COVID-19: Social Media as Moderator in-between the Pandemic and the Market

R. Tommasetti, V. Moth é Maia, and M. A. da Silva Macedo

***Abstract*—Emerged as a black swan event that stifled the global economy, the COVID-19 is the first social media (SM) pandemic. In an unsocial age due to social distancing, SM relevance is intuitively magnified during a pandemic. The present study investigates the effect of contagious diseases and the direct and moderator effects of Twitter activity on the Italian Stock Market during the info-pandemic related to COVID-19. As a natural experiment, a time-series regression measures the effect of the COVID-19 virus, proxied by the active cases, and the marginal impact of the pandemic-related tweets on the Italian stock market. The choice of the country is due to its central role in the pandemic scenario. Results show that local active cases and number of topic-related tweets - both on a stand-alone basis and as moderator of the local active cases - are significant in explaining the market returns and predicting their volatility. It demonstrates that social media play a role in-between the COVID-19 and market, amplifying the pandemic impact. The originality of the study is that it goes beyond a purely empirical investigation of the catalyst (this is the pandemic), thus contributing to current theoretical debates on SM impact on investor's behaviour. The paper gives a comprehensive reading of the impact of the black swan on the local financial market. Its empirical findings could be used to prepare policymakers and market participants for analogous epidemics.**

***Index Terms*—COVID-19, Italy, Twitter, stock return, volatility.**

I. Introduction

Literature about the impact of public media on stock prices highlights that they play a key role in the investor's decision process ([1], [2]). This is even more important in a digital age where investor's sentiment can be derived from social media ([3], [4]) which represents a society behaviour's database.

Scholars investigating the relationship between the aggregate social media opinion and stock returns are not novel in finance. Prior research has examined how companies exploit SM in engaging stakeholders ([5], [6]) or whether the aggregate users' activity (comments, likes, retweets) predicts the stock market as a whole ([7]-[9]) or individual ticker return ([10]). Even the relationship between one influential user's tweets and the stock market has already been studied ([11], [12]).

Emerged as a black swan event that stifled the global economy, COVID-19 pandemic has several unique characteristics that distinguish it from previous crises, and open a new avenue for research of investor's behaviour and contagion, as moderated by the social media. According to [13], among the reasons for this crisis to be significantly different from previous shocks, are: (i) the possibility to timestamp the crisis and identify its main catalyst (the spread of a deadly contagious disease); (ii) the central role played by social media - when compared to past crisis episodes - in providing pressure on governments, and shaping investors' expectations. "Therefore, in comparison to previous approaches to financial contagion, the transmission of the information via media channels will be more significant for facilitating the response to the crisis, and one of the main determinants of spillovers in financial markets" ([13]).

Interestingly, more than one month before the virus to be declared as a pandemic on March 11 ([14]), on February 2, the WHO labelled the situation as infodemic, due to the amount of information, true and false, circulating this topic ([15]), confirming that the risk is not only associated to the catalyst in itself, but to the medium too.

The COVID-19 is indeed not immune to misinformation since it is the "first social media pandemic" ([16]). Additionally, the role of social media in investor's behaviour is intuitively magnified during a pandemic which forces people-investors to social distancing and then to an intensive SM use.

For this reason, some of the rapidly growing numbers of empirical papers assessing the financial effects of COVID-19 pandemic, recognize without quantifying, the significance of social media in-between the pandemic and market. [17], who mapped the general patterns of country-specific and systemic risks demonstrating the pandemic impact on global financial markets volatility, hypothesizes that such dramatic movement cannot simply occur because of long-term expectations (see also: [18]), instead, it is "almost certain that sentimental factors play important roles" ([17]). Consistently with discussion on investor attention ([19]), Economic Policy Uncertainty ([20], [21]) and market behaviour during the pandemic, the underlying paper's assumption is that the market sentiment in response to the outbreak can be quickly amplified through social media, which then stimulate trade activities and cause extreme price movements ([22]). In an attempt to assess the interaction of the market volatility and media during the COVID-19 pandemic, [23] finds a positive relationship between the US Economic Policy Uncertainty (EPU) variable, an index based on newspaper coverage of policy-related economic uncertainty, and the Chinese market financial volatility.

Thus, the purpose of the present work is to combine the experience done by recent studies on the relationship between the pandemic figures and the market with those about the public media and market, proposing the novel

Manuscript received March 31, 2021; revised July 30, 2021.

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doi: 10.18178/ijtef.2021.12.5.710

contribution of the social media in this sense. Additionally, social media role is not only proposed as a stand-alone regressor of the investor's behaviour, but also as moderator in-between the pandemic evolution and the market.

In this respect, the present study addresses the following research questions:

RQ1. Do local (and worldwide) pandemic figures affect market returns and volatility?

RQ2. Do social media COVID-related discussions affect market returns and volatility?

RQ3. Do social media exacerbate the relationship between pandemic and market?

The choice of Italy is due to its central role in the COVID scenario, being the country where the virus has spread first outside China. Italy represented the epicentre of the virus in Europe for weeks and still holding the sad record of being the country with the highest number of victims (35,082 as of July 23, 2020) in continental Europe ([24]). Also, Italy has been the first country where Twitter's COVID-related data can be collected and observed, since this platform does not operate in China. Finally, Italian is a language almost uniquely spoken in Italy, thus returning a more accurate measure in terms of the contribution of the social media on that specific market.

The contribution of this paper is threefold, with each of those contributions generating particular novelty in the associated results.

First, previous scant financial literature on the pandemic relates epidemiologic data with either stock return ([25]) or market volatility ([17], [23]), while the present study aims to integrate both impacts, to give a comprehensive reading of the phenomenon. Also, in the present paper, the cumulative active cases - instead of using daily new cases or deaths as in previously cited works - are used as a proxy of the pandemic spread, to take into consideration the curve of the recovered cases as well.

Second, in comparison to numerous papers on COVID-19 that recently have been published in finance journals, this paper goes beyond a purely empirical investigation of the catalyst (this is the pandemic). The purpose is to contribute to current theoretical debates on the influence of social media on financial markets, using the COVID-19's black swan event, which is particularly interesting and important for a wide range of investors across the globe.

Finally, empirical findings could be used to prepare for policymakers and market participants for analogous epidemics.

The remainder of this paper is organized as follows. The next sections outline the data source and the research method adopted. Subsequently, results and their implications are discussed together with final remarks.

II. Data

Daily data on FTSE Italy Index are gathered from S&P Capital IQ to calculate daily returns and volatility, while the COVID-related statistics are gathered from the Worldometer site (https://www.worldometers.info/coronavirus/).

As far as Twitter data, the process of data collection has been achieved using a python web crawler named GetOldTweets which operates in nearly real-time as a background activity. It is based on the use of the advanced research of the Twitter web page which provided access to the public accounts on the chosen virtual community.

Data collection has been performed by establishing and then implementing specific filters to identify all Twitter users' comments, whose declared language is Italian, including "COVID", "C19" and "Coronavirus" up to May 31, 2020. This process produced a total of 573,807 tweets collected including account, date, numbers of likes, and retweets.

In the following Table I, the average weekly figures of both the pandemic and the infodemic related to COVID-19 are presented together with the corresponding Italian stock market data. As far as twitter data, virality and popularity index can be measured to offer a better view of reactivity, dialogues, and users' engagement ([26]). Virality is measured by the number of times a single tweet is "retweeted", that is shared with other users, while popularity is calculated as the number of "likes" to a single tweet.

TABLE I: Variable Statistics

Week	Market		Pandemic		Infodemic		
	RET	VOL	ACI	ACW	TWE	POP	VIR
Feb 3rd	(0.1%)	16.6%	14	56,869	0	0	0
Feb 4th	(10.5%)	27.9%	515	45,634	3,621	7.72	2.20
Mar 1st	(2.5%)	31.0%	2,951	37,010	27,210	10.38	2.74
Mar 2nd	(34.1%)	73.7%	12,453	47,367	42,745	10.95	2.73
Mar 3rd	0.9%	100.0%	36,079	129,875	23,200	8.38	2.27
Mar 4th	10.3%	82.3%	67,136	395,476	55,976	7.34	2.05
Apr 1st	1.2%	65.4%	87,969	775,319	15,109	5.76	1.70
Apr 2nd	(3.9%)	53.0%	100,782	1,141,515	59,587	4.72	1.57
Apr 3rd	(0.7%)	46.9%	107,606	1,455,042	69,359	5.88	1.81
Apr 4th	5.9%	40.3%	105,269	1,744,166	71,726	4.94	1.50
May 1st	(4.2%)	37.7%	97,346	2,026,210	62,069	5.45	1.73
May 2nd	(1.6%)	34.0%	80,856	2,302,343	47,818	5.07	1.69
May 3rd	3.5%	32.7%	63,876	2,586,644	51,735	5.00	1.65
May 4th	7.3%	30.0%	49,466	2,837,882	43,652	6.56	1.88
Period	**(28.5%)**	**48.5%**	**58,023**	**1,112,954**	**573,807**	**6.34**	**1.87**

The period of analyses is from 15th of February to 31st of May, 2020, divided in weeks. RET = FTSE Italy Index return; VOL = FTSE Italy Index annualized volatility; ACI = Italian COVID-19 weekly average active cases; ACW = weekly average world COVID-19 active cases (less ACI); TWE = number of virus-related tweets; POP = virus-related weekly tweets' average popularity, calculated as likes divided by tweets; VIR = virus-related weekly tweets' average virality of the weekly tweets, calculated as retweets divided by tweets. As to the values in the row "Period": for the variables RET and TWE is a sum for the period, while for the variables VOL, ACI and ACW is the average. POP and VIR are calculated as per their respective formulas.

Three phases can be identified in the above Table I.

The first, which relate to February and March, where financial markets are jittery, assisting to the "virus wave" coming together with the related flow of information and disruption: the annualized volatility reaches 100%, the market capitalization collapses by 47% since the beginning of February and 34% in a single week (the 2nd week of March), and the COVID-related tweets reach the highest levels of popularity and virality.

The second phase, around April, is linked to the "virus plateau": the number of active cases is the highest, but the increase in daily cases and deaths is slowing. Correspondently the number of related tweets is high, but Twitter users are less engaged. Volatility decreasing and the market appears to be preparing for a slow recovery.

The third phase, starting from May, is characterized by a decrease in the active cases, in social media attention and market volatility.

III. Model

To assess how the outbreak of COVID-19 has shaken the Italian stock market, the model used by [27] to evaluate the impact of the flu cases in the US stock market, has been adapted to include COVID-19 infodemic data in Table I, as supported by [13] who state that public attention and social

media will play an important role during the pandemic, increasing the financial markets spillover effect on both local returns and volatility. The following time-series regression is run:

$$RET_d = \alpha_0 + \beta_1 ACI_d + \beta_2 ACW_d + \beta_3 TWE_d + \beta_4 (ACI_d * TWE_d) + \varepsilon \quad (1)$$

In the equation above, RET_d is the daily FTSE Italy Index natural log return, ACI_d is the natural log change in the number of daily COVID-19 Italian active cases, this is total cases deducted deaths and recoveries (cases still waiting for an outcome), ACW_d is the natural log change in the number of daily COVID-19 world active cases (less ACI_d), while TWE_d is the natural log change in daily virus-related tweets, as an indicator of the Italians speaking users' topic attention. α_0 and ε_d represent the intercept and the error term respectively.

Similarly, for the volatility the following regression is run to investigate if the pandemic and infodemic data of the day before (d-1) would predict the following market day volatility, based on the [17]'s findings, that the pandemic had a central role in increasing market risk.

$$VOL_d = \alpha_0 + \beta_1 VOL_{d-1} + \beta_2 ACI_{d-1} + \beta_3 ACW_{d-1} + \beta_4 TWE_{d-1} + \beta_5 (ACI_{d-1} * TWE_{d-1}) + \varepsilon \quad (2)$$

In the equation above, VOL_d is the FTSE Italy Index volatility, calculated using the Garch(1,1) model methodology of [28], applied to the daily Index natural log returns from January 1, 2010 to May 31, 2020.

ACI and TWE coefficients, respectively representing the direct effects of the pandemic and related tweets, are expected to be negative (thus reducing) for return (Equation 1) and positive (thus increasing) for volatility (Equation 2).

As per research questions, the social media is not only proposed as a stand-alone regressor of the investor's behaviour but also as moderator in-between the pandemic and market. For this purpose, it is proxied by the interaction variable (ACI * TWE), whose coefficient is expected to be negative under Equation 1 and positive under Equation 2. This would demonstrate that SM marginally strengthen the effects of the pandemic.

Finally, the variable ACW is to control markets' interdependence during a crisis, this is to understand whether the Italian market reacts to the international COVID-19 figures' change, independently from the local active cases' evolution.

IV. Results

In the following Table, the time-series regression model outcome of our panel to verify the multivariate significance, sign, and strength of the relationships between the model variables is proposed:

The Table II shows that both models are, as a whole, significant (at 0.01 level) with an adjusted r squared of 22.38% for the model under Equation 1 and 91.19% for the model under Equation 2. As expected per formulated hypotheses, the daily change in COVID-19 active cases has a significant (negative/decreasing) effect on local stock return and (positive/increasing) on market volatility.

TABLE II: Time-Series Regression

Equation (1)			Equation (2)		
Variables	**Sign**	RET_d	**Variable**	**Sign**	VOL_d
α_0	Na	0.0012	α_0	na	0.0010
			VOL_{d-1}	[+]	0.8634***
ACI_d	[-]	(0.0720)*	ACI_{d-1}	[+]	0.0130*
ACW_d	[-]	0.0371	ACW_{d-1}	[+]	0.0252
TWE_d	[-]	(0.0050)*	TWE_{d-1}	[+]	0.0002
$TWE_d * ACI_d$	[-]	(0.1335)***	$TWE_{d-1} * ACI_{d-1}$	[+]	0.0222***
Adjusted R^2		22.38%	Adjusted R^2		91.19%
F-test p-value		< 0.01	F-test p-value		< 0.01
Residual correlation p-value		> 0.10	Residual correlation p-value		> 0.10
Homoschedacity p-value		> 0.10	Homoschedacity p-value		> 0.10

RET_d = daily FTSE Italy Index return; VOL_d = daily FTSE Italy Index volatility, calculated using Garsh(1,1); ACI_d = change in number of daily COVID-19 Italian active cases, this is total cases deducted deaths and recoveries; ACW_d = change in number of daily COVID-19 world active cases (less ACI_d); TWE_d = change in the daily virus-related tweets. α_0 and ε_d represent the intercept and the error term respectively. "d-1" indicates the variable calculated for the day before. "Sign" is the expected sign associated to the variable. Significance: *p < 0.10; ** p < 0.05; *** p < 0.01.

Findings are in line with previous literature on epidemic disease impact on financial markets. [29] investigate the impact of the 2014-2016 Ebola outbreak events in the U.S. market, finding that the catalyst's effect is negative and the strongest for the stocks' return of companies with their operations in West African countries (WAC). The event effect is also followed by the elevated perceived risk; that is, the implied volatility increases after the Ebola outbreak events. Consistently with studies ([29]-[31]) which demonstrate that investors react more to news/events that are closer in distance to them, the ACW_d variable is not significant both in the return and in the volatility model.

Findings are also in line with the recent literature on the topic concerning COVID-19 impact on financial markets. [25] indicate that both the daily growth in total confirmed cases and total deaths impact negatively on the Chinese Stock Market. [32] illustrate the freefall of the global markets, especially for financial firms ([33]), with an increase in volatility ([23]) and country-specific and systemic risks ([17]). [34] examined the relation between stock market price variability and the revisions of predicted infections from the epidemic model. They found that the volatility of US stock returns was decreasing as the trajectory of the pandemic's development was becoming clearer, coherently with what described in phases 2 and 3 in the Italian case (see Section II).

As to the financial market reaction to the social media discussion on COVID-19, our results indicate that the virus-related Twitter activity is negatively associated with market returns and positively with their volatility. Also, in both cases, the coefficient of the interaction between pandemic data (active cases) and infodemic data (tweets) is significant and, consistently, negatively associated with market returns and positively with their volatility. This means that the social network users can moderate - amplifying - the impact of virus data on market, confirming a social media role in investor's behaviour.

Results are consistent with [29] and [35] who observe, in the Ebola case, that the outbreak events are overemphasized in the media and create sentiment effects. [29] find that the event effect is stronger for securities that are exposed to the intense media coverage compared to securities less covered in the media, concluding that media-driven pessimism and optimism, induced in that case by the Ebola outbreak events, can significantly influence investors' decision-making process when investing in companies of different capitalization size and industry of operation.

As far as the COVID-19 disease specifically, [19]), who explored a link between the differences in the responses of the financial market in the US to the outbreak, analyse the content and tone of conference calls. Overall, their results illustrate how the anticipated real effects of the health crisis, a rare disaster, were amplified through financial channels. Similar results for [18] who investigated the response of the stock market to different news within the sequence of events following the initial outbreak of COVID-19 in China and its subsequent spread around the world.

The underlying reason for this outcome is probably revealed by interdisciplinary researches on the relationship between COVID-19 and Twitter which show that, in social media, falsehood is shared far more than evidence-based information ([36]) and that kind of platforms are well known for the spread of misinformation and denial of scientific literature ([37], [38]), page 943, citing the Canadian 1960s social analyst Marshal McLuhan who said that "the medium is the message", concludes her paper saying that "today that message is chaos". Going deeper, [39] identify the most relevant and accurate topics related to coronavirus outbreak and run a sentiment analysis confirming the prevalence of negative sentiments like fear along with positive sentiments like trust. [40] group into four main concerns the COVID-19 topic discussed on Twitter, "economic losses" being the one with more tweets and likes. For this reason, [38], page 942, states that "financial panic went viral", suggesting that "financial markets are jittery about the flow of information and disruption to production and supply chains with the global spread of COVID-19".

V. Conclusions

Differently from SARS, dated in a pre-social media era, and Ebola, geographically limited to West African Countries, COVID-19 is the first worldwide social media pandemic of an unprecedented magnitude. Thus, represents a unique - since is the first - opportunity to submit the market to the social media test during a pandemic.

In this sense, the purpose of the present article is to propose social media as a regressor of stock market behaviour and its capacity to moderate the relationship between the market and the catalyst (in this case the pandemic).

Consistently with discussion on investor's behaviour and media attention, literature studied the relationship between emotions or economic policy uncertainty, as represented by public media, and previous ([29], [35]) or current epidemics outbreak ([18]-[21], [23]).

Other studies ([13], [17], [22]) suppose that social media could be one of the main determinants of spillovers in financial markets, playing a role in-between the pandemic and market.

The present study not only confirms the above, by demonstrating that the number of topic-related tweets as a stand-alone variable is significant in explaining the market returns and predicting their volatility, but also that is responsible for the financial contagion.

Indeed, the finding that infodemic proxy, when interacted with the pandemic, is negatively associated with returns and positively with their volatility, means that social media are not only the vehicle but represent the message in itself. In other terms, Twitter amplifies the impact of the catalyst (the virus disease) on the stock market.

"Bad mood" and anxiety transmitted through social media - rather than rational behaviour - affect investor decisions, in the context of the COVID-19 outbreak, against taking risks, contribute to pessimism regarding future returns, and thus dictating asset price movements. In this sense, recent studies demonstrate that the investors' perception of coronavirus risk will shape the economic anxiety, the economic policy uncertainty, and the stock market behaviour ([20], [21]).

The contribution of this paper is threefold: (i) it relates epidemiologic data, taking into consideration the curve of the recovered cases as well, with either stock return and market volatility, giving a comprehensive reading of the phenomenon; (ii) it goes beyond a purely empirical investigation of the catalyst (this is the pandemic), contributing to the recent discussion on investor attention and social media and, more specifically, to literature which relate COVID-19 and EPU; (iii) its empirical findings could be used to prepare for policymakers and market participants for analogous epidemics. Future research could be dedicated to investigating how specific topics discussed by SM users during the pandemic can be relevant for building an investor's perceptual map.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

R. Tommasetti and V. Mothé Maia conceived of the presented idea. R. Tommasetti developed the theory, while V. Mothé Maia and M. A. da Silva Macedo developed the methodology and tested the model. All authors discussed the results and contributed to the final manuscript, having approved the final version.

Acknowledgment

This paper is dedicated to the memory of professor Claudio Ulysses Ferreira Coelho, coordinator of the accounting undergraduate and graduate courses at State University of Rio de Janeiro (UERJ), died from COVID-19 virus in May 2021.

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