

Forecasting financial markets with semantic network analysis in the COVID-19 crisis

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Motivation

- ▶ **Individuals attempt to anticipate future movements** of economic variables and business cycle dynamics. This is particularly important for **investment decisions** in financial markets.
- ▶ There is a large body of literature on predicting financial markets and many indicators have been used as predictors.
- ▶ However, the predictability power of such indicators is often questionable and evidence of **systematic predictability is weak**, see Welch and Goyal (2008).
- ▶ Recently, a new theory based on a different type of data has received increasing attention, namely the **news media perception and evaluation of the business cycles**, see Beaudry and Portier (2006).
- ▶ Beaudry and Portier (2014) state that **“according to the news media view of the business cycle, both the boom and the bust are direct consequences of people’s incentive to speculate on information related to future developments of the economy.”**

Motivations

- ▶ One of the main challenges of this theory is the **definition of news** and how to empirically measure it.
- ▶ Recently Larsen and Thorsrud (2019) propose a novel and direct measure of media news based on their semantic content.
- ▶ Using text data from a Norwegian financial newspaper, they document a superior predictability power of their indicator for Norwegian stock indices returns.
- ▶ The recent COVID-19 crisis has rendered the task of predicting financial market fluctuations even more difficult.
- ▶ In this context, **Italy** represents a peculiar case.
 - ▶ **First country** in Europe to experience a **major outbreak of COVID-19**
 - ▶ **Finances were already under stress**, posing serious doubts about the short-term sustainability of the economy, as well as the long-term outlook.
- ▶ Such period of economic and social turmoil, where the news media have not merely covered the role of broadcasting information but also that of conveying perceptions and expectations about future states of the economy, represents an unprecedented testing ground to evaluate the link between **news media information** and **macro-finance variables**.

Contributions

- ▶ We introduce a new **index of semantic importance**, based on a **novel methodology** that evaluates the **relative importance** of one or more general **economic related keywords (ERKs)** that appear in the news.
- ▶ The new index combines methods drawn from both **network analysis** and **text mining** and evaluates semantic importance along the three dimensions of
 - ▶ **prevalence**, i.e. frequency of word occurrences,
 - ▶ **connectivity**, i.e. degree of centrality of a word in the discourse,
 - ▶ **diversity**, i.e. richness and distinctiveness of textual associations.
- ▶ Previous research mainly looked at **media sentiment** or **media coverage**, without analysing the embeddedness that ERKs have in the corpus and their relationships with other words.
- ▶ Fronzetti Colladon et al. (2020) and Jussila et al. (2017) have been questioned the reliability of sentiment algorithms.

Contributions

- ▶ We identify **38 relevant ERKs** and using a large database of articles published by Italian newspapers, over the period spanning between January 2017 and August 2020. We assign a **score** to each ERK, compounding the three dimensions mentioned above.
- ▶ We then aggregate the information from the 38 ERKs in a single composite news index applying the **Partial Least Squares (PLS)** between the target variable and the (38 ERKs) predictors.
- ▶ We evaluate the power of our media news index in **predicting** not only the **Italian stock market aggregate return** but also various **short and long maturity government bonds index returns**, as well as their **volatility**.

Findings

- ▶ Our findings show that the index is able to **anticipate the different phases** of the market and capture idiosyncratic features of each series.
- ▶ We find evidence of **economically meaningful and statistically significant predictability** for government bond returns and volatilities.
- ▶ For stock market data, we find evidence of predictability of the market portfolio returns only to a limited extent.
- ▶ When predicting stock market volatility, adding information contained in the news media **improves the prediction accuracy up to 9%**, compared to standard benchmark forecast models.
- ▶ Alternative (standard) methods for dealing with newspaper information, such as the **sentiment index**, do **not** offer similar gains.

Outline of the talk

- ▶ A new index for textual data
- ▶ Italian application
- ▶ Forecasting exercise
- ▶ Conclusions

A new index for textual data

- ▶ The methodology labelled Semantic Brand Score was introduced by Fronzetti Colladon (2018) for commercial brands' but has never been applied in the economic and financial environment.
- ▶ Network representation of the sentence **The proud and unfeeling landlord views his extensive fields, and without a thought for the wants of his brethren, in imagination consumes himself the whole harvest** (from The Theory of Moral Sentiments of Adam Smith)



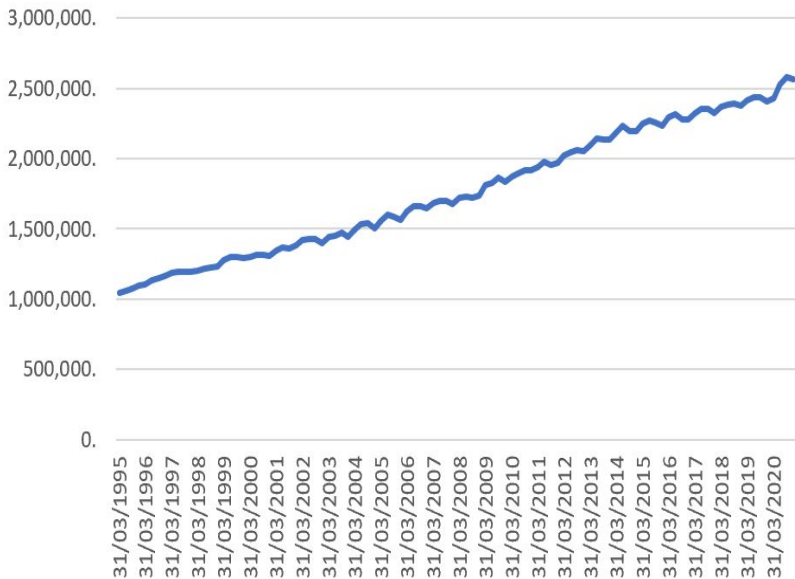
Three dimensions of prevalence, diversity and connectivity.

- ▶ **Prevalence** relates to the notion of **awareness** and measures how **frequently** an ERK is mentioned. Prevalence of a particular set of words could ultimately influence the opinions and behaviours of the readers. Triggering fear or an optimistic view about the current, as well as future, states of the economy.
- ▶ **Diversity** measures the degree of **heterogeneity** of the semantic context in which a word is used. It can disentangle if the word has a trivial connection or not. For example:
 - ▶ Democrats, election, is a trivial connection.
 - ▶ Democrats, Biden, Impeachment, White House, Trump is a more important connection.
 - ▶ In the first case the index takes small value, in the second a very high value.

Three dimensions of prevalence, diversity and connectivity.

- ▶ **Connectivity** measures how much a word is **embedded** in a article acting as a **bridge** between its parts, or more specifically, how often a word appears in-between the network paths which interconnect the other words in the text.
- ▶ For example take two words Santa Claus, Red, CocaCola. The red is a bridge.
- ▶ Finally, an index is constructed as a composite score obtained by **summing** the **standardized measures of prevalence, diversity and connectivity**.

Forecasting stock and bond markets: Italian Public Debt in thousand euros

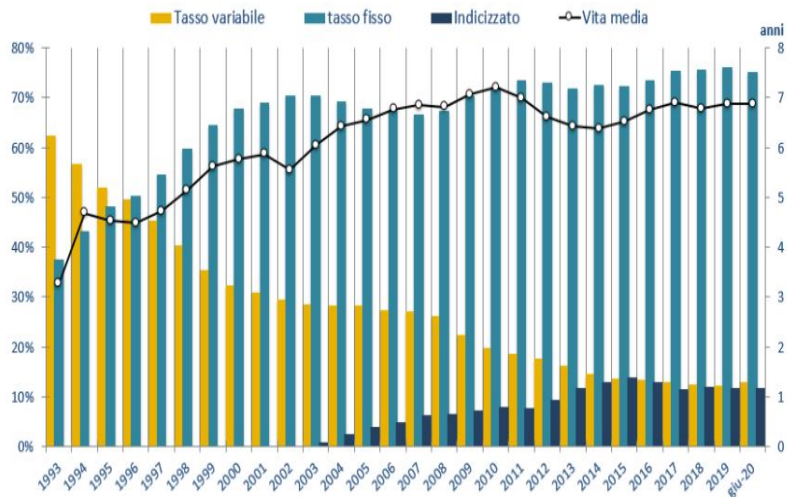


Forecasting stock and bond markets: Sustainability of Italian public debt

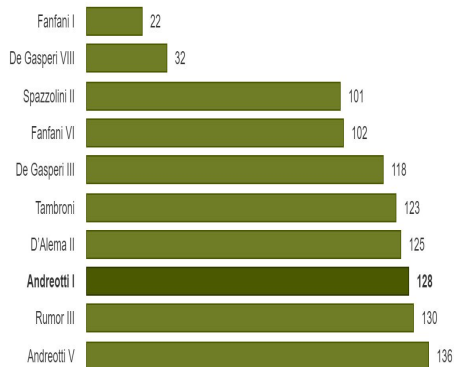
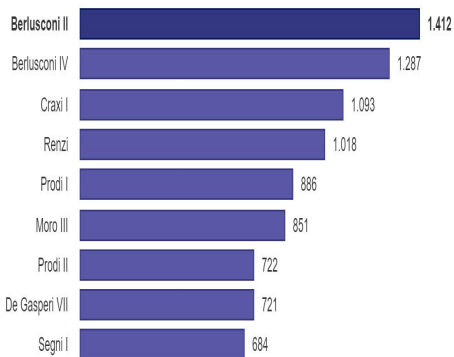
Public debt per capita		Public Debt/GDP		External Debt/GDP	
Country	\$	Country	%	Country	%
Japan	102503	Japan	223.8	Malta	879.0
Singapore	97852	Greece	180.0	Cyprus	597.0
Qatar	77278	Lebanon	142.0	Singapore	453.0
Greece	50562	Yemen	135.5	UK	313.0
Italy	49060	Italy	132.2	France	277.0

2019 Data.

Forecasting stock and bond markets: Italian public debt composition



Forecasting stock and bond markets: Duration of Italian government in days



Political news matter

Forecasting stock and bond markets: Dataset

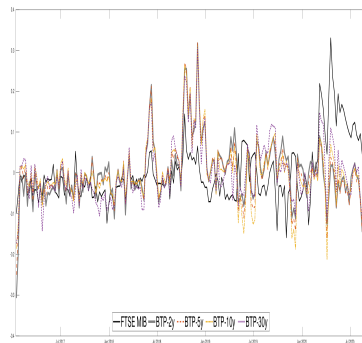
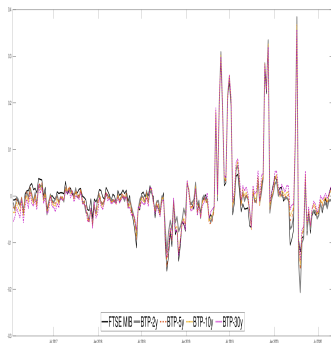
- ▶ Our set of target variables comprises the aggregate stock market portfolio, FTSE MIB index, and 2, 5, 10 and 30-year maturity Italian government bond indices, collected from Datastream.
- ▶ For each of these variables, available daily, we compute logarithmic returns and realised volatilities (measured in percentage), aggregated at a weekly frequency.
- ▶ We opt for a **weekly** aggregation frequency following evidence in Fronzetti Colladon (2020), which showed that daily news data is highly variable and proved that the effect produced by multiple news in one-week has more impact on citizens' behaviour.
- ▶ Weekly realised volatility is computed using the range estimator of Parkinson (1980), i.e. $(4 \log 2)^{-1}(\log H_t/L_t)^2$, where h_t and l_t represent the highest and lowest prices of week t , respectively.
- ▶ The sample period spans from January 6, 2017 to August 28, 2020, totalling 191 weekly observations.

Forecasting stock and bond markets: choose the ERKs

Choosing pertinent keywords to search in a database of newspapers articles is crucial for the construction of an informative textual index.

Word singletons							
1	Spread	7	Quantitative easing	13	Rating	19	Real economy
2	Interest rates	8	Monetary policy	14	Eurogroup	20	European Commission
3	Euro	9	Bank of Italy	15	coronabond	21	Eurobond
4	European troika	10	ESM ¹	16	SURE ²	22	EIB ³
5	Junk bond	11	Oil	17	Gold	23	Financial markets
6	Strikes	12	INPS ⁴	18	GDP	24	Confindustria ⁵
Word sets							
1	COVID, coronavirus	5	BTP, BOT, CCT	9	savings, savers	13	european union, EU
2	lockdown, quarantine	6	inflation, prices	10	deficit, gov.t debt	14	consumption, -umers
3	taxes, taxation, wealth tax	7	Borsa Italiana, FTSE MIB, FTSE MIB	11	unions, CGIL, UIL ⁷ CISL,		
4	economic crisis, recession, economic pandemic	8	unemployment, redundancy, unemployment benefit	12	smart working, distance work		

Forecasting stock and bond markets: Media news index



(a) Media news index targeted to the returns (b) Media news index targeted to the volatility series

Figure: Aggregate information from the 38 ERKs in a single composite news index applying the PLS between the target variable and the (38 ERKs) predictors. Panel A shows the semantic importance indices applied to Italian stock returns (FTSE MIB) and Italian bond returns (BTP-2y, BTP-5y, BTP-10y, BTP-30y). Panel B shows the indices applied to volatility of Italian stock markets and Italian bond markets.

Forecasting exercise

- ▶ We employ a recursive forecasting scheme, using an expanding estimation sample, to produce 1-week ahead forecasts.
- ▶ The first estimation sample spans from 6 January 2017 to 26 April 2019. The out-of-sample (OOS) forecast evaluation period spans the following 70 weeks, i.e. from 3 May 2019 to 28 August 2020.
- ▶ We opt for a simple forecasting model, i.e. the ARX(1):

$$y_{t+1} = \alpha + \gamma y_t + \beta x_t + \varepsilon_{t+1} \quad \varepsilon_{t+1} \sim WN(0, \sigma^2) \quad (1)$$

where y_{t+1} is the target variable we aim at predicting, x_t is a set of news information predictors.

- ▶ An obvious choice for x_t is the pool (or a subset) of the 38 indexes assigned to the ERK (EW).
- ▶ Another choice is to use the media index news in x_t (ERK).
- ▶ Two standard benchmarks: the white noise model when the target is the return of either stocks (RW) and bonds and the AR(1) model when we aim at forecasting volatility.
- ▶ Moreover, we also compare our index to an alternative and well-known text evaluation method: the sentiment index (SI), see Fraiberger et al. (2018).
- ▶ Mean squared prediction errors (MSPEs) and Diebold and Mariano test (Diebold and Mariano, 1995, DM).

Out-of-sample evidence

Models	FTSE MIB	BTP-2y	BTP-5y	BTP-10y	BTP-30y					
Panel A: Returns										
<i>RW</i>	3.07	0.18	0.59	1.02	1.89					
<i>AR</i>	1.07	0.99	1.00	1.01	1.00					
<i>ERK</i>	1.02	0.98	*	1.02	1.01	0.99				
<i>EW</i>	1.06	0.98	*	1.03	1.05	1.05				
<i>SI</i>	1.07	1.00		1.01	1.01	1.00				
Panel B: Volatility										
<i>AR</i>	0.92		0.94	0.88	0.85	0.80				
<i>ERK</i>	0.91	**	0.97	*	0.96	*	0.94	**	0.99	*
<i>EW</i>	1.00		1.00	1.02	1.02	1.01				
<i>SI</i>	0.95		1.00	1.00	1.00	0.99				

Table: Panel A provides mean square prediction error (MSPE) results when forecasting Italian stock returns (FTSE MIB) and Italian bond returns (BTP-2y, BTP-5y, BTP-10y, BTP-30y). Panel B provides MSPEs when forecasting the volatility of Italian stock and bond markets. One * and two ** indicate that the alternative model provides superior statistical forecasts at 10 and 5 % significance level, respectively.

Conclusions

- ▶ This paper introduces a **new textual data index** for predicting stock market data based on a novel methodology applied to a **large set of newspaper articles** to evaluate the importance of one or more general **economic related keywords** that appear in a text.
- ▶ The methodology is applied to online Italian press and 38 economic related keywords are selected and are used to predict the Italian stock market and government bond returns and volatilities in the 2017-2020 period, including the inception of the COVID-19 crisis.
- ▶ Our findings show that the semantic importance index based on media news text data is able to **capture the different phases and individual features of return and volatility dynamics** of financial variables.
- ▶ When used to predict weekly market and bond returns and volatilities, we find **strong evidence of predictability of bond returns and volatility**, as well as of **stock market volatility**.

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