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 → HUGE

* 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
  - Next 12-month returns
  - Next month’s realized volatility
  - Next 12-month maximum 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)
  \[
  H_j = - \sum_{i \in \{4\text{-grams}\}} p_i \log m_i
  \]
  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

Mkt # words (mm) = 113.80

percent
market
expect
investor
central
bank
exchange
money
gold
interest
rate
sector
growth
trade
firm
stock
share
bank

Govt # words (mm) = 76.58

elect
parliament
brief
attack
control
media
house
police
officers
people
public
support
fight
war
run
opposition
leader
commission
religion
nation
head
state

Corp # words (mm) = 58.77

compani
invest
debt
risk
current
rate
result
result
supply
demand
import
export

Comms # words (mm) = 58.90

price
buy
crude
oil
demand
import
export
new
report

Macro # words (mm) = 15.98

5 topics
Topic similarity
## Sample EM 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>Corp</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>
</tr>
<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 inflacão no começo 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>
<tr>
<td>Topic</td>
<td>Date</td>
<td>Sent</td>
<td>Headline</td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<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 euramax’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
- $s\text{Mkt} / f\text{Mkt}$
- $s\text{Govt} / f\text{Govt}$
- $s\text{Corp} / f\text{Corp}$
- $s\text{Comms} / f\text{Comms}$
- $s\text{Macro} / f\text{Macro}$ (EM)
- $s\text{Credit} / f\text{Credit}$ (DM)

EM or DM specific
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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
**More principal components**

**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.)
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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Empirical results

- 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

EM drawdown residuals  DM drawdown residuals
## Control variables

### Data definitions summary

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

<table>
<thead>
<tr>
<th></th>
<th>Emerging markets</th>
<th>Developed markets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>return</td>
<td>return&lt;sup&gt;12&lt;/sup&gt;</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>$\text{return}_{t-1}$</td>
<td>+</td>
<td>$\emptyset$</td>
</tr>
<tr>
<td>$\text{return}_{t-2}$</td>
<td></td>
<td>$\emptyset$</td>
</tr>
<tr>
<td>$\text{retmi}_{t-1}$</td>
<td>$\emptyset$</td>
<td>$\emptyset$</td>
</tr>
<tr>
<td>$\text{retmi}_{t-2}$</td>
<td>$\emptyset$</td>
<td>$\emptyset$</td>
</tr>
<tr>
<td>$\text{value}_{t-1}$</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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

**EM panel summary**

**DM panel summary**
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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?