Full Length Article

Is ESG investing an 'equity vaccine' in times of crisis? Evidence from the 2020 Wuhan Lockdown and the 2022 Shanghai Lockdown

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Abstract

In the literature on sustainable investing, most studies assume normal market conditions. However, research is limited regarding the specific role of sustainable investing during stressed market conditions. In this paper, we contribute to the literature by investigating the role of ESG investing in market turbulence for the case of China. To that end, we examine the performance of ESG equity indices and compare against their benchmarks amid market turmoil in China, which were triggered in response to the 2020 Wuhan Lockdown and the recent 2022 Shanghai Lockdown. Specifically, we address two key issues that are of particular concern to most investors: (i) is ESG investing safe haven in times of crisis?; and (ii) can ESG investing improve portfolio diversification? Overall, our findings shed light on the role of sustainable investing amid uncertainty in turbulent times.

1. Introduction

In late 2019, there was an outbreak of a novel coronavirus disease (COVID-19), which was determined as a public health emergency of international concern and was declared as a global pandemic by the World Health Organization (WHO). On January 23, 2020, the central government of China imposed an abrupt and unprecedented[1] lockdown in the Chinese city of Wuhan in an effort to quarantine the epicenter of a sudden onset of the coronavirus. The 2020 Wuhan Lockdown

was the first of many such responses to the spread of the COVID-19 pandemic around the world (Yang, 2022). More recently in November 2021, the Omicron variant of COVID-19 was first reported to the WHO. As Omicron cases soared, the Chinese government imposed a lockdown in the city of Shanghai with its 25 million residents in the spring of 2022.[2] Triggered in response to the public health crisis, both the 2020 Wuhan Lockdown[3] and the recent 2022 Shanghai Lockdown caused market-wide financial crisis, with China's stock markets experiencing synchronized declines in the three main

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[1] "Wuhan lockdown 'unprecedented', shows commitment to contain virus: WHO representative in China", Reuters, January 23, 2020. See https://www.reuters.com/article/us-china-health-who-idUSKBN1ZM1G9.

[2] "What Shanghai lockdowns mean for China Inc", The Economist, April 2, 2022. See https://www.economist.com/business/what-shanghai-lockdowns-mean-for-china-inc/21808450.

[3] See Baker et al. (2020).

Fig. 1. China's main stock market benchmarks during the Wuhan Lockdown and the Shanghai Lockdown. *Data Source*: tushare.pro.

benchmarks: the Shanghai Stock Exchange Composite Index (000001.SH), the Shenzhen Component Index (399001.SZ), and the CSI 300 Index (000300.SH). (See Fig. 1.[4]).

In the wake of this public health crisis, there is a growing view that the coronavirus pandemic may be a turning point for responsible business. Active investors are now asking what CEOs are doing to protect their wider ecosystems. As corporate social responsibility activities help to build social capital and trust, those corporations, which look after all their stakeholders and strive to serve a purpose bigger than profits, may be better placed to weather the immediate health crisis and economic downturn ahead. This helps explain the resilience of sustainable investing amid uncertainty during the COVID-19 crisis (Pastor & Vorsatz, 2020). In light of the shift in investor preferences for sustainable investment (Cornell, 2021; Pastor, Stambaugh, & Taylor, 2021), the objective of this study is to revisit the debate on the role of sustainable investing during pandemic-induced market conditions (Demers, Hendrikse, Joos, & Lev, 2021), and explore whether sustainable investing is an 'equity vaccine' in times of crisis for the case of China, which has a growing and significant market in sustainable investment.[5]

Sustainable investing is an investment approach that considers not only financial objectives, but also environmental, social, and governance (ESG) factors.[6] In the literature on sustainable investing, most studies assume normal market conditions. However, research is limited regarding the role of sustainable investing during stressed market conditions. Nevertheless, some insights have been gleaned from the 2007/

08 Global Financial Crisis (GFC) (Cornett, Erhemjamts, & Tehranian, 2016; Lins, Servaes, & Tamayo, 2017, 2019; Nofsinger & Varma, 2014). Unlike traditional financial crises, the COVID-19 is a public health crisis with a significant impact on the global economy. Along the line of research on sustainable investing during stressed market conditions, most recent studies examine sustainable investing during the COVID-19 (Albuquerque, Koskinen, Yang, & Zhang, 2020; Bae, El Ghoul, Gong, & Guedhami, 2021; Demers et al., 2021; Diaz, Ibrushi, & Zhao, 2021; Ding, Levine, Lin, & Xie, 2021; Zhou & Zhou, 2022). Along this line of research, Khew, Lopez, Su, and Quek (2020) focuses on both the periods of the GFC and the COVID-19.

Among studies on sustainable investing during the COVID-19 pandemic, there are studies that add in the dimension of geography, including Broadstock, Chan, Cheng, and Wang (2021) on China; Takahashi and Yamada (2021) on Japan; Lee, Lee, Hong, and Park (2022) on Korea; Beloskar and Rao (2022) on India; Palma-Ruiz, Castillo-Apraiz, and Gomez-Martinez (2020) on Spain; Chiappini, Vento, and De Palma (2021) on Europe; Engelhardt, Ekkenga, and Posch (2021) on Europe; Pisani and Russo (2021) on Europe; Mousa, Saleem, and Sagi (2021) on the Arab Region.

In this paper, we contribute to the literature by investigating the specific role of ESG investing in market turbulence for the case of China. In particular, we examine the performance of ESG equity indices and compare against their market benchmarks during crisis periods in China, which were triggered in response to the 2020 Wuhan Lockdown and the recent 2022 Shanghai Lockdown. Specifically, we address two key issues that are of concern to most investors: (i) is ESG investing safe haven in times of crisis? and (ii) can ESG investing improve portfolio diversification? In our analysis, we concentrate on sustainable investing in ESG equity indices. In the literature on sustainable investing, relatively few studies have analyzed ESG equity indices, including Schroder (2007); Consolandi, Jaiswal-Dale, Poggiani, and Vercelli (2009); Belghitar, Clark, and Deshmukh (2014); Sherwood and Pollard (2017); Cunha et al. (2019); Dai (2021) during normal market conditions; Wu, Lodorfos, Dean, and Gioulmpaxiotis (2015); Azmi, Ng, Dewandaru, and Nagayev (2019); Lean and Pizzutilo (2020); Chiappini et al. (2021) during stressed market conditions.

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[4] In Fig. 1: left panel, the vertical line is the start date (January 23, 2020) of the Wuhan Lockdown. In Fig. 1: right panel, the vertical line is the date of March 11, 2022. On the morning of that day, the nearby Zhejiang Province suddenly announced that people from Shanghai would be quarantined for 14 days. Then from March 12 onwards in Shanghai, those communities with confirmed cases started their 14-day quarantine, with compulsory Covid tests on the 1st, 2nd, 4th, 7th, and 14th days of quarantine. All other communities with no confirmed cases started their 48-h quarantine on a rolling basis across the city, with compulsory Covid tests. So we use the date of March 11 as a proxy for the start of the pandemic period during the 2022 Shanghai Lockdown.

[5] See GSIA (2020): p.22).

[6] See GSIA (2020): p.7); CSIF (2021: p.5); Munoz, Vargas, and Marco (2014: p.552).

Table 1
China's "ESG select" equity indices.

Ticker	"ESG Select" Equity Index	Benchmark Index	
000048.SH	SZSE Corporate Social Responsibility Index	SHSE Composite Index	000001.SH
399341.SZ	SZSE Component Total Return Index	SZSE Component Total Return Index	399002.SZ
399369.SZ	CHI-CBN-AEGON Industrial CSR Index	CSI 300 Index	000300.SH
399378.SZ	CNI ESG 300 Index	CSI 300 Index	000300.SH
399550.SZ	CCTV 50 Index	CSI 300 Index	000300.SH
399555.SZ	CCTV 50 CSR Index	CSI 300 Index	000300.SH
000846.CSI	CSI ECPI ESG China 100 Index	CSI 300 Index	000300.SH
931268.CSI	CSI CUFE SH-SZ 100 ESG Leading Index	CSI 300 Index	000300.SH
931476.CSI	CSI ESG 120 Strategy Index	CSI 300 Index	000300.SH
931598.CSI	CSI BOC International 300 ESG Index	CSI 300 Index	000300.SH
000970.CSI	CSI ECPI ESG China 40 Index	SSE 180 Index	000010.SH
399651.SZ	SZSE SME CSR Index	SZSE SME Index	399005.SZ

Source: CSIF (2021: Table 3).

The remainder of this paper is organized as follows. In Section 2, we analyze whether the ESG equity indices under study exhibit a different performance compared to their conventional benchmark indices in 'crisis' periods during the 2020 Wuhan Lockdown and the recent 2022 Shanghai Lockdown. We also apply spanning tests to examine whether the ESG equity indices can be replicated by their market benchmarks. In Section 3, we conduct Monte Carlo simulation to analyze the effect of integrating the ESG equity indices on portfolio diversification. Section 4 concludes and discusses implication.

2. Is ESG investing safe haven in times of crisis?

Along the line of research on the performance of sustainable investing in times of crisis, the notion that sustainable investing will enhance shareholder value in normal times, and even more so in crisis periods, is premised upon the risk management hypothesis that sustainable investing offers an 'insurance-like' protection (Godfrey, 2005; Godfrey, Merrill, & Hansen, 2009). On the one hand, some research studies with a focus on the GFC period find evidence to support the case for ESG as a mitigator of downside risk (Cornett et al., 2016; Lins et al., 2017, 2019; Nofsinger & Varma, 2014). Several contemporaneous studies with a focus on the COVID-19 period also find supportive evidence on ESG as a resilience factor amid uncertainty (Broadstock et al., 2021; Diaz et al., 2021). On the other hand, some recent studies suggest that earlier evidence on the resilience of sustainable investing is not consistent across crises (Bae et al., 2021; Chiappini et al., 2021; Demers et al., 2021).

To contribute to the line of research on the performance of ESG investing in times of crisis, we analyze whether the ESG equity indices under study exhibit a different performance than their conventional benchmark indices during the 2020 Wuhan Lockdown and the recent 2022 Shanghai Lockdown. We first compare the main risk-return characteristics of the ESG equity indices with their benchmarks. We then conduct spanning tests to examine whether the ESG equity indices can be replicated by their conventional benchmark indices.

Our analysis concentrates on sustainable investing in ESG equity indices, which are easily accessible to investors. CSIF

Table 2
2020 Wuhan Lockdown and 2022 Shanghai Lockdown: definition of 'crisis' periods.

	2020 Wuhan Lockdown	2022 Shanghai Lockdown
'crisis' period	January 23—April 8, 2020	March 11—May 13, 2022

(2021) maps out exiting ESG equity indices in China. As of the end of October 2021, there were 66 broad-based ESG equity indices that were released by the Shanghai Stock Exchange (SHSE) and the Shenzhen Stock Exchange (SZSE). There are 23 ESG equity indices that are in the "ESG Select" category, whose constituent stocks are screened that are based on all three factors of E, S, and G. Given the availability of data, we analyze 12 "ESG Select" equity indices for China in our study. (See Table 1).

We next define the periods of stressed market conditions in our study. The dates of the Wuhan Lockdown were from January 23[7] to April 8,[8] 2020. We use the date range from March 11 to May 13[9], 2022 as a proxy for the pandemic period during the Shanghai Lockdown. (See Table 2).

In Fig. 2, we present a graphical overview of the relative performance of the 12 ESG equity indices (in blue) versus their benchmarks (in orange) for the time period that covers both the 2020 Wuhan Lockdown and the recent 2022 Shanghai Lockdown.

In Table 3, we provide a statistical overview of the comparison of the main risk-return characteristics of the 12 ESG equity indices with their conventional benchmark indices. The annualized mean logarithmic returns are calculated as first differences of the daily time series in logarithms, multiplied by 252 trading days. The comparison shows that the annualized mean logarithmic returns of all the ESG equity indices are

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[7] "Wuhan lockdown 'unprecedented', shows commitment to contain virus: WHO representative in China", Reuters, January 23, 2020. See https://www.reuters.com/article/us-china-health-who-idUSKBN1ZM1G9.

[8] "China to lift lockdown over virus epicenter Wuhan on April 8". Bloomberg, March 24, 2020. See https://www.bloomberg.com/news/articles/2020-03-24/china-to-lift-lockdown-over-virus-epicenter-wuhan-on-april-8.

[9] "Shanghai aiming for zero-COVID at community level by mid-May—city official", Reuters, May 13, 2022. See https://www.reuters.com/world/china/shanghai-aiming-zero-covid-community-level-by-mid-may-city-official-2022-05-13/.

Fig. 2. China's ESG Equity Index vs. Benchmark Performance–graphical overview. *Note*: January 2, 2020 = 100. *Source*: author's computation in Python.

higher than those of their benchmark indices during the recent 2022 Shanghai Lockdown (in Table 3B). A higher mean might be the result of a higher risk exposure. But the ESG screening process takes hidden company risks into account, and should avoid selecting companies with a high exposure to ESG-related risks, which in turn should lead to a selection of companies with a relatively low risk. The comparison in Table 3 shows that the annualized standard deviations of many ESG equity indices are lower than their benchmarks during the two lockdowns in China. Our result is consistent with the finding in Albuquerque et al. (2020); Engelhardt et al. (2021) on higher returns and lower risk of ESG investing during the COVID-19.

To compare the returns for the entire period, we follow Diaz et al. (2021) to calculate the total return[10], which is the summation of the daily returns during each crisis period. We find

that the total returns of all the ESG equity indices are higher than their benchmarks during the recent 2022 Shanghai Lockdown (in Table 3B).

To compare the returns on a risk-adjusted basis, we assess the performance by the Sharpe (1994) ratio, which measures the excess return of the investment divided by the total risk of the investment. In our analysis, we use the overnight SHIBOR (Shanghai Interbank Offered Rate) to proxy the risk-free interest rate. As the ESG screening process reduces the available investment universe, it should lead to a reduction in the risk-adjusted returns (Markowitz, 1952, 1991). The comparison in Table 3 shows that many ESG equity indices have lower risk-adjusted returns than their benchmark indices during stressed market conditions.

To further investigate the role of ESG investing during times of crisis in China, we follow Huberman and Kandel (1987) and apply spanning tests to examine whether the ESG equity indices under study can be replicated by their

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[10] See Diaz et al. (2021: Table 1, Column 2).

Table 3a
China's ESG Equity Index vs. Benchmark Performance–statistical overview: 2020 Wuhan Lockdown.

	000048.SH	399341.SZ	399369.SZ	399378.SZ	399550.SZ	399555.SZ	000846.CSI	931268.CSI	931476.CSI	931598.CSI	000970.CSI	399651.SZ
annualized mean	−0.5578	−0.2643	−0.4361	−0.2752	−0.3584	−0.4325	−0.2656	−0.4269	−0.3056	−0.3280	−0.3840	−0.5397
annualized stdev	0.0993	0.1528	0.1329	0.1347	0.1047	0.0996	0.1101	0.1096	0.1163	0.1080	0.1016	0.1885
total return	−12.23	−7.42	−10.46	−7.03	−8.67	−9.93	−7.10	−9.96	−7.88	−8.11	−9.29	−11.74
Sharpe ratio	−0.86	−0.65	−0.73	−0.69	−0.80	−0.84	−0.77	−0.80	−0.75	−0.78	−0.82	−0.62
	000001.SH	399002.SZ	000300.SH								000010.SH	399005.SZ
annualized mean	−0.2985	−0.1498	−0.3080								−0.3230	−0.1746
annualized stdev	0.0971	0.1652	0.1166								0.1009	0.1791
total return	−7.44	−4.82	−7.78								−8.01	−4.95
Sharpe ratio	−0.82	−0.61	−0.75								−0.81	−0.59

Table 3b
China's ESG Equity Index vs. Benchmark Performance–statistical overview: 2022 Shanghai Lockdown.

	000048.SH	399341.SZ	399369.SZ	399378.SZ	399550.SZ	399555.SZ	000846.CSI	931268.CSI	931476.CSI	931598.CSI	000970.CSI	399651.SZ
annualized mean	−0.2783	−0.5337	−0.4633	−0.4618	−0.4355	−0.2766	−0.4376	−0.4625	−0.4591	−0.4428	−0.2851	−0.5650
annualized stdev	0.0931	0.1061	0.0920	0.0895	0.0807	0.0722	0.0844	0.0911	0.0769	0.0867	0.0873	0.1221
total return	−3.08	−6.99	−6.21	−6.23	−5.32	−2.90	−5.88	−6.23	−6.16	−6.04	−3.58	−8.30
Sharpe ratio	−0.92	−0.91	−0.96	−0.98	−1.01	−1.04	−1.00	−0.97	−1.05	−0.99	−0.96	−0.86
	000001.SH	399002.SZ	000300.SH								000010.SH	399005.SZ
annualized mean	−0.4445	−0.6766	−0.4831								−0.4540	−0.6729
annualized stdev	0.0801	0.1218	0.0932								0.0832	0.1244
total return	−6.02	−9.17	−6.62								−6.30	−9.65
Sharpe ratio	−1.03	−0.87	−0.96								−1.01	−0.87

Source: author's calculation in Python and Excel.

Table 4a
China's ESG Equity Index vs. Benchmark–Spanning Tests: 2020 Wuhan Lockdown.

	000048.SH		399341.SZ		399369.SZ		399378.SZ		399550.SZ		399555.SZ		000846.CSI		931268.CSI		931476.CSI		931598.CSI		000970.CSI		399651.SZ	
Const	−0.1295		−0.1467		0.0275		0.0931		−0.1158	*	−0.1736	**	−0.0389		−0.1013	**	−0.0029		−0.0642	***	−0.0645		−0.1338	
p-value	0.1490		0.1970		0.6450		0.2300		0.0810		0.0050		0.5240		0.0330		0.9330		0.0010		0.4950		0.1420	
Shanghai Composite Index	0.9814	***																						
p-value	0.0000																							
Shenzhen Component Total Return Index			0.9401	***																				
p-value			0.0000																					
CSI 300 Index					1.0518	***	1.0481	***	0.9394	***	0.9198	***	0.9669	***	0.9651	***	0.9994	***	0.9642	***				
p-value					0.0000		0.0000		0.0000		0.0000		0.0000		0.0000		0.0000		0.0000					
SSE 180 Index																					0.9766	***		
p-value																					0.0000			
SZSE SME Index																							1.0049	***
p-value																							0.0000	
Spanning Tests	not rejected		not rejected		not rejected		not rejected		rejected		rejected		not rejected		rejected		not rejected		rejected		not rejected		not rejected	
Adjusted R-squared	0.9470		0.9330		0.9810		0.9680		0.9710		0.9750		0.9760		0.9860		0.9930		0.9980		0.9420		0.9630	
Number of observations	48		48		48		48		48		48		48		48		48		48		48		48	

Table 4b

China's ESG Equity Index vs. Benchmark–Spanning Tests: 2022 Shanghai Lockdown.

	000048.SH	399341.SZ	399369.SZ	399378.SZ	399550.SZ	399555.SZ	000846.CSI	931268.CSI	931476.CSI	931598.CSI	000970.CSI	399651.SZ
Const	0.0660	−0.1538	−0.0412	−0.0466	−0.1460	−0.1998 *	−0.0808	−0.0274	−0.1813 ***	−0.0703	0.0181	0.3038 **
p-value	0.6220	0.2580	0.6540	0.4290	0.1310	0.0770	0.1200	0.5970	0.0040	0.1720	0.8810	0.0190
Shanghai Composite Index	0.9932 ***											
p-value	0.0000											
Shenzhen Component Total Return Index		0.8900 ***										
p-value		0.0000										
CSI 300 Index			0.9718 ***	0.9691 ***	0.9022 ***	0.8402 ***	0.9457 ***	0.9796 ***	0.8941 ***	0.9535 ***		
p-value			0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
SSE 180 Index											0.9734 ***	
p-value											0.0000	
SZSE SME Index												0.2133 ***
p-value												0.0000
Spanning Tests	not rejected	not rejected	not rejected	not rejected	not rejected	rejected	not rejected	not rejected	rejected	not rejected	not rejected	rejected
Adjusted R-squared	0.9003	0.9001	0.9513	0.9794	0.9398	0.9093	0.9835	0.9843	0.9751	0.9840	0.9142	0.3724
Number of observations	41	41	41	41	41	41	41	41	41	41	41	41

*,**,*** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

LHS variable = return of the ESG index–SHIBOR, RHS variable = return of the benchmark index–SHIBOR.

Source: author's estimation in Python and Stata.

conventional benchmark indices during the 2020 Wuhan Lockdown and the recent 2022 Shanghai Lockdown. Technically, this is a question of whether the ESG equity indices can be spanned by their benchmark indices. The spanning test is stronger and more informative than the pure comparison of the performance by the Sharpe ratio in Table 3.

In our regression-based test, the dependent variable is the excess return of the ESG equity index ($r_{i,t}^{ESG}$), which is calculated as the difference between the rate of logarithm return of the ESG equity index and the overnight SHIBOR. The independent variable is the excess return of the benchmark index ($r_{i,t}^{BM}$), which is calculated as the difference between the rate of logarithmic return of the benchmark index and the overnight SHIBOR.

$$r_{i,t}^{ESG} = \alpha_i + \beta_i r_{i,t}^{BM} + \varepsilon_{i,t}$$

The parameter α_i is Jensen (1968)'s alpha, which is the constant of the regression model. It measures the relative risk-adjusted performance of the ESG equity index, and it estimates the extra return of the ESG equity index that is not explained by the risk exposure with respect to its benchmark index.

The parameter β_i is the estimated value of the correlation coefficient between $r_{i,t}^{ESG}$ and $r_{i,t}^{BM}$. It measures the relative risk of the ESG equity index versus its benchmark. As in the Capital Asset Pricing Model (CAPM), a beta coefficient $\beta_i > 1$ indicates that the ESG equity index has a higher risk than its benchmark index; a beta coefficient $\beta_i = 1$ implies that the ESG equity index proxies the systemic risk as represented in its benchmark; a beta coefficient $\beta_i < 1$ implies that the ESG equity index has a lower risk compared to its benchmark index (see Table 3).

In our spanning tests, we have the joint null hypothesis $H_0 : (\alpha_i = 0, \beta_i = 1)$. If the null hypothesis of spanning is not rejected, then the ESG equity index can be replicated by its benchmark index. In this case, investing in the benchmark index is, on average, equivalent to investing in the ESG equity index, without difference in return and/or risk. In Table 4, we summarize the results from our regression-based spanning tests during the 2020 Wuhan Lockdown (upper panel) and the recent 2022 Shanghai Lockdown (lower panel).

In Table 4, Row 1 contains the estimated values for the parameter alpha. The results show that Jensen's alpha, which measures the relative risk-adjusted performance, is not significantly different from zero in most of the cases. This is a clear indication that the performance of the ESG equity indices does not deviate systematically from their benchmarks during stressed market conditions in China. The ESG equity index 3999555.SZ exhibits a different performance (with a negative alpha though) than its benchmark during both crisis periods. Only the ESG equity index 399651.SZ exhibits an out-performance (with a positive alpha) over its benchmark during the Shanghai Lockdown, at the 5% significance level.

In Table 4, we also summarize the estimated values for the parameter beta. The results show that the beta coefficient, which is a measure of risk relative to the benchmark index,

is lower than one in most of the cases during the Wuhan Lockdown, and is lower than one in all the cases during the Shanghai Lockdown. So these ESG equity indices are characterized by significantly lower risk. This finding is consistent with our result on annualized standard deviation in Table 3.

We document the outcome for the spanning tests in Table 4. Spanning cannot be rejected for 8 out of the 12 ESG equity indices during the Wuhan Lockdown, and it cannot be rejected for 9 out of the 12 ESG equity indices during the Shanghai Lockdown. In these cases, an investor who is primarily interested in ESG investing can expect no significant difference in performance compared to the benchmark. An investor who is only interested in the financial outcome of the investment can equally invest in the benchmark. In sum, we show that most of the ESG equity indices exhibit no out-/under-performance compared to the benchmark. The relatively high values for the adjusted R-squared show that the majority of the ESG equity indices can be well approximated by their benchmarks. Our result is in contrast to the finding in Nofsinger and Varma (2014); Cornett et al. (2016); Lins et al. (2017, 2019); Diaz et al. (2021) [11]; Pisani and Russo (2021), where they find that ESG investing can outperform the market during crisis periods. But our result is consistent with the finding in Bae et al. (2021); Chiappini et al. (2021); Demers et al. (2021).

In Table 5, we check the trading activities for the ESG equity indices. As a comparison, we use the date range of the two lockdowns in the year 2021 as the two 'normal' periods in our study. We find that the trading activities in most of the ESG equity indices do not intensify in crisis periods, in terms of average daily trading amount. [12] This suggests that ESG equity indices in China are relatively more resilient in times of crisis, with investors being more patient and not selling to avoid losses during times of market turbulence. Our result is consistent with the finding in Broadstock et al. (2021).

In this section, we analyze whether the ESG equity indices under study exhibit a different performance compared to their conventional benchmark indices. We first compare the main risk-return characteristics of the ESG equity indices with their benchmarks. We find that the annualized mean logarithmic returns and total returns of all the 12 ESG equity indices are higher than their benchmarks during the Shanghai Lockdown; but with a relatively lower standard deviation during both lockdowns. We also calculate the Sharpe ratio to assess the risk-adjusted returns. Next, we conduct spanning tests to examine whether the ESG equity indices can be replicated by their conventional benchmark indices. The spanning test is stronger and more informative than the pure comparison of the performance by the Sharpe ratio. From our spanning tests, we find that most of the ESG equity indices exhibit no out- or under-performance compared to their benchmarks. Last, we check the trading activities for the ESG equity indices, with the finding that most of them are resilient during stressed market

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[11] See Diaz et al. (2021: Table 1).
[12] See Broadstock et al. (2021: Table 3, Column 4).

Table 5
China's ESG Equity Indices–average daily trading amount (in million RMB).

	000048.SH	399341.SZ	399369.SZ	399378.SZ	399550.SZ	399555.SZ	000846.CSI	931268.CSI	931476.CSI	931598.CSI	000970.CSI	399651.SZ
normal period #1	59.55	83.89	64.57	262.51	70.35	59.54	135.96	163.17	130.15	345.3	40.98	30.30
crisis period #1	48.71	73.37	56.43	57.81	58.64	43.80	91.91	104.04	107.92	252.21	27.93	33.15
normal period #2	46.92	67.29	50.95	204.70	53.57	46.50	105.08	127.12	100.26	263.38	32.91	23.62
crisis period #2	60.84	57.89	52.98	182.34	50.15	41.36	109.78	113.56	107.74	250.57	33.86	21.34

Source: author's calculation in Excel.

conditions. So we answer our research question that ESG investing is safe haven during times of crisis in China.

3. Can ESG investing improve portfolio diversification in times of crisis?

Along the line of research on the effect of ESG investing on portfolio diversification, an interpretation of the modern portfolio theory (Markowitz, 1952, 1991) is that the integration of ESG criteria in investment processes must worsen portfolio diversification (Barnett & Salomon, 2006; Benson & Humphrey, 2008; Renneboog, Ter; Capelle-Blancard & Monjon, 2014; Horst, and Zhang, 2008; Lee, Humphrey, Benson, & Ahn, 2010; Rudd, 1981). Hoepner (2010) challenges it by developing a theoretical model with three main drivers of portfolio diversification: (i) the number of stocks, (ii) the weighted average correlation of stocks, and (iii) the weighted average specific risk of stocks. The model argues that whilst the inclusion of ESG criteria into investment processes could worsen portfolio diversification through the first and second drivers, it could improve portfolio diversification through a reduction in the third driver.

To contribute to this line of research on the effect of ESG investing on portfolio diversification, and to further contribute to the line of research on sustainable investing during stressed market conditions, we examine whether ESG investing can improve portfolio diversification during times of crisis in China. We first cluster equity indices based on co-movement similarity. Based on the analyses of the co-movement similarity of returns among the 12 ESG equity indices using agglomerative clustering algorithm, we then conduct Monte Carlo simulation to analyze the effect of integrating the ESG equity indices on portfolio diversification. We first determine the co-movement similarity, that is, the correlation, of the daily returns of the ESG equity indices in crisis periods. We calculate the pairwise distance, that is, the Euclidean distance, between vectors of the returns of any two equity indices. Each pairwise distance is an element of a distance matrix with zero diagonals. See Fig. 3, with the left panel for the first crisis period and the right panel for the second crisis period under study.

For diversification purposes, we want the correlation of returns between the ESG equity indices to be low. We use clustering to identify the most similar ESG equity indices, and
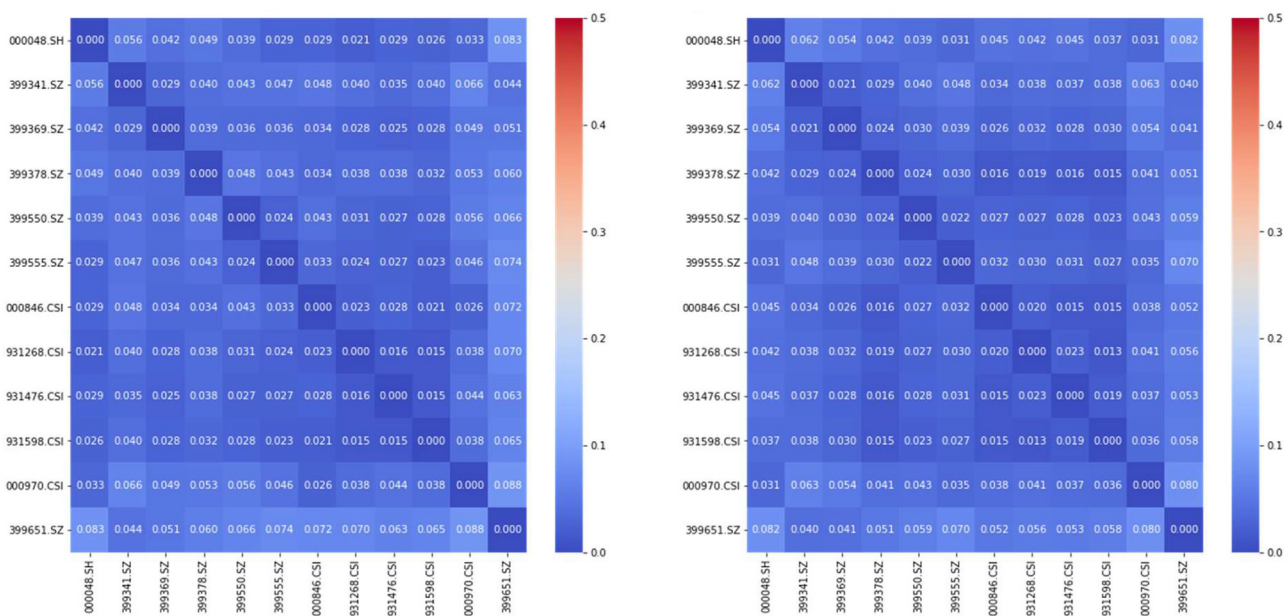

Fig. 3. Distance matrices for hierarchical agglomerative clustering: (left panel: 2020 Wuhan Lockdown; right panel: 2022 Shanghai Lockdown). *Source*: author's computation in Python.
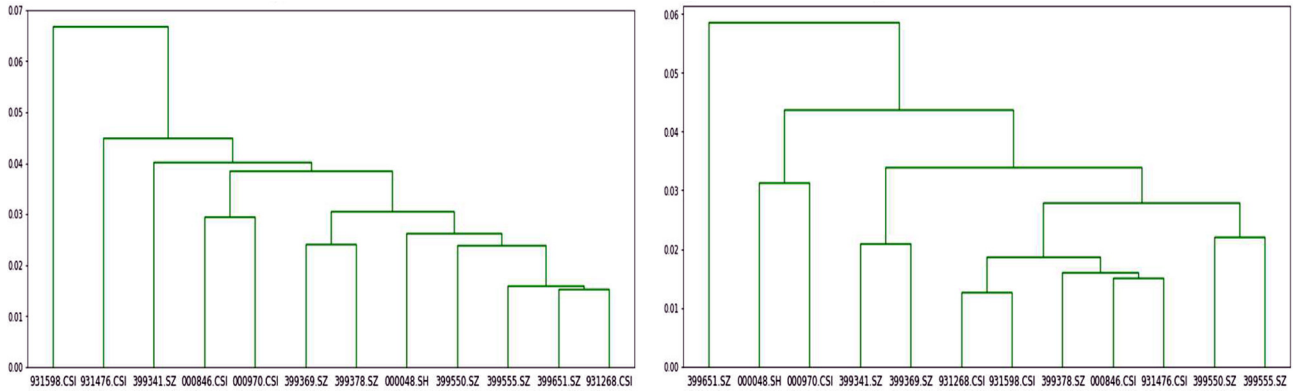
Fig. 4. Dendrogram for hierarchical agglomerative clustering: (left panel: 2020 Wuhan Lockdown; right panel: 2022 Shanghai Lockdown). *Source*: author's computation in Python.

then choose one index from each cluster. We focus mainly on hierarchical agglomerative clustering. We start with each equity index as its own cluster, find the pair of clusters which are closest to each other, and then redefine them as a new cluster. We find the distances from this new cluster to the remaining return clusters. Using a process called average (centroid) linkage, we determine the distances from the center of the new cluster to the centers of the remaining clusters. Put it simply, we combine the pair of clusters which are closest, redefine them as a new cluster, and recalculate the distances to the remaining clusters.

We plot the resulting dendrogram to visualize the hierarchical clusters and draw the highest horizontal line interacting

three vertical lines (or dendrites) to determine the appropriate cluster configuration. See Fig. 4, with the left panel for the first crisis period and the right panel for the second crisis period under study. The dendrogram in the left panel of Fig. 4 reveals that the closest pair of ESG equity indices is 399651. SZ and 931268.CSI. Therefore, this pair becomes the first combined cluster. We treat the mean of their two return vectors as a new point. We repeat this step until all the ESG equity indices are aggregated into a single large cluster. Our 'representative' ESG equity index is 931598.CSI during the first crisis period; and 399651.SZ during the second crisis period.

Based on the analyses of the co-movement similarity of returns among the 12 ESG equity indices using agglomerative
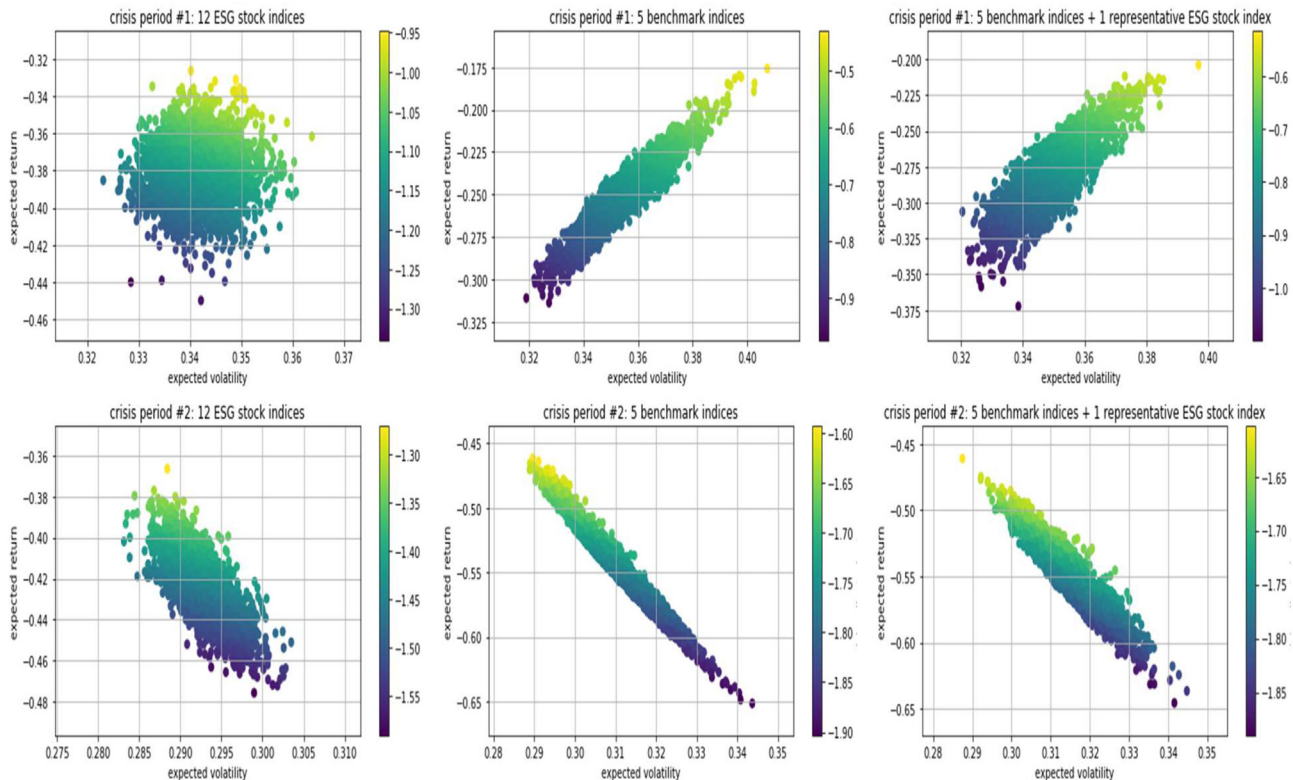

Fig. 5. Portfolio diversification—Monte Carlo simulation: (upper panel: 2020 Wuhan Lockdown; lower panel: 2022 Shanghai Lockdown). *Source*: author's simulation in Python.

clustering algorithm, we next conduct Monte Carlo simulation to analyze the effect of including the ESG equity indices on portfolio diversification. In Fig. 5, we present the simulation results, with the upper panel for the first crisis period and the lower panel for the second crisis period under study. In the left column, we have the simulation results for the effect of the 12 ESG equity indices on portfolio diversification. In the middle column, we have the simulation results for the effect of the 5 benchmark indices on portfolio diversification. In the right column, we have the simulation results for the effect of incorporating the 'representative' ESG equity index (as identified in Fig. 4) on portfolio diversification. In each sub-figure, the horizontal axis measures the expected volatility, the left vertical axis measures the expected return, and the right vertical axis measures the risk-adjusted return.

From our simulation results in Fig. 5, we observe that during the first crisis period under study, a higher expected return is associated with a higher expected volatility; but during the second crisis period, a higher expected return is associated with a lower expected volatility. This result from the most recent crisis period is consistent with our finding in Table 3, and is also consistent with the finding in Albuquerque et al. (2020); Engelhardt et al. (2021) on higher returns and lower risk of ESG investing during the COVID-19.

We also observe that the diversification effect of a portfolio of the 12 ESG equity indices (left column) differs significant from that of a baseline portfolio composed of the 5 benchmark indices (middle column). This calls for the potential of portfolio diversification. By integrating the 'representative' ESG equity index (as identified in Fig. 4) from each crisis period into the baseline portfolio of the 5 benchmark indices, we find that portfolio diversification can be improved upon (right column) relative to the baseline portfolio (middle column). This result indicates the dominance of the third driver in Hoepner (2010).

4. Conclusion and implication

In the literature on sustainable investing, most studies assume normal market conditions. However, research is limited regarding the role of sustainable investing during stressed market conditions. In this paper, we contribute to the literature by investigating the specific role of investing in ESG equity indices in times of crisis for the case of China, which has a growing and significant market in sustainable investment. To that end, we examine the performance of ESG equity indices and compare against their market benchmarks in China during pandemic-induced market conditions, which were triggered in response to the 2020 Wuhan Lockdown and the 2022 Shanghai Lockdown. In our study, we concentrate on sustainable investing in ESG equity indices from the latest *China Sustainable Investment Review 2021*, which may be the first one in the empirical literature. By including the recent 2022 Shanghai Lockdown in our analysis, we aim to provide insight into the ongoing investigation on the role of ESG investing during the

COVID-19. In this paper, we address two key issues that are of concern to most investors: (i) whether ESG investing is safe haven in times of crisis, and (ii) whether ESG investing can improve portfolio diversification.

To answer the *first* research question, we analyze whether the ESG equity indices under study exhibit a different performance compared to their conventional benchmark indices. Throughout the study, we compare the main risk-return characteristics of the ESG equity indices with their benchmark indices; we test for out-/under-performance, for differences in risk exposure, and test for spanning, in order to examine whether the ESG equity indices can be replicated by their conventional market benchmark indices; and finally we check the trading activities for the ESG equity indices during stressed market conditions. From our empirical study, we find that many ESG equity indices have a lower risk than their conventional benchmark indices, with resilience during the periods of the two lockdowns. So ESG investing is safe haven in times of crisis for the case of China.

To answer the *second* research question, we examine whether ESG investing can improve portfolio diversification during times of crisis in China. We first cluster equity indices based on co-movement similarity. Based on the analyses of the co-movement similarity of returns among the 12 ESG equity indices using agglomerative clustering algorithm, we then conduct Monte Carlo simulation to analyze the effect of integrating the ESG equity indices on portfolio diversification. From our simulation results, we find evidence that the integration of ESG investing can improve portfolio diversification.

Sustainable investment is a major force shaping global capital markets, with assets under management reaching US$35.3 trillion at the outset of 2020, and in total equating to 36% of all professionally managed assets across regions (GSIA, 2020). Given the market trend in global sustainable investments, our study draws implication for both academic researchers and practitioners on the resilience of sustainable investing as an 'equity vaccine' against pandemic-induced market conditions. For academic researchers, more study could be conducted at the country level with recent empirical evidence, to contribute to the literature on sustainable investing during stressed market conditions. For investors, sustainable investing generates both financial returns and non-financial utility. Our analysis concentrates on sustainable investing in ESG equity indices, which are easily accessible to investors. For portfolio managers, the option of investing in ESG equity indices provides a set of safer haven during economic downturn, and an opportunity to diverse the portfolio without sacrificing on the financial grounds. Our findings imply an exploitable investment strategy that can be pursued with exchange-traded funds.

Conflicts of interest

The author declares no conflict of interest.

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