

Organizations, climate change, and transparency: Reviewing the literature on carbon disclosure

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Abstract The debate surrounding climate change often centers on companies’ contributions to global warming, which has led to an increase in the importance of carbon disclosure. We evaluate the current state of related research and identify its trends, coherences, and caveats via a systematic literature review. Socio-political theories of disclosure, economic theories of disclosure, and institutional theory serve as the main theoretical anchors for our exploration. The existing research emphasizes the determinants and, to a lesser extent, effects of carbon disclosure, as well as the associated regulatory issues such as voluntary versus mandatory disclosure. Additionally, we discuss related topics, such as assurance and risks. We find that a large portion of scholarly work provides no link to theory, despite the fact that such links can be identified, for

example, from the financial disclosure literature. Finally, we report on the established knowledge and examine the need for additional research.

Keywords Carbon Disclosure, Carbon Reporting, Literature Review, Greenhouse Gas Disclosure, Climate Change Reporting, Global Warming Disclosure, Emissions, CO₂, Research

INTRODUCTION

Recent years have seen an intense societal and scientific debate about climate change that often centers on companies (Howard-Grenville, Buckle, Hoskins, & George, 2014). This is not surprising, given that, for example in 2010, commercial and industrial sources in the U.S. emitted three times the CO₂ of residential sources (not including energy generation and transportation) (U.S. Environmental Protection Agency, 2012). Consequentially, voluntary initiatives, such as the non-profit Carbon Disclosure Project (CDP), have emerged on the international level and put pressure on companies to report their efforts and performance regarding greenhouse-gas (GHG) emissions. Moreover, mandatory initiatives, aiming at increased transparency or at improved emissions management, have recently surfaced at the national level. In the U.S., for example, all facilities emitting at least 25,000 metric tons of CO₂ equivalents are now required to disclose their emissions (U.S. Environmental Protection Agency, 2012); in the UK, all stock-listed companies must report their GHG emissions (UK Government, 2013).

Companies can benefit in many ways from the recording and subsequent disclosure of their GHG emissions. In a meta-analysis, Albertini (2013) confirmed a positive relationship between environmental disclosure and corporate financial performance. Proactive climate-related

measures and carbon disclosures, as well as the development of climate-friendly products, can improve a company's image (Sullivan & Gouldson, 2012). Furthermore, the pressure to disclose emissions can lead to improved carbon management and, consequently, to reduced energy consumption and energy costs (Matisoff, 2013). This improved carbon management can help companies deal with natural (e.g., drought, flood) and regulatory risks related to climate change. Moreover, carbon disclosure helps investors estimate a company's regulatory and natural risks related to climate change (see, e.g., McLaughlin, 2011). More generally, nonfinancial disclosure is associated with improved stock performance and cost of capital (Dhaliwal, Li, Tsang, & Yang, 2011). Depending on the ways in which companies handle these risks and opportunities, they can position themselves as attractive options for climate-conscious investors (Juravle & Lewis, 2009). Carbon accounting is, thus, the first necessary step toward improved management of GHG emissions, and carbon disclosure is the means of providing improved transparency (Simnett, Nugent, & Huggins, 2009).

Stechemesser and Guenther (2012) recently offered a review of the contemporary literature on carbon *accounting*. Relying on an internal management accounting perspective, they explicitly excluded voluntary or mandatory *disclosures*, which address external audiences. Other reviews of the literature address the overarching topics of corporate social responsibility or sustainability reporting (e.g., Fifka, 2013; Hahn & Kühnen, 2013). These, however, do not yield any specific insights into the role of carbon disclosure. To the best of our knowledge, no existing overview specifically addresses carbon disclosure. We consider this a shortcoming for several reasons. First, climate change attracts a massive amount of political and public attention. For example, the development of emission trading schemes means that firms face concrete regulatory risks. As a result, the capital market is increasingly interested in carbon information, and firms perceive

climate change to be a material issue (Weinhofer & Busch, 2013). Second, significant attention has been paid to developing voluntary carbon-disclosure initiatives and mandatory climate change reporting. Third, in this journal, Boons (2013), called for an incorporation of direct ecological effects into organizational research. The emergence of carbon disclosure research indicates that scholars agree with this need and have begun to include ecological issues, such as the organizational impact on climate change, in their research agendas. The aim of this literature review, therefore, is to evaluate the current state of the research on carbon disclosure and to identify its trends, coherences, and caveats. In doing so, we investigate the current state of knowledge regarding several important questions, such as: How do regulations and reporting schemes influence disclosure? What are the common carbon disclosure practices, that is, what is the output of corporate reporting? Which determinants trigger carbon disclosure? What is the final outcome of this disclosure, for example, how does the capital market react to carbon disclosure? Finally, what are the main shortcomings and gaps in current scholarly research that should be addressed to further develop our understanding of carbon disclosure?

RESEARCH LENSES ON CARBON DISCLOSURE

A prerequisite of carbon disclosure is the collection and preparation of the information to be disclosed. This process involves organizational practices to systematically collect data, to measure direct and indirect carbon emissions, and to communicate with third parties regarding information needs or guidance. These actions of measurement and processing of carbon-related information are subsumed under the term carbon accounting, which has been extensively covered in the review by Stechemesser and Guenther (2012) and, therefore, will not be included in our literature review. Our description of the carbon disclosure process is inspired by Healy and Palepu's (2001) financial accounting disclosure framework, which comprises the general topics

of disclosure regulation, management’s disclosure decisions, assurance, and market consequences. These topics are also relevant to carbon disclosure decisions.

Research on disclosure covers three areas. First, boundary conditions, such as regulations or the institutional setting in which a company is active, are likely to have an impact on carbon disclosure. This suggests a need for research on the efficiency and effectiveness of voluntary versus mandatory disclosure, as well as on the influence of legal or market systems on the processes or outputs of corporate disclosure, among others. Second, the disclosed information is the output of the disclosure process. This output can be made available to either the public, for example via sustainability reports or the CDP, or a limited set of actors, such as public authorities or institutional investors. From a researcher’s perspective, the output of carbon disclosure is especially relevant in cases of voluntary disclosure or in which regulations allow for management discretion about the content and/or form of the disclosure. Furthermore, companies might decide to assure disclosed information in order to give their carbon disclosures greater reliability. Scholars focus on the quantity and quality of disclosed information and on the respective determinants of carbon disclosure. Third, the outcome of disclosure links carbon disclosure to further actors, company behaviors, and society in general. While the output dimension focusses on the disclosed information itself, the outcome of disclosure links this output to subsequent effects of performance, reactions etc. Thus, research questions on disclosure output scrutinize the ultimate effects of disclosure; including capital markets reactions, a company’s subsequent disclosure behaviors, and a company’s subsequent creation of carbon emissions. Figure 1 provides a simplified framework of carbon disclosure to guide the subsequent literature review.

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METHOD

We followed the systematic and structured approach suggested by Fink (2014) to provide a thorough review of the research landscape for carbon disclosure and to ensure objectivity. First, we defined our research questions. Our initial objective was to present an overview of the current state of the research on carbon disclosure—to determine the general trends and relationships and to identify major research gaps and (in)consistencies in the results. Over the course of our review of the literature, we inductively refined our research questions by identifying relevant topics in the sources at hand that required further scrutiny. The second step was to identify relevant databases. The Social Science Citation Index (SSCI) extensively covers Anglophone peer-reviewed journals in business, management, and accounting. It includes all journals with an impact factor, which are, supposedly, the most important outlets in the field. To extend our coverage of journals, we complemented our search with the EBSCO Business Source Premier database. The databases selected contributed to validity due to their extensive coverage of high-impact, peer-reviewed journals (Podsakoff, MacKenzie, Bachrach, & Podsakoff, 2005).

Third, we decided on specific search terms. Our priority was to achieve extensive coverage, while avoiding missing any relevant articles. We identified potential search terms in extensive discussions among the authors, from communications with other experts, and from scientific articles dealing with carbon disclosure. To enhance reliability, all authors were included constantly from this phase on, and all authors are experienced scholars with extensive background knowledge on the relevant topics of reporting, disclosure, carbon management, sustainability, and/or accounting. Furthermore, this phase was used as a training phase (Fink, 2014) to align any potential preexisting discrepancies in the coders' mental schemes (Seuring & Gold, 2012). We arrived at seven anchor keywords related to carbon and emissions (carbon, CO₂,

greenhouse gas, emission, climate change, pollution, global warming) and two anchor keywords related to disclosure (disclos*, report*). We combined these two sets of keywords using different wildcards. For example, the combination of the two anchor keywords “carbon” and “disclos*” resulted in four search terms (“carbon* disclos*”, “carbon* * disclos*”, “disclos* carbon*”, “disclos* * carbon*”). In sum, the combination of the different keywords and wildcards resulted in 60 search terms, which allowed us to achieve the broad coverage we desired.

Fourth, we determined the practical screening criteria to include or exclude studies from the review. In order to cover only the relevant knowledge disseminated broadly in the worldwide scientific community, we considered only peer-reviewed, scholarly articles written in English, starting with the year 2005 in which the Kyoto Protocol was ratified. In February 2014, this approach resulted in 433 articles. We screened these articles to determine whether they were scientific articles, excluding book reviews, news pieces, editorial notes, comments, and so on. Furthermore, we assessed whether the content of the articles was essentially relevant to carbon disclosure in the sphere of individual businesses related to management, finance, or accounting. Due to the extensive keyword search and the broad coverage of the journals (and article types) in the two databases, the pre-screening revealed that the vast majority of the articles were not relevant for a scientific literature review on the specific topic. We nevertheless chose *not* to narrow the keyword search, as we did not want to miss any important articles. Instead, all authors manually screened every article independently in order to reduce the potential effect of the personal biases that might stem from the backgrounds of individual researchers. In only a few sporadic cases the coders had different judgment on the relevance of articles, which points to the success of the above-mentioned training phase. To ensure validity, we relied on mediation among the reviewers and monitoring of review quality (Fink, 2014). After a joint assessment and

discussion, we reached a consensus for each article. This approach began with the practical screening test and was continued throughout our study. The screening process resulted in 66 articles with substantial relevance to carbon disclosure. These were included in this review.

Fifth, we conducted the actual review on the relevant body of literature, synthesized and assessed our findings. We applied a generic, qualitative, content analysis process model developed by Mayring (2010). Following the definition and delimitation of the collected material, we began with a descriptive analysis. Then, we independently searched the literature for recurring patterns in the research and used these patterns to inductively identify structural categories. These categories constituted the major analysis topics and helped in inductively refining the research aim. Finally, all of the material was scrutinized in terms of the structural categories in order to identify relevant themes and interpret the findings. The underlying approach is, therefore, a hermeneutic and iterative process, which includes multiple interplays of critically reflecting on the data, searching for research patterns, and questioning and refining the literature-review categories.

DESCRIPTIVE ANALYSIS

The research field of carbon disclosure gained increasing attention following the ratification of the Kyoto Protocol in 2005. Since 2008, there is a continuous increase in the number of relevant publications, which we attribute to a growing interest in the topic and to an increasing availability of data from voluntary and mandatory reporting initiatives, such as the Canadian Voluntary Climate Reporting Program (VCR) and the CDP. Since 2011, a robust number of papers have been published each year, indicating steady scholarly interest in the topic (see Fig. 2).

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With regard to the research methods applied, approximately 70% of the papers are empirical studies (46 articles), with the others representing conceptual/theoretical work (19) and a mathematical model. The empirical studies are heavily dominated by quantitative analyses of published reports and data (37). Other empirical approaches, such as interviews and case studies (6), surveys (2), and experiments (1), are scarce. The plethora of data available from different reporting schemes—and, especially, data from the CDP—makes quantitative studies relying on secondary data a convenient research approach. This is underlined by the types of documents used as data sources (shown in Fig. 3). Data from the CDP directory were used by 19 studies, with other studies utilizing sustainability or environmental reports (12) and annual reports (11). Other sources included corporate homepages (8); reports from national reporting schemes, such as the VRC directory or the SEC annual report (4); and other documents. One reason for the increasing use of CDP reports in recent years derives from the specific research aims of the respective document analyses, which often sought to scrutinize the quality of CDP data and the benefits of the initiative. Furthermore, the CDP offers the largest directory of climate-related corporate information. This provides a basis for comparisons of reporting practices and environmental performance across companies or industries (Carbon Disclosure Project, 2014).

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Some articles relied on more than one external data source. Articles using CDP data often also referred to company sustainability or annual reports (e.g., Cotter & Najah, 2012; Freedman & Jaggi, 2011; Weinhofer & Hoffmann, 2010), while articles that referred to country-specific schemes relied solely on one source (e.g., Brouhle & Harrington, 2010; Doran & Quinn, 2009; Fried, Holtzman, & Li, 2012).

The 66 papers, published across 43 different journals, were in the areas of accounting and finance (27); environmental/sustainability management and corporate social responsibility (18); general business and management (7); and economics, policy, and (business) law (14). This indicates a broad dissemination of the topic across many functional areas. A citation analysis using HistCite, performed on the SSCI subsample, illustrates the heterogeneity and relative novelty of the topic. Within the subsample, only the article by Kolk, Levy, and Pinkse (2008) received a double-digit Local Citation Score¹ of 13. The next most-cited articles within the sample are Reid and Toffel (2009), with eight citations, Bebbington and Larrinaga-González (2008), with seven, and Stanny and Ely (2008), with six.

THEORETICAL PERSPECTIVES

Although our literature review only considered peer-reviewed, scholarly papers, fewer than half of the articles explicitly refer to theories. We identified three main theoretical anchors explaining different issues of carbon disclosure: socio-political theories of disclosure, economic theories of (voluntary) disclosure, and institutional theory.

Socio-political theories (Gray, Kouhy, & Lavers, 1995) explain disclosure as the quest of companies to respond to social and/or political pressure exerted by various stakeholders (Hahn & Lülfs, 2014). Accordingly, disclosing information on carbon emissions can be an instrument for generating positive impressions of a company’s carbon performance or for satisfying external demands for improved transparency. The two main anchors of this group of theories were stakeholder and legitimacy theory, which mainly differ with regard to their focus on actors. Stakeholder theory specifically addresses the different interest groups related to a company and

¹ The Local Citation Score attributes the count of citations to each publication within the collection.

their roles in shaping management strategies, whereas legitimacy theory more broadly refers to society as a whole (Cotter & Najah, 2012).

According to stakeholder theory (e.g., Roberts, 1992), carbon disclosure can be explained as a response to stakeholder demand for information on climate change as a pressing societal issue. A company responds to stakeholder pressure by providing information on carbon emissions. Thus, the varying power of stakeholders influences the urgency of a company’s reaction (Deegan, 2006). Freeman, Harrison, Wicks, Parmar, and Colle (2010) argue that stakeholder thinking has contributed to the development of social and ethical accounting, auditing, and reporting. In our literature sample, the term “stakeholders” broadly refers to investors, the public, contractors, and policy makers.

Legitimacy theory (e.g., Suchman, 1995) also offers an explanation of the motivating factors for carbon disclosure. According to legitimacy theory, carbon disclosure (or, more generally, environmental disclosure) is, again, a reaction to external pressure (Patten, 2000). Deegan (2002) illustrates how environmental disclosure can be used to maintain the implicit social contract between a company and society. If this contract is broken, the company may be subject to increased scrutiny (Hrasky, 2012). This is especially relevant for a topic such as climate change, which is a subject of intense public debate. Accordingly, legitimacy theory involves determinants like media exposure and corporate size, since larger companies are usually more visible and, therefore, pressured to legitimize their actions (e.g., Choi, Lee, & Psaros, 2013; Chu, Chatterjee, & Brown, 2013; Gallego-Álvarez, Rodríguez-Domínguez, & García-Sánchez, 2011). In general, socio-political theories—and, especially, legitimacy theory—mainly explain the *output* of corporate carbon disclosure. Stakeholder theory, furthermore, builds a bridge to the preceding *process* dimension because it also explains the potential influence of powerful stakeholders on

carbon management. For example, the CDP has become an important player in the realm of carbon disclosure, such that its requirements are often considered early on in carbon management and accounting procedures.

Economics-based theories of disclosure (e.g., Verrecchia, 1983) suggest that companies voluntarily disclose information to interested actors based on an evaluation of costs and benefits (Clarkson, Li, Richardson, & Vasvari, 2008). According to signaling theory arguments (e.g., Connelly, Certo, Ireland, & Reutzel, 2010), reporting potentially reduces the principal-agent problem of asymmetric information by increasing transparency. This proactively prevents scrutiny and possible boycotts from, for example, environmental pressure groups. However, carbon disclosure needs to be perceived as honest and trustworthy to have value in this regard. The public and potential customers value transparency; thus, signaling can improve a company's reputation. For example, Brouhle and Harrington (2010), argue that companies use continuous reporting to signal environmental responsibility to regulators and investors. Moreover, similar to socio-political theories, economics-based theories of disclosure focus on the *output* dimension of carbon disclosure. This is linked to the (economic) *outcome* of disclosure in terms of (market) reactions to corporate carbon disclosure. Signaling theory argues that, in the case of voluntary disclosure, companies prefer to convey good performance (Clarkson et al., 2008) and investors and analysts value proactive disclosure.

Another theory applied in the context of disclosure is institutional theory, which states that organizations are driven not merely by their aim to maximize profits, but also by the requirements of different institutions (e.g., CDP, institutional investors, or governments). These expectations lead organizations to progressively adjust their behaviors (Meyer & Rowan, 1977; for an overview, see Powell & DiMaggio, 1991). In addition to such forms of normative or

coercive isomorphism, mimetic tendencies might be relevant. According to this traditional notion of institutional theory, the disclosure behaviors of organizations should converge over time (Cormier, Magnan, & van Velthoven, 2005; Luo, Lan, & Tang, 2012; Matisoff, Noonan, & O'Brien, 2013). For carbon disclosure, Jira and Toffel (2013) argue that the supply chain influences organizational conformity. Although carbon disclosure literature seems to focus on the more traditional notion of institutional theory, the emergence of voluntary disclosure regimes also motivates research on institutional entrepreneurship. Here, research is concerned with organized actors such as the CDP, which transform institutions. In particular, the transformation of corporate disclosure to entail issues of carbon emissions and management is of interest (Kolk et al., 2008).

Table 1 presents a matrix that combines the different theoretical perspectives identified in the literature with our framework of carbon disclosure research perspectives. The table makes evident that the research area of general regulations and frame conditions cannot be associated with any of the three main theoretical anchors introduced above. One reason might be that several of the respective articles exist in the intersection of business and law or politics, a situation that might explain the lack of core theories from the business or management domain. Furthermore, legitimacy and economic theories of disclosure, in particular, specifically refer to companies as the main actors, making these theories less suitable to explain issues of regulation or frame conditions on the macro level. However, we also did not identify a dominant theory from any other domain.

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GENERAL REGULATIONS AND FRAME CONDITIONS

The central issue concerning general regulations and frame conditions for carbon disclosure is that of reporting guidelines of voluntary and mandatory natures. In the area of non-financial disclosure, including carbon disclosure, reporting is predominantly voluntary (e.g., Hahn & Lülfs, 2014). The discussion of voluntary versus mandatory carbon disclosure regulation is a prominent topic in the literature, and the following overview can be seen as a launching pad for deeper analyses of carbon disclosure systems in future research.

In favor of voluntary disclosure, Knox-Hayes and Levy (2011) attribute the success of the voluntary CDP scheme to its ability to bring together multiple stakeholders and build legitimacy for its particular reporting standard. Similarly, Green (2010), in her analysis of private standards, judges the ability to reduce user transaction costs as an advantage of voluntary carbon reporting schemes. From the perspective of the disclosing companies, organizations meet stakeholder demands for information by publicly reporting their activities. Legitimacy theory, thus, directly abets the quest for voluntary disclosure. Harmes (2011) and Sullivan and Gouldson (2012), however, critically argue, from an economic lens that financial incentives for carbon disclosure have been considerably overestimated, which puts the success of voluntary disclosure into question. In their analysis of the CDP, Andrew and Cortese (2011a) argue, from a financial accounting perspective, that important attributes, such as comparability, understandability, and reliability, have so far not been met; thus, voluntary reporting under this scheme is not sufficient to improve users' decision making. Similarly, McFarland (2009) suggests that voluntary schemes “are not effecting changes in disclosure practices quickly enough.” (p. 281)

Some authors—especially those with backgrounds in law—call for mandatory reporting schemes or for pressures such as securities litigation (e.g., Erion, 2009). Raingold (2010) sees an

opportunity for mandatory reporting standards to “help companies identify costs savings and address climate risks and opportunities” (p. 85). Others propose a combination of voluntary and mandatory reporting (e.g., Knox-Hayes & Levy, 2011; Sullivan & Gouldson, 2012), arguing that the “market logic” (Andrew & Cortese, 2011b) of voluntary schemes can advance the current climate debate and enhance the diffusion of disclosure. Therefore, voluntary approaches lay the groundwork for future mandatory guidelines (Andrew & Cortese, 2011b). However, even mandatory reporting could be inadequate unless investors demonstrate an increased interest in the reported data (Sullivan & Gouldson, 2012). Moreover, mandatory standards require enforcement, which poses a challenge for regulating bodies.

Some studies explore the issues of climate change and carbon emissions as fundamental risks for firms—a perspective that connects to the discussion of voluntary versus mandatory disclosures. The SEC Climate Change Guidance inspired literature at the intersection of business and law that evaluates the costs and potential problems related to climate-change risk disclosure (Burton, 2010; McFarland, 2009). Bebbington and Larrinaga-González (2008) discuss issues of carbon trading and accounting, such as the valuation of pollution allowances and fines for exceeding these allowances. Both discussions show how carbon disclosure issues enter the domain of financial reporting. If a firm faces material financial risks related to climate change, a disclosure of these risks is *per se* mandatory. Therefore, material financial risks encourage increased disclosure and governance (Pattberg, 2012). As a consequence, U.S. firms increasingly report such risks (Doran & Quinn, 2009), and institutional investors have begun to perceive carbon-related information as risk-relevant and material (Solomon, Solomon, Norton, & Joseph, 2011). The transition of climate-change-related risk from non-financial factors to financial factors calls for research on the valuation and management of such risks.

In general, the debate around voluntary and mandatory disclosures has existed mostly on a conceptual and non-empirical level. We nevertheless find it to be mostly non-theoretical. The few empirical studies touching upon the issue of regulation investigate the effects of specific regulatory issues on disclosure (e.g., Freedman & Jaggi, 2005; Jira & Toffel, 2013; Luo, Tang, & Lan, 2013). In such a context, regulation is a determinant of disclosure. Therefore, we discuss papers touching upon regulation as a determinant in the following section on the output perspective.

THE OUTPUT PERSPECTIVE: DETERMINANTS OF VOLUNTARY CARBON DISCLOSURE

The output perspective is most intensely researched in the field of carbon disclosure, with more than half of the papers of our review capturing topics from this perspective. The main topics include management’s disclosure decisions, assurance, and the measurement of carbon performance.

Research concerned with discussing or analyzing management’s carbon disclosure decisions represents the majority of the analyzed papers and is very heterogeneous, as evidenced by the different underlying theoretical frameworks and empirical foci. We find that socio-political theories form the largest group, followed by economics-based theory and institutional theory. Furthermore, some papers apply theories that are not utilized by any other paper in our sample. In general, research on management’s disclosure decisions is predominantly of empirical nature. For the following discussion, we rely on studies that apply sophisticated quantitative analyses to test their hypotheses. In total, we find 24 relevant papers² and identify four main categories for the

² Another 13 articles that were coded as quantitative analyses of secondary data and documents in Figure 1 provided only limited descriptive analyses, without robust statistical methods or findings, on the outcome perspective; these are, thus, not discussed here.

most commonly applied determinants: (1) economic, (2) ecological, (3) regulatory, and (4) disclosure determinants. Table 2 summarizes the findings for these determinants. Additional determinants, each of which were analyzed in fewer than five papers, include auditing, corporate governance, environmental-activist groups, sustainability indices, environmental-management systems, capital-market influences, litigation risks, foreign sales, and reputation. We see this as evidence of an emerging research field, in which many different themes are explored and an overarching theme cannot yet be identified.

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Regarding economic determinants, 13 studies analyze the relationship between financial performance and carbon disclosure, with mostly insignificant findings. Market-to-book (including Tobin’s Q), leverage, and size are often applied as control variables. While there is little support for market-to-book and leverage, most studies report a significantly positive relationship between size and carbon disclosure. This is noteworthy because many studies focus on samples of large firms, which leads to less variation in the size variable and can bias results towards lower significance. Not surprisingly, the two papers that find no significance for size focus on large firms (Dawkins & Fraas, 2011; Gallego-Álvarez et al., 2011).

Ecological determinants include measures of emissions and comparisons of carbon-intensive versus non-carbon-intensive industries. Emissions are reported to be either insignificantly or positively associated with carbon disclosure—that is, the greater the amount of emissions, the more carbon disclosure is to be expected (Apergis, Eleftheriou, & Payne, 2013; Gallego-Álvarez et al., 2011; Luo et al., 2013). The relatively low number of studies addressing this relationship is likely due to the relationship’s interdependent nature—that is, data on carbon emissions are

usually only available if a firm engages in carbon disclosure. This also becomes evident in the measurement of the emissions variable, in which some studies focus on toxic emissions instead of carbon emissions (Reid & Toffel, 2009), apply the average carbon emissions for a firm's corresponding industry (Jira & Toffel, 2013), or estimate the CO₂ emissions of non-reporting firms (Luo et al., 2013). The determinant of carbon-intensive industry is applied as a binary variable to control for the effects of an industry that is more directly related to climate change issues. The results are somewhat confounding, showing positive, negative, and insignificant correlations. A closer look reveals that methodological issues might explain these inconsistencies. Studies that find a positive relationship use self-created climate-disclosure indices devised by applying content analysis to corporate reports (Choi et al., 2013; Choi et al., 2013; Hrasky, 2012; Liu & Anbumozhi, 2009). Such self-created indices favor carbon-intensive industries because they cover issues that are more relevant to these firms. Studies that find no significant relationship between carbon-intensive industries and carbon disclosure measure carbon disclosure as a binary variable capturing whether a firm answered the CDP questionnaire or not (Jira & Toffel, 2013; Stanny & Ely, 2008). Negative findings are reported in studies that focus on the Carbon Disclosure Score (Wegener, Elayan, Felton, & Li, 2013; Yu & Ting, 2012), which is calculated by the CDP to measure how thoroughly the questionnaire is answered. Firms in non-carbon-intensive industries are less threatened by indirect costs (e.g., litigation risks or environmental-activist groups) and, therefore, provide answers that are more complete. Many papers that did not apply a measure for carbon-intensive industries included industry-related dummy variables to control for industry-specific effects.

The third category of determinants covers the effect of regulatory actions on carbon disclosure.³ Governments are seen to play a major role in motivating firms to address climate-change issues (Stoddart, Tindall, & Greenfield, 2012). The most prominent example is the effect of the Kyoto Protocol. The majority of studies find that firms headquartered in countries that are signatories of the Kyoto Protocol tend to disclose more carbon-related information. Similarly, the category of “other GHG-specific” regulations, such as state-specific regulations in Canada (Brouhle & Harrington, 2009) and the USA (Kim & Lyon, 2011b), emission-trading schemes (Luo et al., 2012; Rankin, Windsor, & Wahyuni, 2011), industry-specific regulations, and the threat of potential regulatory efforts of a government (Stanny, 2013), capture different issues. Here, again, positive relationships prevail. Finally, we subsume further regulatory variables that do not specifically aim at carbon disclosure into the category of “other”. This includes country-specific dummy variables covering general regulatory differences or variables capturing whether the country in which a firm is headquartered follows common or civil law. These findings add to the perspective of general regulation by showing that the regulatory setting in which a company operates is associated with management’s carbon disclosure decisions.

Finally, disclosure determinants cover the effects of prior carbon disclosures and other related disclosures, for example, environmental or corporate social responsibility disclosures. All but one study found a positive association, supporting the argument that firms tend to stick to their disclosure decisions and to engage in multiple disclosure mediums to report their carbon-related information.

³ In this category, the topics of general regulation and output overlap. We discuss these studies here, because empirical research investigates regulatory actions along with other determinants of management disclosure decisions and within the same methodological set.

Looking at the theoretical lenses, we do not find any obvious relation between the theories applied and the determinants analyzed in a study. This also implies that theories are not mutually exclusive with regard to their corresponding determinants. In some cases, different theories intuitively explain the same direction for a determinant, while, in other cases, the directions of theories might differ. For example, following socio-political theories, size is argued to be associated with increased carbon disclosure because larger firms are more visible and, therefore, have a greater need to legitimize their actions; economics-based theories argue that larger firms have more resources to invest in information systems. An example for different relationships is the case of carbon emissions. While, under socio-political theories, firms with high emissions should experience more pressure to legitimize emissions, economics-based theories argue that firms would prefer to disclose good news, such as low emissions, rather than bad news.

In addition to the determinants of disclosure, we identified further topics that were relevant from an output perspective. Voluntary assurance of carbon-related information, for example, seems to respond well to critiques on the quality of carbon disclosure (see, e.g., Raingold, 2010; Sullivan & Gouldson, 2012). Even with assurance, GHG statements seem to be interpreted in diverse ways (Kolk et al., 2008)—or, alternatively, their respective third-party reports seem to be inaccurate (Downie & Stubbs, 2013). Against this background, qualitative or conceptual assurance-related research focused mainly on propositions and discussions of an international assurance standard for GHG statements (see Huggins, Green, & Simnett, 2011; Olson, 2010; Simnett et al., 2009). The recently released carbon assurance standard ISAE 3410 provides comprehensive guidance on the assurance of carbon emission disclosures and could stimulate academic debate on this topic. In line with this, there seems to be a general trend towards assuring carbon disclosure (Green & Zhou, 2013). Within the set of quantitative research articles,

two papers actually address assurance as a determinant of voluntary carbon disclosure (Berthelot & Robert, 2011; Rankin et al., 2011) and another two articles analyze the current assurance practices related to carbon disclosure (Green & Taylor, 2013; Green & Zhou, 2013). However, these studies do not build upon a common theoretical background. Overall, empirical research on the assurance of carbon disclosure is still scarce. This can probably be attributed to limited data availability.

Another topic is the measurement of carbon emissions. Due to the mainly voluntary nature of carbon disclosure, managers can choose which guidelines to apply in order to measure carbon emissions. Many such guidelines exist: for example, the Greenhouse Gas Protocol, the guidelines of the European Emissions Trading Scheme, the joint guidelines of the International Petroleum Industry Environmental Conservations Association (IPIECA), and the American Petroleum Institute (API), among others. Andrew and Cortese (2011b) note that this large variety of methodologies for measuring carbon emissions hampers comparisons of carbon performance. Beyond the reporting of direct carbon emissions, there is also a measurement issue with regard to indirect carbon emission. Indeed, this measurement problem seems to be more serious, since there is no consensus on the relevant sources of such indirect emissions. Although the carbon emissions guidelines provide some information, firm reporting behaviors show differences in the recognition of emission sources (Downie & Stubbs, 2013). This discussion is closely connected to the discussion of mandatory versus voluntary disclosure and calls for a close examination of the different measurement approaches (Andrew & Cortese, 2011a).

THE OUTCOME PERSPECTIVE: EFFECTS OF DISCLOSURE

Compared to research on the output perspective, research related to the outcome perspective of carbon disclosure is still scarce and underrepresented. Furthermore, more than half of the articles

addressing the outcome perspective do not explicitly refer to an underlying theoretical framework and, rather, rely on prior empirical evidence to develop their hypotheses. Of the applied theories, only the economic theory of disclosure is referred to by more than one article.

Table 3 shows the two main outcome categories of carbon disclosure: economic effects and ecological effects. Within the first subgroup, Kim and Lyon (2011a) analyzed whether and how emissions-related disclosures affect stock prices for disclosing firms, while Gallego-Álvarez (2012) focused on performance variables. Overall, there is some indication that carbon disclosure has a positive effect on stock performance, which supports arguments of signaling theory. However, this effect might be only valid for firms facing significant regulatory threats (Kim & Lyon, 2011a). Regarding firm performance, evidence of the positive or negative influence of carbon disclosure is ambiguous.

Ecological effects typically comprise the total carbon-dioxide emissions, the carbon dioxide intensity (emissions divided by output), and the fuel or electricity costs. There is some evidence that participation in a carbon-disclosure program is associated with a decrease in total carbon dioxide emissions. This decrease depends on the specific program in which a company participates. For example, the Chicago Climate Exchange has a more significant effect than the CDP (Matisoff 2012, 2013). Interestingly, participation in (all) disclosure programs is actually associated with an increase in carbon dioxide intensity, while the effects on fuel and electricity costs are rather inconsistent.

Finally, in addition to economic and ecological effects, carbon disclosure is associated with future disclosure outcomes. For example, Stanny and Ely (2008) and Stanny (2013) found that previous disclosures represent the most significant variable in determining subsequent

disclosures. Thus, a firm’s decision to engage in carbon disclosure seems to be a rather consistent choice.

--- INSERT TABLE 3 HERE ---

OPEN FLANKS, KNOWLEDGE GAPS, AND FUTURE RESEARCH

Apart from the findings discussed above, one of the most important insights of our review is the theoretical anchor that is missing in many papers as well as the otherwise heterogeneous application of theory. Only socio-political, economic, and—to a lesser extent—institutional theories were used frequently in our body of literature and, thus, provide steady explanations in the realm of carbon disclosure. However, we do not find strong evidence in favor of only one of these theories. Therefore, we see opportunities for future research seeking to provide a solid picture of carbon disclosure by grounding empirical research more strongly in theory, which will allow for more precise predictions and lasting explanations beyond isolated issues and cases. In the following, we will exemplarily illuminate some of the opportunities within these topics that still seem to be underrepresented in the literature.

Carbon disclosure assurance currently lacks a common theoretical basis. This is surprising, given that economics-based theories provide a solid explanation that verified carbon disclosures are a costly signal and, thus, should result from a cost-benefits analysis. Similar thoughts have been applied to regular financial reporting issues; these could be transferred to research on carbon disclosure. From a socio-political point of view, a question arises concerning whether assurance is only a tool to improve legitimacy or whether it is connected to real reduction targets.

Compared to research on determinants, far fewer studies illuminate the outcome effects of carbon disclosure. This is noteworthy because the general discussion on carbon disclosure often

starts with the socio-political aim of reducing carbon emissions. Thus, from a societal viewpoint, the ecological and economic effects of carbon disclosure should be of greater interest than the determinants of disclosure. This perspective, however, is not mirrored in the research. This disconnect is surprising, since the pays-to-be-green literature (e.g., Clarkson, Li, Richardson, & Vasvari, 2011) in the field of environmental disclosure seems especially well suited for use in a carbon disclosure context due to the high public visibility of climate change issues, the materiality of this issue for companies, and the connection between GHG emissions and financial risks.

With regard to environmental effects, future research could explore the role of carbon disclosure in reducing GHG emissions. Current research (Kim & Lyon, 2011b; Matisoff, 2012, 2013; Pizer, Morgenstern, & Shih, 2011) provides mixed evidence, which seems to depend on the analyzed disclosure regime. Additional studies on the capital market effects of carbon disclosure are needed to develop a better understanding of the confounding results in the existing literature (Gallego-Álvarez, 2012; Kim & Lyon, 2011a). Indeed, recent literature addresses the question of the firm-value effect of carbon emissions (Matsumura, Prakash, & Vera-Muñoz, 2014). Ultimately, the many different voluntary disclosure schemes and the emergence of mandatory disclosures offer opportunities and highlight a need to assess the characteristics of the disclosure regulations that motivate GHG emissions reduction and are useful to investors.

The measurement of carbon disclosure is another essential issue for all perspectives of carbon disclosure research. Future studies are needed to validate carbon disclosure measures and to assess the dimensions of disclosure captured by different measures. Currently, we find three general approaches: content analysis, binary variables for disclosure/no disclosure, and the CDP disclosure score. Content analyses are based on self-created indices covering different aspects of

carbon disclosure, and they focus on annual and sustainability reports. Binary variables measure whether a firm participates in a voluntary carbon-disclosure scheme (usually the CDP or, for U.S.-based firms, the 1605b voluntary program). The CDP disclosure score measures how thoroughly a firm answers the CDP questionnaire. Although the CDP disclosure score and content analysis both capture the quality of information, the former provides a more objective measure than self-created disclosure indices; however, it does not necessarily fit well with different research questions. Additionally, some papers apply carbon emissions or surveys to assess carbon disclosure. Future research thus requires a method for validating disclosure indices. Furthermore, a solid theoretical background is necessary to justify the chosen measurement method. Socio-political theories initially focus on participation in disclosure schemes and on the quantity of disclosures, while economics-based theories are more concerned with the content of disclosures (see, e.g., Clarkson et al., 2008). This follows the underlying assumption that, other than financial investors, disclosure recipients do not scrutinize the given information and that firms would prefer to disclose positive signals, which lead actors to grant legitimacy to any disclosing organization. However, if non-financial recipients of carbon information professionalize their information processing and if firms report more balanced information, both theoretical foci could merge. In the current state of the literature, we find no clear association between the theoretical background of a study and the applied measurement method. Thus, future research is challenged to more directly address the link between theory and measurement method.

Finally, beyond the process framework of carbon disclosure initially introduced, scholarly research has sporadically discussed carbon disclosure in a supply chain context, which merits further attention. On the one hand, this issue is of interest for carbon management and accounting (Hartmann, Perego & Young, 2013). On the other hand, the first empirical papers analyze

disclosure in a supply chain context in which, roughly speaking, the downstream customer of a company is a stakeholder who can motivate the management to engage in carbon disclosure (Jira & Toffel, 2013; Scholtens & Kleinsmann, 2011). Although results suggest that customers have a positive impact on carbon disclosure and that there are country-specific differences, research supporting this association is still scarce.

CONCLUSIONS

Carbon-disclosure research has gained increasing attention due to regulatory developments, the implementation of emission-trading schemes, the recognition of carbon emissions as financial risks, and non-governmental initiatives. This development has motivated many studies over the last few years and has enabled researchers to analyze previously unavailable datasets. A main contribution of our review is a summary of the current state of research in the field and the identification of commonalities and differences across the body of analyzed literature. It is of special interest to consolidate the more accounting-related perspectives affected by economics-based theories, for example the signaling and institutional theories, with the more climate-change-related perspective influenced by socio-political theories, for example legitimacy theory. We also identified the current trends and research gaps.

In general, we found a broad range of articles covering many different topics at the intersection of environmental research, accounting, law, and political science. Although few studies explicitly rely on theories, we identify the legitimacy, signaling, and institutional theories as promising anchors for future research. A considerable number of studies provide empirical research on the determinants of carbon disclosure. Here, a significant number of articles do not explicitly state any theory. In these cases, scholars usually rely on prior empirical evidence to

develop their hypotheses. We find this approach troublesome because it demands that readers have a deep understanding of the theoretical foundations of the cited empirical papers in order to understand a study’s contribution.

We find relatively consistent evidence that larger firms with prior GHG reporting (often from countries that signed the Kyoto Protocol and implemented more GHG-specific regulations) are more likely to provide (higher quality) carbon disclosures. Our review reports mixed evidence for other determinants, such as profitability, leverage, market-to-book ratio, and affiliation with a carbon-intensive industry. Moreover, previous empirical studies do not build on a common set of control variables, which hampers comparisons. Based on our findings, we provide a base of control variables for future research. The effects of carbon disclosure represent a major gap that should be filled by future research. This is especially true considering that the public debate on climate change regulations often relies on the argument that increased carbon disclosures positively affect both organizations and the environment, but current research includes only a small number of studies offering mixed evidence for capital-market effects and the subsequent decrease of GHG emissions. For both, determinants and effects, methodological and measurement issues seem to explain the inconsistent results. Thus, we require more research, especially with regard to the validity of carbon-disclosure measures and the application of different research methods. Finally, there is an ongoing debate on the suitability of voluntary and mandatory disclosure regimes for achieving transparency. Empirical research on the efficiency and effectiveness of such schemes could complement the conceptual discussion.

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⁴ All 66 articles from our literature are marked with a “*”.

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TABLES AND FIGURES

Table 1. Theories in carbon disclosure research

		Regulations and frame conditions	Output dimension	Outcome dimension
Socio-political theories	Stakeholder theory	Cotter & Najah, 2012	Berthelot & Robert, 2011; Cotter & Najah, 2012; Freedman & Jaggi, 2005, Freedman & Jaggi, 2011; Gallego-Álvarez et al., 2011; Liu & Anbumozhi, 2009; Luo et al., 2012; Luo et al., 2013; Prado-Lorenzo, Rodríguez-Domínguez, Gallego-Álvarez, & García-Sánchez, 2009; Stanny, 2013	Stanny, 2013
	Legitimacy theory		Berthelot & Robert, 2011; Choi et al., 2013; Chu et al., 2013; Freedman & Jaggi, 2005, Freedman & Jaggi, 2011; Gallego-Álvarez et al., 2011; Hrasky, 2012; Liu & Anbumozhi, 2009; Luo et al., 2012; Luo et al., 2013; Prado-Lorenzo et al., 2009; Stanny, 2013; Wegener et al., 2013	Stanny, 2013
Economic theories of disclosure			Berthelot & Robert, 2011; Dawkins & Fraas, 2011; Freedman & Jaggi, 2005; Jira & Toffel, 2013; Luo et al., 2012; Prado-Lorenzo et al., 2009; Stanny, 2013; Stanny & Ely, 2008	Kim & Lyon, 2011a; Stanny, 2013; Stanny & Ely, 2008
Institutional theory			Jira & Toffel, 2013; Kolk et al., 2008; Luo et al., 2012; Matisoff et al., 2013	
Other theories		Ascui & Lovell, 2011, Ascui & Lovell, 2012; Evans, Gilpatric, & Liu, 2009; Green, 2010; Kolk et al., 2008; Reid & Toffel, 2009; Solomon et al., 2011; Yu & Ting, 2012	Ascui & Lovell, 2011, Ascui & Lovell, 2012; Dawkins & Fraas, 2011; Jira & Toffel, 2013; Kolk et al., 2008; Luo et al., 2013; Rankin et al., 2011; Reid & Toffel, 2009; Scholtens & Kleinsmann, 2011; Solomon et al., 2011	Haigh & Shapiro, 2012

Table 2. Studies on determinants of carbon disclosure

Authors (year)	Country	Industry	<i>Economic determinants</i>				<i>Ecological determinants</i>		<i>Regulatory determinants</i>			<i>Disclosure determ.</i>
			Perfor- mance measures	Market- to-book	Leve- rage	Size	Emis- sions	Carbon- intensive industry	Kyoto Protocol	Other GHG specific regulation	others	Other GHG- related disclos.
Apergis et al., 2013	UK, France, Germany	CO2-intensive					+				sig.	
Berthelot & Robert, 2011	Canada	CO2-intensive				+						
Brouhle & Harrington, 2010	Canada	CO2-intensive				+				o		+
Choi et al., 2013	Australia	all	o		o	+		+				
Chu et al., 2013	China	all	o			+		+				
Cotter & Najah, 2012	Global	all	o		+	+						+
Dawkins & Fraas, 2011	USA	all	o		o	o						
Freedman & Jaggi, 2005	Global	CO2-intensive	o		o	+			+		o	
Freedman & Jaggi, 2011	Global	all				+	o		+		sig.	
Gallego-Álvarez et al., 2011	Global	CO2-intensive		o	o	o	+		+			
Hrasky, 2012	Australia	all						+				
Jira & Toffel, 2013	Global	all	+				o	o	+			+
Kim & Lyon, 2011b	USA	CO2-intensive				+	o			-/+	o	
Liu & Anbumozhi, 2009	China	all	o		o	+		+				
Luo et al., 2012	Global	all	o	o	o	+			o	+	sig.	
Luo et al., 2013	Global	all	o		-	+	+			+	sig.	
Prado-Lorenzo et al., 2009	Global	CO2-intensive	o/-	+	o	+			+			o
Rankin et al., 2011	Australia	all	o		o	+						+
Reid & Toffel, 2009	Global	all				+	o			+		
Scholtens & Kleinsmann, 2011	UK, Netherlands	CO2-intensive						o/+		o/+	sig.	
Stanny & Ely, 2008	USA	all	o	o	o	+		o				+
Stanny, 2013	USA	all				+				+		+
Wegener et al., 2013	Canada	all	o	o	-	+		-				
Yu & Ting, 2012	Global	all						-			sig.	

Table 3. Studies on effects of carbon disclosure

Article	Country	Industry	Economic effects		Ecological effects			Disclosure effects
			Stock returns	Performance measures	Emissions	Emissions intensity	Electricity & fuel	Past on current
Gallego-Álvarez, 2012 Kim & Lyon, 2011b	Global USA	all CO ₂ -intens.		-/o	o			
Kim & Lyon, 2011a Matisoff, 2012	Global USA	all CO ₂ -intens.	+/o		o/-	+	o/-	
Matisoff, 2013	USA	CO ₂ -intens.			+/-	+	-	
Pizer et al., 2011	USA	CO ₂ -intens.					+/-/o	
Stanny, 2013	USA	all						+
Stanny & Ely, 2008	USA	all						+

Figure 1. Process framework of carbon disclosure with exemplary research questions

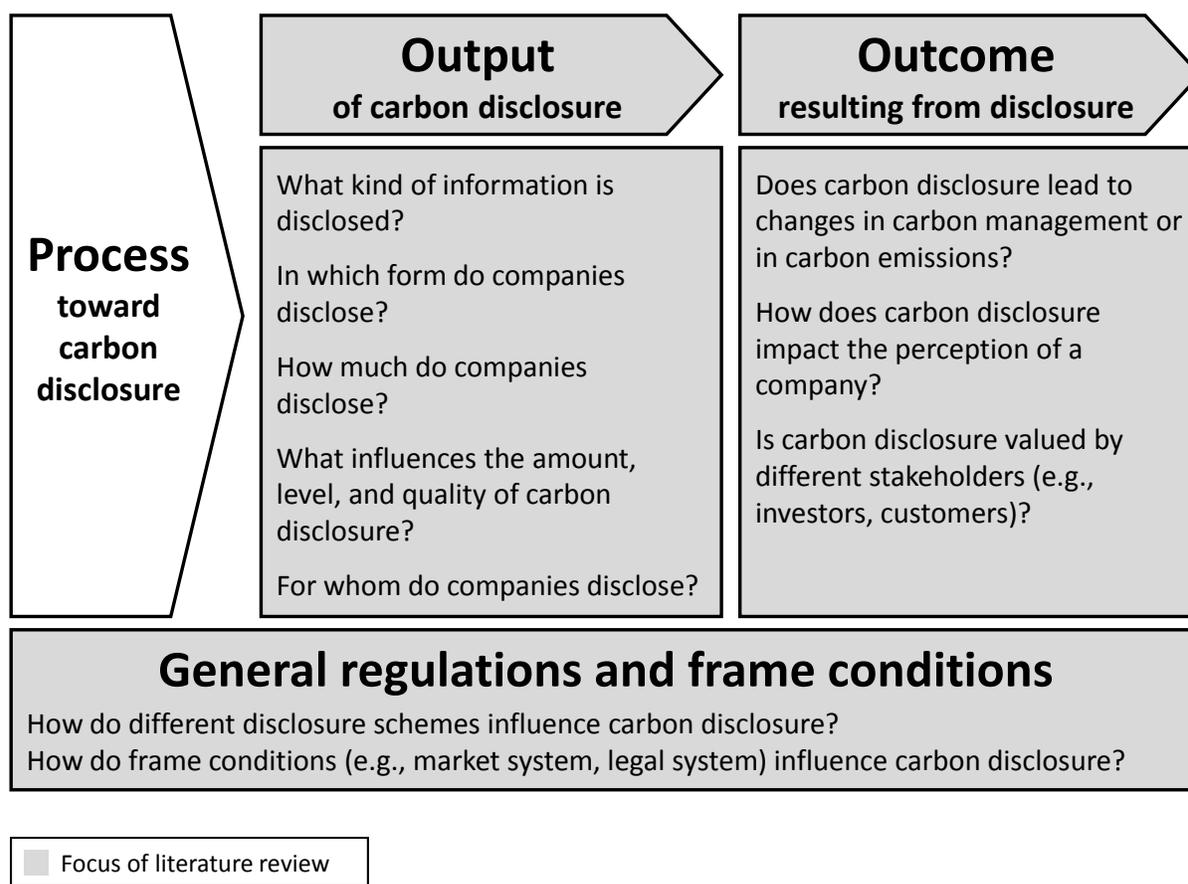


Figure 2. Development of articles and research approaches over time

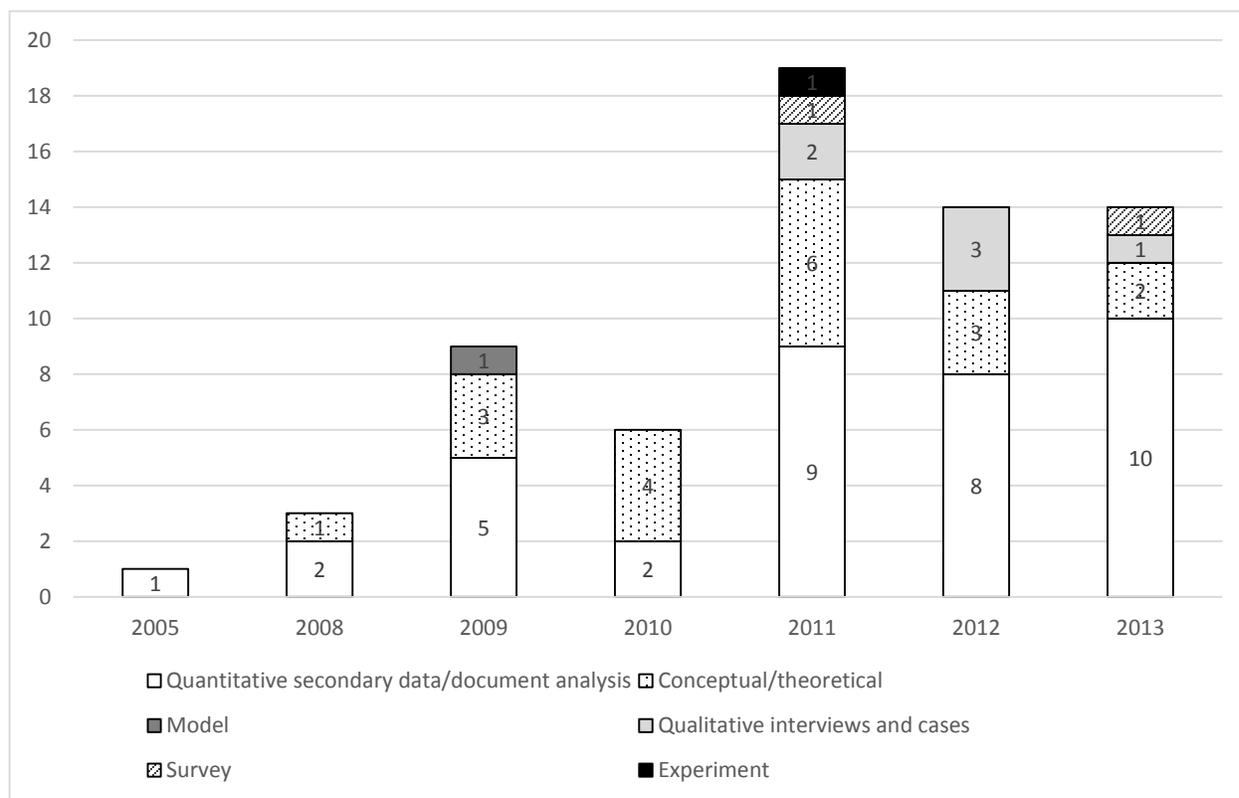


Figure 3. Secondary data sources in quantitative carbon disclosure research

