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Corporate biodiversity accounting and reporting in mega-diverse countries: An examination of indicators disclosed in sustainability reports

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ABSTRACT

Ongoing biodiversity decline threatens ecosystem stability and reflects an overarching planetary boundary being breached. It undermines enabling conditions for sustainable development and posits alarming risks to the global economy. All business entities are dependent to biological diversity and the planetary spectrum of ecosystem services either directly or indirectly and there is a strong debate on why and how the private sector can effectively contribute to ecologically sustainable societies. In this context, corporate biodiversity accounting and reporting seeks to capture information relevant to biodiversity management by employing a certain set of comprehensive, valid and credible quantitative as well as qualitative indicators. This paper seeks to contribute to this direction by providing a critical evaluation of what business entities of mega-diverse countries report on biodiversity conservation and management through widely-accepted performance metrics disclosed in their sustainability reports along with underlying determinants. The assessment relies on a composite disclosure index devised to investigate the comprehensiveness of reported performance on biodiversity management and conservation. By employing Poisson and Gaussian Bayesian regression modeling, potential associations of biodiversity indicators with national specificity, organizational size and industrial affiliation are examined. Crucially, the constructive role of biodiversity accounting and reporting in communicating performance and discharging accountability towards relevant stakeholders is investigated, under the scope of an ecologically sustainable society. Most important predictors of biodiversity indicators disclosure pertain to spatial characteristics (i.e. country effects), along with the industry affiliation of the organizations. In contrast, organizational size does not seem to have a significant effect on the disclosure of biodiversity indicators. In particular, Brazilian, Bolivian and Malaysian enterprises exhibit the highest disclosure levels in biodiversity indicators, whereas the lowest levels are observed for those from Philippines. In terms of differences according to the business sector the sample reporters pertain to, we find biodiversity indicators are mostly reported by enterprises of the materials, energy, industrials, consumer staples and utilities sectors. Comparatively lowest levels are observed for the health care and information technology sectors. Considerable variation among companies, sectors, countries as well as individual indicators is evident. The analysis derived from the study suggests that performance indicators of biological diversity, as part the firm's broader management accounting system, are still underreported and in most cases confined to generic and/or vague statements, with quantitative data and narratives on managing biodiversity being sporadic and limited.

1. Introduction

The notion of biodiversity encompasses variation within or between species and of ecosystems (e.g. Ketola, 2009). All these aspects are strongly interconnected and signify the stability of natural assets and the quality of services they offer (Laurila-Pant et al., 2015; Schneiders et al., 2012). Biodiversity is the key factor to the resilience of global biomes (Holling, 1986; Whiteman et al., 2013). The 'buffering' effect it provides (Wackernagel et al., 2002), predicates that, in the era of the Anthropocene, we are to maintain such buffer as much as possible. This is particularly critical in localities defined as biodiversity hotspots (Myers et al., 2000) that cover a mere 1.4% of terrestrial surface but host the (remaining) habitats of 44% of the vascular plant species and 35% of species in four of five vertebrate groups (Wackernagel et al., 2002).

Ongoing biodiversity decline threatens ecosystem stability and reflects an overarching planetary boundary being breached (Wijkman and

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Rockström, 2013; Rockström et al., 2009). It undermines enabling conditions for sustainable development (Willison and Cote, 2009) and posits alarming risks to the global economy (e.g. EBI, 2003; Barrington, 2004; Athanas, 2005; Duffy et al., 2017; Venter et al., 2016). Ceballos et al. (2015) stress incontrovertible evidence that extinction rates have now reached unprecedented levels in human history and unparalleled in planet's history. Indeed, current trends suggest that the planet is entering a sixth period of mass extinction fueled by human activities (Ceballos et al., 2017) and estimation methods have accounted for 10,000–25,000 species lost every year (Lawton and May, 1995). The Food and Agriculture Organization (FAO) reports that since the 1900s more than 75% of the total global plant genetic diversity has been lost (FAO, 2010). Such loss of biodiversity can be identified at a local scale (e.g. coral reefs) but as it accumulates up to regional and global scales it is bound to affect global ecosystem stability and its ability to recover from other 'grand challenges' (e.g. climate disruption). With critical natural capital being irreplaceable, such as the genetic pool of endangered species, active intervention through conservation and stewardship is essential towards the mitigation of ecologically-based systems' degradation and the creation of enabling conditions for sustainable management of global biodiversity (Daly, 1985; Turner, 1987; Gray, 1992).

In this context, the key role of biodiversity is not merely an ecological one but it also encapsulates a fundamental socioeconomic perspective for prosperity. In line with the Green Economy discourse (UNEP, 2011; Gasparatos et al., 2017), where socioeconomic prosperity in terms of income and employment growth is coupled with the prevention of ecological scarcities, biodiversity conservation reflects an essential component for sustainability transitions (Markard et al., 2012). Affected either by the overexploitation of natural resources necessary for human consumption (FAO, 2010) or, indirectly, by other planetary thresholds (e.g. land use, nitrogen and phosphorus cycles), biodiversity decline dictates the development of new business models and mechanisms to address such grand challenge and secure the prosperity of future generations through compensatory mitigation for an overall no net loss of biological diversity (Whiteman et al., 2013; Gardner et al., 2013). Indeed, there is a strong debate on why and how the private sector can effectively contribute to ecologically sustainable societies (Jackson, 2009; Milne and Gray, 2013). However, while there is considerable research attention attached to climate change mitigation, GHG accounting and reporting, disproportionately low levels of emphasis has been placed to other specific elements of corporate environmental performance such as biodiversity conservation (Heller and Zavaleta, 2009). This is despite the fact that all business entities are dependent to biological diversity and the planetary spectrum of ecosystem services either directly or indirectly.

Primary business sectors, such as agriculture, fisheries and forestry, rely on biological resources which underscores an instrumental value to investing to natural capital enhancement. Likewise, secondary sectors, such as construction and manufacturing retain a steady strategic goal of resource efficiency optimization as a response to natural capital depreciation (with biodiversity loss included). Service sectors, such as tourism and hospitality, cannot exist without well-preserved ecosystems and supporting functions (Edwards and Abivardi, 1998; JBIB, 2014). In this respect, business organizations are expected to act proactively in endorsing the conservation of biological diversity, the sustainable use of its components and the distribution of benefits from the utilization of genetic resources (UNEP, 2012). The TEEB Report for Business (2010) relevantly points out the key role of business in safeguarding biodiversity due to the high stocks of financial capital and technological resources. For instance, extractive industries, being under scrutiny for impact mitigation, are nowadays increasingly making commitments to biodiversity conservation and along with other sectors (e.g. food and beverages, technology and financial services) are taking steps to this direction (Adler et al., 2017; Rainey et al., 2015). Yet, scholars stress that such actions still remain in their infancy (e.g. Adler et al., 2017; Boiral, 2016; Jones and Solomon, 2013).

The rise of the Integrated Reporting framework as well as the US Sustainability Accounting Standards Board initiative, the Natural Capital Protocol, the United Nation's Sustainable Development Goals (SDGs) and the Aichi Targets of the Convention on Biological Diversity, all raise biodiversity decline as a critical issue for corporate disclosure (de Villiers et al., 2017; King and Atkins, 2016). Setting corporate biodiversity goals is also actively endorsed through the International Finance Corporation Performance Standard 6 which effectively introduces high standards of biodiversity-specific performance to private sector project finance of $USD 10 m and is followed by over 75 large financial institutions subscribed to the Equator Principles (IFC, 2012; Morgera, 2012). The Aichi Targets specifically provide an "overarching framework on biodiversity, not only for the biodiversity-related conventions, but for the entire United Nations system and all other partners engaged in biodiversity management and policy development". Aichi Target 7 indicates that "by 2020 areas under agriculture, aquaculture and forestry [should be] managed sustainably, ensuring conservation of biodiversity", while Target 4 states that "by 2020 private sector organizations along with governments and key stakeholders should have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits" (CBD, 2010). Targets such as the previous have spurred the formation of the Global Partnership for Business and Biodiversity, working towards the 'mainstreaming biodiversity' agenda (CBD, 2010; Redford et al., 2015) through greater business engagement on biodiversity-related issues and the development of relevant management tools such as stewardship accounting (Siddiqui, 2013), certification (Elad, 2014), offsetting (Tregidga, 2013) as well as corporate biodiversity reporting and relevant performance indicators' disclosure (e.g. Atkins et al., 2014; Thomson, 2014; Adler et al., 2017). In this respect, PwC (2010) and Hanson et al. (2012) highlight both financial risks stemming from biodiversity mismanagement and emerging opportunities linked with actionable responses linked with biodiversity conservation goals. Organizations which fail to aspire to such voluntary initiatives may be exposed to threats pertaining to operational productivity, environmental compliance, access to finance, reputational damages or increased scrutiny from advocacy groups (Adler et al., 2017; Addison and Bull, 2018).

Whiteman et al. (2013) point out the need for more studies on corporate responses to biodiversity impacts, emphasizing on sector-specific perspectives as well as regional outlooks. In this context, corporate biodiversity accounting and reporting seeks to capture information relevant to biodiversity management by employing a certain set of comprehensive, valid and credible quantitative as well as qualitative indicators (Pintér et al., 2012). Such set can demonstrate a monitoring mechanism describing trends in biodiversity over time, geographical areas critical for conservation along plans, programs and actions in place that endorse species richness, efficient ecosystem management and minimization of related threats from business operations (Singh et al., 2007; Singh et al., 2009; Dočekalová and Kocmanová, 2016). Meaningful accountability of corporate impacts to biodiversity has been identified as a key parameter to confront environmental degradation (TEEB, 2010). Through time-bound, specific and measurable indicators business entities are increasingly becoming engaged in goals pertaining to 'net positive impact' or 'no net loss' on biological diversity[1]. Public disclosure of commitments, actions and actual performance through corporate biodiversity accounting and reporting is a key components of organizational legitimacy and stewardship as it potentially reflects a strong identification signal of

[1] According to BBOP (2012), no net loss reflects an overarching target "for a development project in which the impacts on biodiversity caused by the project are balanced or outweighed by measures taken to avoid and minimize the project's impacts, to undertake on-site rehabilitation/restoration, and finally to offset the residual impacts, so that no overall biodiversity loss results. Where the gain exceeds the loss, the term "net gain" [or net positive impact] may be used instead of no net loss'. Where offsets are required, these approaches are also sometimes referred to as 'compensatory mitigation'".

biodiversity as a material issue (Boiral, 2016; Addison et al., 2018). Miller and Power (2013) characterize accountability for biodiversity as a 'productive force' that goes beyond a passive recording of data and towards paradigm shifts where biodiversity impacts gain (through disclosure) increased visibility by interested parties and stimulate behavioral changes built around conservation and stewardship while being devoid from activities causing biodiversity decline (Jones, 2014).

It is therefore necessary for corporate biodiversity accounting and reporting not to be viewed as a peripheral element of organizational responsibility but as an integral part of performance appraisal requiring urgent and increased attention (Houdet et al., 2012). Jones and Solomon (2013) relevantly comment that the accounting practice "can be harnessed as an emancipatory device which can, by reporting organizations' impacts on biodiversity and their efforts to enhance and protect biodiversity, raise stakeholders' awareness of corporations' impact on wildlife and the extent to which organizations are attempting to mitigate this impact". By placing emphasis on such lines of research we can "illuminate the extent to which companies are acting as "stewards" of the earth's biodiversity" and "by accounting for biodiversity impacts, by reporting on actions taken to enhance and protect biodiversity, (…) will be spurred on to take further and more effective action to conserve, preserve and enhance the variety of species on Planet Earth" (p.670). Taking into account the nascent nature of corporate biodiversity indicators research, scholars are likely to focus initially on attempting to sketch out the extent to which organizations are currently disclosing biodiversity-related performance data and descriptive information. This will allow to assess the current practice of biodiversity indicators disclosure and give room for recommendations as a basis for more refined and comprehensive reporting (Jones and Solomon, 2013). Jones and Solomon relatively add that by "taking a global view researchers also need to establish whether current accounting for biodiversity practice is consistent across geographical regions or whether there are significant international differences according to geography" (2013, p.680).

Our paper seeks to contribute to this direction by providing a critical evaluation of what business entities in mega-diverse countries have to 'say' about biodiversity conservation and management through widely-accepted performance metrics disclosed in their sustainability reports along with underlying determinants. In line with the inventory approach, which reflects tasks of recording, monitoring and reporting aspects of natural assets (Gray et al., 1993), we assess the external reporting practices on biodiversity conservation of companies seeking to discharge their accountability as societal stewards of critical natural capital. By employing Poisson and Gaussian Bayesian regression modeling potential associations of biodiversity indicators (BIs) with national specificity, organizational size and industrial affiliation are examined. Crucially, the constructive role of corporate biodiversity accounting and reporting in communicating performance and discharging accountability towards relevant stakeholders is investigated, under the scope of an ecologically sustainable society.

The organization of the article is as follows. Section 2 outlines prior literature on organizational accounting and reporting on biodiversity management. Section 3 explains the data and methods employed. This is followed by the presentation of findings (Section 4). Section 5 reiterates the objectives of this research, discusses the range of principal findings in line with earlier studies and concludes with some reflective comments and possible implications for mainstreaming biodiversity accounting and reporting among practitioners and researchers.

2. Background

As biodiversity and ecosystems are under increasing threat (Remme et al., 2016) a pressing need of implementing conservation strategies supported by comprehensive accounting and reporting systems has emerged. The business case for biodiversity protection is nowadays strong (TEEB, 2010) and seeks to incorporate such considerations into accounting and reporting mechanisms in order to refine performance appraisal beyond short-term capital appreciation by owners of the firm. Evaluating tradeoffs of business operation and growth requires estimates of the impacts on the environment, with proxies of the value of biological diversity lost or preserved incorporated in such assessments. Moreover, mainstreaming proactive biodiversity management into economic-business planning and shared value-creation (Porter and Kramer, 2019) allows for new opportunities in reshaping competitive advantages through biodiversity-related initiatives, better risk management, cost reductions, improved stakeholder relations and/or reputational gains (Athanas, 2005).

Key point in business' engagement with the environmental stewardship agenda is management accounting and reporting of impacts beyond the financial domain (Gray and Bebbington, 2000; Spence and Gray, 2008; Gray, 2010), a practice that reflects how the organization comprehends and seeks to endorse environmental sustainability (see Gray et al. 1995 in this context). For-profit entities are accountable to their social constituents for their impacts on natural assets they own as well as environmental resources they 'hold in trust for future generations' (Gray et al., 1993). Providing material information on pressures to ecosystem functioning due to corporate activities (as well as on business growth obtained at the expense of biological diversity) enables social constituents to make informed decisions with regards to corporate performance and environmental stewardship efforts. In this respect, Macve and Carey (1992) stress that private organizations 'will be wise to ensure that appropriate information is provided to all those groups … in a position to take action, in the light of their perception of a company's environmental performance' (p. 12), under the scope of prudent management, innovation and leadership (Vinten, 1993). Theoretical underpinnings of biodiversity accounting and accountability rely on the environmental stewardship perspective that offers a "comprehensive understanding and effective management of critical environmental risks and opportunities related to (…) biodiversity protection and ecosystem services" (UN, 2010, p. 9). Under the environmental stewardship construct, business entities are accountable to society at large for protecting and contributing to environmental quality and balance. Legitimacy, accountability and stakeholder theories provide overlapping and supporting arguments for this maintenance and account-keeping of natural assets (Rubinstein, 1992; Guimaraes and Liska, 1995; Siddiqui, 2013).

Still, beyond these conceptual underpinnings, Bhattacharya and Managi (2013) comment that, since the inception of the UN Convention on Biological Diversity in 1992, little progress has been made in engaging the business community to biodiversity management. By drawing on the Fortune 500 companies these authors provide fruitful industry trends and stress that rarely is biodiversity loss addressed in company policy or tools for estimating the impact of biodiversity losses in terms of appropriate metrics. Moreover, it is those firms with direct impacts to biodiversity which are more prone to report relative action plans due to underlying organizational liabilities stemming from inaction to do so (Bhattacharya and Managi, 2013). Focusing on the sustainability reports of the 2016 Fortune 100 Global firms, Addison et al. (2018), confirm the low penetration of corporate biodiversity disclosure among large business as it is only 49% of the sample that briefly mention biodiversity and 31% that indicate clear commitments. Likewise, while a mere 5% of these firms disclose measurable and time-specific goals, none discloses quantitative outcomes, undermining the ability to evaluate whether corporate actions actually yield positive outcomes and whether they are of adequate magnitude to address impacts. In a similar vein, Adler et al. (2018) examine disclosures related to threatened species and habitats published by the world's largest multinationals comprising the Fortune Global 150 and find that less than 10% are providing relatively substantial information which, nevertheless, lack consistency in terms of indicators employed to outline performance.

By following a mixed methods approach combining descriptive content analysis of published information with qualitative data derived from business executives, Rimmel and Jonäll (2013) examine biodiversity disclosure among Swedish firms. Findings from their study indicate low penetration of such disclosures among domestic firms with those pertaining to low-risk sectors to provide comparatively more relevant information, partially explained by a non-systematic interaction with pressure groups. Additional evidence from the Nordic region are found in van Liempd and Busch (2013) who study ethical considerations linked to biodiversity accounting and accountability among the Danish large-cap companies and further confirm the low quality of reporting on aspects of biodiversity conservation which contradicts normative assumptions related to the intrinsic value of biological diversity. Evidence from South Africa (Mansoor and Maroun, 2016; Usher and Maroun, 2018) suggest that the domestic food, fishing and mining sectors are providing limited disclosures of insufficient detail leaving much to be desired, despite the fact that the country ‘boasts one of the most developed codes on corporate governance and has been advancing the preparation of integrated reports since 2010’ (Mansoor and Maroun, 2016, p. 608). Similar findings are presented for Australian metals and mining firms by Adler et al. (2017) who devise a composite biodiversity disclosure measure and observe that very few companies scored relatively high on this index, also denoting organizational size effects on the extent and completeness of disclosures. Roca and Searcy (2012) indicate that Canadian mining firms report on the location and size of land owned or adjacent to protected areas but the domestic business sector on the whole tends to disregard information provision on IUCN Red List species and national conservation list species with habitats in areas affected by organizational operations.

Supporting evidence for this claim are also found in Potdar et al. (2016) who focus on a diverse set of geographical locations and industries, following a descriptive analysis of BIs reported. These authors highlight that the most frequently-reported indicator refers to the identification of significant business impacts on biodiversity in protected areas and areas of high biodiversity value outside protected areas, along with the description of restorative strategies/actions for managing biodiversity impacts and the characterization of land owned adjacent to areas of high biodiversity value. Ketola (2009) denotes that forest companies tend to react mainly to external pressures related to biodiversity aspects and to retain a minimum legal compliance stance which gives room to severe criticism from NGOs and other stakeholder groups. Similarly, Lähtinen et al. (2016) investigate how leading companies of the global forest industry address biodiversity and ecosystem services in supply chain management through sustainability reporting and in reference to relevant performance indicators. Their findings denote that forest companies tend to disclose indirect biodiversity and ecosystem impacts over direct ones, seek to highlight positive organizational achievements over negative outcomes and emphasize in upstream activities of the supply chain rather than in aspects of downstream activities. Boiral and Heras-Saizarbitoria (2017) analyze how mining and forestry companies manage biodiversity issues through stakeholder involvement. Their study sheds light on underlying motives for such engagement, the nature of stakeholder groups involved in such actions and the measures in place for biodiversity conservation. Boiral (2016) investigates the rhetoric mining organizations demonstrate with regards to biodiversity protection and the legitimization techniques employed in the context of stakeholder impression management. The study reveals that mining firms opt for four main approaches in discharging their accountability for biodiversity: claims of a net neutral or positive impact on biodiversity, denial of having significant impact, distancing themselves from the impact of their operation or they attempt to dilute their responsibilities. Rainey et al. (2015) review corporate publicly disclosed biodiversity goals of ‘no net loss’ or ‘net positive impact’ and find wide variation in the detail and disclosure quality of published goals with mining companies leading the pace which is partially explained by the industry’s high profile impacts, its increased subscription to best-practice bodies and the higher profit margins per area of impact.

Overall, there is an emerging wave of evidence indicating whether or how organizations of the private sector are endorsing the mitigation of biodiversity loss and how they report their respective planning and performance (Metcalfe and Vorhies 2010). Nevertheless, current understanding of how business entities contribute to ecological processes, including biodiversity, can be characterized as limited and fragmentary (Sharma and Nguan, 1999; Westley and Vredenburg, 1997; Whiteman et al., 2013) with very few notable exemptions in terms of quantitative assessments (Lin and Buongiorno, 1998; Meester et al., 2004; Gallego-Álvarez and Vicente-Villardón, 2012). In sum, previous research on organizational nonfinancial reporting suggests that BIs are rarely reported compared to other measures of environmental responsibility (e.g. see Yongvanich and Guthrie, 2007; Sawani et al., 2010; Mazzi et al., 2012; Roca and Searcy, 2012; Romolini et al., 2014; Mäkelä, 2017). This is further supported by international organizations such as WEF which relevantly reports that it is only 27% of the companies at a global scale which are concerned about biodiversity decline of and its potential effects on business performance, partially explained by the particularly ‘slow’ impacts of biodiversity loss on business operations (WEF, 2010). A recent wave of insightful frameworks set forth by Atkins et al. (2018), Atkins and Maroun (2018) as well as Maroun and Atkins (2018) draw upon the concept of extinction accounting and stress the expansion of organizational accountability for species under threat of extinction while offering potentially practical tools for institutional investors and NGO engagement with for-profit entities. Drawing on the unsystematic, inconsistent and piecemeal practice of corporate biodiversity indicators reporting, Dey and Russell (2014) pinpoint that “organization-centred disclosures may perpetuate, rather than reform, unsustainable organizational and societal behavior” (p. 245). Moreover, despite the aforementioned attempts for descriptive analysis of corporate accountability to biodiversity, there has not been a single study exploring the potential of operationalizing corporate accountability in the context of multiple mega-diverse countries.

3. Material and methods

3.1. Sample identification

Corporate biodiversity accountability is examined for the business sectors of Bolivia, Brazil, Colombia, China, India, Indonesia, Malaysia and the Philippines, all regarded as mega-diverse countries. Mega-diverse countries harbor the majority of the planet’s species and are therefore considered extremely rich in biological diversity (60–70% of the world’s biodiversity). These countries have effectively joined efforts in promoting common interests and strategic priorities on preservation and sustainable use of biological diversity. They have been actively engaged in negotiating the development of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits arising from their utilization to the Convention on Biological Diversity (CBD), adopted in Japan in 2010. In this context, one can expect that the domestic business sector in these countries maintains a considerable impact on local biodiversity and/or encounter high stakeholder pressures, demands or expectations for accountability on how they contribute to these aspects of (national) natural capital conservation.

A desk search was performed between September and December 2017 in order to gather the available sustainability reports published in English. We relied on the GRI database (database.globalreporting.org/) where organizations are invited to submit their integrated/sustainability reports and actively promote their accountability efforts towards a broad range of interested parties and stakeholder groups. We focused on the reports published by these firms in 2017 (i.e. referring to performance achievements of the previous year). In cases where these were not available, the most recent report was included in the assessment (i.e. from the 2015–2016 reporting cycles). Only those reports prepared by domestic companies or those that provided information and data on the company’s

Table 1
Countries and number of companies comprising the sample.

Country	Number of companies
Bolivia	1
Brazil	18
Colombia	6
China	3
India	91
Indonesia	40
Malaysia	17
Philippines	6

Table 2
Distribution of business sectors comprising the sample.

Business sector	Number of companies
Consumer Discretionary	28
Consumer Staples	19
Energy	24
Health Care	10
Industrials	23
Information Technology	4
Materials	56
Utilities	18

Note
Industry classification relies on the Global Industry Classification Standard (GICS).

Table 3
Distribution of companies according to their size.

Organizational size	Number of companies
Multinational enterprise	38
Large company	138
Small and medium-sized enterprise	6

operations in the aforementioned countries were considered. In this regard, multinational corporations with operations in any of the sample countries were excluded if they only published a global-level corporate report that included no breakdown of information at the country level. This task of data gathering focused only on stand-alone reports and excluded cross-references to other corporate communications material and/or online information available on the corporate websites. Only in the case where links to specific webpages or other publicly-available relevant data-information about the organization assessed were available, these were then included in the assessment. This resulted in 182 reports from companies established in mega-diverse regions, broken down by country and business activity in Tables 1–3.

In order to assess the comprehensiveness of information disclosed, a composite index was devised in line with previous applied rating schemes found in the literature (e.g. Skouloudis et al., 2013; Evangelinos et al., 2016; Halkos and Skouloudis, 2016). This measure was derived from the disclosure requirements of the Global Reporting Initiative (GRI) G4 guidelines specifically referring to biodiversity management and conservation measures. These GRI biodiversity indicators, rated on a 5-point scale, are outlined in Table 4, while the rationale describing the applied generic scoring scheme is presented in Table 5. Based on the defined indicators-criteria the proposed composite biodiversity disclosure index (BDI) was constructed as follows:

$$BDI_{(i)} = \sum_{j=0}^{5} t_j \quad (1)$$

where t_j equals to zero for non-disclosure, 1 if the organization i discloses vague statements on the jth topic, 2 if it provides relevant but very brief information/data, 3 if the disclosure is comprehensive and 4 if reported data-information fully conforms to the prerequisites of the GRI implementation manual for indicator compilation and disclosure. This evaluation approach results to a maximum score of 20 points. These disclosure scores are expressed in percentages in the following section. Scoring of biodiversity indicators was undertaken independently by the lead and the second author. Discrepancies or inconsistencies between the two sets of coding were reconciled by the two coders to ensure inter-coder consensus between scores, in line with previous methodological schemes (Boiral and Heras-Saizarbitoria 2017; Addison et al., 2018). The final coding was randomly checked by an independent researcher with significant experience in quantitative content analysis methods to enhance the generated data's reliability (Milne and Adler, 1999).

3.2. Linking biodiversity indicators disclosures with organizational characteristics Bayesian Poisson regression modeling

Contributing to the biodiversity disclosure literature we examine potential associations between the BIs and the explanatory variables of size, country of origin and industry affiliation (Tables 1–3) through the fit of suitable Poisson and Gaussian regression models, following the Bayesian paradigm. Among the advantages offered by Bayesian methods is that they permit model flexibility and inference is exact for any sample, regardless of its size (see e.g. Bernardo, 2003). Relying on the nature of the data collected, we opted for models that assume the grading of BIs to follow distributions suitable for discrete count data, such as the Poisson and the ordered logit (OL). Through the Poisson regression modeling, the dependent variable data is assumed to be the outcome of a Poisson random variable, with a log-mean parameter that is a linear function of the vector of independent covariates. In this respect, continuous sampling distributions for modeling the biodiversity indicator variables (i.e. DMA_Bio, EN11, EN12, EN13 and EN14) are not utilized due to the well-documented issues arising when using continuous sampling distributions for datasets consisting of point observations (see Fernandez and Steel, 1998 for more on this critical problem). Linear modeling is unsuitable for non-normal responses (such as the gathered data for the current analysis) since it relies on assumptions pertaining to Gaussian distribution. Our response variables refer to either one of the BIs. Due to the similarity of the likelihood functions between assuming multinomial and Poisson distributions fitting our models using a multinomial regression model was not pursued as it was expected to obtain similar parameter estimates as with the Poisson-response logistic regression model.

Additionally, the data used in the analysis demonstrate a panel structure, since outcomes from various reporting entities can be processed under a country-specific scope. Panel data analysis requires taking account of the panel specific structure of collected observations for each country. In order to investigate the potential effects of these nested associations we have additionally attempt to model the data taking into consideration the panel data structure. However, fitting the Poisson models in a panel data framework did not produce improved goodness-of-fit or parameter estimates, hence, the results of the non-hierarchical Poisson regression models are present here.

Along with the fit of the Poisson regression models for the individual BIs we examine the effects of explanatory variables on the aggregated variable, comprising of the sum of scores on all the BIs. For the aggregate Biodiversity Disclosure Index, the Gaussian distribution has been utilized for the link of the latter with the independent variables of size, country of origin and business sector.

More specifically, y_{ij} denotes the *i–th* company response of the *j–th* dependent variable ($i = 1,2,\ldots,182;\ j = 1,2,\ldots,16$) and $\mathbf{X}^T$ denotes the

Table 4
The indicators comprising the composite BDI index.

GRI-G4 indicator	Description
DMA-bio	Description of the organization's management approach/strategy for achieving its policy on biodiversity management. Disclosure of integration of biodiversity considerations in analytical tools applied by the organization, such as environmental site impact assessments.
EN11	Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas. Report the following information for each operational site owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas: • Geographic location • Subsurface and underground land that may be owned, leased, or managed by the organization • Position in relation to the protected area (in the area, adjacent to, or containing portions of the protected area) or the high • biodiversity value area outside protected areas • Type of operation (office, manufacturing or production, or extractive) • Size of operational site in km • Biodiversity value characterized by • (a) The attribute of the protected area or high biodiversity value area outside the protected area (terrestrial, freshwater, or maritime ecosystem), and/or (b) Listing of protected status (such as IUCN Protected Area Management Categories, Ramsar Convention, national legislation)
EN12	Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas. Report the nature of significant direct and indirect impacts on biodiversity with reference to one or more of the following: • Construction or use of manufacturing plants, mines, and transport infrastructure • Pollution (introduction of substances that do not naturally occur in the habitat from point and non-point sources) • Introduction of invasive species, pests, and pathogens • Reduction of species • Habitat conversion • Changes in ecological processes outside the natural range of variation (such as salinity or changes in groundwater level) Report significant direct and indirect positive and negative impacts with reference to the following: • Species affected • Extent of areas impacted • Duration of impacts • Reversibility or irreversibility of the impacts
EN13	Habitats protected or restored. Report the size and location of all habitat protected areas or restored areas, and whether the success of the restoration measure was or is approved by independent external professionals. Report whether partnerships exist with third parties to protect or restore habitat areas distinct from where the organization has overseen and implemented restoration or protection measures. Report on the status of each area based on its condition at the close of the reporting period. Report standards, methodologies, and assumptions used.
EN14	Total number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk. Report the total number of IUCN Red List species and national conservation list species with habitats in areas affected by the operations of the organization, by level of extinction risk, i.e. Critically endangered, Endangered, Vulnerable, Near threatened or Least concern

(17 × 182) matrix comprising of the values of the independent variables, which comprise of the categories of the discrete factors of [COUNTRY], [SIZE] and [SECTOR], plus a constant column of 1′s for the intercept. In particular, for assessing the [COUNTRY] effects on the dependents, "India" has been set as the reference category. "Large companies" are the reference category for the covariate of [SIZE], whereas for assessing industry effects, the "Materials" sector has been set as reference.

In view of the above, following the Bayesian paradigm (Chib, 2008), a Poisson data regression-type model of the following form is utilized:

$$y_{ij} \sim Poisson(\lambda_{ij})$$

$$\begin{aligned}\log(\lambda_{ij}) = \mathbf{X}^t\cdot\boldsymbol{\beta} = {} & \beta_0 + \beta_1\cdot[Indonesia] + \beta_2\cdot[Bolivia] + \beta_3\cdot[Brazil] \\ & + \beta_4\cdot[Malaysia] + \beta_5\cdot[Colombia] + \beta_6\cdot[Philippines] \\ & + \beta_7\cdot[China] + \beta_8\cdot[MNC] + \beta_9\cdot[SME] \\ & + \beta_{10}\cdot[Consumer\ Discretionary] + \beta_{11}\cdot[Energy] \\ & + +\beta_{12}\cdot[Industrials] + \beta_{13}\cdot[Consumer\ Staples] + \beta_{14}\cdot[Utilities] \\ & + \beta_{15}\cdot[Health\ Care] + \beta_{16}\cdot[Information\ Technology]\end{aligned} \quad (2)$$

where λ_{ij} indicates the parameter of the Poisson distribution and $\boldsymbol{\beta} = (\beta_0, \beta_1, ...,\beta_j)^t$ is the vector including the intercept (β_0) and the regression coefficients of the different categories of predictors excluding the reference categories ($j = 16$).

As regards to the most important procedure of the selection of the

Table 5
The rating qualification scheme.

Score	Rating qualifications/requirements
0	The report does not include any information relevant to the specific GRI topic/indicator. No coverage.
1	The report provides generic or brief statements, without specific information on the organisations approach to the topic/indicator.
2	The report includes valuable information on the topic/indicator but there are still major gaps in coverage. The organisation identifies the assessed issue, but fails to present it sufficiently.
3	The provided information is adequate and clear. It is evident that the reporting organisation has developed the necessary systems and processes for data collection on the assessed topic/indicator and attempts to present it in a consistent manner.
4	Coverage of the specific issue can be characterised as "full" in the report. It provides the organisation's policy, procedures/programs and relevant monitoring results for addressing the issue. The organisation meets the GRI OHS-specific requirements, allowing comparison with other organisations.

Table 6
Descriptive statistics (mean and standard deviation) of the sample of BIs (standard deviations in the parentheses).

	DMA_Bio	EN11	EN12	EN13	EN14	BDI
Aggregated results	1.23 (1.61)	1.02 (1.5)	0.93 (1.37)	1.24 (1.59)	0.8 (1.35)	5.21 (6.1)
SIZE						
Large	1.28 (1.64)	1.14 (1.53)	0.94 (1.37)	1.26 (1.59)	0.86 (1.38)	5.49 (6.16)
MNC	1.13 (1.49)	0.58 (1.31)	1.03 (1.48)	1.29 (1.69)	0.63 (1.30)	4.66 (6.10)
SME	0.67 (1.63)	1.00 (1.67)	0.00 (0.00)	0.50 1.22)	0.33 (0.82)	2.50 (4.46)
COUNTRY						
India	0.77 (1.37)	0.64 (1.27)	0.60 (1.17)	0.78 (1.35)	0.35 (0.91)	3.14 (5.04)
Indonesia	1.25 (1.60)	1.40 (1.60)	0.93 (1.35)	1.65 (1.61)	1.38 (1.48)	6.60 (5.94)
Bolivia	2.22 (1.66)	1.72 (1.84)	1.83 (1.38)	1.61 (1.88)	1.11 (1.68)	8.50 (6.29)
Brazil	2.00 (1.80)	0.94 (1.29)	1.24 (0.68)	1.82 (1.74)	0.76 (1.48)	6.76 (6.54)
Malaysia	3.00 (0.89)	1.67 (0.86)	2.17 (1.47)	2.83 (0.98)	2.17 (1.83)	11.83 (5.11)
Colombia	1.17 (1.83)	2.00 (1.89)	1.17 (1.83)	1.33 (2.07)	1.50 (1.76)	7.17 (8.70)
Philippines	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
China	4.00 (0.00)	3.00 (0.00)	3.00 (0.00)	4.00 (0.00)	3.00 (0.00)	17.00 (0.00)
SECTOR						
Materials	1.71 (1.67)	1.27 (1.58)	1.32 (1.42)	1.66 (1.61)	1.05 (1.49)	7.02 (6.17)
Consumer Discretionary	0.61 (1.37)	0.96 (1.59)	0.39 (1.07)	0.61 (1.34)	0.68 (1.16)	3.25 (5.58)
Energy	1.17 (1.61)	1.08 (1.56)	1.00 (1.53)	1.33 (1.61)	0.75 (1.29)	5.33 (6.00)
Industrials	1.04 (1.49)	1.00 (1.35)	0.74 (1.25)	0.87 (1.46)	0.65 (1.26)	4.30 (5.21)
Consumer staples	1.42 (1.83)	0.63 (1.30)	1.05 (1.51)	1.26 (1.73)	0.89 (1.60)	5.26 (6.63)
Utilities	1.39 (1.61)	1.39 (1.75)	1.28 (1.53)	1.83 (1.72)	0.83 (1.46)	6.72 (7.19)
Health care	0.30 (0.95)	0.20 (0.63)	0.00 (0.00)	0.40 (1.26)	0.20 (0.63)	1.10 (3.48)
Information technology	0.75 (1.50)	0.00 (0.00)	0.00 (0.00)	0.75 (1.50)	0.00 (0.00)	1.50 (3.00)

statistical significant covariates, a hyper *g*-prior approach is utilized for variable selection by using the most common family of prior distributions for Bayesian variable selection, i.e. the Zellner's *g*-prior (Zellner, 1986; Zellner and Siow, 1980). This approach performs well under various cases and datasets (see e.g. Malesios et al., 2017; Ley and Steel, 2012).

The selected Bayesian variable selection framework involves the introduction of a vector of binary indicators, $\gamma = (\gamma_0, \gamma_1, \ldots, \gamma_{16})^t$, acting as inclusion probabilities for each one of the covariates to be included in the model (i.e. γ_i taking the value 0 or 1 if coefficient β_i is small or large, respectively). In this way, for instance, for the *j*-th covariate X_j, if $\gamma_j = 1$ then X_j is proposed to be included in the set of predictor variables, whereas if $\gamma_j = 0$, then X_j is excluded. The Markov chain Monte Carlo (MCMC) methodology can be then employed to estimate the posterior distribution of γ's. Concerning the prior specification of model indicators γ, we use the uniform prior with $\gamma_j \sim Bernoulli(0.5)$.

Specifically, Zellner's *g*-prior is defined by specifying the set of **β** parameters of the examined covariates as:

$$\boldsymbol{\beta}_\gamma | g, \varphi \sim N\left(0, \frac{g}{\varphi}(\mathbf{X}_\gamma^t \mathbf{X}_\gamma)^{-1}\right), \tag{3}$$

where γ denotes the set of variable selection indicators described, and ϕ signifies the precision parameter (i.e. inverse of variance). Hyperparameter *g* acts as an inverse relative prior sample size, hence its influence on the results is quite strong. Many suggestions have been presented in the literature on the selection of *g*. We utilize the unit root prior of Kass and Wasserman (1995), that assigns $g = n$ (unit information prior) and *n* denotes the sample size of the data.

Upon selecting the most important covariates through the variable selection scheme, we subsequently fit the models with selected covariates to derive the parameter estimates assigning suitable prior distributions to the β_i parameters of chosen covariates. The parameters are assumed following a Gaussian distribution, $\beta_i \sim N(\mu_i, \sigma^2)$ where σ^2 demonstrates an inverse Gamma distribution, with $1/\sigma^2 \sim Gamma(10^{-3}, 10^{-3})$.

To assess the predictive accuracy of the Bayesian Poisson models, posterior predictive model is employed for checking and comparing replicated data constructed under the fitted models with the observed data. Hence, simulated values $y_i^{rep} (i = 1, 2, \ldots 182)$ from the six dependent count variables are drawn from the posterior predictive distribution of replicated data through:

$$y_i^{rep} \sim Poisson(\lambda_i), \tag{4}$$

The latter are compared to the observed data y_i, with similar values between y_i and y_i^{rep} indicating a good fit.

WinBUGS (Lunn et al., 2000) software was used for fitting the Bayesian models. Model selection was performed using the Deviance Information Criterion (DIC) (Spiegelhalter et al., 2002), where models with smaller DIC value are better supported by the data. The posterior results for the models' parameters have been obtained by using 5000 iterations as initial burn-in period and an additional sample of 50,000 iterations, with a thinning of 10 iterations to avoid possible autocorrelations.

4. Findings

In this section, the findings from the fit of the six Bayesian Poisson regression models are presented. Specifically, in the following subsection a preliminary descriptive analysis is presented. Next sub-section 4.2 includes the posterior inclusion probabilities results as obtained by the application of the Zellner's *g*-prior approach. Upon selecting the statistically significant covariates through the *g*-prior approach, in the next sub-section 4.3 the posterior median parameter estimates are presented for the final selected models. In the final sub-section 4.4, the results of the goodness-of-fit analysis for the fitted models are presented.

4.1. Descriptive analysis

The descriptive statistics for the five BIs and the aggregate index are presented in Table 6. Specifically, means and standard deviations of the sample of BIs for the complete data are included and broken down by size, country and business activity. Likewise, Figs. 1–4 provide a visual representation of the above descriptive variables for the five BIs (the aggregate index is not included due to considerable variations in the scales in comparison to the individual BIs).

According to the average levels of samples of GRI BIs, the EN13 and DMA_Bio indicators have the highest scores among the 182 companies (overall average score: 1.24 and 1.23, respectively). The lowest score is

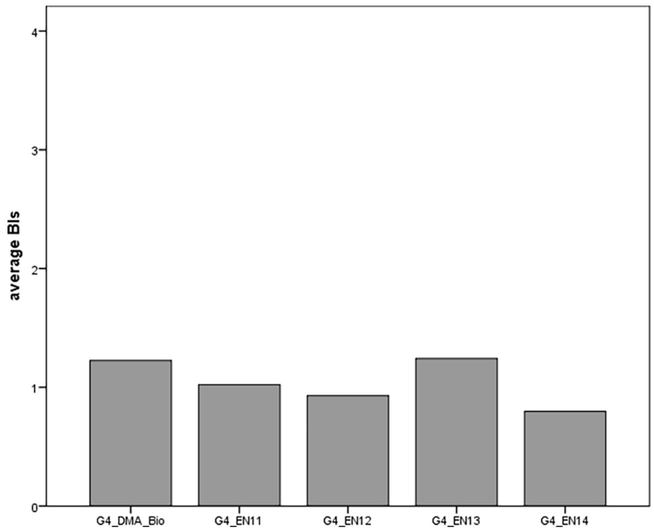

Fig. 1. Average BI scores for the complete data.

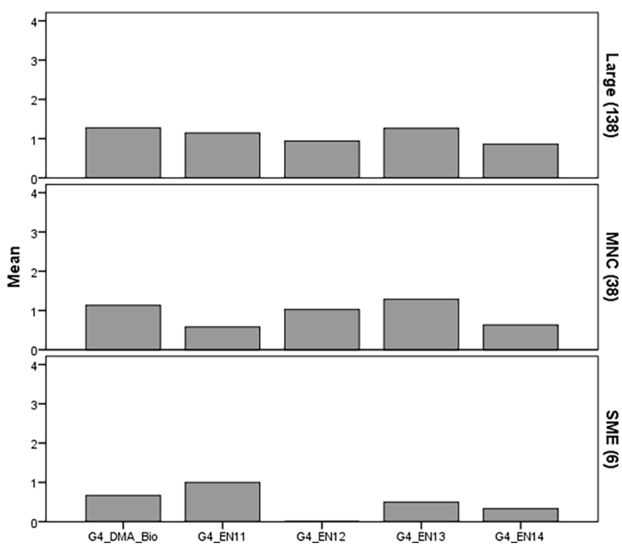

Fig. 2. Average BI scores by size of the enterprises.

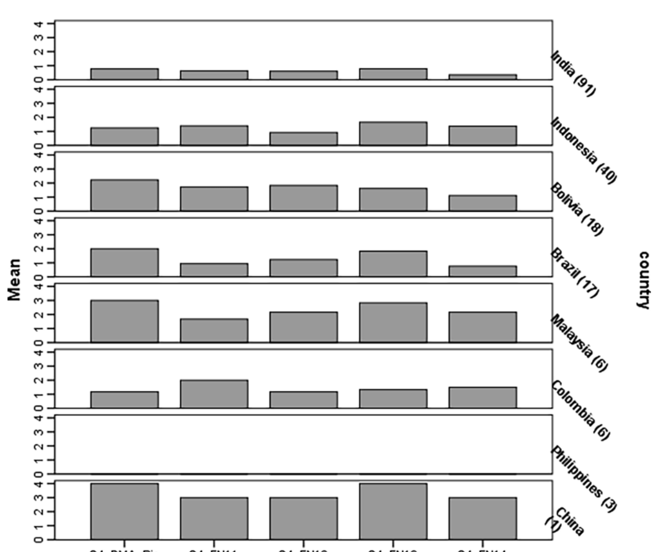

Fig. 3. Average BIs by country.

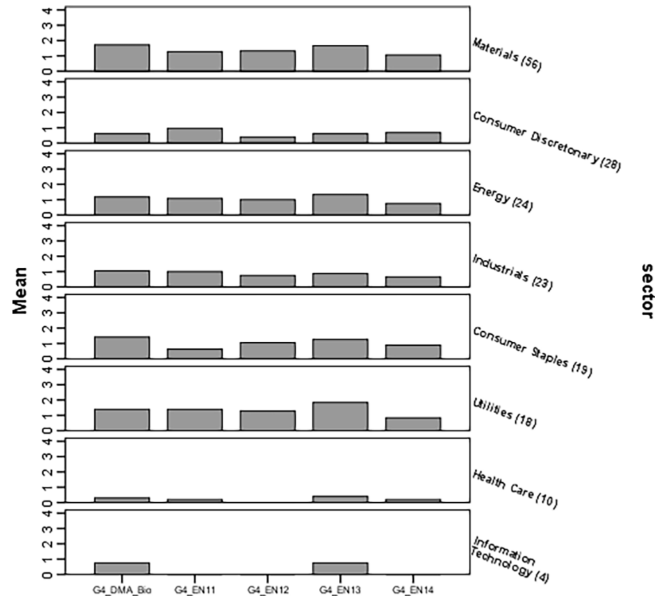

Fig. 4. Average BIs by sector.

observed for the EN14 indicator (average score: 0.8). These overall results, however, differentiate by sector, country of origin or size of companies in the sample. Large companies, pertaining to the Materials industry are found to be more actively engaged in BI disclosure, followed by those of the Utilities sector. Likewise, Malaysian and Bolivian firms provided more comprehensive information on biodiversity management, yet sample size is too small to consider the results other than indicative. The BI most frequently reported is EN13 referring to habitats protected or restored along with the management approach of the reporting entity to biodiversity conservation (DMA_Bio). In relation to the integration of biodiversity considerations in analytical tools applied by the organization, such as environmental site impact assessments, it is less than ten reports in our sample that include information relating to the costs of biodiversity protection programmes or restoration activities; most of the companies tend to disclose brief statements of support/funding to external initiatives or multi-stakeholder partnerships but do not specify outlays.

4.2. Covariate selection for the Bayesian Poisson models

Table 7 presents the posterior selection probabilities, γ_i ($i = 0, 1, 2, \ldots, 16$), for the set of predictors included in the six Poisson models. Inclusion probabilities are also shown for the intercept. Using a threshold value of 0.5, we include in the selected models the covariates that exceed this threshold (highlighted in bold in Table 7). The preliminary results of Table 7 suggest that not all the variables under consideration, are to be included in the final model. Findings also suggest that there are significant differences among the various models, indicating that there are significant variations among the BIs as regards the effect of selected covariates on them.

The covariate selection results indicate that most important factor for the BIs is the country of origin of the reporting entities. Organizational size does not seem to be a significant predictor, apart from the case of biodiversity indicator EN12. Lastly, the Health Care industry is found to be the most important sector for explaining the variability of indicators as regards the business activities comprising the sample.

The country and industry effects are much more pronounced when considering the composite indicator BDI, with most of the corresponding covariates being included in the final selected model.

Table 7
Posterior selection probabilities (γ) for the Poisson regression models (covariates with γ > 0.5 are selected for inclusion in the final selected models).

Covariate	DMA_Bio	EN11	EN12	EN13	EN14	BDI
Intercept(γ_0)	0.037	0.045	0.027	0.214	**0.998**	**1.000**
Country (ref. category: India)						
Indonesia(γ_1)	0.109	**0.622**	0.028	**0.841**	**0.999**	**1.000**
Bolivia(γ_2)	**0.995**	**0.609**	**0.913**	0.268	**0.748**	**1.000**
Brazil(γ_3)	**0.927**	0.031	0.054	**0.619**	0.197	**1.000**
Malaysia(γ_4)	**0.972**	0.160	0.279	**0.788**	**0.986**	**1.000**
Colombia(γ_5)	0.030	0.176	0.032	0.034	**0.592**	**0.916**
Philippines(γ_6)	**0.885**	**0.896**	**0.851**	**0.890**	**0.669**	**1.000**
China(γ_7)	0.167	0.064	0.062	0.152	0.272	**0.996**
Size (ref. category: Large)						
MNC(γ_8)	0.042	0.428	0.084	0.037	0.083	0.020
SME(γ_9)	0.067	0.030	**0.979**	0.092	0.069	0.104
Sector (ref. category: Materials)						
Consumer discretionary(γ_{10})	0.334	0.028	**0.920**	**0.540**	0.047	**0.815**
Energy(γ_{11})	0.040	0.030	0.029	0.041	0.234	**0.858**
Industrials(γ_{12})	0.065	0.033	0.125	0.327	0.062	**0.983**
Consumer staples(γ_{13})	0.026	0.208	0.029	0.033	0.040	0.381
Utilities(γ_{14})	0.029	0.042	0.029	0.138	0.052	0.053
Health care(γ_{15})	**0.613**	**0.809**	**0.999**	**0.601**	0.429	**1.000**
Information technology(γ_{16})	0.057	**0.965**	**0.966**	0.070	**0.899**	**0.999**

4.3. Parameter estimates for the Bayesian Poisson models

In this section the results of the fitted models presented, as were obtained after the covariate selection procedure of the previous subsection. Hence, Table 8 includes the posterior median parameter estimates ($\hat{\beta}$) of the most significant covariates in all six fitted models. Disclosure of management approach (DMA_Bio) is higher for enterprises operating in Bolivia, Brazil and Malaysia in comparison to their Indian counterparts ($\beta_2 = 0.749$, $\beta_3 = 0.685$ and $\beta_4 = 1.083$, respectively). Much lower values of the DMA_Bio are observed for the enterprises from Philippines ($\beta_6 = -22.48$, $p-value < 0.05$), whereas enterprises in India, Indonesia, Colombia and China are of similar DMA_Bio disclosure levels.

Organizational size and industry affiliation do not seem to play an important role in the differentiation in the levels of DMA_Bio disclosure, apart from the sample reporting entities pertaining to the Health Care sector, which seems to demonstrate lower levels of DMA_Bio disclosure when compared to the other business sector categories ($\beta_{15} = -1.308$, $p-value < 0.05$). Similar results are also observed for the disclosure of G4-EN11. Lower disclosure levels are found for the Malaysian enterprises in comparison to the DMA_Bio results. Likewise, Health Care ($\beta_{15} = -1.789$, $p-value < 0.05$) and Information Technology ($\beta_{16} = -22.45$, $p-value < 0.05$) industries are those with lowest levels of EN11 disclosure. Disclosure of EN12 indicator exhibits a more uniform pattern with regards to the country of origin. It is only the Bolivian and the Philippines's reporting entities demonstrate the highest ($\beta_2 = 0.636$, $p-value < 0.05$) and the lowest ($\beta_6 = -22.42$, $p-value < 0.05$) disclosure levels of EN12 indicator compared to the other countries. However, the specific biodiversity indicator is found to have size-effects, as SMEs demonstrate the lowest disclosure levels ($\beta_9 = -22.62$, $p-value < 0.05$) compared to large and multinational enterprises.

Variations are also evident when considering the business activity, with enterprises of the Consumer Discretionary, Health Care and Information Technology sectors having the lowest levels of EN12 disclosure.

Analysis of EN13 reveals that enterprises from Indonesia, Brazil and Malaysia share high disclosure scores in comparison to reporting entities from India, Bolivia, Colombia and China. The lowest disclosure levels are observed for the enterprises from the Philippines, while

Table 8
Median parameter estimates (β_i) for the final selected Poisson models and 95% credible intervals. In the last line the Deviance Information Criterion (DIC) for comparison of model fit is presented.

Covariate	DMA_Bio	EN11	EN12	EN13	EN14	BDI
Intercept	−0.003 (−0.181, 0.166)	−0.123 (−0.329, 0.067)	0.052 (−0.129, 0.222)	0.118 (−0.085, 0.309)	−0.799 (−1.096, −0.532)	1.404 (1.269, 1.537)
Country (ref. category: India)						
Indonesia	n.s.	n.s.	n.s.	0.449 (0.139, 0.758)	1.137 (0.751, 1.528)	0.725 (0.552, 0.897)
Bolivia	0.794 (0.428, 1.141)	0.521 (0.188, 0.846)	0.636 (0.24, 1.005)	n.s.	0.888 (0.347, 1.401)	0.811 (0.604, 1.011)
Brazil	0.685 (0.291, 1.056)	0.655 (0.238, 1.047)	n.s.	0.473 (0.049, 0.859)	n.s.	0.812 (0.593, 1.027)
Malaysia	1.083 (0.555, 1.551)	n.s.	n.s.	0.901 (0.351, 1.394)	1.547 (0.882, 2.134)	1.218 (0.939, 1.487)
Colombia	n.s.	n.s.	n.s.	n.s.	1.168 (0.365, 1.84)	0.662 (0.321, 0.974)
Philippines	−22.48 (−71.25, −2.319)	−22.28 (−70.7, −2.232)	−22.42 (−71.44, −2.258)	−22.3 (−71.47, −2.32)	−21.81 (−71.27, −2.308)	−23.22 (−71.85, −3.638)
China	n.s.	n.s.	n.s.	n.s.	n.s.	1.41 (0.869, 1.876)
Size (ref. category: Large)						
MNC	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
SME	n.s.	n.s.	−22.62 (−71.64, −2.868)	n.s.	n.s.	n.s.
Sector (ref. category: Materials)						
Consumer Discretionary	n.s.	n.s.	−0.939 (−1.628, −0.638)	−0.664 (−1.21, −0.185)	n.s.	−0.376 (−0.611, −0.150)
Energy	n.s.	n.s.	n.s.	n.s.	n.s.	−0.348 (−0.546, −0.151)
Industrials	n.s.	n.s.	n.s.	n.s.	n.s.	−0.455 (−0.677, −0.245)
Consumer staples	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Utilities	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Health care	−1.308 (−2.79, −0.306)	−1.789 (−3.729, −0.568)	−22.99 (−71.22, −3.468)	−1.23 (−2.45, −0.345)	n.s.	−1.532 (−2.204, −0.979)
Information technology	n.s.	−22.45 (−71.34, −2.666)	−22.63 (−71.17, −2.697)	n.s.	−22.25 (−71.27, −2.308)	−1.509 (−2.472, −0.783)
DIC	602.18	562.63	493.71	609.31	478.95	1579.8

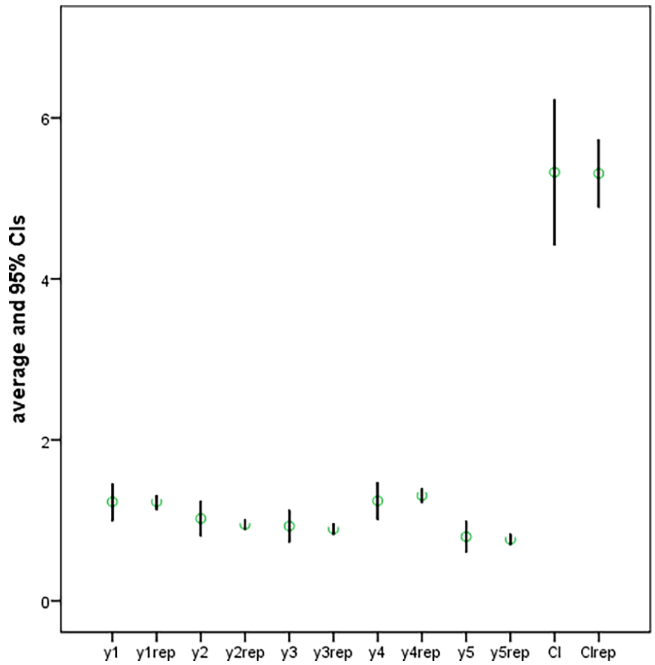

Fig. 5. Goodness-of-fit through the comparison of posterior and observed means for the dependent variables.

enterprises of the Consumer Discretionary and Health Care sectors demonstrate comparatively lower levels of EN13 reporting. Similar results are also found for the EN14 indicator, with higher levels of disclosure observed for Indonesian, Bolivian, Malaysian and Colombian enterprises, while IT companies tend to disclose EN14 less than the other industries are describing in the sample.

Finally, the effects of covariates on the composite BDI indicator indicate a classification of the countries into two distinct groups: those performing better in the composite index (i.e. Indonesia, Bolivia, Brazil, Malaysia, Colombia and China) in comparison to the countries with low BDI scores (i.e. the Philippines and India). Size effects are found to be negligible on the composite index, whereas, based on the industry categorization, higher disclosure levels of the BDI are found for the enterprises of the Materials, Consumer Staples and Utilities industries.

4.4. Fit of the Poisson models

Posterior predictive model checking is performed by the visual comparison of the posterior means and 95% corresponding credible intervals of the estimates derived from the McMC simulations in comparison with the observed means and the estimates of the 95% credible intervals, calculated based on assumed binomial variation. The results are shown in the following graph (Fig. 5).

Overall, it is evident that the fit of all models is good since sample and predicted values are in agreement, with the estimated means being less variable in comparison to the observed proportions.

5. Discussion and concluding remarks

This study sought to provide an analysis of reporting trends of biodiversity indicators disclosed in the stand-alone sustainability reports of companies operating in mega-diverse countries. Our assessment relied on 182 reports gathered from the GRI database and a composite disclosure index was devised to investigate the comprehensiveness of reported performance on biodiversity management and conservation. In summary, key findings are as follows. Most important predictors of biodiversity disclosure of businesses are the spatial characteristics (i.e. country effects), followed by the industry affiliation of the organizations. On the other hand, organizational size does not seem to have a significant effect on the disclosure of biodiversity indicators. In particular, Brazilian, Bolivian and Malaysian enterprises exhibit the highest levels in most BIs, whereas the lowest levels were observed for Philippines. In terms of differences according to the business sector the sample reporters pertain to, it has been found that the highest levels in BIs are present for the materials, energy, industrials, consumer staples and utilities sectors. The lowest levels, on the other hand, are observed for the health care and information technology sectors. Considerable variation among companies, sectors, countries as well as individual indicators is evident. The frequency analysis derived from the study suggests that BIs as part of the management accounting system of a firm are still underreported and mostly confined to generic and/or vague statements with quantitative data and narratives on managing biodiversity being sporadic and limited. Released information is too vague to speculate on its usefulness, dominated by qualitative narratives of biodiversity planning, with relevant quantitative data as metrics of actual achievements leaving much to be desired. Rather disconnected from real impact assessment, corporate accountability for biodiversity is in many cases merely reduced to a rhetoric of (corporate) environmental responsibility, obscured by legitimation arguments and deficient of reliability and transparency (Boiral, 2016). This is in line with Bansal and Kistruck (2006), who draw on the complexity and uncertainty of environmental problems and assert that it is such characteristics that drive business entities to publicly report a merely symbolic commitment and emphasize on self-laudatory statements for positively influencing stakeholder impressions rather than challenging the business-as-usual model (Milne et al. 2009; Milne and Gray, 2013). In this respect, the disclosed information can hardly be considered as material or unbiased, devoid from reputational and window-dressing motives (e.g. Cho et al., 2010, 2012; Hahn and Lülfs, 2014). Assessing integrated reports of South African firms, Solomon and Maroun (2012) relevantly comment that companies try to make the most from a small amount of information, a practice which may undermine the quality of accountability efforts. Thus, our results suggest that companies lack awareness of and commitment to accounting for biodiversity, with relevant disclosed information being in its early stages and suggesting a need for rethinking of current practices even for those firms that publish relatively more comprehensive sustainability reports (and therefore are most likely aware of biodiversity reporting requirements).

Disclosure of mission statements and the management approach to biodiversity conservation are ambiguous and lack clarity. Firms tend to conceal biodiversity management information within generic corporate social responsibility and environmental management activities undermining both the soundness of reported biodiversity protection measures and the ability of stakeholders to make informed decisions by obtaining a comprehensive and transparent view of a company's vision and performance (Fonseca et al. 2014; Vörösmarty et al. 2018). Despite previous research demonstrates that organizations that experience stronger stakeholder pressures shape appropriate response measures by publicly disclosing more information to maintain legitimacy of their operations (e.g. Cho and Patten, 2007), our study failed to confirm such an assertion as assessed biodiversity disclosures did not entail meaningful identifications of related challenges or risks confronted. Likewise, target-setting and time-specific biodiversity management objectives are in most cases unclear, reducing the ability to estimate progress over time or the effectiveness of actions in place to address impacts on disturbed habitats and endangered species.

Focusing on biodiversity disclosure in the mining industry, Fonseca et al. (2014) comment that the GRI indicators can be interpreted in a tacit issues-based conceptual framework and may run the risk of being translated into generic, non-contextual statements about the organization's overall planning related to biodiversity. At worst, this could be mere impression management exercises (Slack, 2012) in order to maintain stakeholder support, driven by an attempt to reduce public scrutiny while, at worst, to camouflage unsustainable business practice

(s) (Solomon et al., 2013; Fonseca et al. 2014; Cho et al., 2015; Vörösmarty et al. 2018).

The paper makes a number of contributions to the ecological indicators literature. The article evaluates business contribution to biodiversity protection through the assessment of widely-acknowledged management accounting metrics and sheds light on trends and determinants of corporate voluntary disclosure of actions. A study such as ours may help in the advancement of the field pertaining to organizational accounting and accountability for biodiversity. We adopt an inductive approach, presenting quantitative observations for biodiversity disclosure, supported by qualitative information from examined reports to highlight key findings. In line with previous findings from specific industrial sectors and/or geographical regions (Jones and Solomon, 2013; Rimmel and Jonäll, 2013; van Liempd and Busch, 2013; Mäkelä, 2017; Adler et al., 2017), this paper sheds new light on the current status of corporate justifications for biodiversity management in megadiverse countries. There is hardly any empirical evidence on corporate biodiversity disclosure in these regions, hence, the novelty of the paper is clearly demonstrated. While sustainability accounting and reporting has attracted significant attention over the past two decades, research focusing on the disclosure of BIs is still scant, with notable exceptions studies such as those of Adler et al. (2017), Potdar et al. (2016), Rimmel and Jonäll (2013), Grabsch et al. (2011), Boiral (2016) and Addison et al. (2018). Previous studies have either tended to concentrate on underlying enabling conditions or the comprehensiveness of environmental reporting in such geographical areas (e.g. Ahmad and Sulaiman, 2004; Imam, 1999), but research seeking to examine corporate accountability for biological diversity has been absent. Thus, the paper adds to this emerging field of organizational accounting and reporting, by providing an outlook of biodiversity indicators' disclosure in countries considered extremely rich in biological diversity, harboring 60–70% of the planet's species. Our assessment responds to calls for more empirical research on the accountability efforts of organizations on biodiversity management and conservation (Jones and Solomon, 2013). It contributes to the nascent literature on management accounting and reporting for biodiversity, an aspect largely overlooked in the sustainability disclosure research stream which essential focuses on the broad and relatively unspecific aspects of nonfinancial disclosure (Gray 2010; Cho et al., 2010, 2012; Boiral, 2013). Likewise, the environmental management literature largely overlooks parameters linked to biodiversity loss despite it remains a pressing worldwide challenge (Jones and Solomon, 2013; Winn and Pogutz, 2013).

In view of the above, these findings are of interest to environmental/sustainability management consultants and managers alike who are concerned with sustainability data gathering systems within the enterprise and are focusing on stakeholder communication through nonfinancial reporting channels. The study carries valuable implications for the firm across four dimensions. Firms seem to underutilize the various principles, guidelines and metric tools offered by NGOs (e.g. the International Union for Conservation of Nature, Earthwatch Institute, Rainforest Alliance), international and national environmental governance bodies (e.g. UNEP) or multi-stakeholder associations (such as the GRI) which could catalyze biodiversity disclosure, limiting the reported BIs to impression/brand management and window-dressing narratives. Additionally, it is critically important to nurture social engagement and the formation of partnerships with related external expert groups (ecologists, eco-biologists or biochemists-biophysicists) and NGOs with the aim of generating baseline biodiversity data, biodiversity inventories and refining the underlying accountability mechanisms of biodiversity action plans under the scope of materiality and completeness. Likewise, developing eco-literate and cross-disciplinary teams within the organization (involving accountants, management executives, environmental managers and natural scientists) could have a positive effect on the objectivity and completeness of biodiversity disclosures (Jones, 1996; Jones and Solomon, 2013). In this respect, utilizing novel approaches to organizational performance indicators construction, such as remote sensing techniques, could offer unique opportunities in accounting for biodiversity impacts (Pereira et al., 2013) and expand the current scope of BIs (that places emphasis on species) to more nuanced aspects such as ecosystems' functional diversity (Mace et al., 2012). Aspects of conservation science can provide fruitful avenues to indicators development to monitor progress over defined commitments. Indeed, essential biological variables (e.g. ecosystem structure or function metrics, and species persistence), global biodiversity measures assessing state, pressure and response or even scalable composite indicators (Butchart et al. 2010; Pereira et al. 2013; Burgass et al. 2017) provide fertile ground for a better understanding of losses and gains in biodiversity conditions stemming from the footprint of business impacts (Addison et al., 2018).

In conjunction with previous findings (e.g. Grabsch et al., 2011), such rethinking should be supported by relevant changes in policy design and standard setting to deflect from this fundamental questioning of the value of current biodiversity disclosures. The disclosure trends and determinants identified here can feed into critical policy appraisals of biodiversity reporting schemes and corporate environmental reporting initiatives in general. Indeed, the threshold analysis of the planetary boundaries stresses an urgent need for comprehensive disclosure of organizational impacts on species and ecosystems as a starting point for actions to combat biodiversity decline. To increase private sector effort to this direction, necessary conditions on the policy-making level may still be needed in terms of firm- and market-based incentives closely linked to managerial efforts (Berrone and Gomez-Mejia, 2009; Bhattacharya and Managi, 2013) coupled with appropriate guidance on priority areas or low-hanging fruits to initiate target-setting. Transnational policy-making should primarily focus on those large, highly connected, businesses forming a "super-entity" of the global economy (Vitali et al., 2011) which could act 'keystone species' in their respective industries (see Österblom et al., 2015). Under appropriate policy and guidance measures such keynote entities should be stimulated to effectively address and account for their disproportionate impact on biodiversity especially in regions characterized as biohotspots.

Future research needs to be undertaken in key respects. Our quantitative content analysis approach may perhaps reflect a crude measure of information quantity and quality making our results indicative rather than definitive. Yet, such scoring system methods are well-established in the literature (e.g. Ingram and Frazier, 1980; Beattie et al., 2004; Singh et al., 2007; Morhardt, 2010) and do allow comparative analyses over cross-sectional data. Still, taking into account that provided information, despite the adoption of the GRI guidance, is far from standardized and essentially descriptive, rigorous quantitative content analysis should be performed with caution and can be particularly difficult (Rimmel and Jonäll, 2013). Moreover, the assessment bears linguistic limitations as we included only those reports published in English, a point which future studies need to address by expanding their sample with reports in other languages. While our assessment relies on a limited sample of firms from certain industries, additional research is essential in order to gain a better understanding of how accountability for biodiversity is mainstreamed in the private sector and the underlying techniques applied to gather, process and publicly disclose related performance information. Future research could focus on specific sectors facing significant risks from biodiversity decline (e.g. agriculture, forestry, fisheries, pharmaceuticals or tourism) and draw from more detailed diverse data sources including interviews with business representatives and organizational stakeholders respectively. This would allow a deeper investigation of (best) practices and measures implemented by companies as well as how these are received by critical stakeholders. Research on organizational BIs should place emphasis on the internal data collection mechanisms and underlying processes for compiling and reporting performance indicators on the specific aspect of environmental management. In this regard, longitudinal and action research studies focusing on individual enterprises could offer fruitful and actionable insights on how BIs gradually evolve. Likewise, as regards future lines of research, sustainability reporting scholars need to examine the status of third-party assurance of biodiversity disclosures, an aspect largely overlooked in this emerging stream of biodiversity accounting and reporting highlighting a critical factor defining the reliability of disclosures (Boiral, 2013). Finally, the role of contextual factors such as the government effectiveness and control of corruption in the country of origin/domicile of the reporting entity, market and industrial structure, ownership status, institutional and cultural differences among countries or the maturity of environmental management systems in place could be examined through hypotheses testing and provide a better understanding of internal and external determinants of biodiversity disclosure.

It is critical for business entities with far from negligible impacts to biodiversity, embedded in supply chain networks with substantial externalities to ecosystem functions or facing high biodiversity risks, to advance related accounting and reporting systems as part of their long-term planning. This should be achieved through commonly-accepted sets of indicators that would allow regional and/or national outlook of private sector's contribution to biodiversity protection. Indeed, there is an urgent need for comprehensive and material information on causes, types and stress factors from business operations on biodiversity along with estimates of impacts to human welfare. Reflecting an interdisciplinary field of inquiry involving both management accounting and ecology perspectives, accountability for biodiversity conservation predicates novel ways in communicating performance and evaluating progress towards such grand challenge. Thus, as our study suggests, organizational accountability for biodiversity should be enhanced as it illuminates whether business entities act as stewards of the planet's biological diversity, how they manage their footprint on ecosystems and species and actively respond to extinction of life on earth. Placing emphasis on this strand of the mainstreaming-biodiversity agenda will eventually help shift business thinking from compensatory measures of remediation and offsets towards proactive goals of impact avoidance-minimization.

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