Circular Economy, Corporate Sustainability Reporting, and Equity Risk: Evidence from European Markets

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ABSTRACT — As a response to a growing demand for sustainability-related information, companies are expanding and improving their non-financial disclosure. Moreover, both investors and regulators are becoming increasingly aware of how relevant the circular economy (CE) is to deliver on sustainable development goals; hence, the market for circular assets is growing rapidly. Given these dynamics, we investigate the relationship between a company's degree of circularity, sustainability-related disclosure, and market-based equity risk. By using a sample made of 644 entities, listed in EU-15 markets plus Switzerland, and operating in 17 different industries (mostly manufacturing), we look at sustainability-related data over a 2018-19 timespan, and market data over 2019-20. Via a two-step research methodology, we test the following hypotheses at company level: *(1)* the intensity of non-financial information disclosure positively contributes to the degree of circularity; *(2)* "core" circularity – i.e., net of the disclosure component — is negatively associated with equity risk; *(3)* the intensity of non-financial information disclosure is negatively associated with equity risk. Our results lend strong support Hp. 1, corroborating the so-called 'stakeholder theory'. Besides, we find a negative association between circularity, once cleared of its disclosure component, and measures of both total and systematic risk: hence, the CE is confirmed as a powerful de-risking factor even in absence of high-quality non-financial disclosure. Additional analyses reveal that, although not exerting any relevant influence on systematic risk, corporate sustainability reporting does enable circularity to trigger de-risking, thereby acting as a powerful "mediator". Our findings would suggest managers to actively engage in the transition toward more circular business models and practices, as well as recommend investors to boost the circularity of their portfolios.

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1. Introduction

A growing number of entities is currently reporting on corporate sustainability. Just to mention a recent analysis, out of the 5,200 large corporations surveyed by KPMG (2020), roughly 90% were found to engage therein. Even in absence of a commonly agreed definition, corporate sustainability reporting is generally understood as the disclosure of environmental, social and governance (ESG) information and data, alongside financial ones. Such view is upheld by the European Commission's proposal for a Directive on that subject, where issues pertaining to all pillars — e.g., the protection of human rights and the contrast to corruption — are explicitly mentioned.

The literature has identified two main drivers for this recent trend (Bini & Bellucci, 2020). On the one hand, policymakers are mandating both financial and non-financial entities to disclose sustainability-related information. On the other, stakeholders — mostly investors, but customers, suppliers and employees too — tend to require an increasing amount of sustainability-related information, deeming ESG factors to be a relevant source of non-financial risk.

More in general, a growing body of literature has been investigating both the relationship between non-financial information disclosure and sustainability performance, as well as the association between sustainability reporting and financial performance, in terms of costs of capital, company valuation and stock returns. However, just a few of these studies are focused on measures of market risk, either total or the systematic component thereof. Besides, although the financial performance of sustainable assets has been receiving significant academic attention in the past two decades, the effect on risk jointly played by sustainability performance and disclosure remains under-explored.

Finally, researchers have largely neglected the specific circular economy (CE) topic, as well as the financial performance of circular assets (i.e., securities issued by companies adopting circular business models). In this respect, Zara et al. (2020) found that publicly-traded stocks of circular companies enjoy both lower volatility and higher risk-adjusted performance.

This work aims to close such gaps, thereby shedding some light on the entity-level relationship between sustainability reporting, degree of circularity, and risk. Also, understanding whether sustainability reporting has an influence on how a company performs is vital to shape public policies, *a fortiori* in the light of investors' surging demand for knowledge. In fact, market players are attaching increasingly high value to the information on companies' sustainable business practices, which are regarded as both a source of value creation and a tool to tackle sustainability risks (connected to purely financial ones, too).

We use data on manufacturing companies whose stocks are traded in EU-15 markets, plus Switzerland. This choice reflects the fact that the European Union has taken significant regulatory steps to enhance sustainable business practices, and reporting thereof, at least for listed companies.

Furthermore, Circular Economy principles have been promoted at the European Community Level by means of the Circular Economy Package[1], initially launched in 2015 and revised in 2020.

The research methodology adopted is conducted in two stages. Firstly, the hypothesis of a positive association between quality of sustainability reporting practices and companies' degree of circularity is tested. Afterwards, measures of both total and systematic risks are regressed against the residuals of the first step regression, which represent the companies' degree of circularity net of the effects of information disclosure. In addition, different specifications of the second step have been developed to further investigate and compare the specific contributions offered by each factor, i.e., degree of circularity, non-financial information disclosure, and residuals, to explaining the differences in companies' financial risk. Finally, a dominance analysis has been performed to examine the relative importance of the variables under investigation.

The main contribution of this thesis is to provide a better understanding of two closely interrelated matters: the relationship between degree of circularity and level of risk, and the association between non-financial disclosure and level of risk.

This remainder of this work is structured as follows. Section 2 provides a theoretical and regulatory background in respect of corporate sustainability reporting; Section 3 reviews the extant literature, with a focus on risk; Section 4 describes the methodological approach and shows the descriptive statistics from our sample; Section 5 presents the econometric modelling; Section 6 reports the empirical findings. Finally, Section 7 discusses the conclusions and suggests potential avenues for future research.

2. Background

2.1. *Theoretical framework*

Upon its very inception, the idea of sustainability was not tackled on a comprehensive basis but looking at standalone "pillars" instead: namely, the environmental, the social, and the economic one. For long time, it has been mainly tied up to the widespread concerns on global environmental problems and resource scarcity (Giovannoni & Fabietti, 2013). In particular, while environmental concerns and legislation date back to several decades ago, the social dimension has not been receiving the same amount of attention; also, the literature has hitherto failed to draw up a commonly agreed definition. Nevertheless, in the so-called *Brundtland Report*, the United Nations (1987) did provide the first-ever definition of sustainable development; that is, "development that meets the needs of the present today without compromising the ability of future generations to meet their own needs". Such

[1] The Circular Economy Package was revised in 2020 as part of the broader set of policies of the European Green Deal with the objective of decoupling economic growth from the overconsumption of natural, scarce resources.

definition encompasses all the key dimensions of sustainability: namely, economic, environmental, and social, thus favouring an integrated approach that is fundamental to address the tensions, trade-offs and synergies that may arise among all the three. The extant literature has investigated at length the tensions between the economic dimension, on the one hand, and the social and environmental ones, on the other. Nonetheless, tensions might arise also between the last two. Therefore, separately considering the three dimensions would hinder the right management of these potential fault lines, leading to a drift in favour of one single dimension.

As sustainability-related matters started receiving growing attention, companies began to investigate how they could apply the concept of sustainability to business models and strategies. Corporations have always had a pivotal role in the transition towards a more sustainable economic model, given that they are regarded as both the main source of large-scale innovations, which are necessary to support the shift to sustainable development, and the primary culprits of environmental deterioration and social inequalities (Gray, 2010). Hence, the public opinion acknowledged the importance of companies' engagement in the path towards a more sustainable economic model; also, policymakers started to urge entities to be more accountable for the consequences their economic activities have on the environment and society at large.

Taking inspiration from the Brundtland Report, at business level, sustainability was interpreted as meeting the needs of current stakeholders without compromising the ability to meet the needs of future ones (Dyllick & Hockerts, 2002). However, at its very first stage, corporate actions took the shape of *corporate social responsibility* (CSR)[2], intended as those policies and practices mitigating the negative impacts that companies have on the environment and society. More narrowly, 'corporate sustainability' relates to a company's integration of economic, social, and environmental concerns and goals in business operations, while considering the interest and claims of its (present and future) stakeholders (Ogrean & Herciu, 2018).

Given these premises, the concept of CSR may be paired with that of a "weak form" of sustainability, which does not challenge the 'business-as-usual' by fostering a breakthrough change in economic development, but rather propose an amended version of the traditional approach (Bebbington, 2000). In fact, CSR is often interpreted in terms of compliance with existing laws and regulations. Nonetheless, sustainable strategies have evolved throughout time: in their most advanced stage, corporations began to explore the business opportunities offered by sustainable development and how to leverage them in order to gain competitive advantages from differentiation and innovation (Baumgartner & Ebner, 2010). In other words, they started including sustainability within their corporate strategies (Derqui, 2020). In particular, it was the 1970s that witnessed the emergence and spreading of social reports, published by firms in the United States and Western Europe (Kolk, 2010). In the 1980s, then, environmental reporting quickly became widespread (Daub, 2007), mainly in pursuit of the goal of

[2] Although the CSR acronym is increasingly meant — particularly in the regulatory field — as 'corporate sustainability reporting', in this paper we employ it only with its traditional meaning of 'corporate social responsibility'.

providing information on ecological effectiveness, i.e., the level of corporate environmental impacts (in terms of CO_2 emissions, types and amounts of waste, etc.).

This approach requires a full commitment from entities and an integrated approach, too, for the three dimensions of sustainability to be addressed simultaneously. This is a crucial aspect thereof; moreover, it is apparent from the fact that, even though corporate sustainability lacks a unique and clear definition, there is an implicit consensus among academicians and practitioners about the composite and multifaceted construct encompassing all the three pillars of sustainable development (Hahn & Figge, 2011). The need for an integrated approach to corporate sustainability was reflected on corporate sustainability reporting, too. Thus, environmental aspects first and social issues later were included in annual reports alongside economic ones (Bini & Bellucci, 2020), surpassing the one-dimensionality oriented communication activities.

Back in 1994, John Elkington coined the phrase *Triple Bottom Line* (TBL, 3BL), which refers to an accounting methodology that escapes the traditional assessment of a financial bottom line only but rather measures the economic, environmental and social values that companies add or destroy. The TBL concept gained great recognition among corporations that started to address issues related to sustainable development. However, TBL accounting has not escaped criticisms over time. The most important ones include its vagueness: none of the major advocates of the TBL have actually proposed, presented, or sketched a methodology to compute a net environmental or social bottom line (Macdonald, 2004). Moreover, according to the author himself, the tool has not yet generated the intended effect: that is, trigger a systemic change of the current economic model; nor has it yielded any significant influence on the behaviour of businesses. By contrast, it has *de facto* turned into a mere accounting tool (Elkington, 2018), except for a few business cases that have interpreted it correctly.

2.2. *Accounting standards and regulation*

Introducing the TBL concept was not the only attempt to create reporting standards that emphasized the multidimensional nature of sustainability. In fact, its core concept of managing, measuring, and reporting the environmental, social, and economic impacts of corporations would permeate all the subsequent non-financial reporting initiatives and guidelines (Milne & Gray, 2013). Then, back in 2000, the Global Reporting Initiative (GRI) launched the first sustainability reporting guidelines, categorizing standards into the three sustainability pillars. Among the most recent initiatives, the standards developed by the Sustainability Accounting Standards Board (SASB), the International Integrated Reporting Council (IIRC), the Climate Disclosure Standards Board (CDSB) and the Climate Disclosure Project (CDP) are most noteworthy. However, the proliferation of such standards and guidelines has given rise to some major issues that will spur further evolution of sustainability reporting in the near future.

First, there is still a lack of comparability between sustainability reports: in fact, companies often fail to identify the 'material' (i.e., key) issues. With regard to non-financial information, *materiality* carries a twofold connotation: *financial*, as companies are required to disclose information on those ESG aspects that affect corporate financial performance and, thus, are deemed to be salient for a "reasonable" investor interested in the pursuit of financial value (Barman, 2018); or *environmental and social*, which requires companies to disclose information on the impact of their activities on the environment and society-at-large. There are, too, other issues related to the identification of material information: namely, sector-specific materiality and stakeholder's engagement in developing sustainability matrices. The risk is to disclose information that do not satisfy stakeholders' information needs and creating the risk of an information overload. Also, this is a threat to the reliability of sustainability reports, since undertakings can take advantage of the regulation gap in the field to adopt greenwashing practices.

Moreover, the amounts invested in accounting and information management systems remain limited, as small and medium-sized enterprises (SMEs) have hitherto been quite reluctant to voluntarily report on sustainability matters (Herzig & Schaltegger, 2011), despite constituting the largest portion of the economy globally and, thus, accounting for the most of social and environmental effects of businesses.

2.3. *Regulation*

The adoption of comparable and consistent reporting standards is crucial to employ corporate sustainability as an efficient market mechanism for improving social and environmental performance on a macro-scale (Tschopp & Nastanski, 2014). Hence, both supranational organisations and national governments have started introducing legal requirements for non-financial information reporting.

Finally, since the United Nations (2015) established the Sustainable Development Agenda with a global outreach, large corporations have been strongly encouraged to take a proactive role in the achievement of the 17 main *Goals* (Scheyvens, Banks, & Hughes, 2016). Similarly, in the realm of sustainability reporting, an increasing number of companies began to voluntarily disclose information on their responsible business practices, as a means to regain trust from stakeholders in an era marred by some accounting and governance scandals. At that point, phrases such as 'sustainability report', 'corporate social responsibility report' and 'corporate citizenship report' were used interchangeably, nor were there any prevailing standards or guidelines. By means of these reports, despite the lack of comparability, investors and stakeholders in general could at least partially assess the positive and negative impacts corporations had on environment and society.

Despite all the shortcomings that prevented non-financial information from reaching the same level of importance and recognition of financial information (Eccles, Krzus, Rogers, & Serafeim, 2012), an increasing number of corporations are currently disclosing non-financial information to the public.

According to data from CorporateRegister.com[3], the number of reports grew from 26 in 1992 to 143,325 in 2021. The interest shown by both internal and external stakeholders has been growing. Therefore, several reporting standards and non-mandatory guidelines — issued by both governmental and non-governmental organizations, based on practical experience — have arisen over time (Herzig & Schaltegger, 2011).

On 1 January 2018, Dir. 2014/05/EU — so-called *Non-Financial Reporting Directive* (NFRD) — eventually came into force. Aiming not to overburden SMEs with compliance costs, said piece of legislation has since applied to a wide number of large entities, considering that several EU Member States have also expanded the perimeter of undertakings whereto it applies. Pursuant to it, both financial and non-financial large corporates are now required to either integrate their management report or produce a separate sustainability report with relevant and material information on their policies, outcomes and risks related to the aforementioned sustainability matters.

In April 2021, the European Commission published a proposal for a new piece of legislation amending the NFRD, named *Corporate Sustainability Reporting Directive*. Compared to the existing provisions, it would expand the scope of application to all large companies, whether they are listed or not, regardless of their number of employees; as well as to listed SMEs, regardless of their size, with the sole exception of listed micro-enterprises. Also, Member States would no longer be allowed to exempt undertakings form the obligation to include sustainability-related information in the annual management report, and doing this in a harmonised format. Moreover, the amendments would introduce an EU-wide assurance requirement for sustainability reports; enhance the development of detailed reporting standards for sustainability-related information; and scrap a one-size-fits-all approach, thereby subjecting SMEs to differentiated provisions, pursuant to the 'think small first principle'.

3. Literature Review

The Circular Economy (CE) framework offers a viable solution combining a compelling business rationale and an economic system that is 'regenerative' and 'restorative' by design (Ellen MacArthur Foundation, 2012a). Moreover, as pointed out by Ghisellini, Cialani, & Ulgiati (2016), the CE framework also promotes innovative employment opportunities and contributes to the creation of social equity, both within and between current and future generations. Therefore, the CE can be thought of as a new economic paradigm offering an effective "toolbox" to deliver on many of the objectives enshrined in the United Nations' SDGs (Schröder, Anggraeni, & Weber, 2018).

[3] CorporateRegister.com is a global online directory of corporate responsibility (CR) reports past and present, across all sectors and including all types of organisations.

The CE paradigm is based on closed loops rather than linear processes and relies on three main levers of value creation:

— use of regenerative and restorative inputs to reduce the consumption of scarce natural resources;
— increase of product efficiency to optimise product usage and maximise the potential thereof;
— design of end-of-life management to eliminate waste and pollution.

Through these levers, companies can reduce costs, increase revenues and hedge against external shocks, such as growing trends and volatility in commodity prices and disruptions in linear supply chains (Bocconi University, Ellen MacArthur Foundation, & Intesa Sanpaolo, 2021). These three levers have been operationalised through the conceptualisation of five circular business models: namely, 'circular inputs', 'product life extension', 'product as a service', 'sharing economy' and 'resource recovery' (Lacy & Rutqvist, 2015)

The relevance of the CE topic for this work is related to the opportunities that it offers to the financial sector from a risk-based perspective. In particular, thanks to the lower exposure of circular companies to the price of virgin raw materials, the providers of financial services/activities that invest in circular asset classes can benefit from a de-risking effect, with positive spillover effects at systemic level (Zara, 2020). Moreover, circular business models face risks that are intrinsically different from their linear alternatives: with regard to the transition, the net balance between the newly- taken risks and the linear ones against which companies are hedged is expected to be positive. Finally, circular asset classes are hedged against the risks entailed by the progressive shift of the costs of negative externalities from society and the environment toward companies and economic actors, driven by public policies.

In the financial sector, it seems that companies have ultimately come to acknowledge these opportunities. In fact, according to an analysis conducted by the Ellen MacArthur Foundation (2020), the size of equity funds invested in circular economy has witnessed a tenfold increase thanks to both the transition undertaken by many public companies and the listing of emerging circular companies.

In the following paragraphs, we review the extant literature based on the three main fields of investigation it has been addressing:

— the relationship between non-financial information disclosure and non-financial performance;
— the relationship between corporate sustainability performance and risk;
— the relationship between non-financial information disclosure and risk.

3.1. *Non-financial information disclosure vs. corporate sustainability performance*

The extant literature provides a relatively poor understanding of the relationship between sustainability disclosure and performance, from both a theoretical and an empirical perspective. With regard to the former, the driving forces of sustainability-related reporting advances three main theories: namely, the 'agency', the 'legitimacy' and the 'stakeholder' ones (Zamil, Ramakrishnan, Jamal, Hatif, & Khatib, 2021).

Agency theory posits that companies do voluntarily disclose non-financial information in order to reduce the agency costs stemming from the problem of information asymmetries (see par. 3.3 below). Thus, companies with a good sustainability performance would engage in voluntary disclosure in order to signal it to the market, distinguishing themselves from those peers that perform poorly in terms of sustainability.

Legitimacy theory, instead, holds that companies do voluntarily engage in sustainability disclosure to conform to the expectations of their stakeholders. The idea is that entities cannot operate in a *vacuum;* hence, to make their business viable and sustainable, they need to gain social approval and legitimize their operations within the environment in which they operate through an implicit social contract. Therefore, disclosing information on sustainability-related matters will allow companies to show that they are consistently abiding by the contract. In fact, if a company is poorly perceived by the surrounding community, stakeholders may not consent on accessing the resources needed to run the business, possibly endangering the survival of the firm (Hahn & Kühnen, 2013).

However, this theory suggests a negative association between sustainability performance and reporting. In fact, companies with a poor sustainability performance would have a stronger incentive to disclose non-financial information, for they need it to mitigate the negative consequences yielded by their loss of legitimacy.

Finally, pursuant to the *stakeholder theory*, companies are accountable for their actions and operations not only to shareholders but to a much larger audience that includes third parties that can either influence or be influenced by corporations (i.e., employees, customers, governments, etc.). Thus, non-financial information disclosure is a fundamental means for catering to the information needs of those stakeholders that could have an economic impact on the company (Omran & Ramdhony, 2015).

While legitimacy theory posits a negative relationship between sustainability performance and disclosure, both agency and stakeholder theories support a positive association between the two (Hummel & Schlickb, 2016).

However, from an empirical standpoint, prior research has yielded mixed results: some studies find no significant relationship, others a positive association, others still a negative one (Herbohn, Walker, & Loo, 2014). Moreover, the extant literature has mainly focused on environmental matters only (Clarkson, Yue, Richardson, & Vasvari, 2008; Qian & Schaltegger, 2017; Luo & Tang, 2014), which represent a subset of the broader sustainability topic. Finally, researchers have always encountered difficulties in measuring both companies' sustainability performance and disclosure, and many different approaches have been applied (e.g., metrics provided by specialized agencies, environmental disclosure indicators, content-based measures). These issues might have played a role in the mixed empirical evidence found by prior research.

The latest research in the field has attempted to reconcile the different theories by focusing their studies on the *quality* of sustainability-related information disclosure, rather than the mere quantity thereof. In particular, the hypothesis is that companies characterized by superior sustainability

performance tend to publish higher-quality sustainability reports, which poor sustainability performers are unable to mimic (Hummel & Schlickb, 2016).

3.2. *Corporate sustainability performance vs. risk*

Recent research has focused on the relationship between corporate sustainability performance (CSP) – operationalized and evaluated through the adoption of the ESG framework – and corporate financial performance (CFP), traditionally measured in terms of either market value or cost of capital. Moreover, several of these studies focused on different specific dimensions of the ESG framework (E, S or ES). Even though results are inconclusive, most of the studies in the field find a positive association between CSP and CFP, as outlined by some recent meta-analyses and systematic literature reviews (Friede, Busch, & Bassen, 2015; Revelli & Viviani, 2015). Moreover, it is worth mentioning that differences in results could be linked to both diverse context of research (e.g., time, country and industry) and disparate corporate sustainability measurement frameworks (Gregory, Tharyan, & Whittaker, 2014).

Gregory, Tharyan, & Whittaker (2014) furtherly investigate the determinants of the positive association between CSP and CFP, separately examining the impact of ESG on a company's cash flow, risk, and growth. Firstly, superior sustainability performers benefit from higher cash flows in the long run thanks to improved customers' relationship, increased brand equity and reputation, and a more efficient resource use, as well as a better innovation management. Corporate sustainability also generates more stable (i.e., less volatile) cash flows, thanks to its effective mitigation action on operational risks (e.g., reduced risk of legal disputes, potentially ending up with fines, increased talent attraction and retention). Finally, they show that superior sustainability performers enjoy better growth prospects thanks to their sustained competitive advantages.

As long as risk is concerned, the literature has mainly focused on the reduction of firm-specific (i.e., idiosyncratic) risk. In recent years, however, a growing body of literature has shown interest in systematic risk too (Giese, Lee, Melas, Nagy, & Nishikawa, 2019). In particular, these authors argue that companies engaged in sustainable business practices are better hedged against the negative impacts of adverse macroeconomic circumstances by virtue of a more stable relationship with stakeholders. In accordance with this line of reasoning, Godfrey, Merrill, & Hansen (2008) showed that more sustainable companies experience a smaller loss of shareholders' value in case of negative events.

However, the few studies that are specifically focused on the relationship between sustainability performance and market-based risk measures, such as total market risk, systematic risk, and idiosyncratic risk (Sassen, Hinze, & Hardeck, 2016), provide mixed and ambiguous evidence.

Furthermore, the research is even more scarce when considering the specific topic of CE within the broader realm of sustainability. In this sense, the research conducted by Zara *et al.* (2020) carries a relevant contribution. In fact, through an analysis of the relationship between stocks' degree of circularity and their absolute and systematic risk (i.e., the standard deviation and the market beta,

respectively), they conclude that a company's level of risk is a declining function of its degree of circularity. Furthermore, they contribute to the research in the field by developing a new indicator to assess a company degree of circularity. In fact, even though measurement frameworks at macro- (i.e., national/regional) and meso- (i.e., industry/supply chain) levels, had already been developed (Linder, Sarasini, & van Loon, 2017), they have addressed a gap in the literature with respect to circularity indicators at company level.

3.3. *Non-financial disclosure vs. financial performance*

One of the underlying assumptions of the idea of efficient capital markets is perfect information (Modigliani & Miller, 1958), i.e., that all market participants have the same information all the time. This assumption reflected the neoclassical theory of perfect competition, pursuant to which all the information regarding market conditions is always available to all market participants. However, information is rarely perfect: hence, markets are often tattered by 'imperfections' (or 'frictions'), whereof one of the roots is the widely acknowledged problem of information asymmetry (IA). The latter arises whenever one subject of a transaction possesses greater material knowledge than his counterparty.

The relationship between companies' insiders (e.g., managers) and their stakeholders (e.g., investors) is by its very nature marred by IA (Ghio & Verona, 2020). IA arise because companies' insiders hold an intrinsic information advantage in respect of financial performance, managerial practices and future prospects of the company they are running; hence, they might take advantage of the perquisites associated with such information distribution to either direct capital toward their company or "expropriate" the value of investors' financial pledges (Han, Kim, Lee, & Lee, 2014; Bank & Lawrenz, 2005).

Thus, this relationship lends itself well to the applicability of the two main forms of the asymmetric information problem in business environments, namely the problems of *adverse selection* or 'lemons[4]' problem – named after the theory put forward by Akerlof (1970) – and *moral hazard*.

The lemons problem theory goes as follows: if market participants lack the necessary information to make rational decisions that maximise their utility function, they will value all companies at an equal average value. In fact, there will be buyers that agree to the seller at the lowest price, unaware that they are investing in a low-quality asset that they would have otherwise paid even less. In parallel, good investments will be undervalued because buyers, unable to discriminate between good and bad investments, will not be willing to pay a price higher than the one paid for the low-quality product.

Unlike adverse selection, moral hazard occurs after an agreement on the transaction has been reached. It is defined as a situation in which one of the two parties of a transaction takes actions with a higher level of risk because it does not bear their consequences. One of the special forms of moral hazard is

[4] In American slang, a lemon is a car that is found to be defective after it has been bought.

the *principal-agency theory* (Dutta & Radner, 1994). According to the principal-agency theory, an agency relationship is: *…a contract under which one or more persons (the principal(s)) engage another person (the agent) to perform some service on their behalf which involves delegating some decision-making authority to the agent. If both parties to the relationship are utility maximisers, there is good reason to believe that the agent will not always act in the best interests of the principal* (Jensen & Meckling, 1976). In this case, managers would clearly play the role of agents, and investors that of principals. An additional issue consistent with agency theory is that managers and investors interests might conflict, leading to opportunistic behaviour by managers (Healy & Palepu, 2001).

In order to both allow stakeholders to make informed decisions and enable investors to control managers and prompt them to act in their interests, there are different alternative mitigating solutions, such as optimal contracts (e.g., compensation agreements and debt contracts), the institution of a board of directors, intermediary agents (i.e., financial analysts and credit agencies) and companies' disclosure of financial and non-financial information in regulated reports (Healy & Palepu, 2001). These methods are labelled *corporate control mechanisms* and may be classified into two major categories: internal vs. external mechanisms. Among them, one of major interest within the scope of this work is that of corporate disclosure (Bushmana & Smithb, 2001).

Corporate disclosure is the provision of internal information to the external world, including financial figures, narratives, mandatory provisions required from the law, and insights voluntarily made public (von Alberti-Alhtaybat, Hutaibat, & Al-Htaybat, 2012).

Despite the growing interest shown by academia and practitioners toward the topic of non-financial information disclosure, the extant literature provides limited evidence on the relationship between sustainability reporting and corporate financial performance (Benlemlih, Shaukat, Qiu, & Trojanowski, 2018).

Nonetheless, a few studies have been published on the capital market implications of extensive and objective non-financial information disclosure. Most of these works revolve around the (negative) association between sustainability-related information disclosure and the cost of capital (Dhaliwal, Zhen Li, Tsang, & Yang, 2011; Orens, Aerts, & Cormier, 2010). Pursuant to agency theory, if companies do not disclose an adequate level of information, investors will demand higher returns for bearing either monitoring costs or costs of uncertain future pay-offs from their investment, which thereby incorporates a non-diversifiable risk. Therefore, firms with a higher level of disclosure benefit from a lower cost of capital (Healy & Palepu, 2001).

Furthermore, Cheng, Ioannou, & Serafeim (2014) argued that firms with better corporate sustainability information disclosure face lower capital constraints. Pursuant to stakeholder theory, companies that disclose ESG information will benefit from enhanced visibility and stronger stakeholders' relationships, leading to improved competitiveness and performance and, in turn, to easier access to external financing (Cortesi, 2020).

Some evidence on the negative relationship between non-financial information disclosure and risk comes from country-specific studies. Benlemlih *et al.* (2018) examine the relationship between environmental and social disclosures, on the one hand, and risk, on the other, in terms of total, systematic and idiosyncratic risk, based on a dataset of UK listed firms. Their findings support the hypothesis of a negative association between non-financial information disclosure and total and idiosyncratic risk. However, contrary to expectations, no statistically significant relationship arises between environmental and social disclosure and systematic risk. This allows the authors to conclude that, while non-financial information disclosure can enhance a firm market value, it is driven by a reduction not in the company's exposure to market fluctuations but in the specific component of risk instead. Inspired by Benlemlih *et al.* (2018), the study of Alsaifi, Elnahass, Al-Awadhi, & Salama (2021) confirm the negative relationship between sustainability reporting and risk in UK-listed firms, focusing on the specific topic of carbon disclosure. It may be concluded that UK-listed firms with better non-financial information disclosure exhibit lower performance volatility.

A geographically broader dataset – made of Europan manufacturing firms – is employed by Tzouvanas, Kizys, Chatziantoniou, & Sagitova (2020). Yet, the focus of this study has been narrowed down to the association between environmental disclosure and idiosyncratic risk only. Their findings confirmed the claim of a negative relationship between environmental disclosure and idiosyncratic risk, justified by both legitimacy and stakeholder theories.

In conclusion, the literature review shows considerable disagreement about the relationship between corporate sustainability performance and non-financial information disclosure. Additionally, there is limited evidence on the association between stock price volatility and companies' sustainability performance. Besides, very few work focus on the specific topic of CE. Finally, the research on the financial implications of corporate sustainability disclosure has tended to focus on the relationship with firm value and growth, rather than the volatility of stock returns.

As the CE has gained traction – in academia, business world and in the debates of policymakers – and the extent of disclosure has grown, there is certainly a need for further empirical work on the relationship between corporate sustainability reporting, degree of circularity, and risk.

4. Empirical analysis

4.1. *Research design*

Our goal is to investigate the relationship between non-financial corporate disclosure, degree of circularity and equity risk. A two-step statistical approach is implemented:

(1) first, we assess the relationship between a company's commitment to non-financial disclosure and its degree of circularity;

(2) then, we clear a company's degree of circularity from its disclosure-related component; then, we investigate how circularity — whether 'total' or its 'core' version only — does affect equity risk.

A company's degree of circularity is estimated through the revised version of the Circularity Score (CS) proposed by Zara, Bellardini, & Gobbi (2021), which is built upon Thomson Reuters ASSET 4 (TR-A4) ESG data. Its value ranges between 0 (least circular) and 1 (most circular). Information disclosure variables are considered either on a standalone basis or combined into factors resulting from a Principal Component Analysis (PCA). To assess the level and quality of disclosure, we perform a content analysis of those data that have been retrieved to compute the CS. Additionally, we consider whether a company does integrate its non-financial reporting into the traditional financial statements (e.g., in a section akin to the 10-K's *Management Discussion & Analysis*). Finally, following La Porta, Lopez-de-Silanes, & Shleifer (2008), we control for the legal traditions — i.e., English (common law) or French, German, Scandinavian (civil law) — of the country where a company is headquartered, based on the assumption that a higher investors' protection is associated with a higher quality of disclosure.

Based on the findings from the extant literature, we expect that companies exhibiting a higher degree of circularity and a higher quality of non-financial disclosure do benefit from lower equity risk. This is grounded on the evidence that investors have been attaching growing value to information on sustainability-related matters, as they perceive them as a major source of risks that can affect their future financial performance. Hence, the relationship between non-financial corporate disclosure, degree of circularity and equity risk is explored by testing three hypotheses:

Hp. 1 — *For a company, the intensity of non-financial information disclosure positively contributes to the degree of circularity.*

Hp. 2 — *For a company, 'core' circularity – i.e., net of the disclosure component — is negatively associated with equity risk.*

Hp. 3 — *For a company, the intensity of non-financial information disclosure is negatively associated with equity risk.*

4.2. *Sample construction*

Our sample is made of 644 companies — retrieved from the Orbis database — that match the following criteria, set forth by Zara et al. (2020):

(a) being listed in EU-15 markets[5], or Switzerland. This geographical focus acknowledges the pioneering role played by the European economic system in respect of the transition from linear to circular business models, driven both by private and public initiatives. At public level, it is worth mentioning the *Circular Economy Action Plan*, which sets forth provisions in respect of products' design, production processes and sustainable consumption, aiming to improve waste prevention and increasing resources' usage (European Commission, 2020);

(b) operating in the manufacturing, construction, metal mining, oil & gas extraction and utilities sectors, pursuant to the Standard Industry Classification (US SIC) system[6]. The choice of the industries must be traced back to the suitability of these sectors for the promotion and adoption of circular business models, as they use resource-intensive technology and are instrumental for climate change;

(c) having accounts available over the 2018-2019 time horizon; that is, allowing to compute their CS for at least one of the two fiscal years.

With regard to the object of a company's business, pursuant to US SIC, we selected 15 two-digit industries from Division D (*Manufacturing*), 2 industries from Division B (*Mining*), 3 from Division C (*Constructions*, fully covered), and 1 from Division E (*Transportation, Communications, Electric, Gas, and Sanitary Services*), for a total amount of 21 two-digit industries. Then, by reconciling — shown in **Table 1** — between US SIC and the Sustainable Industry Classification Standards (SICS) issued by the Sustainable Accounting Standards Board (SASB), and following both mergers and breakdowns, we ended up with identifying 19 industries pursuant to the latter classification.

[INSERT TABLE 1 HERE]

By jointly applying *(a)* and *(b)*, we get an investable universe made of 2,028 entities; then, following the application of *(c)*, we end up with 644 companies in 17 industries, as two of them — namely, *Agricultural Products* and *Building & Furnishing Products* — turn out being not populated by any firm. More in detail, we computed the CS for 622 companies relative to 2018 and 638 companies relative to 2019, whereas 616 do exhibit that measure for both years.

The CS coverage remains very limited: in fact, because of it, the final sample is just 31.75% of the investable universe. However, the availability of ESG data did score some gains vis-à-vis Zara et al.

[5] The 'EU-15' phrase denotes those 15 countries that were members of the European Union between 1 January 1995 and 30 April 2004: namely, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

[6] It is a system that assigns companies a four-digit numerical identifier on the basis of their primary line of business. Thus, each sector has a unique identifier. The SIC system arrays the economy into 11 divisions, that are divided into 83 2-digit major groups, that are further subdivided into 416 3-digit industry groups, and finally disaggregated into 1,005 4-digit industries.

(2021), as we were able to compute the degree of circularity for one more company relative to 2018, and 47 additional companies relative to 2019. This suggests that the disclosure of non-financial information has been growing over the last years.

4.3. *Degree of circularity*

The Circularity Score (CS) is a quantitative and concise metric proposed by Zara et al. (2020) to measure the degree of circularity at company level: that is, the extent whereto companies engage in circular business strategies and operations.

The CS results from an algorithm built upon 164 *Indicators*, retrieved from the ESG section of Thomson Reuters Datastream[7] and selected based on their relevance to measuring a company's degree of circularity. Also, they are classified in seven categories (namely, *Emissions*, *Resource Use*, *Innovation*, *Agenda 2030*, *Community*, *Product Responsibility*, and *Disclosure & Signalling*), which are in turn organized into 4 Pillars (namely, *Circular Inputs*, *Product Usage*, *End of Life*, and *Disclosure & Signalling* **(Table 2)**.

[INSERT TABLE 2 HERE]

The first three reflect those of the CE framework: namely, the introduction of renewable and regenerative resources, the circulation of products and materials and the design of products that can be easily separated in their materials and components at the end of their life cycle. The fourth Pillar, instead, is intended to measure the level of sustainability-related information disclosure and the commitment to sustainability goals that might contribute to the transition to a circular economy.

The measurement process follows a bottom-up approach:

1. A score is assigned to each company-indicator combination. In order to account for the inherent barriers that companies operating in certain industries face when transitioning from a linear to a circular economy (thus, to ensure a "level playing field"), the score assigned is adjusted for the performance of all the companies operating in the same industry. The Indicator score is computed as the ratio of the number of companies performing worse or equal in terms of the Indicator of reference, over the total number of companies having an available value for that Indicator on the Thomson Reuters Datastream platform;
2. Then, a company-Category score is computed as the arithmetic mean of the scores of the indicators classified in the category of reference.
3. To move on from the Category score to the Pillar score, the latter is computed as the weighted average of Category scores. The weight of each category is defined as the ratio between the

[7] The data retrieval process took place during the period Sept. 14th – Sept 28th, 2020.

number of indicators belonging to that Category (numerator) and the overall number of Indicators encompassed by the Pillar whereto it belongs (denominator).

4. The 'plain' version of the CS is computed as the weighted average of the Pillar score. The weight of each pillar is defined as the ratio between the number of Indicators encompassed by the Pillar (numerator) and the overall number of Indicators (denominator);
5. Finally, the plain CS is adjusted to account for the different levels of financial materiality that a given category of indicators assumes for different industries. Financial materiality is measured based on the SASB-developed *Materiality Map*, which identifies the most financially material categories of sustainability issues for each SICS industry. Once matched the Categories relative to sustainability issues with those relative to circularity, industry-specific weights are assigned to each circular Category based on the latter's financial materiality.

This process results in a Circularity Score whose value ranges between 0 and 1, growing along with the degree of circularity. Computational details are available upon request.

4.4. *Intensity of disclosure*

Although content analyses

In line with the extant literature (Laskar & Maji, 2018; Li & Liu, 2018), we employ disclosure metrics that are based on a 'content analysis' approach. Although failing to capture the very quality of disclosure, this method is an objective one, as it distinguishes between disclosing and not disclosing data. By applying it, we construct two variables: namely, *Disclosure quality* and *Disclosure level*.

With regard to the former, we assign a score of 2 if an item is quantitatively disclosed, 1 if disclosure is merely qualitative, and 0 if there is no disclosure at all. Among the 164 Indicators retrieved from Thomson Reuters Datastream and included in CS computation, 69 are quantitative (i.e., expressed as continuous values), whereas 95 are Boolean (i.e., expressed in qualitative terms that may be quantified only as discrete values), the maximum possible disclosure score is $2 \cdot 69 + 1 \cdot 95 = 233$. For each company in the dataset, the *Disclosure quality* score is computed as the ratio between the sum of the scores assigned to each item and the maximum possible value.

$$[1] \quad \text{Disclosure Quality}_i = \frac{\sum_{i=1}^{n} x_i}{233}$$

where i indexes disclosure items, $x \in \{0; 1; 2\}$ is the score assigned, and 233 is the maximum score possible. *Disclosure level* is a similar but less informative measure, defined as the ratio between the number of disclosed circular items (numerator) and the total number of items considered (denominator):

$$[2] \quad \text{Disclosure Level}_i = \frac{\sum_{i=1}^{n} x_i}{164}$$

where 164 is the maximum number of items that can be disclosed.

Given that the various disclosure-related variables measure different aspects of a company's non-

financial information, we run a Principal Component Analysis (PCA) to identify possible interrelationships between variables, thereby squeezing the dimension of GLS estimations. The input variables were *Disclosure Quality*, *Disclosure Level*, *Integrated Reporting* and *Legal Tradition*.
Table 3 shows the PCA results.

[INSERT TABLE 3 HERE]

Component 1 shows a high level of correlations with *Disclosure quality* and *Disclosure level*, whereas Component 2 is highly correlated with *Integrated reporting* and *Legal tradition*. Since they jointly explain ~81% of the variance of the input variables, we took only these two components as PCA output. They were renamed *Information content factor* and *Information integration factor*, respectively.

4.5. *Other variables*

The quantity and typology of information disclosure are not the only drivers to consider when evaluating companies' non-financial information disclosure. Both academicians and practitioners have investigated at length the role played by integrated reporting, too (Stacchezzini, Melloni, & Lai, 2016). Integrated reports are believed to better communicate sustainability-related information, for they provide a more holistic view: in fact, even though stand-alone sustainability reports provide relevant information, combining financial and non-financial information in one single report allows investors to better understand the real drivers of value creation.
Thomson Reuters ASSET4 provides an ESG indicator called *Integrated Strategy in MD&A*, assessing whether a company does integrate financial and non-financial information in the *Business Review* section of its reports. However, by comparing the observations on such variable with the requirements set forth by the States where entities are incorporated, it is possible to notice a few contradictions. In fact, the NFRD entrusts Member States with discretionary powers in respect of mandating such integration. A few countries — e.g., France, Greece, the Netherlands, and the United Kingdom — do mandate companies to include sustainability-related information within the management annual report, yet not all the companies located therein are reported as actually integrating. This may be explained by considering Thomson Reuter's approach to such assessment: in fact, the information provider might have taken a judgemental stance (i.e., pursuant to the 'substance over form' principle), thereby attaching 0 to those companies that in practice, though subject to a mandate, *de facto* fail to integrate their sustainability-related disclosure with financial one.
Furthermore, there is an extensive body of research in the economic field suggesting that the "cultural" characteristics of a country's jurisdiction — i.e., its 'legal tradition' — can significantly shape corporate strategies: e.g., in respect of the relationships between a company and its stakeholders,

including disclosure practices. In this regard, we applied the classification developed by La Porta et al. (2008), the rationale being that the level of investor protection is reflected by the quality of disclosure. According to that work, investor protection is highest in common law countries (i.e., with an English legal tradition), orderly followed by civil law countries whose jurisdictions have a Scandinavian, German, and French origin, respectively. Hence, the *Legal tradition* variable is encoded in accordance with the degree of investor protection, on a scale from 1 (lowest) to 4 (highest), where 1 = French, 2 = German, 3 = Scandinavian, and 4 = English.

With regard to dependent variables, we measure a company's total risk as its stock return volatility (i.e., the annualised standard deviation of returns), and the systematic component as the market Beta, computed against two alternative indices: namely, the STOXX Europe 600 (i.e., a "local" measure) and the MSCI World (i.e., a "global" measure). The former of these two allows us to account for the geographical market wherein the observed companies operate; the latter, conversely, entails a broader geographical diversification.

We employ both accounting-based and market-based characteristics of a company as control variables, retrieved from Bloomberg and Thomson Reuters Datastream, respectively. Amongst accounting data, those that are dimensionally stocks (e.g., total assets, total debt) are taken as the average between the beginning-of-year and end-of-year figures of the fiscal year; conversely, flows (e.g., EBITDA) are taken just as the figure reported in end-year financial statements, which account for the whole fiscal period.

The natural logarithm of total assets (*Total assets, log*) proxies firm size. Profitability is defined as the profit margin, in percentage terms (*Profit-on-sales ratio*). Leverage (*Debt-to-equity ratio*) describes a company's capital structure. *Interest coverage ratio* captures the ability to meet short term financial obligations. We use *Market-to-book ratio* to control for different risk features of growth and value companies, is included and computed as the market capitalization divided by the equity book value (*Market-to-book ratio*). Finally, a dichotomic variable (*Negative equity, dummy*) indicates whether a company does exhibit an impaired equity. We also add the interaction between the last two variables, in order to gauge whether a negative market-to-book ratio — that is, signalling a pathological situation — does actually play a differentiated effect on risk.

The firms' readiness to innovate is captured by the ratio of the R&D expense as a proportion of total revenue (*R&D to revenues*). Finally, since the extant literature suggests a positive association between the quality of corporate governance and the disclosure of non-mandatory strategic information, both financial and non-financial information (Michelon & Parbonetti, 2012), we include a variable (*Governance Score*) that reports the TR-A4 comprehensive measure of various corporate governance elements, such as — *inter alia* — board independence, CEO duality, board diversity and the presence of a CSR committee within the board.

Since equity risk is expected to significantly vary across time and industries, we use both year-fixed and industry-fixed effects, which take value 1 if an observation belongs to that specific year or industry, and 0 otherwise.

A full description of variables is provided in **Table 4**.

[INSERT TABLE 4 HERE]

4.6. *Summary statistics*

Table 5 represents the correlation matrix of the variables that we employed. **Table 6** provides the descriptive statistics thereof.

[INSERT TABLE 5 HERE]

[INSERT TABLE 6 HERE]

The mean Circularity Score is 0.4 and it goes from a minimum of 0.19 to a maximum of 0.65. This reflects a low level of adoption of circular business practices. Companies are mainly concentrated in four industries: Chemicals, Industrial Machinery and Goods, Electrical and Electronic Equipment and Construction Materials. This is probably due to the fact they are also those industries where circular economy principles have found broad application. The industries with the lowest number of observations, instead, are Toys & Sporting Goods and Meat, Poultry and Dairy.

Disclosure quality exhibits a mean value of 0.56, while the average firm in the sample discloses 66% of the 164 indicators considered to compute the circularity score. This shows that companies tend to prefer disclosing 'soft' (qualitative) rather than 'hard' (quantitative) information. Furthermore, the disclosure level variable is expected to grow in the near future, due to the expansion of the scope of application of regulations in the field of sustainability reporting (see **Errore. L'origine riferimento non è stata trovata.**).

About 72% of the companies in the dataset integrate financial and non-financial information in the business review section of their report. Moreover, the majority of the observations pertain to companies located in countries of English legal traditions: i.e., in our sample, the United Kingdom and Ireland.

The mean *Stock return volatility* is 0.33, whereas the mean systematic risk is 0.89 when considering STOXX 600 Index and 0.77 when considering the MSCI World Index. This indicate that the average company is less volatile with respect to both market indices. The mean value of total risk is comparable to prior research on firm risk (Sassen, Hinze, & Hardeck, 2016).

Table 7 reports the main variables on circularity and disclosure — namely, *Circularity Score*, *Disclosure quality*, *Disclosure level*, and *Integrated reporting* — by year, highlighting that a slight improvement in both fields did materialise in 2019 vis-à-vis 2018 (except for the practice of integrating non-financial information within financial statements).

[INSERT TABLE 7 HERE]

Charts 1-4 show how the four variables above distribute across industries. Those with the highest mean values for the CS are Utilities & Power Generators and Containers & Packaging for both years, which also exhibit the highest values of *Disclosure quality* (see **Errore. L'origine riferimento non è stata trovata.** and **Errore. L'origine riferimento non è stata trovata.**) and *Disclosure level*. Conversely, Medical Equipment & Supplies shows the lowest mean value: this seems reasonable indeed, as the disposal of pharmaceutical waste is one of the biggest challenges faced by companies aiming at transitioning toward a more circular economy.

[INSERT CHARTS 1-4 HERE]

5. Models

We implemented a two-step methodology to examine the relationship between a company's non-financial information disclosure, its degree of circularity and the equity risk it faces.
Firs, we investigated the association between quality of non-financial disclosure and the degree of circularity. This was done by running the following panel regression, through a Generalised Least Squares (GLS) methodology:

[4] $$\mathrm{CS}_{it} = \alpha + \beta_1 \mathrm{DISCL\_QUALITY}_{it} + \beta_2\, \mathrm{MDA\_INTREP}_{it} + \tau \mathrm{D\_YEAR}_t + \mathbf{D\_INDUSTRY}_i \boldsymbol{\delta} + \mathbf{D\_LEGAL}_i \boldsymbol{\lambda} + \varepsilon_{it}$$

where CS is *Circularity Score*; DISCL_QUALITY is *Disclosure Quality*; MDA_INTREP is *Integrated Reporting*. D_YEAR is a dummy variable that takes value 1 if the observation on the dependent variable pertains to 2019, and 0 otherwise, **D_INDUSTRY** a $[1 \times h]$ vector of fixed-effect industry dummies and $\boldsymbol{\delta}$ the $[h \times 1]$ vector of related coefficients, **D_LEGAL** a $[1 \times k]$ vector of fixed-effect legal tradition dummies and $\boldsymbol{\lambda}$ the $[k \times 1]$ vector of related coefficients. α is a constant; ε is the idiosyncratic error term. The regression is performed with cluster-robust standard errors at industry level. *Disclosure Level* has been excluded because of its high correlation with *Disclosure Quality* (~0.86).

Then, we included them in our first-step regression model, thereby replacing Eq. 4 with this alternative specification:

$$[5] \quad \mathrm{CS}_{it} = \alpha + \varphi_1\ \mathrm{F1\_INFO\_CONTENT}_{i(t-1)} + \varphi_2\ \mathrm{F2\_INFO\_INTEG}_{i(t-1)} \tau\ \mathrm{YEAR}_t + \mathbf{D\_INDUSTRY}_i \boldsymbol{\delta} + \mathbf{D\_LEGAL}_i \boldsymbol{\lambda} + \varepsilon_{it}$$

where F1_INFO_CONTENT is *Information content factor* and F2_INFO_INTEG is *Information integration factor*.

Although PCA factors are more difficult to interpret, we preferred using the estimates from Eq. 5 to conduct the second step of the analysis, as its two focus regressors are independent one another, by definition. Once examined the relationship between the CS and the two disclosure-related factors, the unexplained portion of the CS — i.e., the residuals from Eq. 5 — was included in the second-step models, whose dependent variables are alternatively represented by measures of total or systematic risk. The goal was to test whether circularity does play a de-risking effect even in case the contribution of information disclosure factors be taken out.

First of all, Eq. 6 — that is, entailing only control variables and fixed-effect dummies — was estimated to provide a "benchmark" against which to assess the actual contribution of our focus variables. Then. Eq. 7 was used to prove the de-risking benefit which benefit higher circular assets, as shown by Zara et al. (2020). Then, the CS was replaced by *Residuals from first-step regression* in Eq. 8, to test Hp. 2. Finally, since firms with higher CS also tend to have better non-financial information disclosure as confirmed by the results of the first-step regression (see par. Errore. L'origine riferimento non è stata trovata.), the two variables were both included in Eq. 9, thereby investigating the effect of disclosure on risk to test Hp. 3.

Hence, second-step analyses were performed by running the following GLS models:

$$[6] \quad y_{it} = \alpha + \mathbf{CONTROLS}_{i(t-1)} \boldsymbol{\gamma} + \tau\ \mathrm{YEAR}_t + \mathbf{D\_INDUSTRY}_i \boldsymbol{\delta} + \varepsilon_{it}$$

$$[7] \quad y_{it} = \alpha + \beta\ \mathrm{CS}_{i(t-1)} + \mathbf{CONTROLS}_{i(t-1)} \boldsymbol{\gamma} + \tau\ \mathrm{YEAR}_t + \mathbf{D\_INDUSTRY}_i \boldsymbol{\delta} + \varepsilon_{it}$$

$$[8] \quad y_{it} = \alpha + \beta\ \mathrm{F1\_F2\_CS\_RESID}_{i(t-1)} + \mathbf{CONTROLS}_{i(t-1)} \boldsymbol{\gamma} + \tau\ \mathrm{YEAR}_t + \mathbf{D\_INDUSTRY}_i \boldsymbol{\delta} + \varepsilon_{it}$$

$$[9] \quad y_{it} = \alpha + \beta\ \mathrm{F1\_F2\_CS\_RESID}_{i(t-1)} + \varphi_1\ \mathrm{F1\_INFO\_CONTENT}_{i(t-1)} + \varphi_2\ \mathrm{F2\_INFO\_INTEG}_{i(t-1)} + \mathbf{CONTROLS}_{i(t-1)} \boldsymbol{\gamma} + \tau\ \mathrm{YEAR}_t + \mathbf{D\_INDUSTRY}_i \boldsymbol{\delta} + \varepsilon_{it}$$

$$[10] \quad y_{it} = \alpha + \varphi_1\ \mathrm{F1\_INFO\_CONTENT}_{i(t-1)} + \varphi_2\ \mathrm{F2\_INFO\_INTEG}_{i(t-1)} + \mathbf{CONTROLS}_{i(t-1)} \boldsymbol{\gamma} + \tau\ \mathrm{YEAR}_t + \mathbf{D\_INDUSTRY}_i \boldsymbol{\delta} + \varepsilon_{it}$$

In Eq.'s 6-9, y is an equity risk measure: that is, alternatively, *Stock return volatility*, or *Beta against STOXX Europe 600*, or *Beta against MSCI World*. F1_F2_RESID_CS is *Residuals from first-step regression*. The independent variables are lagged with a lag of one period (i.e., one year). All analyses were performed with cluster-robust standard errors at the industry level.

6. Results

6.1. *"Full" circularity vs. disclosure*

Table 8 reports the results from the first-step regression, considering the two PCA factors — namely, *Information content* and *Information integration* — as focus regressors. Both coefficients turn out being positive and statistically different from zero at 99% confidence level. This lends support to Hp. 1 and — more in general — stakeholder theory, according to which superior sustainability performance is positively associated with a better non-financial information disclosure. Although it is not reported in the Appendix, we performed a robustness check by using *Disclosure quality* and *Integrated reporting* as alternative focus regressor, getting basically the same result. Given that both the disclosure quality score and the CS lie on a 0-1 scale and may be interpreted as percentages in decimal form, we get that a 1 percentage point (pp) increase in a company's *Disclosure quality* score results in a larger than 0.6 pp increase in its *Circularity score*.

In terms of the remaining explanatory variables, the coefficients of industry dummies are almost always statistically different from zero, suggesting that the cross-industry differences in CS are not negligible. So does the year that we consider, as 2019 exhibits consistently larger CS figures. Conversely, the effect of the legal tradition is statistically insignificant.

[INSERT TABLE 8 HERE]

6.2. *Equity risk vs. circularity and disclosure*

Table 9 reports results from estimating Eq. 6: that is, regressing the annualised standard deviation of stock returns and the two versions of systematic risk — i.e., *Beta against STOXX 600* and *Beta against MSCI World* on control variables only.

Company size — i.e., the natural logarithm of an entity's total assets — is negatively associated with the stock price volatility, at 99% confidence level. This is line with the commonly acknowledged idea that a company's intrinsic risk decreases as firm size increases (Benlemlih, Shaukat, Qiu, & Trojanowski, 2018). The market-to-book ratio variable, instead, shows a non-monotonic relationship with the standard deviation of returns, highlighting some noteworthy peculiarities in case of clearly troubled companies. In fact, the sign of the effect is positive (negative) when the book value of equity

is negative (positive): this implies that, given the presence of an equity impairment, a lower (higher) market value — which makes the ratio higher (lower), i.e., smaller (larger) in its negative magnitude — is seen by investors as risk-mitigating (risk-accruing), as they would seek the narrowest possible spread between equity's book and market value.

Profit-on-sales ratio exhibits a negative association with total risk at 5% significance level, suggesting that higher (lower) profitability makes companies exhibit less (more) volatile stock returns and are less (more) exposed to market fluctuations. Conversely, a company's financial leverage is positively related to every measure of risk, reflecting the fact that the degree of indebtedness is the clearest indicator of a company's likelihood of defaulting, which in turn leads to increased equity risk.

With regard to systematic risk, firm size is positively associated with both its measures, as it increases the correlation with market factors. Profitability, instead, shows a negative relationship at a 1% significance level. The coefficient of *R&D to revenues* is positive and statistically significant in each regression model.

ESG Governance Score does not exhibit any statistically significant relationship with a firm's level of risk. In fact, its coefficient is statistically different from zero only if the dependent variable is the systematic risk measured against a "local" (i.e., European) benchmark, but disappears if a larger market index is chosen. The coefficient of *Interest coverage ratio* fails to achieve statistical significance.

[INSERT TABLE 9 HERE]

Table 10 reports the estimates from Eq. 7. It shows that the CS exerts an economically meaningful de-risking effect, as its coefficient is negative and statistically significant at 95% confidence level if used to explain the risk measures that we have adopted. In particular, a 0.10 increase in the CS yields a 0.03 decrease (i.e., 3%) in the volatility of stock returns, as well as a reduction in market Beta that is larger than 0.04, if the STOXX Europe 600 is chosen as benchmark, or even larger than 0.07, if the MSCI World is taken instead. Our results show that not only a more circular business model does contribute to squeezing the systematic component of a company's equity risk: also, we observe that the magnitude of such effect grows along with the extent of portfolio diversification, potentially suggesting that circularity does act as diversification *per se*.

The sign and statistical significance of control variables' estimated coefficients are the same as in the previous model, except for the Governance Score, whose statistical significance rises.

Moreover, we can appreciate an increase in the R^2 vis-à-vis the baseline model, wherein risk measures were regressed against control variables only. This suggests that adding the CS in the model does allow to explain a greater portion of the risk measures' variance.

[INSERT TABLE 10 HERE]

Table 11 reports the estimates from Eq. 8, i.e., the formal second-step regression. The estimated coefficient of *Residuals from first-step regression* is negative and statistically significant at 95% confidence level, if *Stock return volatility* is regressed thereon. Besides, it is negatively associated with both systematic risk measures; however, the coefficient partially loses statistical significance if the dependent variable is *Beta against MSCI World* (90% confidence level). Nevertheless, this suggests that even when cleared of the effect of non-financial information disclosure, circularity exhibits a negative and statistically significant association with a company's financial risk, thereby confirming Hp. 2.

[INSERT TABLE 11 HERE]

Table 12 reports the results from estimating Eq. 9. It shows that the estimated coefficient of the residuals is negative and statistically significant at 99% confidence level if the dependent variable is *Stock return volatility*; however, the confidence level drops to 95% when considering systematic risk measures (against both the STOXX Europe 600 and the MSCI World market indices).

Moreover, *Information content factor* exhibits a negative and statistically significant association with both *Stock return volatility* and *Beta against MSCI World*, at 99% and 95% level respectively, whereas the information content is statistically different from zero only when the "global" Beta is regressed thereon. These findings partially support Hp. 3. Moreover, results confirm the negative association between sustainability disclosure and total risk found by Benlemlih et al. (2018). However, even though the size of disclosure-related coefficients is much lower vis-à-vis that of *Residuals from first-step regression*, there is not enough empirical evidence to conclude that that the de-risking effect is mainly driven by "core" circularity, rather than the "full" version thereof (i.e., including the informational component).

[INSERT TABLE 12 HERE]

Table 13 reports the estimates from estimating Eq. 10. With regard to these models too, our results lend partial support to Hp. 3. In fact, the estimated coefficient of *Information content factor* is negative and statistically significant at 95% confidence level, when the dependent variable is the standard deviation of returns. However, no evidence of a statistically significant relationship arises between the former and the "global" Beta. Finally, the estimated coefficient is negative and statistically significant at 90% confidence level if the market index is the MSCI World. Overall, Information content factor loses significance vis-à-vis the previous models.

In line with the results of Table 12, the estimated coefficient of the information integration factor is negative and statistically significant (at 95% confidence level) only if *Beta against MSCI World* is regressed thereon.

[INSERT TABLE 13 HERE]

6.3. *Dominance analysis*

To assess the relative importance of explanatory variables and overcome the limitations given by differences in scale, a *dominance analysis* has been conducted. Given an array of variables, the dominance analysis (DA) ranks the independent ones based on the contribution that each of them makes to the R^2 (that is, how much of the dependent variable's variance is explained). We implemented the method originally proposed by Johnson (2000), which focuses on idiosyncratic error terms and can be applied after running GLS estimations.

The output is a ranking of independent variables, ordered in accordance with their relative importance in estimating the dependent variable. Results are shown in **Tables 14-15**, after removing the positions held by fixed-effect year, industry, and legal dummies.

[INSERT TABLES 14 HERE]

[INSERT TABLE 15 HERE]

From these results, it seems that the CS and its residuals from the first-step regression are among the most powerful explanatory variables; also, their ranking is relatively stable across different specifications, always ranging between the first and the third position. Moreover, the CS is the most powerful explanatory variable when the dependent variable is the annualised standard deviation of returns. However, *Information content factor* is the most relevant variable when it comes to explaining the variance of a firm's total risk through Eq. 9. The other two main explanatory variables are *Total assets, log* and *Profit-on-sales ratio*.

6.4. *Findings*

The results lend broad support to Hp.'s 1 and 2, whereas Hp. 3 should be furtherly investigated.

First-step regressions exhibit close alignment with the agency and stakeholder theories, showing that there exists a positive and statistically significant association between sustainability reporting and the companies' degree of circularity measured by the CS. However, these results should be interpreted cautiously. In fact, not only does the CS measurement framework inherently penalise those companies that do not disclose sustainability information (in particular, by assigning them a very low company-indicator score if a disclosure item is missing) but, also, it directly includes ESG indicators retrieved from Refinitiv ASSET-4 relating to non-financial reporting. Hence, the statistically significant and positive relationship between disclosure factors and the CS is a very intuitive one, given how those variables have been constructed. This was exactly the reason behind computing residuals: that is, a circularity metric that be cleared of disclosure's dominating role.

From an investor perspective, findings from second-step regressions suggest that the adoption of circular business practices is associated with a reduction in total and, more in details, the systematic component thereof; in turn, this yields a lower cost of capital and higher shareholder value. The negative relationship persists also when the effect of non-financial information disclosure is cut out, as shown by the results of equation [8]. This is confirmatory of the results by Zara *et al.* (2020), whose scope is widened by proving that the de-risking effect of circular assets holds even in absence of an extensive and high quality non-financial information.

On the contrary, the disclosure of non-financial information does not exert any relevant influence on risk. In fact, the information content factor exhibits a non-zero association only with the standard deviation of returns and the Beta against MSCI World index. Conversely, the information integration factor is negatively associated only with the Beta against MSCI World Index. The last two statements hold true for Eq.'s [8] and [9]. These findings are consistent with Benlemlih *et al.* (2018), according to which the disclosure of sustainability-related information does not reduce a company's systematic risk. Moreover, they find that extensive and objective environmental and social disclosures do reduce a firm's business (i.e., idiosyncratic) risk. In the light of this, we might conclude that companies that provide high quality non-financial information disclosure do benefit from lower total risk by virtue of a reduction in idiosyncratic risk. These findings are particularly relevant to those stakeholders who have their undiversified financial or human capital tied up to the continued operational success of the firm, such as employees and managers.

Finally, results from the dominance analysis show that the CS is the variable that offers the most important contribution to explaining risk, even compared to those control variables of financial nature that are usually regarded as holding a strong explanatory power in respect of equity risk.

When the CS is disaggregated into the first-step residuals and the information disclosure factors, the results from the dominance analysis suggest that the degree of circularity, once isolated from the effects of non-financial information disclosure, is one of the most powerful variables in explaining both total and systematic risk, ranking 3rd and 2nd respectively. Nonetheless, the information content ranks 1st if the dependent variable is the standard deviation of returns, yet its relative importance gets no corroboration from the other two analyses. Hence, it would appear to offer additional evidence to a strong association with the idiosyncratic risk. Conversely, in line with the results of second-step regressions, the information integration factor shows a weak explanatory power.

In conclusion, these results further validate the de-risking effect exerted by a higher degree of circularity, corroborating the findings by Zara et al. (2020). Nonetheless, this study adds considerable insights to the topic. In fact, it shows that an effective circular business strategy is valuable per se (i.e., regardless of its disclosure), for it is shown to be negatively associated with systematic risk and constitutes one of the most powerful explanatory variables thereof. Conversely, information disclosure factors appear to be crucial to convey valuable information to stakeholders on a firm's

operational success. Hence, this work provides further justification for managers to engage in circular business strategies, and for market participants to invest in circular assets.

7. Conclusions

This work is motivated by the need to conduct a deeper investigation on two main trends that are underway: on the one hand, the increasing public concern about sustainability reporting, primarily driven by the growing demand for more reliable and comparable non-financial information (coming from both investors and policymakers); on the other, the rising interest shown by academicians and practitioners in respect of the financial implications of adopting more sustainable business strategies. Furthermore, this work focuses on the specific topic of circular economy (CE) because it has been gaining prestige in both scientific research and the economic realm, and is now regarded as one of the most important macro-trends at global level. In fact, both the public and the private sectors are becoming increasingly aware of the challenges posed by the scarcity of natural resources; moreover, the CE paradigm is deemed to hold great promise for accomplishing a sustainable development. However, for the transition to take place, it is necessary to redirect funds towards more circular assets, once empirically ascertained that they yield a better financial performance.

As outlined in the literature review, there appears to be a dearth of research about the relationship between sustainability reporting, degree of circularity and financial performance, particularly with regard to risk: this study aims to address such gap. Moreover, given that the CE is a characterization of sustainability, this research contributes to the extant literature related to the financial performance of sustainable investments too.

This work employs a European panel dataset of 1,244 firm-year observations, covering the 2018-2019 period, to examine the relationship between sustainability disclosure practices, degree of circularity, and risk. Three hypotheses are formulated: (1) *disclosure quality factors are positively associated with the degree of circularity; (2) there is a negative association between the residuals of the first step regression – i.e., the variance of the degree of circularity not explained by disclosure factors - and firm risk; (3) there is a negative association between information disclosure related to a company degree of circularity and firm risk.* They have been tested through a two-step methodology: firstly, the degree of circularity has been regressed against variables attempting to capture both the quantity and the quality of non-financial disclosure. Afterwards, the residuals of the first step regression have been included in second-step equations, whose dependent variable was represented by either total risk, proxied by the standard deviation of returns, or systematic risk, measured through the Beta against STOXX 600 and the Beta against MSCI World.

Jointly considered, the results seem to improve current understanding of the financial implications entailed by the adoption of circular business practices. The first contribution consists in digging deeper on the relationship between circularity and financial performance already investigated by Zara *et al.* (2020), by showing that a company's degree of circularity exerts a negative and statistically significant influence on a firm's level of risk, even when cleared of the effects of non-financial information. Moreover, a considerable insight has been gained on the relationship between sustainability

reporting and risk. In fact, a more nuanced picture arises when including disclosure factors in second-step regressions: although non-financial information alone does not provide any relevant contribution to explaining risk, it is critical for the degree of circularity to fully exert its de-risking effect, given that sustainability reporting is the most powerful explanatory variable in explaining total risk, presumably by virtue of its negative association with idiosyncratic risk.

While this study sheds some light on the relationship between sustainability reporting, circularity, and risk, there are plenty of avenues for future research. An obvious one would be to develop a more fine-grained measure of non-financial disclosure and to consider many additional factors that could better reflect stakeholders' interests, such as external assurance and reporting formats. Moreover, future research might test the hypothesised negative relationship between the disclosure of non-financial information regarding circular business practices and idiosyncratic risk. Finally, a more detailed understanding of these relationships might be obtained by separately studying the effects of disclosure on environmental, social, and governance matters.

In summary, by shedding additional light on the negative association between circularity and risk, this work lends further support for managers to engage in more circular business practices and for market participants to invest in more circular assets, thereby contributing to the transition toward a more sustainable development.

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9. APPENDIX

Table 1 — *Reconciliation between US SIC and SASB's SICS*

SIC 2-digit industry			SASB	Notes	Number of companies *(% of population)*		No. of companies with CS available for 2018	No. of companies with CS available for 2019
B	**10**	Metal Mining	Metals & Mining		18	*2.80%*	17	18
B	**13**	Oil & Gas Extraction	Oil & Gas Exploration and Prod.		38	*5.90%*	36	37
C	**15**	Building Construction, General Contractors […]	Construction Materials		62	*9.63%*	61	62
C	**16**	Heavy Construction						
C	**17**	Construction Special Trade Contractors						
D	**20**	Food & Kindred Products	Meat, Poultry & Dairy	*201-202 only*	8	*1.24%*	8	8
			Processed Foods	*203, 205-207, 209 only*	28	*4.35%*	26	28
			Agricultural Products	*204 only*	0	*0.00%*	0	0
			Beverage	*208 only*	15	*2.33%*	15	15
D	**22**	Textile Mill Products	Apparel, Accessories & Footwear		23	*3.57%*	22	23
	23	Apparel & Other Textile Products						
	31	Leather & Other Leather Products						
	39	Miscellaneous Manufacturing Industries		*391 only*				
D	**24**	Lumber & Wood Products	Containers & Packaging	*244-246 only*	24	*3.73%*	24	23
	26	Paper & Allied Products		*except 268 and 269*				
D	**25**	Furniture & Fixtures	Building & Furnishing Products	*251-254 and 259 only*	0	*0.00%*	0	0

D	**28**	Chemicals & Allied Products	Chemicals		137	*21.27%*	132	136
	30	Rubber & Miscellaneous Plastic Products		*except 309*				
D	**34**	Fabricated Metal Products	Iron & Steel Producers		23	*3.57%*	23	23
D	**35**	Industrial and Commercial Machinery […]	Industrial Machinery & Goods		78	*12.11%*	76	77
	37	Transportation Equipment		*373 and 374 only*				
D	**36**	Electronic & Other Electrical Equipment	Electrical & Electronic Equipment		67	*10.40%*	65	67
D	**37**	Transportation Equipment	Automobiles	*371 and 375 only*	29	*4.50%*	29	29
D	**37**	Transportation Equipment	Aerospace & Defence	*372 only*	15	*2.33%*	14	14
D	**38**	Measuring, Analysing and Controlling Instruments […]	Medical Equipment & Supplies	*except 388 and 389*	47	*7.30%*	43	46
D	**39**	Miscellaneous Manufacturing Industries	Toys & Sporting Goods	*394 and 395 only*	4	*0.62%*	4	4
E	**43**	Electric, Gas & Sanitary Services	Electric Utilities & Power Gen.	*493 only*	28	*4.35%*	27	28
					644	***100%***	**622**	**638**

Table 2 — *Classification system of CE Indicators*

Pillar	Category	No. of indicators
Circular Inputs	Emissions	65
	Resource use	39
	Total Circular Inputs Pillar	**104**
Product Usage	Innovation	27
	Agenda 2030	8
	Community	7
	Total Product Usage Pillar	**42**
End of Life	Product Responsibility	9
	Total End of Life Pillar	**9**
Disclosure & Signalling	Disclosure & Signalling	9
	Total Disclosure & Signalling Pillar	**9**
Total Indicators		**164**

Table 3 — *Principal component analysis*

Principal components/correlation

Number of obs. = 671
Number of comp. = 4
Trace = 4
Rho = 1.0000

Rotation: (unrotated = principal)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.013	0.778	0.503	0.503
Comp2	1.235	0.561	0.309	0.812
Comp3	0.674	0.595	0.168	0.980
Comp4	0.079	.	0.020	1.000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
Disclosure quality	0.683	0.076	0.148	0.712	0
Disclosure level	0.676	0.109	0.197	-0.701	0
Integrated reporting	0.062	0.756	-0.651	-0.005	0
Legal tradition	-0.269	0.640	0.718	0.041	0

Table 4 — *Description of variables*

Variable	Description	Source of input data
Dependent variables		
Stock return volatility	Annualised standard deviation of daily returns on a company's publicly-listed stock	Bloomberg
Beta against STOXX Europe 600	Annual average of the daily market Beta of a company's publicly-listed stock against the STOXX Europe 600 index	Bloomberg
Beta against MSCI World	Annual average of the daily market Beta of a company's publicly-listed stock against the MSCI World index	Bloomberg
Focus explanatory variables		
Circularity Score	A company's degree of circularity, adjusted pursuant to the SASB Materiality Map	Thomson Reuters Datastream
Disclosure quality	The intensity of a company's non-financial information disclosure, computed by distinguishing between quantitative and qualitative disclosure	Thomson Reuters Datastream
Disclosure level	The intensity of a company's non-financial information disclosure, computed without distinguishing between quantitative and qualitative disclosure	Thomson Reuters Datastream
Integrated reporting	Dummy variable that takes value 1 if the company integrates non-financial disclosure within financial statements, and 0 otherwise	Thomson Reuters Datastream
Information content factor	The first factor resulting from a Principal Component Analysis (PCA) on *Disclosure quality*, *Disclosure level*, *Integrated reporting*, and *Legal tradition* (see below)	Thomson Reuters Datastream
Information integration factor	The second factor resulting from a Principal Component Analysis (PCA) on *Disclosure quality*, *Disclosure level*, *Integrated reporting*, and *Legal tradition* (see below)	Thomson Reuters Datastream
Residuals from first-step regression	The "core", non-disclosure component of *Circularity Score*, computed as the residuals from regressing the former on *Information content factor* and *Information integration factor*	Thomson Reuters Datastream
Control explanatory variables		
Total assets, log	Natural logarithm of a company's total assets, averaged between BoY and EoY figures	Bloomberg
Debt-to-equity ratio	Ratio between a company's total debt (numerator) and total equity (denominator), both averaged between BoY and EoY figures	Bloomberg
Interest coverage ratio	Ratio between a company's EBITDA (numerator) and interest expense (denominator)	Bloomberg
Profit-on-sales ratio	Ratio between a company's net income (numerator) and revenues (denominator)	Bloomberg

Market-to-book ratio *(A)*	Ratio between a company's market capitalisation (numerator) and total equity (denominator), both averaged between BoY and EoY figures	Bloomberg
Negative equity *(B)*	Dummy variable that takes value 1 if the company's total equity is negative, and 0 otherwise	Bloomberg
A × B, interaction term	The product of *Market to book ratio* and *Negative equity*	Bloomberg
R&D to revenues	The ratio between a company's research and development expenditure (numerator) and total revenues (denominator)	Bloomberg
ESG Governance Score	A company's score in the Governance pillar of the ESG framework	Thomson Reuters Datastream
Fixed effects		
Year 2020, dummy	Dummy variable that takes value 1 if the observation on the dependent variable relates to 2020, and 0 otherwise	-
Industry	Vector of dummy variables, each one taking value 1 if the company belongs to a given industry, and 0 otherwise	Thomson Reuters Datastream
Legal tradition	Vector of dummy variable, each one taking value 1 if the company is incorporated in a country with a given legal tradition, and 0 otherwise	La Porta et al. (2008)

Table 5 — *Correlation matrix*

		1	2	3	4	5	6	7	8	9	10	11
Stock return volatility	**1**	1.00										
Beta against STOXX Europe 600	**2**	0.40	1.00									
Beta against MSCI World	**3**	0.46	0.83	1.00								
Circularity Score	**4**	-0.43	0.07	-0.07	1.00							
Disclosure quality	**5**	-0.37	0.12	0.00	0.89	1.00						
Disclosure level	**6**	-0.34	0.11	-0.01	0.83	0.91	1.00					
Integrated reporting	**7**	-0.13	-0.04	-0.21	0.12	0.08	0.09	1.00				
Information content factor	**8**	-0.37	0.15	0.01	0.87	0.97	0.96	0.08	1.00			
Information integration factor	**9**	-0.08	-0.13	-0.24	0.10	0.06	0.10	0.84	-0.02	1.00		
Residuals from first-step regression	**10**	-0.18	-0.07	-0.08	0.46	0.06	0.00	-0.12	0.00	-0.01	1.00	
Total assets, log	**11**	-0.39	0.14	0.10	0.61	0.65	0.59	0.02	0.63	0.02	0.13	1.00
Debt-to-equity ratio	**12**	0.08	-0.02	0.05	-0.06	-0.06	-0.06	-0.06	-0.07	-0.02	0.02	0.04
Interest coverage ratio	**13**	0.02	0.08	0.01	-0.05	-0.06	-0.07	0.03	-0.06	0.01	0.00	-0.13
Profit-on-sales ratio	**14**	-0.21	0.00	-0.09	0.19	0.16	0.15	0.14	0.16	0.11	0.07	0.16
Market-to-book ratio	**15**	-0.04	-0.02	-0.02	0.00	-0.01	-0.02	-0.04	0.00	-0.07	0.00	-0.11
Negative equity	**16**	0.10	0.04	0.07	-0.01	0.00	0.00	-0.02	-0.01	0.01	0.02	0.06
R&D to revenues	**17**	0.16	-0.05	0.01	-0.13	-0.12	-0.10	-0.21	-0.11	-0.18	-0.02	-0.17
ESG Governance Score	**18**	-0.22	0.15	0.06	0.46	0.43	0.41	0.19	0.41	0.21	0.19	0.46
Year 2020, dummy	**19**	-0.02	0.02	0.23	0.00	0.01	-0.03	0.01	0.00	-0.01	0.01	-0.01
Industry	**20**	0.12	-0.05	-0.03	-0.08	-0.08	0.02	0.08	-0.05	0.14	-0.02	0.01
Legal tradition	**21**	0.12	-0.20	-0.15	-0.21	-0.25	-0.20	0.24	-0.40	0.71	0.11	-0.17

		12	13	14	15	16	17	18	19	20	21
Debt-to-equity ratio	**12**	1.00									
Interest coverage ratio	**13**	-0.01	1.00								
Profit-on-sales ratio	**14**	-0.02	0.10	1.00							
Market-to-book ratio	**15**	-0.55	0.09	0.00	1.00						
Negative equity	**16**	0.43	-0.02	0.00	-0.57	1.00					
R&D to revenues	**17**	0.00	-0.04	-0.25	0.01	-0.01	1.00				
ESG Governance Score	**18**	-0.04	-0.09	0.10	-0.01	0.03	-0.12	1.00			
Year 2020, dummy	**19**	-0.05	-0.04	-0.01	0.05	-0.03	0.04	0.02	1.00		
Industry	**20**	-0.04	0.01	0.05	0.05	-0.04	-0.11	0.09	-0.02	1.00	
Legal tradition	**21**	0.05	0.00	-0.01	-0.07	0.05	-0.03	0.02	-0.01	0.15	1.00

Table 6 — *Summary statistics*

Variable	Obs.	Mean	Std. Dev.	Min.	1st Q.	Median	3rd Q.	Max.	Skewness	Kurtosis
Stock return volatility	1,905	0.33	0.14	0.05	0.23	0.30	0.39	1.75	2.33	14.41
Beta against STOXX Europe 600	1,905	0.89	0.41	-0.64	0.61	0.84	1.13	2.61	0.57	3.79
Beta against MSCI World	1,905	0.77	0.46	-0.48	0.46	0.67	0.97	3.67	1.30	5.73
Circularity Score	1,247	0.40	0.09	0.19	0.34	0.41	0.47	0.65	-0.08	2.28
Disclosure quality	1,247	0.56	0.12	0.33	0.45	0.56	0.65	0.82	0.04	1.92
Disclosure level	1,247	0.66	0.10	0.35	0.59	0.66	0.73	0.86	-0.21	2.41
Integrated reporting	671	0.72	0.45	0.00	0.00	1.00	1.00	1.00	-0.96	1.93
Information content factor	671	0.00	1.42	-3.53	-1.20	-0.04	1.18	3.36	0.14	2.12
Information integration factor	671	0.00	1.11	-2.43	-0.77	0.22	0.97	1.40	-0.63	2.16
Residuals from first-step regression	670	0.00	0.04	-0.23	-0.02	0.00	0.02	0.27	0.47	8.46
Total assets, log	1,271	7.97	1.71	2.89	6.72	7.81	9.07	13.07	0.31	2.95
Debt-to-equity ratio	1,269	1.14	12.65	0.00	0.25	0.52	0.89	443.56	33.95	1183.45
Interest coverage ratio	1,270	62.51	281.20	-751.36	7.01	14.97	34.40	5698.56	11.96	193.75
Profit-on-sales ratio	1,271	-0.01	0.93	-16.30	0.02	0.06	0.11	2.88	-11.80	166.65
Market-to-book ratio	1,268	2.93	9.41	-252.54	1.43	2.32	3.86	107.82	-16.53	469.08
Negative equity	1,272	0.01	0.10	0.00	0.00	0.00	0.00	1.00	9.74	95.86
R&D to revenues	1,269	0.05	0.16	0.00	0.00	0.01	0.05	3.38	11.50	192.52
ESG Governance Score	1,187	53.46	22.31	2.74	35.90	54.02	71.37	97.54	-0.13	2.11

Table 7 — *Detail of circularity and disclosure variables by year*

		Circularity Score	Disclosure quality	Disclosure level	Integrated reporting
Obs.	Overall	1,247	1,247	1,247	671
	2019	631	631	631	355
	2018	616	616	616	316
Mean	Overall	0.4032	0.5559	0.6590	0.7168
	2019	0.4060	0.5607	0.6599	0.7127
	2018	0.4002	0.5509	0.6580	0.7215
Std. Dev.	Overall	0.0895	0.1199	0.0953	0.4509
	2019	0.0891	0.1185	0.0982	0.4532
	2018	0.0898	0.1212	0.0922	0.4490
Min.	Overall	0.1890	0.3305	0.3476	0
	2019	0.2137	0.3348	0.3476	0
	2018	0.1890	0.3305	0.4634	0
1st Quartile	Overall	0.3361	0.4506	0.5854	0
	2019	0.3389	0.4549	0.5854	0
	2018	0.3323	0.4464	0.5854	0
Median	Overall	0.4072	0.5579	0.6646	1
	2019	0.4097	0.5665	0.6646	1
	2018	0.4040	0.5536	0.6646	1
3rd Quartile	Overall	0.4727	0.6524	0.7317	1
	2019	0.4756	0.6567	0.7378	1
	2018	0.4711	0.6438	0.7256	1
Max.	Overall	0.6450	0.8197	0.8598	1
	2019	0.6450	0.8197	0.8598	1
	2018	0.6390	0.8197	0.8598	1
Skewness	Overall	-0.0812	0.0423	-0.2122	-0.9626
	2019	-0.0439	0.0573	-0.3184	-0.9400
	2018	-0.1173	0.0335	-0.0843	-0.9884
Kurtosis	Overall	2.2831	1.9211	2.4070	1.9266
	2019	2.2658	1.8720	2.6226	1.8836
	2018	2.2872	1.9548	2.1126	1.9769

Chart 1 — *Circularity Score* by industry (mean, whole dataset)

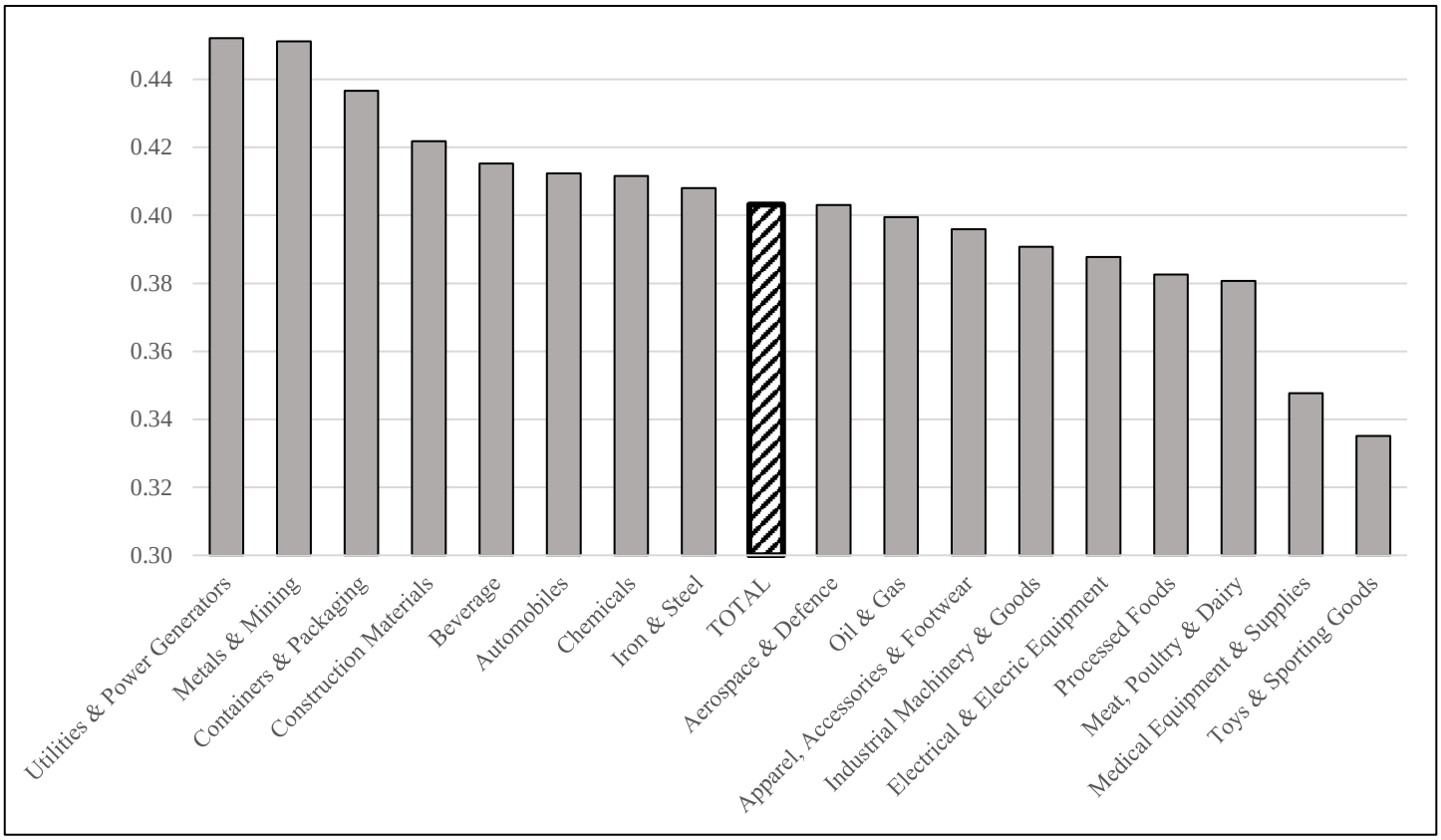

Chart 1 — *Integrated reporting* by industry (mean, whole dataset)

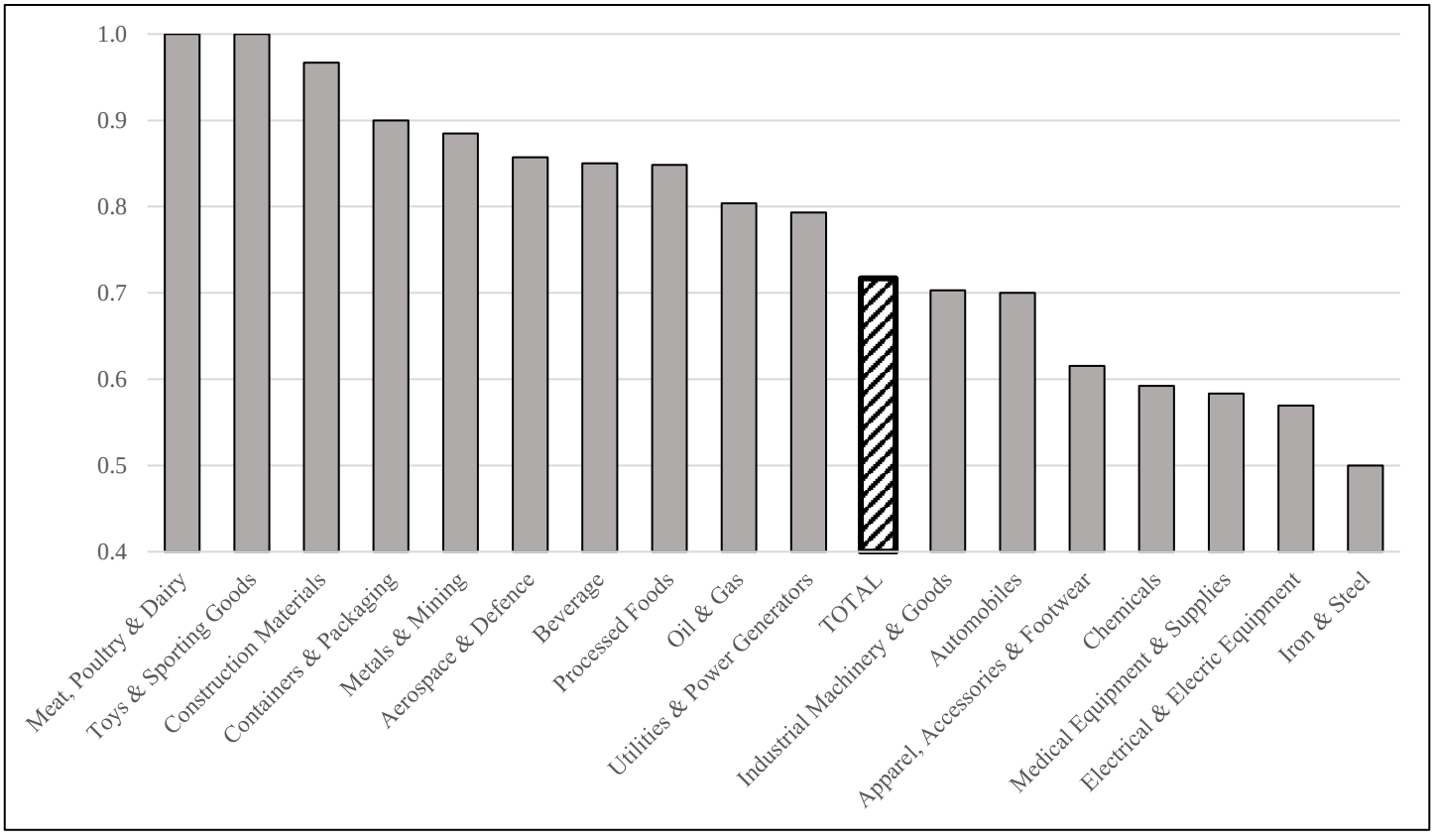

Chart 3 — *Disclosure quality* by industry (mean, whole dataset)

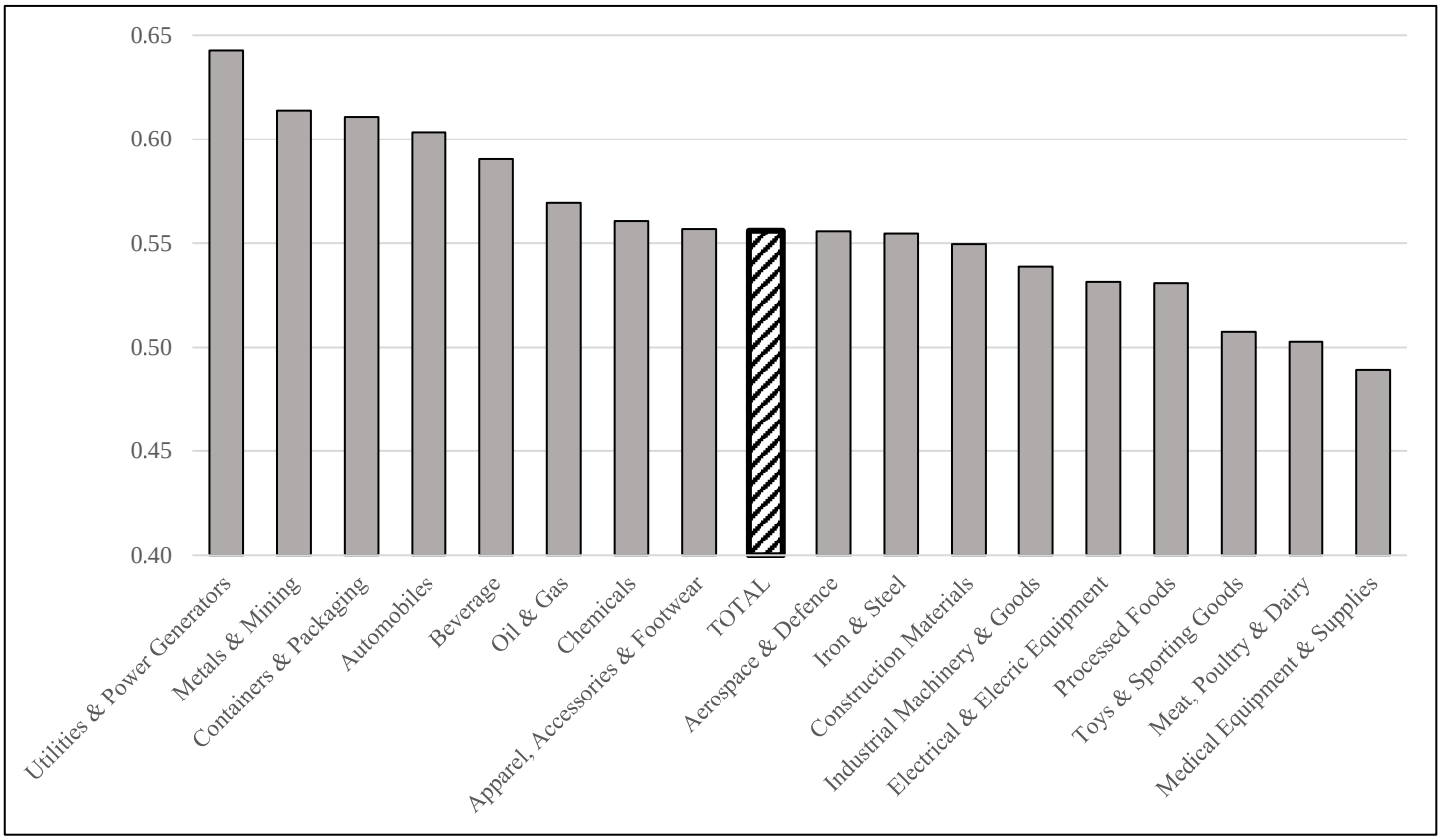

Chart 4 — *Disclosure level* by industry (mean, whole dataset)

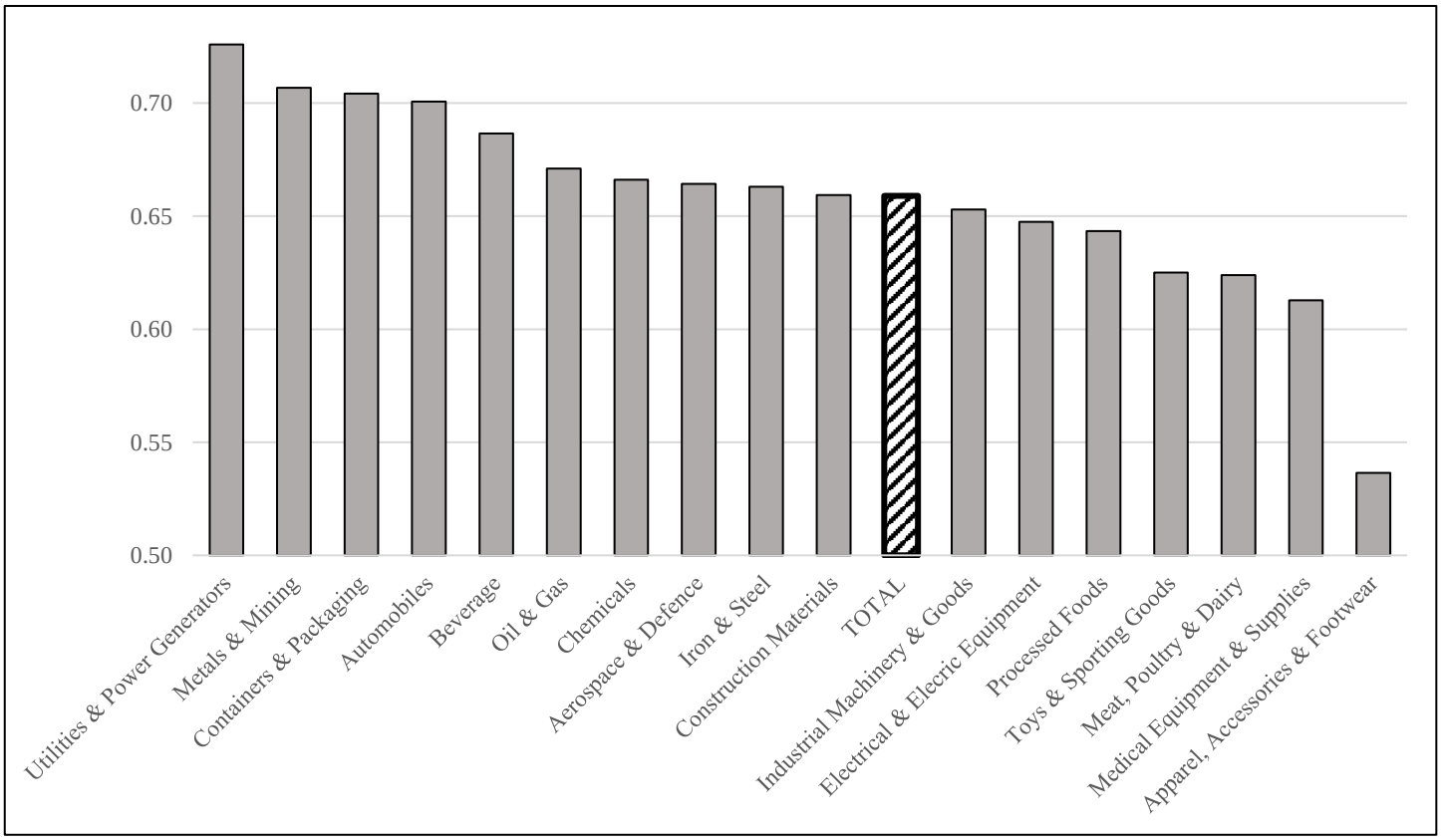

Table 8 — Circularity vs. disclosure

	(1) Circularity Score
Information content factor	**0.055***** *(0.002)*
Information integration factor	**0.01***** *(0.002)*
Constant	0.387*** *(0.002)*
Fixed effects	Time, industry, legal tradition
Observations	*670*
R-squared	*0.796*

Table 9 — Equity risk vs. controls only

	(1) Stock return volatility	(2) Beta against STOXX 600	(3) Beta against MSCI World
Year 2020, dummy	0.142*** *(0.015)*	-0.208*** *(0.058)*	-0.405*** *(0.062)*
ESG Governance Score	0.000 *(0.000)*	0.001** *(0.000)*	0.000 *(0.000)*
R&D to revenue	0.048*** *(0.016)*	0.104*** *(0.021)*	0.184*** *(0.030)*
Total assets, log	-0.025*** *(0.003)*	0.039*** *(0.008)*	0.040*** *(0.009)*
Debt-to-equity ratio	0.001*** *(0.000)*	0.001*** *(0.000)*	0.003*** *(0.000)*
Interest coverage ratio	0.000 *(0.000)*	0.000 *(0.000)*	0.000 *(0.000)*
Profit-on-sales ratio	-0.017** *(0.008)*	-0.031*** *(0.006)*	-0.037*** *(0.006)*
Market-to-book ratio *(A)*	-0.004*** *(0.001)*	-0.001 *(0.003)*	0.002 *(0.003)*
Negative equity, dummy *(B)*	0.123 *(0.072)*	0.147* *(0.079)*	0.156** *(0.060)*
A × B, interaction	0.005*** *(0.001)*	0.002 *(0.003)*	-0.001 *(0.003)*
Constant	0.537*** *(0.032)*	0.78*** *(0.082)*	0.767*** *(0.083)*
Industry-fixed effects	YES	YES	YES
Observations	1,181	1,181	1,181
R-squared	0.42	0.264	0.331

*Robust standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*

Table 10 — Equity risk vs. "full" circularity

	(1) Stock return volatility	(2) Beta against STOXX 600	(3) Beta against MSCI World
Circularity Score	**-0.300****	**-0.440****	**-0.748****
	(0.118)	*(0.174)*	*(0.286)*
Year 2020, dummy	0.144***	-0.206***	-0.403***
	(0.015)	*(0.059)*	*(0.063)*
Governance Score	0.000*	0.001***	0.001*
	(0.000)	*(0.000)*	*(0.001)*
R&D to revenue	0.046***	0.100***	0.178***
	(0.015)	*(0.024)*	*(0.038)*
Total assets, log	-0.016***	0.051***	0.06***
	(0.004)	*(0.009)*	*(0.011)*
Debt-to-equity ratio	0.001***	0.001***	0.003***
	(0.000)	*(0.000)*	*(0.000)*
Interest coverage ratio	0.000	0.000	0.000
	(0.000)	*(0.000)*	*(0.000)*
Profit-on-sales ratio	-0.015*	-0.028***	-0.031***
	(0.008)	*(0.006)*	*(0.004)*
Market-to-book ratio *(A)*	-0.003***	-0.001	0.003
	(0.001)	*(0.003)*	*(0.003)*
Negative A, dummy *(B)*	0.119	0.141*	0.146***
	(0.069)	*(0.072)*	*(0.043)*
A × B, interaction	0.004***	0.001	-0.002
	(0.001)	*(0.003)*	*(0.003)*
Constant	0.568***	0.827***	0.848***
	(0.035)	*(0.083)*	*(0.088)*
Industry-fixed effects	YES	YES	YES
Observations	1,180	1,180	1,180
R-squared	0.437	0.269	0.341

*Robust standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*

Table 11 — Equity risk vs. "core" circularity

	(1) Stock return volatility	(2) Beta against STOXX 600	(3) Beta against MSCI World
Residuals from first-step regression	**-0.351****	**-1.476****	**-1.683***
	(0.121)	*(0.678)*	*(0.851)*
Year 2020, dummy	0.160***	-0.169**	-0.372***
	(0.019)	*(0.066)*	*(0.070)*
Governance Score	0.000	0.002***	0.001
	(0.000)	*(0.001)*	*(0.001)*
R&D to revenue	0.053**	0.068*	0.149***
	(0.021)	*(0.033)*	*(0.029)*
Total assets, log	-0.027***	0.029**	0.043***
	(0.004)	*(0.010)*	*(0.012)*
Debt-to-equity ratio	0.001***	0.001***	0.003***
	(0.000)	*(0.000)*	*(0.000)*
Interest coverage ratio	0.000	0.000**	0.000
	(0.000)	*(0.000)*	*(0.000)*
Profit-on-sales ratio	-0.013	-0.032**	-0.040**
	(0.008)	*(0.013)*	*(0.015)*
Market-to-book ratio *(A)*	-0.003**	0.000	0.004
	(0.001)	*(0.004)*	*(0.004)*
Negative A, dummy *(B)*	0.142	0.178	0.171
	(0.168)	*(0.130)*	*(0.125)*
A × B, interaction	0.005***	0.001	-0.002
	(0.001)	*(0.004)*	*(0.005)*
Constant	0.593***	0.772***	0.685***
	(0.052)	*(0.127)*	*(0.129)*
Industry dummies	YES	YES	YES
Observations	*639*	*639*	*639*
R-squared	*0.44*	*0.278*	*0.33*

*Robust standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*

Table 12 — Equity risk vs. "core" circularity and disclosure-related factors

	(1) Stock return volatility	(2) Beta against STOXX 600	(3) Beta against MSCI World
Residuals from first-step regression	**-0.492***** *(0.123)*	**-1.635**** *(0.643)*	**-2.021**** *(0.816)*
Information content	**-0.033***** *(0.011)*	**-0.033** *(0.021)*	**-0.069**** *(0.029)*
Information integration	**-0.006** *(0.005)*	**-0.021** *(0.015)*	**-0.051**** *(0.018)*
Year 2020, dummy	0.161*** *(0.019)*	-0.169** *(0.066)*	-0.372*** *(0.070)*
Governance Score	0.001 *(0.000)*	0.003*** *(0.001)*	0.002*** *(0.001)*
R&D to revenue	0.047** *(0.020)*	0.055 *(0.032)*	0.117*** *(0.034)*
Total assets, log	-0.013 *(0.008)*	0.043*** *(0.013)*	0.070*** *(0.016)*
Debt-to-equity ratio	0.001*** *(0.000)*	0.000*** *(0.000)*	0.002*** *(0.000)*
Interest coverage ratio	0.000 *(0.000)*	0.000** *(0.000)*	0.000 *(0.000)*
Profit-on-sales ratio	-0.009 *(0.008)*	-0.028** *(0.012)*	-0.03** *(0.014)*
Market-to-book ratio *(A)*	-0.003** *(0.001)*	0.000 *(0.005)*	0.004 *(0.005)*
Negative A, dummy *(B)*	0.141 *(0.144)*	0.173 *(0.116)*	0.159 *(0.098)*
A × B, interaction	0.004*** *(0.001)*	0.001 *(0.005)*	-0.003 *(0.005)*
Constant	0.424*** *(0.083)*	0.608*** *(0.171)*	0.349* *(0.192)*
Industry dummies	YES	YES	YES
Observations	*639*	*639*	*639*
R-squared	*0.471*	*0.285*	*0.353*

*Robust standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*

Table 13 — Equity risk vs. disclosure-related factors

	(1) Stock return volatility	(2) Beta against STOXX 600	(3) Beta against MSCI World
Information content	**-0.030****	**-0.023**	**-0.056***
	(0.011)	*(0.023)*	*(0.03)*
Information integration	**-0.005**	**-0.017**	**-0.047****
	(0.005)	*(0.014)*	*(0.019)*
Year 2020, dummy	0.160***	-0.169**	-0.372***
	(0.019)	*(0.065)*	*(0.070)*
Governance Score	0.000	0.002***	0.001*
	(0.000)	*(0.001)*	*(0.001)*
R&D to revenue	0.047**	0.054	0.116***
	(0.020)	*(0.033)*	*(0.035)*
Total assets, log	-0.015**	0.036**	0.062***
	(0.007)	*(0.013)*	*(0.015)*
Debt-to-equity ratio	0.001***	0.001***	0.002***
	(0.000)	*(0.000)*	*(0.000)*
Interest coverage ratio	0.000	0.000**	0.000
	(0.000)	*(0.000)*	*(0.000)*
Profit-on-sales ratio	-0.010	-0.031**	-0.034**
	(0.008)	*(0.011)*	*(0.013)*
Market-to-book ratio *(A)*	-0.003***	-0.002	0.003
	(0.001)	*(0.005)*	*(0.005)*
Negative A, dummy *(B)*	0.142	0.176	0.163*
	(0.145)	*(0.113)*	*(0.093)*
A × B, interaction	0.004***	0.002	-0.001
	(0.001)	*(0.005)*	*(0.006)*
Constant	0.46***	0.724***	0.491**
	(0.077)	*(0.179)*	*(0.191)*
Industry dummies	YES	YES	YES
Observations	*640*	*640*	*640*
R-squared	*0.461*	*0.265*	*0.332*

*Robust standard errors are in parentheses *** p<.01, ** p<.05, * p<.1*

Table 14 — Dominance analysis: Equity risk vs. "full" circularity

	(1) Stock return volatility	(2) Beta against STOXX 600	(3) Beta against MSCI World
Circularity Score	**1**	**3**	**2**
Total assets, log	2	1	1
Profit-on-sales ratio	3	4	4
Negative A, dummy *(B)*	4	5	7
Debt-to-equity ratio	5	9	3
R&D/Revenues ratio	6	6	6
Market-to-book ratio *(A)*	7	8	10
A × B, interaction term	8	10	9
Governance Score	9	2	5
Interest coverage ratio	10	7	8

Table 15 — Dominance analysis: Equity risk vs. "core" circularity and disclosure-related factors

	(1) Stock return volatility	(2) Beta against STOXX 600	(3) Beta against MSCI World
Information content	**1**	**7**	**4**
Total assets, log	2	1	1
Residuals from first-step regression	**3**	**2**	**2**
Profit-on-sales ratio	4	4	6
Negative A, dummy *(B)*	5	6	8
Debt-to-equity ratio	6	9	5
R&D/Revenues ratio	7	12	9
Governance Score	8	3	7
Market-to-book ratio *(A)*	9	10	11
A × B, interaction term	10	11	10
Interest coverage ratio	11	8	12
Information integration	**12**	**5**	**3**