</td>
<td>-0.22</td>
<td>Uganda shilling weakens against dollar</td>
</tr>
<tr>
<td>Mkt</td>
<td>1999-09-06</td>
<td>0.12</td>
<td>Hungarian shares open higher on Dow gains</td>
</tr>
<tr>
<td>Mkt</td>
<td>2015-03-05</td>
<td>0.12</td>
<td>BUZZ-USD/THB eked out small gains</td>
</tr>
<tr>
<td>Govt</td>
<td>2011-03-16</td>
<td>-0.23</td>
<td>US objects to ’excessive force’ in Bahrain</td>
</tr>
<tr>
<td>Govt</td>
<td>1997-09-18</td>
<td>-0.22</td>
<td>Tehran mayor rejects resignations of 12 mayors</td>
</tr>
<tr>
<td>Govt</td>
<td>2000-06-04</td>
<td>0.10</td>
<td>Clinton says Putin can build strong, free Russia</td>
</tr>
<tr>
<td>Govt</td>
<td>2008-04-03</td>
<td>0.11</td>
<td>Mugabe’s party expects runoff, says he will win</td>
</tr>
<tr>
<td>Corp</td>
<td>2011-01-19</td>
<td>-0.25</td>
<td>BRIEF-Moody’s downgrades Tunisia’s to Baa3, outlook negative</td>
</tr>
<tr>
<td>Corp</td>
<td>2011-01-31</td>
<td>-0.25</td>
<td>BRIEF-Moody’s downgrades Egypt to Ba2, negative outlook</td>
</tr>
<tr>
<td>Corp</td>
<td>2013-05-02</td>
<td>0.14</td>
<td>CORRECTED-TABLE-Philippines’ sovereign credit rating history</td>
</tr>
<tr>
<td>Comms</td>
<td>2013-03-27</td>
<td>0.16</td>
<td>TABLE-Philippines’ sovereign credit rating history</td>
</tr>
<tr>
<td>Comms</td>
<td>2008-09-12</td>
<td>-0.13</td>
<td>BP says Baku-Supsa oil pipeline remains shut</td>
</tr>
<tr>
<td>Comms</td>
<td>1996-05-09</td>
<td>-0.12</td>
<td>Russia’s Novorossiisk oil port still shut by fog</td>
</tr>
<tr>
<td>Comms</td>
<td>2006-12-27</td>
<td>0.08</td>
<td>Great Offshore buys anchor-handling tug vessel</td>
</tr>
<tr>
<td>Comms</td>
<td>1997-06-26</td>
<td>0.08</td>
<td>Tunisia tender for 150,000 T U.S. wheat detailed</td>
</tr>
<tr>
<td>Macro</td>
<td>1996-03-07</td>
<td>-0.12</td>
<td>Hungary 1995 C/A deficit falls to $2.48 billion</td>
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<tr>
<td>Macro</td>
<td>2003-04-30</td>
<td>-0.11</td>
<td>Turkish Jan-Feb c/a deficit jumps to $1.178 bln</td>
</tr>
<tr>
<td>Macro</td>
<td>2006-03-10</td>
<td>0.00</td>
<td>Sao Paulo volta a registrar inflaccao no comeco de marco</td>
</tr>
<tr>
<td>Macro</td>
<td>2012-09-11</td>
<td>0.01</td>
<td>CORRECTED-Lithuania current account surplus rises in June</td>
</tr>
</tbody>
</table>
## Sample articles in each topic for developed markets

<table>
<thead>
<tr>
<th>Topic</th>
<th>Date</th>
<th>Sent</th>
<th>Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkt</td>
<td>2012-05-21</td>
<td>-0.20</td>
<td>BRIEF-FINRA Panel awards John Galinsky $3.5 mn in compensatory damages for breach of contract against Advanced Equities</td>
</tr>
<tr>
<td>Mkt</td>
<td>2003-03-25</td>
<td>-0.20</td>
<td>Euro rises above $1.07 against dollar on war</td>
</tr>
<tr>
<td>Mkt</td>
<td>1996-01-18</td>
<td>0.12</td>
<td>UK’s Clarke confident about inflation, growth</td>
</tr>
<tr>
<td>Mkt</td>
<td>2010-11-02</td>
<td>0.12</td>
<td>BRIEF-Metro CEO cautiously optimistic for good christmas</td>
</tr>
<tr>
<td>Govt</td>
<td>2009-01-08</td>
<td>-0.30</td>
<td>BRIEF-UK Serious Fraud Office to probe Madoff’s UK operations</td>
</tr>
<tr>
<td>Govt</td>
<td>2005-09-09</td>
<td>-0.25</td>
<td>Soccer-Former secretary’s claim against English FA dismissed</td>
</tr>
<tr>
<td>Govt</td>
<td>2014-04-29</td>
<td>0.13</td>
<td>BUZZ-GBP-4/5 on UKIP to win a seat in 2015 UK elections</td>
</tr>
<tr>
<td>Govt</td>
<td>2013-09-20</td>
<td>0.13</td>
<td>BUZZ-GBP-5/4 UKIP win most votes in European election</td>
</tr>
<tr>
<td>Corp</td>
<td>2014-07-21</td>
<td>-0.15</td>
<td>BRIEF-Valence Pharmaceuticals contacts Quebec and U.S. regulators about Allergan’s false and misleading statements</td>
</tr>
<tr>
<td>Corp</td>
<td>2015-12-16</td>
<td>-0.15</td>
<td>BRIEF-NQ Mobile announces termination of proposed divestment of Beijing Tianya</td>
</tr>
<tr>
<td>Corp</td>
<td>1996-05-26</td>
<td>0.13</td>
<td>Rangatira has 9.77 pct stake in Advantage &lt;ADV.NZ&gt;</td>
</tr>
<tr>
<td>Corp</td>
<td>2015-08-11</td>
<td>0.14</td>
<td>BRIEF-Tom Tailor to improve earnings in 2016 - CEO</td>
</tr>
<tr>
<td>Comms</td>
<td>2002-04-17</td>
<td>-0.07</td>
<td>Australasia port conditions - Lloyds</td>
</tr>
<tr>
<td>Comms</td>
<td>2012-06-13</td>
<td>-0.07</td>
<td>Cooperatives cut German 2012 wheat crop forecast</td>
</tr>
<tr>
<td>Comms</td>
<td>2006-10-10</td>
<td>0.13</td>
<td>TAKE A LOOK- Weekly US state crop progress reports</td>
</tr>
<tr>
<td>Comms</td>
<td>2006-10-16</td>
<td>0.13</td>
<td>TAKE A LOOK- Weekly US state crop progress reports</td>
</tr>
<tr>
<td>Credit</td>
<td>1998-11-16</td>
<td>-0.29</td>
<td>TABLE - NeoPharm Inc &lt;NEO.A&gt; Q3 net loss</td>
</tr>
<tr>
<td>Credit</td>
<td>1998-07-10</td>
<td>-0.27</td>
<td>TABLE - NDC Automation Inc &lt;AGVS.OB&gt; Q2 loss</td>
</tr>
<tr>
<td>Credit</td>
<td>2012-02-21</td>
<td>0.22</td>
<td>BRIEF-Moody’s revises euromax’s outlook to stable from positive</td>
</tr>
<tr>
<td>Credit</td>
<td>2011-04-21</td>
<td>0.23</td>
<td>BRIEF-Moody’s revises Pulte’s outlook to stable from positive</td>
</tr>
</tbody>
</table>
The final country level measures

- Let $f_{\tau,j}$ be the fraction of econ words in article $j$ that are about topic $\tau$
- Article sentiment is $s_j$
- Topic sentiment is $s_{\tau,j} \equiv f_{\tau,j} \times s_j$
- Aggregate the article level measures into daily measures (weighted by number of overall words)

For a given country, we have 12 daily text measures:

- entropy
- article count
- $sMkt / fMkt$
- $sGovt / fGovt$
- $sCorp / fCorp$
- $sComms / fComms$
- $sMacro / fMacro$ (EM)
- $sCredit / fCredit$ (DM)
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* Empirical observations

**EM Sentiment**

- For 140 EM sentiment series (28 countries x 5 topics) we look at first 2 principal components
- PC2 – relative sentiment of Markets to Government
- Some evidence of a regime shift in PC2 around the financial crisis
DM Sentiment

• For 120 DM sentiment series (24 countries x 5 topics) we look at first 2 PCs

• PC2 – relative sentiment of Markets to Government (again!)

• Some evidence of a regime shift in PC2 a little before the financial crisis
Event studies – EM

- Cumulative abnormal returns in 10 day windows around news events
- Bottom, middle and top decile of news sentiment
- Lots of caveats

Observations

- Stock index prices drift into news (news not exogenous)
- No drift around neutral news
- Topics with post event drift:
  - Mkt (both)
  - Comms (negative)
- Different from single name results, where there is little evidence of drift post negative news (e.g. Tetlock et al., Henderschott et al.)
**Event studies – DM**

**Observations**

- News is more of a **surprise** in DM’s
  - Bigger event-day jumps

- Some topics show post event drift:
  - Mkt (negative, both?)
  - Corp (positive)
  - Credit (both)
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• For EM and DM samples, run panel regressions – with country fixed effects – to forecast $t+1$ observations of:
  ✓ return
  ✓ $return^{12}$
  ✓ sigma
  ✓ drawdown

• Control for many variables that have been shown to have forecasting power for future returns
  • The no-text measure regression is our Baseline model

• All text measures (except entropy) are normalized to unit variance

• Run regressions in the 1$^{st}$ and 2$^{nd}$ half of the sample, as well as for the overall sample
## Data definitions summary

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>return</code></td>
<td>Total monthly stock returns (in %) including capital gains and dividend yield</td>
</tr>
<tr>
<td><code>return^{12}</code></td>
<td>Cumulative stock returns from the start of month $t$ to the end of month $t + 11$</td>
</tr>
<tr>
<td><code>sigma</code></td>
<td>Rolling 20-day realized volatility reported in annualized terms</td>
</tr>
<tr>
<td><code>drawdown</code></td>
<td>Next 12-month maximum drawdown in percent</td>
</tr>
<tr>
<td><code>retmi</code></td>
<td>Negative portion of returns</td>
</tr>
<tr>
<td><code>retpl</code></td>
<td>Positive portion of returns</td>
</tr>
<tr>
<td><code>value</code></td>
<td>Stock price level of five years ago divided by current stock price level</td>
</tr>
<tr>
<td><code>gdp</code></td>
<td>Rate of growth of real GDP</td>
</tr>
<tr>
<td><code>gdpdeflator</code></td>
<td>Rate of change of the GDP deflator</td>
</tr>
<tr>
<td><code>cp</code></td>
<td>Private sector credit to GDP ratio</td>
</tr>
<tr>
<td><code>dcp</code></td>
<td>First differenced of credit to GDP ratio</td>
</tr>
<tr>
<td><code>rate</code></td>
<td>Interest rate</td>
</tr>
<tr>
<td><code>dexchange</code></td>
<td>Change in currency exchange rate to US Dollar, truncated at ±50%</td>
</tr>
<tr>
<td><code>pre</code></td>
<td>Dummy variable set to 1 if month $t$ is 6 or fewer months prior to an election</td>
</tr>
<tr>
<td><code>post</code></td>
<td>Dummy variable set to 1 if month $t$ is 6 or fewer months after an election</td>
</tr>
<tr>
<td><code>entropy</code></td>
<td>Measurement of unusualness</td>
</tr>
<tr>
<td><code>artcount</code></td>
<td>Number of articles writing about a country given one-month period</td>
</tr>
<tr>
<td><code>s[T\text{opic}]</code></td>
<td>Sentiment in a given month due to $Topic$</td>
</tr>
<tr>
<td><code>f[T\text{opic}]</code></td>
<td>Frequency of articles in a given month due to $Topic$</td>
</tr>
</tbody>
</table>
Summary of results

• News matters for EM and DM!
• But results differ across EM and DM
  • Baseline $R^2$ lower for EM
  • % increase in $R^2$ from text measures larger for EM
• Sign of effects (i.e. good news or bad) is consistent across $return$, $return^{12}$, $sigma$, and $drawdown$
• Context matters:
  • positive sentiment in $Govt$, $Corp$ $\rightarrow$ bad news
  • positive sentiment in $Mkt$ $\rightarrow$ good news
• Incremental explanatory power largest for $return^{12}$ and $drawdown$; explanatory power lower for $return$ and $sigma$
• Evidence of state dependence, especially for $entropy$
  • Goes from a “bad” pre-crisis to a “good” post-crisis
<table>
<thead>
<tr>
<th></th>
<th>Emerging markets</th>
<th>Developed markets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>return</td>
<td>return$^{12}$</td>
</tr>
<tr>
<td>sigma$_{t-1}$</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>sigma$_{t-2}$</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>return$_{t-1}$</td>
<td>-</td>
<td>-</td>
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<tr>
<td>return$_{t-2}$</td>
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<td>-</td>
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<td>retmi$_{t-1}$</td>
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<td>-</td>
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<tr>
<td>retmi$_{t-2}$</td>
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<td>value$_{t-1}$</td>
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<td>gdp$_{t-1}$</td>
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<td>gdpdeflator$_{t-1}$</td>
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<td>cp$_{t-1}$</td>
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<tr>
<td>pre</td>
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<td>+</td>
</tr>
<tr>
<td>post</td>
<td>+</td>
<td>+</td>
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<tr>
<td>entropy$_{t-1}$</td>
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</tr>
<tr>
<td>artcount$_{t-1}$</td>
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<td>sMkt$_{t-1}$</td>
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<td>+</td>
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<tr>
<td>fMkt$_{t-1}$</td>
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<td>+</td>
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<tr>
<td>sGovt$_{t-1}$</td>
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<td>fGovt$_{t-1}$</td>
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<tr>
<td>sCorp$_{t-1}$</td>
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<td>-</td>
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<td>fCorp$_{t-1}$</td>
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<tr>
<td>sComms$_{t-1}$</td>
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<td>fComms$_{t-1}$</td>
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<td>fMacro$_{t-1}$</td>
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<td>sCredit$_{t-1}$</td>
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<td>+</td>
</tr>
<tr>
<td>fCredit$_{t-1}$</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

- Ø means variable is excluded from regression
- Standard errors:
  - For return and sigma regressions we cluster by time
  - For return$^{12}$ and drawdown cluster along both dimensions (Thompson 2011)
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* Out-of-sample testing

• Do we have too many explanatory variables?
• What about regime shifts?
• Check out-of-sample forecasting performance
• Run rolling 5-year lasso regressions in $t-60,...,t-1$ for forecasting month $t$ outcomes
• Evidence of out-of-sample forecasting ability for $return^{12}$ and $drawdown$, for both EM and DM
  • Especially for EM
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*Useful information in text for medium-term country-level outcomes!*

- Different dimensions of text matter
  - In particular, context
- Effects differ across EM and DM
- Effects differ over time
- Evidence of out-of-sample forecasting ability
- Next:
  - Currency effects?
  - Trading strategies?