CHAPTER 4

Using E from ESG in Systemic Risk Measurement

Ewa Dziwok, Marta Anita Karaś, and Michał Stachura

4.1 HOW SYSTEMIC RISK AFFECTS FINANCIAL INSTITUTIONS

More than ten years after the global financial crisis and dozens of papers about systemic risk, the importance of this risk is no longer in question. It seems that we have also reached a consensus regarding its definition. Generally speaking, systemic risk is "*the risk of a breakdown of an*

E. Dziwok (✉)
University of Economics in Katowice, Katowice, Poland
e-mail: ewa.dziwok@ue.katowice.pl

M. A. Karaś
Wroclaw University of Economics and Business, Wrocław, Poland
e-mail: marta.karas@ue.wroc.pl

M. Stachura
Jan Kochanowski University, Kielce, Poland
e-mail: michal.stachura@ujk.edu.pl

P. Wachtel et al. (eds.), *Creating Value and Improving Financial Performance*, Palgrave Macmillan Studies in Banking and Financial Institutions, https://doi.org/10.1007/978-3-031-24876-4_4

entire system rather than simply the failure of individual parts (…) and denotes the risk of a cascading failure in the financial sector caused by linkages within the financial system, resulting in a severe economic downturn" (CFA Systemic Risk Council, 2022). Alternatively, we may see it as the risk of experiencing a strong endogenous or exogenous systemic event that affects systemically important intermediaries or markets (ECB, 2009, p. 134). Common denominators are the disturbance in the financial systems' continuity and its effect on economic development and societies' well-being.

By 2022, while the COVID-19 pandemic is still ongoing and has lasting effects on economies worldwide, we are moving beyond that classical understanding of systemic risk. The high energy prices in Europe and rising inflation seem to unravel yet another new crisis. Risk exposures that used to be negligible are becoming new systemic risk triggers for financial institutions. Among them, we may count not only financial or economic factors but also geopolitical and environmental ones.

With each crisis, we learn that we must look at systemic risk in new dimensions. It is no longer just the short term and medium term. It seems that more attention should be paid to the long-term perspective. It complicates systemic risk measurement and management, making it even more challenging. The only answer to this challenge is to constantly improve and expand these measures to match developments in the financial and economic systems and to utilize the new data that becomes available. Thus, systemic risk measurement and management are in constant flux.

In light of the newest research and the upcoming standardization of ESG data, we discuss and illustrate how it may become a source of information for systemic risk analysis. We propose a model that augments systemic risk measurement with the environmental factor (E-factor) extracted from ESG data. Markedly, our solution applies to a large set of econometric systemic risk measures. For clarity and transparency, we use the example of the environmental ("E") factor; however, the framework we discuss is universal and can use any of the three factors extracted from ESG scores.

The outline of the chapter is as follows. We start by discussing the role of environmental risk in systemic risk analysis. Then, we discuss how one may extract the environmental risk factor from the ESG score and augment systemic risk measures with it using a beta-independent exposure-based approach. Next, we illustrate and discuss the theoretical properties of our model. Subsequently, we demonstrate its application to the data stylized based on a large sample of systemically important European banks. Our study encompasses the period from 2007 to 2022. Finally, we discuss the model's utility and possible empirical applications by central banks, macroprudential regulators, investors, and other stakeholders of the financial systems.

4.2 Environmental Risk in Systemic Risk Analysis

Much of the existing literature focuses only on climate risk. The conclusions and findings of this literature, referenced in this subchapter, are relevant to our study. However, in systemic risk analysis, one must focus on a wider scope of the environmental impact. Thus, we define environmental risk as the potential for adverse consequences for human or ecological systems that can arise from the impacts of environmental factors, including but not limited to climate change, as well as human responses to such factors (cf. Reisinger et al., 2020).

BIS proposes a simple framework of risk drivers (2021) that translates environmental exposures into financial risk. These risk drivers are the environmental (e.g., climate related) changes that impact economies. They typically occupy one of the two categories: physical risks—the losses related to, e.g., changes in weather, climate, or pollution—that directly impact businesses, institutions, and the economy; transition risks, which arise from the costs of transition toward a low-carbon economy and other sustainable solutions. Notably, "climate risk drivers have a number of distinct features, including unprecedented frequencies, speeds, and intensities and the non-linear form that the risks are expected to take. Together, these factors give rise to a material level of uncertainty as to how climate risk drivers and their impacts will evolve" (BIS, 2021, p. 5).

The Network of Central Banks and Supervisors for Greening the Financial System (NGFS, 2020) illustrates how environmental risk drivers link with financial risks of the banking sector via microprudential and macroprudential transmission channels and their direct and indirect effects. Let us show this in Table 4.1.

Bank of England (2018) also describes the transmission mechanism of environmental risk with physical and transition risk drivers but adds one more category—liability risks. While physical risks refer mainly to materializing of various catastrophic risks, transition risks refer to green

Table 4.1 Transmission channels of environmental risk drivers

	Microprudential channel	*Macroprudential channel*
Definition	The causal chains by which risk drivers affect financial institutions' counterparties, causing financial risk to banks and the financial system	The mechanisms by which climate risk drivers affect macroeconomic factors and how these, in turn, impact banks
Direct effects	The impact on financial institutions' operations and their ability to fund themselves	The impact on macroeconomic indicators, e.g., inflation, labor productivity, economic growth
Indirect effects	The effects on name-specific financial assets held by financial institutions, e.g., bonds, single-name CDSs, equities	The effects on market variables, e.g., interest rates, commodities prices, foreign exchange rates

Source Own elaboration based on NGFS (2020)

innovation-related cash flows. In contrast, liability risks are related to potential compensation payouts that may arise from the above exposures.

It is becoming apparent that transition risks may materialize as unexpectedly high financial losses across financial systems and economies. As Sarah Breeden (2022), the Executive Director for Financial Stability Strategy at the Bank of England, points out, the financial scale of risk may be underestimated when we focus on direct risks of extractive companies, the producers, and sellers of fossil fuels (coal, oil, and gas). In fact, transition risks are also prone to impact assets in other sectors, including petrochemicals, heavy industry, utilities, ground transportation, aviation, shipping, agriculture, and real estate. As Breedeen (2022) argues, "the lost value of these assets is potentially worth trillions or even tens of trillions of dollars".

Lamperti et al. (2021), who study the impact of climate change on global financial stability, reach similar conclusions. The authors show that financial constraints exacerbate climate shocks' effect on the economy, while climate-related monetary damages make financial systems more fragile. Furthermore, their results demonstrate that environmental risks and their cascading multifaceted impacts could increase the frequency of crises by as much as 26—even to 248% (Lamperti et al., 2019).

The recent spikes in inflation across the world, driven, *inter alia*, by increasing brown energy prices, seem to be a new trigger for global systemic risk. According to Professor Robert Engle (2022), this is a manifestation of transition risk that the financial markets should have expected, a market price "tax"[1] on decarbonization. As the investment horizon for brown energy companies decreases, they heavily disinvest (Mehta, 2022). At the same time, the uncertainty regarding their assets' useful life horizon increases, affecting profitability margins and strongly driving prices upwards. According to Engle (2022), this is not a passing trend but rather a new normal; the actual cost of decarbonization—and the prices will remain high, putting strain on businesses, debtors, and financial institutions until the global economy truly decarbonizes.

These observations align with a study by Zhang et al. (2022). They show that environmental changes (especially low-carbon transition) drive the banking sector's risk, climate policy, and banking stability. The study by Tol (2019) indicates that the transition cost may be exceptionally high for developing countries that have the highest social costs of carbon emissions.

Alessi et al. (2022) demonstrate that the potential impact of transition risk on banks' balance sheets is very significant, especially for banks in carbon-intensive economies. They demonstrate that fossil fuel and high-carbon assets may be between 15 and 25% riskier than reflected in banks' risk assessments. In a crisis scenario, this could lead to an increase in losses of up to 40%. Their model shows that fire-sale dynamics, even if triggered by a slight initial depreciation of fossil-fuel or high-carbon assets, lead to significant losses for the whole European Union's banking system and default of many financial institutions (Alessi et al., 2022, pp. 15–19).

Prominent financial institutions and market regulators also admit that environmental factors can significantly influence systemic risk. For instance, the Bank of England (2018, 2021), European Central Bank (2021a, 2021b, 2022), Financial Stability Oversight Council (2021), and International Monetary Fund (2022) point out various environmental risk factors in their systemic risk reports. Similarly, the Financial Stability Oversight Council (2021), Bank of International Settlements (2021), European Systemic Risk Board (2021), European Securities and Markets

---

[1] A market price correcting mechanism that works as the alternative to the carbon tax that is still not very effective in decarbonizing the global energy markets. Alessi et al. (2022, p. 19) demonstrate that under an orderly transition and actual greening of the economy, banks' transition risk exposure could decrease so significantly that it would reduce the fire-sale losses by a factor of 10 compared to today.

Authority (2022), and European Banking Authority (2022a, 2022b) all recognize that climate change is an emerging threat to financial system stability.

Brunetti et al. (2021) illustrate how significant the shocks related to the degradation of the natural environment and climate change are for economies and financial systems. Similar conclusions are drawn by Toma and Stefanelli (2022), who argue that possessing reliable information about banks' exposure to environmental risk factors will benefit the regulators and the financial industry. Thus, it is vital to research these risks further.

On that note, the European Central Bank (2021a, 2021b) performed an economy-wide European climate stress test. Its results showed how significant the environmental risk may be for systemically important European banks and that climate change "represents a major source of systemic risk, particularly for banks with portfolios concentrated in certain economic sectors and specific geographical areas" (ECB, 2021a, 2021b, p. 3). ECB (2022) is currently running the first climate risk stress test developed to assess the susceptibility of European banks to transition risk. Joint Research Centre of the European Commission studies this issue as well, and their initial results show that many European banks require an additional capital buffer of 0.5% RWA (or 3% of existing capital) to shelter them from systemic risk triggers generated by climate change (Alessi et al., 2022, p. 17).

Despite the unquestioned significance of environmental exposures for systemic risk materialization, methods quantifying them are still scarce. As BIS (2021) states, there is limited data and research reconnoitering how environmental risk drivers feed into the financial risks of banks. Furthermore, it is currently challenging to translate changes in environmental variables into changes in financial institutions' credit, market, liquidity, and operational risk exposures or balance sheet losses (cf. Nieto, 2017).

Toma and Stefanelli (2022) point out that firms do not have sufficient analytical frameworks to combat environmental risk using financial management or internal control tools. Also, policy frameworks designed to deal with environment-related financial risks are bound to be impaired because efficient price discovery is too challenging (Battiston, 2019; Chenet et al., 2021).

Existing econometric systemic risk measures do not explicitly include all environmental risk drivers. They are focused on climate risk. Jung et al. (2021) propose the CRISK model that quantifies the impact of brown emissions-based exposures of banks on their fragility. Authors estimate financial institutions' betas based on "brown investments" and use the SRISK (Brownlees & Engle, 2017) model to incorporate climate risk in systemic risk measurement. A major benefit of this approach is the ability to estimate the individual betas of financial institutions. However, applying this method to Europe requires confidential data, while the output would still consider only a fraction of the actual environmental risk exposure.

Other authors quantifying the link between green finance and larger-scale risk include Battiston et al. (2021), who investigate the spillover of risk in stylized networks, and Sohag et al. (2022), who show that green investments are sensitive to geopolitical risk-based shock transmission. Perhaps the scarcity of methods quantifying environmental risk is related to the fact that econometric methods require precise and granular data that is still very difficult to obtain.

4.3 ESG Data for Systemic Risk Measurement

In recent years, there has been an increasing interest in ESG data reporting and ESG investing. It is coupled with a growing volume of data and intensifying efforts to standardize it. This presents an opportunity to study how environmental, social, and governance issues affect systemic risk and whether the ESG data can be used in systemic risk analysis by financial institutions and market regulators.

So far, ESG factors have been extensively researched in relation to investment (reviews by, e.g., Berg et al., 2022; Billio et al., 2021; Gillan et al., 2021). ESG scores try to capture how investors and companies use ESG factors when running their business (Bahadori et al., 2021; Cornett et al., 2016; Liu et al., 2021), investing (e.g., Bătae et al., 2020; Cormier et al., 2011; Renneboog et al., 2011; Wong & Zhang, 2022) and managing risk (Albuquerque et al., 2019; Boubaker et al., 2020; Bouslah et al., 2018; Kim et al., 2021; Sassen et al., 2016).

Several papers also focus on the relationship between financial institutions' risk and ESG factors. They are either focused on the role of ESG factors in risk management or as risk transmission channels (Brunetti et al., 2021; Candelon et al., 2021; Chiaramonte et al., 2021; Delis et al., 2021; Finger et al., 2018; Gangi et al., 2019; Murè et al., 2021; Neitzert & Petras, 2021; Scatigna et al., 2021). In a most recent study, Fioravante, Polato, and Palmieri (see Chapter 3) find a significant relationship between ESG ratings and borrowers' probability of default, pointing to a relationship between ESG scores and systemic risk. A handful of papers focus on financial systems' risk (Anginer et al., 2014, 2018; Cerqueti et al., 2021). Although none of these papers proposes econometric methods for measuring systemic risk, they prove that the link between ESG factors and risk exists and is significant.

In a very recent paper, Aevoae et al. (2022) find a statistically significant relationship between two econometric systemic risk measures (Delta CoVaR proposed by Adrian and Brunnermeier (2016) and SRISK proposed by Brownlees and Engle [2017]) and ESG scores. The results obtained for a sample of 367 banks from 47 countries indicate a robust relationship between systemic risk and ESG that is especially strong for the environmental factor (Aevoae et al., 2022, pp. 4, 16–20). Eratalay and Cortés Ángel (2022) draw parallel conclusions from a larger-scale study of blue chip firms, 63 of which are financial institutions.

Mentioned studies show an unused potential and opportunity to use ESG data in systemic risk measurement. To do that, one would have to take an exposure approach that assumes using a readily available environmental score (E-score) as the source of information about financial institution exposure to environmental risks. Such a framework is among the ones recommended by the European Banking Authority (2022a, 2022b). One unquestionable benefit of this approach is cost efficiency—using the data that already exists, that has been gathered by financial institutions for other purposes, and has been pre-processed by external specialized parties.

There are further benefits to using this data. As the Financial Stability Board argues, third-party verification strengthens the reliability of environmental risk data while relying on external metrics available to the broader financial market may "play an important role in avoiding greenwashing risks" (FSB, 2022, *Recommendation II*). Similarly, the *OECD's Report on Environmental Pillar Scoring and Reporting* (Boffo et al., 2020) uncovers that climate risk management and governance are crucial in E-score determination. Because of it, the score can "help investors understand elements of long-term transition" (2020, p. 7) and related longer-term risks.

Also, as EBA (2021) states, the ESG ratings provided by specialized rating agencies account not only for the direct risk exposure to ESG factors but also for the managers' ability to deal with risks and opportunities. This human factor is critical, yet it is difficult to quantify directly in systemic risk measurement. Furthermore, current scoring methodologies "build on a quantitative analysis of key issues identified for each industry (and hence company), as well as qualitative information collected by analysts from public information and engagement with companies" (EBA, 2021, p. 75). Furthermore, score providers compete in the market to provide the best (i.e., most accurate, most transparent, most comprehensive) scores that correlate with effective ESG investment strategies. Thus, it is in their interest to minimize the ESG-washing effects, and they can put most resources into doing this. For these reasons, using ESG scores in systemic risk analysis is potentially very beneficial.

Major developments that should lead to increased availability, transparency, and standardization of Environmental Pillar (Scopes I, II, and III) data are currently taking place. The European Banking Authority (2022a) developed a disclosure template for the ESG factors exposure that large banks will use from January 2023. Moreover, in March 2022, the International Financial Reporting Standards Foundation established the International Sustainability Standards Board. The ISSB has been tasked with the creation of a comprehensive global baseline of sustainability disclosures and is currently working on two new reporting standards: IFRS S1 "General Requirements for Disclosure of Sustainability-related Financial Information" and IFRS S2 "Climate-related Disclosures" (IFRS, 2022).

There seems to be a global need and consensus that these standards are necessary, and the IFRS Foundation is the right institution to provide them. During the 120-day comment period, the ISSB has received more than 1300 comment letters on the two proposals (IFRS, 2022). This may be "a major step toward convergence of the currently fragmented reporting landscape" (KPMG, 2022) that should also help with the problem of green-washing and objectivity of the E-scores.

Even if the ESG data is, to some point, prone to green-washing, no better readily accessible dataset exists that could be used for quantifying the E, S, and G factors in systemic risk analysis. Furthermore, the E-factor is the least subjective, most fact-based, and the least diverse in the way it is calculated by various scorers, suggesting it may serve systemic risk analysis already (cf. Boffo et al., 2020). Finally, the upcoming developments in the

IFRS framework that aim to objectivize sustainability and environmental exposure reporting give grounds to expect further improvements in data quality by the beginning of the year 2023.

4.4 The E-Factor Model

Let SRM be a systemic risk measure (e.g., Marginal Expected Shortfall, Conditional Value at Risk, Systemic Noise Measure, SRISK) that we consider in its absolute or relative version. To add the E-factor to this measure, we follow the rule: the lower the environmental (E) score is, the stronger increase in the SRM is induced (see Eq. 4.2). This property is in line with the findings of the ECB (2022) and the recommendations of the EBA (2021).

To modify the SRM into E-SRM (as we refer to the augmented systemic risk measure) following the above postulate, the empirical time series of the E-factor must be consistent with the SRM series in terms of frequency. Usually, the E-score is published less frequently, so its quotes need to be assigned to the appropriate moments/periods (e.g., days or weeks) of the SRM series. We build the series of the E-factor by extending (e.g., by linear-piecewise interpolation) these sparsely spaced values into the remaining (intermediate) moments/periods for which SRM series values are available. If it is necessary to additionally create E-score values for moments/periods later than the latest quote, one may maintain this latest quote till the end of the considered period. This solution is in line with the findings of behavioral finance theory, which shows how decision-makers utilize the last known data point in their decisions (cf. Kahneman, 2013).

Given the above, without the loss of generality, we assume that both time series are daily. Therefore, $\mathrm{SRM}_{i,t}$ stands for the estimated value of the SRM of the i-th institution on t-th trading day. Likewise, $\mathrm{E}_{i,t}$ is the value of the E-score of the same institution on the same day. Then we define the E-SRM as:

$$\mathrm{E\_SRM}_{i,t} = \mathrm{SRM}_{i,t}\left(1 + \beta\left(100 - \mathrm{E}_{i,t}\right)\right), \tag{4.1}$$

where $\beta > 0$ is a coefficient scaling E-factor influence intensity.

In general, the β coefficient may be time-varying, i.e., $\beta = \beta(t) = \beta_t$ (then β takes the form of a function of time). It may also differ from institution to institution, i.e., $\beta = \beta_i(t) = \beta_{i,t}$. The time variability of the

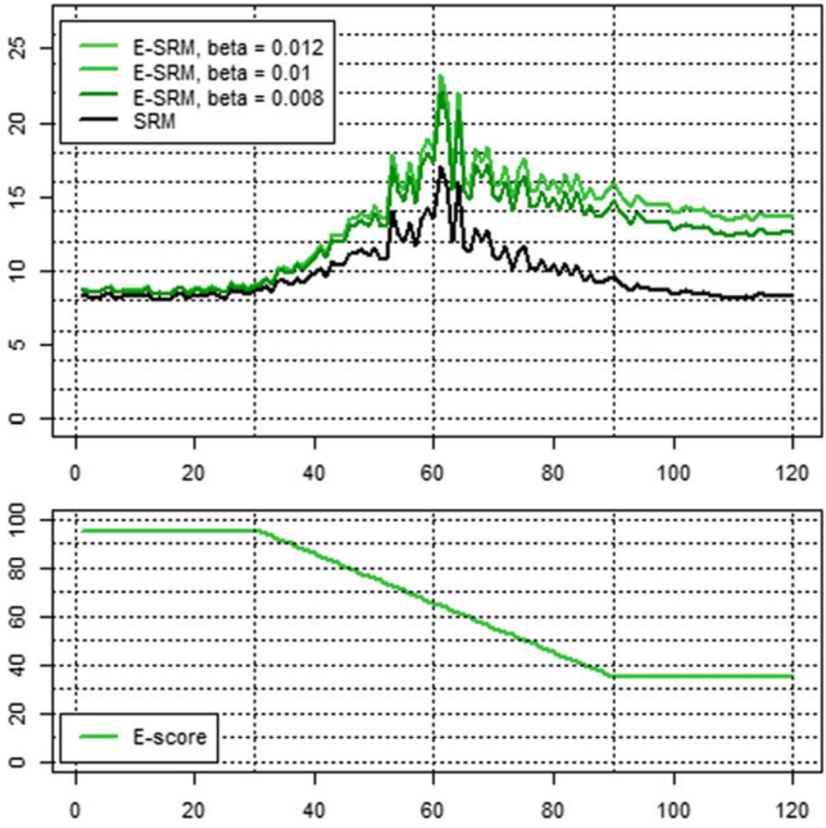

Fig. 4.1 E-SRM–combination A1

β coefficient fits the postulates of the literature, where the time-varying strength of the impact of the E-factor on risks of financial institutions and systemic risk is essential (ECB, 2021a, 2021b, 2022).

Equation (4.1) may be rewritten as:

$$\mathrm{E\_SRM}_{i,t} = \mathrm{SRM}_{i,t} + \beta\left(100 - \mathrm{E}_{i,t}\right)\mathrm{SRM}_{i,t}, \tag{4.2}$$

which demonstrates that the increase in E-SRM is proportional to the decrease in the E-score on a scale defined by the product of β and the current value SRM.

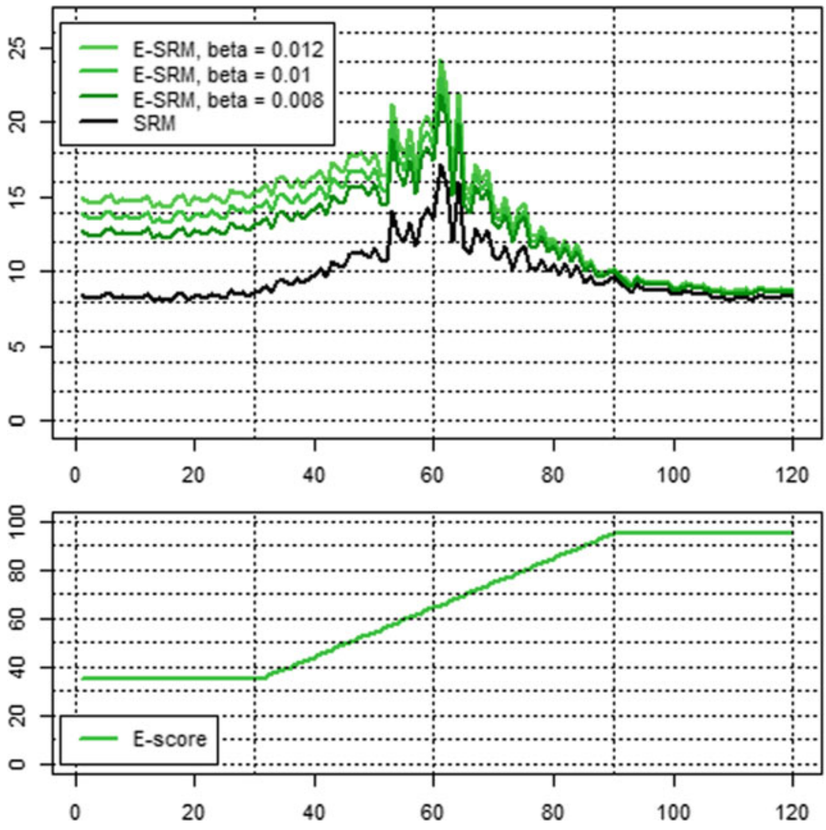

Fig. 4.2 E-SRM–combination A2

In a few selected examples of combinations, we show how significant the influence of the E-factor can be and that the E-SRM course can significantly deviate from the original SRM. For this purpose, we consider two SRM series which represent two different characteristic courses: (A) related to a temporary increase in risk, i.e., a pick (A-shaped), and (B) relatively constant during the period in between two consecutive picks (U-shaped). We combine them with four selected types of E-factor courses that concern only the inner half of the duration: (1) decrease of the E-factor, (2) increase of the E-factor, (3) down-swing and return of the E-factor, and (4) up-swing and return of the E-factor. In each case,

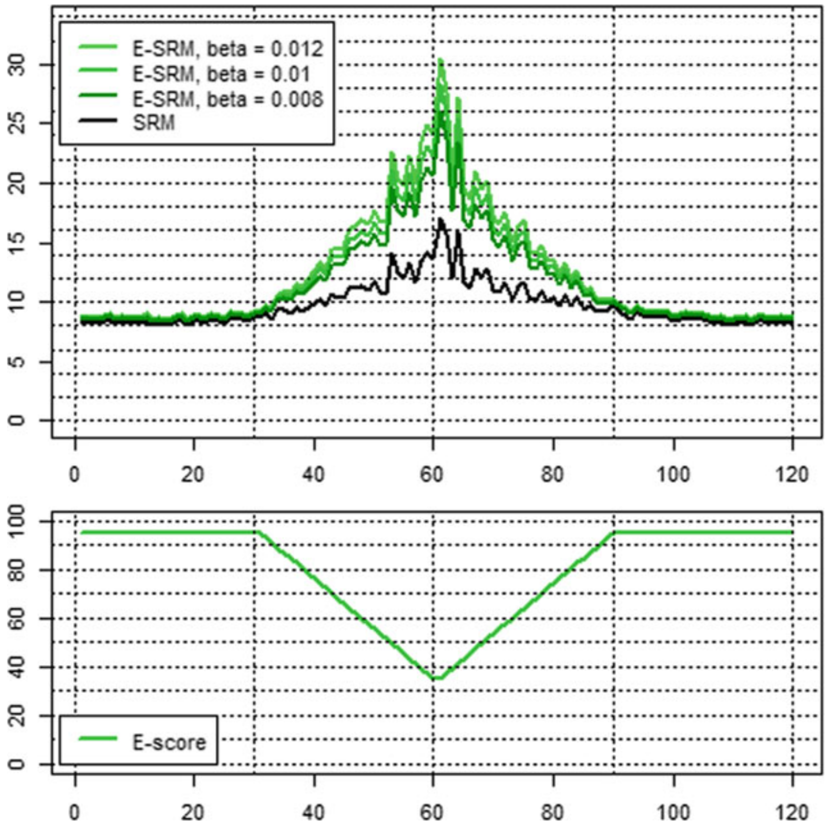

Fig. 4.3 E-SRM–combination A3

we span the E-factor between an arbitrarily chosen low value (set at 35) and a very high value (set at 95). Every time series used as the illustrative example cover 120 trading days, and the E-factor changes over 60 days (31–90). We assume three different values of the time-constant β coefficients: 0.008, 0.010, and 0.012.

Figures 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, and 4.8 show how strong the E-score's impact on the SRM can be, especially when the score assumes

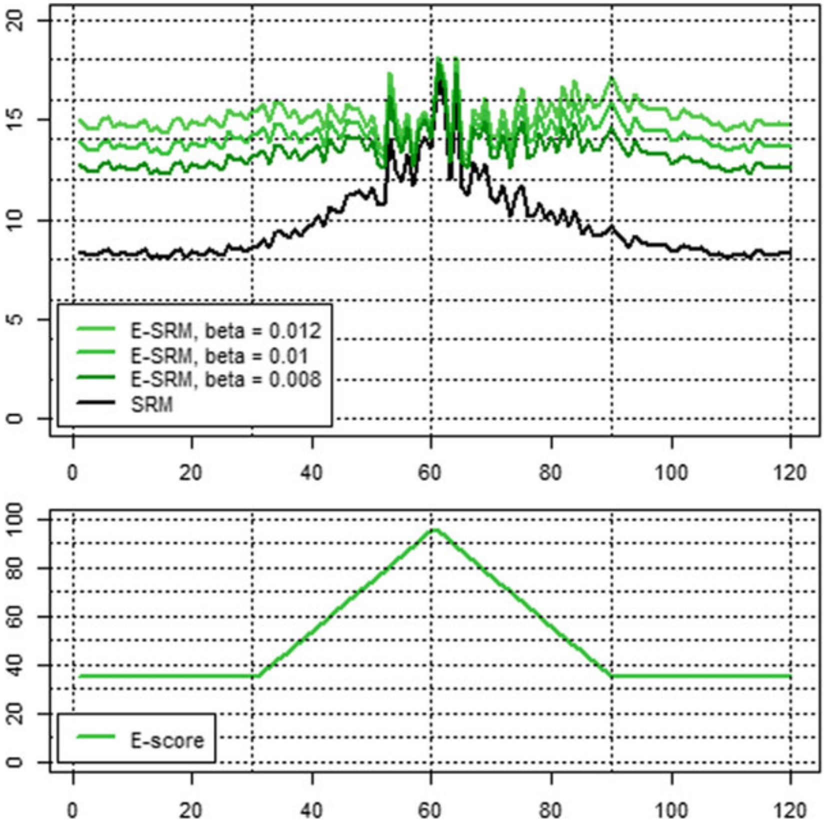

Fig. 4.4 E-SRM–combination A4

particularly low values.[2] Different combinations presented above demonstrate that the meeting in time of changes in the SRM and E-score series may cause a disproportionate increase (A1, A3, B1) or decrease (A2, B2, B4) in the E-SRM compared to the SRM series. It may even change the E-SRM series' general character (A4, B3). Figures 4.3, 4.4, and 4.7 are especially interesting in this context. In the case of combination A3, the E-SRM is particularly strongly amplified, while combination A4 illustrates

---

[2] Empirical results show that such low E-scores can be traced back to several systemically important European banks (cf. Dziwok et al., 2022).

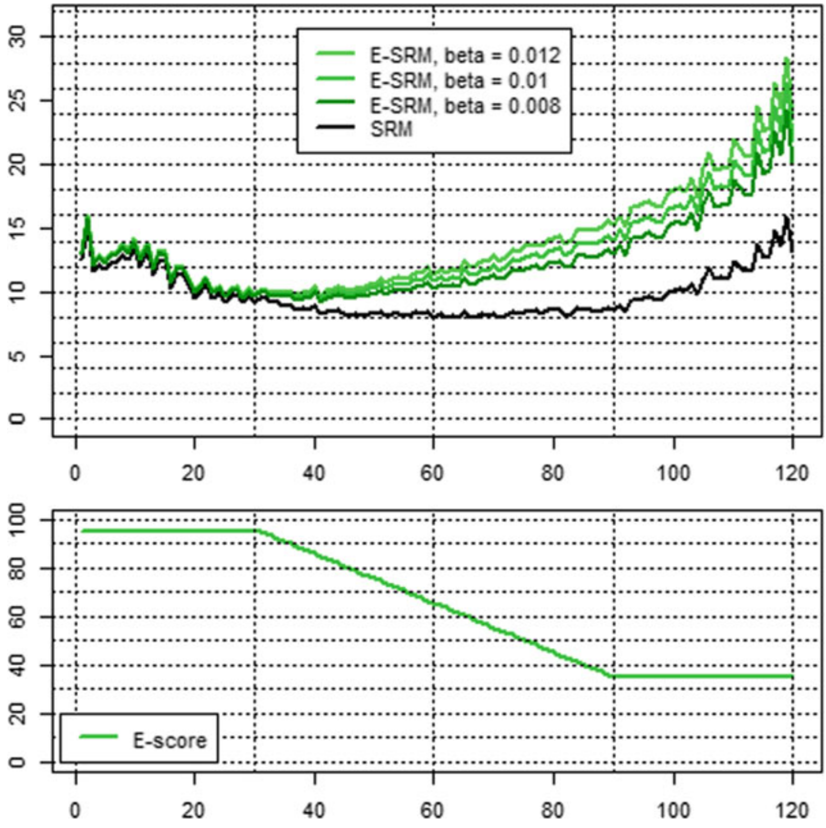

Fig. 4.5 E-SRM–combination B1

the leveling effect of the E-factor. Finally, the B3 combination presents the E-driven peak effect, when the otherwise flat SRM series turns into a peaking E-SRM series after augmentation with the E-factor.

4.5 Examples of the E-SRM Model Application to Stylized Data

In this subchapter, we present four examples that reflect the courses of a prototypical econometric quantile-based systemic risk measure (SRM). It is stylized for systemically important European financial institutions

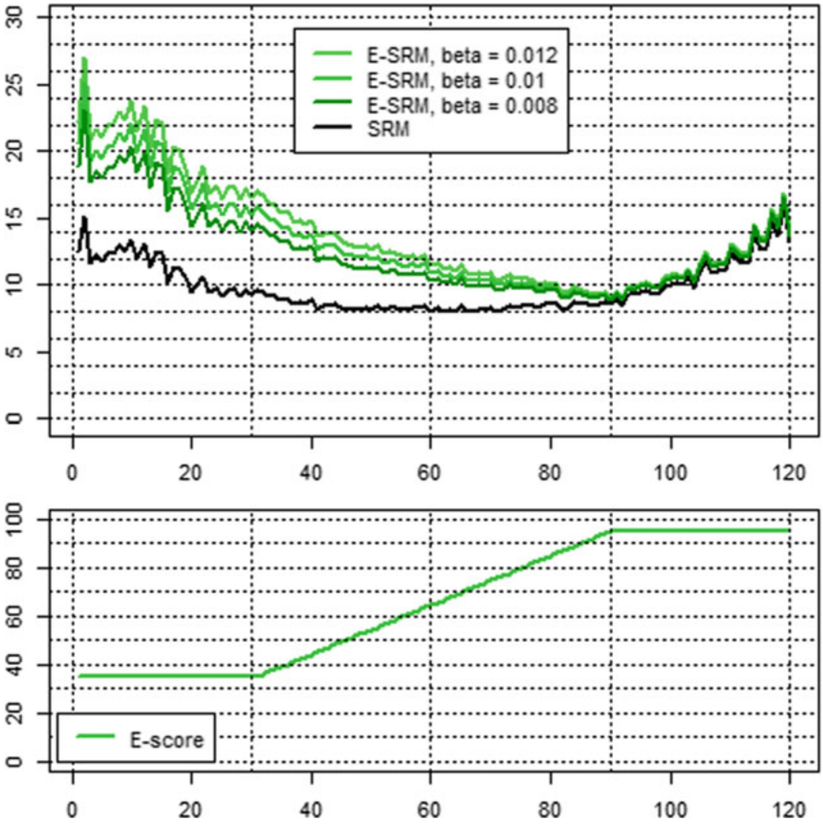

Fig. 4.6 E-SRM–combination B2

grouped by different characteristics. We style the courses of the SRM based on our empirical results from several previous systemic risk studies (Dziwok & Karaś, 2021; Jajuga et al., 2017; Karaś & Szczepaniak, 2020, 2021a, 2021b) and the precise methodology discussed thereof.

In the examples, we use the theoretical SRM measure in its relative form, i.e., SRM%, i.e., as if it was expressed relative to the market capitalization of a given financial institution. In each example, we focus on different periods and geographical locations in Europe, but the common factor for all examples is the materialization of systemic risk measured

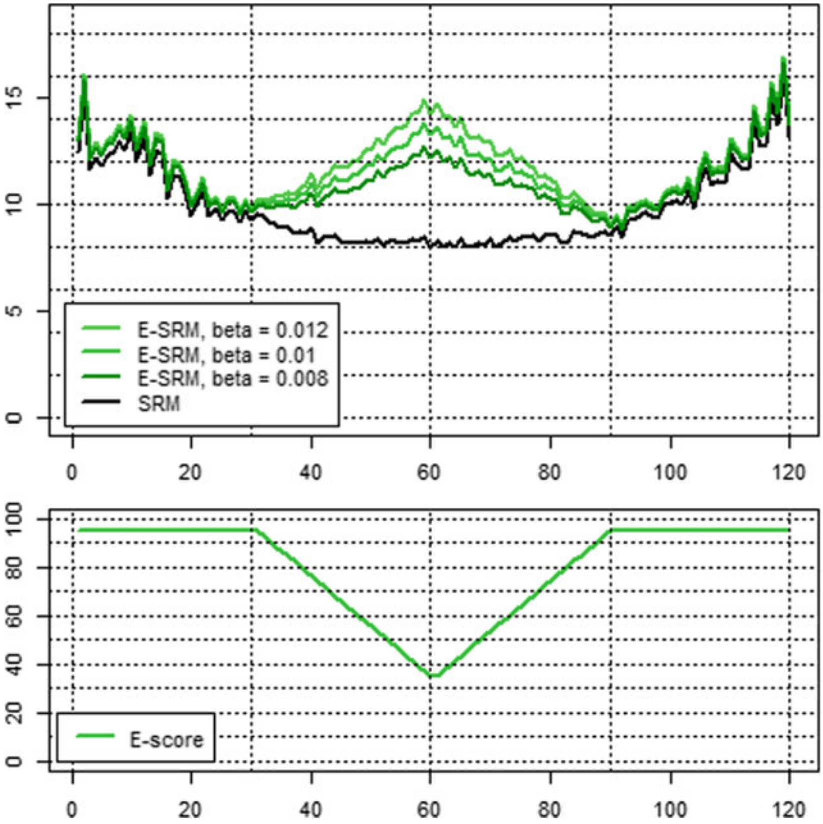

Fig. 4.7 E-SRM–combination B3

for systemically important financial institutions. In selecting systemically important banks, we use the list of Other Systemically Important Institutions prepared yearly by the EBA (2022b).

In each example, we establish a stylized course of the daily SRM measure illustrating the properties described by our previous empirical findings for the period between 2006 and 2022. Then, we attach selected possible courses of the E-factor based on the empirical observation that the E-scores tend either to fall or to stop rising around financially turbulent periods (cf. Dziwok et al., 2022). All so-obtained variants are presented in Figs. 4.9, 4.10, 4.11, and 4.12.

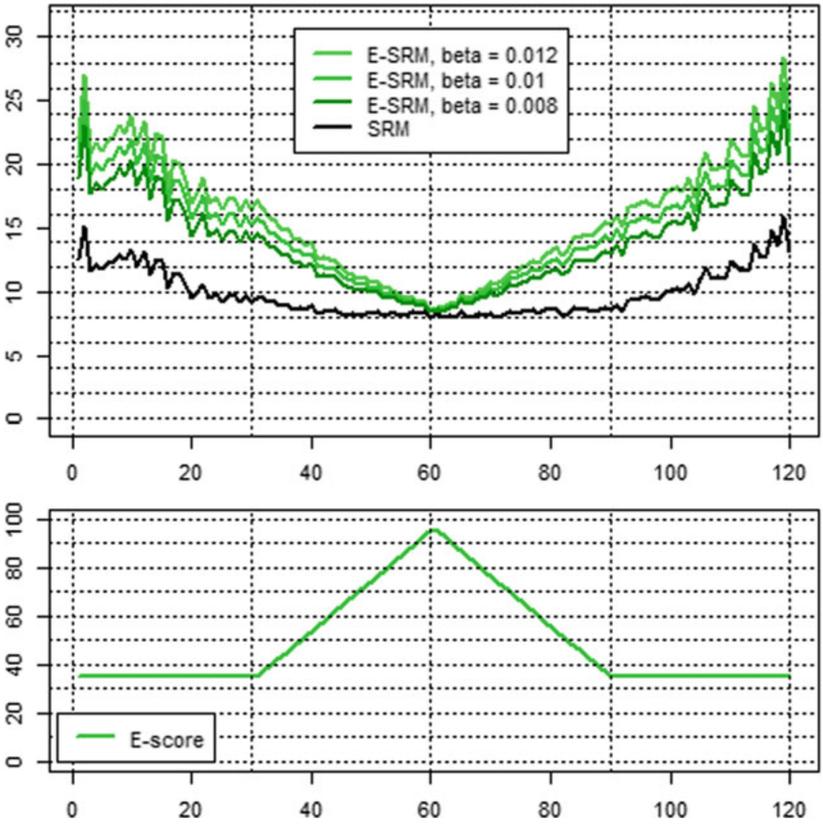

Fig. 4.8 E-SRM–combination B4

Example 1 The first example depicts a typical course of a systemic risk measure for the Nordic and Baltic systemically important banks. Figure 4.9 shows the course of the SRM throughout the study period. Figure 4.10 illustrates (magnifies) the reaction to the global financial crisis that was the most significant manifestation of systemic risk in these countries.

This example depicts several properties of the baseline SRM (the black line) and the E-SRM augmented by the E-factor (the green line). Above all, for the Nordic-Baltic region, the level of financial stability characteristic of systemically important banks is generally very high. Throughout

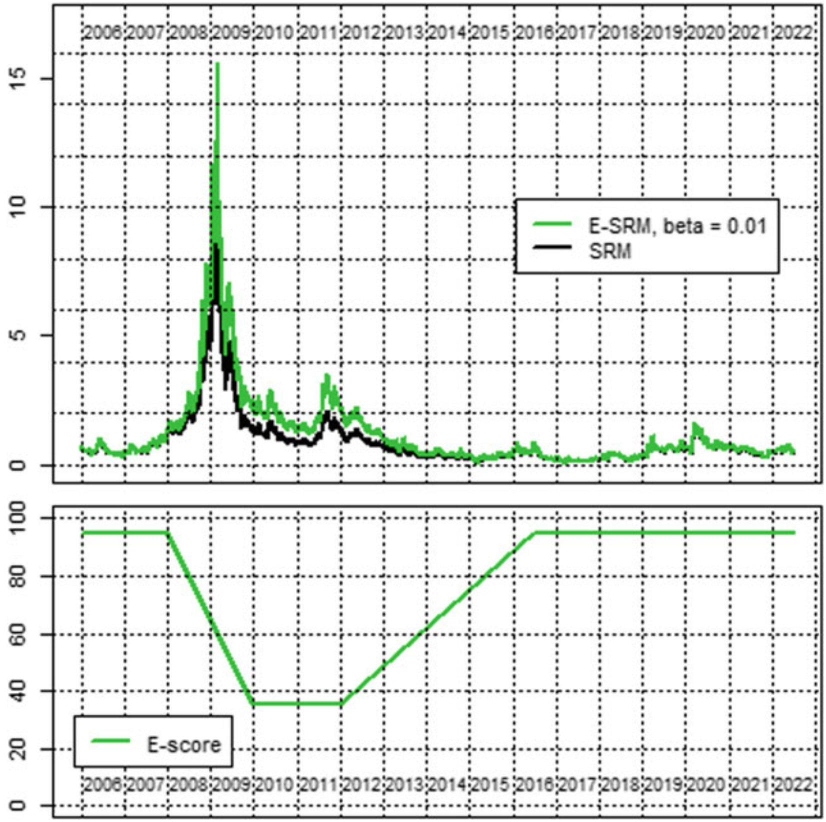

Fig. 4.9 SRM and E-SRM of the Nordic and Baltic OSIIS 2006–2022

the studied fifteen-year period, the SRM measure remains mostly around 0 and 5%, pointing to low systemic fragility. However, during the global financial crisis, there was a large spike in risk that subsided quite fast—over one year.

Figure 4.10 demonstrates how the falling E-factor (bank's increasing exposure to environmental risk) may increase the scale of systemic risk materialization. A crucial property of the model is that by construction, the impact of this exposure automatically increases with the rising levels of the SRM. As discussed in previous sections, this is theoretically justified and empirically expected. In this example, although the assumed beta

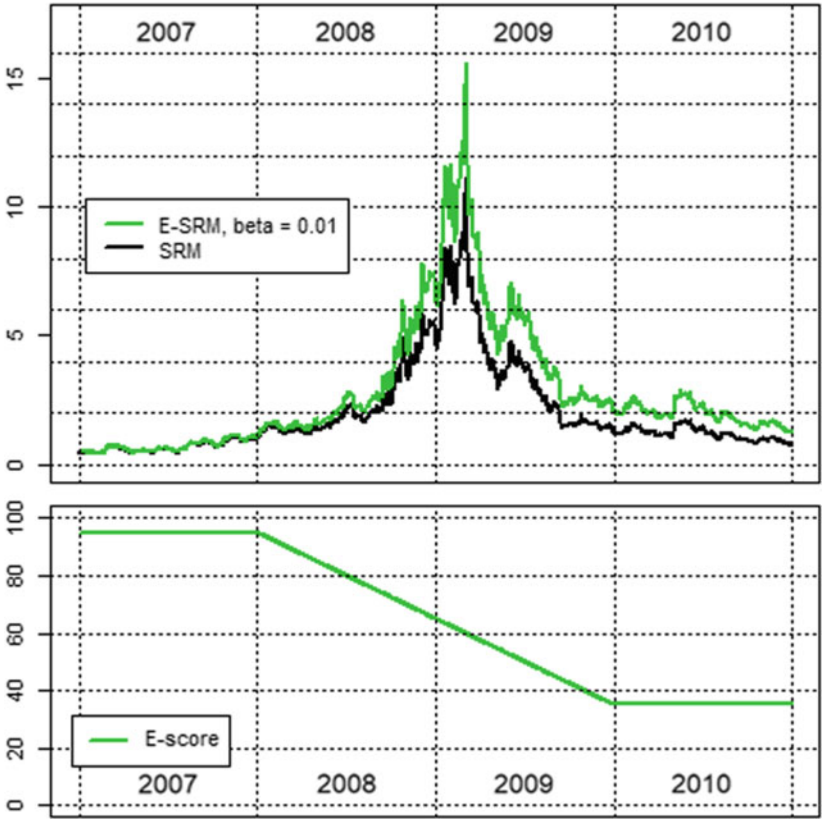

Fig. 4.10 SRM and E-SRM of the Nordic and Baltic OSIIs 2007–2010

coefficient is particularly small (1%), the impact of the E-factor on the SRM reaches 5%—almost one-third of the total systemic risk in its peak of early 2009, when the primary wave of the global financial crisis hit Northern Europe.

Example 2 Systemically important banks of several European countries were particularly strongly hit by the public debt crisis between 2010 and 2013 when the markets reacted to the uneven risk of the sovereign bonds that was reflected by the increasing CDS spreads between euro-denominated bonds of those countries. Banks' exposures were not equal

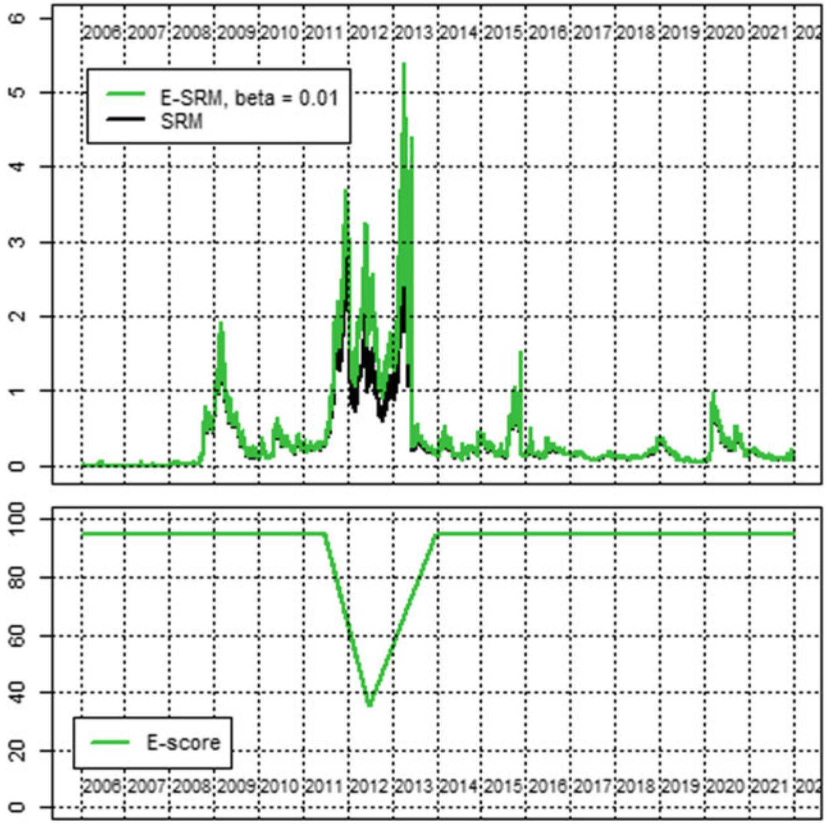

Fig. 4.11 SRM and E-SRM of the OSIIs most affected by the European public debt crisis 2006–2022

throughout the banking sector and higher for those banks that were more invested in such bonds. Notably, this risk materialized not only for such countries as Greece but also for others in Southern Europe and the Balkans. For most affected banks, the systemic risk reaction was sequential to the CDS markets' reactions and lagged by several months.

In this example, we have selected these OSIIs for which the systemic materialization of the European public debt crisis was stronger than that of the global financial crisis. As illustrated in Figs. 4.11 and 4.12, for these banks, systemic risk spikes have a U-shaped recurring pattern and

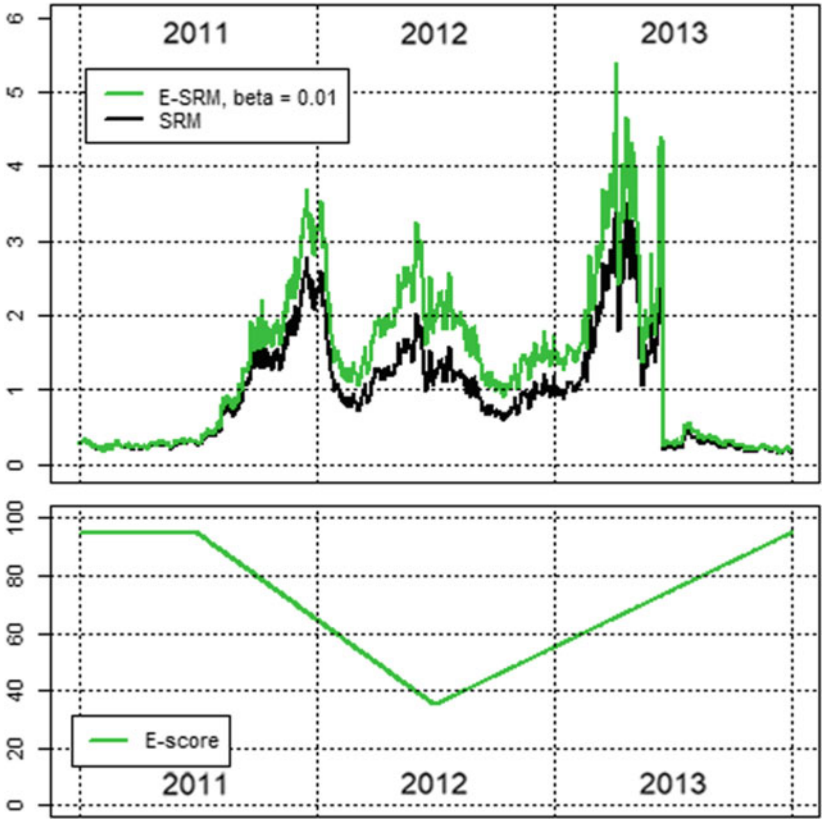

Fig. 4.12 SRM and E-SRM of the OSIIs most affected by the European public debt crisis 2011–2013

a much more prolonged impact than in the previous case. A distinctive property captured by the stylized course of the SRM is the sudden drop in risk that coincides with various rescue measures. They include emergency assets programs and bail-outs, but also mergers and take-overs of the straggling banks. As for the E-SRM, we stylize the E-factor for a temporary drop that may hypothetically be the effect of the government stopping subsidies and tax-relief programs that stimulate green innovation and decarbonization. The impact on systemic risk is significant but smaller than in the previous case.

Example 3 For another example, we have selected systemically important banks of highly industrialized countries, such as Germany, Italy, or France. The courses of systemic risk measures for such banks are characterized by a strong reaction to the global financial crisis that is followed by a more permanent upward shift in the mean level of systemic risk and equally sizable risk spikes in all the subsequent periods of systemic risk materialization (Fig. 4.13).

In this example, it is worth noticing the spike in risk between 2015 and 2017 that corresponds to the low profitability of systemic European

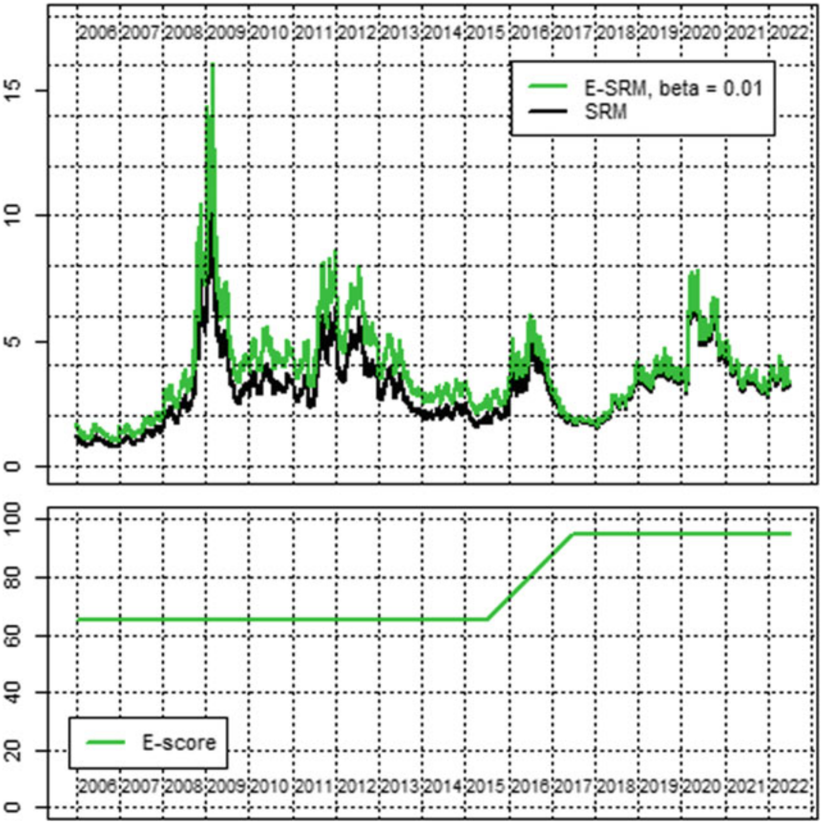

Fig. 4.13 SRM and E-SRM of the OSIIs in highly industrialized European countries 2006–2022

banks imposed by the negative interest rates in the Eurozone. In our simulation, this systemic risk event coincides with the gradual but significant increase of the E-score that may be associated with the fact that the environment of negative interest rates may actually be inductive of investment in green innovation and may lead to decreases in environmental risk exposures. Figure 4.14 demonstrates how the proposed model accounts for this scenario, when the green time series (E-SRM) closes to the black (baseline SRM) time series in 2017. When the hypothetical E-factor increases to 95%, the impact of the environmental risk on the E-SRM decreases to a minimum.

Example 4 The final example is based on selected systemically important financial institutions in geographically varied locations for which the common denominator is the exceptionally strong reaction to the ongoing COVID-19 pandemic (Figs. 4.15 and 4.16).

Empirical studies show that there are systemically important financial institutions, especially in Central and Eastern Europe, characterized by high fragility in the face of the ongoing COVID-19 pandemic. This stylized example shows how this may be coupled with increased environmental risk, reflecting the materialization of the transition risk we are currently experiencing in Europe and globally (see Subchapter 2). The E-SRM course shows how significant this aspect of systemic risk may become in the pessimistic scenario described earlier.

4.6 CONCLUSIONS AND PERSPECTIVES

The chapter presents a solution that uses the ESG scoring data in systemic risk analysis. We discuss how systemic risk affects financial institutions and what part of this risk is due to environmental risk exposure. We report the findings about systemic and environmental risk interactions, pointing to the past and current materializations of this risk in the financial systems. Then we discuss why and how the ESG data may be a source of information for systemic risk analysis and present our approach of augmenting systemic risk measurement with the E-factor derived from the ESG scores.

There are many applications of the mentioned modeling approach presented in this chapter. The most obvious is risk measurement by policymakers, e.g., central banks or macroprudential regulators. However, entities exposed to systemic and environmental risk, like financial institutions, can also use such a method to measure their changing exposure

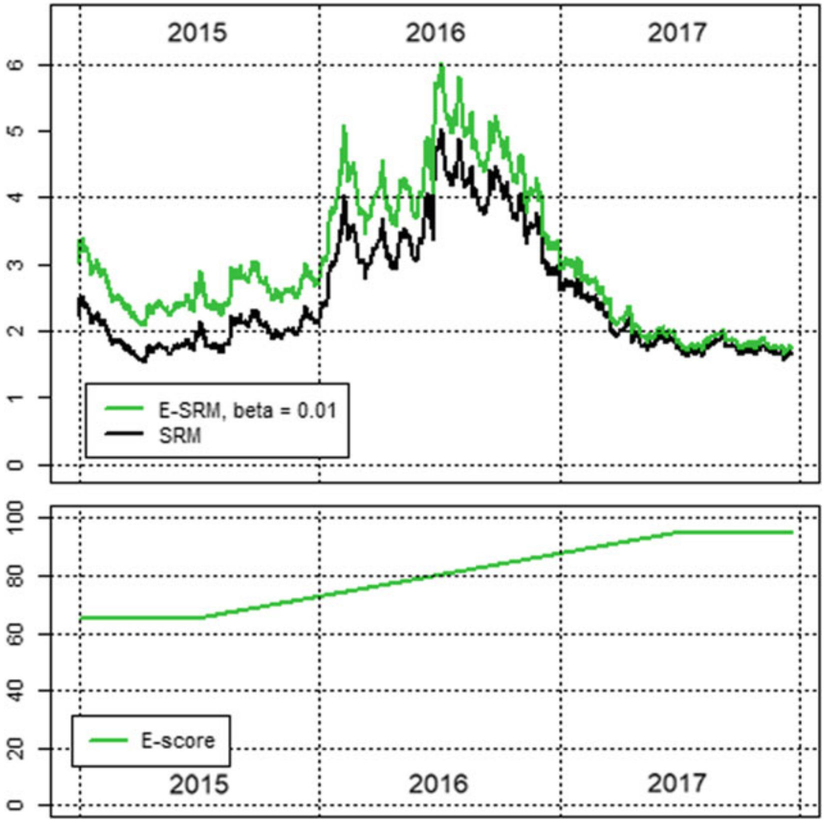

Fig. 4.14 SRM and E-SRM of the OSIIs in highly industrialized European countries 2015–2017

to these risks. Furthermore, other stakeholders, such as investors and debtors—businesses and individual clients of banks—can utilize such a tool when choosing a bank. It might be especially worthwhile when making longer-term financing decisions.

A less obvious but potentially even more valuable application of the proposed model is its use in scenario analyses and stress tests to understand how different decisions related to the size of the E-factor could affect banks' systemic risk exposures. Similarly, the model can be used to analyze and stress-test systemic risk exposure of each financial institution

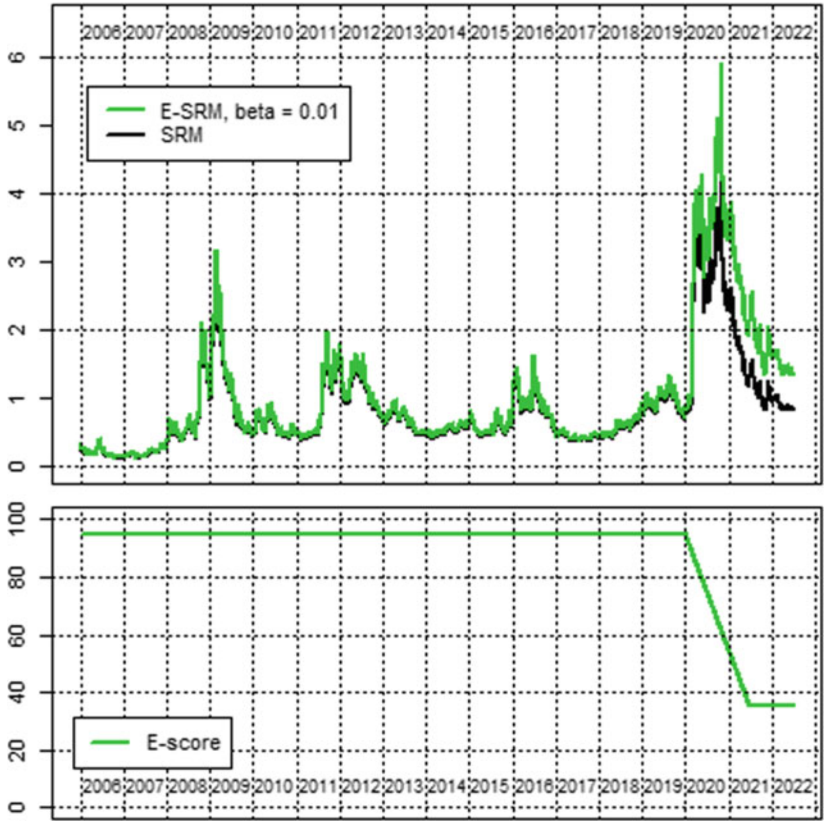

Fig. 4.15 SRM and E-SRM of the OSIIs most affected by the COVID-19 pandemic 2006–2022

in the context of the changing sensitivity to environmental risk (changing betas). Consequently, each of the two variables, the E-factor and the beta, can be stressed—separately or in combination.

The simplistic and transparent construction of the model makes it applicable to a broad spectrum of network-based stress-testing analyses performed by macroprudential regulators and central banks in financial stability analyses. In this context, augmentation can be performed not only on individual banks but also on banking networks, where the effect of the spillover of risk may be observed and measured.

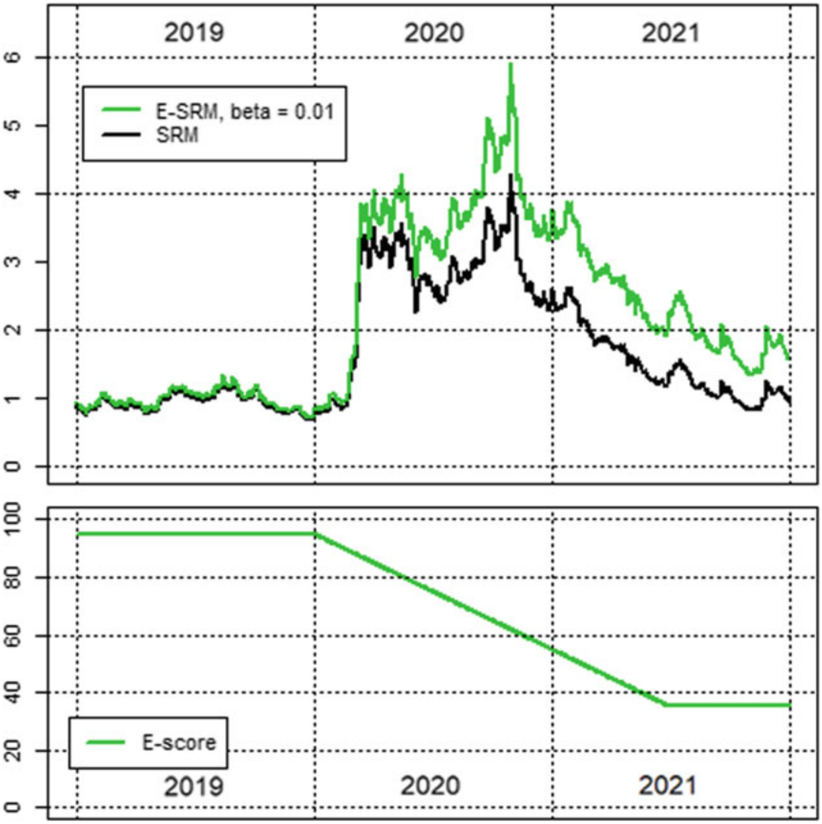

Fig. 4.16 SRM and E-SRM of the OSIIs most affected by the COVID-19 pandemic 2019–2021

With the increasing ESG data availability and improving quality of reporting of this data related to the upcoming IFRS reform, the utility of our solution will rise significantly. Finally, it should be noted that using the ESG data is not only cost-efficient but also the sole feasible solution for the frontier and emerging markets, where other data are very limited. Thanks to the global popularity of ESG scoring, our approach is a solution for measuring environmental risk exposure that is readily applicable to systemic risk analysis in both—developed and developing—markets.

Funding and Acknowledgments The National Science Centre funded this research project under Agreement UMO-2018/29/N/HS4/02783. We thank the participants of the 15th International Risk Management Conference and 21st CREDIT Conference for the insightful feedback that helped improve the paper significantly.

References

Adrian, T., & Brunnermeier, M. K. (2016). CoVaR. *American Economic Review, 106*, 1705–1741.

Aevoae, G.-M., Andries, A. M., Ongena, S., Sprincean, N., & ESG and Systemic Risk. (2022). Swiss Finance Institute Research Paper No. 22–25. https://doi.org/10.2139/ssrn.4058477

Albuquerque, R., Koskinen, Y., & Zhang, C. (2019). Corporate social responsibility and firm risk: Theory and empirical evidence. *Management Science*, *65*, 4451–4469.

Alessi, L., Di Girolamo, F. E., Pagano, A., & Petracco, M. (2022). *Accounting for climate transition risk in banks' capital requirements* (JRC Working Papers in Economics and Finance, 2022/8).

Anginer, D., Demirguc-Kunt, A., Huizinga, H., & Ma, K. (2018). Corporate governance of banks and financial stability. *Journal of Financial Economics, 130*, 327–346.

Anginer, D., Demirguc-Kunt, A., & Zhu, M. (2014). How does competition affect bank systemic risk? *Journal of Financial Intermediation, 23*, 1–26.

Bahadori, N., Kaymak, T., & Seraj, M. (2021). Environmental, social, and governance factors in emerging markets: The impact on firm performance. *Business Strategy & Development, 4*, 411–422.

Bank for International Settlements (BIS). (2021, April). *Climate-related risk drivers and their transmission channels*. Basel Committee on Banking Supervision. https://www.bis.org/bcbs/publ/d517.pdf. Accessed 6 October 2022.

Bank of England (BoE). (2018, November). *Climate change: What are the risks to financial stability*? Knowledge Bank. https://www.bankofengland.co.uk/knowledgebank/climate-change-what-are-the-risks-to-financial-stability. Accessed 6 October 2022.

Bank of England (BoE). (2021, December). *Financial stability report*. https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-report/2021/december-2021.pdf?la=en&hash=62FF3E7484FF0FD1AD650FE41A77D32B3750F8CF. Accessed 6 October 2022.

Bătae, O. M., Voicu, D., & Feleagă, L. (2020). Environmental, social, governance (ESG), and financial performance of European Banks. *Journal of*

Accounting and Management Information Systems, 19(3). https://doi.org/10.24818/jamis.2020.03003

Battiston, S. (2019). The importance of being forward-looking: Managing financial stability in the face of climate risk (Banque de France Financial Stability Review No. 23—June 2019—Greening the Financial System: The New Frontier). Banque de France, Paris: Financial. https://www.banque-france.fr/sites/default/files/media/2019/08/27/financial_stability_review_23.pdf. Accessed 6 October 2022.

Battiston, S., Dafermos, Y., & Monasterolo, I. (2021). Climate risks and financial stability. *Journal of Financial Stability, 54*, 100867.

Berg, F., Koelbel, J., & Rigobon, R. (2022). Aggregate confusion: The divergence of ESG ratings. *Review of Finance*. https://doi.org/10.1093/rof/rfac033

Billio, M., Costola, M., Hristova, I., Latino, C., & Pelizzon, L. (2021). Inside the ESG ratings: (Dis)agreement and performance. *Corporate Social Responsibility and Environmental Management, 28*(5), 1426–1445. https://doi.org/10.1002/csr.2177

Boffo, R., Marshall, C., & Patalano, R. (2020). *ESG investing: Environmental pillar scoring and reporting*. OECD. www.oecd.org/finance/esg-investing-environmental-pillar-scoring-and-reporting.pdf. Accessed 6 October 2022.

Boubaker, S., Cellier, A., Manita, R., & Saeed, A. (2020). Does corporate social responsibility reduce financial distress risk? *Economic Modelling, 91*, 835–851.

Bouslah, K., Kryzanowski, L., & M'Zali, B. (2018). Social performance and firm risk: Impact of the financial crisis. *Journal of Business Ethics, 149*, 643–669.

Breeden, S. (2022, April 28). *Macropru – fit for the future?* – speech at Lancaster University. https://www.bankofengland.co.uk/speech/2022/april/sarah-breeden-speech-at-lancaster-university-during-an-agency-visit-to-the-north-west. Accessed 6 October 2022.

Brownlees, C., & Engle, R. (2017). SRISK: A conditional capital shortfall measure of systemic risk. *Review of Financial Studies, 30*(1), 48–79.

Brunetti, C., Dennis, B., Gates, D., Hancock, D., Ignell, D., Kiser, E., Kotta, G., Kovner, A., Rosen, R., Tabor, N. (2021, March). *Climate change and financial stability, FEDS notes*. Board of Governors of the Federal Reserve System. https://www.federalreserve.gov/econres/notes/feds-notes/climate-change-and-financial-stability-20210319.htm. Accessed 6 October 2022.

Candelon, B., Hasse, J. B., & Lajaunie, Q. (2021). ESG-washing in the mutual funds industry? From information asymmetry to regulation. *Risks, 9*(11), 199. https://doi.org/10.3390/risks9110199

Cerqueti, R., Ciciretti, R., Dalò, A., & Nicolosi, M. (2021). ESG investing: A chance to reduce systemic risk. *Journal of Financial Stability, 54*, 100887.

CFA. (2022). *Systemic risk and management in finance*. Retrieved 23 September 2022. https://www.cfainstitute.org/en/advocacy/issues/systemic-risk

Chenet, H., Ryan-Collins, J., & van Lerven, F. (2021). Finance, climate-change and radical uncertainty: Towards a precautionary approach to financial policy. *Ecological Economics, 183*(May), 106957. https://doi.org/10.1016/j.ecolecon.2021.106957

Chiaramonte, L., Dreassi, A., Girardone, C., & Piserà, S. (2021). Do ESG strategies enhance bank stability during financial turmoil? Evidence from Europe. *European Journal of Finance*. https://doi.org/10.1080/1351847X.2021.1964556

Cormier, D., Ledoux, M., & Magnan, M. (2011). The informational contribution of social and environmental disclosures for investors. *Management Decision, 49*, 1276–1304.

Cornett, M. M., Erhemjamts, O., & Tehranian, H. (2016). Greed or good deeds: An examination of the relation between corporate social responsibility and the financial performance of U.S. commercial banks around the financial crisis. *Journal of Banking & Finance, 70*, 137–159.

Delis, M. D., de Greiff, K., Iosifidi, M., & Ongena, S. (2021). *Being stranded with fossil fuel reserves? Climate policy risk and the pricing of bank loans* (Swiss Finance Institute Research Paper Series No. 18–10).

Dziwok, E., & Karaś, M. (2021). Systemic illiquidity noise-based measure—A solution for systemic liquidity monitoring in frontier and emerging markets. *Risks, 7*, 124. https://doi.org/10.3390/risks9070124

Dziwok, E., Karaś, M., Stachura, M., & Szczepaniak, W. (2022). *E-SRISK – A method to quantify the environmental factor in systemic risk analysis*. 21st international conference CREDIT 2022 long run risks, Venice, 22–23 September. https://doi.org/10.2139/ssrn.4156777

Engle, R. F. (2022). *Long run risk and climate hedge portfolios – Invited talk*. 21st international conference CREDIT 2022 long run risks, Venice, 22–23 September.

Eratalay, M. H., & Cortés Ángel, A. P. (2022). The impact of ESG ratings on the systemic risk of european blue-chip firms. *Journal of Risk and Financial Management, 15*(4), 153. https://doi.org/10.3390/jrfm15040153

European Banking Authority (EBA). (2021). *Report on management and supervision of ESG risks for credit institutions and investment firms*. https://www.eba.europa.eu/sites/default/documents/files/document_library/Publications/Reports/2021/1015656/EBA%20Report%20on%20ESG%20risks%20management%20and%20supervision.pdf. Accessed 6 October 2022.

European Banking Authority (EBA). (2022a). *EBA publishes binding standards on Pillar 3 disclosures on ESG risks*. https://www.eba.europa.eu/eba-publishes-binding-standards-pillar-3-disclosures-esg-risks. Accessed 6 October 2022a.

European Banking Authority (EBA). (2022b). *O-SIIs, other systemically important institutions*. https://www.eba.europa.eu/risk-analysis-and-data/other-systemically-important-institutions-o-siis-. Accessed 6 October 2022b.

European Central Bank (ECB). (2009, December). *Financial stability review*. https://www.ecb.europa.eu/pub/pdf/fsr/art/ecb.fsrart200912_02.en.pdf. Accessed 6 October 2022.

European Central Bank (ECB). (2022). *ECB banking supervision launches 2022 climate risk stress test*. https://www.bankingsupervision.europa.eu/press/pr/date/2022/html/ssm.pr220127~bd20df4d3a.en.html?utm_source=ecb_twitter&utm_campaign=220127_pr_climate_stress_test. Accessed 6 October 2022.

European Central Bank (ECB). (2021a, November). *Financial stability review*. https://www.ecb.europa.eu/pub/pdf/fsr/ecb.fsr2021a11~8b0aebc817.en.pdf. Accessed 6 October 2022.

European Central Bank (ECB). (2021b, May). *Financial stability report*. https://www.ecb.europa.eu/pub/financial-stability/fsr/html/ecb.fsr2021b05~757f727fe4.en.html. Accessed 6 October 2022.

European Securities and Markets Authority (ESMA). (2022). *Sustainable finance roadmap 2022–2024*. https://www.esma.europa.eu/policy-activities/sustainable-finance/sustainable-finance-roadmap-2022-2024. Accessed 6 October 2022.

European Systemic Risk Board (ESRB). (2021). *Climate-related risk and financial stability*. https://www.esrb.europa.eu/pub/pdf/reports/esrb.climateriskfinancialstability202107~79c10eba1a.en.pdf?71a273dc36a85ef05c8bed530466f900. Accessed 6 October 2022.

Financial Stability Board (FSB). (2022, April). *Supervisory and regulatory approaches to climate-related risks interim report*. https://www.fsb.org/2022/04/supervisory-and-regulatory-approaches-to-climate-related-risks-interim-report/. Accessed 6 October 2022.

Financial Stability Oversight Council (FSOC). (2021). *Report on climate-related financial risk 2021*. https://home.treasury.gov/system/files/261/FSOC-Climate-Report.pdf. Accessed 6 October 2022.

Finger, M., Gavious, I., & Manos, R. (2018). Environmental risk management and financial performance in the banking industry: A cross-country comparison. *Journal of International Financial Markets, Institutions and Money, 52*, 240–261.

Gangi, F., Meles, A., D'Angelo, E., & Daniele, L. M. (2019). Sustainable development and corporate governance in the financial system: Are environmentally friendly banks less risky? *Corporate Social Responsibility and Environmental Management, 26*, 529–547.

Gillan, S. L., Koch, A., & Starks, L. T. (2021). Firms and social responsibility: A review of ESG and CSR research in corporate finance. *Journal of Corporate Finance, 66*, 101889.

International Financial Reporting Standards Foundation, IFRS. (2022). *ISSB receivers global response on proposed sustainability disclosure standards*. https://www.ifrs.org/news-and-events/news/2022/08/issb-receives-global-response-on-proposed-sustainability-disclosure-standards/. Accessed 5 October 2022.

International Monetary Fund. (2022). *Global financial stability report*. https://www.imf.org/en/Publications/GFSR/Issues/2022/04/19/global-financial-stability-report-april-2022. Accessed 6 October 2022.

Jajuga, K., Karaś, M., Kuziak, K., & Szczepaniak, W. (2017). Ryzyko systemu finansowego [Risk of the financial system]. In: *Materiały i Studia* (p. 329). National Bank of Poland. https://www.nbp.pl/publikacje/materialy_i_studia/ms329.pdf. Accessed 6 October 2022.

Jung, H., Engle, R. F., & Berner, R. (2021). Climate stress testing (FRB of New York Staff Report No. 977). Rev. June 2022. https://doi.org/10.2139/ssrn.3931516

Kahneman, D. (2013). *Thinking, fast and slow*. Macmillan.

Karaś, M., & Szczepaniak, W. (2020). Fragility or contagion? Properties of systemic risk in the selected countries of Central and East-Central Europe. In: K. Jajuga, H. Locarek-Junge, L. Orlowski & K. Staehr (Eds.). *Contemporary trends and challenges in finance. Springer proceedings in business and economics*. Springer. https://doi.org/10.1007/978-3-030-43078-8_19

Karaś, M., & Szczepaniak, W. (2021a). Systemic risk in selected countries of Western and Central Europe. In: K. Jajuga, H. Locarek-Junge, L. T. Orlowski, K. Staehr (Eds.). *Contemporary trends and challenges in finance. Springer proceedings in business and economics*. Springer. https://doi.org/10.1007/978-3-030-73667-5_10

Karaś, M., & Szczepaniak, W. (2021b). Three ways to improve the systemic risk analysis of the Central and Eastern European region using SRISK and CoVaR. *Journal of Credit Risk, 17*(2). https://ssrn.com/abstract=3908027

Kim, S., Lee, G., & Kang, H.-G. (2021). Risk management and corporate social responsibility. *Strategic Management Journal, 42*, 202–230.

KPMG International Limited. (2022). *IFRS announce new ESG reporting standard*. https://home.kpmg/dp/en/home/insights/2021/10/ifrs-announce-new-esg-reporting-standard.html. Accessed 5 October 2022.

Lamperti, F., Bosetti, V., Roventini, A., & Tavoni, M. (2019). The public costs of climate-induced financial instability. *Nature Climate Change, 9*(11), 829–833. https://doi.org/10.1038/s41558-019-0607-5

Lamperti, F., Bosetti, V., Roventini, A., Tavoni, M., & Treibich, T. (2021). Three green financial policies to address climate risks. *Journal of Financial Stability, 54*, 100875. https://doi.org/10.1016/j.jfs.2021.100875

Liu, W., Shao, X., De Sisto, M., & Li, W. H. (2021). A new approach for addressing endogeneity issues in the relationship between corporate social responsibility and corporate financial performance. *Finance Research Letters, 39*, 101623.

Mehta, A. (2022). *Symbols vs. Solutions: Quant as a driver for value creation*. Quant insights conference: ESG & climate risk in finance, CQF Institute, online, 29 September. https://hopin.com/events/quant-insights-conference-esg-climate-risk-in-quant-finance. Accessed 29 September 2022.

Murè, P., Spallone, M., Mango, F., Marzioni, S., & Bittucci, L. (2021). ESG and reputation: The case of sanctioned Italian banks. *Corporate Social Responsibility and Environmental Management, 28*(1), 265–277.

Neitzert, F., & Petras, M. (2021). Corporate social responsibility and bank risk. *Journal of Business Economics*. https://doi.org/10.1007/s11573-021-01069-2

Network for Greening the Financial System, NGFS. (2020, June). *The macroeconomic and financial stability impacts of climate change: Research priorities, technical report*. Bank of France. www.ngfs.net/sites/default/files/medias/documents/ngfs_research_priorities_final.pdf. Accessed 6 October 2022.

Nieto, M. (2017, October). *Banks and environmental sustainability: Some financial stability reflections*. International Research Centre on Cooperative Finance. https://doi.org/10.2139/ssrn.3082107

Reisinger, A. Howden, M., Vera, C., Garschagen, M., Hurlbert, M., Kreibiehl, S., Mach, K. J., Mintenbeck, K., O'Neill, B., Pathak, M., Pedace, R., Pörtner, H. S., Poloczanska, E., Corradi, M. R., Sillmann, J., van Aalst, M., Viner, D., Jones, R., Ruane, A. C., Ranasinghe, R. (2020). *The concept of risk in the IPCC sixth assessment report: A summary of cross-working group discussions*. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/2021/02/Risk-guidance-FINAL_15Feb2021.pdf. Accessed 6 October 2022.

Renneboog, L., Ter Horst, J., & Zhang, C. (2011). Is ethical money financially smart? Nonfinancial attributes and money flows of socially responsible investment funds. *Journal of Financial Intermediation, 20*, 562–588.

Sassen, R., Hinze, A.-K., & Hardeck, I. (2016). Impact of ESG factors on firm risk in Europe. *Journal of Business Economics, 86*, 867–904.

Scatigna M., Xia D., Zabai A., & Zulaica O. (2021, December). Achievements and challenges in ESG markets. *BIS Quarterly Review*. Bank for International Settlements.

Sohag, K., Hammoudeh, S., Elsayed, A., Mariev, O., & Safonova, Y. (2022). Do geopolitical events transmit opportunity or threat to green markets? Decomposed measures of geopolitical risks. *Energy Economics*, 106068. https://doi.org/10.1016/j.eneco.2022.106068

Tol, R. S. J. (2019). A social cost of carbon for (almost) every country. *Energy Economics, 83*, 555–566. https://doi.org/10.1016/j.eneco.2019.07.006

Toma, P., & Stefanelli, V. (2022). What are the banks doing in managing climate risk? Empirical evidence from a position map. *Ecological Economics, 200*(October), 107530. https://doi.org/10.1016/j.ecolecon.2022.107530

Wong, J. B., & Zhang, Q. (2022). Stock market reactions to adverse ESG disclosure via media channels. *The British Accounting Review, 54*, 101045.

Zhang, X., Zhang, S., & Lu, L. (2022). The banking instability and climate change: Evidence from China. *Energy Economics, 106*, 105787. https://doi.org/10.1016/j.eneco.2021.105787