The Annals of Regional Science
https://doi.org/10.1007/s00168-023-01243-0

ORIGINAL PAPER

Anxiety about the pandemic and trust in financial markets

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Received: 11 February 2022 / Accepted: 21 August 2023

Abstract
The COVID-19 pandemic has generated a novel context of global financial distress. This paper enters the related scientific debate and focuses on the relationship between the anxiety felt by the population of a wide set of countries during the pandemic and the trust in the future performance of financial markets. Precisely, we move from the idea—grounded on some recent literature contributions—that the volume of Google searches about "coronavirus" can be considered as a proxy of anxiety and, jointly with the stock index prices, can be used to produce indicators of the population mood—in terms of pessimism and optimism—at country level. We analyse the "very high human developed countries" according to the Human Development Index plus China and the main stock market indexes associated with them. Namely, we propose both a time-dependent and a global indicator of pessimism and optimism and classify indexes and countries accordingly. The results show the existence of different clusters of countries and markets in terms of pessimism and optimism. Moreover, specific regimes emerge, with optimism increasing around the middle of June 2020. Furthermore, countries with different government responses to the pandemic have experienced different levels of mood indicators, so countries with less stringent lockdown measures had a higher level of optimism.

JEL Classification D83 · G15 · G41

1 Introduction

The world has experienced the rapid and dramatic widespread of COVID-19 (Li et al. 2020; Zhu et al. 2020)—a pandemic generated by a coronavirus—with millions of infected and a large number of deaths. Beyond the sanitary aspects of such

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Published online: 15 September 2023

an infectious disease, one of the main concerns experienced by communities regards the economic impact of the measures taken for contrasting the virus (see, for example, Siddique et al. 2022, where authors have analysed the role of regional poverty during the COVID-19 pandemic in the USA).

The financial distress we have observed in the international stock markets—whose entity has been much more evident during the so-called *first wave* of the pandemic, in the period February–June 2020, can be reasonably interpreted also through the *anxiety* of the people, whose worries for the pandemic affected the expectations of financial markets' future performance.

The term *anxiety* in our setting demands some words to contextualise its meaning. For us, *anxiety* (for the pandemics) stands for a feeling of worry and/or fear about the future uncertain evolution (of the pandemics). In this respect, anxiety is, for us, synonymous of fear and worry. It consequently generates *pessimism*, i.e. the tendency to feel that the most negative scenarios (in the context of the pandemic, in our case) will occur. Conversely, a positive view of the future is associated with *optimism*.

This paper enters this debate. Specifically, it explores how the anxiety expressed by the population about COVID-19 mirrors the strategies of investing/disinvesting capital in financial markets, here represented by major stock market indexes. In particular, we discuss the relationship between anxiety about COVID-19 and the view of financial markets, aiming to investigate optimism and pessimism.

Consistently, we focus only on the first wave of the pandemic; indeed, empirical evidence suggests that financial distress is remarkably evident at the beginning of COVID-19 diffusion (see, Deb 2021where a focus on the industry of airlines is presented). The analysis deals with the country-level moods relaying on Zimmermann et al. (2020)'s conclusions that human factors should be monitored and considered at the outbreak in such a globalised world. We explore the relationship mentioned above for a large set of countries to derive the different behaviours of the populations. Fetzer et al. (2021) and Binder (2020) are remarkably relevant for contextualizing our study. The authors discuss the economic anxiety stemming from the coronavirus. Binder (2020) conducts a survey study of over 500 US consumers and shows that the serious concern about coronavirus implications leads to pessimistic expectations about macroeconomic turnaround via deterioration of the economic fundamentals. Fetzer et al. (2021) complement Binder (2020)'s perspective by also including the time dimension and the causal effect of the pandemic on the increased economic anxiety. The methodological ground of Fetzer et al. (2021) lies in the meaningfulness of Google Trends data, which is assumed to give in-depth information on the development of anxiety in the specific context of the economic outcomes (for additional supportive pieces of evidence that relates web searches and population anxiety see Rovetta and Castaldo 2020; Monzani et al. 2021; Halford et al. 2020). We adopt Fetzer et al. (2021)'s view and hypothesise that anxiety about COVID-19 is proxied by the irrepressible persistence of related web searches (on the significance such a type of data, see Cinelli et al. 2020; Choi and Ahn 2020 in the former an analysis of the *infodemic* is presented, in the latter the Google Trends data are used in an influenza spread forecast model). In so doing, we also follow Mertens et al. (2020), where a survey-based study over a large number of respondents confirms that media exposure and online searches are good predictors of the increasing

fear of coronavirus (in this, see also the review paper by Garfin et al. 2020). Additionally, in Hisada et al. (2020), the authors have underlined the relevance of online searches in predicting emerging COVID-19 clusters of infections.

In detail, we collect and compare two datasets over the same reference period, from January 6, 2020, to June 19, 2020. On one side, we consider the daily Google Trends data. Specifically, we examine the search volumes of the word *"coronavirus"* along with its translations for different countries' most spoken languages. Data retrieved at a country level allow for sounding out similarities and discrepancies in the search for information practised by users in need of awareness. In our approach, such compulsive searching is intended as a proxy for the anxiety generated by the pandemic. On the other side, we consider the daily levels of the main stock indexes, including companies related to the countries. The source of financial data is Eikon - Datastream (in line with studies such as Lewis and Bozos 2019, and Chizema 2010). In order to have a reliable and consistent dataset (in terms of countries' features of interest), countries are chosen by using the Human Development Index (HDI) used by the United Nations Development Programme (UNDP) in the Human Development Report Office to rank countries on the basis of their human development. Specifically, we select areas with an HDI index greater than 0.8, calculated with the 2018 information. The choice of 0.8 as a threshold is appropriate because all countries with at least that level can be considered as "very high human developed countries" (see, UNDP 2019for additional information on the definition). It ensures a good enough level of connections between socio-financial entities within the countries. Namely, it guarantees the incorporation of the necessary links between citizens' cognitions of the problems, ability to get informed about them, access to the relevant resources and financial strategists presence (this choice is in line with the findings presented in Chundakkadan and Ravindran 2020about the relevance of the access to online sources to increase the response capacity of a country). Indeed, the starting point of our study is that the data on Google Trends about searches offers a reliable description of how people search for information in a given country. This statement is valid where access to the web is widespread and granted to citizens. Therefore, it is not valid for less developed countries such as those classified as "Low human development" in UNDP (2019), where a large portion of the population has poor internet access for causes such as lack of infrastructure, devices or limited digital literacy. Thus, including all the world's countries would lead to a biased analysis, with some underdeveloped countries represented by the "privileged club" of people living at the highest standards. Therefore, taking the subset of countries corresponding to those under the locution "very high human developed countries" makes the analysis less biased and more rigorous. We add China, which is ranked below the 0.8 threshold – specifically, 0.75, to such a list of nations. We reasonably do so because China is central to the phenomenon under investigation. Moreover, the countries without data on stock exchanges in our source, Datastream, have been obviously excluded from the list.

Our work departs from Fetzer et al. (2021) in two keys respects: first, the quoted paper deals with topics detected in Google Trends, and we deal with one crucial word, "coronavirus". In so doing, we have a translation task to face, as acknowledged by Fetzer et al. (2021). Nevertheless, the use of one word allows us to obtain intuitive results and is far from being restrictive in our context (we are also in line

with Baig et al. 2020; Goodell and Huynh 2020). Indeed, a preliminary inspection of the Google Trends data shows that the considered word is the most relevant related to the studied pandemic; second, the quoted paper directly derives information about economic anxiety from Google Trends. Differently, we here start from the idea that the anxiety is manifested through the Google searches of the word *"coronavirus"* (and its translations); in doing so, we differ from Chundakkadan and Ravindran (2020), and we are in line with Bento et al. (2020) where such a keyword is employed. After that, we move to stock indexes' performances to assess the links with financial markets and with the trust in them.

Indicators synthesising the considered time series have been suitably introduced in this work to offer a broad perspective on the connections between the variables. We conceptualise such indicators focusing on specific dates and offering global information on the entire reference period. All the proposed indicators range in the unitary interval [0, 1], making the comparative analysis of different countries possible.

Several interesting results emerge. Countries and stock indexes can be clustered in terms of their resulting mood during the first wave of the pandemic period. Regularities and deviations at individual week levels can also be identified. Moreover, the analysis of the daily variations of the levels of anxiety and trust in financial markets gives insights about countries' behaviours in the period. A general trend of pessimism was concentrated in early, and mid-March 2020 when many countries adopted the lockdown, and the international community started to gauge the problem's severity. A focus on some noticeable cases of hard and weak lockdown policies has also been presented. In this respect, countries with a stricter lockdown had a more persistent and higher level of pessimism.

The obtained findings can be placed in a wide literature strand on the pandemics' effects on people's moods. In this respect, we mention, e.g. Francisco et al. (2020); Hennessy et al. (2021); Kolakowsky-Hayner et al. (2021); Yuksel et al. (2021). However, to the best of our knowledge, the analysis proposed in the present study is the first one giving an overview of the mood of citizens for a large set of countries and proposing time-varying and global studies of such a mood. Indeed, for example, Francisco et al. (2020) restrict the analysis to children and adolescents whilst we consider the entire population in each country. The authors describe the case of three countries (Spain, Italy and Portugal) and explore only different ways to measure pessimism. From a different perspective, Hennessy et al. (2021) offer an analysis based on the music as a device for measuring the mood. The authors refer to the early phases of COVID-19 in India, the UK, the USA and Italy. They carry out an interesting study on a small sample of individuals. Kolakowsky-Hayner et al. (2021) insist on a gender-based analysis of the mood for 59 countries but offered aggregate results based on a small sample of individuals. Finally, Yuksel et al. (2021) deal with several countries and implemented a survey on the quality of sleep, certainly related to mood during the pandemic. Also, the sample is small in their case, which is utterly appropriate for a survey-based study.

The rest of the paper is organised as follows. Section 2 discusses some key contributions on the roots of the anxiety for a pandemic and its links with the stock indexes' performance. Section 3 presents the employed dataset by also providing details on the data collection procedure. Section 4 illustrates the indicators used

for the study. Section 5 outlines and discusses the analysis results. The last section concludes.

2 Literature review

The individuals' behaviours, attitudes and choices are at the core of the interest of many scientific studies given that those are the ground for a deep understanding of the economic patterns; this is even more relevant when peculiar social settings occur, such as those realised as a consequence of the pandemic. For example, sadly, social interactions represented a threat in the context of a pandemic spreading, see, Xiong et al. (2020). In this respect, Bonacini et al. (2020) discusses the effectiveness of the lockdown policies in the paradigmatic case of Italy, while social distance and freedom restrictions are the basis of Qiu et al. (2020) and Venter et al. (2020), the former provides an exploration of the influence of contagion in nearby cities in China and the latter estimates the improvement in air-pollution deriving from actives reduction indirectly caused by the pandemic. The quoted papers suggest pointing attention to the evidence that several businesses require physical interactions among the involved actors—and such interactions have been reduced by the lockdown policies and by the natural attitude of people avoiding possible sources of contagion—while virtual connections allow another set of economic relevant activities, such as investing in financial markets. In Danisman and Tarazi (2020), the authors consider the "uncertain prospects after the COVID-19 pandemic" as a premise for including new financial technologies through fintech as a response taken in the financial sector. Zahra (2020) discusses the uncertainty of the post-COVID-19 world and the role of innovation activities in international entrepreneurship initiatives. Similarly, Dias et al. (2020) discusses changes in the online learning environment that is having disruptive innovations and changes worldwide.

In Oldekop et al. (2020), the authors remark that the global development paradigm is based on three main factors, and the first mentioned is "the interconnectedness of contemporary capitalism" across countries and its permeation with global development. This point constitutes the theoretical ground for understanding the increasing interest in financial markets' performance and catastrophes. Goodell (2020) provides a brief discussion on the financial markets reactions to rare catastrophic events of non-financial nature. The author points the readers to the plausible parallelisms between pandemics and natural disasters, terrorist attacks and even nuclear conflict. Some features of the markets manifested in such cases have been outlined by Lyócsa and Molnár (2020), associating Google searches and S&P 500 returns and volatility. Less recently, Kaplanski and Levy (2010) elaborate on how aviation disasters can generate a decline in related stock prices. Goel et al. (2017) treat the special case of terrorist attacks exploring the vulnerability of financial markets to terrorist incidents. In general, empirical evidence proves that prices collapse in concomitance to rare and unexpected disasters (see, e.g. Barro 2006; Gabaix 2012; Gourio 2012). On the same line, but from a broader perspective, several authoritative studies highlight that anxiety and negative mood might increase investors' risk aversion, hence leading to the collapse of stock prices (see, e.g. Ariel

1990; Kamstra et al. 2000, 2003; Cohen-Charash et al. 2013). Interestingly, in Ho and Wyer (2023), a focus on the relationship between risk-taking, optimism and pessimism is presented, and in Buchheim et al. (2022), referring to the German context, the authors state that "firms incorporate this sentiment [optimism and pessimism] regarding the shutdown duration in their more general business outlook", confirming the conceptual framework according which the mood and the economics and financial expectations interacted, affecting each other during the pandemic.

3 Data[1]

We now present the employed data. As we will see in detail below, the considered dataset is associated with Google Trends and the stock indexes at the country level. As a premise, stock indexes data are not always available; moreover, some countries have regions and territories whose inhabitants have limited resources to gather information from the web. In these circumstances, the validity of the Google Trends data for the intended purposes is questionable because the detected volumes of searches may not be representative of the entire population but just of a set of more privileged citizens. To avoid such sources of bias and inconsistency, we focus on a qualified set of countries whose data provide a good description of the situation of their inhabitants. At this aim—and for providing a consistent analysis—we have used the Human Development Index (HDI) adopted by United Nations Development Programme (UNDP)'s Human Development Report Office as the criterion for selecting the countries to be investigated. Indeed, HDI is a composite index made of factors like life expectancy, education, per capita income indicators, and other relevant factors whose details are recollected in Ul Haq (1995) by Mahbub ul Haq, one of the two designers of the index. HDI is used to rank countries on the basis of human development. More specifically, we take all the countries defined as "very high human developed countries", namely those having an HDI index greater than 0.8. The selection is based on data from 2018, Table 1 of UNDP (2019). China is added to the considered countries—even if the HDI of China is 0.75—because of its centrality in the COVID-19 propagation; the first known human infections were in China.

Employing Google Translate, the word *"coronavirus"* is translated from English to the equivalent word in the most used language in each of the considered countries. In so doing, we obtain the translations reported in Table 1.

The translated terms are employed to query the web search indicator from Google Trends. Namely, for each country, one looks for the index of search of the *"coronavirus"* translations in the language awarding the largest number of speakers. The period investigated captures the first wave of the pandemic; it goes from January 6, 2020, to June 19, 2020.

At the end of this process, one gets a time series matrix regarding 63 countries. In our analysis, we are interested in examining the Google Trend search indicator

[1] The data that support the findings of this study are available from the corresponding author upon request

Table 1 Google Trends data. The table contains the country name, translation of "coronavirus" from English to the most used language in the respective country and a statistical summary of the related time series. The varying number of observations is due to the first day on which a positive value for search volumes is recorded

Country	Terms	N. obs.	μ	σ	Skew	Kurt	μ/σ
Andorra	Coronavirus	151	21.993	19.640	1.794	3.867	1.120
Argentina	Coronavirus	151	29.079	24.462	1.206	0.609	1.189
Australia	Coronavirus	151	26.735	22.690	1.207	0.306	1.178
Austria	Coronavirus	151	20.430	20.572	1.928	3.838	0.993
Bahamas	Coronavirus	155	22.303	20.927	1.528	2.039	1.066
Bahrain	ف ريوس كورونا	151	11.768	9.360	5.880	51.919	1.257
Barbados	Coronavirus	155	26.800	22.471	1.293	1.209	1.193
Belarus	каранавірус	148	1.973	11.097	7.449	58.031	0.178
Belgium	Coronavirus	151	23.669	21.221	1.243	0.912	1.115
Brunei	Koronavirus	149	3.651	17.847	4.746	20.878	0.205
Bulgaria	коронавирус	154	22.786	21.561	1.341	1.104	1.057
Canada	Coronavirus	152	25.039	22.082	1.398	1.268	1.134
Chile	Coronavirus	152	21.914	19.096	1.625	2.406	1.148
China	新冠 病毒	150	30.513	24.353	0.677	− 0.032	1.253
Croatia	Koronavirus	154	22.539	23.752	1.169	0.157	0.949
Cyprus	κορωνοϊόσ	115	13.322	21.840	1.587	2.013	0.610
Czech Republic	Koronavirus	150	18.880	20.863	1.877	3.188	0.905
Denmark	Coronavirus	154	20.994	20.459	1.595	2.090	1.026
Estonia	Koroonaviirus	163	17.773	22.791	2.068	3.554	0.780
Finland	Koronaviirus	152	12.974	15.485	2.597	10.577	0.838
France	Coronavirus	151	23.060	21.109	1.465	2.102	1.092
Germany	Coronavirus	152	22.296	19.562	1.411	1.765	1.140
Greece	κορωνοϊόσ	115	3.774	14.466	6.049	35.634	0.261
Hong Kong	新冠 病毒	154	32.175	20.736	0.780	0.649	1.552
Hungary	Koronavírus	151	26.543	24.531	1.189	0.361	1.082
Iceland	Kórónaveira	148	6.128	17.692	2.926	8.299	0.346
Ireland	Coronavirus	151	27.245	23.121	1.114	0.584	1.178
Israel	הנורוק דיגנ	154	29.182	21.834	1.166	0.811	1.337
Italy	Coronavirus	150	25.960	22.112	1.130	0.554	1.174
Japan	コロナウイルス	163	25.540	19.700	1.113	1.137	1.296
Kazakhstan	коронавирус	151	32.086	24.145	0.727	− 0.504	1.329
Kuwait	ف ريوس كورونا	151	12.695	10.626	3.974	29.089	1.195
Latvia	Koronavīruss	150	15.533	22.113	2.207	3.816	0.702
Liechtenstein	Coronavirus	151	19.927	15.596	1.817	5.039	1.278
Lithuania	Koronavirusas	159	23.572	26.291	1.369	0.775	0.897
Luxembourg	Coronavirus	153	22.529	21.246	1.482	1.884	1.060
Malaysia	Koronavirus	155	5.884	11.544	5.493	36.443	0.510
Malta	Koronavirus	146	4.192	14.699	3.795	15.588	0.285
Montenegro	вирус Корона	115	10.765	21.945	1.909	2.946	0.491
Netherlands	Coronavirus	152	23.072	22.431	1.236	0.857	1.029

Table 1 (continued)

Country	Terms	N. obs.	μ	σ	Skew	Kurt	μ/σ
New Zealand	Coronavirus	152	26.013	22.373	1.360	1.025	1.163
Norway	Koronavirus	150	11.373	22.099	3.053	8.220	0.515
Oman	ف ريوس كورونا	152	11.776	10.691	4.038	29.401	1.102
Palau	Coronavirus	150	17.420	21.531	1.012	0.542	0.809
Poland	Koronawirus	150	23.940	22.218	1.448	1.644	1.078
Portugal	Coronavírus	149	5.383	11.303	7.275	57.320	0.476
Qatar	ف ريوس كورونا	160	16.350	12.382	2.138	11.681	1.321
Romania	Coronavirus	151	22.338	22.240	1.513	1.619	1.004
Russia	коронавирус	151	16.762	15.348	1.776	5.187	1.092
Saudi Arabia	ف ريوس كورونا	149	12.409	12.271	2.984	16.307	1.011
Seychelles	Coronavirus	149	31.342	20.223	0.993	0.979	1.550
Singapore	新冠 病毒	148	23.757	18.333	0.892	1.760	1.296
Slovakia	Koronavírus	149	16.201	18.168	2.181	5.867	0.892
Slovenia	Koronavirus	152	18.901	20.257	1.743	2.969	0.933
South Korea	코로나 바이러스	152	8.967	16.827	3.654	13.159	0.533
Spain	Coronavirus	151	22.490	21.035	1.601	2.516	1.069
Sweden	Coronavirus	155	22.271	20.375	1.306	1.197	1.093
Switzerland	Coronavirus	151	22.093	20.035	1.472	2.050	1.103
Turkey	Koronavirüs	151	28.934	22.757	0.923	0.533	1.271
United Arab Emirates	ف ريوس كورونا	164	15.878	13.302	2.037	8.827	1.194
United Kingdom	Coronavirus	151	27.576	23.148	1.238	0.748	1.191
United States	Coronavirus	151	25.397	23.879	1.329	0.896	1.064
Uruguay	Coronavirus	151	19.570	20.028	1.809	3.270	0.977

from the first day a relevant search volume is recorded in each country; i.e. on the first day in which Google Trends offers a non-null value for the translated terms. See columns one, two and three of Table 1 and Fig. 1 for an idea of the main trends in the data. The most noticeable point is the high volume of searches around mid-March 2020.

We associate at least one stock index with each country on the abovementioned list. Per each index, the closing prices are downloaded from Thomson Reuters Datastream. The period is the same adopted for collecting the Google Trends data (see Table 2 and Fig. 2) so that one has the same amount of data. Andorra, Bahamas, Barbados, Belarus, Brunei, Liechtenstein, Palau, Seychelles and Uruguay do not have a stock market index of reference in our data source, so we exclude them because we need to have data points for both the variables under consideration. The final list of considered countries contains 54 elements. Furthermore, we align the Google Trends and financial data so that the volume of web searches can be used in the analysis for each day in which prices are recorded. Indeed, as we will see, the indicators proposed in the paper are grounded on the joint observation of the Google Trends data and the stock indexes' performance. Therefore, it is

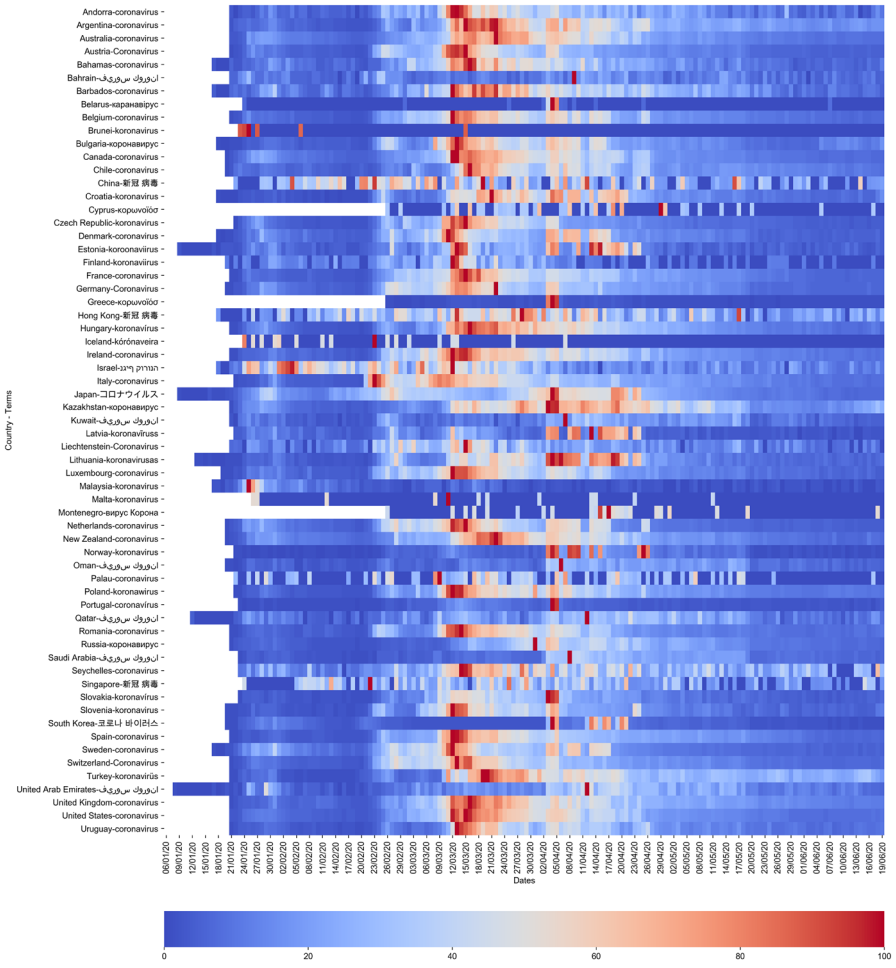

Fig. 1 Heatmap representation of the Google Trends search indicators of the word *"coronavirus"* and its translations in the respective most spoken language for each country. The indents give a clear view of the beginning of the interest in COVID-19 for each country

necessary to work on these two quantities considering only the days when Google Trends data and the stock indexes' performance are registered and can be jointly elaborated. More than this, a biased and incomplete analysis would be the outcome of the study of only one of such factors. Hence, reducing the Google Trends data for having a shared time frame with the stock indexes' performance ones lets the study be free of biases and suitable to pursue the intended aim. In this respect, we notice that Google searches data are available daily. In contrast, financial data are available only when the financial markets are open, i.e. during trading days, typically not on weekends or other special dates. This explains why the Google Trends data are reduced. As a reference for the number of observations, one can look at column "N. Obs." in Table 2.

Table 2 The statistical summary of the stock indexes' closing prices is reported. The last four columns regard the normalized time series, according to Eq. (1)

Country	Index	N. obs.	μ	σ	μ_{norm}	σ_{norm}	$Skew_{norm}$	$Kurt_{norm}$	μ_{norm}/σ_{norm}
Argentina	S&P MERVAL INDEX	109	35486.915	6392.100	72.598	13.077	− 0.399	− 0.920	5.552
Australia	S&P/ASX 200	109	5911.601	747.938	82.535	10.442	0.465	− 1.120	7.904
	S&P/ASX 300	109	5871.308	746.514	82.512	10.491	0.451	− 1.122	7.865
Austria	ATX - AUSTRIAN TRADED INDEX	109	2430.447	451.639	75.656	14.059	0.602	− 1.060	5.381
Belgium	BEL 20	109	3329.824	468.996	79.313	11.171	0.510	− 0.971	7.100
Bulgaria	BULGARIA SE SOFIX	110	483.159	57.005	82.488	9.732	0.662	− 1.198	8.476
Canada	S&P/TSX COMPOSITE INDEX	110	15309.834	1702.964	85.320	9.490	− 0.070	− 0.765	8.990
	S&P/TSX 60 INDEX	110	922.101	95.774	86.235	8.957	− 0.130	− 0.672	9.628
Chile	S&P/CLX IGPA CLP INDEX	110	19958.315	2275.439	82.770	9.437	− 0.061	− 0.485	8.771
China	SHANGHAI SE A SHARE	108	3019.785	91.141	93.812	2.831	− 0.056	− 0.572	33.133
	SHENZHEN SE B SHARE	108	874.845	52.208	88.023	5.253	0.589	− 1.001	16.757
Croatia	CROATIA CROBEX	110	1695.045	214.439	82.471	10.433	0.577	− 1.112	7.905
Cyprus	CYPRUS GENERAL	83	50.145	5.027	76.969	7.715	2.246	3.667	9.976
Czech Republic	PRAGUE SE PX	108	924.318	115.479	80.871	10.104	0.376	− 0.834	8.004
Denmark	OMX COPENHAGEN (OMXC20)	110	1158.501	82.213	91.520	6.495	− 1.038	0.293	14.091
	OMX COPENHAGEN (OMXC)	110	931.722	71.290	90.021	6.888	− 0.872	− 0.073	13.070
Estonia	OMX TALLINN (OMXT)	117	1191.718	118.272	86.711	8.606	0.021	− 1.203	10.076
Finland	OMX HELSINKI (OMXH)	110	8951.857	1069.305	83.364	9.958	− 0.048	− 1.037	8.372
France	FRANCE CAC 40	109	4926.751	683.725	80.618	11.188	0.532	− 1.070	7.206
	SBF 120	109	3889.479	543.649	80.484	11.250	0.516	− 1.082	7.154
Germany	DAX 30 PERFORMANCE	110	11498.195	1463.513	83.387	10.614	− 0.023	− 1.031	7.857
	MDAX FRANKFURT	110	24631.730	3074.107	83.909	10.472	− 0.102	− 1.037	8.013
	PRIME ALL SHARE (XETRA)	110	4716.334	611.388	83.047	10.766	0.026	− 1.048	7.714
Greece	ATHEX COMPOSITE	83	619.443	62.320	76.348	7.681	0.483	0.903	9.940
	FTSE/ATHEX LARGE CAP	83	1508.975	168.287	73.491	8.196	0.901	1.558	8.967

Table 2 (continued)

Country	Index	N. obs.	μ	σ	μ_{norm}	σ_{norm}	$Skew_{norm}$	$Kurt_{norm}$	μ_{norm}/σ_{norm}
Hong Kong	HANG SENG	110	24983.880	1691.153	86.762	5.873	0.525	− 0.811	14.773
	HANG SENG CHINA ENTERPRISES	110	10024.493	551.686	88.466	4.869	0.211	− 0.231	18.171
	HANG SENG CHINA AFFILIATED CORP	110	3894.232	302.801	85.101	6.617	0.286	− 0.434	12.861
Hungary	BUDAPEST (BUX)	109	37429.623	4776.098	81.048	10.342	0.450	− 1.224	7.837
Iceland	OMX ICELAND ALL SHARE	106	1395.103	96.631	89.616	6.207	− 0.328	− 0.894	14.437
Ireland	ISEQ ALL SHARE INDEX	109	5918.513	831.809	81.577	11.465	0.249	− 1.153	7.115
Israel	ISRAEL TA 125	110	1427.398	154.637	84.756	9.182	0.114	− 0.792	9.231
Italy	FTSE MIB INDEX	108	19418.503	3093.527	76.218	12.142	0.658	− 1.027	6.277
Japan	TOPIX	117	1531.508	139.025	87.808	7.971	− 0.024	− 1.064	11.016
	NIKKEI 225 STOCK AVERAGE	117	21131.002	2114.473	87.741	8.780	− 0.260	− 1.016	9.994
	TSE SECOND SECTION	117	6170.147	774.153	82.443	10.344	0.229	− 1.201	7.970
Latvia	OMX RIGA (OMXR)	108	1003.015	54.737	94.273	5.145	− 1.477	1.249	18.324
Lithuania	OMX VILNIUS (OMXV)	115	695.252	47.960	92.656	6.392	− 1.025	− 0.131	14.497
Luxembourg	LUXEMBOURG SE GENERAL	110	482.199	95.839	72.382	14.386	0.760	− 1.002	5.031
Malaysia	FTSE BURSA MALAYSIA KLCI	111	1447.520	91.933	90.708	5.761	− 0.273	− 0.895	15.745
Malta	MALTA SE MSE	105	4165.910	324.601	88.641	6.907	0.598	− 1.311	12.834
Netherlands	AEX INDEX (AEX)	110	535.687	55.943	85.134	8.891	− 0.077	− 0.561	9.576
	AEX ALL SHARE	110	765.096	83.728	84.605	9.259	− 0.025	− 0.706	9.138
New Zealand	S &P/NZX 50	110	4622.743	351.083	89.366	6.787	− 0.451	− 0.401	13.167
Norway	OSLO EXCHANGE ALL SHARE	108	876.964	98.544	83.512	9.384	0.132	− 0.898	8.899
Oman	OMAN MUSCAT SECURITIES MKT	110	3705.503	288.851	88.283	6.882	0.617	− 1.422	12.828
Poland	WARSAW GENERAL INDEX	108	48442.017	5980.053	82.655	10.204	0.315	− 0.984	8.101
Portugal	PORTUGAL PSI-20	107	4473.655	517.801	82.299	9.526	0.538	− 0.945	8.640
	PORTUGAL PSI ALL-SHARE	107	1293.501	131.589	83.217	8.466	0.374	− 0.871	9.830

Table 2 (continued)

Country	Index	N. obs.	μ	σ	μ_{norm}	σ_{norm}	$Skew_{norm}$	$Kurt_{norm}$	μ_{norm}/σ_{norm}
Romania	ROMANIA BET (L)	109	8725.098	922.946	85.375	9.031	0.272	− 1.180	9.454
Russia	RUSSIA RTS INDEX	109	1237.167	204.970	75.699	12.542	0.361	− 0.938	6.036
	MOEX RUSSIA INDEX	109	2739.974	252.593	85.378	7.871	0.054	− 0.561	10.847
Singapore	STRAITS TIMES INDEX L	106	2741.389	281.596	84.610	8.691	0.638	− 1.057	9.735
Slovakia	SLOVAKIA SAX 16	107	342.573	14.839	94.204	4.081	− 0.188	− 1.647	23.085
Slovenia	SLOVENIAN BLUE CHIP (SBI TOP)	110	846.764	85.949	86.072	8.737	0.206	− 1.087	9.852
South Korea	KOREA SE COMPOSITE (KOSPI)	110	1989.641	187.604	87.756	8.275	− 0.563	− 0.192	10.606
	KOREA SE KOSPI 200	110	266.169	24.970	86.961	8.158	− 0.319	− 0.510	10.659
Spain	IBEX 35	109	7729.301	1252.259	76.652	12.419	0.727	− 1.107	6.172
	MADRID SE GENERAL (IGBM)	109	765.974	126.374	76.468	12.616	0.736	− 1.119	6.061
Sweden	OMX STOCKHOLM 30 (OMXS30)	111	1621.549	156.619	85.332	8.242	0.113	− 0.924	10.353
	OMX STOCKHOLM (OMXS)	111	621.746	64.915	84.860	8.860	− 0.101	− 0.879	9.578
Switzerland	SWISS MARKET (SMI)	109	9889.044	736.210	87.801	6.537	− 0.042	− 0.310	13.432
Turkey	BIST NATIONAL 100	109	104932.181	10880.241	84.927	8.806	0.035	− 1.023	9.644
United Kingdom	FTSE 100	109	6286.916	736.578	82.606	9.678	0.515	− 0.950	8.535
	FTSE ALL SHARE	109	3478.904	425.013	82.373	10.063	0.492	− 0.980	8.185
	FTSE 250	109	17623.833	2586.914	80.597	11.830	0.401	− 1.037	6.813
	FTSE TECHMARK FOCUS (£)	109	5226.403	573.801	85.119	9.345	− 0.100	− 0.668	9.108
United States	S &P 500 COMPOSITE	109	2958.381	282.570	87.367	8.345	− 0.373	− 0.505	10.470
	DOW JONES INDUSTRIALS	109	25186.118	2723.498	85.228	9.216	− 0.057	− 0.677	9.248
	NASDAQ COMPOSITE	109	8841.200	826.366	88.232	8.247	− 0.741	− 0.367	10.699
	RUSSELL 2000	109	1379.807	202.794	81.353	11.957	0.090	− 1.086	6.804
	NASDAQ 100	109	8871.472	773.012	87.886	7.658	− 0.732	− 0.243	11.477
	NYSE COMPOSITE	109	11880.292	1407.200	84.037	9.954	0.178	− 0.895	8.443

Table 2 (continued)

Country	Index	N. obs.	μ	σ	μ_{norm}	σ_{norm}	$Skew_{norm}$	$Kurt_{norm}$	μ_{norm}/σ_{norm}
Bahrain	MSCI BAHRAIN	109	88.203	17.119	76.635	14.874	0.658	− 1.358	5.152
	MSCI BAHRAIN $	109	87.436	17.452	75.904	15.150	0.676	− 1.352	5.010
Kazakhstan	MSCI KAZAKHSTAN	109	502.812	83.111	75.749	12.521	0.409	− 1.129	6.050
	MSCI KAZAKHSTAN U$	109	405.035	66.949	75.749	12.521	0.409	− 1.129	6.050
Montenegro	MONTENEGRO SE MONEX	83	10439.545	411.055	92.385	3.638	1.122	0.039	25.397
Qatar	MSCI QATAR	115	742.311	55.968	86.851	6.548	0.715	− 0.730	13.263
	MSCI QATAR $	115	742.235	55.970	86.849	6.549	0.715	− 0.729	13.261
Saudi Arabia	MSCI SAUDI ARABIA	107	857.739	75.097	84.553	7.403	0.152	− 0.823	11.422
	MSCI SAUDI ARABIA $	107	856.837	75.450	84.485	7.439	0.161	− 0.836	11.356
United Arab Emirates	MSCI UAE	118	280.885	40.723	81.191	11.771	0.394	− 1.410	6.897
	MSCI UAE $	118	280.876	40.722	81.191	11.771	0.394	− 1.410	6.897
Kuwait	DJ Islamic Market Kuwait	109	658.603	80.377	83.045	10.135	0.610	− 1.235	8.194

4 Indicators

To face the problem, we design indicators that capture the connection between anxiety about the pandemic and the outcomes of financial markets. The underlying idea relates to the synchronicity between increments and decrements of Google searches and stock index levels so that increasing (decreasing) volumes of searches and decreasing (increasing) prices are associated with pessimistic (optimistic) moods. Thus, optimism and pessimism are measured by combining the analysis of Google searches and stock indexes' performance. Namely, the connection between optimistic and pessimistic phases and the evolution of the financial markets are captured, including the assessment of bullish and bearish periods.

One intuitively expects the mood indicator to lean towards optimism during a bullish period (or towards pessimism in a bearish one). However, including the Google Trends index in our proposed indicators means that a bullish (or bearish) period can only be associated with optimism or pessimism after a jointly analysing financial performances and Google searches. This joint analysis provides a clear proxy for anxiety about the pandemic. This can be clarified further by looking at the formal presentation of the indicators below and reflecting on their functioning mechanism. The employed methodology can be described after some notation is introduced.

We denote the number of considered countries by J—and J is 54 for us, see Sect. 3—and label the generic country by $j = 1, \dots, J$. Each country is associated with K stock indexes. The number of stock indexes depends on the selected country, so one should write $K = K(j)$. Such a dependence will be omitted when unnecessary i.e., when there is only one stock index of reference for that country. Often, $K > 1$ —i.e. most countries are associated with more than one stock index. However, there are cases of countries with $K = 1$. The generic stock index is $k = 1, \dots, K$.

As already discussed in Sect. 3, we have daily data on prices and Google searches of the word *"coronavirus"* (and its translations) in a common reference period of T days. For country j, we denote the available time series of the prices of the stock index k by $\mathbf{p}_k^j = (p_k^j(1), \dots, p_k^j(T))$. Analogously, the sample of the Google searches for country j is $\mathbf{w}^j = (w^j(1), \dots, w^j(T))$.

Notice that the range of variation of the components of $\mathbf{p}_k^j$ and $\mathbf{w}^j$ is different. Indeed, $\mathbf{p}_k^j$ has non-negative components without a pre-defined ceiling, while the components of $\mathbf{w}^j$ are integer numbers ranging in [0, 100], and there exists $\bar{t}$ such that $w^j(\bar{t}) = 100$. Time $\bar{t}$ represents the day with the maximum level of searches over the period $[1, T]$ and depends on j. Also, such dependence will be conveniently omitted. The minimum value of the elements of $\mathbf{w}^j$ is not necessarily null. Indeed, null search means the absence of interest for the considered word in the country j—i.e. null amount of Google searches; such an occurrence does not necessarily appear over the period $[1, T]$. Assigning value 100 to the highest daily magnitude of Google searches over $[1, T]$ and null value to null searches allows a easy normalisation—implemented directly by the Google Trends proprietary algorithm—of the Google search data in the range [0, 100].

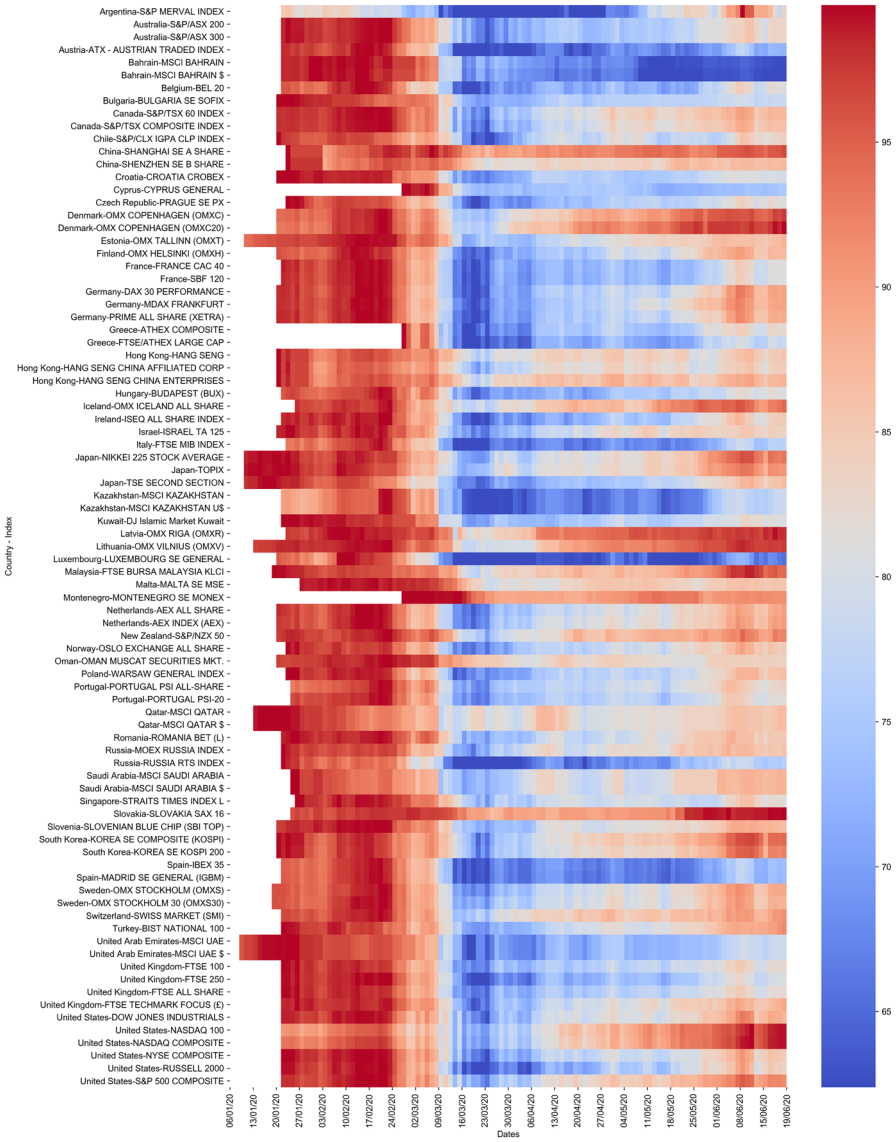

Fig. 2 Heatmap representation of the normalised prices recorded for each stock index (see, Eq. 1). The time series starting points are different because the prices are stored from the first day in which relevant volumes of Google searches (of the word "coronavirus") in that country are recorded

For facilitate comparisons, we impose the variation range [0, 100] also to the series $\mathbf{p}_k^j$ for each j and k through a simple normalisation procedure. We denote the normalised series of the prices by $\bar{\mathbf{p}}_k^j$.

First, we identify $\bar{t} \in \{1, \ldots, T\}$ such that $p_k^j(\bar{t}) = \max\{p_k^j(t) : t = 1, \ldots, T\}$. Then, we set $\bar{p}_k^j(\bar{t}) = 100$. Null price is associated with zero value for the normalized

series, so that we set $\bar{p}^j_k(t) = 0$ when $p^j_k(t) = 0$. Evidently, one can have $p^j_k(t) > 0$ for each $t = 1, \ldots, T$, so that one has $\bar{p}^j_k(t) > 0$ for each t.

The entire series can be derived as follows

$$\bar{p}^j_k(t) = \left[100 \times \frac{p^j_k(t)}{p^j_k(\bar{t})} \right], \qquad \forall\, t = 1, \ldots, T, \tag{1}$$

where $[\bullet]$ is the integer part of the real number $\bullet$.

The analysis and comparison of the normalised financial data and Google Trends index is performed at the country level. It is implemented by conceptualising suitable indicators that provide several insights into countries' regularities and discrepancies as presented in the next sections.

4.1 Time-dependent indicators

We first propose an indicator based on the comparison between the time-dependent normalised accumulations of prices and Google searches. We consider $t_1, t_2 \in \{1, \ldots, T\}$ with $t_1 \leq t_2$ and define

$$A_j([t_1, t_2];k) = \frac{1}{2} \cdot \sum_{s=t_1}^{t_2} \left[\frac{\bar{p}^j_k(s)}{\bar{P}^j_k} - \frac{w^j(s)}{W^j} \right] + \frac{1}{2}, \tag{2}$$

where

$$W^j = \sum_{t=1}^{T} w^j(t), \qquad \bar{P}^j_k = \sum_{t=1}^{T} \bar{p}^j_k(t).$$

By construction, it results $A_j([t_1, t_2];k) \in [0, 1]$. A high value of $A_j([t_1, t_2];k)$ means that $[t_1, t_2]$ is a period accounting for a high percentage of the price of index k and a low percentage of Google searches—where percentages have to be intended in terms of the total amount on the overall period.[2] Thus, $A_j([t_1, t_2];k)$ close to one means that $[t_1, t_2]$ is an optimistic period. Differently, $A_j([t_1, t_2];k)$ is close to zero when fraction of prices are relatively low, and Google searches of the word *"coronavirus"* are relatively high. In this case, $[t_1, t_2]$ is a time interval where country j has experienced anxiety about COVID-19 and a lack of trust in index k.

Notice that the case $t_1 = 1$ and $t_2 = T$ is trivial and not interesting, being $A_j([1, T];k) = 1/2$ for each j and k—i.e. in the middle (fair) situation between optimism and pessimism. Indeed, $[1, T]$ is the entire period, hence is associated with the full percentages of prices and Google searches. More reasonably, the proper selection of t_1 and t_2 allows exploring elements of the considered sample in relevant sub-periods.

At a country level, we can average the A_j's in Eq. (2) with respect to the stock indexes. In particular, we define

[2] It is worth recalling that both quantities are ranging between 0 and 100.

$$A_j([t_1,t_2]) = \frac{1}{K(j)} \sum_{k=1}^{K(j)} A_j([t_1,t_2];k). \tag{3}$$

We observe that $A_j([t_1,t_2]) \in [0,1]$, and all the comments reported above remain valid for the indicator presented in Eq. (3).

4.2 Global indicators

We here compare the considered series on the basis of the signs of their daily variations. Precisely, we assess how often an increase (a decrease) in Google searches is associated with a reduction (an increase) in the stock indexes prices. The entity of the daily variation is also taken into account.

Consistently with our framework, we refer hereafter to a generic series $\mathbf{x} = (x(1), \ldots, x(T))$, whose components range in [0, 100].

Thus, given a threshold $\zeta \in [0,100]$ and $t = 1, \ldots, T-1$, we define the series $\mathbf{x}$ variation's sign between t and $t+1$ at the threshold ζ as follows:

$$\delta_t^{(\zeta)}(\mathbf{x}) = \begin{cases} 1, & \text{if } x(t+1) - x(t) > \zeta; \\ 0, & \text{if } -\zeta \leq x(t+1) - x(t) \leq \zeta; \\ -1, & \text{if } x(t+1) - x(t) < -\zeta. \end{cases} \tag{4}$$

The parameter ζ is decided a priori; it represents the entity of the daily variation to be crossed for declaring that the series have an increase (or a decrease, by taking the variation with negative sign) from time $t-1$ to time t. Evidently, the case $\zeta = 0$ leads to $\delta_t^{(0)}(\mathbf{x}) = 1$ when $x(t+1) > x(t)$, $\delta_t^{(0)}(\mathbf{x}) = -1$ when $x(t+1) < x(t)$ and $\delta_t^{(0)}(\mathbf{x}) = 0$ when $x(t+1) = x(t)$.

The comparison between the behaviours of the Google searches and the stock indexes can be performed at the country level, employing the δ's defined in Eq. (4) and using the two series on interested instead of the generic $\mathbf{x}$.

For each $j = 1, \ldots, J$ and $k = 1, \ldots, K(j)$, we compare the series $\mathbf{w}^j$ with $\bar{\mathbf{p}}_k^j$.

We define

$$\Delta^{(\zeta)}(t,j,k) = \delta_t^{(\zeta)}(\mathbf{w}^j) - \delta_t^{(\zeta)}(\bar{\mathbf{p}}_k^j). \tag{5}$$

By definition, the Δ's in Eq. (5) can take values in $\{-2,-1,0,1,2\}$. Such values have specific meanings to be mapped in the optimism and pessimism setting.

When $\Delta^{(\zeta)}(t,j,k) = -2$, then we observe a decrease in the Google searches related to *"coronavirus"* and an increase in the price of the stock index k. This case has a straightforward interpretation in terms of optimism. Indeed, people exhibit decreasing anxiety about the pandemic disease—they weaken the number of searches on Google—and simultaneously exhibit an increasing interest in investing in the stock index. The value -1 is associated with constant Google searches and an increase in the price or decreasing level of Google searches and an invariant price. The value 0 is related to the cases of identical behaviour between Google searches and price so that they can be invariant between date t and $t+1$ or both can increase/decrease. The value +1 relies on

an increasing level of Google searches and invariant price or a constant level of Google searches and decreasing price. The value +2 describes the situation in which Google searches grow and price decrease. This is the other corner case associated with pessimism, in which anxiety about the spread of the disease—mirrored by the growth of Google searches—is associated with decreasing investments in the stock index.

In general, the positive values of the Δ's describe situations of pessimism, captured by anxiety for the disease and decreased investments in the stock indexes. Conversely, the cases of negative Δ's are related to optimism, with decreasing interest in COVID-19 and growing attention to the future evolutions of stock indexes, investing in them.

Some indicators with high information content are derived from Eq. (5).

We measure the aggregated connection between the considered trends in Google searches and the price of stock index k in country j over the considered period by defining

$$H_j^{(\zeta)}(k) = \frac{1}{4(T-1)} \left[\sum_{t=1}^{T-1} \Delta^{(\zeta)}(t,j,k) + 2(T-1) \right]. \tag{6}$$

By construction, $H_j^{(\zeta)}(k) \in [0,1]$. If such an indicator approaches zero, then people in country j tend to be at the highest level of optimism—in a sense expressed when the case of $\Delta = -2$ was discussed—when analysing the Google searches of the considered word and its connections with stock index k. The converse situation appears when $H_j^{(\zeta)}(k)$ is close to one, namely when we are in the presence of a high level of pessimism.

By averaging the H_j's in Eq. (6) with respect to k, we obtain an indicator describing the mood at the country level for all the connections between the considered word searches and the prices of stock indexes, as follows:

$$H_j^{(\zeta)} = \frac{1}{K(j)} \sum_{k=1}^{K(j)} H_j^{(\zeta)}(k). \tag{7}$$

Clearly, $H_j^{(\zeta)} \in [0,1]$ and the arguments above—opportunely cascaded for a country level view—remain valid.

We now provide a measure describing how a country has experienced optimism versus pessimism. At this aim, we consider a ratio indicator as follows:

$$R_j^{(\zeta)}(k) = \frac{1}{2(T-1)} \left[\sum_{t=1}^{T-1} \mathbf{1}\left(\Delta^{(\zeta)}(t,j,k) = 2\right) - \sum_{t=1}^{T-1} \mathbf{1}\left(\Delta^{(\zeta)}(t,j,k) = -2\right) + T - 1 \right] \tag{8}$$

where

$$\mathbf{1}(\bullet) = \begin{cases} 1, & \text{if } \bullet \text{ is true;} \\ 0, & \text{otherwise.} \end{cases}$$

By construction, $R_j^{(\zeta)}(k) \in [0,1]$. For country j and stock index k, there is a high percentage of optimistic days with respect to pessimistic ones as the value of such an

indicator approaches zero, while we are in a substantial context of pessimism when the indicator in Eq. (8) is close to one. The corner cases have a clear interpretation: when $R_j^{(\zeta)}(k) = 0$, then all the days in the considered period present decreasing anxiety about COVID-19 coupled with increasing trust in the performance of stock index k; differently, $R_j^{(\zeta)}(k) = 1$ is associated with an entire period of increasing need of awareness on COVID-19 and decreasing price of stock index k.

Also in this case, we can focus on country j by averaging the R_j's over the stock indexes:

$$R_j^{(\zeta)} = \frac{1}{K(j)} \sum_{k=1}^{K(j)} R_j^{(\zeta)}(k). \tag{9}$$

Evidently, $R_j^{(\zeta)} \in [0, 1]$ and the discussion reported above applies also in this more general case.

The global indicators presented above capture two aspects of the phenomenon under analysis. $H_j^{(\zeta)}$ and $H_j^{(\zeta)}(k)$ provide information on moods as an average of Δ's over all the days of the considered sample. Differently, $R_j^{(\zeta)}(k)$ and $R_j^{(\zeta)}$ focus only on the dates where the daily variations of volumes of searches and stock index levels have had discordant behaviours. Namely, the indicators R's offer more details on the ratio between entirely optimistic days and wholly pessimistic ones, i.e. intuitively, on the proportion of the days in which the Google searches have decreased, and the indexes' prices have increased and those with an increase in searches and a decrease in prices.

5 Results and discussion

The normalised time series of the stock index prices are obtained via Eq. (1). The outcome of such normalisation is presented in Fig. 2, and the main statistical indicators of both original and normalised time series are shown in Table 2. The visual inspection of this Fig. 2 allows the reader to confirm the general trends of the stock markets, with a decline inducted by the incorporation of the pandemic effects of the first wave. Figure 1 and Table 1 show the increased Google searches of the translated *"coronavirus"* in different countries. The search activities started at a different time and with a general delay with respect to the decline recorded by the stock indexes.

As a preliminary comment, we notice that A_j in Eq. (2) and (3) compares the normalised values of Google searches and prices, while H_j in Eq. (6) and (7), and the R_j in Eq. (8) and (9) compare their daily increments and decrements. Thus, A_j offers a view on anxiety about COVID-19 and trust in stock markets; differently, H_j and R_j propose an evolutive perspective on the daily variations of the Google search and the stock indexes data, presenting insights on a synthesised version of the mood.

5.1 Analysis of the global indicators

In computing the index $A_j([t_1, t_2];k)$ employing Eq. (2), we take $t_2 - t_1$ constantly equal to five days, hence studying the weekly behaviour of the indicator. The outcomes per each stock index are summarized in Fig. 4 and Table 3. Moreover, the results of $A_j([t_1, t_2])$ across the stock indexes of each country—namely, those in Eq. (3)—are reported in Fig. 5 and Table 4. From this view, some facts emerge:

- The paths have drastically changed between the 7th and the 8th weeks of the year, namely between 17/02/2020 and 01/03/2020. During this period, the international community started to take the situation seriously despite the controversial statements of national governments' heads. On 11/03/2020, WHO's Director declared, "WHO has been assessing this outbreak around the clock, and we are deeply concerned both by the alarming levels of spread and severity, and by the alarming levels of inaction. We have, therefore, made the assessment that COVID-19 can be characterised as a pandemic." WHO (2020).
- Greece and South Korea have spent more than 90% of the analysed weeks in a quite positive mood, precisely reporting an $A_j([t_1, t_2]) > 0.5$.
- Cyprus and Iceland have experienced mild pessimism for quite a large number of weeks. They present $A_j([t_1, t_2]) < 0.5$ at least 40% of the times in the studied period.
- Weeks 10 and 11 are characterized by the lowest average of $A_j([t_1, t_2])$. Their means across the countries are, respectively, 0.485 and 0.483.
- The highest number of countries experiencing a $A_j([t_1, t_2]) < 0.5$ is met on week 11. During 16/03/2020 - 20/03/2020, 81% of the analysed countries experienced a high volume of Google searches and low normalised prices. Therefore, a high level of pessimism is recorded. On the other hand, the tails (weeks 1-4 and 20-24) present a higher index level, with an increased presence of positivism in most countries during the most recent weeks.

In Table 5, the considered countries are week-wise ranked by using $A_j([t_1, t_2])$. Montenegro holds the first position for five weeks. Similarly, Greece, Iceland and Malta usually sit in the first four positions. This outcome suggests that Greece, Iceland and Malta experienced waves of optimism and pessimism; interestingly, for the quoted countries, consecutive weeks may have a large discrepancy in the ranking positions. Thus, one can say that the waves are impulsive and compulsive—perhaps, they are driven by news on the pandemic or statements of the Governments- and this leads to sudden changes in people's behaviour towards searching on Google and adjusting positions in the stock markets.

We also propose a focus on weekly rankings of some paradigmatic cases: Sweden, Iceland and South Korea—countries which experienced an "*easy*" lockdown, see Wikipedia (2020a, 2020b); Normile et al. (2020); Florida and Mellander (2021)—and Italy, UK, USA and China—which are countries that experienced harder lockdown. By inspecting Fig. 6, one can appreciate that the countries that

have experienced an easier lockdown have spent more optimistic moods in recent weeks.

The results show some regularities in the behaviour across countries and indexes, as Figs. 4 and 5 testify. An initial phase of optimism was probably induced by sceptical statements from national governments and media agencies; in fact, the emergence has been underestimated by many people at its inception, see Colarossi (2020). Then, once the situation escalated, Google searches drastically increased (see Fig. 3), and the stock indexes reacted plausibly in the light of the lockdown policies implemented worldwide. The blue bands represent the raised pessimism in Figs. 4 and 5 in weeks 10–15. A general relief came in after that. In a few cases, the anxiety was boosted from the very beginning. This is clearly the case for Iceland, Malaysia, Malta, and, more mildly, for Singapore; see Fig. 5 and Table 5. Considering week 24th, the stock indexes and so the countries reporting the highest level of A_j from Eq. (3) are Greece, Iceland and Malta, with values 0.527, 0.524, 0.523, respectively. On the other hand, those having the lowest values are Montenegro, Bahrain and Singapore, with 0.508, 0.507 and 0.504, respectively.

Figure 6 offers a comparison of the weekly rank of the countries—based on $A_j([t_1, t_2])$—having experienced an easy (upper panel) and hard (lower panel) lockdown. Countries with a stricter lockdown show more pervasive pessimistic moods than those with a weaker lockdown. In particular, one can notice the presence of common waves of optimism (low rank) and pessimism (high rank) over the considered period. Importantly, there is an evident countertendency among some countries, with opposite moods in peculiar sub-periods. Iceland, South Korea and Sweden show pessimism at the beginning of the pandemic and optimism for the rest of the period, with a spike of pessimism around weeks 15-16. The case of South Korea is significant and in line with the findings presented in Park and Chung (2021). The situation is more scattered for China, the UK, Italy, and the USA. However, there is optimism at the beginning for the UK, Italy and the USA, and substantial pessimism for all the considered countries in the last part of the period. China and Italy seem to exhibit similar trends during the latter portion of the period under study; a possible explanation can be found in the strict collaboration between such countries during the lockdown, which can be seen as the driver of a common mood. From a more general point of view, the results showed in Fig. 6 can be further considered in the light of the findings reported in Harring et al. (2021). Namely, the trust in stock markets is affected and affects the trust in government policies.

5.2 Analysis of the time-dependent indicators

Eqs. (6) and (8) indicators employ different levels of ζ, which is the threshold used to capture the variations of the observed series daily. Specifically, we use $\zeta = 0, 1, \ldots, 50$.

The results for $H_j^{(\zeta)}(k)$ (see Eq. 6) are reported in Fig. 7 and Table 6.

Stock indexes show quite similar behaviours in their links with the Google Trends indicator, mainly in the maximum values of $H_j^{(\zeta)}(k)$. Indeed, the variation range in the maxima is 0.502− 0.530, with stock indexes associated with Bahrain being

Table 3 Main statistical indicators of $A_j([t_1, t_2];k)$ from Eq. (2) at stock index level

Country	Index	μ	σ	Skew	Kurt	μ/σ
Argentina	S&P MERVAL INDEX	0.507	0.016	− 1.075	0.147	31.047
Australia	S&P/ASX 200	0.507	0.015	− 1.018	− 0.112	33.143
	S&P/ASX 300	0.507	0.015	− 1.018	− 0.113	33.086
Austria	ATX - AUSTRIAN TRADED INDEX	0.507	0.018	− 1.405	1.891	28.855
Bahrain	MSCI BAHRAIN	0.506	0.010	− 1.064	2.100	52.517
	MSCI BAHRAIN $	0.506	0.010	− 1.032	2.024	52.041
Belgium	BEL 20	0.507	0.016	− 0.837	− 0.387	31.297
Bulgaria	BULGARIA SE SOFIX	0.507	0.016	− 0.849	− 0.382	31.820
Canada	S&P/TSX 60 INDEX	0.507	0.016	− 1.150	0.231	32.262
	S&P/TSX COMPOSITE INDEX	0.507	0.016	− 1.138	0.201	32.048
Chile	S&P/CLX IGPA CLP INDEX	0.507	0.015	− 1.561	2.619	32.734
China	SHANGHAI SE A SHARE	0.508	0.007	− 0.291	− 0.900	69.022
	SHENZHEN SE B SHARE	0.508	0.007	− 0.224	− 0.917	73.086
Croatia	CROATIA CROBEX	0.507	0.017	− 0.703	− 0.895	29.432
Cyprus	CYPRUS GENERAL	0.506	0.018	0.139	− 1.095	28.743
Czech Republic	PRAGUE SE PX	0.507	0.018	− 1.595	2.014	27.678
Denmark	OMX COPENHAGEN (OMXC)	0.506	0.017	− 1.314	1.049	29.865
	OMX COPENHAGEN (OMXC20)	0.506	0.017	− 1.327	1.093	30.002
Estonia	OMX TALLINN (OMXT)	0.506	0.017	− 1.601	2.413	29.180
Finland	OMX HELSINKI (OMXH)	0.506	0.017	− 2.163	5.441	29.680
France	FRANCE CAC 40	0.507	0.016	− 1.062	0.903	31.220
	SBF 120	0.507	0.016	− 1.064	0.905	31.176
Germany	DAX 30 PERFORMANCE	0.507	0.015	− 0.906	0.235	34.239
	MDAX FRANKFURT	0.507	0.015	− 0.896	0.160	34.282
	PRIME ALL SHARE (XETRA)	0.507	0.015	− 0.895	0.212	34.235
Greece	ATHEX COMPOSITE	0.516	0.023	− 3.681	14.420	22.250
	FTSE/ATHEX LARGE CAP	0.516	0.023	− 3.673	14.390	22.210
Hong Kong	HANG SENG	0.508	0.008	− 0.370	− 0.183	60.783
	HANG SENG CHINA AFFILIATED CORP	0.508	0.009	− 0.393	− 0.195	58.726
	HANG SENG CHINA ENTERPRISES	0.508	0.008	− 0.418	− 0.269	61.537
Hungary	BUDAPEST (BUX)	0.506	0.017	− 1.029	0.254	30.412
Iceland	OMX ICELAND ALL SHARE	0.505	0.025	− 1.059	− 0.222	20.333
Ireland	ISEQ ALL SHARE INDEX	0.507	0.016	− 0.824	− 0.299	32.556
Israel	ISRAEL TA 125	0.507	0.010	− 0.959	− 0.123	50.712
Italy	FTSE MIB INDEX	0.507	0.014	− 0.803	0.127	35.194
Japan	NIKKEI 225 STOCK AVERAGE	0.506	0.012	− 0.537	− 0.722	43.446
	TOPIX	0.506	0.011	− 0.538	− 0.722	44.073
	TSE SECOND SECTION	0.506	0.012	− 0.516	− 0.663	42.277
Kazakhstan	MSCI KAZAKHSTAN	0.507	0.014	− 0.252	− 1.378	36.482
	MSCI KAZAKHSTAN U$	0.507	0.014	− 0.252	− 1.378	36.482

Table 3 (continued)

Country	Index	μ	σ	Skew	Kurt	μ/σ
Kuwait	DJ Islamic Market Kuwait	0.506	0.013	− 1.209	2.126	39.475
Latvia	OMX RIGA (OMXR)	0.506	0.020	− 1.713	2.434	25.431
Lithuania	OMX VILNIUS (OMXV)	0.506	0.017	− 1.185	0.339	29.350
Luxembourg	LUXEMBOURG SE GENERAL	0.507	0.017	− 0.934	0.297	29.277
Malaysia	FTSE BURSA MALAYSIA KLCI	0.507	0.017	− 2.683	8.680	29.648
Malta	MALTA SE MSE	0.504	0.028	− 1.119	− 0.072	18.248
Montenegro	MONTENEGRO SE MONEX	0.505	0.033	− 2.264	6.125	15.321
Netherlands	AEX ALL SHARE	0.507	0.017	− 0.961	− 0.322	30.288
	AEX INDEX (AEX)	0.507	0.017	− 0.970	− 0.293	30.392
New Zealand	S&P/NZX 50	0.507	0.015	− 1.291	0.794	33.972
Norway	OSLO EXCHANGE ALL SHARE	0.508	0.023	− 2.237	5.170	21.625
Oman	OMAN MUSCAT SECURITIES MKT	0.507	0.013	− 1.375	2.646	37.753
Poland	WARSAW GENERAL INDEX	0.507	0.016	− 1.093	0.449	30.770
Portugal	PORTUGAL PSI ALL-SHARE	0.510	0.012	− 1.266	1.360	43.377
	PORTUGAL PSI-20	0.510	0.012	− 1.202	1.268	42.707
Qatar	MSCI QATAR	0.507	0.010	− 0.075	− 1.102	51.130
	MSCI QATAR $	0.507	0.010	− 0.074	− 1.102	51.130
Romania	ROMANIA BET (L)	0.507	0.017	− 1.189	0.333	29.378
Russia	MOEX RUSSIA INDEX	0.507	0.016	− 1.033	0.462	32.642
	RUSSIA RTS INDEX	0.507	0.017	− 0.888	0.119	29.871
Saudi Arabia	MSCI SAUDI ARABIA	0.507	0.016	− 1.609	3.124	32.374
	MSCI SAUDI ARABIA $	0.507	0.016	− 1.607	3.117	32.346
Singapore	STRAITS TIMES INDEX L	0.507	0.008	0.491	0.214	61.183
Slovakia	SLOVAKIA SAX 16	0.507	0.016	− 1.096	− 0.001	32.341
Slovenia	SLOVENIAN BLUE CHIP (SBI TOP)	0.507	0.017	− 1.300	1.403	29.858
South Korea	KOREA SE COMPOSITE (KOSPI)	0.507	0.026	− 3.395	12.267	19.488
	KOREA SE KOSPI 200	0.507	0.026	− 3.395	12.262	19.467
Spain	IBEX 35	0.507	0.017	− 1.066	0.902	30.213
	MADRID SE GENERAL (IGBM)	0.507	0.017	− 1.052	0.872	30.194
Sweden	OMX STOCKHOLM (OMXS)	0.506	0.015	− 1.008	0.216	33.044
	OMX STOCKHOLM 30 (OMXS30)	0.506	0.015	− 1.026	0.291	33.372
Switzerland	SWISS MARKET (SMI)	0.507	0.015	− 1.188	0.720	33.293
Turkey	BIST NATIONAL 100	0.506	0.014	− 0.759	0.214	35.367
United Arab Emirates	MSCI UAE	0.507	0.012	− 0.223	− 0.665	43.329
	MSCI UAE $	0.507	0.012	− 0.223	− 0.665	43.329
United Kingdom	FTSE 100	0.506	0.015	− 1.009	0.359	32.823
	FTSE 250	0.506	0.016	− 0.971	0.350	31.828
	FTSE ALL SHARE	0.506	0.016	− 1.003	0.360	32.642
	FTSE TECHMARK FOCUS (£)	0.506	0.015	− 1.097	0.529	32.673

Table 3 (continued)

Country	Index	μ	σ	Skew	Kurt	μ/σ
United States	DOW JONES INDUSTRIALS	0.506	0.017	− 1.095	0.172	30.084
	NASDAQ 100	0.506	0.017	− 1.151	0.227	30.388
	NASDAQ COMPOSITE	0.506	0.017	− 1.139	0.193	30.092
	NYSE COMPOSITE	0.506	0.017	− 1.070	0.116	29.925
	RUSSELL 2000	0.506	0.018	− 1.030	− 0.002	28.860
	S&P 500 COMPOSITE	0.506	0.017	− 1.116	0.175	30.276

outliers with 0.551 and 0.567. However, there are noticeable differences in the minimum values of the $H_j^{(\zeta)}(k)$, with a range of 0.4 - 0.498. Noticeable differences also appear within the same country, like the minima of $H_j^{(\zeta)}(k)$ for the USA − with NYSE COMPOSITE at 0.468 and NASDAQ at 100 and NASDAQ COMPOSITE at 0.403.

The averaged results at the country level obtained with the indicator represented by Eq. (7) are shown in Fig. 8 and Table 7.

Some cases are particularly interesting and can be noticed by visually inspecting the results:

- Latvia, Montenegro, Norway, Denmark and Canada have a vast majority of $H_j^{(\zeta)} > 0.5$ manifesting a high average level of contemporaneous Google searches growth and stock indexes declines. Across the ζs used in calculating $H_j^{(\zeta)}(k)$, such an occurrence appears at least in the 90% of the cases.
- Malta has 92% of $H_j^{(\zeta)} < 0.5$, representing an average low level of decreasing Google searches and stock indexes increments at the same time.
- The highest value of $H_j^{(\zeta)}$ occurs in Bahrain, with 0.559, for $\zeta = 0$. This finding is in agreement with those discussed already for $H_j^{(\zeta)}(k)$ above
- The smallest value of $H_j^{(\zeta)}$ occurs in Italy, with 0.4, for $\zeta = 0$.

The $R_j^{(\zeta)}(k)$ presented in Eq. (8) are calculated and reported in Fig. 9 and Table 8.

The variation range in the maxima for the case of $R_j^{(\zeta)}(k)$ is 0.5—0.565, with Bahrain's stock indexes having the highest values. Differences in the minimum values are also noticeable; the range goes from 0.421 to 0.5. The lowest value is associated with Italy's index once again. Remarkable differences appear for the stock indexes within the same country, in the specific case of $R_j^{(\zeta)}(k)$; the USA is again one of the most remarkable examples of a wide variation range at a stock index level.

The results at the country level are presented in Fig. 10 and Table 9; they have been calculated through Eq. (9). The most relevant facts are listed below:

Table 4 Main statistical indicators of $A_j([t_1, t_2])$ in Eq. (3) at country level

Country	μ	σ	Skew	Kurt	μ/σ
Argentina	0.507	0.016	− 1.075	0.147	31.047
Australia	0.507	0.015	− 1.018	− 0.112	33.115
Austria	0.507	0.018	− 1.405	1.891	28.855
Bahrain	0.506	0.010	− 1.048	2.062	52.279
Belgium	0.507	0.016	− 0.837	− 0.387	31.297
Bulgaria	0.507	0.016	− 0.849	− 0.382	31.820
Canada	0.507	0.016	− 1.144	0.216	32.155
Chile	0.507	0.015	− 1.561	2.619	32.734
China	0.508	0.007	− 0.262	− 0.908	71.104
Croatia	0.507	0.017	− 0.703	− 0.895	29.432
Cyprus	0.506	0.018	0.139	− 1.095	28.743
Czech Republic	0.507	0.018	− 1.595	2.014	27.678
Denmark	0.506	0.017	− 1.321	1.071	29.935
Estonia	0.506	0.017	− 1.601	2.413	29.180
Finland	0.506	0.017	− 2.163	5.441	29.680
France	0.507	0.016	− 1.063	0.904	31.198
Germany	0.507	0.015	− 0.900	0.203	34.254
Greece	0.516	0.023	− 3.678	14.411	22.232
Hong Kong	0.508	0.008	− 0.394	− 0.215	60.339
Hungary	0.506	0.017	− 1.029	0.254	30.412
Iceland	0.505	0.025	− 1.059	− 0.222	20.333
Ireland	0.507	0.016	− 0.824	− 0.299	32.556
Israel	0.507	0.010	− 0.959	− 0.123	50.712
Italy	0.507	0.014	− 0.803	0.127	35.194
Japan	0.506	0.012	− 0.532	− 0.702	43.270
Kazakhstan	0.507	0.014	− 0.252	− 1.378	36.482
Kuwait	0.506	0.013	− 1.209	2.126	39.475
Latvia	0.506	0.020	− 1.713	2.434	25.431
Lithuania	0.506	0.017	− 1.185	0.339	29.350
Luxembourg	0.507	0.017	− 0.934	0.297	29.277
Malaysia	0.507	0.017	− 2.683	8.680	29.648
Malta	0.504	0.028	− 1.119	− 0.072	18.248
Montenegro	0.505	0.033	− 2.264	6.125	15.321
Netherlands	0.507	0.017	− 0.966	− 0.308	30.340
New Zealand	0.507	0.015	− 1.291	0.794	33.972
Norway	0.508	0.023	− 2.237	5.170	21.625
Oman	0.507	0.013	− 1.375	2.646	37.753
Poland	0.507	0.016	− 1.093	0.449	30.770
Portugal	0.510	0.012	− 1.235	1.314	43.045
Qatar	0.507	0.010	− 0.075	− 1.102	51.130
Romania	0.507	0.017	− 1.189	0.333	29.378
Russia	0.507	0.016	− 0.959	0.280	31.207
Saudi Arabia	0.507	0.016	− 1.608	3.120	32.360

Table 4 (continued)

Country	μ	σ	Skew	Kurt	μ/σ
Singapore	0.507	0.008	0.491	0.214	61.183
Slovakia	0.507	0.016	− 1.096	− 0.001	32.341
Slovenia	0.507	0.017	− 1.300	1.403	29.858
South Korea	0.507	0.026	− 3.395	12.265	19.478
Spain	0.507	0.017	− 1.059	0.887	30.203
Sweden	0.506	0.015	− 1.017	0.253	33.208
Switzerland	0.507	0.015	− 1.188	0.720	33.293
Turkey	0.506	0.014	− 0.759	0.214	35.367
United Arab Emirates	0.507	0.012	− 0.223	− 0.665	43.329
United Kingdom	0.506	0.016	− 1.021	0.399	32.497
United States	0.506	0.017	− 1.107	0.152	29.962

- Qatar has the highest percentage of ζs such that $R_j^{(\zeta)} > 0.5$, namely 19.6%; therefore, it is the country having contemporaneous increases in Google searches and decreases in stock index prices for a large number of thresholds ζs. Belgium, Spain and France follow, with 17.6% of the ζs leading to $R_j^{(\zeta)}$ in the range (0.5,1].
- Greece, Malaysia, Argentina and New Zealand have the highest percentages of ζs such that $R_j^{(\zeta)} < 0.5$, with the first two countries having 11.8% of the observations falling within [0,0.5) and the latest two ones having a proportion of 9.8%.
- The lowest value of $R_j^{(\zeta)}$ occurs in Italy, with 0.421, for $\zeta = 0$.
- The highest value of $R_j^{(\zeta)}$ occurs in Bahrain, with 0.565, for $\zeta = 0$.

By analysing the global indicators, the case of $\zeta = 0$ is the most relevant to be commented for the information carried out. The proposed indexes are sensible to the smallest daily variation in such a case. Bahrain, Malta, Israel, Cyprus, United Arab Emirates, Singapore, Oman and Japan have $H_j^{(\zeta=0)} > 0.5$. Thus, on average, these countries have experienced significant anxiety about COVID-19 and a small trust in the stock markets' future performances. Differently, Italy, Canada, Lithuania, Germany, the UK and Spain have the lowest positions, with $H_j^{(\zeta=0)} < 0.5$. In such countries, an optimistic mood is preponderant, on average. Notice that such a list of countries with "optimistic moods" are highly developed and had a noticeable spread of the pandemic. Reasonably, in those countries, people's optimism is connected to their trust in the healthcare system, financial industry, and the collaborative efforts of science in addressing the widespread pandemic.

For the case of $R_j^{(\zeta=0)} < 0.5$, the lowest positions are held by Russia, Switzerland, Lithuania, Romania, Germany and Italy. These countries have experienced a large number of days of contemporaneous decreases in Google searches and increase in stock index prices. Bahrain, Israel, Japan, Singapore, Oman, Malta and Iceland are the countries with $R_j^{(\zeta=0)} > 0.5$. Of course, results for $H_j^{(\zeta=0)}$ and $R_j^{(\zeta=0)}$ are often overlapping, and some countries confirm their general mood when the comparison between entirely optimistic days and wholly pessimistic ones is performed.

Table 5 The ranked data week by week. Columns represent weeks, while rows are ranks. Specifically, countries are sorted in descending order on the basis of the value of $A_j([t_1, t_2])$. The codes are taken from ISO 3166-1, alpha-3

Rank\ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	ARE	ARE	LUX	SGP	MLT	LUX	ESP	MLT	CYP	KOR	ISL	MLT	ISL	MNE	ISL	ISL	GRC	MNE	GRC	GRC	MNE	MNE	MNE	GRC
2	JPN	QAT	HRV	NOR	ESP	ESP	AUT	KAZ	GRC	GRC	KOR	GRC	MYS	MLT	MYS	GRC	MLT	GRC	ISL	ISL	CYP	GRC	CYP	ISL
3	EST	JPN	BGR	HRV	NOR	ITA	LUX	RUS	MNE	OMN	GRC	KOR	CHN	MYS	ISR	FIN	ISL	MLT	LVA	MLT	GRC	ISL	GRC	MLT
4		EST	DEU	ESP	ITA	AUT	KAZ	GRC	MLT	MNE	NOR	MNE	MNE	ISR	FIN	ISR	LVA	ISL	FIN	LVA	ISL	MLT	ISL	KOR
5		LTU	SVN	FRA	HRV	HRV	HUN	SAU	KOR	SAU	SAU	NOR	KOR	GRC	CHN	NLD	MYS	LVA	MYS	FIN	MLT	NOR	MLT	NOR
6		SWE	HKG	PRT	TUR	NOR	BEL	NOR	TUR	RUS	KWT	LVA	ISR	FIN	GRC	MYS	NLD	MYS	CYP	NLD	NOR	LVA	NOR	LVA
7		MYS	OMN	BGR	LUX	KAZ	MLT	PRT	KAZ	KWT	BHR	BHR	PRT	KOR	PRT	SWE	SWE	ISR	NLD	DNK	LVA	KOR	KOR	NLD
8			ARE	GBR	AUT	BEL	NOR	AUS	RUS	BHR	OMN	KWT	BHR	CZE	CZE	PRT	FIN	NLD	CZE	NOR	DNK	DNK	LVA	MYS
9			NZL	IRL	POL	TUR	HRV	ARE	HRV	MYS	JPN	MYS	SAU	ITA	SVN	DNK	EST	EST	EST	KOR	SVK	SVK	FIN	FIN
10			CAN	ITA	FRA	POL	FRA	TUR	SAU	ARE	ARE	SAU	OMN	CHN	ITA	CHN	ISR	SWE	SVK	CYP	NLD	NLD	CHN	DNK
11			CHL	BEL	KAZ	FRA	POL	CHL	BHR	CHN	QAT	OMN	KWT	HKG	SGP	CHE	DNK	CZE	SWE	SWE	KOR	DEU	MYS	CZE
12			LTU	POL	SVN	HUN	IRL	CAN	OMN	KAZ	SGP	CHN	SGP	CHE	AUT	CZE	CZE	FIN	LTU	ISR	SWE	CZE	ARG	DEU
13			AUT	SVN	CZE	RUS	ISL	GBR	KWT	CHL	HKG	QAT	ARE	PRT	CHE	HKG	PRT	PRT	DNK	MYS	CHN	SWE	NLD	SWE
14			ESP	ROU	PRT	CZE	CZE	USA	NOR	NOR	LVA	ARE	QAT	SGP	HKG	BGR	KOR	ROU	SGP	EST	DEU	USA	DNK	SVK
15			NLD	TUR	BEL	SVN	PRT	KOR	BGR	NZL	CHN	JPN	LVA	SVN	SVK	ROU	ROU	DNK	ROU	LTU	LTU	ARG	CZE	USA
16			KOR	SAU	HUN	PRT	RUS	MYS	ROU	LTU	ISR	ISR	ITA	AUT	ESP	LUX	NZL	LTU	CHE	SVN	CZE	MYS	SVK	BEL
17			DNK	RUS	GBR	IRL	GBR	ARG	HUN	JPN	MNE	DNK	CYP	DEU	DEU	CYP	CAN	CAN	CAN	DEU	USA	FIN	DEU	FRA
18			JPN	AUT	IRL	ARG	SVN	HUN	LTU	SGP	MYS	ISL	DNK	QAT	POL	AUT	CHE	KOR	NZL	USA	NZL	FRA	SWE	CHE
19			EST	LUX	ROU	BGR	ROU	CYP	MYS	TUR	RUS	EST	NLD	ESP	FRA	DEU	USA	SVK	PRT	SVK	CHE	LTU	USA	LTU
20			IRL	ARG	BGR	DEU	DEU	QAT	ARG	QAT	EST	PRT	CHE	ISL	HUN	ITA	CHN	SVN	ARG	ARG	MYS	NZL	SGP	IRL
21			FRA	SVK	RUS	USA	TUR	NZL	CHL	HRV	LTU	SWE	DEU	EST	TUR	BEL	CHL	USA	SVN	CHE	ROU	CHE	FRA	EST
22			GBR	HKG	ARG	KWT	AUS	OMN	LVA	HKG	KAZ	HKG	CHL	SVK	ROU	POL	AUT	NZL	ISR	CZE	PRT	CAN	NZL	ITA
23			HUN	CHL	CHL	SAU	SAU	BEL	CAN	CYP	DNK	DEU	SWE	FRA	IRL	FRA	LTU	CHE	USA	BGR	CAN	EST	BEL	CAN
24			SWE	USA	KWT	ROU	ITA	SVK	QAT	AUS	CYP	NLD	FRA	GBR	USA	SVK	LUX	CHL	HRV	NZL	BGR	AUT	CHE	CYP
25			ROU	LTU	USA	CHL	USA	FRA	POL	ARG	SWE	ITA	EST	IRL	CAN	ESP	BEL	AUT	KOR	ROU	AUT	ROU	JPN	NZL

Table 5 (continued)

Rank\ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
26			AUS	CHE	CHE	GBR	ARG	POL	EST	LVA	PRT	SGP	LUX	TUR	GBR	SGP	SVK	LUX	AUT	CAN	SVN	AUS	AUT	JPN
27			RUS	OMN	SVK	CHE	BGR	ESP	ESP	HUN	ITA	BGR	BEL	RUS	BHR	IRL	HRV	ARG	AUS	AUS	AUS	POL	LTU	AUS
28			TUR	KAZ	SAU	SVK	NLD	HKG	PRT	ISR	FIN	RUS	ESP	LUX	NZL	CHL	HKG	BGR	JPN	PRT	EST	SVN	HUN	AUT
29			BEL	HUN	DEU	NLD	CHE	HRV	ARE	GBR	HRV	FIN	AUT	CAN	QAT	TUR	BGR	IRL	CHN	HRV	POL	BEL	ITA	HUN
30			QAT	BHR	AUS	AUS	ARE	SGP	AUS	PRT	IRL	KAZ	IRL	CYP	AUS	GBR	AUS	AUS	HKG	IRL	HUN	CYP	CAN	POL
31			KAZ	AUS	OMN	LTU	KWT	IRL	NZL	FRA	SVN	AUT	GBR	POL	LUX	CAN	SVN	BEL	BEL	JPN	ARG	IRL	SVN	ESP
32			ARG	CZE	LTU	BHR	CAN	LUX	SVK	CAN	POL	CHE	HKG	ROU	CHL	NZL	DEU	POL	BGR	POL	IRL	ITA	AUS	LUX
33			CHE	CHN	ARE	EST	SVK	SVN	HKG	USA	AUS	CYP	NOR	NZL	ARG	HUN	ITA	HRV	HUN	AUT	BEL	HRV	ESP	ARG
34			USA	KWT	NLD	CAN	CHL	EST	SGP	BEL	BGR	SVK	BGR	ARE	JPN	USA	POL	NOR	DEU	HUN	HRV	KAZ	IRL	SVN
35			ISR	DEU	CAN	ARE	OMN	CZE	GBR	EST	SVK	POL	FIN	HUN	BGR	ARG	NOR	DEU	MNE	BEL	FRA	LUX	LUX	ROU
36			FIN	NZL	BHR	OMN	SWE	MNE	AUT	DEU	NLD	SVN	ROU	AUS	OMN	BHR	IRL	ITA	POL	SGP	ISR	ESP	ROU	GBR
37			ITA	QAT	EST	DNK	EST	LTU	USA	SVK	DEU	FRA	CAN	BEL	KAZ	AUS	GBR	CHN	IRL	HKG	JPN	JPN	PRT	SAU
38			POL	CAN	HKG	SWE	LTU	ROU	SVN	IRL	TUR	LUX	ARG	USA	BEL	KWT	FRA	JPN	LUX	FRA	ITA	PRT	POL	RUS
39			KWT	EST	NZL	QAT	DNK	DNK	LUX	BGR	ESP	BEL	LTU	JPN	NLD	SVN	ARG	FRA	NOR	LUX	LUX	SGP	HRV	CHL
40			NOR	NLD	DNK	KOR	NZL	BGR	CZE	CHE	BEL	LTU	TUR	KAZ	CYP	HRV	SGP	GBR	ITA	ITA	RUS	HUN	ISR	ISR
41			CZE	DNK	QAT	NZL	LVA	LVA	BEL	ITA	NZL	ESP	NZL	SWE	KWT	OMN	BHR	HUN	FRA	GBR	KAZ	BGR	EST	HRV
42			CHN	LVA	LVA	LVA	QAT	SWE	FIN	LUX	ROU	CZE	MLT	CHL	ARE	KAZ	TUR	HKG	GBR	CHN	HKG	ISR	GBR	KWT
43			LVA	FIN	SWE	JPN	FIN	ISR	CHN	NLD	CHE	IRL	CZE	ARG	SWE	MLT	JPN	SGP	CHL	RUS	ESP	CHN	RUS	CHN
44			BHR	SWE	JPN	FIN	SGP	AUT	JPN	ROU	CAN	CHL	HRV	NLD	SAU	QAT	ESP	TUR	ESP	KAZ	GBR	RUS	KAZ	PRT
45			SAU	ISR	SGP	HKG	KOR	KWT	IRL	SWE	AUT	CAN	SVN	BGR	HRV	ARE	HUN	ESP	TUR	KWT	QAT	GBR	CHL	OMN
46			PRT	JPN	FIN	ISR	BHR	DEU	DNK	POL	GBR	ROU	USA	BHR	RUS	SAU	KWT	BHR	RUS	CHL	FIN	SAU	QAT	ARE
47			SVK	ARE	KOR	CHN	MYS	BHR	FRA	ESP	LUX	HRV	AUS	HRV	DNK	RUS	RUS	KAZ	KAZ	TUR	SAU	CHL	SAU	BGR
48			SGP	KOR	CHN	SGP	JPN	CHN	ISL	DNK	ARG	USA	KAZ	DNK	LTU	LTU	KAZ	RUS	QAT	SAU	CHL	HKG	HKG	HKG
49			MYS	MLT	ISL	MYS	ISR	NLD	ISR	CZE	HUN	GBR	POL	LVA	NOR	NOR	ARE	CYP	ARE	MNE	SGP	KWT	KWT	KAZ

Table 5 (continued)

Rank\ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
50			ISL	ISL	ISR	MLT	HKG	CHE	DEU	SVN	USA	TUR	JPN	KWT	EST	JPN	OMN	QAT	OMN	ESP	OMN	QAT	OMN	QAT
51				MYS	MYS	ISL	CHN	FIN	NLD	AUT	FRA	HUN	HUN	OMN	MLT	EST	SAU	KWT	KWT	QAT	ARE	BHR	BGR	TUR
52								JPN	CHE	FIN	CZE	ARG	SVK	LTU	LVA	MNE	QAT	ARE	SAU	ARE	TUR	OMN	TUR	MNE
53								ITA	ITA	ISL	CHL	NZL	RUS	SAU	KOR	LVA	CYP	OMN	BHR	BHR	KWT	TUR	ARE	BHR
54								ISL	SWE	MLT	MLT	AUS	GRC	NOR	MNE	KOR	MNE	SAU	MLT	OMN	BHR	ARE	BHR	SGP

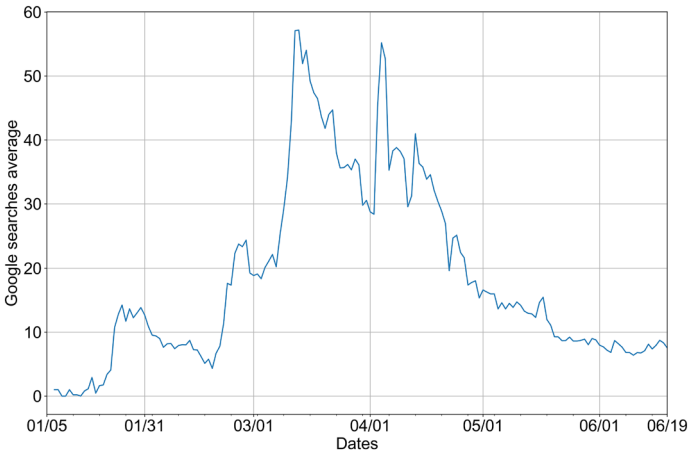

Fig. 3 Averaged Google searches of *"coronavirus"*—along with its translations in the different languages—across countries with $HDI > 0.8$ plus China, on time-basis

Interestingly, in places where the pandemic's consequences have been managed quite brightly, the general feelings have been more pessimistic than optimistic (see, e.g. the case of Israel).

6 Conclusions

The study investigates the relationship between the Google search volumes of *"coronavirus"* and the stock index prices. The first wave of the pandemic has been considered to include the financial distress that occurred in the prompt reaction to the initial events. The analysis is carried out at the country level. Thus, the word *"coronavirus"* has been opportunely translated with the appropriate language when needed. Such an analysis allows for mapping interrelationships between COVID-19 anxiety in nations and lack of trust in stock markets' future performance. These aspects are related to the uncertainty surrounding the evolution of the pandemic and expectations about its effects. In our framework, we follow Rovetta and Castaldo (2020); Monzani et al. (2021); Fetzer et al. (2021); Binder (2020) and hypothesise that anxiety is manifested via the intensity of the searches run on Google and related to the virus.

The proposed indicators allow for capturing the changes in moods over time—for the case of the A_j presented in Eq. (2) and (3)—and also facilitate classification of countries under a more global perspective on the overall considered period—see H_j presented in Eq. (6) and (7) and R_j in (8) and (9). Moreover, A_j accounts for the values of Google searches and prices, while H_j and R_j compare the daily increments/decrements of such quantities.

To make research on a reasonably homogeneous setting and for a fair treatment of the considered dataset, we have taken into consideration only "very high human

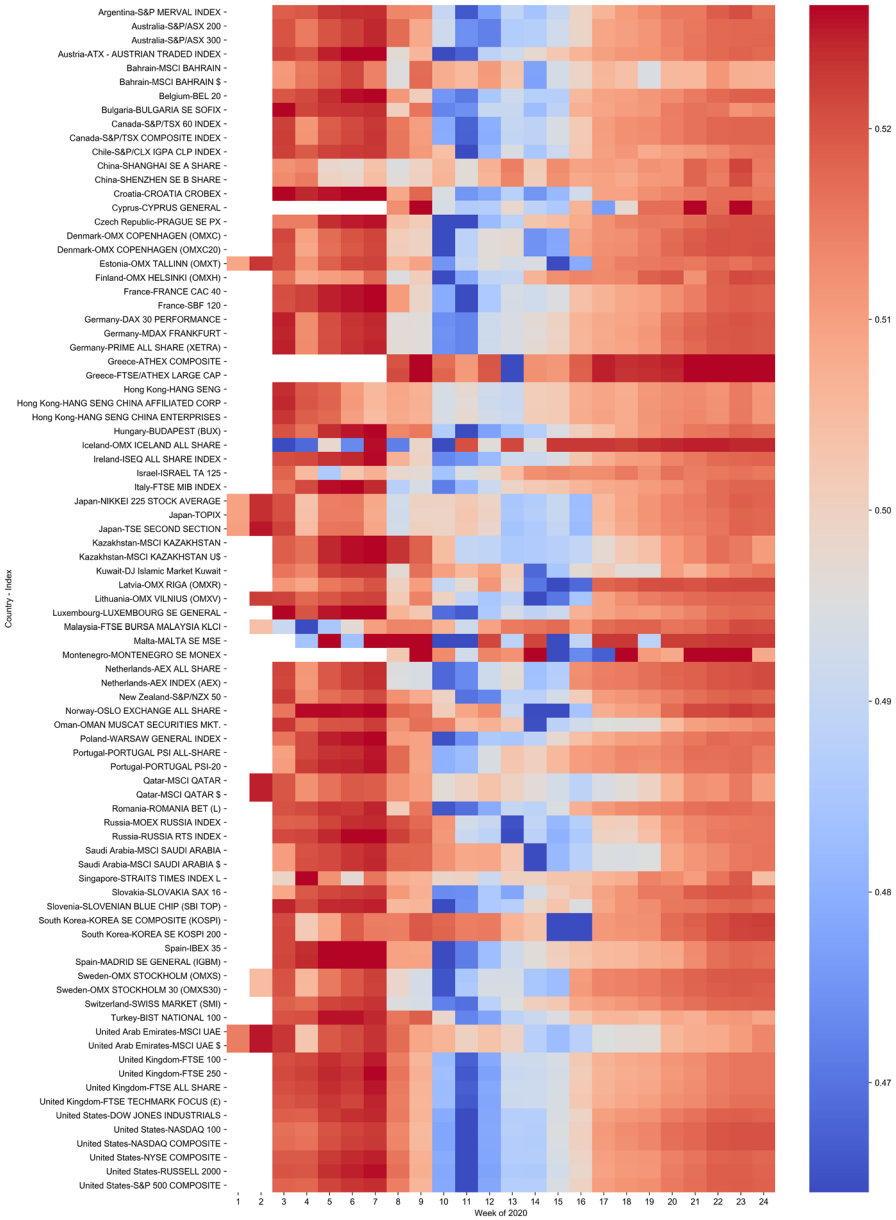

Fig. 4 Heatmap representation of $A_j([t_1, t_2];k)$ in Eq. (2), at stock index level. Indents represent the differences in the starting date of the related Google Trends data—i.e. the first date with a nonnull Google search volume recorded

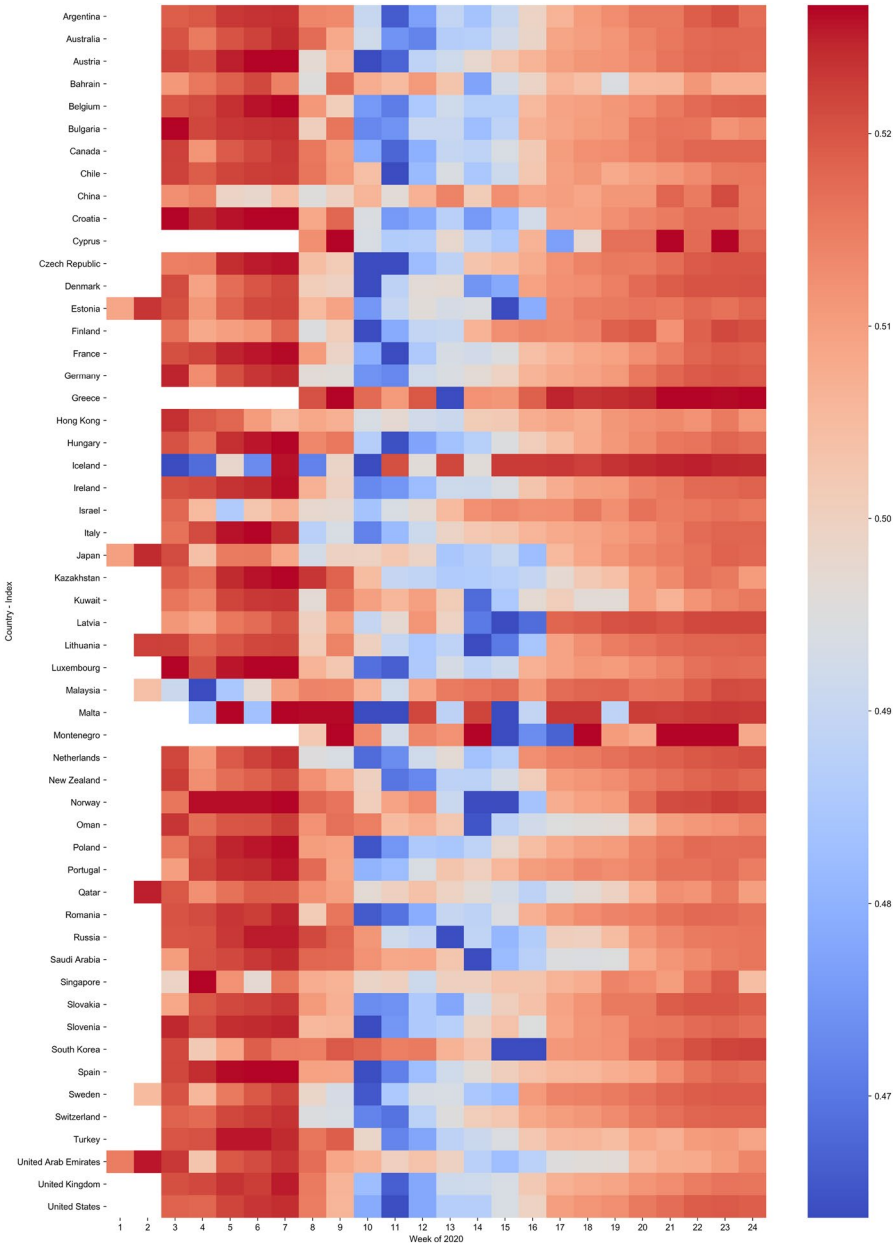

Fig. 5 Heatmap representation of $A_j([t_1, t_2])$ in Eq. (3), at country level. Also in this case, indents represent the differences in the starting date of the Google Trends data at country level

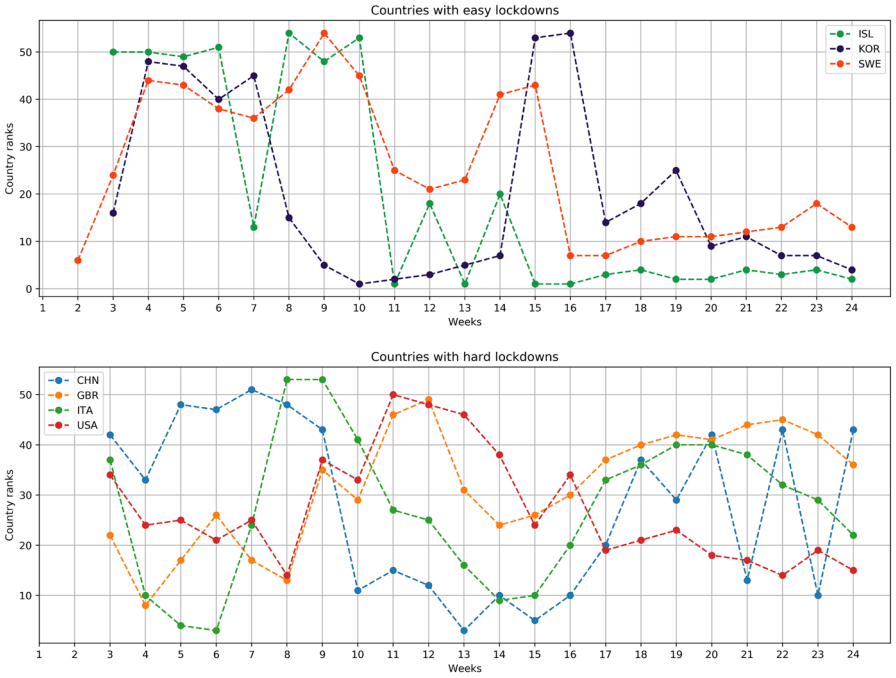

Fig. 6 A comparison of the weekly mood of the countries—based on the ranks of $A_j([t_1, t_2])$—having experienced an easy/hard lockdown. The lower the rank, the higher the optimism experienced in that week by the countries characterised by colours

developed countries"—i.e. those with an HDI greater than 0.8—and have added China for its relevance in the studied phenomenon. Some countries with HDI greater than 0.8 but without an associated stock index had to be removed from the list to respect the formulation of the mood indicators proposed.

The study allows a panoramic view of the evolution of the mood related to the pandemic in its first wave, jointly considering the behaviour of people and the stock markets. Furthermore, the country-level approach gives insights into similarities and discrepancies of the different populations regarding the link between anxiety about COVID-19 and the expectations about stock market performance.

In conclusion, we offer some considerations that emerged while designing this study. Those might be seen as open questions that keep the scientific debate ongoing.

Taking Google searches of the word "coronavirus" (and its translations in suitable languages depending on the country) presents the limitation of narrowing the analysis to only one word. Even if it is a crucial word in the search data about the pandemic, we reckon it can be seen as a limitation. A wider selection of terms to be tested for creating an aggregated indicator of Google searches related to the pandemic might lead to a more comprehensive view of the pandemic's anxiety but also to its overestimation or to an equally biased recording of it. Selecting more words would increase the computational complexity of the empirical experiments while providing a less intuitive definition of mood indicators. Such complexity would also

Table 6 Main statistical indicators of $H_j^{(\zeta)}(k)$ in Eq. (6), at stock index level. The values of the reference thresholds ζs are also shown

Country	Index	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Argentina	S&P MERVAL INDEX	0.514	9	0.465	1	0.500	0.008	− 2.744	9.300	61.631
Australia	S&P/ASX 200	0.509	5	0.440	0	0.499	0.009	− 6.300	42.788	56.705
	S&P/ASX 300	0.509	5	0.440	0	0.499	0.009	− 6.293	42.719	56.645
Austria	ATX - AUSTRIAN TRADED INDEX	0.507	9	0.477	1	0.501	0.005	− 3.228	13.247	100.479
Bahrain	MSCI BAHRAIN	0.551	0	0.498	15 16 18	0.503	0.009	4.182	19.640	57.820
	MSCI BAHRAIN $	0.567	0	0.498	15 16 18	0.503	0.011	4.810	26.024	47.043
Belgium	BEL 20	0.521	3	0.440	0	0.501	0.011	− 4.304	22.483	46.232
Bulgaria	BULGARIA SE SOFIX	0.516	4	0.489	1	0.502	0.005	0.652	1.995	105.606
Canada	S&P/TSX 60 INDEX	0.507	3 8 9	0.438	0	0.501	0.009	− 6.381	42.982	53.798
	S&P/TSX COMPOSITE INDEX	0.507	7 8 9	0.415	0	0.501	0.013	− 6.740	46.717	40.372
Chile	S&P/CLX IGPA CLP INDEX	0.509	3 4	0.452	0	0.501	0.008	− 5.474	34.981	66.096
China	SHANGHAI SE A SHARE	0.502	38 39 44 45	0.470	1	0.491	0.008	− 0.374	− 0.190	65.452
	SHENZHEN SE B SHARE	0.502	38 39 44 45	0.481	4 5 19	0.492	0.007	0.006	− 1.320	74.779
Croatia	CROATIA CROBEX	0.509	13 17 18	0.484	0	0.500	0.005	− 0.822	2.309	102.002
Cyprus	CYPRUS GENERAL	0.527	1	0.485	37	0.502	0.010	− 0.134	− 1.083	49.747
Czech Republic	PRAGUE SE PX	0.505	13	0.465	0	0.499	0.007	− 3.918	17.128	76.321
Denmark	OMX COPENHAGEN (OMXC)	0.511	11 12 [19–22]	0.459	0	0.504	0.010	− 4.029	17.348	52.754
	OMX COPENHAGEN (OMXC20)	0.511	11 12 [19–22]	0.450	0	0.504	0.011	− 4.241	18.684	45.541
Estonia	OMX TALLINN (OMXT)	0.515	3 4	0.453	0	0.503	0.008	− 4.721	28.766	61.084
Finland	OMX HELSINKI (OMXH)	0.507	3	0.484	1	0.498	0.005	− 0.791	− 0.380	91.540
France	FRANCE CAC 40	0.516	3	0.454	0	0.500	0.008	− 4.757	29.627	66.787
	SBF 120	0.519	3	0.449	0	0.500	0.008	− 4.750	30.238	61.046
Germany	DAX 30 PERFORMANCE	0.509	8	0.445	0	0.498	0.009	− 5.020	30.841	58.365
	MDAX FRANKFURT	0.509	3 8	0.440	0	0.498	0.010	− 4.583	24.677	50.543
	PRIME ALL SHARE (XETRA)	0.509	3 8	0.445	0	0.498	0.009	− 4.756	28.379	57.124

Table 6 (continued)

Country	Index	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Greece	ATHEX COMPOSITE	0.518	5	0.473	0	0.501	0.005	− 2.020	17.092	93.853
	FTSE/ATHEX LARGE CAP	0.515	5	0.491	0	0.501	0.004	1.814	4.978	126.988
Hong Kong	HANG SENG	0.507	32 35 36 37	0.475	8 9	0.494	0.009	− 0.587	− 0.451	55.998
	HANG SENG CHINA AFFILIATED CORP	0.507	32 35 36 37	0.475	8 9	0.494	0.009	− 0.691	− 0.116	58.235
	HANG SENG CHINA ENTERPRISES	0.507	32 35 36 37	0.454	0	0.493	0.010	− 1.390	3.030	48.525
Hungary	BUDAPEST (BUX)	0.514	3	0.438	0	0.500	0.010	− 5.290	32.563	50.278
Iceland	OMX ICELAND ALL SHARE	0.512	3	0.490	1	0.502	0.003	− 0.849	10.345	190.485
Ireland	ISEQ ALL SHARE INDEX	0.512	5	0.468	0	0.501	0.006	− 3.413	17.699	81.892
Israel	ISRAEL TA 125	0.516	3	0.493	19 40 41 42	0.500	0.005	1.244	1.194	94.872
Italy	FTSE MIB INDEX	0.505	17 18 19	0.400	0	0.496	0.017	− 4.751	24.584	29.866
Japan	NIKKEI 225 STOCK AVERAGE	0.524	3	0.498	7 [14–23] [30–34]	0.501	0.005	3.447	12.867	99.641
	TOPIX	0.522	0 3	0.498	7 [14–23] [30–34]	0.501	0.005	2.774	7.487	92.170
	TSE SECOND SECTION	0.526	3	0.491	0	0.501	0.006	2.838	8.749	84.948
Kazakhstan	MSCI KAZAKHSTAN	0.512	3	0.449	1	0.499	0.009	− 4.280	22.439	57.636
	MSCI KAZAKHSTAN U$	0.512	3	0.449	1	0.499	0.009	− 4.280	22.439	57.636
Kuwait	DJ Islamic Market Kuwait	0.512	3 6 7	0.479	0	0.501	0.005	− 1.317	10.495	109.350
Latvia	OMX RIGA (OMXR)	0.514	1	0.484	0	0.506	0.004	− 4.249	27.331	139.940
Lithuania	OMX VILNIUS (OMXV)	0.511	8	0.428	0	0.502	0.012	− 5.380	32.209	42.485
Luxembourg	LUXEMBOURG SE GENERAL	0.507	11	0.461	0	0.500	0.007	− 4.539	21.268	68.256
Malaysia	FTSE BURSA MALAYSIA KLCI	0.502	3 4	0.493	1 5	0.499	0.002	− 1.188	0.897	243.889
Malta	MALTA SE MSE	0.514	1	0.493	44	0.498	0.003	3.985	18.747	158.192
Montenegro	MONTENEGRO SE MONEX	0.512	1 49 50	0.466	0	0.505	0.006	− 5.740	38.116	85.054

Table 6 (continued)

Country	Index	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Netherlands	AEX ALL SHARE	0.511	3	0.445	0	0.501	0.011	− 4.483	20.758	47.356
	AEX INDEX (AEX)	0.509	3	0.440	0	0.501	0.011	− 4.687	22.875	46.212
New Zealand	S&P/NZX 50	0.507	4 [6–14]	0.482	0	0.501	0.004	− 2.059	11.283	126.313
Norway	OSLO EXCHANGE ALL SHARE	0.507	3 6	0.472	0	0.502	0.005	− 5.071	27.999	101.428
Oman	OMAN MUSCAT SECURITIES MKT	0.507	0 3 8 9 10	0.495	1	0.502	0.002	0.690	1.077	212.642
Poland	WARSAW GENERAL INDEX	0.509	6 8 9	0.472	0	0.501	0.006	− 2.889	14.892	90.044
Portugal	PORTUGAL PSI ALL-SHARE	0.514	3	0.465	0	0.497	0.006	− 3.514	22.349	86.154
	PORTUGAL PSI-20	0.517	3	0.469	0	0.498	0.005	− 2.735	25.398	100.432
Qatar	MSCI QATAR	0.513	1	0.463	0	0.497	0.006	− 3.840	25.296	85.521
	MSCI QATAR $	0.513	1	0.463	0	0.497	0.006	− 3.840	25.296	85.521
Romania	ROMANIA BET (L)	0.512	10 11	0.438	0	0.501	0.011	− 4.731	26.581	47.579
Russia	MOEX RUSSIA INDEX	0.519	3	0.477	0	0.501	0.005	− 0.749	13.386	100.234
	RUSSIA RTS INDEX	0.519	3 4	0.477	0	0.501	0.006	0.104	7.538	83.881
Saudi Arabia	MSCI SAUDI ARABIA	0.509	6	0.467	0	0.501	0.006	− 4.384	25.394	88.382
	MSCI SAUDI ARABIA $	0.509	6	0.476	0	0.501	0.005	− 3.191	15.193	105.779
Singapore	STRAITS TIMES INDEX L	0.512	[22–25]	0.481	8 9	0.500	0.009	− 0.489	− 1.109	53.898
Slovakia	SLOVAKIA SAX 16	0.507	12	0.491	3	0.501	0.002	− 0.924	5.984	203.538
Slovenia	SLOVENIAN BLUE CHIP (SBI TOP)	0.505	3 10 11 12 [15–20]	0.454	0	0.500	0.007	− 6.068	40.443	71.938
South Korea	KOREA SE COMPOSITE (KOSPI)	0.509	3	0.452	0	0.499	0.007	− 5.542	36.007	68.519
	KOREA SE KOSPI 200	0.507	1 3	0.447	0	0.499	0.008	− 5.715	37.381	63.011
Spain	IBEX 35	0.507	8	0.438	0	0.500	0.009	− 6.340	42.924	53.920
	MADRID SE GENERAL (IGBM)	0.507	8	0.433	0	0.500	0.010	− 6.507	44.612	50.699
Sweden	OMX STOCKHOLM (OMXS)	0.530	3	0.475	0	0.504	0.008	0.108	4.526	63.761
	OMX STOCKHOLM 30 (OMXS30)	0.527	3	0.480	0	0.505	0.007	0.349	3.149	68.270

Table 6 (continued)

Country	Index	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Switzerland	SWISS MARKET (SMI)	0.512	7	0.438	0	0.500	0.011	− 4.758	26.526	48.007
Turkey	BIST NATIONAL 100	0.509	[9–14]	0.484	0	0.502	0.005	− 1.214	3.323	101.176
United Arab Emirates	MSCI UAE	0.528	1	0.494	4	0.500	0.005	4.768	28.447	109.837
	MSCI UAE $	0.528	1	0.494	4	0.500	0.005	4.602	26.559	108.167
United Kingdom	FTSE 100	0.516	3 4	0.433	0	0.501	0.011	− 5.370	35.587	47.697
	FTSE 250	0.519	4	0.442	0	0.501	0.009	− 4.928	32.381	53.838
	FTSE ALL SHARE	0.521	3	0.438	0	0.501	0.010	− 4.884	32.159	49.932
	FTSE TECHMARK FOCUS (£)	0.516	4	0.433	0	0.500	0.010	− 5.748	38.462	48.849
United States	DOW JONES INDUSTRIALS	0.514	3	0.468	0	0.502	0.006	− 3.841	24.215	85.246
	NASDAQ 100	0.509	5 6	0.403	0	0.500	0.014	− 6.601	45.426	35.075
	NASDAQ COMPOSITE	0.512	6	0.403	0	0.500	0.015	− 6.406	43.439	34.691
	NYSE COMPOSITE	0.512	[4–7]	0.468	0	0.502	0.006	− 4.019	25.496	86.318
	RUSSELL 2000	0.519	6	0.449	0	0.502	0.009	− 4.863	31.991	59.408
	S&P 500 COMPOSITE	0.514	3	0.444	0	0.502	0.009	− 5.687	37.627	57.465

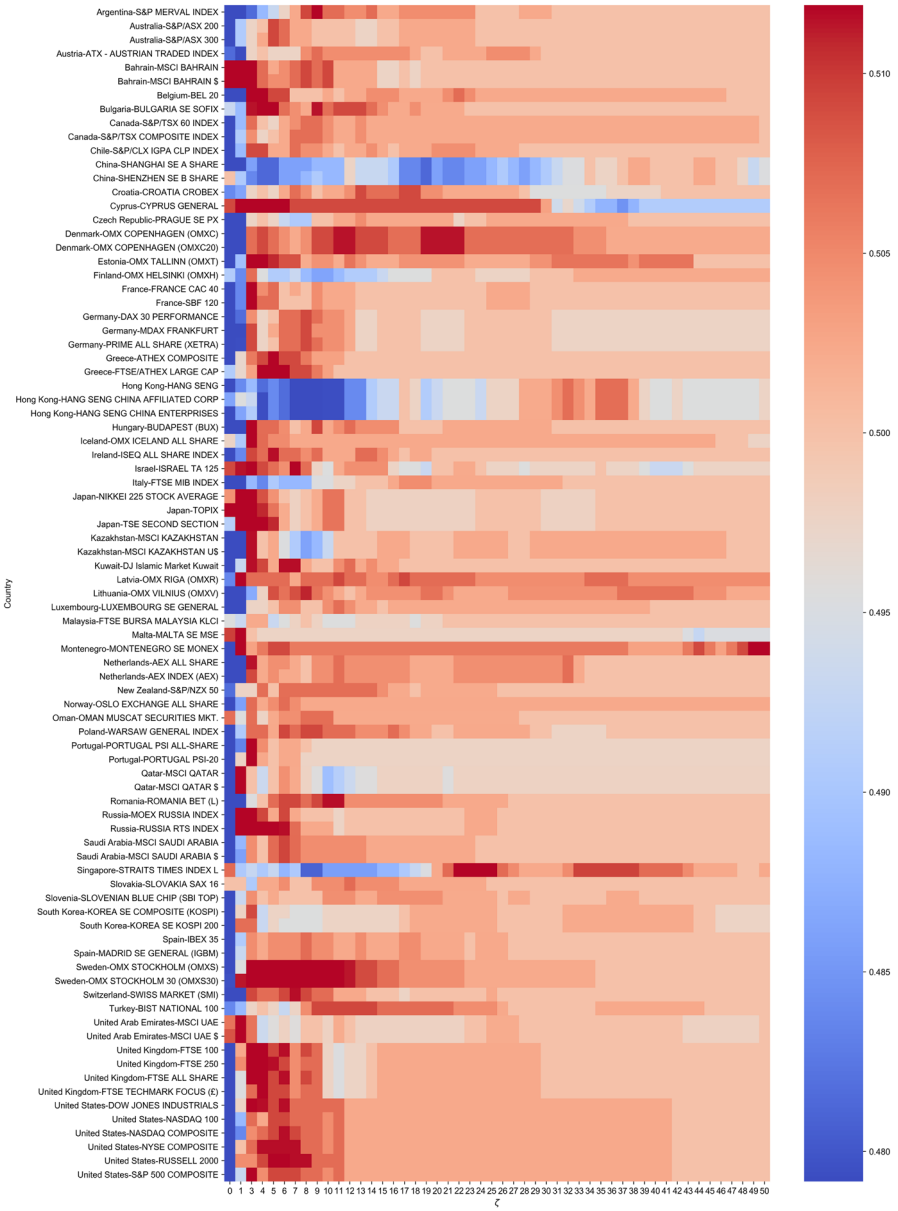

Fig. 7 Heatmap representation of $H_j^{(\zeta)}(k)$ reported in Eq. (6), at stock index level and based on the thresholds ζs

be expressed by the inevitable discussion around semantic and contextual meanings triggered by the selection of words to include, and its resolution does not present straightforward answers. The employment of tools from the field of

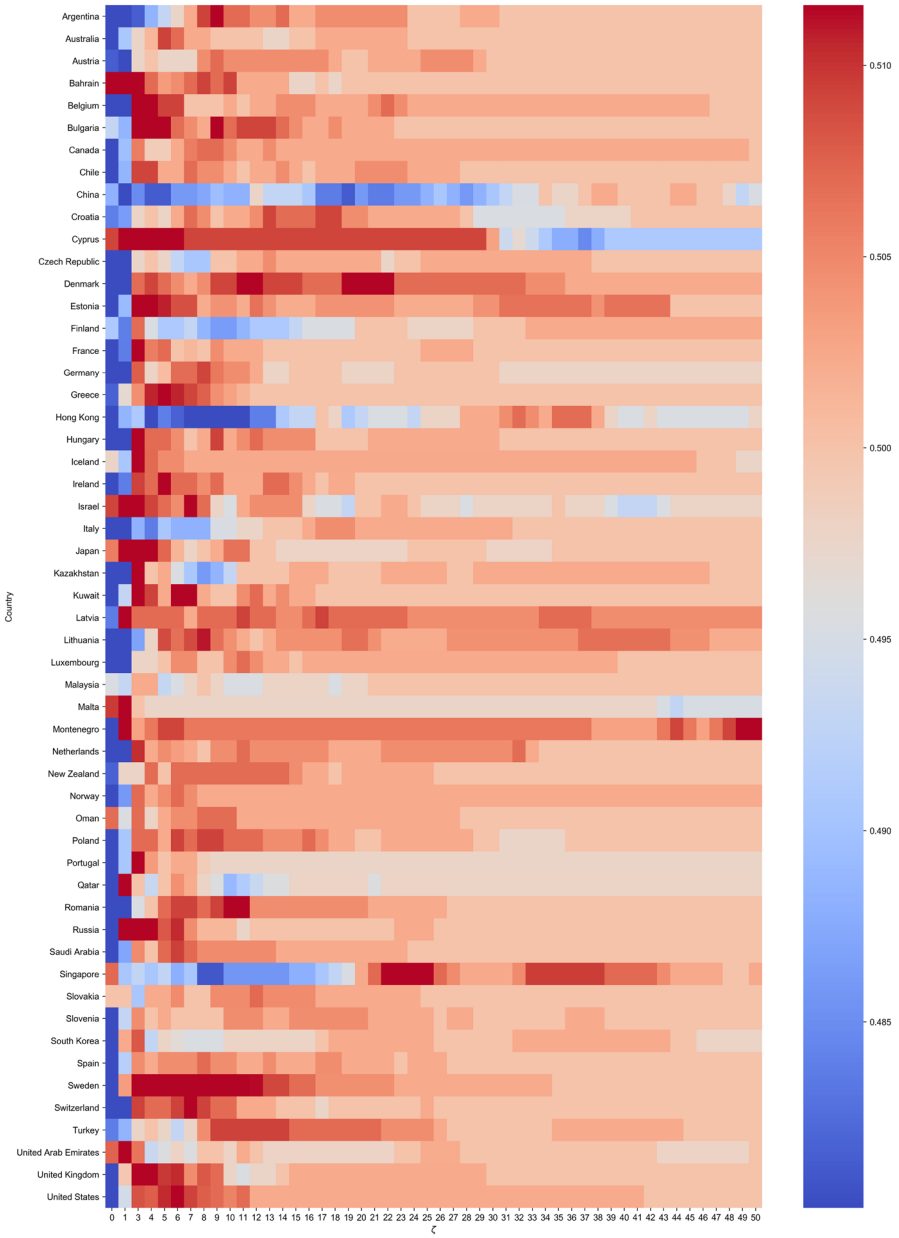

Fig. 8 Heatmap representation of $H_j^{(\zeta)}$ in Eq. (7), at country level and on the basis of the thresholds ζs

Natural Language Processing field might help, but that would initiate a new thread of research requiring a different methodological toolkit.

On the methodological front, other devices could be exploited to capture the population's mood during a pandemic. Referring to the literature discussed in the first

Table 7 Main statistical indicators of $H_j^{(\zeta)}$ in Eq. (7), at country level. The values of the reference thresholds ζs are illustrated

Country	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Argentina	0.514	9	0.465	1	0.500	0.008	− 2.744	9.300	61.631
Australia	0.509	5	0.440	0	0.499	0.009	− 6.300	42.784	56.684
Austria	0.507	9	0.477	1	0.501	0.005	− 3.228	13.247	100.479
Bahrain	0.559	0	0.498	15 16 18	0.503	0.010	4.523	23.068	51.964
Belgium	0.521	3	0.440	0	0.501	0.011	− 4.304	22.483	46.232
Bulgaria	0.516	4	0.489	1	0.502	0.005	0.652	1.995	105.606
Canada	0.507	8 9	0.427	0	0.501	0.011	− 6.609	45.353	46.197
Chile	0.509	3 4	0.452	0	0.501	0.008	− 5.474	34.981	66.096
China	0.502	38 39 44 45	0.480	1	0.492	0.007	0.074	− 1.293	73.282
Croatia	0.509	13 17 18	0.484	0	0.500	0.005	− 0.822	2.309	102.002
Cyprus	0.527	1	0.485	37	0.502	0.010	− 0.134	− 1.083	49.747
Czech Republic	0.505	13	0.465	0	0.499	0.007	− 3.918	17.128	76.321
Denmark	0.511	11 12 [19–22]	0.454	0	0.504	0.010	− 4.145	18.072	48.899
Estonia	0.515	3 4	0.453	0	0.503	0.008	− 4.721	28.766	61.084
Finland	0.507	3	0.484	1	0.498	0.005	− 0.791	− 0.380	91.540
France	0.517	3	0.451	0	0.500	0.008	− 4.761	30.006	63.821
Germany	0.509	8	0.443	0	0.498	0.009	− 4.787	27.922	55.327
Greece	0.517	5	0.482	0	0.501	0.005	− 0.106	9.170	111.827
Hong Kong	0.507	32 35 36 37	0.472	0	0.494	0.009	− 0.702	− 0.172	55.112
Hungary	0.514	3	0.438	0	0.500	0.010	− 5.290	32.563	50.278
Iceland	0.512	3	0.490	1	0.502	0.003	− 0.849	10.345	190.485
Ireland	0.512	5	0.468	0	0.501	0.006	− 3.413	17.699	81.892
Israel	0.516	3	0.493	19 40 41 42	0.500	0.005	1.244	1.194	94.872
Italy	0.505	17 18 19	0.400	0	0.496	0.017	− 4.751	24.584	29.866
Japan	0.524	3	0.498	7 [14–23] [30–34]	0.501	0.005	3.091	10.265	97.770
Kazakhstan	0.512	3	0.449	1	0.499	0.009	− 4.280	22.439	57.636
Kuwait	0.512	3 6 7	0.479	0	0.501	0.005	− 1.317	10.495	109.350

Table 7 (continued)

Country	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Latvia	0.514	1	0.484	0	0.506	0.004	− 4.249	27.331	139.940
Lithuania	0.511	8	0.428	0	0.502	0.012	− 5.380	32.209	42.485
Luxembourg	0.507	11	0.461	0	0.500	0.007	− 4.539	21.268	68.256
Malaysia	0.502	3 4	0.493	1 5	0.499	0.002	− 1.188	0.897	243.889
Malta	0.514	1	0.493	44	0.498	0.003	3.985	18.747	158.192
Montenegro	0.512	1 49 50	0.466	0	0.505	0.006	− 5.740	38.116	85.054
Netherlands	0.510	3	0.443	0	0.501	0.011	− 4.583	21.763	46.811
New Zealand	0.507	4 [6–14]	0.482	0	0.501	0.004	− 2.059	11.283	126.313
Norway	0.507	3 6	0.472	0	0.502	0.005	− 5.071	27.999	101.428
Oman	0.507	0 3 8 9 10	0.495	1	0.502	0.002	0.690	1.077	212.642
Poland	0.509	6 8 9	0.472	0	0.501	0.006	− 2.889	14.892	90.044
Portugal	0.515	3	0.467	0	0.498	0.005	− 3.255	25.052	94.406
Qatar	0.513	1	0.463	0	0.497	0.006	− 3.840	25.296	85.521
Romania	0.512	10 11	0.438	0	0.501	0.011	− 4.731	26.581	47.579
Russia	0.519	3	0.477	0	0.501	0.005	− 0.407	10.179	92.818
Saudi Arabia	0.509	6	0.472	0	0.501	0.005	− 3.806	20.311	96.753
Singapore	0.512	[22–25]	0.481	8 9	0.500	0.009	− 0.489	− 1.109	53.898
Slovakia	0.507	12	0.491	3	0.501	0.002	− 0.924	5.984	203.538
Slovenia	0.505	3 10 11 12 [15–20]	0.454	0	0.500	0.007	− 6.068	40.443	71.938
South Korea	0.508	3	0.450	0	0.499	0.008	− 5.714	37.367	65.922
Spain	0.507	8	0.435	0	0.500	0.010	− 6.430	43.834	52.273
Sweden	0.528	3	0.477	0	0.505	0.008	0.246	4.104	66.680
Switzerland	0.512	7	0.438	0	0.500	0.011	− 4.758	26.526	48.007
Turkey	0.509	[9-14]	0.484	0	0.502	0.005	− 1.214	3.323	101.176
United Arab Emirates	0.528	1	0.494	4	0.500	0.005	4.686	27.527	109.050
United Kingdom	0.516	4	0.436	0	0.501	0.010	− 5.343	35.349	50.233
United States	0.512	6	0.439	0	0.502	0.010	− 5.949	39.841	53.236

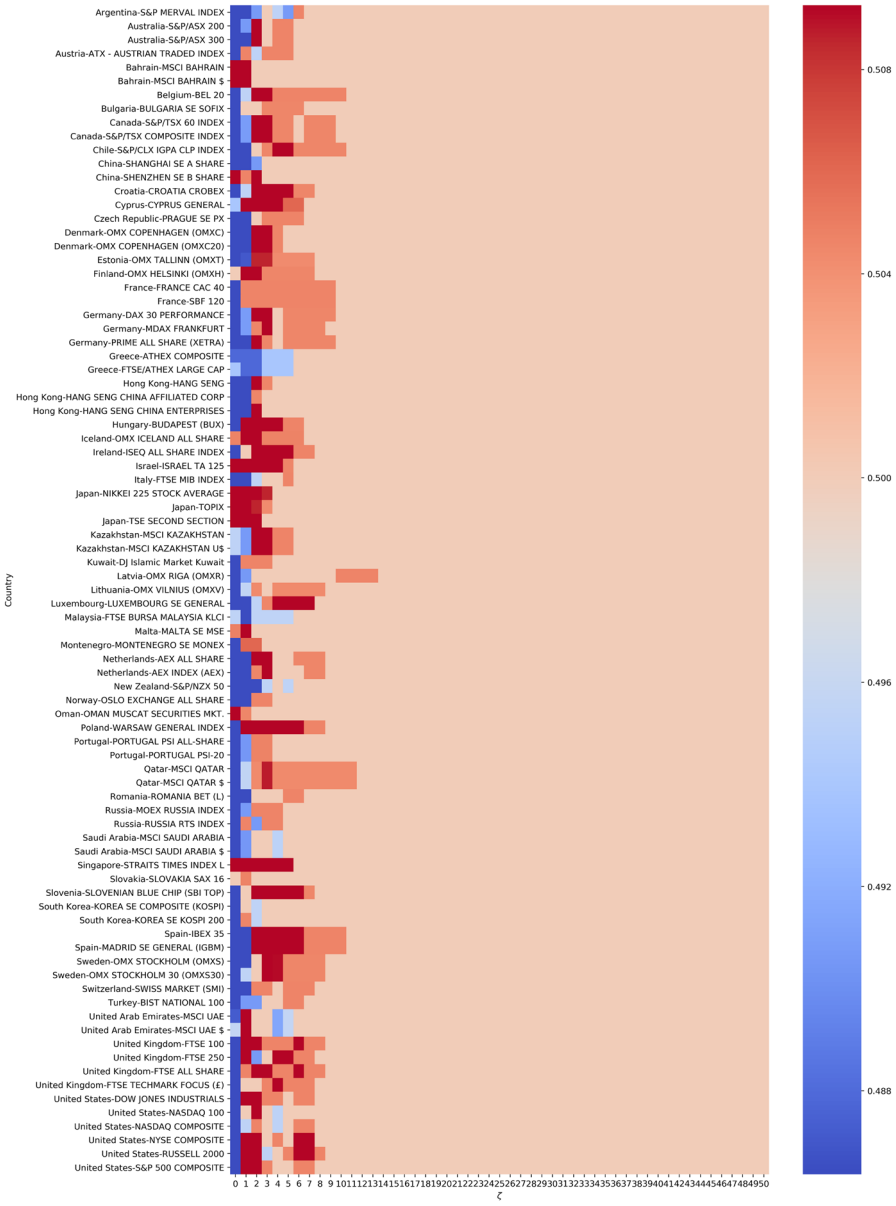

Fig. 9 Heatmap representation of $R_j^{(\zeta)}(k)$ in Eq. (8), at stock index level and based on the thresholds ζs

two sections of this paper, the most prominent examples are based on surveys to be submitted to a sample of the population. This would be extremely interesting but also challenging and expensive, especially to have a global view comparable to the one presented here. Indeed, one should contact groups of qualified citizens in the

Table 8 Main statistical indicators of $R_j^{(\zeta)}(k)$ in Eq. (8), at stock index level, along with the meaningful thresholds ζs

Country	Index	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Argentina	S&P MERVAL INDEX	0.505	6	0.468	0 1	0.498	0.007	− 4.252	18.219	76.251
Australia	S&P/ASX 200	0.514	2	0.454	0	0.499	0.007	− 5.632	38.317	72.133
	S&P/ASX 300	0.514	2	0.454	0	0.499	0.007	− 5.357	35.016	70.676
Austria	ATX - AUSTRIAN TRADED INDEX	0.505	1 3 4 5	0.472	0	0.500	0.004	− 5.806	39.154	120.645
Bahrain	MSCI BAHRAIN	0.537	0	0.500	[2–50]	0.501	0.006	5.295	28.336	83.518
	MSCI BAHRAIN $	0.565	0	0.500	[2–50]	0.502	0.010	5.906	36.395	51.702
Belgium	BEL 20	0.523	2	0.463	0	0.501	0.007	− 2.665	22.162	75.245
Bulgaria	BULGARIA SE SOFIX	0.505	[3–6]	0.477	0	0.500	0.003	− 5.628	38.402	144.571
Canada	S&P/TSX 60 INDEX	0.509	2 3	0.450	0	0.500	0.008	− 5.856	39.296	66.291
	S&P/TSX COMPOSITE INDEX	0.518	2	0.436	0	0.500	0.010	− 5.708	38.948	51.904
Chile	S&P/CLX IGPA CLP INDEX	0.509	4 5	0.454	0	0.500	0.008	− 4.796	26.899	66.081
China	SHANGHAI SE A SHARE	0.500	[3–50]	0.481	0 1	0.499	0.004	− 4.284	17.705	130.729
	SHENZHEN SE B SHARE	0.514	0	0.500	[3–50]	0.501	0.002	4.741	23.030	209.801
Croatia	CROATIA CROBEX	0.518	2 3	0.486	0	0.501	0.005	1.844	7.965	105.528
Cyprus	CYPRUS GENERAL	0.524	1	0.494	0	0.501	0.005	3.362	13.220	109.736
Czech Republic	PRAGUE SE PX	0.505	[3–6]	0.453	0	0.499	0.007	− 6.031	39.432	72.275
Denmark	OMX COPENHAGEN (OMXC)	0.514	2	0.463	0	0.499	0.006	− 4.141	24.040	80.504
	OMX COPENHAGEN (OMXC20)	0.514	2	0.454	0	0.499	0.008	− 4.642	26.610	66.297
Estonia	OMX TALLINN (OMXT)	0.509	2 3	0.453	0	0.499	0.007	− 5.644	36.742	69.621
Finland	OMX HELSINKI (OMXH)	0.518	1	0.500	0 [8–50]	0.501	0.003	4.229	20.731	163.965
France	FRANCE CAC 40	0.505	[1–9]	0.458	0	0.500	0.006	− 6.206	42.539	81.298
	SBF 120	0.505	[1–9]	0.454	0	0.500	0.007	− 6.369	43.954	73.868
Germany	DAX 30 PERFORMANCE	0.514	2	0.431	0	0.499	0.010	− 6.182	42.386	49.564
	MDAX FRANKFURT	0.509	3	0.422	0	0.499	0.011	− 6.679	46.596	44.906
	PRIME ALL SHARE (XETRA)	0.518	2	0.427	0	0.499	0.011	− 5.955	40.462	46.002

Table 8 (continued)

Country	Index	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Greece	ATHEX COMPOSITE	0.500	[6–50]	0.488	0 1 2	0.499	0.003	− 2.940	7.654	159.558
	FTSE/ATHEX LARGE CAP	0.500	[6–50]	0.488	1 2	0.499	0.003	− 3.081	9.081	178.302
Hong Kong	HANG SENG	0.509	2	0.468	0	0.499	0.006	− 4.514	22.529	88.329
	HANG SENG CHINA AFFILIATED CORP	0.505	2	0.477	0	0.499	0.004	− 5.072	27.369	133.253
	HANG SENG CHINA ENTERPRISES	0.509	2	0.445	0	0.499	0.009	− 5.428	31.527	58.017
Hungary	BUDAPEST (BUX)	0.519	2 3	0.458	0	0.501	0.007	− 3.121	22.725	68.434
Iceland	OMX ICELAND ALL SHARE	0.514	1 2	0.500	[7–50]	0.501	0.003	3.546	13.001	165.438
Ireland	ISEQ ALL SHARE INDEX	0.514	2 3 4	0.463	0	0.500	0.006	− 3.489	24.217	78.581
Israel	ISRAEL TA 125	0.523	0	0.500	[6–50]	0.501	0.004	3.920	17.515	126.334
Italy	FTSE MIB INDEX	0.505	5	0.421	0	0.498	0.012	− 5.911	36.715	41.962
Japan	NIKKEI 225 STOCK AVERAGE	0.517	1	0.500	[4–50]	0.501	0.004	3.545	11.735	139.959
	TOPIX	0.526	0	0.500	[4–50]	0.501	0.004	4.623	22.160	113.310
	TSE SECOND SECTION	0.526	1	0.500	[3–50]	0.501	0.005	4.274	17.791	102.089
Kazakhstan	MSCI KAZAKHSTAN	0.509	2 3	0.491	1	0.500	0.003	0.822	9.432	200.434
	MSCI KAZAKHSTAN U$	0.509	2 3	0.491	1	0.500	0.003	0.822	9.432	200.434
Kuwait	DJ Islamic Market Kuwait	0.505	1 2 3	0.472	0	0.500	0.004	− 6.271	43.554	123.714
Latvia	OMX RIGA (OMXR)	0.505	[10–13]	0.463	0	0.499	0.006	− 6.000	39.837	90.399
Lithuania	OMX VILNIUS (OMXV)	0.504	2 [4–8]	0.439	0	0.499	0.009	− 6.777	47.575	57.276
Luxembourg	LUXEMBOURG SE GENERAL	0.509	[4–7]	0.459	0	0.499	0.007	− 4.185	22.310	70.029
Malaysia	FTSE BURSA MALAYSIA KLCI	0.500	[6–50]	0.486	1	0.499	0.002	− 4.174	20.378	219.740
Malta	MALTA SE MSE	0.510	1	0.500	[2–50]	0.500	0.001	5.654	33.118	338.369
Montenegro	MONTENEGRO SE MONEX	0.506	1 2	0.482	0	0.500	0.003	− 4.926	34.715	176.675
Netherlands	AEX ALL SHARE	0.514	3	0.450	0	0.499	0.008	− 4.650	25.601	59.359
	AEX INDEX (AEX)	0.514	3	0.445	0	0.499	0.009	− 4.846	26.221	54.684

Table 8 (continued)

Country	Index	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
New Zealand	S&P/NZX 50	0.500	4 [6–50]	0.472	0	0.499	0.005	− 4.201	18.213	101.422
Norway	OSLO EXCHANGE ALL SHARE	0.505	2 3	0.467	0	0.499	0.006	− 4.876	24.372	88.643
Oman	OMAN MUSCAT SECURITIES MKT	0.509	0	0.500	[2–50]	0.500	0.001	5.654	33.120	354.632
Poland	WARSAW GENERAL INDEX	0.519	3	0.463	0	0.501	0.007	− 2.761	19.523	72.977
Portugal	PORTUGAL PSI ALL-SHARE	0.505	2 3	0.467	0	0.499	0.005	− 6.051	39.932	102.842
	PORTUGAL PSI-20	0.505	2 3	0.458	0	0.499	0.006	− 6.429	43.769	81.772
Qatar	MSCI QATAR	0.509	3	0.469	0	0.500	0.005	− 4.997	32.597	102.766
	MSCI QATAR $	0.509	3	0.469	0	0.500	0.005	− 4.997	32.597	102.766
Romania	ROMANIA BET (L)	0.505	5 6	0.431	0	0.499	0.010	− 6.669	46.032	50.601
Russia	MOEX RUSSIA INDEX	0.505	2 3 4	0.440	0	0.499	0.009	− 6.714	46.751	58.481
	RUSSIA RTS INDEX	0.505	1 3 4	0.444	0	0.499	0.008	− 6.646	46.072	63.137
Saudi Arabia	MSCI SAUDI ARABIA	0.500	2 3 [5–50]	0.448	0	0.499	0.007	− 6.750	46.843	68.313
	MSCI SAUDI ARABIA $	0.500	2 3 [5–50]	0.467	0	0.499	0.005	− 6.293	41.657	104.742
Singapore	STRAITS TIMES INDEX L	0.510	[0-5]	0.500	[6–50]	0.501	0.003	2.446	4.144	163.309
Slovakia	SLOVAKIA SAX 16	0.505	1	0.500	0 [2–50]	0.500	0.001	7.141	51.000	764.662
Slovenia	SLOVENIAN BLUE CHIP (SBI TOP)	0.514	2 3	0.477	0	0.501	0.005	− 1.308	13.235	105.358
South Korea	KOREA SE COMPOSITE (KOSPI)	0.500	1 [3–50]	0.459	0	0.499	0.006	− 7.015	49.685	86.853
	KOREA SE KOSPI 200	0.505	1	0.454	0	0.499	0.006	− 6.920	48.869	77.686
Spain	IBEX 35	0.514	2	0.449	0	0.500	0.008	− 4.789	30.210	61.181
	MADRID SE GENERAL (IGBM)	0.514	2	0.449	0	0.500	0.008	− 4.789	30.210	61.181
Sweden	OMX STOCKHOLM (OMXS)	0.514	3	0.482	1	0.500	0.004	− 1.544	11.137	121.373
	OMX STOCKHOLM 30 (OMXS30)	0.514	3	0.486	0	0.500	0.003	0.170	11.270	152.713
Switzerland	SWISS MARKET (SMI)	0.505	2 3 5 6 7	0.440	0	0.499	0.010	− 5.331	29.966	52.025
Turkey	BIST NATIONAL 100	0.505	5 6	0.486	0	0.500	0.003	− 3.281	13.267	179.107

Table 8 (continued)

Country	Index	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
United Arab Emirates	MSCI UAE	0.513	1	0.487	0	0.500	0.003	− 0.335	16.006	174.802
	MSCI UAE $	0.513	1	0.491	4	0.500	0.002	2.270	22.026	215.834
United Kingdom	FTSE 100	0.509	1 2 6	0.444	0	0.500	0.008	− 6.088	41.749	60.777
	FTSE 250	0.509	1 4 5	0.463	0	0.500	0.006	− 4.808	31.130	85.183
	FTSE ALL SHARE	0.509	2 3 6	0.449	0	0.500	0.008	− 5.911	40.311	65.655
	FTSE TECHMARK FOCUS (£)	0.509	4	0.463	0	0.500	0.006	− 5.931	40.824	90.912
United States	DOW JONES INDUSTRIALS	0.514	1 2	0.477	0	0.500	0.004	− 1.873	18.181	113.195
	NASDAQ 100	0.509	2	0.426	0	0.499	0.010	− 6.914	48.941	48.018
	NASDAQ COMPOSITE	0.505	2 6 7	0.431	0	0.499	0.010	− 6.896	48.649	51.156
	NYSE COMPOSITE	0.509	1 2 6 7	0.481	0	0.500	0.004	− 1.613	14.685	135.393
	RUSSELL 2000	0.519	1	0.463	0	0.500	0.006	− 3.505	25.055	79.248
	S&P 500 COMPOSITE	0.509	1 2	0.458	0	0.500	0.006	− 5.839	40.084	80.415

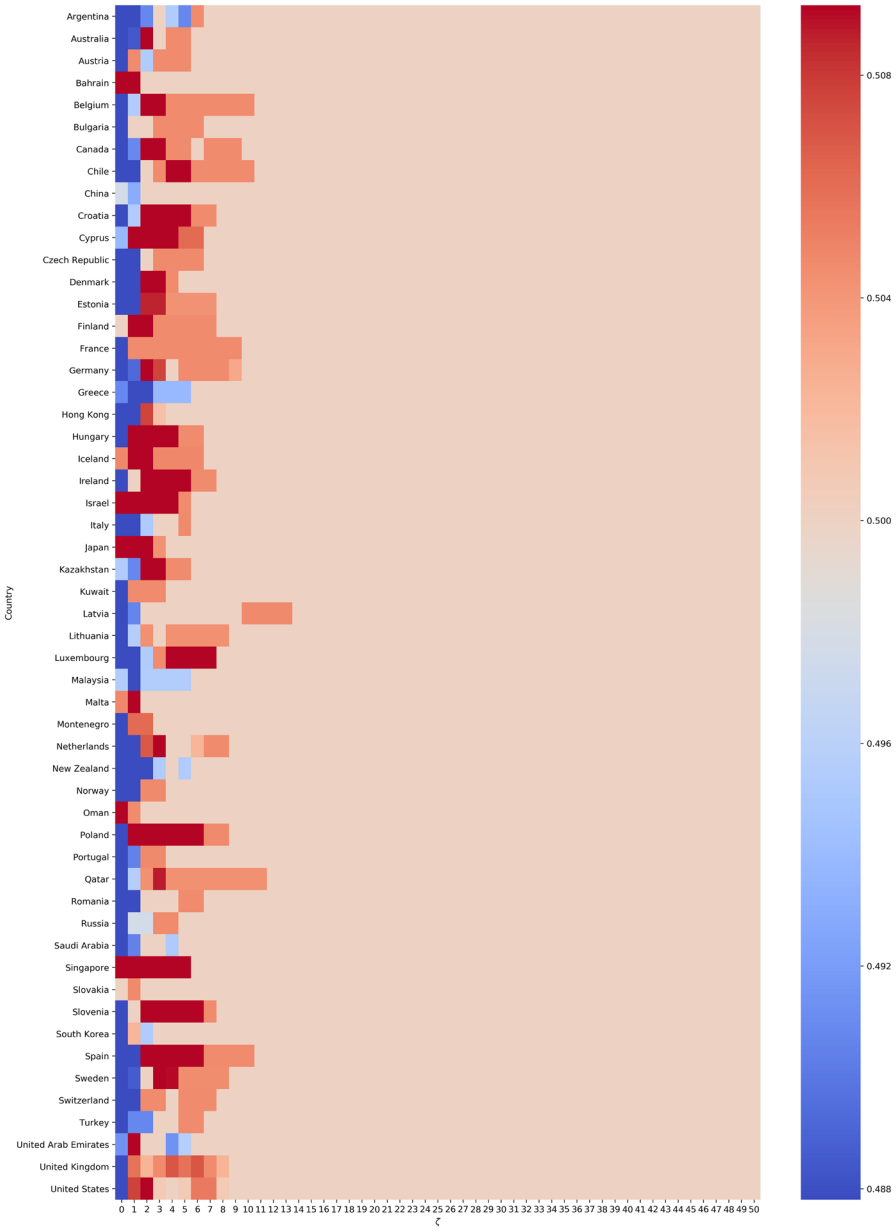

Fig. 10 Heatmap representation of $R_j^{(\zeta)}$ in Eq. (9), at country level and on the basis of the thresholds ζs

countries considered and/or use professional services to gather data in those countries (e.g. one has to have questions translated in all the languages). It is certainly an interesting research item to add to researchers' agenda whose working tools include primary data collection, maybe involving colleagues in various places of the

Table 9 Main statistical indicator of $R_j^{(\zeta)}$ in Eq. (9), at country level. The reference thresholds ζs are reported

Country	Max	ζ_{max}	Min	ζ_{min}	μ	σ	Skew	Kurt	μ/σ
Argentina	0.505	6	0.468	0 1	0.498	0.007	– 4.252	18.219	76.251
Australia	0.514	2	0.454	0	0.499	0.007	– 5.499	36.750	71.468
Austria	0.505	1 3 4 5	0.472	0	0.500	0.004	– 5.806	39.154	120.645
Bahrain	0.551	0	0.500	[2–50]	0.501	0.008	5.654	33.120	64.042
Belgium	0.523	2	0.463	0	0.501	0.007	– 2.665	22.162	75.245
Bulgaria	0.505	[3–6]	0.477	0	0.500	0.003	– 5.628	38.402	144.571
Canada	0.514	2	0.443	0	0.500	0.009	– 5.815	39.342	58.322
Chile	0.509	4 5	0.454	0	0.500	0.008	– 4.796	26.899	66.081
China	0.500	[2–50]	0.493	1	0.500	0.001	– 6.273	41.026	490.895
Croatia	0.518	2 3	0.486	0	0.501	0.005	1.844	7.965	105.528
Cyprus	0.524	1	0.494	0	0.501	0.005	3.362	13.220	109.736
Czech Republic	0.505	[3–6]	0.453	0	0.499	0.007	– 6.031	39.432	72.275
Denmark	0.514	2	0.459	0	0.499	0.007	– 4.427	25.467	72.761
Estonia	0.509	2 3	0.453	0	0.499	0.007	– 5.644	36.742	69.621
Finland	0.518	1	0.500	0 [8–50]	0.501	0.003	4.229	20.731	163.965
France	0.505	[1–9]	0.456	0	0.500	0.007	– 6.293	43.293	77.413
Germany	0.512	2	0.427	0	0.499	0.011	– 6.375	43.869	46.941
Greece	0.500	[6–50]	0.488	1 2	0.499	0.003	– 2.933	7.776	169.887
Hong Kong	0.508	2	0.463	0	0.499	0.006	– 5.076	27.686	83.566
Hungary	0.519	2 3	0.458	0	0.501	0.007	– 3.121	22.725	68.434
Iceland	0.514	1 2	0.500	[7–50]	0.501	0.003	3.546	13.001	165.438
Ireland	0.514	2 3 4	0.463	0	0.500	0.006	– 3.489	24.217	78.581
Israel	0.523	0	0.500	[6–50]	0.501	0.004	3.920	17.515	126.334
Italy	0.505	5	0.421	0	0.498	0.012	– 5.911	36.715	41.962
Japan	0.520	0 1	0.500	[4–50]	0.501	0.004	4.058	15.910	119.395
Kazakhstan	0.509	2 3	0.491	1	0.500	0.003	0.822	9.432	200.434
Kuwait	0.505	1 2 3	0.472	0	0.500	0.004	– 6.271	43.554	123.714
Latvia	0.505	[10–13]	0.463	0	0.499	0.006	– 6.000	39.837	90.399
Lithuania	0.504	2 [4–8]	0.439	0	0.499	0.009	– 6.777	47.575	57.276
Luxembourg	0.509	[4–7]	0.459	0	0.499	0.007	– 4.185	22.310	70.029
Malaysia	0.500	[6–50]	0.486	1	0.499	0.002	– 4.174	20.378	219.740
Malta	0.510	1	0.500	[2–50]	0.500	0.001	5.654	33.118	338.369
Montenegro	0.506	1 2	0.482	0	0.500	0.003	– 4.926	34.715	176.675
Netherlands	0.514	3	0.447	0	0.499	0.009	– 4.779	26.089	57.020
New Zealand	0.500	4 [6–50]	0.472	0	0.499	0.005	– 4.201	18.213	101.422
Norway	0.505	2 3	0.467	0	0.499	0.006	– 4.876	24.372	88.643
Oman	0.509	0	0.500	[2–50]	0.500	0.001	5.654	33.120	354.632
Poland	0.519	3	0.463	0	0.501	0.007	– 2.761	19.523	72.977
Portugal	0.505	2 3	0.462	0	0.499	0.006	– 6.268	42.134	91.164
Qatar	0.509	3	0.469	0	0.500	0.005	– 4.997	32.597	102.766
Romania	0.505	5 6	0.431	0	0.499	0.010	– 6.669	46.032	50.601

Table 9 (continued)

Country	Max	ς_{max}	Min	ς_{min}	μ	σ	Skew	Kurt	μ/σ
Russia	0.505	3 4	0.442	0	0.499	0.008	− 6.959	49.302	61.592
Saudi Arabia	0.500	2 3 [5–50]	0.458	0	0.499	0.006	− 6.584	44.984	82.818
Singapore	0.510	[0–5]	0.500	[6–50]	0.501	0.003	2.446	4.144	163.309
Slovakia	0.505	1	0.500	0 [2–50]	0.500	0.001	7.141	51.000	764.662
Slovenia	0.514	2 3	0.477	0	0.501	0.005	− 1.308	13.235	105.358
South Korea	0.502	1	0.456	0	0.499	0.006	− 6.994	49.508	82.115
Spain	0.514	2	0.449	0	0.500	0.008	− 4.789	30.210	61.181
Sweden	0.514	3	0.486	0	0.500	0.004	− 0.416	9.080	138.936
Switzerland	0.505	2 3 5 6 7	0.440	0	0.499	0.010	− 5.331	29.966	52.025
Turkey	0.505	5 6	0.486	0	0.500	0.003	− 3.281	13.267	179.107
United Arab Emirates	0.513	1	0.491	0 4	0.500	0.003	1.175	17.126	197.300
United Kingdom	0.507	4 6	0.455	0	0.500	0.007	− 6.185	42.517	75.195
United States	0.509	2	0.456	0	0.500	0.007	− 6.095	42.091	77.219

world. On the other hand, for researchers comfortable with secondary data collection, the exploration of the interconnections between stock markets and the evolution of COVID-19 is a very interesting challenge that would complete the view in this arena. Such exploration is of pivotal interest for grounding the reactions to the pandemic (with a focus on investment decisions) on the official data on COVID-19 and its complex interrelations with the patterns of the stock markets.

In designing the present study, we have considered these challenges and open questions; in fact, we carefully developed the indicators so that the non-explored areas in this field do not undermine the results presented.

Acknowledgements The authors sincerely thank Prof. Anna Maria D'Arcangelis for helpful discussions.

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