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Integrated Reporting: The Relevance of Connectivity in Intellectual Capital Disclosures for Market Valuation

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ABSTRACT

We study the relevance of connectivity for market valuation. Connectivity describes the degree to which disclosures reflect interrelations between value drivers that help investors better understand the firm's value creation process. We analyze disclosures on the three intellectual capitals, their interactions, and a self-constructed connectivity score that captures the degree to which disclosures reveal connections within the IC components and with the value creation process. We find significant associations between market value and the interactions of IC capital disclosures as well as our connectivity score. We also find an increase in market value explanatory power in the degree of connectivity.

JEL Classification: C52, G32, M41, O34

1 | Introduction

Driven by new reporting requirements for sustainability such as the EU's Corporate Sustainability Reporting Directive (CSRD) that strongly increase the importance of nonfinancial information, the current debate among standard setters stresses the need of an integration of nonfinancial and financial information (e.g., IFRS Foundation 2025). The integrated reporting (IR) framework (IIRC 2013), originally developed by the International Integrated Reporting Council (IIRC), is now maintained by the IASB Foundation for this purpose.[1] Such IR goes beyond the mere lining up of financial and nonfinancial information in one report, but aims to provide additional value-added from their integration (e.g., Raimo et al. 2025). In particular, it aims at providing investors with decision useful information about the firm's value creation processes along the six capitals of the IR framework (e.g., IFRS 2023; IFRS 2025a; EFRAG 2024), with the intention to provide information on how the different value drivers are connected.[2] Hence, the term "connectivity" as defined by the IR framework,[3] refers to the ability to connect different pieces of information within a report (Brennan and Merkl-Davies 2018). The underlying assumption is that such interconnected information provides superior information about value generation.[4] However, to date, it is yet unclear whether connectivity indeed provides information that is more value relevant than less integrated reports (Kannenberg and Schreck 2019; Dimes and de Villiers 2024). We hence analyze whether market value explanatory power of disclosures increases in the degree of their connectivity.

To capture the connectivity involved in the firms' value creation process, we focus on intangibles as one of the main value drivers in modern times. Intangibles, also known as intellectual capital (IC), are generally considered the firms' most important assets that, because they are missing from financial statements, require their own distinct focus in nonfinancial reporting (e.g., Reitmaier and Schultze 2017).[5] In particular, IC is a relevant area for studying connectivity because the literature in the field of management has found that the IC categories—human, relational, and structural capital—intermingle and create most value if adequately combined within the firm's business model (e.g., Edvinsson and Malone 1997; Albertini 2016; Barrena-Martínez

et al. 2020). Understanding the firm's unique combination of ICs is hence tantamount for understanding the firm's value generation processes.

However, it is yet unclear whether disclosures on such connections are more informative than nonintegrative disclosures. Rieg and Vanini (2023) explicitly call for future research on the interrelations between disclosures on the different IC categories in their meta-analysis on the value relevance of voluntary IC disclosures. We hence analyze the extent to which IC disclosures display interrelations between the IC categories and whether their effect on market valuation depends on how "integrated" they are.

To investigate our research question, we proceed in two steps. First, we use a disclosure score based on the framework of the German Schmalenbach Society (SG 2001, 2003) to measure the quantity and quality of information on IC. It consists of three subscores for human, relational, and structural capital. We analyze the association of each subscore with market value. To account for the connectivity of IC disclosures, we analyze the combined effect of the subscores in different interaction models. Second, we create an IC connectivity score that directly captures the connectivity of IC related disclosures. It measures whether and to what extent information on an IC component describes connections to (A) other IC components, (B) the overall value creation process, (C) other nonfinancial indicators, and (D) financial indicators. For example, disclosures about employee training in isolation inform about the firm's endeavor toward employee development or—technically speaking—an investment in human capital. Connectivity arises if this information is connected to information on, for instance, (A) new innovations because of the employee training, (B) a reduction in the risk of outperformance by competitors, (C) improvements in the production process like a reduction in waste, or (D) increased sales.

Moreover, we do not only consider disclosures on the effects of IC, but also disclosures on firm activities that affect IC. In line with the emphasis of IR, we assume that information on connectivity in disclosures is new information, not just a substitute for other available information. For example, disclosures on the implementation of an in-house kindergarten (social nonfinancial indicator) per se do indeed increase the information set of the reader but do not show any opportunities or threats. Similarly, information on increased employee satisfaction (human capital) does not provide insights on how the firm has achieved this improvement. If the report explains both information in conjunction, that is, that the newly established kindergarten increased employee satisfaction by a particular percentage, the reader gains an additional insight into the connective approach of a firm to meet the complex and existential challenges of our times. We hence analyze the incremental relevance of the IC connectivity score for market value, in addition to the IC disclosure score and its subscores.

We analyze a hand-collected sample consisting of all 266 firms with at least one listing in the three major German stock indices DAX, MDAX, and TecDAX from 1998 to 2019. We do not restrict our analysis to dedicated "integrated reports", to avoid self-selection issues of integrated reporters.[6] Rather, we analyze the IC reporting included in all types of annual reports regarding the degree of connectivity in order to provide a broader basis for conclusion. Germany is characterized by a lack of natural resources and high IC intensity (Lin and Edvinsson 2011; Goebel 2015a), which increases the validity of our tests. Focusing on one rather than several countries holds country-specific factors constant (Leuz 2003) and reduces potential cultural biases (Kumar 2013). For the more detailed analysis of the connectivity score, we use a subsample consisting of all 121 firms with at least one listing in DAX or MDAX from 2014 to 2019, that is, after the introduction of the IR framework and the issuance of the nonfinancial reporting directive (NFRD) 2014/95/EU by the European Parliament and the Council (EU 2014).

We find a positive association of the IC disclosure score with market value and significantly positive interactions for all subcomponents of the IC disclosure score, that is, human, relational, and structural capital, except for the interaction of structural and relational capital, which seems to be of less importance in our sample. When including the interactions of the capitals, the single noninteracted disclosure components turn insignificant, indicating that the joint information is relevant, not the separate. Their stepwise inclusion in the regression increases the market value explanatory power of the model, indicating that IC disclosures and their interrelations incrementally contribute to the explanation of market values.

In the more detailed analyses of the IC connectivity score, we find a significantly positive association with market value, while the IC disclosure score and its subcomponents turn insignificant, indicating that connectivity drives the informativeness of IC disclosures rather than the sole provision of the isolated information items.

Our findings are robust to alternative model and variable specifications as well as alternative sample compositions. Additional analyses show significant relations of IC disclosures and connectivity with lower bid–ask spreads (BAS), that is, increased market liquidity.

Our contribution is threefold: First, as nonfinancial reporting and connectivity are on the agenda of regulatory initiatives around the world, we provide regulatory implications. We contribute to the debate on whether IR is a "failure" (Flower 2015) or "the future" of nonfinancial reporting (Adams 2015) by informing the regulatory assessment of IR. While some research implies benefits like reduced agency costs (Obeng et al. 2021) and less forecast dispersion (Caglio et al. 2020), others criticize the focus on "value for investors" instead of sustainability as initially aspired (Flower 2015), the dependence on professional groups (Humphrey et al. 2017), and the strategic application of rhetoric to gain authority and support (LaTorre et al. 2020). Our results indicate that, independent of the application of the entire IR framework, the principle of connectivity and the description of internal connections in external reporting are relevant for market valuation. Our results support the view that providing context is key for understanding disclosure content (e.g., Adams and Abhayawansa 2022). This further supports the projects on connectivity by EFRAG and IFRS Foundation. While our analysis is limited to IC and the connectivity between overall nonfinancial and financial reporting is up to future research,

we provide support for the assumption that disclosures on connectivity is new and value-relevant information, not substitutive or superfluous information. Hence, connectivity might help reduce the tremendous costs that investors and analysts face when using public information for market valuation (DeHaan et al. 2025) by reducing complexity and impreciseness.

Second, we contribute to the small but growing empirical literature on IR (e.g., Cheng et al. 2014; DeVilliers et al. 2017; Velte and Stawinoga 2017). So far, there is only limited research on the connectivity principle (Kannenberg and Schreck 2019; Soriya and Rastogi 2022), which has focused on its determinants and its application in integrated reports, but has not studied its capital market implications (Haji and Anifowose 2016; Incollingo and Bianchi 2016; Rivera-Arrubla and Zorio-Grima 2016; Maroun 2018; Pistoni et al. 2018; Grassmann et al. 2019). We address this research gap and find that the informativeness of IC disclosures for market valuation largely depends on the degree of connectivity of the provided information.

Third, we contribute to the IC literature (e.g., Orens et al. 2009; Vafaei et al. 2011; Alfraih 2017) by showing that isolated disclosures on single IC aspects are less informative than the integrated information set. This is in line with prior management literature, which shows that the IC categories influence firm performance mainly through combinations and interactions rather than individually (e.g., Edvinsson and Malone 1997; Albertini 2016; Barrena-Martínez et al. 2020). As asked for by Rieg and Vanini (2023), our study contributes to a better understanding of the interrelations between disclosures on IC categories.

The paper proceeds as follows: Section 2 provides background information on IR and connectivity, related research, and the hypotheses. Section 3 describes the measurement of IC disclosures based on our two scores. Section 4 illustrates the research methodology. Section 5 describes the sample. Section 6 provides the results. Section 7 provides additional analyses and robustness tests. Section 8 concludes.

2 | Related Literature and Hypotheses Development

2.1 | Background

Different concepts of nonfinancial reporting have emerged disconnectedly over the past decades (e.g., Rowbottom and Locke 2016).[7] Hence, stakeholders as well as reporting institutions like the Corporate Reporting Dialogue[8] have asked for more comparability and integration in reporting (e.g., Hubbard 2009; Haller and VanStaden 2014). Integration has become ever more important due to the increasing number of topics covered by nonfinancial reporting such as the public's increasing interest in environmental, social, and governance issues and other matters that are often considered to be inadequately reflected in financial statements, like IC. IR has gained momentum integrating the ideas of various concepts of nonfinancial reporting around the ultimate goal of value creation (Reitmaier and Schultze 2017; Lev 2018; Barker et al. 2022). However, the definition of IR highlights that this reporting framework does not only provide guidelines on external reporting but also aims to contribute to internal value creation and organizational change based on a management process called integrated thinking (e.g., Tweedie and Martinov-Bennie 2015; Feng et al. 2017).[9] With integrated thinking, IR emphasizes "the active consideration by an organization of the relationships between its various operating and functional units and the capitals that the organization uses or affects" (IIRC 2013, 2). Hence, IR does not only have direct information effects but also indirect stewardship effects (e.g., Barth et al. 2017).[10] This dual goal is of particular interest for practitioners. The complex and existential challenges of our times require connective thinking, decision making, and acting, which should be reflected in external reporting. In 2019, for instance, a group of international firms formed the Value Balancing Alliance (VBA 2020), which aspires integration of positive and negative impacts of firm behavior on their broader environment into corporate disclosures and into business steering to create and protect multidimensional value.

While the unique concepts of IR gain increased interest, full adoption of the entire IR framework is rare,[11] as is IR research (Zhou et al. 2017). Most IR studies focus on South Africa[12] and Australia, which limits the generalizability of the results (Velte and Stawinoga 2017; Kannenberg and Schreck 2019). In particular, there is a research gap regarding the connectivity principle, which is one of the main novelties of IR in comparison to other nonfinancial reporting concepts and is referred to as the core of IR (e.g., Eccles et al. 2015; SG 2018; Badia et al. 2019).[13] It states that "an integrated report should show a holistic picture of the combination, interrelatedness and dependencies between the factors that affect the organization's ability to create value over time" (IIRC 2013, 16). Connectivity is considered crucial for effective firm communication, independent from IR (Brennan and Merkl-Davies 2018). For instance, the IFRS Foundation (IFRS 2023) and EFRAG (2024) are considering connecting nonfinancial and financial reporting. Comparably to the IR framework, EFRAG defines connectivity as "the attribute of high-quality information that supports the provision of a holistic and coherent set of information within and across the different [annual report] sections" (EFRAG 2024, 11). The common ground of the different understandings is that connectivity concerns the connections between different pieces of information. In this paper, we hence focus on textual connectivity within one report, not intertextual connectivity between different reports nor relational connectivity between firm and audience.[14]

Based on the idea of integrated thinking, the IR framework argues that the internal connectivity of the different capitals should translate into external reporting, possibly heading toward "optimal" reporting (Baret and Helfrich 2019). Still, preparation costs arise because the connectivity of information is difficult to convey in paper format and might lead to repetitions that violate the principle of conciseness (Eccles and Krzus 2015). To be advantageous, connectivity thus needs to provide sufficient benefits. We address the benefits and examine whether connectivity fosters the ultimate IR goal of value creation. To the best of our knowledge, no study has analyzed the value relevance of connectivity in nonfinancial reporting. So far, research on the principle of connectivity is mainly limited to its determinants and application, while research on the value relevance of nonfinancial reporting does not investigate connectivity.

2.2 | Prior Literature on Connectivity in Nonfinancial Reporting

A small set of studies directly investigates connectivity in nonfinancial reporting. In a fuzzy-set qualitative comparative analysis, Rivera-Arrubla and Zorio-Grima (2016) find that the extent of connectivity in the sense of its technical implementation (e.g., digital reporting platforms, cross-referencing, or drill-drown capabilities) depends on the quality of information, corporate characteristics, and communication factors in relation to social media. Incollingo and Bianchi (2016) find heterogeneous degrees of connectivity in the 2013 integrated reports of firms taking part in the IIRC pilot program. Grassmann et al. (2019) also find significant heterogeneity in the extent of connectivity between the six IR capitals in integrated reports of Fortune Global 2000 firms. They find that financial performance, nonfinancial performance, the importance of strategic shareholders, and debt providers are positively associated to the extent of connectivity, while the complexity of the business model and a highly competitive environment are negatively associated. Tirado-Valencia et al. (2024) use a multidimensional index to measure connectivity in integrated reports and find that the level is low. In their study, the main drivers of connectivity are institutional factors (like the obligation to apply the IR framework or the legal system) and internal management decisions (like length and assurance of the report).

A second set of studies investigates connectivity as one aspect in a broader setting. Pistoni et al. (2018) find low IR quality when applying a weighting system that accounts for all IR guiding principles, including connectivity, to each IR content element. Maroun (2018) conducts interviews with auditors and preparers of integrated reports and observes that firms try to explain the connectivity between the different capitals more clearly despite practical challenges. Ruiz-Lozano and Tirado-Valencia (2016) analyze 21 industrial firms of the IIRC pilot program and find that most guiding principles, including connectivity, correlate. Haji and Anifowose (2016) analyze IR in South Africa and find improved connectivity over the period 2011–2013.

Zhou et al. (2017) analyze capital market effects of IR quality in the sense of alignment with the IR prototype framework from October 2012 for a South African sample (2009–2010). In an additional analysis, they extract a connectivity measure from their IR quality score by identifying elements that they expect to reflect connectivity.[15] They find that the aggregate score of these elements is relatively low and negatively related to analyst forecast errors but neither to forecast dispersion nor to cost of equity capital. Also analyzing capital market effects of IR quality in a South African sample (2011–2014), Barth et al. (2017) find a marginally positive relation of connectivity to Tobin's *Q* in an additional analysis. They use data from the Ernst and Young excellence in IR award to measure IR quality. Velte and Stawinoga (2017) attribute only limited validity to such measurement due to the "black box" characteristics of the award.

Only a few studies directly target capital market effects of connectivity in reporting. Lu et al. (2025) find a positive relation of connectivity between sustainability-related disclosures and financial statements with audit quality and fees. Grassmann et al. (2022) find a negative relation between an interaction of assurance quality and connectivity between the six capitals in integrated reports with information asymmetry. However, there are no studies on the value relevance of connectivity within disclosures.

2.3 | Prior Literature on the Value Relevance of nonfinancial Reporting

Ohlson (1995) concludes that "other information" is required in addition to observable accounting information to estimate market values. Francis and Schipper (1999) find that the relevance of earnings information for investors' valuation purposes has decreased over time, while the relevance of balance sheet information has increased. Overall, the value relevance of accounting information has decreased as intangibles become increasingly important (Lev and Zarowin 1999; Vafaei et al. 2011; Lev 2018). The value-based management literature argues that value gaps, that is differences between a firm's current market value and the maximum value possible given a sole focus on shareholder value (Fruhan 1988), can be reduced by communication with shareholders (Copeland et al. 2000). Disclosing additional information can align market value and fundamental value (Koller et al. 2010) and, hence, improve market valuation (Copeland et al. 2000).

A large body of literature finds value relevance of voluntary disclosures in different settings (e.g., Lang and Lundholm 2000; Uyar and Kiliç 2012; Reitmaier and Schultze 2017). Traditional mandatory disclosures are found to be less relevant than additional voluntary disclosures (e.g., Cheung et al. 2010; Givoly et al. 2017). With only very few exceptions (e.g., Ferraro and Veltri 2011), studies investigating voluntary disclosures on intangibles in particular find value relevance. Some studies support the value relevance of single aspects of IC including R&D (e.g., Lev and Sougiannis 1996; Zhao 2002; Ahmed and Falk 2006), human capital (e.g., Gamerschlag 2013), and other single IC proxies (e.g., Ghosh and Wu 2007).[16] Other studies find value relevance of web-based IC disclosures (e.g., Orens et al. 2009). In their literature review, Brennan and Connell (2000) conclude that IC explains a substantial portion of the gap between market and book value. One study explicitly analyzes IC disclosures in integrated reports: Salvi et al. (2020) find a significantly positive relation between a self-constructed score of IC disclosure quality and Tobin's *Q*.[17]

Some studies apply the Ohlson (1995) model to investigate the value relevance of IC as "other information." Using a sample of firms listed on the Johannesburg Stock Exchange, Swartz et al. (2006) find that Pulic's VAIC coefficient, an IC proxy based on observable accounting information, is significant in the Ohlson (1995) model.[18] Other studies measure the extent of IC disclosures in annual reports and find a significantly positive association with market value (Abdolmohammadi 2005; Anam et al. 2011; Ellis and Seng 2015; Alfraih 2017).[19]

Alfraih (2017) further finds significantly positive associations of the interactions between IC disclosures and both book value

of equity and earnings with market value. Vafaei et al. (2011) find a positive effect of IC disclosures on the incremental value relevance of IFRS adjustments in book value of equity and earnings. This suggests that investors use IC disclosures to complement their balance sheet analyses and that they can better analyze and interpret information in mandatory annual reports when firms disclose additional IC information. Moreover, Adams and Abhayawansa (2022) state in their critical discussion of nonfinancial reporting "myths" that users of the disclosed information like fund managers and analysts seek context to understand nonfinancial disclosures. Still, there is no empirical study that directly investigates whether connectivity reduces uncertainty beyond disconnected disclosures. In their meta-analysis on the value relevance of voluntary IC disclosures, Rieg and Vanini (2023) explicitly call for future research on the interrelations between disclosures on the different IC categories.

Few empirical studies have analyzed the value relevance of other aspects of IR, like its adoption (e.g., Baboukardos and Rimmel 2016; Cortesi and Vena 2019; Landau et al. 2020; Wahl et al. 2020), measures of IR disclosure quality (Lee and Yeo 2016; Dey 2020), IR readability (Caglio et al. 2020), or IR as a means to disclose IC information (Camodeca et al. 2019). However, no study has addressed the relevance of the connectivity principle for market valuation.

2.4 | Prior IC Management Literature

To address the outlined research gap, we use the case of nonfinancial disclosures on IC, which is a material value driver within the firm's business model (Bini et al. 2016).[20] Management literature finds that the single IC categories are interdependent and need to be adequately combined within the firm to create value (e.g., Edvinsson and Malone 1997; Wang and Chang 2005; Cabrita and Vaz 2006). In a literature review, Inkinen (2015) concludes that the majority of the empirical literature suggests that not the single capitals, but their interactions enhance firm performance. One example of connective IC management is open innovation (Chesbrough 2003), which relies on both internal (human capital) and external knowledge and skills (relational capital, e.g., university collaborations or online portals to collect customer ideas) to foster innovations (structural capital) and hence increase firm performance.[21]

Studies that analyze different ways of how firms can combine and transform their IC mostly find a positive impact of IC interactions on firm performance (e.g., Huang and Hsueh 2007; Kamukama et al. 2010; González-Loureiro and Dorrego 2012; Jardon and Martos 2012; Cleary 2015). Only a few studies indicate a substitutional rather than complementary effect between the IC categories (e.g., Reed et al. 2006). However, in most studies, the interactions of the IC categories constitute a more important driver of firm performance than the individual categories (Inkinen 2015). Based on semi-structured interviews in two major hospitals, Habersam and Piber (2003) even introduce "connectivity capital" as a fourth IC category because the interviewees stress the importance of linking the traditional three IC categories.

2.5 | Hypotheses

In summary, prior literature finds that IC disclosures are relevant for market valuation but have not jointly analyzed the relevance of disclosures on the single IC categories and their connectivity. Prior management literature shows meaningful interrelations between the IC categories. Based on the principle of integrated thinking, the IR framework advocates translating such internal relations into external disclosures. We consequently expect that disclosures, which display these interrelations, are relevant for market participants and improve market values by decreasing information asymmetries regarding the future performance of the firms. Lower information asymmetries reduce the cost of capital based on the stewardship effect by improving the alignment of managers' and shareholders' interests (Lambert et al. 2007; Lambert and Verrecchia 2015). The reduced agency costs increase expected future payoffs and, thus, reduce the cost of capital and hence improve market valuation (Lambert et al. 2007; Core et al. 2015). When IC disclosures made in one IC category (human, structural, relational) are related to others, disclosures should hence be more informative for purposes of market valuation when they are more connected. We expect that when links between the categories of IC exist, these links will be relevant for market valuation. Accordingly, we expect that a higher degree of connectivity in IC disclosures improves their relevance. We hypothesize:

H1. *The positive association of market value and IC disclosures in one category is positively moderated by IC disclosures in another category.*

H2. *The degree of connectivity of IC disclosures is positively associated with market value.*

3 | Measurement of IC Disclosures

3.1 | Content Analyses of Annual Reports

To measure IC disclosures and their connectivity, we apply two self-constructed scores and collect data via content analyses of annual reports.[22] Self-constructed scores have the advantage to reliably capture what is intended to be measured (Healy and Palepu 2001). Annual reports are an important source of information (Lingwood 2018), if not *the* most important source for financial analysts and investors (Hail 2002). Firms do not necessarily change their traditional reporting processes when they implement IR (Stubbs and Higgins 2014). There is no empirical support for differences in the connectivity of information in traditional opposed to integrated reports (Kannenberg and Schreck 2019). Furthermore, it remains controversial whether IR displays a particular means for IC disclosures (e.g., Dumay and Guthrie 2017; Nielsen et al. 2017). We thus argue that any kind of annual report serves our purpose to investigate the value relevance of connectivity in IC disclosures. This also avoids self-selection issues of integrated reporters and provides a broader basis for conclusion.[23] We investigate IC disclosures that had completely been characterized as voluntary before the introduction of the NFRD (EU 2014) and, hence, focus on the management report and

other nonfinancial information exceeding mandatory financial statements and notes.[24]

We do not analyze additional isolated disclosures in other types of reports because a firm would have to repeat information from another report in the annual report if it was relevant to describe connectivity with information that is included in the annual report. Hence, the information would be included in the annual report and measured by our scores. Moreover, it is exactly the focus of IR and also of current standard setting on nonfinancial reporting, like the European Sustainability Reporting Standards (ESRS), to reduce repetitions and present all firm disclosures in one concise report. Therefore, we analyze the degree of connectivity that is yet present in annual reports.

Content analyses to measure IC have been criticized for subjectivity and missing comparability due to different definitions and categorizations of seemingly equivalent content (e.g., Beattie and Thomson 2007; Dumay and Cai 2014, 2015). Goebel (2015b), however, finds remarkable comparability when meta-analyzing IC studies of content analyzed data. Hand-collecting contents ensures a profound understanding of the context of information (Krause et al. 2017), which is particularly important in the case of IC and its connectivity as the categorization of respective information might not always be straightforward (e.g., Beattie and Thomson 2007). Without context, networks and cooperations, for instance, might belong to innovation capital (R&D cooperations), to process capital (joint ventures in production), or to customer capital (joint acquisition of customers) (SG 2003). When performed correctly, content analyses are a systematic, objective, and reliable way to discover the meaning of disclosures (Whiting and Miller 2008).

We adopt several procedures to validate our hand-collected data. To standardize codification in the beginning of the data collection process, each coder analyzed the same annual reports simultaneously. High homogeneity between the data reduces the risk of survey bias. Throughout the data collection process, coders discussed inconclusive information and regularly exchanged views to reduce potential subjectivity biases. At the end, each coder randomly recollected data that another coder had analyzed previously. Comparisons of both data revealed high homogeneity. In case of differences, the coders discussed and recollected the data jointly.

3.2 | IC Disclosure Score

While there is no ultimate definition of IC, it is commonly accepted that IC is the sum of a firm's "hidden assets", that is resources not displayed on the balance sheet but still relevant for the firm's competitive position (e.g., Edvinsson and Malone 1997; Roos and Roos 1997; Sveiby 1997). Despite terminological differences, a three-dimensional categorization into human, relational, and structural capital has become the quasi-standard to describe and measure IC (e.g., Sharabati et al. 2010; Inkinen 2015). Human capital refers to skills, knowledge, and commitment of the organizational members; relational capital to external relations with customers, suppliers, and investors; and structural capital to internal organizational processes, locational structures, and innovation (e.g., Chen et al. 2004; Cabrita and Bontis 2008; Inkinen 2015).

To capture the entire breadth of IC, we use a detailed and broad IC disclosure score based on the framework of the working group on intangibles of the German Schmalenbach Society of Business Administration (SG 2001, 2003). The framework builds on Edvinsson and Malone's (1997) fundamental work on IC and captures the many different dimensions of IC as proposed by Sveiby (1997) and Stewart (1999). For each IC category, the SG (2001, 2003) provides concrete examples and indicators to allocate an IC resource to that category. The framework consists of three categories, which entail seven capitals: human capital, relational capital (comprising customer, supplier, and investor capital), and structural capital (comprising process, location, and innovation capital). These seven capitals each refer to several related items. Appendix A provides a detailed description of the IC items and the IC disclosure score.

To capture not only quantity but also quality of IC disclosures (as called for by, e.g., Afeltra et al. 2022; Rieg and Vanini 2023), we award score points based on the level of information provided (as in, e.g., Orens et al. 2009; Reitmaier and Schultze 2017): one point if a report provides at least two pieces of general verbal information on any of the items related to the respective capital, two points for qualified information, and three points for quantifiable information. For instance, an example for one piece of general verbal information regarding human capital is mentioning employee trainings, an example for qualified information is specific employee qualifications, and an example for quantifiable information is training time per year. If the same information is repeated within one annual report, it is considered only once.

Overall, firms can attain values between zero and 21 points for overall IC disclosure in their annual report (3 points per capital). All scores are scaled by the maximum number of points achievable and the resulting measures ($IC_{i,t}$, $HC_{i,t}$, $RC_{i,t}$, $SC_{i,t}$) attain values between zero and one.

3.3 | IC Connectivity Score

We collect detailed data on how firms implement connectivity in IC disclosures in their annual reports based on a self-constructed measure, for a subsample of firms. We use (groups of) sentences as the primary coding unit and also take the context of the paragraph as well as graphics, tables, and figures into account. We analyze the connectivity amongst the IC capitals and also the connectivity of IC within the overall setting of the firm.[25] We regard connectivity of IC within the overall value creation process, which is at the core of current debates in standard setting, such as the debate on materiality or the debate on value chain reporting. In addition, we measure connectivity of IC information with other nonfinancial (social and environmental) as well as financial indicators. Thereby, we touch on the current discussion of EFRAG and ISSB about connectivity of nonfinancial and financial information. In particular, we analyze for each information on an IC item whether it contains a connection to other IC items, to

the value creation process, to other nonfinancial indicators or to financial indicators. Thereby, we directly code causal relations as asked for by, for example, Grassmann et al. (2019). In total, the IC connectivity score contains the following four additive dimensions.

First, we analyze how the firm connects its various IC items amongst each other. We capture input–output connections of an IC item with other IC items. An example is disclosures on employee training (human capital; input) and resulting new R&D projects (structural capital; output).

Second, we measure the connectivity between the IC items and the firm's overall value creation process that is based on the eight content elements defined by the IR framework of the IIRC.[26] Examples are disclosures on performance-based compensation (content element "governance") depending on innovativeness (structural capital) or disclosures on risks (content element "risks and opportunities") associated with employee scarcity (human capital).

Third, we capture input–output connections of the IC items with other nonfinancial indicators (both the IC item and the nonfinancial indicator can either be input or output factor). Examples are disclosures on the impact of implementing an in-house kindergarten (social indicator; input) or extended efforts to reduce greenhouse gas emissions (environmental indicator; input) on employee bonding and motivation (human capital; output).

Fourth, we capture input–output connections of the IC items with financial indicators (both can either be input or output factors). Examples are disclosures on new customer attraction (relational capital; input) resulting in higher sales (financial sales indicator; output) or disclosures on expansions toward new locations (structural capital; input) resulting in additional profits (financial profit indicator; output).

We award score points for each input–output relation following the same logic as for the IC disclosure score: one point if the report generally or indirectly mentions connectivity between an input and an output factor; two points if it transparently and directly mentions connectivity; and three points if it additionally quantifies the connectivity with regard to both the input and the output factor.[27] Overall, firms can attain values between zero and 329 points for IC connectivity and our relative measure ($ICCon_{i,t}$) can take values between zero and one.[28] Appendix B provides a detailed description of the IC connectivity score.

With the IC connectivity sore, we directly measure how pieces of information describe connections between the capitals. In contrast, the IC disclosure score allocates each information to only one capital. For instance, if a firm mentions employee training on innovativeness, this information counts for human capital as it increases the reader's information set on the firm's handling of employee topics. If such training does indeed have an impact on innovativeness, the report might additionally mention related information that counts for innovation capital like the number of innovations that result from the particular training. In this case, the IC disclosure score measures both pieces of information—one for human and one for innovation capital. The IC connectivity score, in contrast, measures this information set once, but dependent on the quality of describing the connection. Hence, the IC connectivity captures the additional information that the employee training and the increase in innovations are connected, which implies that the firm recognizes connections between its value drivers, that is, applies integrative thinking.

4 | Research Methodology

To test the value relevance of IC disclosures and their connectivity, we follow prior research and use Ohlson (1995) type valuation models. Ohlson (1995) derives a closed form valuation model, which is frequently applied in empirical accounting studies (e.g., Aboody and Lev 1998; Barth et al. 1998; Cazavan-Jeny and Jeanjean 2006). An important feature of the Ohlson (1995) model is the "other information" component, which comprises all information relevant for market valuation not included in current book values and earnings. Ohlson (2001) suggest to proxy for "other information" by using analysts' consensus forecasts. Equation (1) represents this baseline model:

$$\boldsymbol{MV}_{i,t+3m} = \beta_0 + \beta_1\, BV_{i,t-1} + \beta_2\, E_{i,t} + \beta_3\, FRCST_{i,t} + IND + YEAR + \varepsilon_{i,t} \quad (1)$$

We measure market value 3 months after the end of fiscal year t ($MV_{i,t+3m}$) as in prior literature (e.g., Basu 1997).[29] $BV_{i,t-1}$ is the book value of equity at the beginning of t (i.e., book value before earnings). $E_{i,t}$ is the earnings in t. Based on Barth and Clinch (2009), we do not scale the variables. In a first step, we use OLS regressions with industry (*IND*) and year fixed effects (*YEAR*) to control for industry and time differences. We refrain from including firm fixed effects because the within-firm variation is not considered undesirable.[30]

Since analysts' earnings forecasts do not fully capture relevant nonfinancial information, we integrate the IC disclosure score ($IC_{i,t}$) as an additional proxy for other information to investigate its relevance for market valuation (following, e.g., Alfraih 2017; Reitmaier and Schultze 2017):

$$\boldsymbol{MV}_{i,t+3m} = \beta_0 + \beta_1\, BV_{i,t-1} + \beta_2\, E_{i,t} + \beta_3\, FRCST_{i,t} + \beta_4\, \boldsymbol{IC}_{i,t} + IND + YEAR + \varepsilon_{i,t} \quad (2)$$

$FRCST_{i,t}$ is the 1-year ahead analyst consensus forecast of change in earnings at the end of t (analysts' earnings forecast for $t+1$ minus actual earnings in t).

When estimating Equation (2), we also disaggregate IC into its components. We test the association of each IC disclosure category with market value by replacing $IC_{i,t}$ with either $HC_{i,t}$, $RC_{i,t}$, or $SC_{i,t}$. To test the moderation effect between the IC disclosure categories (*H1*), we estimate three interaction models with bivariate interactions between each two of the subscores ($HC_{i,t}$ and $RC_{i,t}/HC_{i,t}$ and $SC_{i,t}/RC_{i,t}$ and $SC_{i,t}$) and a model with the interactions between all three subscores.

To analyze whether IC disclosures and their subcomponents as well as their connectivity are informative and hence increase the market value explanatory power of the Ohlson (1995) model, we compare the explanatory power of model (1) to model (2) and to the three-way interaction model. We measure explanatory power by the adjusted R^2 of the respective regressions, the root mean squared errors (RMSE), and the Akaike information criterion (AIC).[31] We expect that the criteria enhance from model (1) to model (2) and to the interaction model.

To analyze the relevance of the degree of connectivity (*H2*), we include the IC connectivity score ($ICCon_{i,t}$), which captures the connectivity of IC disclosures, as follows:

$$\begin{aligned} \boldsymbol{MV}_{i,t+3m} = {} & \beta_0 + \beta_1 BV_{i,t-1} + \beta_2 E_{i,t} + \beta_3 FRCST_{i,t} \\ & + \beta_4 \boldsymbol{IC}_{i,t} + \beta_5 \boldsymbol{ICCon}_{i,t} + IND + YEAR + \epsilon_{i,t} \end{aligned} \quad (3)$$

Based on *H2,* we expect a positive coefficient for $ICCon_{i,t}$. We also test different variants where we replace $IC_{i,t}$ by $HC_{i,t}$, $RC_{i,t}$, and $SC_{i,t}$.

To address the possibility of endogeneity biasing our results, we follow prior disclosure studies and in a second step apply an instrumental variable estimation approach, using two-stage least squares (2SLS) estimators (e.g., Core 2001; Healy and Palepu 2001; Dinh et al. 2020). Omitted variables that influence this willingness to disclose and are hence related to our variable *IC* may potentially have an impact on the dependent variable *MV*. To estimate the potentially endogenous variable *IC* in the first stage, we identify three valid instruments that meet the criteria of being relevant and exogenous (Stock and Watson 2012).

Our first instrument is the one year lagged value of *IC* ($laggedIC_{i,t}$). Lagged versions of the potentially endogenous variable are commonly used in literature (e.g., Hilary and Hui 2009; Christensen 2016). Following Christensen (2016) in the context of CSR reporting, it can be assumed that IC disclosures follow a certain pattern and the extent to which information has been published in the past influences the amount of IC disclosure made in year *t*. At the same time *laggedIC* may be considered exogenous, because it is unlikely that the IC score of the previous year should have a direct effect on firms' current market value.

We use $AUDIT_{i,t}$ as our second instrument. The dummy variable indicates whether the company's auditor is one of the big four accounting firms (KPMG, PwC, E&Y, Deloitte). Prior literature demonstrates a positive association between the size of an auditing firm and the company's disclosure level (e.g., Raffournier 1995; Hail 2002; Xiao et al. 2004). The relationship can be attributed to auditors' high-quality standards, as they tend to encourage their clients to maintain a high level of disclosure quality. Because prior literature has identified a positive relationship both for reporting in general and for nonfinancial disclosure, a positive effect of the variable $AUDIT_{i,t}$ can be expected for IC disclosure. Literature findings on the relevance of auditor's size on capital market outcomes are mixed, including studies that reveal no effect of the auditor's size on capital market outcome (e.g., Lawrence et al. 2011; Manoel et al. 2026) that support our assumption that the instrument is exogenous.

Our third instrument is board independence ($BI_{i,t}$). Previous literature in Anglo–Saxon contexts shows a positive association of board independence and voluntary disclosure (e.g., Cerbioni and Parbonetti 2007; Li et al. 2008). However, the concept of board independence cannot be directly transferred to the German two-tier governance system. We therefore define board independence as the extent to which the management board is subject to monitoring by external parties and employees. We measure board independence as a categorical variable, ranging from 0 to 3 with 3 displaying the highest degree of employee participation and external participation. We assume that stronger monitoring encourages greater disclosure, and we therefore expect a positive relationship between *BI* and IC disclosure. All control variables of the second stage are also included in the first stage regressions. Appendix C provides details on the variable measurement.

5 | Sample

Our full sample is based on all 266 firms with at least one listing in the three biggest German stock indices DAX, MDAX, and TecDAX within the period from January 1, 1998 until December 31, 2019. Publicly listed firms dominate the IR database as they publish most integrated reports (Dumay et al. 2016). This indicates that large publicly listed firms apply the concepts of IR more than other firms, although they do not necessarily declare their respective annual reports as "integrated" reports. Germany is a particularly IC-intensive setting (e.g., Lin and Edvinsson 2011; Goebel 2015a), which increases the validity of our tests. In Germany, the importance of intangible assets is high due to the lack of natural resources. Germany spent between 2.4 and 3.2% of its GDP on R&D investments during the last two decades, which is similar to the United States and higher than the average EU or OECD country (OECD 2024). Our sample answers the call for empirical research in the context of IR outside South Africa and Australia (e.g., Zhou et al. 2017). Focusing on one country rather than several countries holds country-specific factors constant (Leuz 2003) and reduces potential cultural distortions (Kumar 2013). We start our analyses in 1998 as this year represents a milestone in German corporate reporting. Since then, regulators have allowed the use of the IFRS or US-GAAP instead of German law for listed firms. Our study investigates a noticeably longer timeframe than other IR studies.

We analyze all 266 firms in all years 1998 until 2019, regardless of whether they were listed in one of the three indices repeatedly or only once during that period. We exclude 1965 inactive firm-year observations. We do not exclude the firms completely to avoid survivorship biases. We exclude another 689 observations due to missing values and 189 outlier observations by trimming all variables except for the scores at the 1st and 99th percentiles. The final sample includes 3009 firm-year observations.

To analyze connectivity of IC information, we use a subsample of all 121 firms listed in DAX and MDAX at least once after the introduction of the IR framework and the issuance of the European NFRD, that is, within the period from January 1, 2014, until December 31, 2019. We exclude 50 inactive firm-year observations, 35 missing value observations, and 41 outliers. The final

subsample includes 601 firm-year observations. While this sample is smaller than the first sample, it is still in the same range as other IR studies' sample sizes (Kannenberg and Schreck 2019). We collect data from annual reports and Thomson Reuters. Appendix C provides details.

Table 1 presents the descriptive statistics. Panel A covers the full sample. The overall IC disclosure score ranges from zero to 95.2% (mean = 45.7%). No firm-year observation scored 100%. Human capital disclosures range from zero to one (mean = 66.6%), as do relational (mean = 47.0%) and

TABLE 1 | Descriptive statistics.

Panel A: Descriptive statistics of the full sample (IC disclosure scores)						
Variable	***n***	**Mean**	**SD**	**Min.**	**Median**	**Max.**
$IC_{i,t}$	3009	0.457	0.192	0.000	0.476	0.952
$HC_{i,t}$	3009	0.666	0.313	0.000	0.667	1.000
$RC_{i,t}$	3009	0.470	0.206	0.000	0.444	1.000
$SC_{i,t}$	3009	0.376	0.233	0.000	0.333	1.000
$MV_{i,t+3m}$	3009	5337.999	10,700.930	24.970	1357.800	77,331.440
$BV_{i,t-1}$	3009	2862.301	6292.790	11.822	577.600	50,881.000
$E_{i,t}$	3009	338.917	845.094	−1536.000	62.343	7207.000
$FRCST_{i,t}$	3009	16.149	231.074	−1530.715	1.763	1804.896
$AUDIT_{i,t}$	2748	0.847	0.360	0	1	1
$BI_{i,t}$	2748	1.518	0.757	0	2	3
$BAS_{i,t}$	2720	−5.773	1.0545	−8.173	−5.854	0.377
$Beta_{i,t}$	2720	0.914	4.557	−0.202	0.816	237.378
$FF_{i,t}$	2720	64.989	26.236	0	69.000	100
$CL_{i,t}$	2720	0.199	0.801	0	0	9
$FOL_{i,t}$	2720	13.286	9.0778	1	12	42
Panel B: Descriptive statistics of the subsample (IC connectivity score)						
Variable	***n***	**Mean**	**SD**	**Min.**	**Median**	**Max.**
$IC_{i,t}$	601	0.558	0.185	0.000	0.571	0.952
$HC_{i,t}$	601	0.796	0.294	0.000	1.000	1.000
$RC_{i,t}$	601	0.587	0.196	0.000	0.556	1.000
$SC_{i,t}$	601	0.450	0.244	0.000	0.444	0.889
$ICCon_{i,t}$	601	0.091	0.046	0.006	0.083	0.309
$MV_{i,t+3m}$	601	12,172.280	17,932.940	409.940	5216.150	99,058.940
$BV_{i,t-1}$	601	6602.599	11,456.750	21.046	2289.000	69,063.000
$E_{i,t}$	601	803.788	1497.289	−3234.000	259.719	8784.000
$FRCST_{i,t}$	601	25.487	390.680	−1936.405	9.570	2039.462
$AUDIT_{i,t}$	486	0.975	0.155	0	1	1
$BI_{i,t}$	486	1.693	0.711	0	2	3
$BAS_{i,t}$	482	−6.722	0.641	−8.184	−6.583	−4.068
$Beta_{i,t}$	482	1.401	10.733	0.099	0.909	237.378
$FF_{i,t}$	482	66.413	25.336	5	74	100
$CL_{i,t}$	482	0.149	0.445	0	0	4
$FOL_{i,t}$	482	17.236	8.085	1	17	40

Note: Table 1 presents the descriptive statistics. **Panel A** covers the full sample. **Panel B** covers the subsample that we use to analyze the IC connectivity score. All variables are defined as in Appendix C.

structural capital disclosures (mean = 37.6%). On average, disclosures are highest for investor capital (mean = 76.7%). This reflects the relative importance of investors as disclosure addressees. Average disclosure is lowest for supplier capital (mean = 17.8%). A reason might be several sample firms belong to industries without significant suppliers, like financial or real estate firms.[32] On average, market values (mean = 5338) are almost 90% higher than book values of equity (mean = 2862). Earnings range from −1536 to +7207 and forecasted changes in earnings from −1531 to +1805.[33]

Figure 1 shows that the mean of $IC_{i,t}$ increases over time, as does the mean of the disclosure subscores. This may be due to the development of accounting standards under IFRS and an overall improvement of reporting systems over time.[34] The mean of $IC_{i,t}$ decreases in 2000, 2011, and 2013. These years represent years of calm shortly before the dotcom crisis and after the financial crisis. Such years are characterized by lower levels of public pressure and legitimacy threats, which are commonly referred to as drivers of additional disclosures (e.g., Patten 1991; Cho and Patten 2007; Melloni 2015). The decrease in 2013 might also result from the request for less information overload that arose with the development of IR (e.g., Kiron 2012; Haller and VanStaden 2014).[35] The mean of $IC_{i,t}$ increases in 2014 and particularly in 2017, when the European NFRD was announced and became effective, respectively.[36]

As depicted in Figure 2, we find the highest amounts of IC disclosures for DAX observations on average, followed by MDAX and TecDAX.[37] Figure 3 further shows that IC disclosures are highly industry specific. On average, IC disclosures are highest for basic materials (ICB industry 55), followed by energy firms (ICB 60) and lowest for real estate (ICB 35), followed by financial firms (ICB 30). One reason may be that financial and real estate firms (categorized as one ICB industry under the former four-digit ICB classification scheme) place higher weight on disclosure topics other than IC, like risk reporting (Goebel 2015a).[38]

Table 1B shows the descriptive statistics for the subsample. On average, the IC disclosure scores are higher than in the full sample: IC disclosures are higher during the later years and for larger firms. Connectivity in IC disclosures is rather low with a mean of 9.1% and a median of 8.3%. The maximum of 30.9% shows that even the firms that best implement connectivity in their IC disclosures are far from fully integrated. One reason might be that not all IC categories are equally important to each firm and, hence, have material connections to other aspects of value creation. Further reasons include phenomena like disclosure precedent or proprietary costs: Firms disclose neither information that might raise stakeholders' expectations to a level that is not achievable in the future (Pistoni et al. 2018) nor sensitive proprietary information threatening competitive advantages (Verrecchia 1983). Higher values for market value, book value, and earnings compared to the full sample reflect that the subsample includes the bigger firms of the full sample.

Figure 4 shows that the average disclosed connectivity was lowest in 2014 (about 8%). It remained at about 9% between 2015 and 2017 and increased to about 10% in 2018 and 2019. Figure 5 shows that DAX firms score highest.[39] Figure 6 shows that, like IC disclosures, their connectivity is highly industry specific. On average, connectivity in IC disclosures is lowest for real estate firms (ICB 35) and highest for consumer staples (ICB 45).

Table 2 shows the Bravais–Pearson and Spearman rank correlations for the IC disclosure scores in the full sample (Panel A) and for the IC connectivity score in the subsample (Panel B). Significant positive correlations of the single IC disclosure scores with market value support their value relevance. Significant correlations between the IC disclosure categories provide indicative

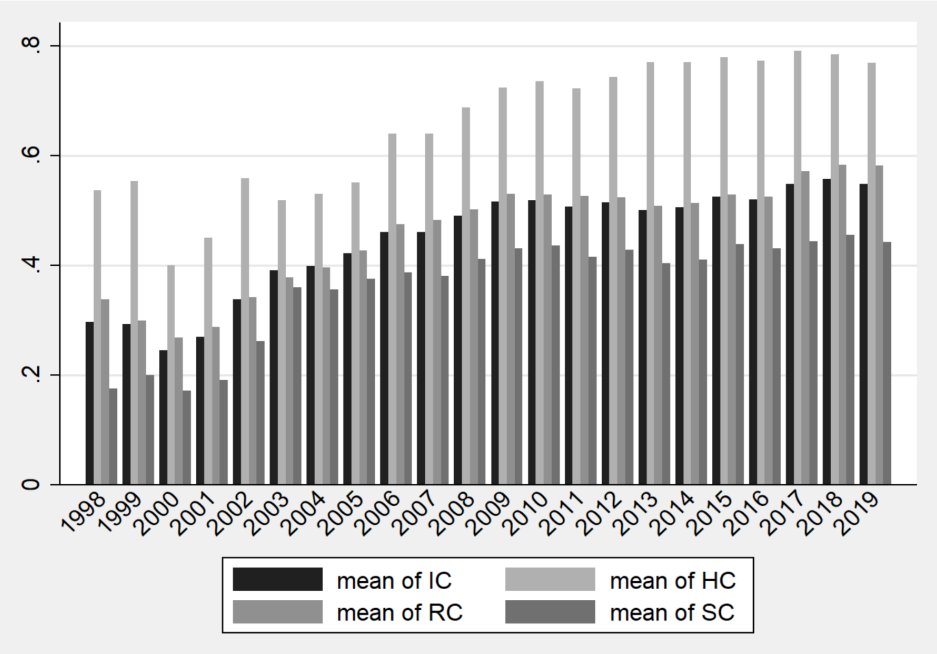

FIGURE 1 | Extent of IC disclosures over time. Figure 1 displays the mean of disclosures on IC and its categories over time (created in STATA).

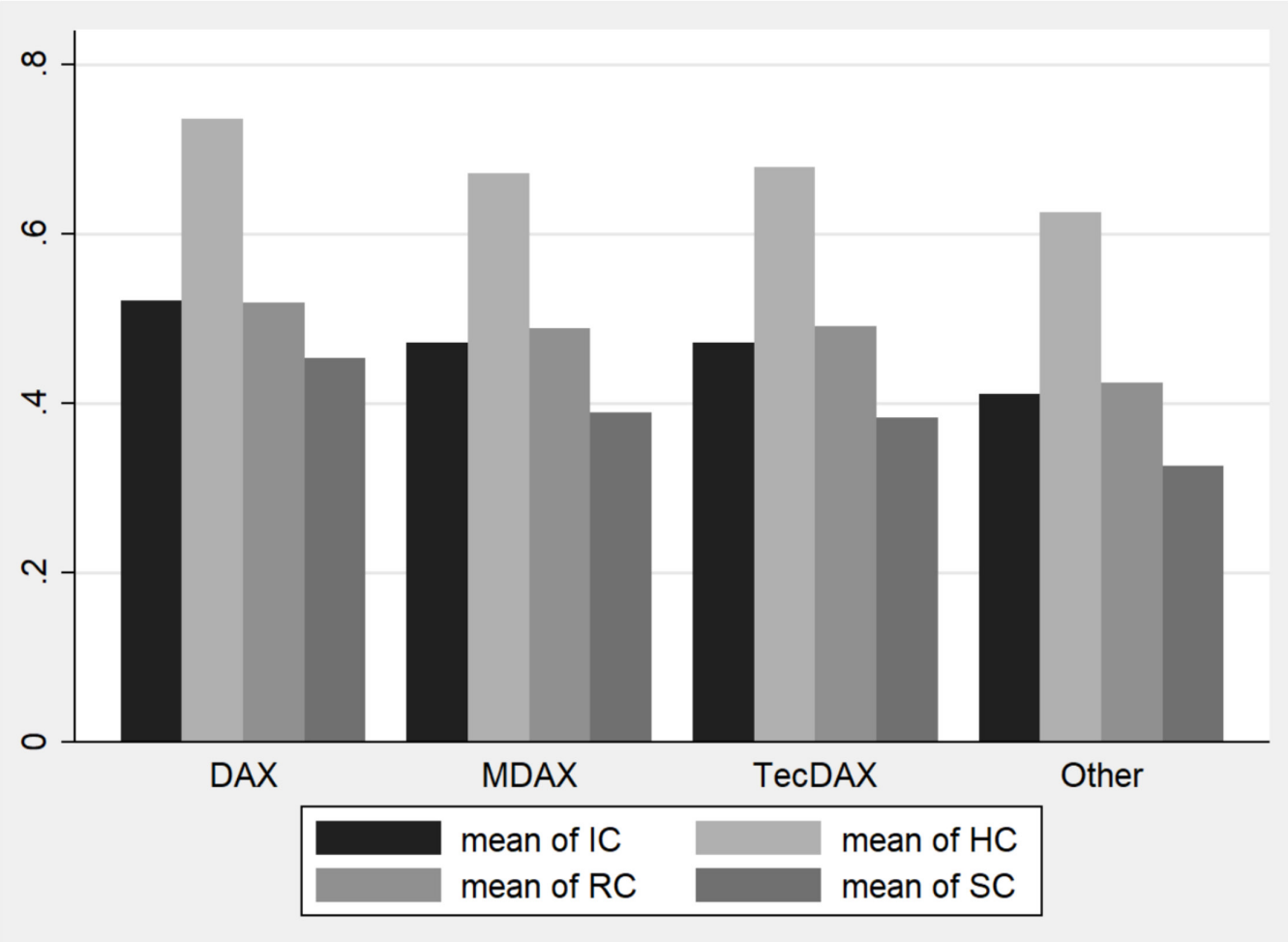

FIGURE 2 | IC disclosures by stock indices. Figure 2 displays the mean of disclosures on IC and its categories per stock index (from 1998 through 2019; created in STATA).

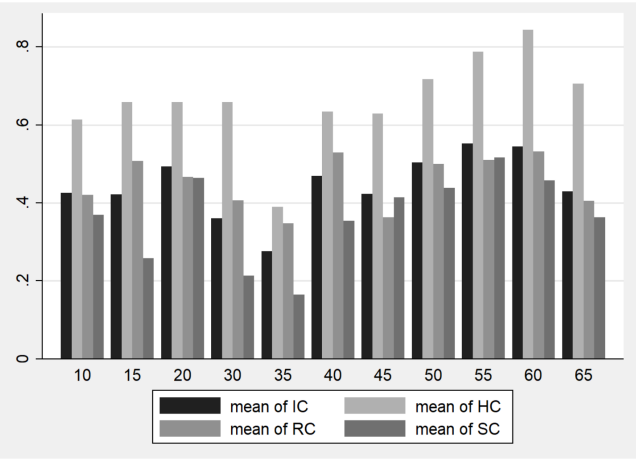

FIGURE 3 | IC disclosures by ICB industries. Figure 3 displays the mean of disclosures on IC and its categories per ICB industry (from 1998 through 2019), where 10 = technology, 15 = telecommunications, 20 = health care, 30 = financials, 35 = real estate, 40 = consumer discretionary, 45 = consumer staples, 50 = industrials, 55 = basic materials, 60 = energy, and 65 = utilities (created in STATA).

support for *H1*. Moreover, the significant positive correlations of the IC connectivity score with market value provide first support for *H2*. All other correlations are consistent with expectations.

6 | Empirical Results

Regression results based on OLS estimation for the value relevance of IC disclosures and their interactions are presented in Table 3 for Equations (1) and (2) and in Table 4 for Equation (3), respectively. The Durbin–Wu–Hausmann Test for endogeneity of the IC scores is significant (*IC*: $\chi^2 = 11.34^{***}$; *HC*: $\chi^2 = 3.06^{***}$; *RC*: $\chi^2 = 11.93^{***}$; *SC*: $\chi^2 = 9.15^{***}$), suggesting that an endogeneity problem is present. We hence present the results for the 2SLS approach in Table 5 for Equations (1) and (2) and Table 6 for Equation (3), which are largely identical to the OLS results. In the following discussion of results, we focus on the 2SLS results.

Table 5A presents the first stage regressions, instrumentalizing the endogenous regressors *IC*, *HC*, *RC*, and *SC*. Because of missing data in the instrumental variables used, the sample size decreases from 3009 to 2748 observations. The coefficients of

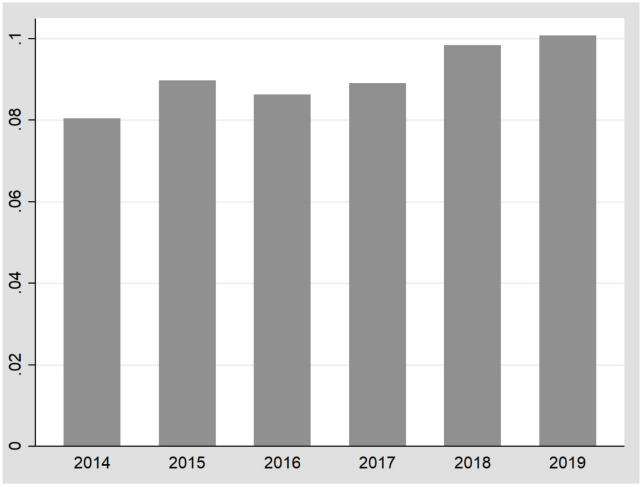

FIGURE 4 | IC connectivity over time. Figure 4 displays the mean of the IC connectivity score over time (created in STATA).

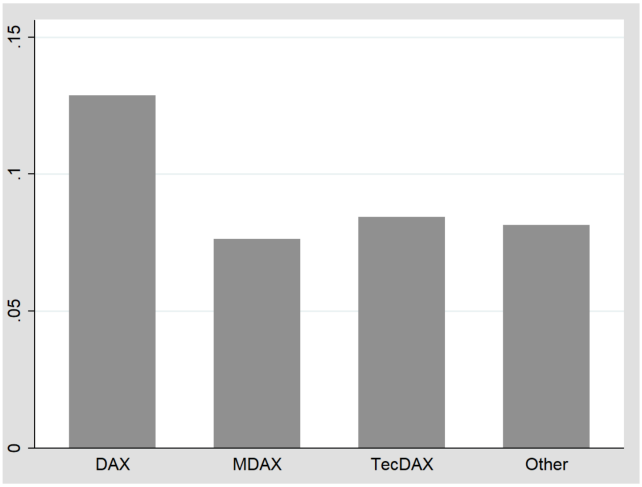

FIGURE 5 | IC connectivity by stock indices. Figure 5 displays the mean of the IC connectivity score per stock index (from 2014 through 2019; created in STATA).

our instruments $laggedIC_{i,t}$, $laggedHC_{i,t}$, $laggedRC_{i,t}$, $laggedSC_{i,t}$, *AUDIT*, and *BI* are statistically significant, suggesting that the instruments are relevant. We present several test statistics to ensure that our instruments are valid. The *F*-test of excluded instruments is consistently significant at the 0.01 level, suggesting that the instruments are jointly significantly different from zero. The Anderson–Rubin Wald test χ^2, the Stock–Wright LM S statistic χ^2 as well as the Anderson canon. corr. LM statistic and the Sargan statistic are highly significant, confirming that our instruments suffer neither from underidentification or weak instrument problems nor from overidentification.

Table 5B presents the second stage regression estimates for Equation (1) without IC disclosures (column (1)) as well as for Equation (2) with IC disclosures (columns (2–5)) and interactions between IC disclosure subscores (columns (6–9)). In all regressions, robust standard errors control for heteroscedasticity. The *F*-tests of model significance are highly significant ($p = 0.000$). Industry and year fixed effects control for industry and time differences. Column (1) shows the results for model (1) without IC disclosures.

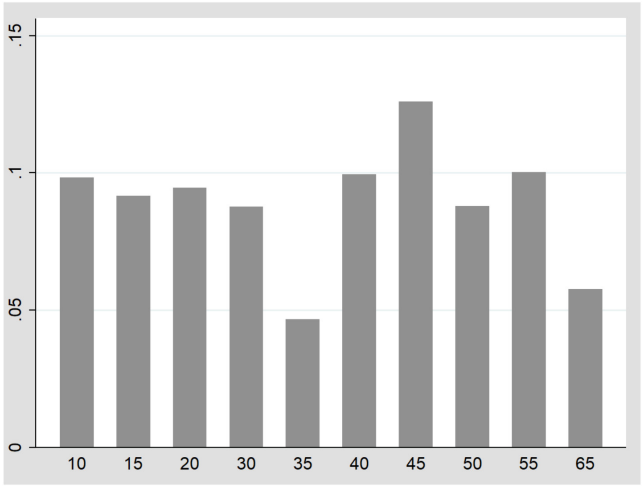

FIGURE 6 | IC connectivity by ICB industries. Figure 6 displays the mean of the IC connectivity score per ICB industry (from 2014 through 2019), where 10 = technology, 15 = telecommunications, 20 = health care, 30 = financials, 35 = real estate, 40 = consumer discretionary, 45 = consumer staples, 50 = industrials, 55 = basic materials, 60 = energy, and 65 = utilities (created in STATA).

The coefficients of $BV_{i,t-1}$, $E_{i,t}$, and $FRCST_{i,t}$ carry positive signs as expected and are highly significant ($p < 0.01$). This holds for all other regressions. In line with prior literature, column (2) shows a significant positive association of aggregate IC disclosures ($IC_{i,t}$) with market value (coeff. = 4160.30; $p < 0.01$). Moreover, columns (3–5) show significant positive associations of market value with the IC disclosure subscores ($HC_{i,t}$: coeff. = 1817.66; $p < 0.01$, $RC_{i,t}$: coeff. = 2505.45; $p < 0.01$, and $SC_{i,t}$: coeff. = 3242.59; $p < 0.01$), indicating that all subcategories are important value drivers.

Columns (6–9) present the results to test *H1* that the association of disclosures on one IC category with market value is positively moderated by disclosures on the other categories. In line with *H1*, column (6) shows that the interaction between *HC* and *RC* is positively associated with market value (coeff. = 7641.26; $p < 0.01$). Accordingly, column (7) shows a positive association for the interaction of *HC* and *SC* (coeff. = 7431.82; $p < 0.01$). When including their interaction, the single noninteracted disclosure subscores turn insignificant, indicating that the joint information is relevant, not the separate. In column (8), the interaction between *RC* and *SC* is not significant, indicating that the relationship between *RC* and *SC* is not of additional relevance beyond the information contained in *RC* and *SC* in our sample.

Column (9) presents the results with each bivariate and the three-way interaction of all disclosure subscores. To interpret the results of the three-way interaction model, the coefficients need to be analyzed in conjunction (Hayes 2013). To do so, we base the computations on structural capital as the foundation, which helps human and relational capital to unfold (F-Jardón and Martos 2009).[40] To evaluate the joint influence, we compute the marginal effects of $SC_{i,t}$ on $MV_{i,t+3m}$ as follows: $\beta_6 + \beta_8 \times HC_{i,t} + \beta_9 \times RC_{i,t} + \beta_{10} \times HC_{i,t} \times RC_{i,t}$. These marginal effects depend on the values of *HC* and *RC*; hence, we set low (high) values of a subscore at one standard deviation below (above) its mean (Aiken and West 1991). Table 5C presents the marginal effects. For high values of *HC* (0.933) and *RC* (0.686), the marginal effect of *SC* is significantly positive at 4298

TABLE 2 | Correlations.

Panel A: Correlation matrix of the full sample (IC disclosure scores, $N = 3009$)

	$HC_{i,t}$	$RC_{i,t}$	$SC_{i,t}$	$IC_{i,t}$	$MV_{i,t+3m}$	$BV_{i,t-1}$	$E_{i,t}$	$FRCST_{i,t}$
$HC_{i,t}$	1	0.4842*	0.4621*	0.6958*	0.1420*	0.1246*	0.1307*	0.0157
$RC_{i,t}$	0.4904*	1	0.5190*	0.8430*	0.1386*	0.1169*	0.1408*	0.0352
$SC_{i,t}$	0.4509*	0.5090*	1	0.8659*	0.1299*	0.0559*	0.1219*	0.0756*
$IC_{i,t}$	0.6901*	0.8268*	0.8680*	1	0.1644*	0.1119*	0.1586*	0.0591*
$MV_{i,t+3m}$	0.1854*	0.2615*	0.2246*	0.2805*	1	0.8108*	0.8158*	0.2532*
$BV_{i,t-1}$	0.1875*	0.2117*	0.2032*	0.2477*	0.8540*	1	0.7633*	0.1622*
$E_{i,t}$	0.1473*	0.2087*	0.1819*	0.2232*	0.7820*	0.6952*	1	0.1674*
$FRCST_{i,t}$	0.0046	0.0737*	0.0835*	0.0803*	0.2709*	0.1807*	0.2709*	1

Panel B: Correlation matrix of the subsample (IC connectivity score, $n = 601$)

	$ICCon_{i,t}$	$MV_{i,t+3m}$	$BV_{i,t-1}$	$E_{i,t}$	$FRCST_{i,t}$
$ICCon_{i,t}$	1	0.4363*	0.3511*	0.3891*	0.1291*
$MV_{i,t+3m}$	0.3274*	1	0.7398*	0.8168*	0.2730*
$BV_{i,t-1}$	0.3041*	0.7559*	1	0.7530*	0.1521*
$E_{i,t}$	0.2795*	0.7171*	0.6752*	1	0.0426
$FRCST_{i,t}$	0.1843*	0.2814*	0.1543*	0.1134*	1

Note: Table 2 presents the correlation matrices with Bravais–Pearson correlations above and Spearman rank correlations below the diagonal. **Panel A** shows the correlation matrix of the IC disclosure scores in the full sample. **Panel B** shows the correlation matrix of the IC connectivity score in the subsample.
All variables are defined as in Appendix C.
*indicates that the estimated correlations are statistically significant at the 5% level.

($p < 0.01$) ($= 6848 + (-4171) \times 0.933 + (-18{,}804) \times 0.686 + 22{,}248 \times 0.933 \times 0.686$). For high *HC* (0.933) and low *RC* (0.277), the marginal effect of *SC* is 3498 ($p < 0.05$). The difference in the marginal effect of SC significantly increases from low to high *HC* when *RC* is high ($p < 0.01$). The significant marginal effects support our expectation that additional information on other IC categories and their connections helps investors to better evaluate firm value. An increase in *RC* does not significantly increase the marginal effect of *SC*, independent of the level of *HC*, which is consistent with the insignificant results on the bivariate interaction between *RC* and *SC* (Panel B, column (8)).

The bottom rows in Panel B present the results for our expectation that the components of IC disclosure and their interactions improve market value explanatory power. We find a stepwise improvement in all information criteria as expected. The adjusted R^2 is higher for model (2) with the comprehensive IC disclosure score than for model (1) without IC (77.31%, column (2) > 77.21%, column (1)). It is again higher for the interaction models with bivariate interactions (77.45%, 77.60%, and 77.47% in columns (6–8)). We observe the highest adjusted R^2 for the model including each bivariate and the three-way interaction of all disclosure subscores (77.63%, column (9)). Regarding RMSE and AIC, lower values are preferable. Both criteria decrease from column (1) (RMSE: 5166; AIC: 54,831) to column (9) (RMSE: 5199; AIC: 54,788) as expected. IC disclosures and their interactions provide an improvement in market value explanatory power.

Tables 4 and 6 present the results for the analysis of the connectivity score based on the subsample, for testing *H2* that the degree of connectivity in IC disclosures is positively associated with market value. Table 4 provides the OLS estimation results, while Table 6 provides 2SLS estimation results.

Table 6A presents the first stage regressions and diagnostic test statistics, confirming concerns about the endogeneity of IC disclosures and supporting the use of an instrumental variable estimation approach. Again, robust standard errors control for heteroscedasticity in all regressions. The *F*-test of model significance is highly significant for all regressions ($p = 0.000$). Industry and year fixed effects control for industry and time differences. In Table 6B, the coefficients of $BV_{i,t}$, $E_{i,t}$, and $FRCST_{i,t}$ are positively significant in all regressions ($p < 0.01$). Column (1) shows the results for model (3). In line with *H2*, we find a significantly positive association of the IC connectivity score with market value (coeff. = 28,511; $p < 0.05$), indicating the relevance of connectivity in IC disclosures for market valuation. The IC disclosure score is not significantly associated with market values when connectivity is included in the model. In columns (2–4) we disaggregate the IC disclosure score into its components and analyze each subscore at a time. In all three specifications, we find a significantly positive association of the IC connectivity score with market value ($p < 0.01/0.05$). When including all IC subcategories in one regression, as shown in column (5), we also find the IC connectivity score to be positively associated with market values (coeff. = 26,573; $p < 0.05$). While the coefficients of $RC_{i,t}$ and $SC_{i,t}$ are insignificant in all specifications (columns (3–5)), $HC_{i,t}$ is significantly associated with market values (coeff. = 3694; $p < 0.05$, column (2) and coeff. = 4223; $p < 0.05$, column (5)). This highlights the particular importance of information on human capital, even beyond connectivity information.

TABLE 3 | OLS regression results for the value relevance of IC disclosures and their interactions (full sample, $N = 3009$).

Panel A: OLS regression analyses of IC disclosures and their interactions on market value ($MV_{i,t+3m}$)

	(1) Without IC disclosures (model (1))	(2) With IC disclosures (model (2))	(3) With HC disclosures	(4) With RC disclosures	(5) With SC disclosures	(6) With bivariate interaction bw. HC and RC	(7) With bivariate interaction bw. HC and SC	(8) With bivariate interaction bw. RC and SC	(9) With all interactions
$BV_{i,t\text{-}1}$	0.8255 (12.44)***	0.8223 (12.42)***	0.8231 (12.39)***	0.8232 (12.39)***	0.8257 (12.52)***	0.8208 (12.36)***	0.8249 (12.50)***	0.8258 (12.51)***	0.8244 (12.47)***
$E_{i,t}$	5.6832 (11.80)***	5.6289 (11.74)***	5.6606 (11.80)***	5.6661 (11.77)***	5.6256 (11.73)***	5.6500 (11.78)***	5.6082 (11.74)***	5.6262 (11.72)***	5.6067 (11.73)***
$FRCST_{i,t}$	4.7206 (4.31)***	4.6821 (4.28)***	4.7484 (4.35)***	4.7124 (4.30)***	4.6386 (4.23)***	4.7345 (4.33)***	4.6521 (4.24)***	4.6360 (4.22)***	4.6733 (4.27)***
$IC_{i,t}$		2682.4920 (5.18)***							
$HC_{i,t}$			1064.0790 (3.45)***			−589.8340 (−0.84)	−204.3589 (−0.40)		−366.5894 (−0.32)
$RC_{i,t}$				1081.2950 (2.50)***		−1849.5610 (−1.87)		−286.2716 (−0.30)	−10.4150 (−0.01)
$SC_{i,t}$					2368.8780 (5.03)***		22.3971 (0.02)	1986.2730 (2.03)**	4109.8640 (1.44)
$HC_{i,t} \times RC_{i,t}$						3621.1730 (2.55)***			758.9656 (0.29)
$HC_{i,t} \times SC_{i,t}$							2802.7710 (1.82)**		−1498.9090 (−0.39)
$RC_{i,t} \times SC_{i,t}$								766.3440 (0.37)	−8081.0790 (−1.48)
$HC_{i,t} \times RC_{i,t} \times SC_{i,t}$									8090.4790 (1.14)
Constant	1474.1390 (1.71)**	514.3900 (0.57)	812.5779 (0.86)	1226.6470 (1.39)*	529.6649 (0.60)	−1454.3030 (−0.80)	−2050.2690 (−1.15)	−2198.3580 (−1.22)	−2244.6670 (−1.18)
Industry fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included

(Continues)

TABLE 3 | (Continued)

Panel A: OLS regression analyses of IC disclosures and their interactions on market value ($MV_{i,t+3m}$)

	(1) Without IC disclosures (model (1))	(2) With IC disclosures (model (2))	(3) With HC disclosures	(4) With RC disclosures	(5) With SC disclosures	(6) With bivariate interaction bw. HC and RC	(7) With bivariate interaction bw. HC and SC	(8) With bivariate interaction bw. RC and SC	(9) With all interactions
F	*F*(43; 2965) = 51.04	*F*(44; 2964) = 54.61	*F*(44; 2964) = 50.35	*F*(44; 2964) = 53.23	*F*(44; 2964) = 51.73	*F*(46; 2962) = 50.33	*F*(46; 2962) = 50.37	*F*(46; 2962) = 52.13	*F*(50; 2958) = 48.60
Prob > *F*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Highest VIF	2.75	2.75	2.75	2.75	2.75	2.76	2.75	2.75	2.76
Mean VIF	2.15	2.02	1.94	1.97	2.00	2.15	2.15	2.15	2.16
R^2	0.7771	0.7786	0.7779	0.7775	0.7789	0.7784	0.7793	0.7789	0.7796
Adjusted R^2	0.7739	0.7753	0.7746	0.7741	0.7756	0.7749	0.7759	0.7755	0.7759
RMSE	5088.1	5072.6	5080.5	5085.5	5069.2	5076.7	5065.8	5070.7	5065.6
AIC	59,944.4	59,927.1	59,936.4	59,942.3	59,923.0	59,933.9	59,920.9	59,926.8	59,924.6

Panel B: Marginal effects with respect to *SC*

	Low *HC* (0.353)	High *HC* (0.978)	Diff. (high–low)
Low *RC* (0.264)	2203.100 (2.22)**	2599.757 (2.73)***	396.657
High *RC* (0.677)	44.214 (0.04)	2531.557 (2.44)***	2487.343*
Diff. (high–low)	−2158.886	−68.200	

Note: Table 3 presents the results of our OLS regression analyses for the full sample. **Panel A** shows the coefficients and *t*-statistics (in parentheses) of our OLS regression analyses with *MV* as the dependent variable. Column (1) does not include IC disclosures (model (1)). Column (2) includes the comprehensive IC disclosure score (model (2)). The next three columns refer to the association between disclosures on one IC category and market value: Column (3) includes human capital. Column (4) includes relational capital. Column (5) includes structural capital. The next four columns refer to *H1* and the moderating effect of one IC disclosure subscore on the association of another IC disclosure subscore with market value. Column (6) includes the bivariate interaction between human and relational capital. Column (7) includes the bivariate interaction between human and structural capital. Column (8) includes the bivariate interaction between relational and structural capital. Column (9) includes all three bivariate interactions plus the three-way interaction between human, relational, and structural capital. The last rows show the results for the information criteria (R^2, adjusted R^2, RMSE, and AIC) of all regressions to evaluate the change in market value explanatory power. **Panel B** further shows the gradients and *t* values (in parentheses) regarding the interaction effects of disclosures on the single IC categories. Based on the interaction model and the corresponding results in Panel A, column (9), it shows the marginal effects with respect to *SC* for a low and high level of *HC* and a low and high level of *RC* (one standard deviation below and above the mean of the regression sample).
All variables are defined as in Appendix C.
*, **, and *** indicate that the estimations are statistically significant at the 10%, 5%, and 1% level, respectively, using a one-tailed test.

TABLE 4 | OLS regression results for the value relevance of connectivity in IC disclosures (subsample, $n = 601$).

Regression analyses of IC disclosures and their connectivity on market value ($MV_{i,t+3m}$)					
	(1) With IC disclosures and IC connectivity (model (3))	**(2) With HC disclosures and IC connectivity**	**(3) With RC disclosures and IC connectivity**	**(4) With SC disclosures and IC connectivity**	**(5) With all disclosure subscores and IC connectivity**
$BV_{i,t-1}$	0.4713 (4.32)***	0.4764 (4.41)***	0.4632 (4.25)***	0.4762 (4.37)***	0.4644 (4.21)***
$E_{i,t}$	7.2630 (8.96)***	7.3104 (8.94)***	7.2130 (8.95)***	7.2724 (8.91)***	7.2393 (8.87)***
$FRCST_{i,t}$	8.3877 (3.84)***	8.5031 (3.88)***	8.1844 (3.77)***	8.4261 (3.83)***	8.2024 (3.76)***
$IC_{i,t}$	−1955.9350 (−0.72)				
$HC_{i,t}$		1733.0210 (1.26)			2442.3600 (1.80)**
$RC_{i,t}$			−5079.4530 (−2.15)		−6502.2540 (−2.63)
$SC_{i,t}$				191.9633 (0.11)	1367.3150 (0.70)
$ICCon_{i,t}$	38,754.3800 (2.84)***	31,146.3600 (2.29)**	43,577.5200 (3.21)***	35,732.3200 (2.65)***	37,688.6000 (2.76)***
Constant	6640.1980 (2.66)***	5300.9210 (2.03)**	7251.8340 (3.14)***	6087.8830 (2.45)**	−3213.0310 (−1.10)
Industry fixed effects	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included
F	$F(28; 572) = 30.97$	$F(28; 572) = 30.81$	$F(28; 572) = 31.94$	$F(28; 572) = 30.22$	$F(30; 569) = 30.13$
Prob > *F*	0.0000	0.0000	0.0000	0.0000	0.0000
Highest VIF	3.45	3.41	3.44	3.44	3.46
Mean VIF	2.39	2.25	2.30	2.31	2.25
R^2	0.7915	0.7919	0.7931	0.7913	0.7945
Adjusted R^2	0.7813	0.7817	0.7830	0.7811	0.7836
RMSE	8386.1	8378.7	8353.4	8389.9	8341.3
AIC	12,593.1	12,592.1	12,588.4	12,593.7	12,588.6

Note: Table 4 presents the coefficients and *t*-statistics (in parentheses) of our OLS regression analyses for the subsample including the IC connectivity score (*H2*). Column (1) includes the comprehensive IC disclosure score and the IC connectivity score (model (3)). Column (2) includes human capital and the IC connectivity score. Column (3) includes relational capital and the IC connectivity score. Column (4) includes structural capital and the IC connectivity score. Column (5) includes all three IC disclosure subscores and the IC connectivity score.
All variables are defined as in Appendix C.
*, **, and *** indicate that the estimations are statistically significant at the 10%, 5%, and 1% level, respectively, using a one-tailed test.

7 | Additional Analyses and Robustness Tests

In additional and robustness analyses, we provide insights into further market mechanisms related to higher connectivity in IC disclosures and address concerns that alternative model, variable, and sample specifications may affect our results. All tests strongly support our main inferences.

7.1 | Additional Analyses: Market Liquidity

We perform additional analyses of market liquidity where we repeat the above analyses and replace market value by *BAS* as the dependent variable ($n = 2720$ in the full sample/482 in the subsample). If connectivity provides value relevant information as suggested by our main analyses, it should also foster market

TABLE 5 | 2SLS regression results for value relevance of IC disclosures and their interactions ($n = 2748$).

Panel A: First stage regression results				
Instrumentalized variable	**(1) $IC_{i,t}$**	**(2) $HC_{i,t}$**	**(3) $RC_{i,t}$**	**(4) $SC_{i,t}$**
$laggedIC_{i,t}$	0.8404***			
	(78.14)			
$laggedHC_{i,t}$		0.7329***		
		(57.17)		
$laggedRC_{i,t}$			0.7951***	
			(66.64)	
$laggedSC_{i,t}$				0.8214***
				(74.02)
$AUDIT_{i,t}$	0.008*	0.0249**	0.006	0.0106*
	(1.75)	(2.43)	(1.02)	(1.73)
$BI_{i,t}$	0.0098***	0.0189***	0.0109***	0.0109***
	(3.82)	(3.39)	(3.31)	(3.22)
$BV_{i,t\text{-}1}$	0.000	0.000	0.000	−0.000
	(0.12)	(0.17)	(1.22)	(−1.02)
$E_{i,t}$	0.000**	0.000	0.000*	0.000
	(2.00)	(1.43)	(1.65)	(1.47)
$FRCST_{i,t}$	0.000	−0.000	−0.000	0.000
	(0.02)	(−0.93)	(−1.00)	(1.47)
Constant	0.0557***	0.1558***	0.0504***	0.0471***
	(4.59)	(5.84)	(3.20)	(2.97)
Industry fixed effects	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included
First stage regression diagnostics				
Sanderson–Windmeijer *F*-test of excluded instruments				
	2250.17***	1172.11***	1559.28***	1976.87***
Anderson–Rubin Wald test χ^2				
	39.14***	28.29***	27.99***	38.31***
Stock–Wright LM S statistic χ^2				
	38.59***	28.00***	27.71***	37.79***

(Continues)

TABLE 5 | (Continued)

Panel A: First stage regression results				
Instrumentalized variable	**(1) $IC_{i,t}$**	**(2) $HC_{i,t}$**	**(3) $RC_{i,t}$**	**(4) $SC_{i,t}$**
Anderson canon. corr. LM statistic (underidentification test)				
	1962.48***	1553.94***	1741.87***	1887.88***
Sargan statistic (overidentification test)				
	9.859**	14.284***	15.606***	11.252***
Test on endogeneity				
Durbin–Wu–Hausman test χ^2				
	11.34***	3.06*	11.93***	9.15***

Panel B: Second stage regression results of IC disclosures and their interactions on market value ($MV_{i,t+3m}$)									
	(1) Without IC disclosures (model (1))	**(2) With IC disclosures (model (2))**	**(3) With HC disclosures**	**(4) With RC disclosures**	**(5) With SC disclosures**	**(6) With bivariate interaction bw. HC and RC**	**(7) With bivariate interaction bw. HC and SC**	**(8) With bivariate interaction bw. RC and SC**	**(9) With all interactions**
$BV_{i,t\text{-}1}$	0.8153*** (11.90)	0.8095*** (31.94)	0.8107*** (31.96)	0.8094*** (31.79)	0.8152*** (32.23)	0.8082*** (31.67)	0.8131*** (32.01)	0.8170*** (32.00)	0.8145*** (31.96)
$E_{i,t}$	5.7569*** (11.47)	5.6724*** (30.80)	5.7145*** (31.05)	5.7168*** (30.99)	5.6804*** (30.89)	5.6703*** (30.61)	5.6295*** (30.48)	5.6699*** (30.63)	5.6118*** (30.36)
$FRCST_{i,t}$	4.5978*** (3.80)	4.5441*** (10.27)	4.6738*** (10.55)	4.5879*** (10.34)	4.4677*** (10.10)	4.6848*** (10.53)	4.5432*** (10.22)	4.4416*** (9.98)	4.6007*** (10.33)
$IC_{i,t}$ *instrumented*		4160.3000*** (5.38)							
$HC_{i,t}$ *instrumented*			1817.6550*** (3.72)			-1287.2750 (−1.11)	−824.4120 (−0.97)		452.6655 (0.22)
$RC_{i,t}$ *instrumented*				2505.4450*** (3.47)		−4787.9400*** (−2.69)		−1744.8680 (−1.28)	1336.607 (0.45)
$SC_{i,t}$ *instrumented*					3242.5920*** (5.18)		−2718.9000 (−1.51)	1505.6600 (0.93)	6848.25 (1.57)
$HC_{i,t} \times RC_{i,t}$ *instrumented*						7641.2600*** (3.26)			−1927.4320 (−0.44)

(Continues)

TABLE 5 | (Continued)

Panel B: Second stage regression results of IC disclosures and their interactions on market value ($MV_{i,t+3m}$)

	(1) Without IC disclosures (model (1))	(2) With IC disclosures (model (2))	(3) With HC disclosures	(4) With RC disclosures	(5) With SC disclosures	(6) With bivariate interaction bw. HC and RC	(7) With bivariate interaction bw. HC and SC	(8) With bivariate interaction bw. RC and SC	(9) With all interactions
$HC_{i,t} \times SC_{i,t}$ *instrumented*							7.431.8230*** (3.35)		−4171.2910 (−0.71)
$RC_{i,t} \times SC_{i,t}$ *instrumented*								4024.325 (1.42)	−18,804.2900** (−2.10)
$HC_{i,t} \times RC_{i,t} \times SC_{i,t}$ *instrumented*									22,248.350*** (2.00)
Constant	4566.8430*** (3.63)	3414.971*** (4.59)	3620.4240*** (4.78)	3860.3870*** (5.20)	3949.1060*** (5.47)	5542.3700*** (5.42)	4861.9210*** (5.44)	4620.1400*** (5.20)	3848.838*** (2.81)
Industry fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included
F	49.14	219.08	218.42	217.33	219.51	210.65	212.51	210.86	195.55
Prob > *F*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R^2/centered R^2	0.7756	0.7767	0.7764	0.7753	0.7772	0.7782	0.7797	0.7784	0.7803
Adjusted R^2	0.7721	0.7731	0.7728	0.7717	0.7736	0.7745	0.7760	0.7747	0.7763
RMSE	5166.7	5114.0	5118.0	5130.0	5108.0	5139.9	5122.4	5138.0	5119.2
AIC	54,831.870	54,820.720	54,824.720	54,837.900	54,814.76	54,806.31	54,787.46	54,804.23	54,788.03

Panel C: Marginal effects with respect to *SC*

	Low *HC* (0.433)	High *HC* (0.933)	Diff. (high–low)
Low *RC* (0.277)	2501.064 (1.45)	3498.346 ** (2.40)	997.281
High *RC* (0.686)	−1240.970 (−0.74)	4298.425 *** (2.85)	5539.395 ***
Diff. (high–low)	−3742.030	800.079	

Note: Table 5 reports the results of an instrumental variable estimation approach, using two-stage least squares (2SLS) estimators. **Panel A** shows the coefficients and *t*-statistics (in parentheses) of the first stage regressions instrumentalizing the potentially endogenous variables of *IC*, *HC*, *RC*, and *SC*. The set of instruments consists of the 1-year lagged values of the potentially endogenous variables (lagged*IC, laggedHC, laggedRC, laggedSC*) and the additional instruments *AUDIT* and *BI*. Independent variables of the second stage regression are included as controls. The final rows report tests evaluating the validity of the instruments employed and include an additional test for potential endogeneity. **Panel B** shows the coefficients and *z*-statistics (in parentheses) of our 2SLS regressions with *MV* as the dependent variable. Column (1) does not include IC disclosures (model (1)). Column (2) includes the

TABLE 5 | (Continued)

comprehensive IC disclosure score (model (2)). The next three columns refer to the association between disclosures on one IC category and market value: Column (3) includes human capital. Column (4) includes relational capital. Column (5) includes structural capital. The next four columns refer to *H1* and the moderating effect of one IC disclosure subscore on the association of another IC disclosure subscore with market value. Column (6) includes the bivariate interaction between human and relational capital. Column (7) includes the bivariate interaction between human and structural capital. Column (8) includes the bivariate interaction between relational and structural capital. Column (9) includes all three bivariate interactions plus the three-way interaction between human, relational, and structural capital. The last rows show the results for the information criteria (R^2, adjusted R^2, RMSE, and AIC) of all regressions to evaluate the change in market value explanatory power. **Panel C** further shows the gradients and *t* values (in parentheses) regarding the interaction effects of disclosures on the single IC categories. Based on the interaction model and the corresponding results in Panel B, column (9), it shows the marginal effects with respect to *SC* for a low and high level of *HC* and a low and high level of *RC* (one standard deviation below and above the mean of the regression sample).

All variables are defined as in Appendix C.

*, **, and *** indicate that the estimations are statistically significant at the 10%, 5%, and 1% level, respectively, using a two-tailed test.

liquidity. We therefore expect the interactions of the IC capitals and our connectivity score to be negatively associated with *BAS*. To account for potential endogeneity, we again apply 2SLS regression models and instrument $IC_{i,t}$ using the same instruments as in our main analyses: $laggedIC_{i,t}$, $AUDIT_{i,t}$, and $BI_{i,t}$. We run the following second stage regression models based on prior research (e.g., Mohd 2005; Lotze et al. 2025):

$$\boldsymbol{BAS}_{i,t} = \beta_0 + \beta_1\, MV_{i,t+3m} + \beta_2\, Beta_{i,t} + \beta_3\, FF_{i,t} + \beta_4\, CL_{i,t} + \beta_5\, FOL_{i,t} + IND + YEAR + \varepsilon_{i,t} \tag{4}$$

$$\boldsymbol{BAS}_{i,t} = \beta_0 + \beta_1\, MV_{i,t+3m} + \beta_2\, Beta_{i,t} + \beta_3\, FF_{i,t} + \beta_4\, CL_{i,t} + \beta_5\, FOL_{i,t} + \beta_6\, \boldsymbol{IC}_{i,t} + IND + YEAR + \varepsilon_{i,t} \tag{5}$$

$$\boldsymbol{BAS}_{i,t} = \beta_0 + \beta_1\, MV_{i,t+3m} + \beta_2\, Beta_{i,t} + \beta_3\, FF_{i,t} + \beta_4\, CL_{i,t} + \beta_5\, FOL_{i,t} + \beta_6\, \boldsymbol{IC}_{i,t} + \beta_7\, \mathbf{ICCon}_{i,t} + IND + YEAR + \varepsilon_{i,t} \tag{6}$$

Equation (4) represents the baseline model without considering IC disclosures. Equation (5) incorporates $IC_{i,t}$ to explore its relationship with $BAS_{i,t}$. When estimating Equation (5), we also disaggregate IC into its components and further include bivariate interactions as well as the three-way interaction of the subscores. To analyze the association of the degree of connectivity with $BAS_{i,t}$, we include $ICCon_{i,t}$ (Equation (6)). All variables are defined as in Appendix C.

Table 7B presents the results of the 2SLS regressions examining the relationship between IC disclosures and their interactions with *BAS*. The coefficients for the overall IC disclosure score (coeff. = −0.6691; $p < 0.01$) as well as for the subscores ($HC_{i,t}$: coeff. = −0.1973; $p < 0.01$, $RC_{i,t}$: coeff. = −0.6193; $p < 0.01$, and $SC_{i,t}$: coeff. = −0.3789; $p < 0.01$) are significantly negative. These findings suggest that IC disclosure reduces information asymmetry in the market, thereby fostering higher trading activity and leading to the observed narrower bid-ask spreads.

The significant coefficients of the bivariate interaction terms (columns (6–8)) indicate mutually moderating effects among the individual components. Column (9) additionally considers the three-way interaction, and its marginal effects are reported in Panel C. The significantly negative marginal effects demonstrate that the joint interaction of the subcategories contributes to a substantial reduction in BAS.

Table 8B reports 2SLS regression results for the association of connectivity in IC disclosures with *BAS*. We find a consistently significant negative association between the IC connectivity score and *BAS* across all model specifications. This underlines the importance of connectivity in IC disclosures to reduce information asymmetry and increase market liquidity.

7.2 | Robustness Tests

Robustness tests with alternative model and variable specifications as well as alternative sample compositions support our findings. First, we rerun our regressions without earnings forecasts ($FRCST_{i,t}$) ($n = 3545$ in the full sample/640 in the subsample). This does not affect our main inferences. Next, we

TABLE 6 | 2SLS regression results for the value relevance of connectivity in IC disclosures (subsample, $n = 486$).

Panel A: First stage regression results					
Instrumentalized variable	**(1) $IC_{i,t}$**	**(2) $HC_{i,t}$**	**(3) $RC_{i,t}$**	**(4) $SC_{i,t}$**	**(5) $HC_{i,t}$, $RC_{i,t}$, $SC_{i,t}$**
$laggedIC_{i,t}$	0.8122***				
	(30.63)				
$laggedHC_{i,t}$		0.8208***			0.8223***/0.0069/−0.0122
		(27.80)			
$laggedRC_{i,t}$			0.7461***		−0.0240/0.7332***/−0.0081
			(24.03)		
$laggedSC_{i,t}$				0.8513***	0.0143/0.0283/0.8556***
				(39.39)	
$AUDIT_{i,t}$	0.0347	0.0610	0.0269	0.0294	0.0585/0.0212/0.0304
	(1.55)	(1.35)	(0.86)	(1.09)	
$BI_{i,t}$	0.0107*	0.0240**	0.0140*	0.0025	0.0239**/0.0125/0.0042
	(1.88)	(2.02)	(1.80)	(0.38)	
$BV_{i,t-1}$	−0.0000**	−0.0000	−0.0000*	−0.0000	−0.0000/−0.000/−0.0000
	(−2.21)	(−0.60)	(−2.36)	(−1.32)	
$E_{i,t}$	−0.0000	−0.0000*	−0.0000	0.0000	−0.0000*/−0.000/0.0000
	(−0.71)	(−1.86)	(−0.59)	(0.19)	
$FRCST_{i,t}$	−0.0000	−0.0000	−0.0000**	0.0000***	−0.0000/0.000***/0.0000***
	(−0.11)	(−0.09)	(−2.56)	(2.88)	
$ICCon_{i,t}$	0.5864***	0.8939***	0.8012***	0.3057***	0.9062***/0.7846***/0.3342**
	(5.87)	(4.44)	(5.76)	(2.71)	
Constant	0.0139***	−0.0381	0.0481	0.0175	−0.0309/0.0470/0.0232
	(0.54)	(−0.77)	(1.30)	(0.61)	
Industry fixed effects	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included
First stage regression diagnostics					
Sanderson–Windmeijer *F*-test of excluded instruments					
	346.05***	319.30***	197.87***	539.45***	326.05***/182.90***/435.02***
Anderson–Rubin Wald test χ^2					
	3.44	5.39	4.90	3.49	8.01
Stock–Wright LM S statistic χ^2					
	3.41	5.33	4.85	3.47	7.88
Anderson canon. corr. LM statistic (underidentification test)					
	337.68***	329.26***	274.86***	379.16***	264.65***
Sargan statistic (overidentification test)					
	3.192	1.253	4.074	3.092	1.225
Test on endogeneity					
Durbin–Wu–Hausman test χ^2					
	3.31*	6.56**	1.49	0.11	6.55*

Panel B: Second stage regression results of IC disclosures and their connectivity on market value ($MV_{i,t+3m}$)					
	(1) With IC disclosures and IC connectivity (model (3))	**(2) With HC disclosures and IC connectivity**	**(3) With RC disclosures and IC connectivity**	**(4) With SC disclosures and IC connectivity**	**(5) With all disclosure subscores and IC connectivity**
$BV_{i,t-1}$	0.4158***	0.4127***	0.4029***	0.4154***	0.3998***
	(6.48)	(6.47)	(6.28)	(6.51)	(6.23)

(Continues)

TABLE 6 | (Continued)

Panel B: Second stage regression results of IC disclosures and their connectivity on market value ($MV_{i,t+3m}$)	(1) With IC disclosures and IC connectivity (model (3))	(2) With HC disclosures and IC connectivity	(3) With RC disclosures and IC connectivity	(4) With SC disclosures and IC connectivity	(5) With all disclosure subscores and IC connectivity
$E_{i,t}$	7.4274***	7.5152***	7.3863***	7.4094***	7.4580***
	(15.49)	(15.58)	(15.46)	(15.48)	(15.53)
$FRCST_{i,t}$	7.339***	7.5366***	7.1752***	7.2750***	7.2675***
	(7.13)	(7.28)	(6.95)	(7.08)	(6.97)
$IC_{i,t}$ *instrumented*	1635.1110				
	(0.46)				
$HC_{i,t}$ *instrumented*		3694.3740**			4223.8950**
		(2.01)			(2.24)
$RC_{i,t}$ *instrumented*			−2990.0800		−5670.7740
			(−0.91)		(−1.57)
$SC_{i,t}$ *instrumented*				1485.4500	1983.5670
				(0.61)	(0.76)
$ICCon_{i,t}$	28,511.3500**	20,763.5400*	35,665.5700***	29,565.3700***	26,572.6200**
	(2.37)	(1.73)	(2.96)	(2.67)	(2.10)
Constant	217.6590	−1038.2490	2177.1320	378.3337	478.8649
	(0.10)	(−0.52)	(0.97)	(0.20)	(0.20)
Industry fixed effects	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included
F	59.36	59.27	60.02	59.53	55.89
Prob > *F*	0.0000	0.0000	0.0000	0.0000	0.0000
R^2/centered R^2	0.7776	0.7768	0.7800	0.7782	0.7802
Adjusted R^2	0.7645	0.7636	0.7670	0.7651	0.7662
RMSE	8174	8189	8174	8163	8126
AIC	12,533.61	10,193.52	10,186.52	10,190.39	10,189.96

Note: Table 6 reports the results for the subsample including the IC connectivity score (*H2*) of an instrumental variable estimation approach, using two-stage least squares (2SLS) estimators. **Panel A** shows the coefficients and *t*-statistics (in parentheses) of the first stage regressions instrumentalizing the potentially endogenous variables of *IC*, *HC*, *RC,* and *SC*. The set of instruments consists of the 1-year lagged values of the potentially endogenous variables (lagged*IC, laggedHC, laggedRC, laggedSC*) and the additional instruments *AUDIT* and *BI*. Independent variables of the second stage regression are included as controls. **Panel B** shows the coefficients and *z*-statistics (in parentheses) of our second stage regression analyses with *MV* as the dependent variable. Column (1) includes the comprehensive IC disclosure score and the IC connectivity score (model (3)). Column (2) includes human capital and the IC connectivity score. Column (3) includes relational capital and the IC connectivity score. Column (4) includes structural capital and the IC connectivity score. Column (5) includes all three IC disclosure subscores and the IC connectivity score.
All variables are defined as in Appendix C.
*, **, and *** indicate that the estimations are statistically significant at the 10%, 5%, and 1% level, respectively, using a two-tailed test.

include an indicator variable in each original model to control for whether the analyzed annual report is an integrated report ($N = 3009/601$). About 3.4% (12.8%) of our main sample (subsample) observations are classified as integrated reports. The indicator variable is significantly positively associated with market value ($p < 0.01$; full sample and subsample). Our main inferences remain unchanged.

Furthermore, we log-transform $MV_{i,t+3m}$, $BV_{i,t-1}$, $E_{i,t}$, and $FRCST_{i,t}$ to their natural logarithms in order to adapt our data to normal distribution. Because this transformation is only defined for positive values, the number of observations decreases to $n = 1558/358$. $HC_{i,t}$ turns insignificant in model (2) with $HC_{i,t}$ instead of $IC_{i,t}$, as does the interaction between $HC_{i,t}$ and $SC_{i,t}$ in the bivariate interaction model (full sample). All other results are consistent with our reference estimations. Moreover, we use market values at fiscal year-end date without the 3 months lag ($MV_{i,t}$ instead of $MV_{i,t+3m}$; $n = 3011/601$) and find consistent results.

Furthermore, we analyze an alternative sample composition. We exclude annual reports that do not apply IFRS (mainly HGB or US-GAAP reports) to avoid potential biases due to differences in the reporting regimes (remaining $n = 2477/599$). We find that the marginal effects of *SC* are only significant in case of high *HC* and high *RC* as well as high *HC* and low *RC*, not low *HC*. This result supports our inference even more that the value relevance of disclosures on one IC category is positively moderated by disclosures on the other IC categories in case those are on a high level. All other results are consistent with our reference models.

Lastly, we apply different methods of outlier exclusion. First, we use winsorizing instead of trimming at the 1st and 99th percentile.

TABLE 7 | Additional analyses of market liquidity: 2SLS regression results for the association of IC disclosures and their interactions with bid–ask spreads ($n = 2720$).

Panel A: First stage regression results				
Instrumentalized variable	**(1) $IC_{i,t}$**	**(2) $HC_{i,t}$**	**(3) $RC_{i,t}$**	**(4) $SC_{i,t}$**
$laggedIC_{i,t}$	0.8299***			
	(75.60)			
$laggedHC_{i,t}$		0.7285***		
		(56.35)		
$laggedRC_{i,t}$			0.7792***	
			(64.03)	
$laggedSC_{i,t}$				0.8201***
				(72.91)
$AUDIT_{i,t}$	0.0080*	0.0242**	0.054	0.0102*
	(1.72)	(2.34)	(0.90)	(1.65)
$BI_{i,t}$	0.0081***	0.0153***	0.0076**	0.0095***
	(3.12)	(2.67)	(2.33)	(2.76)
$MV_{i,t}$	−0.0000	0.000	−0.000	−0.000
	(−0.23)	(0.43)	(−0.44)	(−0.13)
$Beta_{i,t}$	0.0013	0.000	0.000*	0.000
	(0.37)	(0.03)	(0.52)	(0.16)
$FF_{i,t}$	0.0001	0.000	0.000	
	(1.33)	(0.48)	(0.66)	
$CL_{i,t}$	−0.0011	−0.0015	−0.0035	
	(−0.52)	(−0.31)	(−1.22)	
$FOL_{i,t}$	0.0011***	0.0015***	0.0018***	0.000
	(4.50)	(2.91)	(5.78)	(1.36)
Constant	0.0351***	0.1359***	0.0225***	0.0288***
	(2.66)	(4.62)	(1.31)	(1.65)
Industry fixed effects	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included
First stage regression diagnostics				
Sanderson-Windmeijer F-Test of excluded instruments				
	2,034.96***	1,119.11***	1,403.64***	1,868.40***

(Continues)

TABLE 7 | (Continued)

Panel A: First stage regression results

Instrumentalized variable	(1) $IC_{i,t}$	(2) $HC_{i,t}$	(3) $RC_{i,t}$	(4) $SC_{i,t}$
Anderson-Rubin Wald test Chi^2				
	123.35***	94.79***	131.69***	104.30***
Stock-Wright LM S statistic Chi^2				
	118.00***	91.59***	125.61***	100.45***
Anderson canon. corr. LM statistic (underidentification test)				
	1,891.93***	1,514.59***	1,664.08***	1,841.94***
Sargan statistic (overidentification test)				
	63.504***	78.622***	71.584***	72.411***
Test on endogeneity				
Durbin-Wu-Hausman Test Chi^2				
	2.08	3.39*	3.94**	67.45***

Panel B: Second stage regression results of IC disclosures and their interactions on bid–ask spreads ($BAS_{i,t}$)

	(1) Without IC disclosures (model (4))	(2) With IC disclosures (model (5))	(3) With HC disclosures	(4) With RC disclosures	(5) With SC disclosures	(6) With bivariate interaction bw. HC and RC	(7) With bivariate interaction bw. HC and SC	(8) With bivariate interaction bw. RC and SC	(9) With all interactions
$MV_{i,t}$	−0.0000***	−0.0000***	−0.0000***	−0.0000***	−0.0000***	−0.0000***	−0.0000***	−0.0000***	−0.0000***
	(−11.51)	(−16.12)	(−16.08)	(−16.33)	(−16.11)	(−16.43)	(−16.00)	(−16.24)	(−16.37)
$Beta_{i,t}$	−0.0018	−0.0014	−0.0019	−0.0013	−0.0016	−0.0012	−0.0012	−0.0012	−0.0011
	(−0.83)	(−0.62)	(−0.79)	(−0.55)	(−0.66)	(−0.52)	(−0.65)	(−0.50)	(−0.46)
$FF_{i,t}$	−0.0038***	−0.0038***	−0.0039***	−0.0039***	−0.0037***	−0.0039***	−0.0038***	−0.0038***	−0.0038***
	(−7.42)	(−8.53)	(−8.55)	(−8.66)	(−8.35)	(−8.64)	(−8.38)	(−8.52)	(−8.49)
$CL_{i,t}$	−0.0041	−0.0106	−0.0047	−0.0118	−0.0076	−0.0123	−0.0071	−0.0145	−0.0132
	(−0.22)	(−0.70)	(−0.31)	(−0.78)	(−0.50)	(−0.82)	(−0.47)	(−0.96)	(−0.87)
$FOL_{i,t}$	−0.0600***	−0.0563***	−0.0590***	−0.0562***	−0.0582***	−0.0579***	−0.0571***	−0.0541***	−0.0542***
	(−32.77)	(−34.80)	(−37.17)	(−34.54)	(−36.61)	(−33.66)	(−35.55)	(−33.21)	(−33.12)

(Continues)

TABLE 7 | (Continued)

Panel B: Second stage regression results of IC disclosures and their interactions on bid–ask spreads ($BAS_{i,t}$)

	(1) Without IC disclosures (model (4))	(2) With IC disclosures (model (5))	(3) With HC disclosures	(4) With RC disclosures	(5) With SC disclosures	(6) With bivariate interaction bw. HC and RC	(7) With bivariate interaction bw. HC and SC	(8) With bivariate interaction bw. RC and SC	(9) With all interactions
$IC_{i,t}$ *instrumented*		−0.6691*** (−7.57)							
$HC_{i,t}$ *instrumented*			−0.1973*** (−3.64)			−0.3968*** (−3.18)	−0.2873*** (−3.09)		−0.2569 (−1.16)
$RC_{i,t}$ *instrumented*				−0.6193*** (−7.54)		−1.3336*** (−6.98)		−1.0372*** (−6.99)	−1.1129*** (−3.50)
$SC_{i,t}$ *instrumented*					−0.3789*** (−5.42)		−0.8688*** (−4.44)	−0.6900*** (−3.92)	−0.3091 (−0.65)
$HC_{i,t} \times RC_{i,t}$ *instrumented*						0.7648*** (3.06)			0.4471 (0.95)
$HC_{i,t} \times SC_{i,t}$ *instrumented*							0.5505** (2.29)		−0.1507 (−0.24)
$RC_{i,t} \times SC_{i,t}$ *instrumented*								0.8147*** (2.67)	−0.2694 (−0.28)
$HC_{i,t} \times RC_{i,t} \times SC_{i,t}$ *instrumented*									0.6876 (0.58)
Constant	−2.8549*** (−36.19)	−2.7373*** (−31.05)	−2.7677*** (−30.45)	−2.7469*** (−31.22)	−2.821*** (−32.26)	−2.467*** (−21.36)	−2.643*** (−25.27)	−2.572*** (−25.45)	−2.4966*** (−16.40)
Industry fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included	Included	Included	Included	Included
F	193.31	160.72	156.47	160.55	158.39	157.96	153.73	158.70	146.47
Prob > *F*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R^2/centered R^2	0.7238	0.7303	0.7246	0.7300	0.7273	0.7353	0.7300	0.7363	0.7368

(Continues)

TABLE 7 | (Continued)

Panel B: Second stage regression results of IC disclosures and their interactions on bid–ask spreads ($BAS_{i,t}$)

	(1) Without IC disclosures (model (4))	(2) With IC disclosures (model (5))	(3) With HC disclosures	(4) With RC disclosures	(5) With SC disclosures	(6) With bivariate interaction bw. HC and RC	(7) With bivariate interaction bw. HC and SC	(8) With bivariate interaction bw. RC and SC	(9) With all interactions
Adjusted R^2	0.7721	0.7257	0.7200	0.7255	0.7227	0.7307	0.7253	0.7316	0.7318
RMSE	0.7193	0.5476	0.5533	0.5479	0.5506	0.5473	0.5528	0.5463	0.5462
AIC	4597.169	4535.006	4591.564	4537.615	4564.468	4487.398	4541.463	4478.008	4480.038

Panel C: Marginal effects with respect to *SC*

	Low *HC* (0.434)	High *HC* (0.935)	Diff. (high–low)
Low *RC* (0.277)	−0.3664** (−2.36)	−0.3465**(−2.12)	0.0199
High *RC* (0.685)	−0.3545** (−1.99)	−0.1943*(−1.85)	0.1602
Diff. (high–low)	0.0119	0.1522	

Note: Table 7 reports the results of an instrumental variable estimation approach, using two-stage least squares (2SLS) estimators. **Panel A** shows the coefficients and *t*-statistics (in parentheses) of the first stage regressions instrumentalizing the potentially endogenous variables of *IC*, *HC*, *RC*, and *SC*. The set of instruments consists of the 1-year lagged values of the potentially endogenous variables (lagged*IC, laggedHC, laggedRC, laggedSC*) and the additional instruments *AUDIT* and *BI*. Independent variables of the second stage regression are included as controls. **Panel B** shows the coefficients and *z*-statistics (in parentheses) of our regression analysis with *BAS* as dependent variable. Column (1) does not include IC disclosures (model (4)). Column (2) includes the comprehensive IC disclosure score (model (5)). The next three columns refer to the association between disclosures on one IC category and market value: Column (3) includes human capital. Column (4) includes relational capital. Column (5) includes structural capital. The next four columns refer to the moderating effect of one IC disclosure subscore on the association of another IC disclosure subscore with market value. Column (6) includes the bivariate interaction between human and relational capital. Column (7) includes the bivariate interaction between human and structural capital. Column (8) includes the bivariate interaction between relational and structural capital. Column (9) includes all three bivariate interactions plus the three-way interaction between human, relational, and structural capital. The final rows report tests evaluating the validity of the instruments employed and include an additional test for potential endogeneity. **Panel C** further shows the gradients and *t* values (in parentheses) regarding the interaction effects of disclosures on the single IC categories. Based on the interaction model and the corresponding results in Panel B, column (9), it shows the marginal effects with respect to *SC* for a low and high level of *HC* and a low and high level of *RC* (one standard deviation below and above the mean of the regression sample).
All variables are defined as in Appendix C.
*, **, and *** indicate that the estimations are statistically significant at the 10%, 5%, and 1% level, respectively, using a two-tailed test.

TABLE 8 | Additional analyses of market liquidity: 2SLS regression results for the association of connectivity in IC disclosures with bid–ask spreads (subsample, $n = 482$).

Panel A: First stage regression results					
Instrumentalized variable	**(1) $IC_{i,t}$**	**(2) $HC_{i,t}$**	**(3) $RC_{i,t}$**	**(4) $SC_{i,t}$**	**(5) $HC_{i,t}$, $RC_{i,t}$, $SC_{i,t}$**
$laggedIC_{i,t}$	0.8210*** (32.00)				
$laggedHC_{i,t}$		0.8168*** (27.99)			0.8175***/0.0089/−0.0188
$laggedRC_{i,t}$			0.7360*** (23.40)		−0.0341/0.7137***/−0.0158
$laggedSC_{i,t}$				0.8667*** (41.93)	0.0345/0.0489*/0.8743***
$AUDIT_{i,t}$	0.0414* (1.92)	0.0772* (1.73)	0.0230 (0.95)	0.0341 (1.38)	0.0714/0.0197/0.0368
$BI_{i,t}$	0.0133** (2.44)	0.0288** (2.45)	0.0167** (2.12)	0.0051 (0.82)	0.0282**/0.0142*/0.0078
$MV_{i,t+3m}$	−0.0000** (−4.41)	−0.000*** (−3.84)	−0.000*** (−5.23)	−0.000 (−0.50)	−0.000***/−0.000***/−0.000
$Beta_{i,t}$	−0.0000 (−0.36)	−0.0000 (−0.27)	−0.0001 (−0.26)	−0.000 (−0.18)	−0.0001/−0.0001/−0.0001
$FF_{i,t}$	−0.0000 (−0.09)	−0.0001 (0.35)	−0.0003 (−1.28)	0.0001 (0.61)	0.0000/−0.0003/0.0001
$CL_{i,t}$	0.0067 (0.83)	0.0014 (0.08)	0.0107 (0.90)	0.0061 (0.65)	0.0030/0.0137/0.0059
$FOL_{i,t}$	0.0003 (0.48)	0.0008 (0.64)	0.0012 (1.44)	−0.0006 (−0.88)	0.0009/0.0013/−0.0005
$ICCon_{i,t}$	0.5043*** (4.86)	0.7591*** (3.56)	0.7533*** (4.96)	0.2269* (1.95)	0.7701***/0.7305***/0.2655**
Constant	0.0180 (0.67)	−0.0406 (−0.76)	0.0644 (1.58)	0.0262 (0.89)	−0.0293/0.0652/0.0382
Industry fixed effects	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included
First stage regression diagnostics					
Sanderson–Windmeijer *F*-test of excluded instruments					
	380.42***	328.98***	187.98***	614.75***	197.13***/113.79***/369.14***
Anderson–Rubin Wald test χ^2					
	8.56*	5.31	6.44*	9.69**	10.00*
Stock–Wright LM S statistic χ^2					
	8.41*	5.25	6.36*	9.50**	9.80*
Anderson canon. corr. LM statistic (underidentification test)					
	345.69***	331.06***	268.08***	387.46***	253.15***
Sargan statistic (overidentification test)					
	6.991**	4.489*	5.886**	6.149**	4.868*

(Continues)

TABLE 8 | (Continued)

Panel A: First stage regression results					
Instrumentalized variable	**(1) $IC_{i,t}$**	**(2) $HC_{i,t}$**	**(3) $RC_{i,t}$**	**(4) $SC_{i,t}$**	**(5) $HC_{i,t}$, $RC_{i,t}$, $SC_{i,t}$**
Test on endogeneity					
Durbin–Wu–Hausman test χ^2					
	0.00	0.51	0.33	1.31	2.57

Panel B: Second stage regression results of IC disclosures and their connectivity on bid–ask spreads ($BAS_{i,t}$)	**(1) with IC disclosures and IC connectivity (model (6))**	**(2) With HC disclosures and IC connectivity**	**(3) With RC disclosures and IC connectivity**	**(4) With SC disclosures and IC connectivity**	**(5) With all disclosure subscores and IC connectivity**
$MV_{i,t+3m}$	−0.0000*** (−9.16)	−0.0000*** (−9.60)	−0.0000*** (−8.73)	−0.0000*** (−9.58)	−0.0000*** (−8.91)
$Beta_{i,t}$	0.0007 (0.38)	0.0006 (0.36)	0.0001 (0.38)	0.0006 (0.36)	0.0005 (0.32)
$FF_{i,t}$	−0.0053*** (−5.87)	−0.0054*** (−6.06)	−0.0052*** (−5.72)	−0.0054*** (−6.08)	−0.0054*** (−5.91)
$CL_{i,t}$	0.1328*** (2.83)	0.1244* (2.66)	0.1273*** (2.73)	0.1384*** (2.94)	0.1360*** (2.89)
$FOL_{i,t}$	−0.0308*** (−9.01)	−0.0301*** (−8.75)	−0.0308*** (−8.95)	−0.0302*** (−8.87)	−0.0299*** (−8.59)
$IC_{i,t}$ *instrumented*	0.2064 (1.21)				
$HC_{i,t}$ *instrumented*		−0.0785 (−0.88)			−0.1164 (−1.26)
$RC_{i,t}$ *instrumented*			0.1168 (0.70)		0.0600 (0.33)
$SC_{i,t}$ *instrumented*				0.2170* (1.84)	0.2291* (1.77)
$ICCon_{i,t}$	−1.6275*** (−2.60)	−1.1686* (−1.89)	−1.5271** (−2.40)	−1.535*** (−2.60)	−1.369** (−2.10)
Constant	−5.6414*** (−45.28)	−5.5044*** (−49.37)	−5.6071*** (−43.79)	−5.6262*** (−52.56)	−5.5930*** (−42.39)
Industry fixed effects	Included	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included	Included
F	25.21	25.08	25.17	25.26	23.63
Prob > *F*	0.0000	0.0000	0.0000	0.0000	0.0000
R^2/centered R^2	0.6182	0.6166	0.6180	0.6179	0.6189
Adjusted R^2	0.5937	0.5920	0.5935	0.5934	0.5927
RMSE	0.3964	0.3973	0.3965	0.3966	0.3960
AIC	535.929	537.953	536.135	536.206	538.966

Note: Table 8 reports the results of an instrumental variable estimation approach, using two-stage least squares (2SLS) estimators. **Panel A** shows the coefficients and *t*-statistics (in parentheses) of the first stage regressions instrumentalizing the potentially endogenous variables of *IC*, *HC*, *RC,* and *SC*. The set of instruments consists of the 1-year lagged values of the potentially endogenous variables (lagged*IC, laggedHC, laggedRC, laggedSC*) and the additional instruments *AUDIT* and *BI*. Independent variables of the second stage regression are included as controls. **Panel B** shows the coefficients and *z*-statistics (in parentheses) of our regression analyses with *BAS* as the dependent variable (model (6)). Column (1) includes the comprehensive IC disclosure score and the IC connectivity score. Column (2) includes human capital and the IC connectivity score. Column (3) includes relational capital and the IC connectivity score. Column (4) includes structural capital and the IC connectivity score. Column (5) includes all three IC disclosure subscores and the IC connectivity score.
All variables are defined as in Appendix C.
*, **, and *** indicate that the estimations are statistically significant at the 10%, 5%, and 1% level, respectively, using a two-tailed test.

While trimming excludes the values of the first and the last percentile, winsorizing adjusts these values to the values of the following or previous percentile (Barnett and Lewis 1996). Hence, sample size increases to $n = 3198/641$. $RC_{i,t}$ turns insignificant in model (2) with $RC_{i,t}$ instead of $IC_{i,t}$, as does the interaction between $HC_{i,t}$ and $SC_{i,t}$ in the bivariate interaction model (full sample). All other inferences remain valid. Second, we do not exclude any outliers ($n = 3198/641$). $RC_{i,t}$ turns insignificant in model (2) with $RC_{i,t}$ instead of $IC_{i,t}$ (full sample). All other inferences remain valid.

8 | Conclusions

We analyze the value relevance of connectivity in the context of IC disclosures. So far, research on connectivity is limited to its determinants and application, while research on the value relevance of nonfinancial reporting does not investigate connectivity. With IC, we analyze material value drivers of the firm that are interrelated and create most value in conjunction (Inkinen 2015). Our first set of results adds to the research on the market value relevance of IC disclosures beyond mandatory reporting on intangibles, hence, informs the EFRAG and IASB project "better information on intangibles" (EFRAG 2021, 2023) and the review of IAS 38 Intangible Assets (IFRS 2025b). Our main finding is that IC disclosures that display the interdependencies between different IC items are significantly associated with higher market values and provide market value explanatory power beyond disconnected IC disclosures. Additional analyses support an increase in market liquidity for connectivity in IC disclosures. Overall, our results support the concept of connectivity, which is currently debated in the context of overall nonfinancial and financial reporting by EFRAG and the IFRS Foundation (IFRS 2023; EFRAG 2024). The results further support IR with respect to integrated thinking and highlight the need for nonfinancial disclosures to reflect connectivity between different items. This evidence will be of interest to preparers and users of firm disclosures as well as to regulators, practitioners, and academics interested in the development of nonfinancial reporting.

An inevitable limitation of our study is that we cannot entirely rule out subjectivity issues in the content analysis of annual reports, even though we take several steps to prevent such issues. In addition, the scores refer to a generalized maximum level of IC disclosures and connectivity. Not all aspects of IC might be equally material to each firm, such that it might not always be desirable to achieve a hypothetical score of 100%. Further research might consider these issues and generate firm specific data from case studies, interviews, or surveys. Such research could further provide insights into the value creation associated with the implementation of integrated thinking and the internal awareness of connectivity in contrast to its application in external reporting. In addition, future research might extend the analysis to the connectivity of a broader circle of capitals such as overall mandatory financial and nonfinancial reporting as debated by EFRAG and the IFRS Foundation (IFRS 2023; EFRAG 2024).

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Data Availability Statement

Data are available from the public sources cited in the text or from the authors upon request.

Endnotes

[1] The International Integrated Reporting Council (IIRC) has merged with the Sustainability Accounting Standards Board (SASB) in 2021 to form the Value Reporting Foundation (VRF) and was integrated into the IFRS foundation in 2024. The concepts investigated in this paper such as connectivity, integrated thinking, and value creation were not affected by these changes.

[2] The connectivity principle is the core feature of integrated reporting (IR) and allegedly distinguishes it from other non-financial reporting concepts (e.g., Eccles et al. 2015; Zhou et al. 2017; IFRS 2022). IR is aimed at coupling reporting with strategy, management, and corporate culture and speaks to the relatedness of different value drivers and the need to recognize, evaluate, and make use of their interconnectivity in order to create value (e.g., Abhayawansa et al. 2019).

[3] See Section 2.1 for the definitions according to the IR framework and other reporting institutions (IIRC 2013; EFRAG 2024).

[4] The IFRS foundation website provides extensive examples of such integrated information.

[5] Intangibles are material value drivers and their importance for nonfinancial reporting has been recognized before the introduction of the IR framework. EFRAG and IASB have acknowledge their importance in the project "better information on intangibles" (EFRAG 2021, 2023) and the review of IAS 38 Intangible Assets (IFRS 2025b). Because of the importance of IC, there is a vast literature on intangibles and value creation. Focusing on this important value driver—rather than analyzing the entire breath of presented information—allows us to focus on value generation based on the findings in prior literature.

[6] About 3.36% of our sample observations are integrated annual reports. We include an indicator variable in all models for robustness purposes (Section 7).

[7] Such concepts include the Jenkins Committee's business reporting, value reporting, IC reporting, corporate sustainability reporting, and lately IR. For overviews see, for instance, Boedker et al. (2008), Abeysekera (2013), Higgins et al. (2014), or Reitmaier and Schultze (2017).

[8] The Corporate Reporting Dialogue is a joint project of influential reporting institutions: CDP, CDSB, FASB, GRI, IASB, IIRC, IOS, and SASB (IIRC 2017). After close collaboration for several years, the IIRC and SASB merged into the Value Reporting Foundation, which turned part of the IFRS Foundation in August 2022 (IFRS 2022).

[9] The IR framework defines IR as "a process founded on integrated thinking that results in a periodic integrated report by an organization about value creation over time and related communications regarding aspects of value creation" (IIRC 2013, 33). IR and integrated thinking are considered two mutually reinforcing practices (e.g., WICI 2013;

Churet and Eccles 2014; SAICA 2015; IIRC 2016). Esch et al. (2019), for instance, find in a scenario-based experiment that IR fosters internal investment decisions with more sustainable value creation. Still, DiVaio et al. (2021) find that markets do not yet perceive IR and integrated thinking as corporate governance tools shaping sustainable business models but rather as reporting mechanisms only.

[10] The distinction of the stewardship and the information effect originates from cost of equity capital research. With more information, the cost of capital can either decrease due to more precise cash flow estimations (Lambert et al. 2007) or increase due to unfavourable content reducing expected payoffs (Johnstone 2015; Johnstone 2016). In contrast, the stewardship effect describes the indirect effect of disclosures on real decisions that better align managers' and shareholders' interests (Lambert et al. 2007; Core et al. 2015). The revised conceptual frameworks of IASB and FASB define stewardship as "how efficiently and effectively the entity's management and governing board have discharged their responsibilities to use the entity's resources" (IFRS 2018, 1.4b; FASB 2021, PR8).

[11] Despite difficulties and limitations (e.g., Eccles et al. 2015), a number of firms has adopted IR (Maroun 2018). Regulators around the world are considering the adoption of IR or the inclusion of IR principles in their reporting regulations. Examples are the IR recommendation of the annual operating and financial review regulations in Australia, the strategic report and directors' report regulations in the United Kingdom, the European NFRD (Simnett and Huggins 2015; Zhou et al. 2017), and the IFRS Foundation's consolidation with the IIRC (IFRS 2022). Only South Africa has mandated IR on an apply-or-explain basis for firms listed on the Johannesburg stock exchange (e.g., Bernardi and Stark 2018).

[12] These studies either refer to the IR framework or earlier regulations like the King Code of Governance Principles for South Africa 2009 ("King III Report").

[13] The principle of connectivity currently also distinguishes IR from mandatory reporting to some extent. IAS 38 (International Accounting Standards Board 2004), for instance, requires *separability* of intangible assets to fulfil the criterion of identifiability. In contrast to connectivity, other guiding principles of IR like materiality, conciseness, and completeness have been subject to several studies (e.g., Bavagnoli et al. 2014; Fasan and Mio 2017; Lai et al. 2017; Melloni et al. 2017; Gerwanski et al. 2019).

[14] For the different forms of connectivity, see Brennan and Merkl-Davies (2018), who argue that digital communication provides particular potential for the latter two.

[15] These IR elements are governance and strategy; remuneration and performance; governance and others; strategy and others; business model and others; KPIs against strategy; past, current, and future performance; financial implications of other capitals; and conciseness and links.

[16] Ghosh and Wu (2007) use relations of IT employees to total employees, R&D to sales, and patents to employees.

[17] Their score awards one point for the presence of the following 14 elements per IC category: dedicated text unit, qualitative information, quantitative nonmonetary information, monetary information, high level of detail, treatment as input, treatment as outcome, summary indicators, graphs and tables, clear and direct language, positive news-tenor, negative news-tenor, forward looking time orientation, and backward looking time orientation.

[18] Some other studies that apply this measure find a significant relation to higher market-to-book-ratios (Chen et al. 2005, Taiwanese setting) and higher market values (Nimtrakoon 2015, ASEAN setting), while others do not find significant relations (e.g., Maditinos et al. 2011, Greek setting).

[19] Abdolmohammadi (2005) analyzes Fortune Global 500 firms from 1993 to 1997. Anam et al. (2011) analyze firms from Bursa Malaysia in 2002 and 2006. Ellis and Seng (2015) apply a computer-based word search to annual reports of firms from New Zealand from 2008 to 2010. Alfraih (2017) analyzes firms from Kuwait in 2013.

[20] Analysing IC disclosures in strategic reports in the UK, Bini et al. (2016) find that firms scarcely use business model disclosures to describe interactions among the business model components and to highlight the role of their IC in value creation. With the introduction of the IR requirement in South Africa, firms increasingly used business models and strategy disclosures but still with limited connectivity (Sukhari and DeVilliers 2019).

[21] A recent study by Barrena-Martínez et al. (2020) directly puts the concepts of IC and open innovation in relation. Analyzing a Spanish sample, they find positive associations between each of the three IC categories and a dichotomous variable capturing open innovation success by collaboration-based product innovations.

[22] The scores do not differentiate between good and bad news and thus do not measure the directional effect of the content disclosed. They focus on the information effect rather than the news effect of IC disclosures.

[23] Our first sample ($N = 3009$) includes 101 firm-year observations with integrated annual reports. Our subsample ($n = 601$) includes 77 firm-year observations with integrated annual reports. We include an indicator variable in all models for robustness purposes (Section 7).

[24] We exclude additional online information from our analyses that some firms refer to within their annual reports.

[25] The background paper on connectivity by the World Intellectual Capital Initiative states that "[c]onnecting material matters is important. It is, however, useless if it is presented without the big picture" (WICI 2013, 11).

[26] In addition to the six capitals (financial, manufactured, intellectual, human, social & relationship, and natural capital) and the seven guiding principles (Strategic focus & future orientation, connectivity of information, stakeholder relationships, materiality, conciseness, reliability & completeness, and consistency & comparability), the IIRC defines eight content elements: Organizational overview & external environment, governance, business model, risks & opportunities, strategy & resource allocation, performance, outlook, and basis of preparation & presentation. These contents are comparable to those named by the German Accounting Standard (GAS) 20 (Accounting Standards Committee of Germany 2012; Kajüter 2015), such that German firms are familiar with these required topics irrespective of applying the IR framework to their annual reports.

[27] The only exception is the connectivity between IC and the content elements: Because the content elements are broader non-quantifiable constructs, we do not consider different levels of quantification of the disclosures, but award one point if a report describes a clear connection between an IC item and a content element; zero otherwise. To account for the different quantification of the content elements dimension, we scale the points awarded per dimension by the maximum value of points achievable and then equally weight each dimension before adding them.

[28] One hundred forty-seven points for the connections of IC components amongst each other (seven IC input items × seven IC output items × three points per connection) / 56 points for the connections with the value creation process (seven capitals × eight content elements × one point) / 42 points for the connections with other non-financial indicators (seven capitals × two categories of non-financial indicators (social and environmental) × three points) / 84 points for the connections with financial indicators (seven capitals × four categories of financial indicators (sales, profit, cashflow, and others (like growth, working capital, return on investment, etc.)) × three points).

[29] Our results are robust to measuring market value at fiscal year-end ($MV_{i,t}$) (see Section 7).

[30] Breuer and DeHaan (2024) caution against the indiscriminate application of fixed effects, emphasizing that "their use needs to be justified by theoretical and institutional considerations, and the misuse of FE can hurt identification rather than help it." In our case, the variation within firms is conceptually interesting to capture the effects of firms' implementation of connectivity in IC disclosures in their annual reports.

[31] We do not calculate the Bayesian information criterion (BIC) as this measure puts high weight on low complexity. Obviously, complexity increases from model (2) to the interaction model due to the interaction effects.

[32] The industry-specific standards of the SASB, which is—like the IIRC—now part of the IFRS Foundation, highlight that certain disclosures are industry-specific (SASB 2022).

[33] All values in millions; see Appendix C for details on variable measurement.

[34] This potential link does not adversely bias the appropriateness of our analyses which focus on whether higher IC disclosure levels and connectivity display in higher market values. Rather, understanding higher IC disclosure levels as a manifestation of the overall reporting improvement, our analyses may in a wider sense be understood as an investigation of whether reporting improvements are relevant for market valuation.

[35] In addition, we observe small decreases by less than 0.01 (untabulated) in the mean of $IC_{i,t}$ in 1999, and in 2016 and 2019, before the Covid-19 crisis. Regarding $HC_{i,t}$, we observe additional decreases in 2003 and 2018 – shortly after the dotcom crisis and before the Covid-19 crisis. Regarding $SC_{i,t}$, we observe additional decreases in 2004 and 2007, shortly after the dotcom and before the financial crisis. Regarding $RC_{i,t}$, we find that the main decreases start earlier (1999 and 2000, 2010 and 2011, and 2012 and 2013).

[36] For a sample of Italian listed firms, Agostini et al. (2022) find an increase in quantity but not in quality of nonfinancial disclosures after the NFRD has become effective. In contrast to their study, we focus solely on IC information and measure the level of disclosures, i.e., a combination of quantity and quality.

[37] The mean of $IC_{i,t}$ and $SC_{i,t}$ is slightly higher for MDAX (0.4715 and 0.3886, untabulated) than for TecDAX firm-year-observations (0.4712 and 0.3829). Regarding $HC_{i,t}$ and $RC_{i,t}$, the opposite applies, and the mean values are slightly higher for TecDAX (0.6780 and 0.4906) than for MDAX firm-year observations (0.6708 and 0.4879).

[38] For $HC_{i,t}$, the mean is highest for energy (ICB 60) followed by basic materials firms (ICB 55) and lowest for real estate (ICB 35) followed by technology firms (ICB 10). For $RC_{i,t}$, the mean is highest for energy (ICB 60) followed by consumer discretionary firms (ICB 40) and lowest for real estate (ICB 35) followed by consumer staples (ICB 45). For $SC_{i,t}$, the mean is highest for basic materials (ICB 55) followed by health care firms (ICB 20) and lowest for real estate (ICB 35) followed by financial firms (ICB 30).

[39] While the subsample is composed of firms with at least one listing in DAX or MDAX between 2014 and 2019, these firms may have been listed in TecDAX or other indices in some of the sample years. Hence, the subsample includes firm-year observations of the same stock index categories as the full sample.

[40] Good quality management as part of process capital, for instance, might improve employee satisfaction (human capital) due to smoother working processes. At the same time, it might improve customer satisfaction (customer capital) or the firm's external rating (investor capital) due to better product quality. We suppose that disclosures mirror these underlying relations between the different IC categories.

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Appendix A

Items and Weighting System of the IC Disclosure Score ($IC_{i,t}$)

IC category	Human capital ($HC_{i,t}$) (Max. 3 points)	Relational capital ($RC_{i,t}$) (Maximum 3 × 3 = 9 points)			Structural capital ($SC_{i,t}$) (Maximum 3 × 3 = 9 points)		
Capitals	**Human capital**	**Customer capital**	**Supplier capital**	**Investor capital**	**Process capital**	**Location capital**	**Innovation capital**
Points per capital	**0/1/2/3**	**0/1/2/3**	**0/1/2/3**	**0/1/2/3**	**0/1/2/3**	**0/1/2/3**	**0/1/2/3**
IC subitems	Qualification High potentials Incentive systems Training Career opportunities Employee satisfaction Fluctuation Employee turnover Age structure Awards/other	Brand (value) Customer satisfaction Customer turnover Customer profile/ image Licensing Awards/other	Supplier quality Supplier flexibility Supplier integration Delivery time Licensing Networks/other	Shareholder structure Share turnover Index rank Analyst following/ recommendation Beta factor Rating Awards/other	Time-to-market Process-cycle-time Quality management Learning organization Capacity/other	Number of subsidiaries Low-cost plants Expansion strategy Integration to firm clusters/other	Number of patents Patents relative to employees Number of researchers Product testing Market share of new products Sales from new products R&D investments Awards/other

Note: We award one point per capital if the report provides at least two pieces of general verbal information on one or more items of the respective capital. Two points for at least two pieces of qualified information (for instance, academic degree of employees and expert groups for human capital). Three points for at least two pieces of quantifiable information (for instance, training time of employees in days per year and fluctuation rate of employees for human capital). To capture the information per capital, we proceed as follows: If a report provides at least two pieces of quantifiable information on any items, it is awarded three points for the respective capital. If it provides only one piece of quantifiable information but at least one piece of qualified information in addition, or if it provides at least two pieces of qualified information, it is awarded two points on the respective capital. If it provides at least two pieces of general information (one of these can be replaced by information classified to a higher category), it is awarded one point. If it provides less than two pieces of information on any items, the report is awarded zero points on the respective capital. To obtain relative measures ($HC_{i,t}$, $RC_{i,t}$, $SC_{i,t}$, and $IC_{i,t}$), we scale the aggregated scores by the respective maximum number of points achievable.

Appendix B

Items and Weighting System of the IC Connectivity Score ($ICCon_{i,t}$)

Connectivity is measured in four additive dimensions that are equally weighted to obtain $ICCon_{i,t}$:

Connectivity among the capitals.

	Human capital OUTPUT	Customer capital OUTPUT	Supplier capital OUTPUT	Investor capital OUTPUT	Process capital OUTPUT	Location capital OUTPUT	Innovation capital OUTPUT
Human capital INPUT	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Customer capital INPUT	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Supplier capital INPUT	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Investor capital INPUT	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Process capital INPUT	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Location capital INPUT	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Innovation capital INPUT	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3

Note: We award zero points if the report does not describe any connectivity between one capital as an input factor and another capital as an output factor. One point if the report generally or indirectly mentions connectivity between two capitals. Two points if it transparently and directly mentions respective connectivity. Three points if it additionally quantifies both the input and the output factor. To obtain a relative measure, we scale the points awarded by the maximum number of points achievable (7 × 7 × 3 = 147).

Connectivity of the capitals and the content elements.

	Organizational overview and external environment	Governance	Business model	Risks and opportunities	Strategy and resource allocation	Performance	Outlook	Basis of presentation
Human capital	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Customer capital	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Supplier capital	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Investor capital	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Process capital	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Location capital	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
Innovation capital	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Note: We award one point if the report describes the connectivity between the respective capital and the respective content element; zero otherwise. To obtain a relative measure, we scale the points awarded by the maximum number of points achievable ($7 \times 8 \times 1 = 56$).

Connectivity of the capitals and other nonfinancial indicators.

	Social indicators (e.g., investments in worker's health, corporate citizenship, awards, etc.)	Ecologic indicators (e.g., greenhouse gas emissions, use of fossil resources, etc.)
Human capital	0/1/2/3	0/1/2/3
Customer capital	0/1/2/3	0/1/2/3
Supplier capital	0/1/2/3	0/1/2/3
Investor capital	0/1/2/3	0/1/2/3
Process capital	0/1/2/3	0/1/2/3
Location capital	0/1/2/3	0/1/2/3
Innovation capital	0/1/2/3	0/1/2/3

Note: We award zero points if the report does not describe any connectivity between a capital and a nonfinancial indicator (both can either be input or output factor). One point if the report generally or indirectly mentions respective connectivity. Two points if it transparently and directly mentions respective connectivity. Three points if it additionally quantifies both the capital and the nonfinancial indicator. To obtain a relative measure, we scale the points awarded by the maximum number of points achievable ($7 \times 2 \times 3 = 42$).

Connectivity of the capitals and financial indicators.

	Sales	Profit	Cashflows	Others (e.g., growth, working capital, return on investment, etc.)
Human capital	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Customer capital	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Supplier capital	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Investor capital	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Process capital	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Location capital	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3
Innovation capital	0/1/2/3	0/1/2/3	0/1/2/3	0/1/2/3

Note: We award zero points if the report does not describe any connectivity between a capital and a financial indicator (both can either be input or output factor). One point if the report generally or indirectly mentions respective connectivity. Two points if it transparently and directly mentions respective connectivity. Three points if it additionally quantifies both the capital and the financial indicator. To obtain a relative measure, we scale the points awarded by the maximum number of points achievable ($7 \times 4 \times 3 = 84$).

Appendix C

Variable Definitions

Variable	Exp. sign	Measurement	Source
Dependent variable			
$MV_{i,t+3m}$		Market value of firm i 3 months after the end of fiscal year t, in millions, trimmed at the 1st and 99th percentile	Thomson Reuters
$MV_{i,t}$		Market value of firm i at the end of fiscal year t (without time lag), in millions, trimmed at the 1st and 99th percentile, (used for robustness purposes)	Thomson Reuters
Scores			
$IC_{i,t}$	+	Comprehensive IC disclosure score of firm i in year t (in percent): $IC_{i,t} = 3/21 \times HC_{i,t} + 9/21 \times RC_{i,t} + 9/21 \times SC_{i,t}$ (for details, see Appendix A)	Annual reports
$HC_{i,t}$	+	Disclosure score on human capital of firm i in year t (in percent) (for details, see Appendix A)	Annual reports
$RC_{i,t}$	+	Disclosure score on relational capital of firm i in year t (in percent) (for details, see Appendix A)	Annual reports
$SC_{i,t}$	+	Disclosure score on structural capital of firm i in year t (in percent) (for details, see Appendix A)	Annual reports
$ICCon_{i,t}$	+	IC connectivity score of firm i in year t (in percent) (for details, see Appendix B)	Annual reports
Control variables			
$BV_{i,t\text{-}1}$	+	Book value of equity of firm i at the beginning of the fiscal year t, i.e., book value before earnings (including minority interests), in millions, trimmed at the 1st and 99th percentile	Annual reports
$E_{i,t}$	+	Earnings of firm i in fiscal year t (including minority interests), in millions, trimmed at the 1st and 99th percentile	Annual reports
$FRCST_{i,t}$	+	One-year ahead analyst consensus forecast of change in firm i's earnings at the end of fiscal year t, i.e., the difference between the 1-year ahead forecast and the actual earnings in year t, in millions, trimmed at the 1st and 99th percentile	Thomson Reuters
IND		Industry fixed effects, i.e., indicator variables for each of the ICB supersectors (8-digit classification scheme)	Thomson Reuters
YEAR		Year fixed effects, i.e., indicator variables for each year	–

Variable	Exp. sign	Measurement	Source
$IR_{i,t}$	+	Indicator variable, 1 = integrated / 0 = nonintegrated report	Annual reports
Instruments			
$LaggedIC_{i,t}$	+	One-year lagged version of the variable IC ($IC_{i,t-1}$)	Annual reports
$LaggedHC_{i,t}$	+	One-year lagged version of the variable HC ($HC_{i,t-1}$)	Annual reports
$laggedRC_{i,t}$	+	One-year lagged version of the variable RC ($RC_{i,t-1}$)	Annual reports
$laggedSC_{i,t}$	+	One-year lagged version of the variable SC ($SC_{i,t-1}$)	Annual reports
$AUDIT_{i,t}$	+	Indicator variable, 1 = big auditor (KPMG, PwC, E&Y, Deloitte) / 0 = otherwise	Annual reports
$BI_{i,t}$	+	Board independence of firm *i* in year *t*, categorical variable, 0 = the supervisory board is not required to include employee representatives / 1 = the supervisory board consists of one-third employee representatives and two-thirds shareholder representatives / 2 = the supervisory board consists of an equal number of employee representatives and shareholder representatives / 3 = the supervisory board consists of an equal number of employee representatives and shareholder representatives, plus one neutral/external member	Annual reports
Additional analyses			
$BAS_{i,t}$		Bid–ask spread of firm *i* in year *t*, calculation following Mohd (2005)	Thomson Reuters
$Beta_{i,t}$	+	One-year beta of firm *i* in firm-year *t* based on CDAX	Thomson Reuters
$FF_{i,t}$	?	Free float of firm *i* in year *t*, percentage of outstanding shares	Thomson Reuters
$CL_{i,t}$	−	Number of cross listings of firm *i* in year *t*	Annual reports
$FOL_{i,t}$	−	Analyst following for firm *i* in year *t* (EPS number of estimates FY1)	Thomson Reuters