

Online Appendix

Sustainable finance: A journey toward ESG and climate risk

A detailed taxonomy of the existing literature

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Country: geographical focus of the research

Title: title of the paper

Authors: name of the authors

Year of publication: when the paper has been published

Journal/ Publisher: name of the journal or the publisher

Data sample: information on the sample developed for the empirical analysis

Used Methodology: methodology involved

ESG pillar: focus of the research where E, S, G, and all stand respectively for Environmental, Social, Governance and all pillars

Key findings: summary of the key finding of the research

Limits of the obtained findings: critical aspects of the research

Appendix 1A: literature on ESG methodology

I. ESG methodology										
	Country	Title	Authors	Year of publication	Journal/Publisher	Data sample	Used Methodology	ESG pillar	Key findings	Limits of the obtained findings
1	Australia	Lifting the veil on environment-social-governance rating methods	W. Stubbs, P. Rogers	2013	Social Responsibility Journal https://doi.org/10.1108/SRJ-03-2012-0035	Regnan data (Australian ESG rating provider)	Case study	all	Existing level of subjectivity in ESG ratings; Necessity for increased transparency of the rating methods.	Just a qualitative evaluation of the used methodology of just one rating provider
2	US and Europe	Socially responsible investing: sustainability indices, ESG rating and information provider agencies	E. Escrig-Olmedo, M. J. Muñoz-Torres, M. Á. Fernández-Izquierdo	2010	Int. J. Sustainable Economy https://doi.org/10.1504/IJSE.2010.035490	<p>•10 ESG agencies: Innovest Strategic Value Advisors, KLD Research & Analytics, oekom research, Vigeo, ECP, SAM, SiRi Company, ASSET4, Accountability and EIRIS</p> <p>•6 Sust. Indexes: Ethibel Sustainability Index, ASPI, Dow Jones Sustainability Index, FTSE4Good, KLD's Domini 400 Social Index and the Calvert Social Index</p> <p>• Data Period: September 2007 - February 2009</p>	<p>Comparison in terms of:</p> <ul style="list-style-type: none"> • Screening criteria • International standards • Scoring systems • Services offered by the ESG agencies • Investment risk 	all	<ul style="list-style-type: none"> • Absence of standard methodology; • differing weightings to analysis criteria; • Different combinations of positive negative criteria; • Different scoring systems; • Different risk measurement 	Just a qualitative evaluation
3	US, Canada, Europe	Do ratings of firms converge? Implications for managers, investors and strategy Researchers	A. K. Chatterji, R. Durand, D.I. Levine, S. Touboul	2015	Strat. Mgmt. J. https://doi.org/10.1002/smj.2407	<ul style="list-style-type: none"> • 6 ESG agencies: KLD, Asset4, Innovest, DJSI, FTSE4Good and Calvert. • Data period: 2002–2010 period for KLD and Asset4; 2004 for DJSI, 2005 for Calvert and Innovest, and 2006 for FTSE4 Good 	<ul style="list-style-type: none"> •Overlaps between SRI raters' indexes •Pairwise tetrachoric correlations •Pairwise Spearman correlations between KLD, Calvert, DJSI, Innovest, and Asset4's top-level scores on Overlapping universes (for 2004, 2005, 2006) 	all	<ul style="list-style-type: none"> • Lack of agreement ; • Differences remain even after adjustment for explicit differences in the definition of CSR used by different raters 	

4	US and Europe	Rating the Raters: Evaluating how ESG Rating Agencies Integrate Sustainability Principles	E. Escrig-Olmedo, M. Á. Fernández-Izquierdo, I. Ferrero-Ferrero, J. M. Rivera-Lirio, M. J. Muñoz-Torres	2019	Sustainability https://doi.org/10.3390/su11030915	<ul style="list-style-type: none"> • 8 ESG agencies: KLD Research & Analytics (MSCI ESG Research), Oekom research (ISS-oekom), Vigeo (Vigeo EIRIS), ECP, SAM (RobecoSAM), SiRi Company (Sustainalytics), ASSET4 (REFINITIV), and EIRIS (FTSE Russell ESG Ratings) • Data Period: 2008 and 2018 	<ul style="list-style-type: none"> • Thematic content analysis common specific assessment criteria among ESG rating agencies) 	all	<ul style="list-style-type: none"> • large heterogeneity among ESG rating agencies concerning the relevance of the different individual components of CSR • ESG rating agencies do not fully integrate the sustainability principles into their corporate sustainability assessment processes 	<ul style="list-style-type: none"> • Constant changes in the sector • Selection of limited cases does not allow to cover all the particularities of ESG rating agencies
5	US and Europe	Aggregate Confusion: The Divergence of ESG Ratings	F. Berg, J. F. Koelbel, R. Rigobon	2019	MIT Sloan School Working Paper https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3438533	<ul style="list-style-type: none"> • 6 ESG agencies: KLD (MSCI Stats), Sustainalytics, Vigeo Eiris (Moody's), RobecoSAM (S&P Global), Asset4 (Refinitiv), and MSCI • baseline year for our analysis is 2014 (robustness check for 2017 without KLD) • full sample: 1,665 to 9,662 companies; common sample: 924 firms 	<ul style="list-style-type: none"> • Pearson Correlations between ESG Ratings+ Mean Absolute Distance (MAD) + Quantile Analysis • Taxonomy development+ Correlation of category scores+ Non-negative Least Squares Regression • Arithmetic Decomposition+ Regression-Based Decomposition • Rater fixed effects + LASSO Regressions 	all	<ul style="list-style-type: none"> • Divergence in ESG ratings related to different scope of categories, different measurement of categories, and different weights of categories (the first 2 are predominant) • presence of a rater effect 	
6	US	Rating the ratings: How good are commercial governance ratings	R. M. Daines, I. D. Gow, D. F. Larcker	2008	Rock Center for Corporate Governance Stanford University Working Paper Series https://doi.org/10.1016/j.jfineco.2010.06.005	<ul style="list-style-type: none"> • 3 primary corporate governance rating firms: ISS Corporate Governance Quotient (CGQ), Governance Metrics International (GMI), and The Corporate Library's TCL rating • Audit Integrity (AGR) • Data Period: 2005- 2007 6,827 companies 	<ul style="list-style-type: none"> • Descriptive statistics • Logistic Regression analysis • OLS 	G	<ul style="list-style-type: none"> • Large heterogeneity among raters grading concerning the same considered company • Commercial ratings do not predict accurately governance-related outcomes 	

7	US and Germany	Four Things No One Will Tell You About ESG Data	S. Kotsantonis, G. Serafeim	2019	Journal of Applied Corporate Finance https://doi.org/10.1111/jacf.12346	<ul style="list-style-type: none"> random 50 large (Fortune 500) publicly listed companies across a variety of sectors + Lufthansa 	<ul style="list-style-type: none"> Distribution analysis Comparison of different imputation methods (Rules based, regression, PMM) for predicting Lufthansa's turnover 	S	<ul style="list-style-type: none"> Important variety, and inconsistency, of used data and measures, and reporting methodology Lack of transparency on benchmarking procedures Gap-filling approaches involving considerable discrepancies. Disagreements increases with the quantity of publicly available information 	
8	International	Corporate scandals and the reliability of ESG assessments: Evidence from an international sample	S. Utz	2019	Rev Manag Sci https://doi.org/10.1007/s11846-017-0256-x	<ul style="list-style-type: none"> Asset4 data 750 single data point assessments for ESG aspects 67 scandals Data period: 2004-2014 + 5000 firms 	<ul style="list-style-type: none"> Event study methodology Bootstrap tests OLS 	all	<ul style="list-style-type: none"> category ratings are unable to predict appropriately the risk of scandals retrospective indicators significantly deteriorate in the year of the release of the scandal 	<ul style="list-style-type: none"> data limitations related to annual data release restricted number of observations and might affect the reliability of the statistical inference results
9	-	Corporate Social Responsibility Rating - A Handbook of Corporate Governance and Social	H. Schäfer	2009	Surrey (Gower Publ.) https://ssrn.com/abstract=2177813	-	<ul style="list-style-type: none"> literature review description 	all		
10	US	Does it pay to be sustainable? Looking inside the black box of the relationship between sustainability performance and financial performance	N. Hussain, U. Rigoni, E. Cavezzali	2018	Corp Soc Resp. and Environ. Management https://doi.org/10.1002/csr.1631	<ul style="list-style-type: none"> ESG data : Bloomberg Companies websites and Corporate Register website 152 sustainability reports Data period: 2007 -2011 44 companies from 12 different industries selected among Global fortune 100 best performing US firms 	<ul style="list-style-type: none"> Manual content analysis technique to analyse the sustainability reports of companies Panel regression models 	all	<ul style="list-style-type: none"> fragmentation in the results is caused by the chosen SP measurement (disclosure vs performance) weak and contradictory interlinkages between different SP dimensions ESG indicators not appropriate tools for analyzing firms' behavior as do not capture companies' sustainable efforts relevance of GRI guidelines (78% of the economic items definitions have been modified in 2012) 	the considered data period might not fully correspond to the current situation

11	US	On the Validity of Environmental Performance Metrics	N. Semenova, L.G. Hassel	2014	Journal of Business Ethics https://doi.org/10.1007/s10551-014-2323-4	<ul style="list-style-type: none"> • ESG data: MSCI ESG STATS, Thomson Reuters ASSET4, Global Engagement Services (GES) • Data period : 2003–2011 • 466 US MSCI World companies (for correlation analysis) • 113 companies from high-risk industries + 124 companies from low-risk industries (for univariate tests) 	<ul style="list-style-type: none"> • Pearson and Spearman correlations • Univariate tests (t test ; Wilcoxon rank-sum test) 	E	<ul style="list-style-type: none"> • ratings have common dimensions, but on aggregate, they do not converge. • For all the considered ESG data providers : environmental ratings of high-risk industries companies are significantly higher than those of low-risk industries companies. • using ratings as proxies for EP, can mask underlying associations between variables and lead to inaccurate interpretation of observed relationships. • Confirmation of the relevance of industry specific materiality
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Appendix 1B: The effect of ESG disagreement on corporate financial performance

I. The effect of ESG disagreement on corporate financial performance									
	Country	Title	Authors	Year of publication	Journal/ Publisher	Data sample	Used Methodology	ESG pillar	Key findings
1	U.S.	ESG Rating Disagreement and Stock Returns	Gibson R. B., Krueger P., Schmidt P. S.	2021	Financial Analysts Journal https://doi.org/10.1080/0015198X.2021.1963186	Constituents of the S&P index. ESG raters analysed: Asset4 , Sustainalytics, Inrate, Bloomberg, FTSE, KLD, and MSCI IVA	Regression analysis using the standard deviation of the ESG ratings as a measure of divergence	all	Stock returns are positively related to ESG rating disagreement

2	World	ESG Confusion and Stock Returns: Tackling the Problem of Noise	F. Berg, J. F. Koelbel, A. Pavlova & R. Rigobon	2022	DOI: 10.3386/w30562	Reprisk, TrueValueLabs, MSCI IVA, Sustainalytics, ISS, Asset4, and S&P Global.	Usage of instrumental variables to "clean" the ESG ratings from potential noise coming from the divergence with other ESG raters	all	Standard estimates of the effects of ESG on stock returns suffer from attenuation bias
3	World	Stock price reactions to ESG news: the role of ESG ratings and disagreement	G. Serafeim & A. Yoon	2022	Review of Accounting Studies https://doi.org/10.1007/s11142-022-09675-3	Rating agencies: MSCI, Sustainalytics, and Thomson Reuters	Regression analysis using TruValue Lab's ESG news score	all	The consensus among ESG rating predicts future ESG news, but this relationship is moderated by the extent of the disagreement between the three raters
4	World	Inside the ESG ratings: divergence and performance	M. Billio, M. Costola, I. Histrova, C. Latino, L. Pelizzon	2021		Four ESG raters: Sustainalytics, MSCI, RobecoSAM and Refinitiv.	Portfolio analysis using the constituents of the MSCI Word index.	all	Disagreement in the scores dispersed the effect of preferences of ESG investors on asset prices, to the point that even when there was agreement, it had no impact on financial performances

Appendix 2A: Literature on ESG and credit risk

II. ESG and credit risk

Country	Title	Authors	Year of publication	Journal/ Publisher	Data sample	Used Methodology	ESG pillar	Results/ Findings	Limits of the obtained findings	
A. ESG and credit ratings										
1	US	Corporate social responsibility and credit ratings	Attig, N., El Ghoul, S., Guedhami, O., Suh, J.	2013	Journal of business ethics https://doi.org/10.1007/s10551-013-1714-2	ESG Data Provider: MSCI ESG STATS ESG Proxy: CSR score obtained as the sum of 7 qualitative issue area CRA: S&P rating Sample: 1585 unique firms over the period 1991–2010	<ul style="list-style-type: none"> Ordered probit regressions of firms' credit ratings on CSR scores and a number of controls Instrumental probit regressions on the effect of CSR on credit ratings (endogeneity check) 	All	<ul style="list-style-type: none"> Positive impact of CSR on credit ratings in terms of both an aggregate ESG score and the scores on the individual components of ESG Larger firms and firms with greater interest coverage and operating margins have higher CSR scores Capital intensive and risky firms have lower CSR scores. 	Their CSR score do not consider the corporate governance
2	Italy and Spain	The Linkage between ESG Performance and Credit Ratings: A Firm-Level Perspective Analysis	Devalle et al. (2017)	2017	International Journal of Business and Management https://doi.org/10.5539/ijbm.v12n9p53	ESG Data Provider: Thomson Reuters/DataStream CRA: Moody's Sample: 56 public companies (2015)	<ul style="list-style-type: none"> Ordered logistic regression of firms' credit rating on ESG metrics (3 variables for each category (E/S/G)), ESG Score and 5 control variables 	All	<ul style="list-style-type: none"> ESG performance is positively associated with higher credit ratings. Social and governance pillars are significantly and positively related to credit ratings. No meaningful results concerning the environmental metrics 	Small sample, results are strictly linked to the provide' scores
3	Germany	Incorporating sustainability criteria into credit risk management	Weber, O., Scholz, R. W., & Michalik, G.	2010	Business strategy and the environment https://doi.org/10.1002/bse.636	ESG proxy: 31 economic sustainability criteria 180 loans by 74 loan officers	<ul style="list-style-type: none"> Questionnaire to credit officers who mainly give loans to SME Multiple linear discriminant analysis to determine whether four predictors (traditional rating, economic risk, environmental risk and social risk) could predict whether a loan would be non-defaulted or defaulted discriminant analysis (McNemar test) 	All	<ul style="list-style-type: none"> Sustainability criteria can predict the financial performance of a debtor and therefore its creditworthiness Sustainability criteria are able to predict traditional ratings 	Based on a questionnaire to loan officers.

4	US and Europe	ESG in credit ratings and the impact on financial markets	F. Kiesel, F. Lücke	2019	Financial Markets, Institutions & Instruments https://doi.org/10.1111/fmii.12114	CRA and ESG data provider: Moody's Sample: 483 companies and 3719 Moody's credit rating reports between 2004 and 2015	<ul style="list-style-type: none"> •LDA method (Blei et al. (2003)) is performed to determine the integration of ESG factors in ratings •Multivariate regression analysis to examine whether ESG considerations in ratings affect capital market reactions (measured by abnormal stock returns and abnormal CDS spread changes). 	All	CRA's consider ESG factors in their rating decisions. However, the degree of integrating ESG is limited	Based on credit rating reports
5	12 countries of EMU	Corporate social responsibility and Eurozone corporate bonds: The moderating role of country sustainability	C. Stellner, C. Klein, B. Zwergel	2015	Journal of Banking & Finance https://doi.org/10.1016/j.jbankfin.2015.04.032	ESG Data Provider: Thomson Reuters ASSET4 ESG ratings CRA: S&P credit ratings Sample: 872 corporate bonds issued by non-financial companies for the period 2006-2012	<ul style="list-style-type: none"> • Ordered logistic regressions to examine the relation between CSP and credit ratings <ul style="list-style-type: none"> • Pooled time-series, cross-sectional regressions using yearly corporate bond z-spreads regressed on the previous year CSP and control variables • 2SLS regression analyses on the influence of corporate ESG rating on corporate bond z-spreads with the former being the instrumental variable. 	All	<ul style="list-style-type: none"> • Weak support for unconditional benefits of CSR investments in terms of z-spread • greater CSP involvement is reducing companies' credit risk only in countries with high ESG performance 	
6	India	Do environment, social and governance performance impact credit ratings: a study from India	S. Bhattacharya, D. Sharma	2019	International Journal of Ethics and Systems https://doi.org/10.1108/IJOES-09-2018-0130	ESG Data Provider: Bloomberg Indian CRAs: Crisil, ICRA and CARE Sample: 122 firms listed on the Bombay Stock Exchange (BSE) 500 for the period 2013-2018	<ul style="list-style-type: none"> • Pearson correlation analysis in order to avoid multicollinearity • Ordered logistic regressions examining the impact of ESG ratings (and separately E,S and G ratings) on credit ratings (including control variables such as market capitalization, net debt to equity ratio, and independent directors) 	All	<ul style="list-style-type: none"> • global ESG ratings do not significantly impact credit rating for large firms which already had higher credit rating • but it has a significant relevance for small and medium size companies <ul style="list-style-type: none"> • environmental and social pillars influence positively and significantly credit ratings of small and medium size companies 	

B. ESG and CDS

1	US	Do Corporate Social Responsibility Activities Reduce Credit Risk? Short and Long-Term Perspectives	T.T.T. Truong, J. Kim	2019	Sustainability https://doi.org/10.3390/su11246962	ESG Data Provider: MSCI ESG CDS data: Markit Sample: 507 firms (companies from utilities and financial sectors excluded) over the period January 2001 to December 2013	<ul style="list-style-type: none"> • Slopes of CDS spreads (difference between long- and short-term CDS spreads) used as proxy for the credit-term structure • Fama- MacBeth regressions run on a monthly basis to obtain time-series of coefficient values, transformed into average time-series values • cross-sectional regressions of the individual slopes of CDS spreads evaluating their relationship with CSR global scores, but also separately with 6 individual CSR categories (community, product characteristics, environment, human rights, employee relations, and diversity) 	ESG	<ul style="list-style-type: none"> • Firms with higher overall CSR scores reduce the difference between long and short term credit risks. • in general, CSR activities reduce both short and long term risks, but the effects are rather greater for the latter • even though the long run risk is reduced, taken separately, not all CSR activities reduce credit risks in the short run, (ex. human rights and product characteristics) thus leading to an increase of short -term borrowing costs. 	Results depend on the scoring method of the data provider
2	18 European countries	Do corporate social responsibility ratings affect credit default swap spreads	D. Drago, C. Carnevale, R. Gallo	2018	Corp Soc Responsibility and Environmental Management https://doi.org/10.1002/csr.1709	ESG Data Provider: ASSET4-Thomson Reuters CDS data: Datastream Sample: 1,349 rating announcements relating to 184 firms for the period 2007 to 2017	<ul style="list-style-type: none"> • Event study and cumulative abnormal returns (CAR) to verify if the announcement of a CSR rating has a statistical significant impact on the CDS market, • Regression analysis evaluating the impact of CSR rating on CDS spread 	ESG	<ul style="list-style-type: none"> • CSR rating upgrades significantly decrease CDS spreads (both for global and individual pillar scores) • no evidence of a significant impact of CSR rating downgrades on the CDS market 	Results depend on the scoring method of the data provider

3	EU	The effect of environmental sustainability on credit risk	C. Klein, A. Höck, A. Landau, B. Zwergel	2020	Journal of Asset Management https://doi.org/10.1057/s41260-020-00155-4	ESG Data Provider: MSCI ESG CDS data: Bloomberg Sample: 149 companies (all industries except financial sector) in the period from 2006 to 2017	<ul style="list-style-type: none"> • Random-effects estimator to assess the impact of the environmental score on CDS spreads • time-clustered White standard errors to correct for heteroscedasticity and serial-correlation • application of the same methodology to several subsamples in order to investigate the moderating effect of creditworthiness 	E	<ul style="list-style-type: none"> • In general, more sustainable firms have lower CDS spreads • environmental sustainability has almost no effect on companies with low credit ratings • but it has an important influence on companies with high credit ratings • the sustainability effect is strong for companies with a low leverage and high market capitalization, while for small and indebted companies it does not pay (no presence of penalty) to be green 	Results depend on the scoring method of the data provider
4	EU (mostly France and Germany)	ESG and Corporate Credit Spreads : evidence from Europe	F. Barth, B. Hübel, H. Scholz	2019	WP Joint Research Centre (JRC) EU Science Hub	ESG Data Provider: Asset4 Thomson Reuters CDS data: Thomson Reuters Eikon Sample: 108 companies between July 2009 and December 2016	<ul style="list-style-type: none"> • Fama- MacBeth regressions run on a monthly basis to obtain time-series of coefficient values • Linear cross-sectional analysis of ESG and CDS spread level • Non-linear cross-sectional relationship of ESG and CDS spreads • Time-series analysis of ESG (Fama and French ESG factor construction) and CDS spread changes 	All	<ul style="list-style-type: none"> • Firms with the worst environmental performance exhibit higher credit spreads. • Firms with low social performance lead to low CDS spreads (with the exception of the lowest level - threshold below which CDS spreads increase) • the time-varying market valuation of ESG significantly influences the variation in credit spread changes 	Results depend on the scoring method of the data provider

5	US and Europe	ESG and Corporate Credit Spreads	F. Barth, B. Hübel, H. Scholz	2020	WP http://dx.doi.org/10.2139/ssrn.3179468	ESG Data Provider: MSCI and Refinitiv EIKON CDS data: Markit Sample: 470 firms (each represented by one CDS for each maturity between one year and 30 year) for the period 2007 - 2019	<ul style="list-style-type: none"> Linear panel regression to assess the relationship between CDS spreads and ESG Quantile regression methodology Robustness check with a different rating provider 	ESG	<ul style="list-style-type: none"> Significant and negative relationship between ESG and credit risk ESG demonstrate a risk mitigation effect in Europe, but not in the U.S. (similar finding to Stellner, (2015), Amiraslani et al. (2019)) Differences in the effect of ESG across industries (substantially stronger effects for Industrials than for Healthcare, Consumer Services and Technology sectors) ESG effect statistically significant during expansions, but disappearing during recessions U-shaped pattern, implying that the risk mitigation effect of ESG is strongest at moderate levels of ESG and less pronounced at very high and very low ESG quantiles 	
6	60 Countries	Do Markets Value ESG Risks in Sovereign Credit Curves?	B. Hübel	2020	WP http://dx.doi.org/10.2139/ssrn.3501100	ESG Data Provider: RobecoSAM CDS data: Refinitiv EIKON Sample: 60 countries from 2007 to 2017	<ul style="list-style-type: none"> Correlation analysis Panel regressions of CDS spread levels on ESG ratings Panel regressions of CDS curve slopes on ESG ratings 	ESG, E, S and G	<ul style="list-style-type: none"> Countries with superior ESG performance show lower CDS spreads (irrespective of the ESG pillar or global ESG score) and flatter CDS implied credit curves 	
C. ESG and bond returns/defaults										
1	Korea	ESG Scores and the Credit Market	G-Y. Jang, H-G. Kang, J-Y. Lee, K. Bae	2020	Sustainability https://doi.org/10.3390/su12083456	ESG Data Provider: Korea Corporate Governance Service (KCGS) CRA: Korea Ratings Corporate bonds data: Korea Asset Pricing Sample: 6832 observation from August 2010 to July 2015	<ul style="list-style-type: none"> Panel regressions to assess the impact of ESG on bond pricing Case studies 	ESG, E, S and G	<ul style="list-style-type: none"> high environmental scores lower the cost of debt financing for small firms. ESG is complementary to credit ratings in assessing credit quality 	

	China	Can ESG Performance Affect Bond Default Rate? Evidence from China	P. Li, R. Zhou, Y. Xiong	2020	Sustainability	<p>ESG Data Provider: China Stock Market & Accounting Research Database (CSMAR)</p> <p>ESG Proxy: the average Standard Energy Consumption (E), Social Responsibility Building Disclosure (S), State-owned enterprises (G)</p> <p>Sample: industrial bonds issued in the period of 2011–2019</p>	<ul style="list-style-type: none"> • Logistic Regression analysis • Robustness analysis (Hosmer–Lemeshow Test) 	All	Bond default rate is positively correlated with the company's energy consumption and negatively correlated with its attention to social responsibilities	<ul style="list-style-type: none"> • Many ESG factors are not considered • the bonds data source is not explicitly defined • the average standard energy consumption is not firm specific (it is defined as the Total Standard Energy Consumption of the Industry/GDP of the industry)
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D. ESG and credit risk miscellaneous

1	-	ESG, Material Credit Events, and Credit Risk	W. J. Henisz, J. McGlinch	2019	<p>Journal of Applied Corporate Finance</p> <p>https://doi.org/10.1111/jacf.12352</p>	<ul style="list-style-type: none"> • ESG Data Provider: MSCI, RepRisk, Sustainalytics, and TruValue Labs • Use of a novel dataset providing systematic coding of material events reported in the media across a variety of empirical settings 	<ul style="list-style-type: none"> • Case studies with analysis of two major ESG issues—indigenous land claims and biodiversity • correlation analysis 	ESG	Empirical evidence of the mechanisms linking ESG performance to credit risk.	rather descriptive statistics, correlation analysis
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Appendix 3A: Literature on Climate change impact on financial stability

III. Climate change impact on financial stability									
Country	Title	Authors	Year of publ.	Journal/ Publisher	Data sample	Used Methodology	ESG pillar	Results/ Findings	
A. Climate change and financial stability									
1	EU	The importance of being forward-looking: managing financial stability in the face of climate risk	S. Battiston	2019	Financial Stability Review, Banque de France https://publications.banque-france.fr/sites/default/files/medias/documents/financial_stability_review_23.pdf	Policy report	Policy report	E	<ul style="list-style-type: none"> Majority of private and public investments not aligned with the climate targets and recommendations defined by the Paris COP21 Agreement in 2015 The assessment and management of climate change risk faces two major difficulties: 1) its endogenous character; 2) the multiple scenarios to be considered Solution: a framework combining climate stress tests and decision theory under uncertainty central banks to play important role through the creation of a public entity collecting, validating and making available climate-relevant data at the European Union level
2	EU and US	A climate stress-test of the financial system	S. Battiston, A. Mandel, I. Monasterolo, F. Schütze, G. Visentin	2017	Nature Climate Change https://doi.org/10.1038/nclimate3255	<ul style="list-style-type: none"> Microlevel data on equity holdings of all EU and US listed companies held by individual financial investors (BVD Orbis : 14,878 companies and 65,059 shareholders) Balance-sheet data for top 50 listed European banks (BVD Bankscope); Financial exposures at sectoral level (ECB Data Warehouse) GHG and CO2 emissions of sectors (Eurostat statistics) <ul style="list-style-type: none"> Data period: 2015 	Network-based climate stress-test methodology <ul style="list-style-type: none"> Reclassification of NACERev2 sectors (4 digit) into climate-policy relevant sectors (CPR) with respect to their CO2 emission potential Evaluation of direct portfolios' exposure to CPR through external assets Evaluation of indirect portfolios' exposure to CPR (amplification of losses resulting from interconnexions) Climate stress testing of EU largest banks using Debrank algorithm (Battiston et al. 2012)	E	<ul style="list-style-type: none"> EU banks direct exposure to fossil -fuel sector alone: 1% of average bank capital Equity holdings' direct exposure to fossil -fuel sector alone: 4–13% Combined exposures to CPR sectors : 36–48% Potential amplification of risk through financial investors' exposures necessity of timely and credible regulatory policies

3	EU	Climate change and financial stability	M. Giuzio, D. Krušec, A. Levels, A.S. Melo, K. Mikkonen, P. Radulova	2019	<p>Financial Stability Review, European Central Bank</p> <p>https://www.ecb.europa.eu/pub/financial-stability/fsr/pecial/html/ebc.fsrart201905_1~47cf778cc1.en.html#toc4</p>	Policy report	Policy report	E	<ul style="list-style-type: none"> • Physical risks can directly impact financial stability through the financial consequences of more frequent and severe disasters and through the created uncertainty relative to the adjustment processes' timing and speed, aiming to cope with climate transition (transition risk). • The evaluation of transition risk is complex (long-term horizon, lack of data, large variety of potential transition paths). • Banks' exposures to transition risk, seem contained in relative terms, but may be significant in absolute values for some banks. • A disorderly transition might be systemically relevant, but further climate risk-related data is necessary for a more comprehensive assessment • The NGFS, the ECB, European System of Central Banks and the ESRB have undertaken several actions for a better monitoring and management of climate-related risks • Climate risk may considerably affect financial institutions' balance sheets and hamper financial stability, especially if markets are unable to price properly the related risks.
4	EU	Climate change as a risk to financial stability	W. Pointner, D. Ritzberger-Grunwald	2019	<p>Financial Stability Report, OeNB</p> <p>https://ideas.repec.org/a/oenb/oenbfs/y2019i38b1.html</p>	Policy report	Policy report	E	<ul style="list-style-type: none"> • The financial risks of climate change: physical and transition risks can affect different financial risks categories (Credit risk, Market risk, Liquidity risk, Operational risk, Systemic risk) and can induce: higher probability of loan defaults, higher risk premiums, higher exchange rate volatility, reduced profits, price volatility, capital depletion, higher operating costs, decline of sovereign bond prices, fewer risk-free assets, higher correlation risk. • The OeNB doesn't recommend a re-calibration of capital requirements promoting sustainable assets. • Awareness of climate change risks' impact on financial stability not widespread among Austrian financial intermediaries

5	EU	The green swan - central banking and financial stability in the age of climate change	P. Bolton, M. Despres -Luiz, A. Pereira, D. A. Silva, F. Samama, R. Svartzman	2020	BIS https://www.bis.org/publ/othp31.pdf	Policy report	Policy report	E	<ul style="list-style-type: none"> • The integration of climate-related risk into financial stability analysis is particularly complex (uncertainty related to constantly evolving interconnected physical, social and economic phenomena) • Traditional backward-looking risk assessments and climate-economic models unable to foresee properly climate-related risks . • The “green swan” risks : potentially extremely financially disruptive events that could lead to the next systemic financial crisis • Climate change mitigation cannot be addressed only by Central Banks, but by all economic actors: governments, private sector, civil society and the international community • Central banks can play a crucial role in coordinating the implemented mitigation measures
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6	EU	A call for action Climate change as a source of financial risk. First comprehensive report	Network for Greening the Financial System	2019	<p>Network for Greening the Financial System</p> <p>https://www.mainstreamingclimate.org/publication/n-gfs-a-call-for-action-climate-change-as-a-source-of-financial-risk/</p>	Policy report	Policy report	E	<p>Recommend. n°1 – Integrating climate-related risks into financial stability monitoring and micro-supervision (identifying physical and transition risk transmission channels, implementing key risk indicators allowing to monitor them and integrating them into prudential supervision)</p> <p>Recommend. n°2 – Integrating sustainability factors into own-portfolio management (and potentially evaluating the effects of climate-related risks on monetary policy frameworks, with respect to the legal mandates).</p> <p>Recommend. n°3 – Bridging data gaps</p> <p>Recommend. n°4 – Building awareness and encouraging technical assistance and knowledge sharing</p> <p>Recommend. n°5 – Achieving robust and internationally consistent climate and environment-related disclosure (all companies issuing public debt/ equity, financial sector institutions are encouraged to disclose following the TCFD recommendations)</p> <p>Recommend. n°6 – Supporting the development of a taxonomy of economic activities</p>
7	Mexico	Climate risk and financial stability in the network of banks and investment funds	Roncoroni A., Battiston S., Escobar Farfan, L. O. and Martinez-Jaramillo S.	2020	<p>WP</p> <p>http://dx.doi.org/10.2139/ssrn.3356459</p>	<ul style="list-style-type: none"> • Banco de Mexico (regulatory reports, contagion data set, other repository containing daily info on the holdings of investment funds, ...) • LIMITS database (economic sectors output scenarios produced by an IAM and consistent with a range of climate targets) 	<ul style="list-style-type: none"> • Evaluation of the impacts of climate policy shocks with four stages of contagion dynamics (losses due to direct exposure, network valuation of financial assets, fire-sales contagion among financial institutions, losses transferred to external creditors) • Extended bank-fund climate stress-test: combination of the Climate Stress-test framework with the network valuation of financial assets framework (accounting for market volatility and for endogenous recovery rates). • Inclusion of common asset contagion dynamics (including not only banks but also investment funds) • Sensitivity analysis using the WITCH model 	E	<ul style="list-style-type: none"> • under mild shock scenarios systemic losses are contained, but there are combinations of climate policy scenarios and market conditions that can induce a threat to financial stability.

8	Austria	A climate risk assessment of sovereign bond portfolios	Battiston S. and Monasterolo I.	2020	WP OeNB http://dx.doi.org/10.2139/ssrn.3376218	<ul style="list-style-type: none"> • OeNB's portfolio holdings dataset (non-monetary policy OECD sovereign bonds' data) • BP Statistical Review of World Energy and IEA World Energy Outlook (energy data) • LIMITS database (economic sectors output scenarios produced by an IAM and consistent with a range of climate targets) • Data period: 2018 	Adaptation of the CLIMAFIN framework	E	<ul style="list-style-type: none"> • Countries where low-carbon sectors play a large role in the economy have lower bond yields and spreads relative to carbon intensive countries (countries where fossil fuels still play a large direct or indirect role) • For carbon intensive countries, the cost of climate misalignment might lead to higher climate spread and thus affect sovereign risk, investors' portfolio performance and potentially financial stability
9	UK	The Bank of England's climate-related financial disclosure 2020	Bank of England	2020	The BoE climate-related financial disclosure 2020	<ul style="list-style-type: none"> • S&P Trucost • MSCI ESG Research 	Policy report	E	<ul style="list-style-type: none"> • Description of the approach to managing climate change risks across its entire operations, and the steps taken to improve the Bank's understanding of these risks.
10	EU/EEA	Climate-related exposures	EIOPA	2018	European Insurance and Occupational Pension Authority Financial Stability Report	Policy report	Policy report	E	<ul style="list-style-type: none"> • The exposure to climate-related risk in their investment portfolios can be considerable for insurers and other financial institutions • Between 10 and 13% of the assets held by insurers may be exposed to risk in a climate-related transition scenario. • The exposed sectors are: housing (7%), energy intensive sectors (1.5%), fossil fuels (0.8%), utilities (0.8%) and transport (0.4%). • The high share of exposures to other financial institutions can lead to significant second round effects.

11	EU	Responding to climate change-related financial stability risks	ECB	2019	Financial Stability Review https://www.ecb.europa.eu/pub/financial-stability/fsr/html/ecb.fsr201911~facad0251f.en.html#toc49	Policy report	Policy report	E	<ul style="list-style-type: none"> significant gaps in : the availability of exhaustive and reliable disclosures, the reporting of carbon emissions data, but also in risk management and stress-testing frameworks Central banks and financial authorities aim to promote (i) the monitoring of climate risks; (ii) the development of taxonomies; (iii) the implementation of disclosure procedures; and (iv) the incorporation of climate-related risks into prudential frameworks
12		Climate Change and Financial Risk	P. Grippa, J. Schmittmann, F. Suntheim	2019	Finance & Development https://www.imf.org/external/pubs/ft/fandd/2019/12/climate-change-central-banks-and-financial-risk-grippa.htm	Policy report	Policy report	E	<p>IMF's role:</p> <ul style="list-style-type: none"> contribute to the understanding of the macro-financial transmission processes of climate risks Further improvement of stress tests capturing physical risks related to disasters, such as insurance losses and nonperforming loans associated with natural disasters. The IMF supports public and private sector efforts to further spread the adoption of climate disclosures across markets and jurisdictions, particularly by following the recommendations of the Task Force on Climate-related Financial Disclosures (2017).

13	France	Climate-Related Scenarios for Financial Stability Assessment: an Application to France	Allen et al.	2020	WP BdF, ACPR	<ul style="list-style-type: none"> • NiGEM (National institute Global Econometric Model), FIBEN, French National Central Credit Register (CCR), EIOPA, Risk Management Institute (RMI) dataset 	<ul style="list-style-type: none"> • analytical framework to quantify the impacts of climate policy and transition narratives on economic and financial variables necessary for financial risk assessment • modelling framework relies on a suite of models, calibrated on the high-level reference scenarios of the Network for Greening the Financial System (NGFS). <ul style="list-style-type: none"> • quantitative scenarios to be submitted to a group of voluntary banks and insurance companies to conduct the first bottom-up pilot climate-related risk assessment. 	<ul style="list-style-type: none"> • The results show the materiality of the negative economic impacts of disorderly transitions toward a low-carbon economy. Although the effects at macroeconomic and financial market levels remain somewhat limited, the impacts on the sectors exposed to the transition policies simulated are substantial • The magnitude of these sectoral and infra-sectoral impacts gives rise to financial stability risks that are potentially much more pronounced than macroeconomic and financial market overall levels would have suggested."
14	EU	Positively green: Measuring climate change risks to financial stability	European Systemic Risk Board	2020	European Systemic Risk Board		<ul style="list-style-type: none"> • DNB methodology and ECB's BEAST model 	<ul style="list-style-type: none"> • costs associated with climate change appear inevitable (either physical resulting from an insufficiency (or lack of timeliness) of mitigating action, or transition costs from stringent action; or both <ul style="list-style-type: none"> • financial markets only price this risk in a limited way • Direct exposures of European financial institutions to CO2-intensive sectors are limited and falling moderately on average, but concentrated exposures in a few sectors and firms • The costs to the economic or banking sector of even a sharp climate policy (transition costs) are likely to be contained, and lower than the potential losses due to physical risks resulting from climate change • data gaps

B. Climate change and portfolio management

1	US	Hedging Climate Change News	R. F. Engle, S. Giglio, B. Kelly, H. Lee, J. Stroebel	2020	The Review of Financial Studies https://doi.org/10.1093/rfs/hhz072	<ul style="list-style-type: none"> • Wall Street Journal climate change news index. • CrimsonHexagon (CH) Negative Climate Change News Index (1000 major news sources) • ESG data : MSCI and Sustainalytics. • Data period: 1995- 2016 	<p>Dynamically hedging climate change risk</p> <ul style="list-style-type: none"> • textual analysis of newspapers • mimicking portfolio approach • Fama-French factor-sorted portfolios 	E	<ul style="list-style-type: none"> • mimicking portfolio approach can be successful in hedging innovations in climate change news • Portfolios based on Sustainalytics E-Scores have a higher ability to hedge innovations in climate news
2	US and Canada	Sustainable portfolio management under climate change	M. Fang, K. S. Tan, T. S. Wirjanto	2018	Journal of Sustainable Finance & Investment https://doi.org/10.1080/20430795.2018.1522583	<ul style="list-style-type: none"> • Online database of S&P Dow Jones Indices (S&P 500 (U.S.) and S&P TSX (Canadian) indices) (Market and sector index prices from July 2007 to 31 July 2017) • online database of U.S. Treasury Department (U.S. interest rates) • Bank of Canada online database for Treasury Bill yields (Canadian interest rates) • Yahoo Finance and corporate filings (Company financial data) • 2013 CDP Global 500 Climate Change Report (Company emission data- carbon intensities in 2013) • WITCH model simulator (Future climate scenarios up to 2100 for Climate scenarios) 	<ul style="list-style-type: none"> • Empirical analysis using historical price data (demonstrating the inferior risk-adjusted performance of carbon-intensive industries) • Risk management modules (risk exposures measured by carbon intensities, risk impacts measured through equity return impact scenarios obtained from climate change paths under IAM) • A model for quantifying stranded asset risk • Joint posterior return distribution of the stocks allowing to define the mean-variance optimal portfolio 	E	<ul style="list-style-type: none"> • Current mitigation strategies focus on divestment in carbon-intensive industries, • Justified empirically by the inferior performance of carbon-intensive sectors comparatively to others on a risk-adjusted basis in the past decade • Necessity to include further risk control modules capturing the complex risk influences

3	China and developing countries	Climate-finance and climate transition risk: an assessment of China's overseas energy investments portfolio	Monasterolo I., Zengh J.I. and Battiston S.	2018	China & World Economy https://doi.org/10.1111/cwe.12264	<ul style="list-style-type: none"> • GEGI China Energy Finance database (Gallagher, 2017) (overseas energy loans of the China Development Bank (CDB) and the Export-Import Bank of China (CEXIM), from 2000 to 2018). • LIMITS database (Kriegler et al., 2013) (economic sectors output scenarios produced by an IAM and consistent with a range of climate targets, for 2005-2050) • GCAM and WITCH models (Climate policy scenarios) 	<ul style="list-style-type: none"> • A modular climate stress-test tailored to energy infrastructure overseas investments and applied to the portfolios of two major Chinese policy banks: CDB and CEXIM (projects financed via loans, export credits, and concessional and preferential loans) • Adaptation of the methodology used by Battiston et al. (2017) appropriate for development finance institutions 	E	<ul style="list-style-type: none"> • Negative shocks are mostly concentrated on coal and oil projects • Given the current leverage of Chinese policy banks, these losses could induce severe financial distress, with implications on macroeconomic and financial stability
4	EU /EEA	Climate risk assessment of sovereign bonds' portfolio of European insurers.	Battiston, S., Jakubik, P., Monasterolo, I., Riahi, K. and van Ruijven, B.	2019	European Insurance and Occupational Pension Authority Financial Stability Report	<ul style="list-style-type: none"> • SII QRT (solo data of insurers from 31 countries in EU/EEA, all insurers' investments into sovereign bonds) • Centralized Security Database (CSDB) (characteristics of the bonds) • LIMITS database (Kriegler et al., 2013) (economic sectors output scenarios produced by an IAM and consistent with a range of climate targets) • 1576 insurance companies, 142 bond issuers and 10746 bonds. 	Adaptation of the CLIMAFIN framework	E	<ul style="list-style-type: none"> • the potential impact of a disorderly transition to low-carbon economy on insurers portfolios of sovereign bonds is moderate in terms of its magnitude. • Regular monitoring is necessary since it is non-negligible in several scenarios.

5		CLIMAFIN Handbook: Pricing Forward-Looking Climate Risks Under Uncertainty	Battiston, S., Mandel, A. and Monasterolo, I.	2019	WP http://dx.doi.org/10.2139/ssrn.3476586	Methodological paper	<ul style="list-style-type: none"> • CLIMAFIN: novel methodological framework combining climate economic modelling and financial risk pricing in sovereign bonds, providing a quantitative assessment of climate risks in sovereign bonds and investors' portfolios under deep uncertainty. • It allows to integrate the forward-looking dimension, deep uncertainty, non-linearity and endogeneity of climate risk in the performance of financial contracts and investors' portfolios • It includes climate scenarios adjusted financial pricing models (for equity holdings, sovereign and corporate bonds, and loans) and climate scenarios conditioned risk metrics (such as the Climate Spread and the Climate VaR). 	E	Methodological paper
6	US, UK, Can, Germany, Italy, Spain, Netherlands, France	The importance of climate risks for institutional investors	Philipp Krueger, Zacharias Sautner, Laura T Starks	2020	The Review of Financial Studies https://doi.org/10.1093/rfs/hhz137	439 survey respondents, including 48 respondents from institutions with more than \$ 100bn in assets under management	Survey	E	<ul style="list-style-type: none"> • institutional investors believe that climate risks impact their portfolio firms namely through regulatory risk • long-term, larger and ESG-oriented investors, consider as a more appropriate approach for addressing climate risk: risk management and engagement, rather than divestment

7		Reinventing climate investing: building equity portfolios for climate risk mitigation and adaptation	J. Bender, T. A. Bridges, K. Shah	2019	Journal of Sustainable Finance & Investment https://doi.org/10.1080/20430795.2019.1579512	<ul style="list-style-type: none"> • S&P Trucost (Carbon Intensity, Brown Revenues, Fossil Fuel Reserves) • FTSE Russell (Green Revenues) • ISS-Oekom (Adaptation Score) • MSCI World Index (Portfolios construction back-testing) • portfolio construction back-testing period: July 31, 2013 to June 30, 2018 	<ul style="list-style-type: none"> • Presentation of the available metrics useful for climate-related investment • five objectives: minimize exposure to carbon emission, minimize exposure to fossil fuel emissions, minimize exposure to brown revenue (mitigation targets), maximize exposure to green revenue, maximize exposure to climate adaptation ratings (adaptation targets) • mean-variance optimization with objective function balancing exposure across all five objectives • maximization of the exposure to companies with low carbon intensity while constraining tracking error and simultaneously imposing constraints with the aim to reach all five objectives • Illustration of the developed framework with a portfolio calibrated to align with the most conservative climate model projections (respecting the 2°C scenario threshold) 	E	<ul style="list-style-type: none"> • framework for building climate strategies within public equities both mitigating the climate risk today (reducing GHG emissions, easing transition to low carbon economy) and adapting to climate risk in the future (improve the portfolio's resilience to physical impacts of climate change) • the 'mitigation and adaptation' framework presents enough flexibility to build portfolios at different levels of concentration, tracking error, and climate risk exposure • can build a portfolio which aligns with climate model projections
8	US	Do Fund Managers Misestimate Climatic Disaster Risk	S. Alok, N. Kumar, R. Wermers	2020	The Review of Financial Studies https://doi.org/10.1093/rfs/hhz143	<ul style="list-style-type: none"> • SHELDUS (climatic disasters data) • CRSP Survivor-Bias-free U.S. Mutual Fund database (actively managed, open-ended diversified U.S. equity mutual funds data) • Data period: 1995– 2016 	<ul style="list-style-type: none"> • Difference-in-differences strategy comparing the portfolio decisions of funds situated close to the disaster zone (treatment group funds) to distant ones (control group funds) • Controls for fund and time fixed effects. • Distributed lag model (testing for the absence of differential pre-trends in the data). 	E	<ul style="list-style-type: none"> • managers within a major disaster region underweight disaster zone stocks to a much greater degree than distant managers • the aversion to disaster zone stocks results from a salience bias decreasing over time and distance from the disaster, rather than the access of more relevant information by close managers • The overreaction can be costly to fund investors, especially for disaster such as: hurricanes and tornadoes

9		Hedging Climate Risk	M. Andersson, P. Bolton & F. Samama	2018	Financial Analysts Journal https://www.tandfonline.com/doi/abs/10.2469/faj.v72.n3.4	<ul style="list-style-type: none"> • CDP (carbon-related data), in partnership with Bloomberg, MSCI ESG, Trucost, etc. • CSR (carbon-related data) • MSCI Europe Index • MSCI Europe Low Carbon Leaders Index • Data period: November 2014 - January 2016 	<ul style="list-style-type: none"> • Tracking Error Minimization with a Multifactor Risk Model • allows to determine the decarbonized portfolio with minimum tracking error • ex ante reducing TE by 1) estimating factor returns; 2) estimating risk; 3) minimizing TE 	E	<ul style="list-style-type: none"> • propose investment strategy allowing long-term passive investors to hedge climate risk without sacrificing financial returns. • develop a decarbonized index, that could be assimilated to “free option on carbon. • under the BAU scenario, the low-carbon index obtains the same return as the benchmark index; but since CO2 emissions are priced, or expected to be priced, the low-carbon index should start to outperform the benchmark.
10	Mexico	Effectiveness of Weather Derivatives as a Cross-Hedging Instrument against Climate Change: The Cases of Reservoir Water Allocation Management in Guanajuato, Mexico and Lambayeque, Peru	M. Juarez-Torres, L. Sanchez-Aragon	2012	IDB WORKING PAPER SERIES IDB-WP-328	<ul style="list-style-type: none"> • Information System for Agricultural and Fisheries • National Meteorological System • Comisión Nacional del Agua • Data period: 1985 - 2012 	<ul style="list-style-type: none"> • introduction of weather derivatives into optimal water allocation model compensating producers for a precipitation shortfall • different climate change scenarios considered • Weather derivatives contracts are structured as an option on a rainfall index 	E	<ul style="list-style-type: none"> • climate change will affect the equilibrium between water supply and demand, the rigid design of water systems, institutions and infrastructure-could hinder the implementation of adaptation policies in water management for Latin American countries • weather derivatives are proposed as a complementary mechanism for the successful adoption of more efficient water allocations in irrigation districts • Weather derivatives spread risks and incorporate a better understanding of climate system behavior, strengthening irrigation districts? ability to deal with water availability and demand.

11		Price of climate risk hedging under uncertainty	A.Rubtsov, W.iXu, A. Šević, Ž. Šević	2020	Technological Forecasting and Social Change https://www.sciencedirect.com/science/article/pii/S0040162520312567	<ul style="list-style-type: none"> • S&P500 and MSCI-ESG World Leaders (monthly returns) • Berkeley Earth (monthly temperature anomalies) • Data period: 2009-2019 	<ul style="list-style-type: none"> • optimal robust investment strategy derived from the Hamilton–Jacobi–Bellman equation. • obtaintion of the price of the climate hedge instrument (as a byproduct of the optimization procedure). • estimation of the parameters of the stock price model • estimation of the welfare loss incurred by an investor due to climate change uncertainty 	E	<ul style="list-style-type: none"> • climate uncertainty reduces stock investment. • an increase in climate uncertainty decreases investor’s welfare even when climate risk hedging instruments are available.
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Appendix 4A: Literature on ESG and financing cost

IV. ESG and cost of equity										
	Country	Title	Authors	Year	Journal/ Publisher	Data sample	Used Methodology	ESG pillar	Results/ Findings	Limits
1	US	Environmental risk management and the cost of capital.	Sharfman and Fernando	2008	Strategic management journal https://doi.org/10.1002/smj.678	ESG Data Provider: United States EPA TRI data and KLD Sample: 267 U.S. firms	<ul style="list-style-type: none"> • hierarchical regression analysis 	E	Improved environmental risk management is associated with a lower cost of capital	The TRI and KLD data are limited in their ability to reflect environmental risk management accurately
2	World	Does corporate social responsibility affect the cost of capital?	El Ghouli et al.	2011	Journal of Banking & Finance https://doi.org/10.1016/j.jbankfin.2011.02.007	ESG Data Provider: KLD STATS Sample: 12,915 observations representing 2809 unique firms between 1992 and 2007	<ul style="list-style-type: none"> • Regression analysis 	ESG	Firms with better CSR scores exhibit cheaper equity financing	Results depend on the scoring method of the data provider. A robustness test using different ESG rating providers is missing
3	Word	Business sustainability performance and cost of equity capital	Anthony C. Ng and Zabihollah Rezaee	2015	Journal of Corporate Finance https://doi.org/10.1016/j.jcorpfin.2015.08.003	ESG Data Provider: MSCI ESG STATS KLD database between 1991 to 2013	<ul style="list-style-type: none"> • Regression analysis 	ESG	Firms that focus on business sustainability performance enjoy a lower cost of equity	Results depend on the scoring method of the data provider. A robustness test using different ESG rating providers is missing

4	20 World Countries	The impact of environmental, social, and governance performance on stock prices: Evidence from the banking industry	Miralles-Quirós, MM, Miralles-Quirós, JL, Redondo-Hernández, J.	2019	Corp Soc Resp Env Ma. https://doi.org/10.1002/csr.1759	ESG Data Provider: Thomson Reuters Eikon Sample: 51 commercial banks form 2005-2015	<ul style="list-style-type: none"> • Regression analysis 	All	E and G are positively and significantly related to stocks' share prices. S is negatively and significantly related to stocks' prices	Results depend on the scoring method of the data provider. A robustness test using different ESG rating providers is missing
5	Hong Kong	The Effect of Environmental, Social, Governance and Sustainability Initiatives on Stock Value – Examining Market Response to Initiatives Undertaken by Listed Companies	Lo, K. Y., and Kwan, C. L.	2017	Corp. Soc. Responsib. Environ. Mgmt https://doi.org/10.1002/csr.1431	ESG Data: constituents of HSCSI, FTSE4Good Global Index (FTSE4Good) and Dow Jones Sustainability Asia Pacific Index (DJSIAP) Sample: 48 events, 17 listed companies from 2010 to 2012	<ul style="list-style-type: none"> • Event study methodology • Regression analysis 	ESG	The market reacts more positively to ESG initiatives than sustainability initiatives	
5	World	Business sustainability performance and cost of equity capital	Ng, Anthony C and Rezaee, Zabihollah	2015	Journal of Corporate Finance https://doi.org/10.1016/j.icorpf.2015.08.003	ESG Data Provider: KLD (MSCI) Sample: about 3000 firms from 1991 to 2013	<ul style="list-style-type: none"> •Regression analysis 	ESG	Financial sustainability performance is negatively associated with cost of equity	Results depend on the scoring method of the data provider. A robustness test using different ESG rating providers is missing
7	US	Dissecting green returns	Pástor L., Stambaugh R.F., Taylor L. A.	2022	Journal of Financial Economics https://doi.org/10.1016/j.jfineco.2022.07.007	ESG Data Provider: MSCI Dataset: CRSP From 2012 to 2020	Spread between the Implied Cost of Capital (ICC) of green and brown assets.	E	Green assets enjoy lower Implied cost of capital	Results depend on the scoring method of the data provider. A robustness test using different ESG rating providers is missing

V. ESG and cost of debt (Corporate bond and bond issue)

	Country	Title	Authors	Year	Journal/ Publisher	Data sample	Used Methodology	ESG pillar	Results/ Findings	Limits
1	US	Financing The Response To Climate Change: The Pricing And Ownership Of U.S. Green Bonds	M. Baker, D. Bergstresser, G. Serafeim, J. Wurgler	2018	NBER https://doi.org/10.3386/w25194	ESG Data: Bloomberg green bond tag Sample: contains 2,083 green bonds, versus 643,299 ordinary bonds over a period of 2010-2016	<ul style="list-style-type: none"> Asset pricing framework that incorporates an investor preference for green versus ordinary bonds 	E	Green municipal bonds are issued at a premium to otherwise similar ordinary bonds	
2	EU	Corporate social responsibility: Is it rewarded by the corporate bond market? A critical note	K-M. Menz	2010	Journal of Business Ethics https://doi.org/10.1007/s10551-010-0452-y	ESG Data Provider: SAM Group Sample: 498 bonds with observed values over 38 months (end of July 2004 - end of August 2007)	<ul style="list-style-type: none"> Panel regressions in order to investigate whether there is a significant correlation between credit spreads (dependent variable) and CSR ("CSR") taking control variables into account 	E, S	CSR has not yet been incorporated into the pricing of corporate bonds.	
3	World	ESG ratings and performance of corporate bonds	S. Polbennikov, A. Desclée, L. Dynkin, A. Maitra	2016	The Journal of Fixed Income https://doi.org/10.3905/jfi.2016.26.1.021	ESG Data Provider: MSCI ESG Source of data: Barclays MSCI ESG fixed income indices	<ul style="list-style-type: none"> Statistical analysis with relevant control variables Simulation of index tracking portfolios designed to deviate from the benchmark index in terms of only the ESG score 	All	Corporate bonds with high composite ESG ratings have slightly lower spreads, all else being equal	Results depend the scoring method of the data provider

VI. ESG and cost of debt (private debt and loans)

	Country	Title	Authors	Year	Journal/ Publisher	Data sample	Used Methodology	ESG pillar	Results/ Findings	Limits
1	US	The impact of corporate social responsibility on the cost of bank loans	Goss and Roberts	2011	Journal of Banking & Finance	ESG Data Provider: KLD Research Sample: 3996 loans extended to 1265 firms over the period from 1991 to 2006.	<ul style="list-style-type: none"> Two-step method to generate optimally scaled principal components on well-defined CSR strength and concern clusters. Exploiting the bank's role as a "quasi-insider" of the firm to document nuanced responses to CSR based on the motivations of lenders 	ESG	Firms with social responsibility concerns pay between 7 and 18 basis points more than firms that are more responsible	Results depend the scoring method of the data provider

2	US	Do Shareholder Rights Affect the Cost of Bank Loans?	Chava, S., Livdan, D. and Purnaanandam, A.	2009	Review of Financial Studies	ESG Data: IRR data (G-Index) Sample: 6000 loans issued to 1274 non-financial public firms between 1990 and 2004	<ul style="list-style-type: none"> • regression analysis with the natural log of the loan spread as the dependent variable 	G	Lower takeover defenses significantly increase the cost of bank loans for a firm	
3	-	Analysts' Roundtable on Integrating ESG into Investment Decision-Making	D. Hanson, T. Lyons, J. Bender, B. Bertocci, B. Lamy	2017	Journal of Applied Corporate Finance	Panel discussion	<ul style="list-style-type: none"> • Panel discussion 	ESG	<ul style="list-style-type: none"> • high ESG scores and rankings viewed as an indicator of management "quality" • some of the world's best "business value investors," have long incorporated ESG considerations into their investment decision-making. • ESG factors can have pronounced effects on performance by generating "tail risks" that can materialize in both going-concern and default scenarios • rating agencies attempt to reflect some of these risks in their analysis, though with mixed success • Beside the "sin" sectors screening, is observed a new orientation of equity portfolios' investors towards positive sustainability factors (low carbon and gender-balanced ETFs and etc) 	no empirical evidence

4	World	Corporate sustainability performance and bank loan pricing: it pays to be good, but only when banks are too	C. Hauptmann	2017	Saïd Business School Research Papers	ESG Data Provider: Thomson Reuters Asset4 Sample: 484 unique borrowing firms and 39 unique lending banks, resulting in 1,226 loan observations from 2002 to 2015.	<ul style="list-style-type: none"> Several regressions with the loan spread as the dependent variable 	ESG	<ul style="list-style-type: none"> Borrowers with strong sustainability performance pay lower loan spreads than borrowers with weak sustainability performance, only when the lending bank exhibits strong sustainability performance. findings hold across various methodological approaches including sample splits, interaction effects, propensity score matching, and identification using within-firm and within-bank differences as well as shocks in ESG performances while controlling for a wide range of possible confounding effects 	Results depend the scoring method of the data provider
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VII. ESG and sovereign bonds

	Country	Title	Authors	Year	Journal/ Publisher	Data sample	Used Methodology	ESG pillar	Results/ Findings	Limits
1	23 OECD countries	The effect of countries' ESG ratings on their sovereign borrowing costs	P. Crifo, M-A. Diaye, R. Oueghlissi	2017	The Quarterly Review of Economics and Finance https://hal-polytechnique.archi-ves-ouvertes.fr/hal-01401718	ESG Data Provider: Vigeo Period: from 2007 to 2012	<ul style="list-style-type: none"> Panel regression model IV fixed effects model 	ESG	<ul style="list-style-type: none"> ESG ratings significantly decrease government bond spreads. ESG impact three times weaker than financial ratings effect 	

2	World	Towards a new framework to account for environmental risk in sovereign credit risk analysis	M. H. Clarvis, M. Halle, I. Mulder, M. Yarime	2014	Journal of Sustainable Finance & Investment https://doi.org/10.1080/20430795.2013.837810	ESG Data: Global Footprint Network, UNCTAD, US Energy Information Administration, World Development Indicators (WB), CIA World Factbook, IMF World Economic Outlook Database	<ul style="list-style-type: none"> Development of E-RISC framework : a framework identifying and quantifying linkages between environmental risks and macroeconomic factors relevant to sovereign credit risk the framework is divided into three components: Natural resource risks, Economic significance of resource risks, Country's economic resilience incorporates 20 qualitative and quantitative indicators across four dimensions (resource balance, trade-related and degradation related risk, financial resilience) 	ESG, E	<ul style="list-style-type: none"> Development application of a framework that aims to improve the financial rationale for assessing the materiality of environmental risk in the sovereign bond market compensate for the lack of consideration of environmental impacts on macroeconomic performance in credit risk analysis allow to improve the assessment of sovereign credit risk in light with the Basel III financial regulation requirements 	
3	20 developed countries	Environmental, Social and Governance (ESG) performance and sovereign bond spreads: an empirical analysis of OECD countries	G. Capelle-Blancard, P. Crifo, M-A. Diaye, B. Scholtens, R. Oueghlissi	2016	WP https://www.sciencedirect.com/science/article/abs/pii/S1062976917301497	ESG Data Providers: VIGEO, HSBC AM, Natexis AM , MSCI ESG Country Ratings Period: from 1996 to 2012	<ul style="list-style-type: none"> Construction of ESG index based on several indicators relating to ESG Dynamic panel regressions 	ESG, E, S and G	Countries with good ESG performance tend to have less default risk and thus lower bond spreads	

Appendix 5A: Literature on ESG and Climate change risk

	Country	Title	Authors	Year of publication	Journal/ Publisher	Summary
1	World	Impacts on the ESG and financial performances of companies in the manufacturing industry based on the climate change related risks	Hsiao-Min Chen, Tsai-Chi Kuo, Ju-Long Chen	2022	Journal of Cleaner Production https://doi.org/10.1016/j.jclepro.2022.134951	<ul style="list-style-type: none"> Since increased frequency of natural disasters (hurricanes, wildfires, droughts, floods, earthquakes, epidemics) manufacturing companies get more involved in activities related to ESG performance indicators and conduct further climate change-related (CCR) risk management through ESG. Investments in environmental performance was strengthened by CCR risk and opportunities disclosure. Besides disclosure of physical risks, further development of strategies related to transformation risk, leading to additional costs. Strengthened investments in environmental performance affect positively but decreasingly manufacturing companies' financial performance (to the point of negative impact, due to transformation costs and increased operating costs), under various ownership structure and CCR risk disclosure conditions.

2	-	Sustainable development and financial system: Integrating ESG risks through sustainable investment strategies in a climate change context	Folqué, M, Escrig-Olmedo, E, Corzo Santamaría, T.	2021	Sustainable Development https://doi.org/10.1002/sd.2181	<ul style="list-style-type: none"> • Evaluation of potential outcomes of different SI strategies aiming to reduce ESG and carbon risks • The transition to a lower-carbon economy demands more advanced investment strategies considering the most relevant solutions for reducing ESG and extrafinancial risks. • Negative screening is still the most used SI strategy • More advanced SI strategies are focusing on activities and industries with positive and measurable effect and impact on sustainability (either through climate change mitigation, SDG) • Following more advanced SI strategies would allow for integrating better practices in terms of risk control, fiduciary duty, legal compliance, competitive advantage and to comply with regulations such as the EU taxonomy regulation.
3		Sovereign rating methodologies, ESG and climate change risk: an overview	Angelova, Denitsa and Bosello, Francesco and Bigano, Andrea and Giove, Silvio	2021	WP Ca' Foscari University of Venice http://dx.doi.org/10.2139/ssrn.3841948	<ul style="list-style-type: none"> • Evaluation of sovereign credit rating methodologies and the integration of CC risk and ESG implemented by Moody's, S&P and Fitch. • Poorly described methodology, lack of rigorous explanation concerning the inherent choices relative to indicators, normalization, weighting, and aggregation processes. • Climate change risk is integrated but just as a correction qualitative factor (analyst opinion) instead of rigorous quantitative approach. • Suggests a limited relative importance of ESG and CC risk in the definition of sovereign risk. • Only Moody's proposes a description of the metrics defining ESG risks and the used data. • S&P methodologies difficult to be reproduced: unclear ESG metrics, their measurement, normalization, weighting and contribution to the sovereign rating process. • All methodologies lack a clear standardized definition of climate risk. • However, several elements from the IPCC risk framework are included in the reporting factors, but caution necessary in order to avoid double counting. • Necessity for a clear definition and harmonization of the considered time horizons in ESG risks definition, for comparability purposes.
4		Failed Theories of Change: Misperceptions About ESG Investment and Investment Efforts to Combat Climate Change	Horster, M.	2021	in Theories of Change. Sustainable Finance. Springer, Cham. https://doi.org/10.1007/978-3-030-52275-9_4	<ul style="list-style-type: none"> • Investors can play a key role in changing the real economy, but need for more sophisticated applied methods and approaches. • Considerable regulatory efforts, but with limited real effects, since they focus on equities and Green Bonds traded on secondary markets and thus do not have a direct and efficient impact on the real economy. • Efficient ESG investing demands a deep understanding of assets' specificities, dynamics and the complex interactions that can influence them. • Simple divesting (on secondary markets) can be a good way for decarbonizing a portfolio, but not the economy, as sources of ESG risks will most likely not be affected. • However, a financier (a bank, loan giver, participant in debt issuance) can impact the real economy through avoiding specific activities and the primary market. • Discrepancy between data availability and impact potential: primary markets are characterized by limited data with important impact potential; secondary markets benefit from a profusion of data but with limited impact. • Secondary market investors can also intervene through intervening during companies' board meetings (shareholder votes).
5	Canada	Green Gaps: Firm ESG Disclosure and Financial Institutions' Reporting Requirements	Jorden Dye, Murdoch McKinnon, Connie Van der Byl	2021	J Sustain Res. https://doi.org/10.20900/jsr20210006	<ul style="list-style-type: none"> • Both ESG investor requirements and firm disclosures suffer from a lack of standardization. • Failure to respond to evolving disclosure requirements can lead to divestment. • Oil and gas companies not acknowledging climate risk may reduce access to capital • Transparency should increase with climate change risks evaluations led by financial institutions

6		ESG Investing is not about saving the planet	Ken Pucker and Andrew King	2022	<p>Harvard Business Review</p> <p>https://hbr.org/2022/08/esg-investing-isnt-designed-to-save-the-planet</p>	<ul style="list-style-type: none"> • ESG ratings do not evaluate the company's impact on environment and society, but rather the effect of the latter on the company. • ESG ratings are unregulated. • Most ESG funds operate in secondary markets and thus have limited effects on real economy, concerning E and S. • ESG funds have yet to prove their superiority in terms of returns. • ESG product creation and overselling are due to the related higher fees (ESG products are more costly) • Addressing climate change issues is very different from evaluating the effects of climate risk on companies' profits. • The boom of ESG investment helps convincing that the necessary investments for the transition to a more carbon/energy sober economy will be available, but it rather reduces the pressure for necessary regulatory reforms and public- private partnerships tackling these challenges. • Solutions: 1) public-private partnerships to spur investment; 2) regulation should focus rather on outcome impacts and not on input disclosure; 3) externalities cannot be addressed properly by market based voluntary actions, necessity for a better alignment between private profit and social welfare; 4) rethinking of the effort repartition among companies, since equal efforts will not lead to equal results.
7		ESG: Hyperboles and Reality	George Serafeim	2021	<p>Harvard Business School Research Paper Series</p> <p>http://dx.doi.org/10.2139/ssrn.3966695</p>	<ul style="list-style-type: none"> • ESG cannot solve all of society's issues, but it can trigger improvements in terms of accountability and progress. • Its efficiency depends both on the interaction between market forces and public policies. • Divestment can have a limited efficiency; it needs to be combined with targeted engagement. • Up to now, ESG focused on activities, but it should rather consider outcomes. • Reporting is a necessary but insufficient condition. • Improving ESG performance can create value for companies, but it might not raise universally their performances. • Regulation is necessary but companies' intentions are also relevant. • ESG outperformance or not can be difficultly demonstrated. • Disagreement among ESG rating providers. • ESG policies implemented by companies do not involve potential changes in capital allocations. • Even if ESG is commonly adopted, there is still a necessity for developing robust management tools and control systems, incentives, and corporate culture in order to achieve tangible outcomes.

Appendix 6A: ESG literature dealing with data endogeneity

	Country	Title	Authors	Year of publication	Journal/ Publisher	Summary
1	USA	CEO power and corporate social responsibility decoupling	Yasir Shahab, Ammar Ali Gull, Tanveer Ahsan, Rizwan Mushtaq	2022	Applied Economics Letters https://doi.org/10.1080/13504851.2021.1966368	<ul style="list-style-type: none"> • Assessment of the impact of CEO power on CSR decoupling (gap between CSR disclosure and CSR performance) • CEOs power is correlated with increased CSR decoupling • Data: ASSET4, EXEUCOMP, period 2002–2017 • Methodologies: GMM, fixed effects (FE), propensity-score matching (PSM), 2SLS • IV: lagged CEO power and industry average of the CEO power
2	World	Do corporate governance mechanisms curb the anti-environmental behavior of firms worldwide? An illustration through waste management	Yasir Shahab, Ammar Ali Gull, Asad Ali Rind, Aitzaz Ahsan Alias Sarang, Tanveer Ahsan	2022	Journal of Environmental Management https://doi.org/10.1016/j.jenvman.2022.114707	<ul style="list-style-type: none"> • Evaluation of the impact of corporate governance on the level of produced waste • Higher levels of produced waste are related to board size, board independence, and the existence of sustainability committee • Gender-diverse boards allow for lower quantities of produced waste and foster waste recycling • Data: ASSET4 and WorldScope, period 2002–2019 • Methodologies: GMM, propensity-score matching (PSM), 2SLS • IV: industry averages and lagged values of corporate governance mechanisms
3	USA, UK, EU	Do socially responsible firms demand high-quality audits? An international evidence	Asif Saeed, Ammar Ali Gull, Asad Ali Rind, Muhammad Shujaat Mubarik, Muhammad Shahbaz	2020	Int J Fin Econ https://doi.org/10.1002/ijfe.2270	<ul style="list-style-type: none"> • Study on the relation between CSR and the demand for high quality audits • Companies with high CSR demand high-quality audits from external auditors • Data: ASSET4, period 2002–2016 • Methodologies: 2SLS • IV: lagged CSR and industry average CSR
4	USA	Help or Hurt? The Impact of ESG on Firm Performance in S&P 500 Non-Financial Firms	Duy Thanh Nguyen, Think Gia Hoan, Hue Gia Tran	2022	Australasian Accounting, Business and Finance Journal https://doi.org/10.14453/aabfj.v16i2.7	<ul style="list-style-type: none"> • Evaluation of ESG performance effects on companies' financial performance • ESG performance is related to higher market values and higher Tobin Q ratio • Data: MSCI ESG database , period 2018 -2020 • Methodologies: 2SLS • IV: predominant political view (democrats vs republicans states) of the company's location state
5	China	Does ESG Performance Affect Firm Value? Evidence from a New ESG-Scoring Approach for Chinese Enterprises	Xiaoling Yu and Kaitian Xiao	2022	Sustainability https://doi.org/10.3390/su142416940	<ul style="list-style-type: none"> • Assessment of the impact of ESG on firm value • Positive relation between ESG performance and firm value, positive impact also for E and S performance • Data: CSMAR database, CNRDS database, period 2010- 2019 • Methodologies: 2SLS, Heckman's two-stage estimation • IV: industry-year average of ESG composite score, industry-year average of E, S and G scores

6	China	Female Board Directorships and Related Party Transactions	Muhammad Usman, Ammar Ali Gull, Alaa Mansour Zalata, Fangjun Wang and Junming Yin	2022	British Journal of Management https://doi.org/10.1111/1467-8551.12568	<ul style="list-style-type: none"> Investigation on the role of female directors on shareholders' interest protection (reduced related party transactions) companies with female directors are less involved into RPTs, especially in the case of State Owned Companies Female directors engage only in efficient and not opportunistic RPTs Data: China Stock Market and Accounting Research (CSMAR) database, period 2005- 2018 Methodologies: 2SLS, propensity-score matching (PSM) IV: ratio female/male directors in the province, average of female directors in the industry
7	USA	Are women eco-friendly? Board gender diversity and environmental innovation	Muhammad Nadeem, Stephen Bahadar, Ammar Ali Gull, Umer Iqbal	2020	Bus Strat Env https://doi.org/10.1002/bse.2563	<ul style="list-style-type: none"> Study on the impact of board gender diversity (BGD) on environmental innovation (process and product innovation) BGD positively related to environmental innovation. Data: ASSET4, period 2002–2018 Methodologies: GMM, 2SLS, Heckman two-stage estimators IV: industry average gender diversity
8	USA	Near and dear? The role of location in CSR engagement	Husted, Bryan W. and Jamali, Dima and Saffar, Walid	2016	Strategic Management Journal https://doi.org/10.1002/smi.2437	<ul style="list-style-type: none"> evaluation of the relation between CSR engagement and cost of equity capital Companies located in areas with high levels of CSR, major cities, financial centers present higher CSR engagement and they can benefit from reduced equity financing costs Data: Compustat North America, U.S. Census Bureau's Gazetteer city files, KLD STATS, period 1998–2009 Methodologies: 2SLS IV: predicted score of CSR engagement (Predicted CSR), CSR density, CSR Density × Predicted CSR
9	USA	Revisiting the association between environmental performance and financial performance: Does the level of environmental orientation matter?	Ammar Ali Gull, Asif Saeed, Muhammad Tahir Suleman, Rizwan Mushtaq	2022	Corp Soc Responsib Environ Manag. https://doi.org/10.1002/csr.2310	<ul style="list-style-type: none"> Evaluation of relationship between environmental and financial performance Best-in-class companies demonstrate higher financial performance Data: Thomson Reuters Asset4 ESG database, Datastream and Worldscope, period 2002–2017 Methodologies: 2SLS, GMM IV: geography-based instruments (% of non-industry best-in-class, within the state companies, average within-industry-year percentile environmental performance score for all remaining companies headquartered in the same state)
10	USA	On the relation between corporate social responsibility and financial performance	Amrou Awaysheh, Randall A. Heron, Tod Perry, Jared I. Wilson	2020	Strategic Management Journal https://doi.org/10.1002/smi.3122	<ul style="list-style-type: none"> Assessment of the relation between CSR and financial performance comparatively to industry peers Best-in-class companies benefit from higher market valuations comparatively to industry peers (Tobin's Q) Data: MSCI ESG Stats (KLD STATS), Compustat, period 2003-2013 Methodologies: 2SLS, limited information maximum likelihood (LIML) IV: location-based instruments (% of non-industry peer companies, best-in-class CSR and headquartered within a 100-mile radius, average within-industry CSR ranking for remaining companies headquartered in the state)
11	China	Does gender promote ethical and risk-averse behavior among CEOs? An illustration through related-party transactions	Muhammad Umar Farooq, Kun Su, Sabri Boubaker, Ammar Ali Gull	2022	Finance Research Letters https://doi.org/10.1016/j.frl.2022.102730	<ul style="list-style-type: none"> study on the relationship between female CEOs and related-party transactions (RPTs are generally associated to signs of expropriation) Companies with female CEOs engage less into RTPs, or if they do, company's performance increases (less opportunistic RPTs) Data: China Stock Market and Accounting Research (CSMAR) database, period 2005- 2018 Methodologies: 2SLS, Heckman two-stage estimators, propensity-score matching (PSM) IV: female executives industry average, proportion female/male executive in headquarter province

Appendix 7A: Literature discussing Scope 3 emissions reporting

	Country	Title	Authors	Year of publication	Journal/ Publisher	Summary
1		Supply-chain data sharing for scope 3 emissions	Stenzel, Aurel and Waichman, Israel	2023	npj Climate Action https://www.nature.com/articles/s44168-023-00032-x	<ul style="list-style-type: none"> • Estimations of Scope 3 emissions mainly based on industry averages and approximations • Solution for more precise measures: primary data sharing along the supply chain, as will provide companies with access to data/information from their suppliers • three main obstacles for such procedure: legal and regulatory challenges, missing interoperability, data privacy concerns • solutions for obstacles
2	World	Disclosure without Solution: First Evidence from Scope 3 Reporting in the Oil and Gas Sector	Hoepner, Andreas G. F. and Schneider, Fabiola	2022	Michael J. Brennan Irish Finance Working Paper Series Research Paper https://ssrn.com/abstract=4100089	<ul style="list-style-type: none"> • Assessment of the impact of Scope 3 emission reporting on share price returns (oil and gas sector) = if investors value Use-of-Product emission reporting as a credible signal for transition risk mitigation • Data: Bloomberg , MSCI Energy Index , MSCI World Index, EIA and Reuters Eikon database, WTI Future Index, Transition Pathway Initiative, period beginning 2020- June 2020 • Methodology: difference in differences analysis • Reporting without clear actions/transition plan is not perceived as a valuable signal by investors ('signaling gone wrong' situation for oil and gas companies) • Solution: necessity to combine reporting with clear transition plans
3	World	Scope 3 Emissions: Data Quality and Machine Learning Prediction Accuracy	Nguyen, Quyen and Diaz-Rainey, Ivan and Kitto, Adam and McNeil, Ben and Pittman, Nicholas and Zhang, Renzhu	2022	USAAE Working Paper https://ssrn.com/abstract=4191648	<ul style="list-style-type: none"> • explores quality of Scope 3 emission (divergence, composition) and the predictive performance of machine-learning models • considerable divergence among data providers: Bloomberg, Refinitiv Eikon, and ISS • datasets divergence also among the reported by the companies' emissions values • companies' reporting is generally incomplete, relevant categories (use of products, processing of sold products) being less complete, comparatively to irrelevant categories (travel emissions) • Solution for more precise measures: machine learning algorithms potential to improve the prediction accuracy (6%-25%) • upstream emissions are more easily predictable than downstream emissions
4	Germany	Determining the Scope 3 Emissions of Companies	Schmidt, Mario and Nill, Moritz and Scholz, Johannes	2022	Chemical Engineering \& Technology https://doi.org/10.1002/ceat.202200181	<ul style="list-style-type: none"> • Difficulties in calculating Scope 3 emissions, as they can be usually traced only to the first supplier • Solution: Economic input-output analysis methods for estimating emissions in supply chains, as possibility to provide origin of emissions by country/ industry sector/ product group • Possibility to continuously improve the calculations through recursive methods in the supply chain

Appendix 8A: Greenwashing literature and alternatives to ESG

	Country	Title	Authors	Year of publication	Journal/ Publisher	Summary
1	North America, Europe, India, China, Australia, South Africa, Brazil, Russia	Alternative ESG Ratings: How Technological Innovation Is Reshaping Sustainable Investment	Hughes, A.; Urban, M.A.; Wójcik	2021	Sustainability https://doi.org/10.3390/su13063551	<ul style="list-style-type: none"> • Use of Tech-driven Alternative ESG ratings (data scraping and Artificial Intelligence (AI)) • Alternative to ESG: AI-based set of ESG ratings sourced from Truvalue Labs vs MSCI ESG ratings • differences in ratings are driven by: differences in ESG based on key issue selection, differences in considered data sources, differences in weightings, differences in controversy analysis • Alternative ESG ratings include higher levels of standardization, improved aggregation process and are more transparent, • risks remain
2	USA	The Agency of Greenwashing	Marco Ghitti, Gianfranco Gianfrate, Lorenza Palma	2022	EDHEC-Risk Institute Working Paper https://climateimpa.ct.edhec.edu/publications/agency-greenwashing	<ul style="list-style-type: none"> • Companies with larger boards (more efficient monitoring activity) are less exposed to greenwashing • Board independence might increase greenwashing behaviors • Voluntary disclosure is related to agency problems • Women's participation in boards presents no impact on greenwashing • Alternative to ESG measure (to capture greenwashing degree): Newsweek Green Rankings (NWG) vs Refinitiv ESG rating scores. • Greenwashing reduces firm value
3	World	Stakeholder legitimacy in firm greening and financial performance: What about greenwashing temptations?	Michael T. Lee, Robyn L. Raschke	2023	Journal of Business Research https://doi.org/10.1016/j.jbusres.2022.113393	<ul style="list-style-type: none"> • Text-data analysis (creation of ESG dictionary) • Alternative to ESG: frequency measure of ESG terms (comparatively to total words) in corporate ESG communication (weighted average) divided by Refinitiv ESG score (minus 1) • The obtained ratio measures the relative (over-) emphasis of corporate actions • Positive ratios correspond to greenwashing • Firms with low ESG more tempted to greenwash even though greenwashing is not related to financial performance
4	World	Is corporate social responsibility reporting a tool of signaling or greenwashing? Evidence from the worldwide logistics sector	Ali Uyar, Abdullah S. Karaman, Merve Kilic	2020	Journal of Cleaner Production https://doi.org/10.1016/j.jclepro.2020.119997	<ul style="list-style-type: none"> • Alternative to ESG: CSR Reporting (existence of a report and number of reports in a fiscal year) vs ESG score (Thomson Reuters EIKON) • Logistics companies with higher CSR score publish more often CSR reports and also a higher number of CSR reports • Verification of signaling theory (more CSR communication= competitive advantage) and rejection of greenwashing hypothesis

5	World	Greenwashing in environmental, social and governance disclosures	Ellen Pei-yi Yu, Bac Van Luu, Catherine Huirong Chen	2020	Research in International Business and Finance https://doi.org/10.1016/j.ribaf.2020.101192	<ul style="list-style-type: none"> • Factors that can reduce greenwashing: independent directors, institutional investors, influential public interests (lower levels of corruption), cross-listing • Alternative to ESG: ESG disclosure (Bloomberg) vs ESG performance (Thomson Reuters, Asset4) • Peer-relative greenwashing score: the difference between normalized ESG disclosure and normalized ESG transparency scores (both representing the company's relative position comparatively to its peers)
6	World	Green, blue or black, but washing—What company characteristics determine greenwashing?	Silvia Ruiz-Blanco, Silvia Romero, Belen Fernandez-Feijoo	2022	Environment, Development and Sustainability https://doi.org/10.1007/s10668-021-01602-x	<ul style="list-style-type: none"> • Proximity- visibility industries (energy, water utilities, food, beverages, textile, telecommunications ...) greenwash more • Environmentally sensitive industries (pharmaceutical, chemical, mining, metals, papers, transportation...) and those following the GRI guidelines greenwash less • Companies issuing CSR reports greenwash less • global, green, blue greenwashing = global, environmental and social • Alternative to ESG: standardized CSR disclosure discourse (Content analysis with 3 levels of weighting: 3 for monetary values, 2 for numerical values, 1 for textual sentences) vs Bloomberg ESG scores
7	Bangladesh	“Green washing” or “authentic effort”? An empirical investigation of the quality of sustainability reporting by banks	Habib Zaman Khan, Sudipta Bose, Abu Taher Mollik and Harun Harun	2021	Accounting, Auditing & Accountability Journal https://doi.org/10.108/AAAJ-01-2018-3330	<ul style="list-style-type: none"> • The adoption of GRI reporting guidelines, regulatory guidelines and Corporate social performance are correlated to higher quality of sustainability reporting (QSR), in the banking sector • Alternative to ESG: adoption of GRI reporting guidelines, regulatory guidelines and Corporate social performance levels
8	EU	ESG practices and the cost of debt: Evidence from EU countries	Yasser Eliwa, Ahmed Aboud, Ahmed Saleh	2021	Critical Perspectives on Accounting https://doi.org/10.1016/j.cpa.2019.102097	<ul style="list-style-type: none"> • Alternative to ESG: ESG performance (Thomson Reuters ESG ratings) vs ESG disclosure (Bloomberg database index) • Lending institutions value both ESG performance and disclosure (no distinction is made) • Companies with important ESG disclosure levels benefit from lower cost of debt, as well as those presenting high ESG performances • The relevance of ESG performance/ disclosure on the cost of debt is more present in stakeholder-oriented countries
9	USA	Does Greenwashing Pay Off? Understanding the Relationship Between Environmental Actions and Environmental Legitimacy	Pascual Berrone, Andrea Fosfuri, Liliانا Gelabert	2017	J Bus Ethics https://doi.org/10.1007/s10551-015-2816-9	<ul style="list-style-type: none"> • 5 environmental actions considered: environmental patents, board committees dedicated to environmental issues, environmental pay policies, voluntary government programs, environmental trademarks • Environmental actions can overcome information asymmetry on companies' environmental positioning. • Alternative to ESG: environmental legitimacy (evaluated by coded text analysis of articles in The Wall Street Journal and defined positively by environmental actions such as: patents, environmental pay policies, and environmental trademarks) • Environmental board committee, environmental pay policies, or environmental trademark and participation to the WasteWise program decrease the environmental legitimacy • Some environmental actions can increase the company's environmental legitimacy if it has strong credibility, but they can be harmful otherwise, especially if intense NGO scrutiny • studied period limitation: 1997–2001

Appendix 9A: Literature proposing solutions for ESG improvement and greenwashing

	Country	Title	Authors	Year of publication	Journal/ Publisher	Summary
1	World	An international empirical study of greenwashing and voluntary carbon disclosure	Antonio J. Mateo-Marquez, Jose M. Gonzalez-Gonzalez, Constancio Zamora-Ramírez	2022	Journal of Cleaner Production https://doi.org/10.1016/j.jclepro.2022.132567	<ul style="list-style-type: none"> • Evaluation of the impact of climate change regulations on the likelihood of firms to engage in greenwashing • Data: 2015 CDP report, Grantham Research Institute on Climate Change and the Environment (GRICCE), World Justice Project (WJP), Refinitiv Eikon Datastream, 12 countries, 1521 companies, period 2015 • Methodology: probit model • A higher number of climate change regulations affects negatively the propensity to engage in greenwashing • National stringent climate-related regulations reduce the risk of greenwashing practices • Solution for greenwashing: increase the number of climate change regulations
2	China	Relationship analysis between greenwashing and environmental performance	Kesen Zhang, Zhen Pan, Mukund Janardhanan, Imran Patel	2022	Environment, Development and Sustainability https://doi.org/10.1007/s10668-022-02381-9	<ul style="list-style-type: none"> • Assessment of the impact of Chinese companies' environmental performance (EP) on greenwashing • Data: China Stock Market & Accounting Research Database (CSMAR), "the list of government environmental protection subsidies" (Ministry of Environmental Protection of China), period 2010- 2018 • Methodology: OLS, 2SLS, D-K (Driscoll-Kraay) standard error method • Negative correlation between EP and greenwashing (signal theory) • Companies receiving environmental protection subsidies less exposed to greenwashing. • The effects on greenwashing are more pronounced for state-owned companies • Solution for greenwashing: environmental protection subsidies
3		A critical look at the ESG market	Agnes Sipiczki	2022	CEPS Policy Insights https://www.ceps.eu/wp-content/uploads/2022/04/PI2022-15_A-critical-look-at-the-ESG-market.pdf	<ul style="list-style-type: none"> • Critical evaluation of ESG and solutions for improvement • Severall issues on ESG: Misallocation of capital due to the inadequacy of ESG criteria, lack of transparency on the ESG services market; false sense of security in result of ESG rankings; insufficient regulatory oversight leading to subjectivity, opacity and unreliability of ESG data and ratings • Solutions: <ol style="list-style-type: none"> 1) wider (including both S and G components), more exhaustive and science-based criteria regulation (Taxonomy Regulation); 2) reliable sustainability reporting standards with clear compliance and enforcement arrangements under CSRD; 3) transparency, organisational and conflict of interest requirements for ESG rating providers; 4) improvement of the sustainable finance literacy; 5) foster synergies between financial regulation and companies' law and corporate regulation

4	World	Carbonwashing: A New Type of Carbon Data-related ESG Greenwashing	Soh Young In, Kim Schumacher	2021	WP Stanford Sustainable Finance Initiative Precourt Institute for Energy https://sfi.stanford.edu/publications/risk-metrics-and-management/carbonwashing-new-type-carbon-data-related-esg	<ul style="list-style-type: none"> • Carbonwashing is related to the absence of mandatory reporting frameworks • Carbon data reporting has moved from observed ex-post performance data to theoretical ex-ante performance goals • A majority of corporate capital markets relies mainly on unaudited, unverified, and largely self-reported data • Solution: Necessity of a new taxonomical framing.
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