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PROGRAMA DE PÓS-GRADUAÇÃO EM ADMINISTRAÇÃO

PROPOSIÇÃO DE UM NOVO MODELO PARA AVALIAR A SUSTENTABILIDADE EMPRESARIAL

DISSERTAÇÃO DE MESTRADO

PALOMA RAYANNE SILVA BEZERRA

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Orientador: Prof. Dr. Fernando Schramm

Co-orientadora: Profa. Vanessa Batista Schramm

Projeto de Dissertação apresentado como pré-requisito para obtenção do grau de Mestre em Administração do Programa de Pós-Graduação em Administração da Universidade Federal de Campina Grande.

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BEZERRA, PALOMA RAYANNE SILVA. **PROPOSIÇÃO DE UM NOVO MODELO PARA AVALIAR A SUSTENTABILIDADE EMPRESARIAL**. 88 folhas. Dissertação de Mestrado em Administração - Universidade Federal de Campina Grande, Paraíba, 2021.

RESUMO

Este trabalho propõe um índice para avaliar a sustentabilidade empresarial baseado em um método multicritério não-compensatório. A pesquisa é descritiva de caráter exploratório com abordagem qualitativa e quantitativa. A pesquisa está dividida em duas etapas: (i) revisão da literatura, visando a identificação dos métodos multicritérios, dimensões e indicadores utilizados para mensurar a sustentabilidade corporativa, etc; (ii) proposição da abordagem para mensurar a sustentabilidade corporativa. Foram realizadas três pesquisas interdependentes, cada uma delas foi conduzida por um objetivo específico da dissertação. No primeiro artigo, concluiu-se que que existe uma predominância de métodos compensatórios, sendo o *Analytic Hierarchy Process* (AHP) o método mais utilizado, seguido do *Analytic Network Process* (ANP) e *Technique for Order of Preference by Similarity to Ideal Solution (*TOPSIS). No segundo artigo concluiu-se que a sustentabilidade corporativa deve ser avaliada sob a perspectiva da *Triple Bottom Line* e também considerar aspectos de governança; a combinação de dados secundários com o julgamento de especialista deve ser incentivada; e pouca atenção é dada à indústria da construção civil. No terceiro artigo, a abordagem foi aplicada em construtoras brasileiras, identificadas por: Alpha, Beta, Delta e Gamma. A classificação das empresas foi realizada baseado no método multicritério PROMETHEE II (Brans & Vincke, 1985). Este modelo permite suavizar os efeitos da compensação entre os critérios agregados e pode ser utilizado por gestores de empresas, certificadoras de sustentabilidade empresarial, gestores públicos, pesquisadores e outros atores sociais.

Palavras-chave: Sustentabilidade empresarial. *Triple bottom line*. Governança. Índice.

BEZERRA, PALOMA RAYANNE SILVA. **PROPOSITION OF A NOVEL MODEL FOR ASSESSING CORPORATE SUSTAINABILITY.** 88 pages. Master Dissertation in Management – Federal University of Campina Grande, Paraíba, 2021.

ABSTRACT

This work proposes an index to assess corporate sustainability based on a non-compensatory multicriteria method. The research is descriptive of an exploratory nature with a qualitative and quantitative approach. The research is divided into two stages: (i) literature review, aiming to identify the multicriteria methods, dimensions and indicators used to measure corporate sustainability, etc; (ii) proposition of the approach to measure corporate sustainability. Three interdependent researches were carried out, each one was conducted by a specific objective of the dissertation. In the first article, it was concluded that there is a predominance of compensatory methods, with the Analytic Hierarchy Process (AHP) being the most used method, followed by the Analytic Network Process (ANP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). In the second article, it was concluded that corporate sustainability must be evaluated from the perspective of the Triple Bottom Line and also consider aspects of governance; the combination of secondary data with expert judgment should be encouraged; and little attention is paid to the construction industry. In the third article, the approach was applied to Brazilian construction companies, identified by: Alpha, Beta, Delta and Gamma. The classification of companies was carried out based on the PROMETHEE II multicriteria method (Brans & Vincke, 1985). This model makes it possible to smooth out the effects of compensation between the aggregate criteria and can be used by managers of companies, certifiers of corporate sustainability, public managers, researchers and other social actors.

Keywords: Corporate sustainability. Triple bottom line. Governance. Index.

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AHP	*Analytic Hierarchy Process*
ANP	*Analytic Network Process*
CBIC	Câmara Brasileira da Indústria da Construção
CP	*Composite Programming*
ELECTRE	*Elimination Et Choix Traduisant la REalité*
GRI	*Global Reporting Initiative*
Instituto Ethos	Instituto Ethos de Empresas e Responsabilidade Social
ISE	Índice de Sustentabilidade Empresarial
MAUT	*Multi-Attribute Utility Theory*
PROMETHEE	*Preference Ranking Qrganization Method for Enrichment Evaluations*
SMART	*Simple Multi-Attribute Rate Technique*
TBL	*Triple Bottom Line*
TOPSIS	*Technique for Order of Preference by Similarity to Ideal Solution*

SUMÁRIO

1. INTRODUÇÃO

1.1. Contextualização

Sustentabilidade empresarial surge como uma resposta a uma nova demanda da sociedade: o valor gerado por uma organização deve refletir em benefícios não apenas para seus acionistas, mas também apresentar um impacto positivo para o conjunto dos afetados por suas operações, em especial, o meio ambiente e a sociedade, respeitando sua cultura e atuando com ética e com transparência. Esta nova atitude de gestão precisa considerar o resultado de suas atividades para com todos os stakeholders: funcionários, fornecedores, consumidores, investidores, concorrentes, governo e sociedade (Berlato, Saussen, & Gomez, 2016).

Segundo Almeida (2002) uma empresa sustentável deve buscar em todas as suas estratégias produzir mais e com melhor qualidade, gerando menos poluição e otimizando os recursos naturais. O autor complementa dizendo que a empresa deve reconhecer que está imersa em um ambiente social em que influi, ao mesmo tempo em que sofre influência, e que a motivação dos gestores empresariais deve ser respaldada numa visão de longo prazo, considerando os custos futuros e não somente os custos presentes.

Neste contexto, vários instrumentos vêm sendo propostos, os quais permitem avaliar a sustentabilidade no contexto corporativo, a exemplo dos indicadores e índices de sustentabilidade empresarial como o *Global Reporting Initiative* (GRI); os indicadores do Instituto Ethos de Empresas e Responsabilidade Social (Instituto Ethos); o Índice de Sustentabilidade *Dow Jones;* e o Índice de Sustentabilidade Empresarial (ISE) da Bolsa de Mercadoria e Futuros e Bolsa de Valores de São Paulo BM&FBOVESPA (Silva, Freire, & Silva, 2014). Uma discussão mais aprofundada sobre esses instrumentos pode ser encontrada em Imperador e Silva (2018).

A metodologia usada para construção, leitura e interpretação de um índice de sustentabilidade deve ser clara e transparente, não deixando dúvidas sobre quais os princípios que estão na base do processo (Siche, Agostinho, Ortega, & Romeiro, 2007). Para refletir a realidade do contexto estudado, garantir transparência e apoiar processos decisórios de forma adequada, Feil e Schreiber (2016) apontam que a elaboração de um índice de sustentabilidade necessita de métodos científicos sólidos para cada uma das etapas, descritas a seguir: seleção de indicadores; normalização; ponderação; agregação; formação do índice; e análise de sensibilidade e incerteza.

Dentre estas etapas, três delas são bastante críticas do ponto de vista matemático: normalização, ponderação e agregação. A normalização é essencial para permitir a operação de

variáveis mensuradas em escalas diferentes; quando isso não é feito, o resultado agregado pode não ter significado matemático. A segunda diz respeito à atribuição de pesos às variáveis (indicadores) que estão sendo consideradas e está diretamente relacionada à etapa seguinte, que é a agregação. Dependendo do método de agregação utilizado, as constantes que irão representar os pesos carregarão apenas informação de importância relativa da variável; entretanto, se é utilizado um método de agregação baseado no modelo aditivo, os pesos carregam também informação de *tradeoff* entre as variáveis, que traduz a ideia de compensação entre critérios, cuja denominação mais apropriada é constante de escala. Uma discussão mais aprofundada sobre esse problema pode ser encontrada em Almeida (2013).

A maioria dos índices são baseados em operadores de agregação aditivo, particularmente, a média ponderada. Porém, as constantes de agregação são erroneamente interpretadas apenas como medidas de importância relativa. Além disso, estes operadores realizam uma compensação entre as variáveis agregadas, ou seja, um desempenho baixo em uma variável pode ser compensado por um bom desempenho em outra. De acordo com Munda (2008), o conceito de sustentabilidade forte está relacionado com a ideia de que recursos naturais não podem ser compensados por recursos financeiros. Assim, não faz sentido utilizar um operador de agregação compensatório na construção de índices de sustentabilidade.

Outros tipos de modelos de agregação são os métodos multicritérios que, segundo Almeida (2013) podem ser classificados como: (i) métodos de critério único de síntese; e (ii) métodos de sobreclassificação. Os primeiros consistem na agregação de diferentes avaliações em uma única função, que depois será otimizada e são compensatórios. Os métodos de sobreclassificação consistem na construção de uma relação de preferência denominada sobreclassificação, que é explorada para ajudar os decisores a resolver seus problemas de decisão; estes métodos são não compensatórios e são, portanto, fortes candidatos a operadores de agregação na construção de índices de sustentabilidade.

Os métodos multicritérios vêm sendo utilizados para o desenvolvimento de índices para avaliar a sustentabilidade, a exemplo do trabalho de Krajnc e Glavic (2005), que utilizaram o método compensatório AHP (*Analytic Hierarchy Process*) na elaboração de um índice composto para avaliar a sustentabilidade em empresas. Este método também foi empregado na construção de um índice verde para pequenas e médias empresas proposto por Rita, Ferreira, Meidutė-Kavaliauskienė, Govindan e Ferreira (2018), que apontam a compensação de valores como uma das principais limitações do AHP. Já Garcia, Cintra, Torres e Lima (2016)

introduzem um modelo para avaliar o desempenho da sustentabilidade no nível corporativo com base na estrutura CP (*Composite Programming*).

Neste estudo, será proposta uma abordagem multicritério não compensatória para avaliar a sustentabilidade empresarial. O procedimento inclui o estabelecimento dos indicadores, com suas respectivas escalas de avaliação e respectivos pesos, a avaliação estruturada de empresas, com base nestes indicadores, a definição dos parâmetros inerentes aos métodos multicritério a ser utilizado e a aplicação do mesmo para construir um *ranking* entre as corporações com base no desempenho de sustentabilidade.

A partir dessas considerações, a pesquisa se pauta no seguinte problema central: Como elaborar um índice de sustentabilidade empresarial que seja matematicamente consistente e que evite a compensação entre as dimensões de sustentabilidade?

1.2. Justificativa

As pressões exercidas pelo ambiente natural somadas ao acompanhamento da sociedade, possibilitadas através de mecanismos que permitem a avaliação das operações das empresas, têm estabelecido uma nova ordem mundial, que exige posturas diferenciadas das organizações de todos os setores e de todas as esferas (Silva et al., 2014).

Na sociedade atual, os valores ligados à sustentabilidade têm sido institucionalizados em maior ou menor grau nos diversos países por intermédio de movimentos sociais e ambientalistas, bem como pelos próprios governos (Barbieri, Vasconcelos, Andreassi, & Vasconcelos, 2010). A sensibilização quanto ao tema, faz com que a sustentabilidade se torne essencial para o setor empresarial, que precisa contribuir com a resiliência do meio ambiente e com a redução da desigualdade social. De acordo com o autor, a sustentabilidade empresarial está diretamente relacionada com a competitividade da organização, sendo necessário, por parte desta, o acompanhamento periódico por intermédio dos indicadores sustentáveis, que é uma nova prática organizacional (Barbieri et al., 2010).

A ideia de desenvolver indicadores direcionados à sustentabilidade surgiu na Conferência das Nações Unidas sobre o Meio Ambiente e o Desenvolvimento, realizada no Rio de Janeiro em 1992, conhecida como Eco-92, que estabeleceu uma agenda de desenvolvimento sustentável para os países membros, denominada Agenda 21, a qual recomendava que os países precisam desenvolver sistemas de monitoramento e de avaliação do progresso relativo ao desenvolvimento sustentável, adotando indicadores que mensuram os avanços nas dimensões econômica, social e ambiental (Silva et al., 2014). A necessidade de mensurar a sustentabilidade através de indicadores e de índices vem crescendo nos últimos anos, tanto na perspectiva macro

(global, regional ou local) quanto na perspectiva micro (organizacional), dado que proporcionam uma orientação geral à sociedade, que pode auxiliar na tomada de decisão e na formulação de estratégias e de políticas. Com isso, esses instrumentos se tornaram elementos institucionais fundamentais para empresas que operam de forma competitiva nos diferentes segmentos, uma vez que possibilitam reduzir as incertezas e turbulências do ambiente, fato que promove o sucesso e a sobrevivência de uma organização (Barbieri et al., 2010).

Os índices de sustentabilidade são úteis para os tomadores de decisões e podem contribuir no desenvolvimento de potencialidades das empresas, bem como na comunicação para com os demais atores sociais envolvidos na busca pelo desenvolvimento sustentável, dado que permitem a interpretação da realidade na qual a empresa está inserida, bem como a divulgação objetiva e transparente dos desempenhos da organização. Assim, os instrumentos criados para mensurar a sustentabilidade das empresas possibilitam agregar valor à organização e melhorar os relacionamentos com as partes interessadas.

1.3. Objetivos

1.3.1. Geral

Propor um modelo para avaliar a sustentabilidade empresarial, baseado em um método multicritério não compensatório.

1.3.2. Específicos

- Realizar uma revisão da literatura sobre o uso de métodos multicritérios para avaliação de sustentabilidade empresarial.
- Fazer um levantamento das dimensões e indicadores utilizados para avaliar a sustentabilidade empresarial.
- Propor uma abordagem para avaliação de sustentabilidade empresarial.

1.4. Estrutura da Dissertação

O trabalho está estruturado em cinco seções, conforme descrito a seguir. A Seção 2 apresenta a fundamentação teórica para o estudo: sustentabilidade e sustentabilidade empresarial; indicadores e índices; procedimentos para elaboração de um índice de sustentabilidade; e análise multicritério. A Seção 3 trata dos procedimentos metodológicos realizados no presente estudo, onde são descritos os atributos que caracterizam a pesquisa, bem como as etapas empregadas para alcançar os objetivos, os instrumentos utilizados para a coleta de dados e os métodos utilizados para a análise desses em cada uma delas. A Seção 4 é dedicada

à apresentação dos resultados da pesquisa, os quais foram descritos em três artigos científicos complementares, e estão apresentados em detalhes nos Apêndices I, II e III da dissertação. Finalmente, na Seção 5, são apresentadas as considerações finais para o estudo.

2. FUNDAMENTAÇÃO TEÓRICA

2.1. Sustentabilidade e Sustentabilidade Empresarial

A palavra sustentabilidade é utilizada com frequência em distintas combinações, a exemplo de desenvolvimento sustentável, comunidade sustentável, indústria sustentável, economia sustentável, agricultura sustentável, entre outras. O termo vem do *Latim* "*Sustentare*", que significa sustentar, conservar em bom estado, manter, resistir. Portanto, sustentável é tudo aquilo que tem a capacidade de ser suportado, de ser mantido (Siche et al., 2007).

Os debates sobre a sustentabilidade têm se multiplicado em quase todas as áreas do conhecimento, mas o enfoque direcionado ao Desenvolvimento Sustentável tem raízes em duas disciplinas científicas: Ecologia e Economia (Veiga, 2010). As perspectivas dessas áreas são descritas a seguir.

Na Ecologia, inicialmente, surgiu a ideia de que a sustentabilidade do ecossistema equivale a um "equilíbrio" e contribuiu para o surgimento do conceito de “resiliência”, que se refere à capacidade de um sistema resistir a perturbações e manter as suas funções e a sua estrutura, isto é, a capacidade de adaptar-se e de reorganizar-se. Na Economia, surgiram, inicialmente, duas concepções: uma delas enfatiza o dever de sustentar pelo menos os serviços de "capital natural" constantes, enquanto a outra fundamenta-se na ideia de que cada geração é composta por três tipos de capital (capital em si, capital natural e capital social).

As interpretações das duas áreas foram levadas em consideração no Relatório de *Brundtland*, onde o conceito de sustentabilidade parte da premissa de que, para desenvolver-se de forma sustentável, é necessário atender às necessidades do presente sem comprometer a capacidade das gerações futuras de suprirem as suas próprias necessidades (Comissão Mundial Sobre Meio Ambiente e Desenvolvimento, 1988). Esta definição traz uma visão crítica ao modelo de desenvolvimento orientado apenas para o crescimento econômico apoiado no uso indiscriminado de recursos ambientais, porém, ela também possui limitações visto que não fica claro qual o tipo de necessidade tem de ser suprido.

Assim, foi criado o conceito do Tripé da Sustentabilidade – TBL (acrônimo para o termo em inglês *Triple Bottom Line*), por John Elkington, que propõe a busca por um padrão de desenvolvimento fundamentado no equilíbrio entre três pilares: (i) econômico, o qual inclui o

valor econômico gerado e a sua contribuição para a economia; (ii) social, que abrange a realização de práticas benéficas para a sociedade; e (iii) ambiental, o qual envolve o uso otimizado de recursos ambientais para não comprometer as gerações atuais e futuras (Elkington, 1994; Elkington, 1997). O conceito TBL é adotado como referência na maioria dos estudos, porém há definições onde outras dimensões aparecem, tais como institucional, cultural, espacial, dentre outras.

Portanto, é possível afirmar que sustentabilidade é um conceito ainda em desenvolvimento e isso tem consequências na mensuração da sustentabilidade e/ou do desenvolvimento sustentável, bem como na operacionalização de estratégias. Face ao exposto, a seleção dos conceitos que norteiam os estudos, bem como das dimensões relativas a essas definições pode variar conforme os propósitos, os paradigmas considerados, as justificativas e os objetos de estudo. Neste trabalho, a sustentabilidade é investigada no contexto das organizações, especificamente das empresas.

Segundo Hepper, Souza, Petrini e Silva (2017), sustentabilidade empresarial ou corporativa é a incorporação de iniciativas de sustentabilidade à estratégia das organizações. Consiste em esforços de gestão sistemáticos que objetivam agregar valor à empresa no desenvolvimento de produtos e serviços, minimizando os impactos ambientais e sociais negativos dos impactos mesmos, sendo necessários a utilização de instrumentos que permitam monitorar tais iniciativas ao longo do tempo.

Atualmente, o aspecto de sustentabilidade está diretamente relacionado à competitividade, sucesso e sobrevivência das empresas (Barbieri et al., 2010). Neste sentido, medir a sustentabilidade é uma prática essencial. Cabe destacar que a seleção do instrumento adequado para mensurar a sustentabilidade empresarial depende do contexto no qual a organização está inserida. É preciso considerar fatores estruturais e ambientais como, por exemplo, o porte da organização, o segmento de atuação, etc. (Olsthoorn, Tyteca, Wehrmeyer, & Wagner, 2001).

O foco deste estudo recai sobre os instrumentos para mensurar o nível de sustentabilidade de empresas. Assim, o próximo item versa sobre a mensuração da sustentabilidade, especificamente a respeito dos indicadores e índices utilizados para esse propósito, bem como dos procedimentos utilizados para a elaboração destes instrumentos de avaliação e de apoio à tomada de decisão.

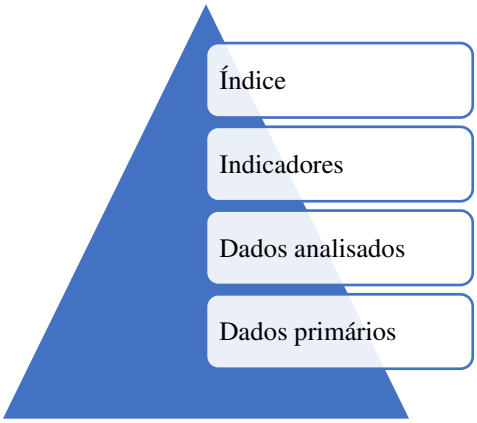
2.2. Mensurando a sustentabilidade

A mensuração da sustentabilidade é uma atividade complexa em razão da multiplicidade de conceitos disponíveis, sendo, geralmente, realizada por meio de indicadores e índices. Índices e indicadores são conceitos diferentes, mas que em algumas situações são utilizados como sinônimos. Portanto, é importante explicar a diferença conceitual de ambos.

2.2.1. Indicadores e Índices

De acordo Hammond, Adriaanse, Rodenburg, Bryant e Woodward (1995), as informações podem ser classificadas da seguinte forma: (i) dados primários, que são coletados através de monitoramento e de pesquisa que ainda não foram transformados; (ii) dados analisados, que descrevem determinado evento com o auxílio de explicação e de interpretação dos achados; (iii) indicadores, que expressam informações que não precisam de explicações; e (iv) índices, que correspondem a uma agregação de indicadores. A Figura 1 ilustra a pirâmide de informações apresentada pelo autor

Figura 1: Pirâmide de informações



Fonte: Hammond et al., (1995)

Um indicador corresponde a um parâmetro, que carrega informação sobre o estado de determinado fenômeno. Os indicadores referem-se a partes de informação que apontam as características dos sistemas, salientando o que está acontecendo no mesmo (Hardi, Barg, Hodge, & Pinter, 1997; OECD, 1993).

Os indicadores podem ser definidos como variáveis individuais ou como uma variável que é função de outras variáveis (Van-Bellen, 2004), também denominados de indicadores compostos ou índices. Segundo Mayer (2008) um "índice" consiste em uma agregação quantitativa de muitos indicadores e pode proporcionar uma visão simplificada, coerente e

multidimensional de um contexto. O principal objetivo dos índices é o de agregar informações de modo que sua significância fique mais aparente, simplificando as informações sobre fenômenos complexos com o intuito de melhorar o processo de comunicação (Van-Bellen, 2002).

De acordo com Van-Bellen (2004), esses instrumentos de avaliação podem ser utilizados com diferentes funções:

- Função analítica: As medidas auxiliam na interpretação dos dados de um sistema coerente, agrupando-os em matrizes ou em índices.
- Função de comunicação: Os instrumentos tornam os tomadores de decisão familiarizados com as definições e os métodos, os indicadores ajudam no estabelecimento e na avaliação de metas.
- Função de aviso e mobilização: As medidas auxiliam os administradores a disponibilizarem os mecanismos de forma pública, por meio de publicações anuais ou de simples relatórios com indicadores específicos.
- Função de coordenação: Sistemas de informações e relatórios precisam integrar dados de distintas áreas, coletados por diferentes agências. Precisa ser factível, em termos de orçamento e em termos de recursos humanos; e necessita ser aberto à população, para que exista a participação e o controle.

A próxima seção trata sobre aspectos metodológicos pertinentes à elaboração de índices de sustentabilidade.

2.2.2. Procedimentos para elaboração de um índice de sustentabilidade

Existe na literatura especializada uma diversidade de orientações apontadas para a elaboração de instrumentos para mensurar a sustentabilidade, entre os mais reconhecidos estão os Princípios de Bellagio, que realçam a necessidade de considerar o sistema e a sua interpelação com as partes, bem como destaca a relevância de que as metodologias desenvolvidas nos estudos viabilizem um acompanhamento periódico, isto é, uma leitura transversal e uma leitura longitudinal de cenários. Estes princípios, apresentados na Tabela 1, podem ser utilizados como "carta de navegação" no desenvolvimento de sistemas mais adequados para mensurar a sustentabilidade em contextos distintos.

Tabela 1: Princípios de Bellagio

ID.	Princípio	Descrição
1	Visão direcionada e objetivos	Avaliação guiada por objetivos claros e direcionada à uma visão de Sustentabilidade.

2	Perspectiva holística	Revisão de um sistema como todo e de suas partes.
3	Elementos essenciais	Considerar a equidade e a disparidade da atual sociedade, bem como entre as gerações presentes e as futuras.
4	Escopo adequado	Adotar um horizonte de tempo suficiente para englobar as escalas de tempo humanas e ecológicas.
5	Foco prático	Abordar categorias explícitas ou uma estrutura organizada que relacione os objetivos, os indicadores e os critérios de avaliação. Também selecionar um número mínimo de questões e de indicadores para fornecer uma visão clara do progresso.
6	Abertura	Utilizar métodos e dados acessíveis a todos.
7	Comunicação efetiva	Fazer uso de uma estrutura simples, com linguagem clara e abrangente, que direcionam as necessidades e apoiem a tomada de decisão.
8	Ampla participação	Obter a participação de atores-chave, tais como profissionais, técnicos e grupos sociais, a fim de considerar distintos valores.
9	Avaliação constante	Ser interativa, de modo a adaptar-se às mudanças e as incertezas, possibilitando o ajuste de objetivos, de estruturas e de indicadores, bem como promover o aprendizado coletivo.
10	Capacidade institucional	Estabelecer claramente as responsabilidades dos atores sociais, e auxiliar periodicamente na tomada de decisão através da coleta e da manutenção de dados.

Fonte: Malheiros, Coutinho e Philippi Júnior (2012)

Segundo Lazarsfeld (1973), como forma de expressar os conceitos em termos de índices, quase sempre se realiza um processo composto por quatro etapas principais: (i) a representação literária do conceito; (ii) a especificação das dimensões; (iii) a seleção dos indicadores; e (iv) o resumo dos indicadores ou elaboração de índices. Estas etapas são descritas a seguir.

- Representação literária do conceito: o investigador começa a conhecer os detalhes de um problema teórico e seleciona uma construção abstrata do que é observado (um conceito).
- Especificação das dimensões: consiste em identificar os componentes que constituem o conceito, dado que podem envolver múltiplas dimensões e aspectos.
- Seleção dos indicadores: refere-se à escolha dos indicadores que compõem as dimensões definidas anteriormente.
- Elaboração de índices: corresponde à síntese dos dados obtidos nas etapas anteriores.

Na elaboração de um índice de sustentabilidade, as etapas de representação literária de um conceito e a especificação de suas dimensões são guiadas através de um marco ordenador. Marcos ordenadores são modelos, conceitos ou outras estruturas utilizadas como base para organizar um conjunto de indicadores em suas respectivas dimensões. Eles orientam a coleta de dados, e ajudam na interpretação e na comunicação de informações (Carvalho & Barcellos, 2010).

De acordo com Feil e Schreiber (2016), a elaboração de um índice de sustentabilidade necesita de métodos científicos sólidos para cada uma das etapas, descritas a seguir: (i) seleção

de indicadores; (ii) normalização; (iii) ponderação; (iv) agregação e formação do índice; e (v) análise de sensibilidade e incerteza.

A etapa de seleção dos indicadores geralmente envolve algumas dificuldades, uma vez que a relação entre cada indicador e o construto é definida em termos de probabilidade e pode envolver, na medida do possível, um grande número de indicadores. Para identificar e selecionar os indicadores de sustentabilidade as duas principais abordagens utilizadas são a top-down e a bottom-up:

- *Top-down*: Os especialistas e pesquisadores determinam o sistema e o grupo de indicadores a ser utilizados pelas diferentes audiências e tomadores de decisão, que podem adaptar o sistema às realidades locais, mas não têm o poder de definir o sistema nem modificar os indicadores. Essa abordagem dispõe com vantagem o fornecimento de uma aproximação homogênea, mais válida em termos de indicadores e índices; sua desvantagem consiste na ausência de um contato direto com as comunidades e não considera as limitações de recursos naturais (Van-Bellen, 2005).
- *Bottom-up*: A temática e os indicadores de mensuração são selecionados a partir de um processo participativo, iniciado com a opinião de distintos atores sociais, a exemplo de líderes, tomadores de decisão, comunidade, finalizando com os especialistas. Essa abordagem além de considerar as prioridades e a escassez para o sistema envolvido, existe maior possibilidade de que a sociedade adote a proposta; entretanto, sua principal limitação consiste na possibilidade de omitir aspectos essenciais à sustentabilidade (Van-Bellen, 2005).

Após selecionar os indicadores, recomenda-se avaliar a possibilidade e a necessidade de normalização ou padronização de suas medidas. A normalização é necessária quando pretende-se agregar indicadores expressos em unidades diferentes. O objetivo é tornar os indicadores adimensionais, facilitando comparações entre eles.

Existem diferentes maneiras de normalizar os valores de um atributo, conforme exposto no Tabela 2.

Tabela 2: Possibilidades de padronização

Padronização	Descrição
Estatística	Trata-se de expressar todos os valores como desvios-padrão, após transformar as variáveis para que sua média seja igual a zero.
Empírica	Várias técnicas podem ser usadas nesse tipo de padronização, as mais comuns consistem em: a) Usar como base para o cálculo um ano-base (por exemplo, o ano em que a pesquisa estatística iniciou) e expressar os valores subsequentes como uma porcentagem da variação desse valor inicial. Essa abordagem é útil para analisar o progresso ou a regressão de determinada situação.

	b) Atribuir um valor 0 (min.) à observação considerada como o pior caso, e 1, 10 ou 100 (máx.) ao correspondente à melhor pontuação. Os valores intermediários são calculados segundo a seguinte fórmula, de modo a continuar dentro dos limites de uma escala que varia de 0 a 1:
Axiológica	É similar à padronização empírica dispõe de limites mínimo e máximo, contudo, os limites não são definidos pelo banco de dados, são selecionados com referência ao contexto de ação ou de avaliação. O evento do qual é necessário diferenciar recebe o valor 0, e a situação considerada como ideal recebe o valor 1.
Matemática	Corresponde à aplicação de uma função matemática aos dados, para que eles permaneçam entre um limite inferior e um limite superior (exemplo, -1 e +1 ou 0 e 1). As mais utilizadas são as funções tangentes logísticas e as hiperbólicas, entretanto, esses procedimentos não são recomendados para os indicadores sociais, uma vez que distorcem até certo ponto a distribuição original, bem como não apresenta transparência para alguns atores sociais.

Fonte: Boulanger (2008)

Para identificar a relevância de determinado indicador em um conjunto de dados, é feito um processo de ponderação. O sistema de ponderação permite atribuir pesos para cada indicador para que, em seguida, sejam transformados em pontuação do componente, bem como agregadas em uma pontuação composta. Os pesos atribuídos podem ser: implícitos, introduzidos durante o dimensionamento; e explícitos, inseridos durante a agregação. Caso os pesos explícitos não sejam empregados, as pontuações do componente e do índice são médias das correspondentes pontuações de variáveis e elementos (Booysen, 2002).

A agregação é o processo que consiste em combinar um conjunto de indicadores e/ou dimensões em um único elemento de informação (Siche et al., 2007). Segundo Nardo, Saisana, Saltelli e Tarantola (2005), a formação de um índice composto combina indicadores, dimensões e medidas em diferentes escalas. Isso implica uma decisão sobre qual técnica será aplicada para agregar essas informações. A literatura oferece várias técnicas de agregação, a exemplo das técnicas multiplicativas ou geométricas, dos métodos não lineares, bem como das técnicas aditivas, que são as mais utilizadas.

Por fim, Nardo et al., (2005) destacam que as etapas para construção de um índice composto envolvem juízo de valor, a exemplo da seleção do modelo conceitual, de indicadores, da ponderação desses, etc. Essas fontes de julgamento subjetivo podem afetar a informação trazida pelos índices. Nesse sentido, para auxiliar na avaliação da robustez de um índice composto, aumentar sua transparência e estruturar um debate em torno dele é recomendada a combinação de duas ferramentas, a saber: (i) análise de incerteza, que analisa como a incerteza nos parâmetros de entrada se propaga através da estrutura do indicador composto; e (ii) análise de sensibilidade, que se concentra na contribuição de cada fonte de incerteza em relação à variação do produto.

A próxima seção apresenta os fundamentos básicos da análise multicritério.

2.2.3. Análise Multicritério

Um problema multicritério se refere a situação na qual, existindo um conjunto de ações A e uma família de critérios F, o decisor deseja: definir um subconjunto de ações, consideradas, por ele, como sendo as melhores de A (problemática de escolha); alocar as ações a diferentes classes definidas, a priori, a partir de um grupo de regras aplicáveis ao conjunto A (problemática de classificação); ordenar as alternativas de A da melhor para a pior (problemática de ordenação) (Vincke, 1992). Neste tipo de situação, não existe ação que sejam simultaneamente ótimas considerando todos os critérios analisados; deste modo, há a necessidade de contribuir para que seja realizada a seleção da melhor opção possível, denominada de solução de melhor compromisso (Vincke, 1992).

A análise multicritério refere-se ao conjunto de abordagens formais para lidar com problemas de decisão multicritério. O objetivo é ajudar os decisores a organizar e sintetizar as informações de uma maneira que os leve a tomar uma decisão, minimizando o potencial de arrependimento, estando convencido de que todos os critérios ou fatores foram devidamente levados em consideração (Belton & Stewart, 2002).

Existem duas abordagens principais no processamento dessas informações: modelos não compensatórios e modelos compensatórios (Hwang & Yoon, 1981). As abordagens não compensatórias não permitem trocas entre atributos, isto é, uma desvantagem ou valor desfavorável em um atributo não pode ser compensado por uma vantagem ou valor favorável em outro atributo. Cada critério deve ser independente, assim, as comparações são feitas de atributo a atributo. Seus principais métodos são os métodos da família ELECTRE e os métodos da família PROMETHEE. Já as abordagens compensatórias permitem trocas entre atributos, isto é, um atributo pode ser compensado por mudanças opostas em quaisquer outros atributos. Com modelos compensatórios, as perdas em um critério podem ser compensadas por ganhos em outros critérios. Os principais métodos distribuídos entre essas classes são: MAUT, TOPSIS, AHP, ANP, família SMART, entre outros.

A análise multicritério pode ser incorporada em um processo amplo de estruturação e resolução de problemas. Segundo Belton e Stewart (2002) esse processo contempla três fases principais: identificação e estruturação de problemas; modelo construção e uso; e o desenvolvimento de planos de ação. A fase inicial de estruturação do problema envolve pensamento divergente, abre a questão e captura a complexidade que existe, sem dúvida, assim, é possível entender como os decisores podem avançar. A fase de construção e de uso do modelo representa uma maneira de pensamento mais convergente, consiste no processo de extrair a

essência da questão complexa de modo a apoiar uma avaliação mais detalhada e precisa das possibilidades de avançar. A determinação do plano de ação, pode ser executada de distintas formas, por exemplo, implementar uma escolha específica, realizar uma recomendação, estabelecer um procedimento para monitorar o desempenho, ou manter um resumo de observação de determinada situação.

3. PROCEDIMENTOS METODOLÓGICOS

3.1. Caracterização do estudo

O objetivo deste estudo é propor um modelo para avaliar a sustentabilidade empresarial baseado em um método multicritério não compensatório. A pesquisa configura-se como descritiva, de caráter exploratório, com abordagem qualitativa e quantitativa.

O objetivo da pesquisa descritiva é descrever um evento, um acontecimento ou fornecer uma descrição factual e precisa do objeto estudado. Para Kultar (2007) em um estudo descritivo, as coisas são medidas como são, enquanto em um experimental os pesquisadores fazem medições, intervenções e, em seguida, mensuram o impacto dessa intervenção. Portanto, o presente estudo é descritivo por buscar apontar a situação de empresas em relação à sustentabilidade baseado em dados descritivos, não havendo intervenção dos pesquisadores nos resultados, tal como ocorre nos estudos experimentais.

A pesquisa é caracterizada como exploratória por buscar compreender o problema enfrentado pelo pesquisador, bem como levantar ideias e informações. É o tipo de pesquisa utilizada para definir o problema com mais precisão, a partir da identificação dos cursos relevantes de ação ou da obtenção de dados adicionais essenciais para o desenvolvimento de determinada abordagem (Malhotra, 2012).

A pesquisa qualitativa tem como objetivo entender e aprofundar os fenômenos, que são explorados a partir das perspectivas dos participantes em um ambiente natural e em relação ao contexto. A análise de dados é indutivamente construída a partir das particularidades dos temas e das interpretações feitas acerca do significado dos achados (Creswell, 2010; Yin, 2016). Este estudo configura-se como pesquisa qualitativa por construir uma nova abordagem para mensurar a sustentabilidade baseado no contexto analisado e na revisão da literatura, que revela tópicos existentes e/ou emergentes sobre o tema central desta abordagem: sustentabilidade corporativa

Além disso, ele também é caracterizado como quantitativo por utilizar uma abordagem dedutiva e por trabalhar com números que permitem a quantificação de um evento. Em estudos

quantitativos, a teoria é utilizada dedutivamente e colocada no início da proposta de estudo. Na sequência, o pesquisador localiza um instrumento para utilizar na medição de eventos. Portanto, a teoria se torna uma estrutura para todo o estudo, um modelo de organização para as questões ou hipóteses de pesquisa e para os procedimentos de coleta de dados (Creswell, 2010).

Para validar a metodologia, foi realizada uma aplicação em empresas nacionais, bem como a classificação destas organizações em um ranking. Na próxima seção são apresentadas as etapas da pesquisa.

3.2. Delineamento do estudo

A pesquisa está organizada em duas fases: revisão da literatura e proposição da abordagem.

3.2.1. Revisão da literatura

Primeiramente foi realizada uma revisão da literatura sobre modelos aplicados para avaliação de sustentabilidade empresarial. A pesquisa foi realizada em artigos científicos publicados em periódicos indexados entre os anos de 1990 e 2019 e disponibilizados na base *Web Of Science*. Esta revisão da literatura implicou em dois artigos científicos: (i) o primeiro artigo corresponde a identificação dos métodos e técnicas multicritérios frequentemente usados para avaliar a sustentabilidade corporativa, das fontes usadas para a coleta de dados na aplicação dos modelos, dos setores nos quais esses modelos são aplicados e dos temas relacionados à sustentabilidade corporativa; (ii) o segundo artigo corresponde ao mapeamento de dimensões e indicadores utilizados para mensurar a sustentabilidade corporativa, as fontes usadas para avaliar esses indicadores, bem como os setores para os quais esses modelos estão sendo propostos / aplicados, etc.

Neste estudo, foi seguido o procedimento proposto por Seuring e Müller (2008), que contempla quatro etapas:

- Coleta de materiais: consiste na definição e na delimitação do material a ser coletado.
- Análise descritiva: inclui a avaliação de aspectos formais do material, a exemplo do número de publicações por ano, produzindo um pano de fundo para a análise teórica.
- Seleção de categoria: se refere à seleção das dimensões estruturais que devem ser aplicadas aos dados coletados. Estas dimensões formam os principais tópicos de análises, constituídas por categorias analíticas únicas.
- Avaliação do material: O material é analisado conforme as dimensões estruturais, possibilitando a interpretação dos resultados e a identificação de questões relevantes.

Na operacionalização dessas etapas utilizou-se a técnica análise de conteúdo, que corresponde ao exame sistemático e objetivo de textos com a intenção de alcançar indicadores que possibilitam a inferência de conhecimentos associados às condições de produção das informações (Bardin, 2016).

A codificação e categorização dos textos (indicadores, dimensões, setores, etc.) foram realizadas com o auxílio da ferramenta NVivo. O processo de organização dos dados no NVivo começa reunindo os dados (textos, áudio, imagens e/ou vídeo) em "nós", que são organizados em pastas definindo uma hierarquização do projeto. Os "nós" funcionam como variáveis que agrupam informações descritivas do texto, permitindo a identificação de tendências. Nesse sentido, os "nós" podem assumir significados diferentes dependendo do objetivo da pesquisa (Alves, Filho, & Henrique, 2016).

A análise qualitativa teve como objetivo identificar: as dimensões e indicadores usados para avaliar a sustentabilidade corporativa; as fontes utilizadas pelos autores para selecionar os indicadores e para coletar dados na aplicação desses modelos; os setores considerados na aplicação dos modelos; etc. Realizou-se também uma análise descritiva, na qual foi utilizado o Software Microsoft Excel para construir os gráficos de distribuição dos artigos por ano de publicação, por periódico científico, etc.

Deste modo, a revisão da literatura (Artigos 1 e 2) foi realizada por meio de análise de conteúdo, combinando aspectos qualitativos e quantitativos, como sugerido por Seuring e Muller (2008). O primeiro artigo incluiu também a análise da rede de citações, que permite analisar a literatura, com base nas publicações que estão interligadas entre si por citações em comum. Para isso foi utilizada a ferramenta *Citation Network Explorer* (*CitNetExplorer*).

3.2.2. Proposição da abordagem

Com a realização da primeira fase da pesquisa, que permitiu identificar o método multicritério mais apropriado para a avaliação de sustentabilidade empresarial e definir as dimensões e indicadores a serem considerados no modelo. O modelo para avaliação de sustentabilidade empresarial foi proposto, conforme o processo de cinco etapas sugeridas por Feil e Schreiber (2016): (i) seleção de indicadores; (ii) normalização; (iii) ponderação; (iv) agregação e formação do índice; e (v) análise de sensibilidade e incerteza.

O modelo foi validado a partir da aplicação em construtoras brasileiras, que estão identificadas nesta pesquisa por Alpha, Beta, Delta e Gamma. Os dados destas empresas foram coletados em fontes secundárias, a saber: base de dados da Câmara Brasileira da Indústria da

Construção (CBIC) e relatórios de sustentabilidade por elas publicados. Os indicadores foram avaliados com base na literatura especializada e no julgamento de especialistas. Para avaliação e classificação das empresas foi utilizado o método multicritério PROMETHEE II, desenvolvido por Brans e Vincke (1985) o qual foi implementado na linguagem de programação R.

A próxima seção apresenta os procedimentos metodológicos realizados para alcançar os objetivos propostos.

3.3. Síntese dos procedimentos metodológicos

O Tabela 3 resume o processo empregado para alcançar os objetivos propostos, incluindo os elementos que caracterizam o estudo, os instrumentos utilizados para a coleta de dados, e os métodos aplicados para o tratamento dos achados em cada etapa da pesquisa.

Tabela 3: Desenho metodológico do estudo

Classificação da pesquisa	Descritiva; Exploratória; Abordagem qualitativa e quantitativa.		
Problema	Como elaborar um índice de sustentabilidade empresarial que seja matematicamente consistente e que evite a compensação entre as dimensões de sustentabilidade?		
Objetivo geral	Propor um índice para avaliar a sustentabilidade empresarial baseado em um método multicritério não compensatório.		
Artigo	Objetivos específicos	Coleta de dados	Tratamento e Análise dos dados
Artigo 1	Realizar uma revisão da literatura sobre o uso de métodos multicritérios para avaliação de sustentabilidade empresarial.	Revisão da literatura (*Web Of Science*).	Análise de conteúdo. (*Microsoft Excel*; NVivo; *CitNetExplorer*).
Artigo 2	Mapear dimensões e indicadores utilizados para avaliar a sustentabilidade empresarial.	Revisão da literatura (*Web Of Science*).	Análise de conteúdo. (*Microsoft Excel;* NVivo;).
Artigo 3	Propor uma abordagem para avaliação da sustentabilidade empresarial.	Artigos 1 e 2, base de dados da CBIC e Relatórios de Sustentabilidade das Construtoras. .	Método Multicritério Promethee II. (R *Studio*)

Fonte: Elaboração própria (2021)

Como pode ser observado, os aspectos enfatizados na tabela possibilitam visualizar de forma objetiva o percurso metodológico do estudo, especialmente, a coesão entre os propósitos e os métodos usados nas etapas, bem como a relação entre o objetivo geral e os objetivos específicos.

4. RESULTADOS

Esta seção traz os principais resultados obtidos na pesquisa, os quais estão detalhados em três artigos científicos: Artigo 1, intitulado “Revisão da literatura sobre avaliação multicritério da sustentabilidade corporativa” (Apêndice I); Artigo 2, intitulado "Revisão da literatura sobre modelos para avaliar a sustentabilidade corporativa " (Apêndice II); e Artigo 3, intitulado “Modelo de multicritérios para avaliação da sustentabilidade corporativa na indústria da construção civil” (Apêndice III).

4.1. Revisão da literatura sobre avaliação multicritério da sustentabilidade corporativa

O primeiro artigo compreende uma revisão da literatura sobre avaliação multicritério da sustentabilidade corporativa em 43 artigos publicados entre 2005 e 2019. Observou-se que 80% dos artigos foram publicados a partir de 2015 e que a maioria desses estudos estão concentrados em periódicos com um escopo que abrange pesquisas transdisciplinares em questões de sustentabilidade, com destaque para *Journal of Cleaner Production, Sustainability Journal* e *Journal of the Operational Research Society.*

A maioria dos modelos é baseada em métodos compensatórios, como AHP, ANP e TOPSIS. Portanto, foi sugerido a aplicação de métodos não compensatórios (ELECTRE, PROMETHEE, etc.) como sendo a abordagem mais adequada para a mensuração da sustentabilidade, dado que possibilita reduzir o efeito da compensação entre as dimensões e critérios de sustentabilidade.

Em relação à seleção e avaliação dos indicadores usados nos modelos, 65% dos estudos utilizaram dados primários (julgamento de especialistas) e 35% utilizaram dados secundários (documentos públicos, como relatórios corporativos, etc). Neste sentido, recomenda-se uma avaliação de indicadores combinando dados secundários e julgamento de especialistas, dado que alguns aspectos da sustentabilidade corporativa são subjetivos e exige uma avaliação baseada no conhecimento das atividades da organização e do contexto no qual ela está inserida.

Quantos aos setores investigados nas aplicações desses modelos, verificou-se que apenas um modelo é destinado à Indústria da Construção, que é um setor crítico para a sustentabilidade do desenvolvimento de qualquer região. Por fim, por meio da análise da rede de citações realizada com o auxílio do *Citation Network Explorer*, constatou-se que os estudos consideram modelos aplicados para a avaliação da sustentabilidade corporativa e se preocupam com aspectos de responsabilidade social corporativa.

4.2. Revisão da literatura sobre modelos para avaliar a sustentabilidade corporativa

O segundo artigo traz uma revisão da literatura de 68 artigos que foram publicados em periódicos revisados por pares entre 2002 e 2019. O aumento do número de publicações desses estudos também ocorreu nos últimos cinco anos, aproximadamente 70% das publicações concentram-se entre 2015 e 2019. Os artigos estão distribuídos em 34 revistas diferentes e os principais periódicos são o *Journal of Cleaner Production* e o *Sustainability Journal e Management of Environmental Quality.*

Observou-se que 66% dos modelos revisados usam o conceito TBL como marco ordenador, portanto, consideram as dimensões econômica, social e ambiental simultaneamente para a avaliação da sustentabilidade empresarial. Alguns estudos consideram uma dimensão extra, denominada como governança corporativa, que inclui aspectos como ética, estratégias, políticas de negócios, relacionamento com as partes interessadas, medição de desempenho, cadeia de suprimentos, etc. Deste modo, concluiu-se que a dimensão de governança deve ser combinada com os indicadores econômicos, sociais e ambientais, pois abrange as esferas da gestão, a exemplo dos objetivos das organizações, estratégias, planos de ação e controles internos para alcançá-los, etc.

Os modelos têm como principal fonte de indicadores a literatura especializada, que em alguns casos é combinada com relatórios de empresas ou agências de classificação e julgamento de especialistas. Verificou-se que a combinação de dados secundários (literatura especializada, relatórios de sustentabilidade corporativa, por exemplo) com o julgamento de especialistas é o mais apropriado para o desenvolvimento de modelos para a avaliação da sustentabilidade, dada a complexidade dos aspectos que envolvem a avaliação da sustentabilidade, inclusive a necessidade de se considerar o contexto das empresas.

Além disso, verificou-se que os modelos que os modelos foram aplicados a empresas de diferentes setores (serviços comerciais e profissionais, bens de consumo discricionários, indústria automotiva, etc), mas pouca atenção vem sendo dada ao setor da construção civil, que é um dos mais importantes para o desenvolvimento sustentável de uma região, gerando impactos econômicos, sociais e ambientais positivos e negativos. Por fim, constatou-se que vários dos modelos analisados, não descrevem os indicadores e não apresentam métricas para mensurá-los. Portanto, carecem de embasamento na literatura especializada em sustentabilidade, a exemplo dos Princípios Bellagio.

4.3. Modelo de multicritérios para avaliação da sustentabilidade corporativa na indústria da construção civil

O modelo foi construído baseado na literatura especializada sobre a mensuração da sustentabilidade. Neste sentido, foram seguidas as etapas para a elaboração de um índice de sustentabilidade propostas por Feil e Schreiber (2016): seleção de indicadores, normalização, ponderação, agregação e formação do índice e análise de sensibilidade e incerteza.

O modelo está dividido em três fases: (i) estruturação do problema; (ii) aplicação do PROMETHEE II; e (iii) análise de sensibilidade.

Na primeira fase, são apresentados os critérios (indicadores), suas respectivas escalas de avaliação e funções de preferência, os pesos desses critérios e outros parâmetros. A seleção das dimensões da sustentabilidade corporativa e dos indicadores foi realizada com base em uma revisão da literatura, que seguiu as etapas propostas por Seuring e Müller (2008): coleta de materiais, análise descritiva, seleção de categorias e avaliação do material. O modelo proposto utilizou como marco ordenador as dimensões do conceito TBL (econômica, social e ambiental) e também considerou a dimensão governança corporativa, dado que essas dimensões foram referências para os modelos analisados. Os Princípios Bellagio foram observados na definição desses indicadores.

O resultado foi um conjunto de nove indicadores mensuráveis, organizados em quatro dimensões: (i) econômica; (ii) social; (iii) ambiental; e (iv) governança. A Tabela 4 apresenta as dimensões, os indicadores e respectivas escalas.

Tabela 4: Dimensões e indicadores para avaliação da sustentabilidade empresarial

Dimensão	Indicador	Descrição
Econômica	Receita	A receita bruta da empresa por ano (valor monetário). Um valor mais alto é preferível a um valor menor.
	Economia	Avalia a contribuição da organização para a economia local, por meio da geração de trabalho e renda. A avaliação deste critério é dada pelo número total de colaboradores da empresa. Um valor mais alto é preferível a um valor menor.
Social	Saúde e Segurança	Número de acidentes por ano. Um valor menor é preferível a um valor mais alto.
	Comunidade	A avaliação desse critério se dá pelo valor (valor monetário) que a empresa investe por ano em benefícios para a comunidade local. Um valor mais alto é preferível a um valor menor.
Ambiental	Energia	Total de energia (MWh) que é consumida por ano pela empresa. Um valor menor é preferível a um valor mais alto.
	Água	Volume total de água consumido por ano (m3). Um valor menor é preferível a um valor mais alto.
	Resíduo	Peso total de resíduos produzidos pela empresa por ano (ts). Um valor menor é preferível a um valor maior.
Governança	Comunicação	Envolve a gestão da comunicação com os *stakeholders* (fornecedores, clientes, comunidade, etc.). A avaliação desse critério é dada por uma escala Likert de 5 pontos: (muito bom (5), bom (4), regular (3), ruim (2), muito ruim (1)). Um valor mais alto é preferível a um valor menor.

Conformidade com a legislação	A avaliação deste critério é dada pela quantidade de multas (em valor monetário) que é paga pela empresa por ano. Um valor menor é preferível a um valor mais alto.

Fonte: Elaboração própria (2021)

Com relação aos pesos das dimensões e critérios, seguiu-se a recomendação do estudo de Munda (2008) de atribuir o mesmo peso a cada dimensão e dividir o valor igualmente entre os critérios de cada dimensão.

Na sequência a matriz de avaliação "empresas *versus* critérios" foi construída. Esta matriz e os parâmetros da primeira fase são a entrada para a segunda fase na qual são aplicadas as etapas do método PROMETHEE II (Brans & Vincke, 1985), resultando em uma priorização das empresas conforme seu desempenho em termos de sustentabilidade (do melhor para o pior). Este método foi escolhido por ser um método não compensatório, ou seja, ele evita que um mau desempenho em um determinado critério seja compensado por um bom desempenho em outro. Entre outros métodos não compensatórios, optou-se pelo PROMETHEE devido à facilidade dos tomadores de decisão em compreender os conceitos e parâmetros dos métodos.

Por fim, na última fase foi realizada uma análise de sensibilidade para avaliar a robustez do resultado, o que é necessário devido à presença de imprecisões e incertezas nos julgamentos.

A proposta foi aplicada no setor de construção civil, em quatro construtoras brasileiras identificadas, neste estudo, por Alpha, Beta, Delta e Gamma. As avaliações dessas empresas em relação aos critérios da dimensão econômica foram obtidas em banco de dados disponibilizado pela Câmara Brasileira da Indústria da Construção. Em relação à avaliação de critérios distribuídos nas dimensões social, ambiental e governança, os dados foram coletados dos relatórios de sustentabilidade corporativa publicados por essas empresas. O algoritmo PROMETHEE II foi implementado em linguagem R.

5. CONSIDERAÇÕES FINAIS

Esta dissertação teve como objetivo geral propor um modelo para avaliar a sustentabilidade empresarial baseado em um método multicritério não compensatório. Para alcançar este propósito, foram conduzidas três pesquisas interdependentes, cada uma delas foi conduzida por um objetivo específico da dissertação, a saber: i) realizar uma revisão da literatura sobre o uso de métodos multicritérios para avaliação de sustentabilidade empresarial; ii) fazer um levantamento das dimensões e indicadores utilizados para avaliar a sustentabilidade empresarial e; iii) propor um modelo para avaliação de sustentabilidade empresarial.

A pesquisa foi desenvolvida em duas fases: revisão da literatura e proposição do modelo. A revisão da literatura visou: i) a identificação dos métodos e técnicas multicritérios frequentemente usados para avaliar a sustentabilidade corporativa e; ii) o mapeamento de dimensões e indicadores utilizados para mensurar a sustentabilidade corporativa, bem como as fontes usadas para avaliar esses indicadores. Além disso, foram apresentados a distribuição temporal das publicações, os periódicos com maior volume de publicações, os setores para os quais esses modelos estão sendo propostos / aplicados, etc.

O primeiro artigo fornece uma revisão da literatura de 43 artigos, que foram publicados em periódico revisado por pares entre 2005 e 2019, focado na avaliação multicritério da sustentabilidade corporativa. Concluiu-se que há uma predominância de métodos compensatórios, sendo o AHP o método mais utilizado, seguido do ANP e TOPSIS. Portanto, para evitar, ou pelo menos reduzir, o efeito de compensação entre as dimensões e critérios de sustentabilidade, foi recomendado a utilização de métodos não compensatórios como o ELECTRE e o PROMETHEE.

O segundo artigo apresenta uma revisão da literatura de 68 artigos que foram publicados em periódicos revisados por pares entre 2002 e 2019. Concluiu-se que a sustentabilidade corporativa deve ser avaliada sob a perspectiva da TBL, mas também é importante avaliar os aspectos de governança. Além disso, a combinação de dados secundários com o julgamento de especialistas deve ser incentivada para mensurar a sustentabilidade, dada a complexidade dos aspectos que compõem esta avaliação e a necessidade de se considerar o contexto das organizações.

Esta etapa também evidenciou que a maioria dos artigos está organizada em periódicos com um escopo que abrange estudos transdisciplinares na área de sustentabilidade, sendo o *Sustainability Journal* e o *Journal of Cleaner Production* as principais fontes de publicação. Além disso, constatou-se que os modelos para avaliação da sustentabilidade corporativa foram aplicados em diversos setores, mas a literatura tem dado pouca atenção ao setor de bens de capital, que inclui a indústria da construção civil (uma das atividades mais críticas para o desenvolvimento sustentável de uma nação).

A segunda fase da pesquisa (terceiro artigo) inclui a proposição e validação da abordagem para mensurar a sustentabilidade corporativa considerando as dimensões econômica, social, ambiental e governança corporativa. Os indicadores (critérios) dessas dimensões foram selecionados com base na literatura especializada e no julgamento de especialistas. Para avaliação e classificação das empresas foi utilizado o método multicritério

PROMETHEE II. O modelo foi aplicado em quatro construtoras brasileiras, identificadas neste trabalho por Alpha, Beta, Delta e Gamma. Os dados dessas empresas foram coletados em fontes secundárias, a saber: base de dados da Câmara Brasileira da Indústria da Construção (CBIC) e relatórios de sustentabilidade por elas publicados. Concluiu-se que as empresas Alpha e Gamma têm os melhores resultados em sustentabilidade corporativa, enquanto que a empresa Beta ocupa a terceira posição do índice, e a construtora Delta possui o pior desempenho de sustentabilidade empresarial.

5.1. Contribuições teórica e empírica da pesquisa

Este trabalho contribuiu com a ampliação dos debates sobre a sustentabilidade, possibilitando (i) compreender os principais subtemas associados à sustentabilidade corporativa por meio da análise da rede de citações realizada com o auxílio do *Citation Network Explorer*; (ii) evidenciar marcos ordenadores que podem ser usados na aplicação de modelos, a exemplo das dimensões Econômica, Social, Ambiental e Governança Corporativa e; (iii) apresentar lacunas encontradas na literatura sobre o uso dos métodos multicritérios, os setores, os indicadores e outros elementos considerados nessas aplicações.

Além disso, oferece uma abordagem para a mensuração da sustentabilidade que permite suavizar os efeitos da compensação entre os critérios agregados, ou seja, reduzindo a possibilidade de que um desempenho baixo em um critério seja compensado por um bom. O modelo proposto pode ser aplicado por gestores nas avaliações de desempenho das organizações, empresas certificadoras de sustentabilidade empresarial, gestores públicos para explorar as especificidades dos setores e traçar políticas de apoio, por pesquisadores e outros atores sociais.

5.2. Limitações da pesquisa

Esta pesquisa possui limitações de ordem teórico-metodológica. A fase de revisão da literatura focou apenas estudos sobre avaliação da sustentabilidade empresarial, portanto, foram retirados diversos subtemas relacionados à sustentabilidade, como: cadeia de suprimentos, turismo, recursos humanos e outros. Além disso, destaca-se o uso do banco de dados *Web of Science* como única fonte de coleta de dados. E os dados das empresas foram coletados de relatórios de sustentabilidade corporativa publicados em diferentes anos.

5.3. Sugestões para pesquisas futuras

Pesquisas futuras podem utilizar diferentes bases de dados para a fase de revisão da literatura, a exemplo da *Scopus*, *ScienceDirect*, *Emerald* e outros. Recomenda-se também uma aplicação deste modelo para avaliação de um número maior de empresas.

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APÊNDICES

Apêndice I: Revisão da literatura sobre avaliação multicritério da sustentabilidade corporativa

Review of Managerial Science

A literature review on multicriteria evaluation of corporate sustainability

--Manuscript Draft--

Manuscript Number:		
Full Title:	A literature review on multicriteria evaluation of corporate sustainability	
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Abstract:	This paper presents a literature review on multicriteria evaluation of corporate sustainability, focusing on new models and application of already existing models. The review identifies the most frequently used methods and techniques, the types of organization in which these evaluations are being performed, and the dynamic of research. The review comprises papers that were published between 2005 and 2019. In the descriptive analysis, we identified distribution of the papers over the years and the main journals in which the papers were published. The qualitative analysis was performed according to five structural dimensions: (i) type of model; (ii) class of method; (iii) type of company; (iv) data sources; and (v) thematic cluster. Most of the models are based on compensatory methods, such as AHP, ANP, and TOPSIS. However, we recommend using non-compensatory methods, such as ELECTRE and PROMETHEE, to avoid, or at least reduce, the effect of compensation among the sustainability dimensions and criteria. Also, we recommend the combination of corporate reports judgment of specialists to assess the indicators used for evaluation of sustainability. This study provides a contribution for future research, especially those that seek to develop or adapt methodologies to assess corporate sustainability, as it contributed to: i) indicate different thematic fields; ii) present a multiplicity of techniques that can assist in the selection of methodologies; iii) map the main references that operate in this field; iv) identify the main journals in the area, which can be used to guide researchers in the selection of publications' sources.

Suggested Reviewers:	

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A literature review on multicriteria evaluation of corporate sustainability

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Abstract This paper presents a literature review on multicriteria evaluation of corporate sustainability, focusing on new models and application of already existing models. The review identifies the most frequently used methods and techniques, the types of organization in which these evaluations are being performed, and the dynamic of research. The review comprises papers that were published between 2005 and 2019. In the descriptive analysis, we identified distribution of the papers over the years and the main journals in which the papers were published. The qualitative analysis was performed according to five structural dimensions: (i) type of model; (ii) class of method; (iii) type of company; (iv) data sources; and (v) thematic cluster. Most of the models are based on compensatory methods, such as AHP, ANP, and TOPSIS. However, we recommend using non-compensatory methods, such as ELECTRE and PROMETHEE, to avoid, or at least reduce, the effect of compensation among the sustainability dimensions and criteria. Also, we recommend the combination of corporate reports judgment of specialists to assess the indicators used for evaluation of sustainability. This study provides a contribution for future research, especially those that seek to develop or adapt methodologies to assess corporate sustainability, as it contributed to: i) indicate different thematic fields; ii) present a multiplicity of techniques that can assist in the selection of methodologies; iii) map the main references that operate in this field; iv) identify the main journals in the area, which can be used to guide researchers in the selection of publications' sources.

Keywords Corporate Governance · Corporate Sustainability · Sustainability Evaluation · Multicriteria Decision Making/Aid (MCDM/A)

1 Introduction

Corporate sustainability is a wide concept that involves understanding and answer to a new demand from the society: the value generated by an organization should provide gains not only for its shareholders, but it also should have a positive impact for the environment and society, respecting their culture and acting ethically and transparently. According to (Bilbao-Terol et al, 2018), the adoption of corporate sustainability practices also serves as a strategy to attract investors: doing this, companies communicate to their various stakeholders that they are investing in their future and hope that this will help increase their profitability. In this context, it is important that society and market act as auditors in order to ensure the effectiveness and transparence of these practices. Sustainability indexes are instruments that measure the global performance of an organization in relation to all dimensions of sustainability. An index is formed by the aggregation of individual indicators (single variable) and/or composite indicators, which compile two or more single indicators (Siche et al, 2007). Indicators provide a quantified information about a given aspect in a given dimension of sustainability and indexes compile this information, revealing a multi-dimensional performance. Various

indexes and composite indicators to evaluate corporate sustainability have been proposed (some examples are: Corporate Sustainability Index (ISE) from B3 S.A, the Dow Jones Sustainability Index World, to cite just a few).

According to (Romero and Linares, 2014), the processes for constructing sustainability indexes (or composite indicators) need to be improved and/or require more transparence. When the construction of these aggregated variable does not observe solid mathematical foundations, the information measured by them may not reflect what happens in practice, leading to wrong conclusions and/or decision-making.

The construction of sustainability indexes (or composite indicators) involves the following steps (Feil and Schreiber, 2017): (i) normalization; (ii) weighting; (iii) aggregation; and (iv) sensitivity and uncertainty analysis. The normalization process converts all information into dimensionless quantity with no physical unit of measurement, allowing to aggregate different types of variables. The weighting refers to the assignment of weights (aggregation constants) to the variables that will be aggregated. According to the aggregation operator used, these constants can have two different mathematical meanings: (i) importance relative; (ii) importance relative + tradeoff information. When the operator aggregator used is based on the additive model, these constants also carry the information about tradeoff among the variables, which represent a compensation rate. Aggregation is the process of condensing information used in each indicator into a single element of information (Boulanger, 2008). The last step is intended for the analysis of robustness of the result, which is necessary due to the existence of imprecision and uncertainties in judgments. The weighting depends on the aggregation operator, which can be classified according to the meaning of weights: when weighting leads to trade-offs amongst criteria, methods are compensatory, which allows for a disadvantage in some criteria to be compensated for by a large advantage in another criterion; when the weights mean relative importance coefficients, methods are non-compensatory, and thus avoid trade-offs amongst criteria (Silva et al, 2010). Both steps are critical in construction of indexes, particularly when the additive model is used.

The weighted sum operator is widely used for constructing sustainability indexes, but in the last years, we observe the use of different techniques, such as the multicriteria methods, optimization techniques, and Artificial Intelligence (AI) techniques. The goal of this paper is to perform a literature review on multicriteria evaluation of corporate sustainability, focusing on studies that propose new models and application of already existing models. The review aims to identify the most frequently used methods and techniques, to identity the types of organization in which these evaluations are being performed, and to understand the dynamic of research (distribution of publication over the years, main journals, related papers, etc.). The review comprises 43 papers that were published between 2005 and 2020.

The paper is organized into five sections: Section 2 presents the methodology; Section 3 presents the results, including a descriptive and qualitative analysis; Section 4 presents the discussion; and conclusions are presented in Section 5.

2 Research Methodology

Literature review is a systematic, explicit and reproducible process that allows identifying, evaluating and interpreting the existing body of documents. The goal is to summarize the existing research, identifying patterns, themes, and issues (Meredith, 1993; Fink, 2019). In this study, the literature review will be performed using a content analysis approach, mixing qualitative and quantitative aspects, according to the process suggested by (Seuring and Müller, 2008), which is divided into three main phases: (i) material collection, which includes the definition and delimitation of the material that will be analyzed; (ii) descriptive analysis, which is useful to show the dynamic of the publications (number of publications per year, main journals, etc.); and (iii) material analysis that includes the structural dimensions, which form the dimensions of analysis, their respective analytical categories, and the reading of the papers according to these categories. Figure 1 presents the flowchart of the review process.

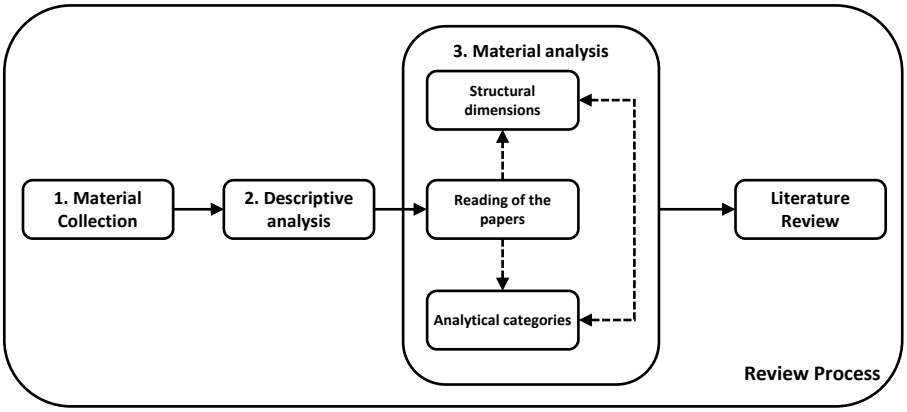

Fig. 1 The flowchart of the review process.

Table 1 Parameters of the search in the Web of Science™

Parameter	Input
Search	TS=("sustainability" OR "sustainability performance" OR "sustainable performance" OR "sustainability dimensions" OR "sustainability index" OR "sustainability indices" OR "sustainability indicator*") AND TS=("business" OR "company" OR "organization" OR "industry" OR "businesses" OR "companies" OR "organizations" OR "industries") AND TS=("multi-criteria" OR "multi criteria" OR "multicriteria" OR "multi-attribute" OR "multi attribute" OR "multiattribute").
Citation Indexes	Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts and Humanities Citation Index (A&HCI), and Emerging Sources Citation Index (ESCI).
Document Type	"Article" or "review".
Timespan	1990-2020
Language	English and Portuguese

2.1 Material collection

The database used was the Web of Science™ Core Collection. This database was chosen because it is the most reputable and comprehensive in the most diverse areas of knowledge (Bhardwaj, 2016). Table 1 presents the parameters used in the search that occurred in May 2020.

At first, the database search returned 598 papers. These documents were submitted to a preliminary analysis, by reading title, keywords and abstract. Then, 530 papers were removed, resulting in 68 papers that were analyzed. At this phase, more 25 papers were removed because they did not fit the delimitation boundary that was stablished for the study: (i) papers should present a new multicriteria approach for evaluating corporate sustainability or present an application of an already existing approach; (ii) evaluating corporate sustainability includes to measure the performance of the organization itself and/or the performance of its various practices/politics/processes in terms of sustainability; (iii) however, papers that focus on the evaluation of environmental management practices only should be removed.

2.2 Methodological aspects of the analysis

The quantitative and qualitative analysis aim to address the following questions related to the evaluation of corporate sustainability using multicriteria approaches:

- How is the dynamic of publications in terms of distribution of publication over the years, main journals, related works?
- Which are the most frequently applied methods and techniques?
- What types of organization for which this type of evaluation is being performed?

The analysis was divided into two parts: (i) descriptive analysis and (ii) qualitative analysis. In the former, we present the distribution of publications over the years, the main journals that the papers were published.

Table 2 Structural dimensions and analytic categories

Structural Dimensions	Analytical categories
Type of model	Single method
	Integration of methods
Class	Multicriteria method
	Optimization technique
	AI technique
	Qualitative technique
	Multicriteria method + Optimization technique
	Multicriteria method + Other techniques
	Others
Type of company	Chemical Industry
	Heating boilers
	Metallurgical Industry
	Manufacturing and Assembly Industry
	Energy Sector
	Mining Industry
	Bank and Financial Institutions
	Information Technology
	Forestry
	Construction Industry
	Cellulose Industry
	Food Industry
Data sources	Secondary data
	Judgments of specialist
Thematic cluster	Green - Evaluation of corporate sustainability
	Blue - Evaluation of sustainability of some aspects of the organizations
	Purple - Corporate social responsibility
	Yellow - Creation of corporate sustainability indexes

Then, by reading the papers, firstly, we identified the structural dimensions and analytical categories that will organize the analysis for which the NVivo was used as a supportive tool; an extra category was created considering an analysis of the co-citation network, for which we used the Citation Network Explorer tool. Finally, the analysis of each paper was performed; as the paper were reviewed, the list of structural dimensions and their respective analytical categories have been updated (Table 2).

3 Analysis

3.1 Descriptive analysis

Figure 2 presents the distribution of the papers over the years, from 2005 to 2020. The first paper that proposes a corporate sustainability index, using a multicriteria method as an aggregation operator was published in 2005. Ten years later, the number of publications have a significant increase, with ∼80% of the papers have been published from 2015 onwards (an average of ∼7 papers per year). The occurrence of the United Nations Conference on Sustainable Development (Rio+20) in 2012 can explain the increase in the number of publications in 2015 because this conference focused on to provide guidelines on green economies policies.

The papers were published into 27 different journals, most of them have a scope that covers transdisciplinary research on sustainability issues. Only 3 journals have more than 2 publications on this topic: Journal

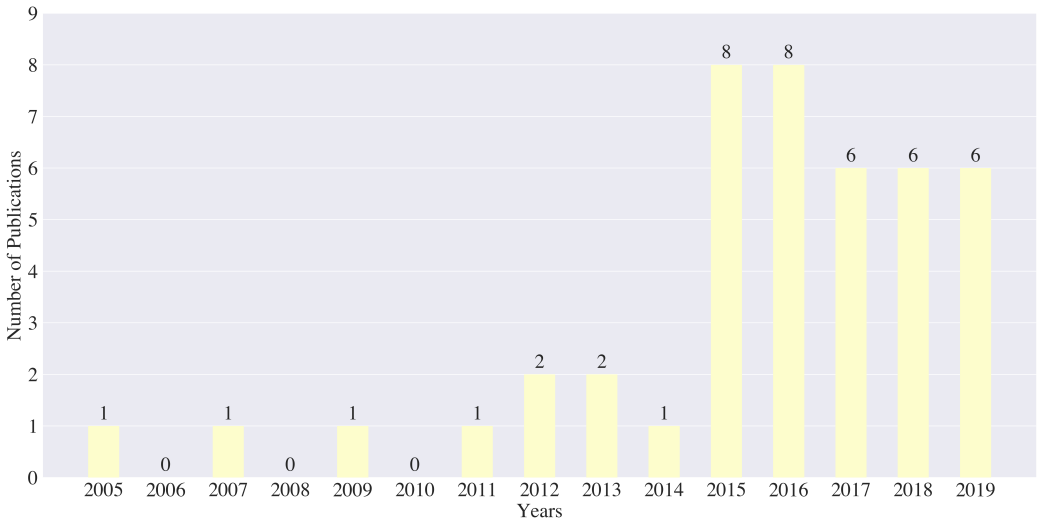

Fig. 2 Distribution of the papers per year.

of Cleaner Production (8 papers, ∼18%), the Sustainability Journal (4 papers, ∼9%), and the Journal of the Operational Research Society (3 papers, ∼7%).

3.2 Qualitative analysis

3.2.1 Data used for assessing the indicators

In 28 papers (∼65%), the evaluations of the indicators were based on primary data obtained from judgment of specialists: (Diaz-Balteiro et al, 2011; Vinodh et al, 2012; Zhou et al, 2012; Costa and Menichini, 2013; Rabbani et al, 2014; Zhao and Li, 2015; Chen et al, 2015; Rowley et al, 2015; Poplawska et al, 2015; Ren et al, 2016; Lähtinen et al, 2016; Metaxas et al, 2016; Kluczek, 2016; Rahdari, 2016; Garcia et al, 2016; Hussain et al, 2017; Mikušová, 2017; Venturelli et al, 2017; Hsu et al, 2017; Karaman and Akman, 2018; Pérez et al, 2017; Raj and Srivastava, 2018; Wang et al, 2018; Liu, 2018; Liern and Pérez-Gladish, 2018; Debnath et al, 2018; Nara et al, 2019; Küçükbay and Sürücü, 2019).

In other cases (15 papers or ∼35%), they used secondary data obtained from public documents, such as corporate reports: (Krajnc and Glavič, 2005; Wang and Lin, 2007; Tsai et al, 2009; Infante et al, 2013; Hsu et al, 2014; Martins et al, 2015; Vicente Galindo et al, 2015; Afful-Dadzie et al, 2016; Lu et al, 2016; Lenort et al, 2017; García-Martínez et al, 2019; Bilbao-Terol et al, 2018, 2019; Kubule and Blumberga, 2019; Vivas et al, 2019).

3.2.2 Methods and techniques

The models were classified into two types: (i) models based on a single method, which corresponds to ∼63% of the cases; and (ii) models based on the integration of methods.

In the models based on a single method, the pairwise comparison method AHP (Analytic Network Process), including its extensions, is the most frequently applied method, with 8 occurrences (∼30%). It was applied in the following studies: (Krajnc and Glavič, 2005; Martins et al, 2015; Kluczek, 2016; Karaman and Akman, 2018; Hussain et al, 2017; Mikušová, 2017; Lenort et al, 2017); a fuzzy version of AHP was used in the study of (Pérez et al, 2017). ANP (Analytic Network Process), which is an extension of AHP, was used in the studies of (Poplawska et al, 2015) and (Debnath et al, 2018), which used a fuzzy version.

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was applied in the following studies: (Afful-Dadzie et al, 2016; Kubule and Blumberga, 2019); and (Hsu et al, 2014) that incorporated GRA (Grey Rational Analysis) technique for dealing with imprecision.

MAUT (Multi-Attribute Utility Theory) was used in (Wang and Lin, 2007) and (Nara et al, 2019). The SMART (Simple Multi-Attribute Rating Technique), which is a MAUT-based method, was used in (Lähtinen et al, 2016). (Bilbao-Terol et al, 2018) used the OWA (Ordered Weighted Averaging) aggregation operator. To determine the alternative's overall performance, these methods use a weighted sum function to aggregate each alternative's performance against all criteria individually, with their respective weights.

The TODIM (acronym in Portuguese of Interactive Multi-criteria Decision Making), which is founded on the Prospect Theory of (Kahneman and Tversky, 1979) was used in the study of (Chen et al, 2015). A fuzzy version of the Best-Worst Method (Fuzzy-BWM) was used in (Raj and Srivastava, 2018) and the outranking method ELECTRE (acronym in French of Elimination et Choix Traduisant la réalité) for ranking problems was used by (Infante et al, 2013)

Other models are based on the use of optimization techniques, such as Goal Programming (GP) (Wang et al, 2018; García-Martínez et al, 2019; Garcia et al, 2016), Compromise Programming (Diaz-Balteiro et al, 2011), and MOORA (Multi-Objective Optimization on the Basis of Ratio Analysis) (Küçükbay and Sürücü, 2019). AI techniques also appeared (Venturelli et al, 2017) and the qualitative technique BSC (Balanced ScoreCard) was applied with 2-tuple fuzzy linguistic representation model for dealing with imprecision (Costa and Menichini, 2013).

Regarding the combination of two or more multicriteria method, ANP was combined in various ways: with AHP (Vinodh et al, 2012); with COPRAS (COmplex PRoportional Assessment) (Rabbani et al, 2014); with TOPSIS (Zhao and Li, 2015); with AHP and PROMETHEE (Preference Ranking Organization METHod for Enrichment of Evaluations) (Ren et al, 2016); and with DEMATEL (Decision Making Trial and Evaluation Laboratory) and VIKOR (acronym in Bosnian of Higher Criteria Optimization Compromise Solution) simultaneously (Lu et al, 2016; Liu, 2018). The method ANP also appeared combined with DEMATEL and an optimization technique (Tsai et al, 2009). Other combination of multicriteria methods is AHP with TOPSIS: (Metaxas et al, 2016; Rahdari, 2016); and (Hsu et al, 2017), who incorporated the qualitative technique QFD (Quality Function Deployment) and Finite-difference methods. The method TOPSIS was also used in combination with the multicriteria method LOWGA (Linguistic Ordered Weighted Geometric Aggregating Operator) (Liern and Pérez-Gladish, 2018) and the technique Design of Experiments (Bilbao-Terol et al, 2019). The outranking method PROMETHEE was used in combination with statistical tools (Vivas et al, 2019).

The Figure 3 shows the frequency in which these methods were used in both single and integration-based techniques.

3.2.3 Sector

The set of models are intended for evaluation of corporate sustainability in a wide range of companies and segments. Different models were developed to evaluate companies in the Energy Sector, including oil and gas: (Zhao and Li, 2015; Martins et al, 2015; Ren et al, 2016; Garcia et al, 2016; Vinodh et al, 2012; Infante et al, 2013; Rabbani et al, 2014; Rahdari, 2016); and (Vivas et al, 2019).

For Manufacturing and Assembly Industry, the following models were identified: (Nara et al, 2019) that proposed model to evaluate tobacco industries; (Kubule and Blumberga, 2019) who focused on rubber, non-mineral metals and wood transformations industries; (Tsai et al, 2009) and (Lu et al, 2016) for electronic devices; (Hussain et al, 2017), and (Küçükbay and Sürücü, 2019) proposed models to evaluate automotive industries companies; and for aviation Industry we identified (Karaman and Akman, 2018) and (Raj and Srivastava, 2018).

(Afful-Dadzie et al, 2016), (Bilbao-Terol et al, 2018), and (Venturelli et al, 2017) evaluated Bank and Financial Institutions.

Other segments are: Chemical Industry (Krajnc and Glavič, 2005; Küçükbay and Sürücü, 2019); Metallurgical Industry (Lenort et al, 2017); Information Technology (Hsu et al, 2017); Mining Industry (Poplawska et al, 2015); Cellulose Industry (Diaz-Balteiro et al, 2011); Construction Industry (Chen et al, 2015); Heating boilers (Kluczek, 2016); Forestry (Lähtinen et al, 2016); and Food Industry (Zhou et al, 2012).

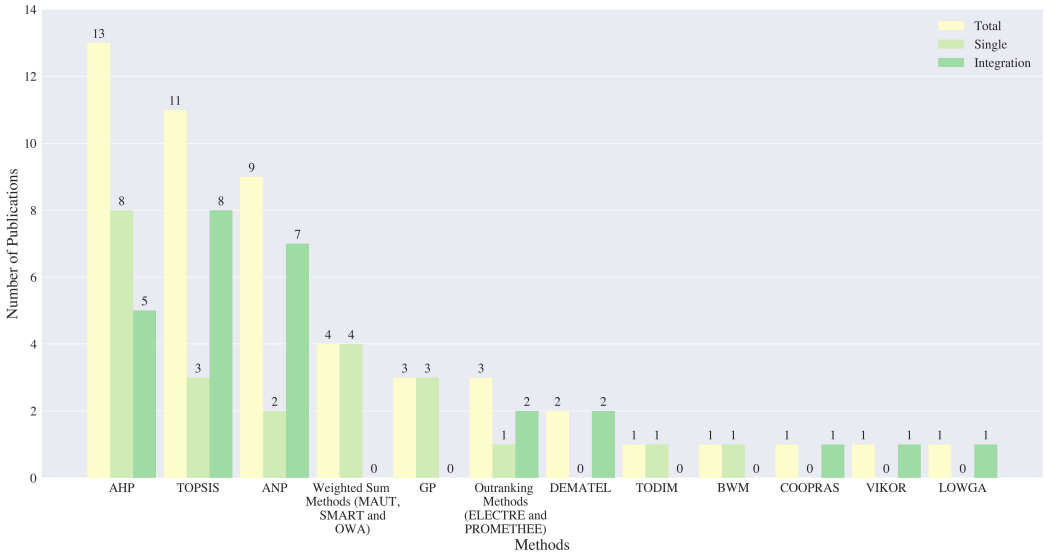

Fig. 3 Frequency of MCDM/A methods.

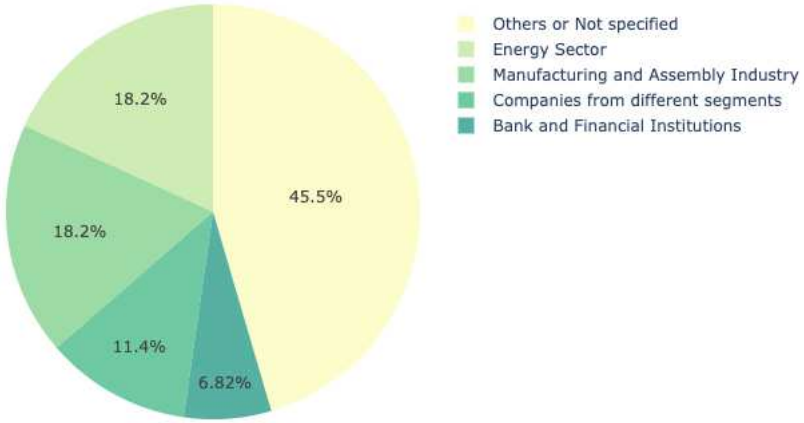

Fig. 4 Percentage of models intended for evaluation of corporate sustainability.

Some studies proposed index that can be used to evaluate sustainability of companies from different segments: (Vicente Galindo et al, 2015; Rowley et al, 2015; Bilbao-Terol et al, 2018; Liern and Pérez-Gladish, 2018); and (Küçükbay and Sürücü, 2019). Moreover, the following studies did not specify the type of company the model are intended for: (Wang and Lin, 2007; Costa and Menichini, 2013; Metaxas et al, 2016; Pérez et al, 2017; Mikušová, 2017; García-Martínez et al, 2019; Hsu et al, 2017; Debnath et al, 2018; Wang et al, 2018); and (Liu, 2018).

The Figure 4 presents the models that are intended for evaluation of corporate sustainability in a wide range of companies and segments.

3.2.4 Co-citation analysis

Figure 5 presents a graphic representation of the co-citation network, showing papers that cite each other. The network aggregates the papers into cluster according to the main thematic that explains the connections among them.

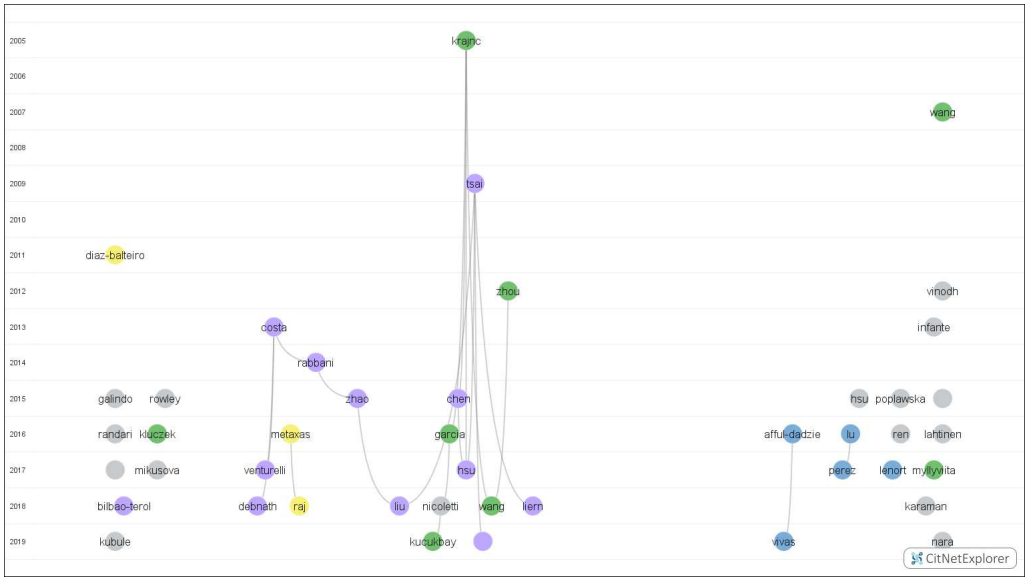

Fig. 5 Citation Network.

The blue cluster gathers the following publications: (Afful-Dadzie et al, 2016; Lenort et al, 2017; Lu et al, 2016; Pérez et al, 2017); and (Vivas et al, 2019). This cluster focuses on the evaluation of sustainability of some aspects of the organizations, such as strategies, policies, practices and processes.

In the green cluster, we find papers that propose models for evaluation of corporate sustainability as a whole. It includes the following works: (Krajnc and Glavič, 2005; Wang and Lin, 2007; Zhou et al, 2012; Garcia et al, 2016; Kluczek, 2016; Wang et al, 2018); and (Küçükbay and Sürücü, 2019). These researches come from different countries.

The yellow cluster is very similar to the green cluster, with the difference that the works included in this cluster focus in the creation of corporate sustainability indexes. This cluster includes the following works: (Diaz-Balteiro et al, 2011; Metaxas et al, 2016); and (Raj and Srivastava, 2018), who are from Spain, Greece and India, respectively. These studies are focused on the creation of corporate sustainability indexes that can be applied to different types of organizations.

The purple cluster includes studies on practices for corporate social responsibility, aiming to evaluate the impact of these practices in the corporate sustainability performance, focusing on the implementation, control and transparency of social actions, such as: labor practices, equal opportunities, training and education, etc. This cluster includes the following works: (Tsai et al, 2009; Costa and Menichini, 2013; Rabbani et al, 2014; Chen et al, 2015; Zhao and Li, 2015; García-Martínez et al, 2019; Hsu et al, 2017; Venturelli et al, 2017; Debnath et al, 2018; Liern and Pérez-Gladish, 2018; Bilbao-Terol et al, 2018; Liu, 2018); and (Bilbao-Terol et al, 2019). Spain seems to be a prominent region on this topic with 4 publications.

The CitNetExplorer tool did not classified some papers into the clusters and they appear in the periphery of the citation network. However, by reading the paper, we identified that it is possible to classify them as follows: blue cluster (Martins et al, 2015); green cluster (Vinodh et al, 2012; Infante et al, 2013; Hsu et al, 2014; Rowley et al, 2015; Vicente Galindo et al, 2015; Rahdari, 2016; Ren et al, 2016; Hussain et al, 2017; Mikušová, 2017; Kubule and Blumberga, 2019; Nara et al, 2019); and yellow cluster (Poplawska et al, 2015; Lähtinen et al, 2016; Karaman and Akman, 2018).

3.2.5 Category analysis

Table 3 presents a summary of the category analysis.

Table 3: Category analysis.

Reference	Type of model	Methods and techniques	Class	Type of company	Data source	Thematic cluster
(Krajnc and Glavič, 2005)	Single method	AHP	Multicriteria method	Chemical Industry	Secondary data	Green - Evaluation of corporate sustainability
(Kluczek, 2016)	Single method	AHP	Multicriteria method	Heating boilers	Judgments of specialist	Green - Evaluation of corporate sustainability
(Lenort et al, 2017)	Single method	AHP	Multicriteria method	Metallurgical Industry	Secondary data	Blue - Evaluation of sustainability of some aspects of the organizations
(Mikušová, 2017)	Single method	AHP	Multicriteria method	Not available	Judgments of specialist	Green -Evaluation of corporate sustainability
(Hussain et al, 2017)	Single method	AHP	Multicriteria method	Manufacturing and Assembly Industry	Judgments of specialist	Green - Evaluation of corporate sustainability
(Karaman and Akman, 2018)	Single method	AHP	Multicriteria method	Manufacturing and Assembly Industry	Judgments of specialist	Purple - Corporate social responsibility
(Martins et al, 2015)	Single method	AHP	Multicriteria method	Energy Sector	Secondary data	Blue - Evaluation of sustainability of some aspects of the organizations
(Pérez et al, 2017)	Single method	Fuzzy-AHP	Multicriteria method	Not available	Judgments of specialist	Blue - Evaluation of sustainability of some aspects of the organizations
(Poplawska et al, 2015)	Single method	ANP	Multicriteria method	Mining Industry	Judgments of specialist	Purple - Corporate social responsibility
(Debnath et al, 2018)	Single method	Fuzzy-ANP	Multicriteria method	Not available	Judgments of specialist	Purple - Corporate social responsibility
(Afful-Dadzie et al, 2016)	Single method	TOPSIS	Multicriteria method	Bank and Financial Institutions	Secondary data	Blue - Evaluation of sustainability of some aspects of the organizations
(Kubule and Blumberga, 2019)	Single method	TOPSIS	Multicriteria method	Manufacturing and Assembly Industry	Secondary data	Green -Evaluation of corporate sustainability
(Hsu et al, 2014)	Single method	TOPSIS with Grey Relational Analysis	Multicriteria method	Information Technology	Secondary data	Green -Evaluation of corporate sustainability
(Wang and Lin, 2007)	Single method	MAUT	Multicriteria method	Not available	Secondary data	Green -Evaluation of corporate sustainability
(Nara et al, 2019)	Single method	MAUT	Multicriteria method	Manufacturing and Assembly Industry	Judgments of specialist	Green -Evaluation of corporate sustainability
(Lähtinen et al, 2016)	Single method	SMART	Multicriteria method	Forestry	Judgments of specialist	Purple - Corporate social responsibility
(Chen et al, 2015)	Single method	TODIM	Multicriteria method	Construction Industry	Judgments of specialist	Purple - Corporate social responsibility
(Bilbao-Terol et al, 2018)	Single method	OWA	Multicriteria method	Bank and Financial Institutions	Secondary data	Purple - Corporate social responsibility
(Raj and Srivastava, 2018)	Single method	Fuzzy-BWM	Multicriteria method	Manufacturing and Assembly Industry	Judgments of specialist	Yellow - Creation of corporate sustainability indexes
(Infante et al, 2013)	Single method	ELECTRE III	Multicriteria method	Energy Sector	Secondary data	Green -Evaluation of corporate sustainability
(Wang et al, 2018)	Single method	Goal Programming	Optimization technique	Not available	Judgments of specialist	Green -Evaluation of corporate sustainability

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Table 3: (Continued)

Reference	Type of model	Methods and techniques	Class	Type of company	Data source	Thematic cluster
(García-Martínez et al, 2019)	Single method	Goal Programming	Optimization technique	Not available	Secondary data	Purple - Corporate social responsibility
(Garcia et al, 2016)	Single method	Goal Programming	Optimization technique	Energy Sector	Judgments of specialist	Green -Evaluation of corporate sustainability
(Diaz-Balteiro et al, 2011)	Single method	Compromise Programming	Optimization technique	Cellulose Industry	Judgments of specialist	Yellow - Creation of corporate sustainability indexes
(Küçükbay and Sürücü, 2019)	Single method	MOORA	Optimization technique	Chemical Industry and Manufacturing and Assembly Industry	Judgments of specialist	Green -Evaluation of corporate sustainability
(Venturelli et al, 2017)	Single method	Fuzzy Expert System	Other (AI technique)	Bank and Financial Institutions	Judgments of specialist	Purple - Corporate social responsibility
(Costa and Menichini, 2013)	Single method	Balanced scorecard (BSC) with 2-tuple fuzzy linguistic representation model	Other (Qualitative technique)	Not available	Judgments of specialist	Purple - Corporate social responsibility
(Tsai et al, 2009)	Integration of methods	DEMATEL, ANP, and 0-1 Goal Programming.	Multicriteria method + Optimization technique	Manufacturing and Assembly Industry	Secondary data	Purple - Corporate social responsibility
(Vinodh et al, 2012)	Integration of methods	AHP and ANP	Multicriteria method	Energy Sector	Judgments of specialist	Green -Evaluation of corporate sustainability
(Zhou et al, 2012)	Integration of methods	"Benefit of the doubt' approach and budget allocation process + NCMC	Others	Food Industry	Judgments of specialist	Green -Evaluation of corporate sustainability
(Rabbani et al, 2014)	Integration of methods	COPRAS and ANP	Multicriteria method	Energy Sector	Judgments of specialist	Purple - Corporate social responsibility
(Vicente Galindo et al, 2015)	Integration of methods	Principal Component Analysis, Logistic Regression and External Logistic Biplots	Others	Several	Secondary data	Green -Evaluation of corporate sustainability
(Rowley et al, 2015)	Integration of methods	Principal Component Analysis and Choquet Integral.	Others	Several	Judgments of specialist	Green -Evaluation of corporate sustainability
(Metaxas et al, 2016)	Integration of methods	Fuzzy-AHP and TOPSIS	Multicriteria method	Not available	Judgments of specialist	Yellow - Creation of corporate sustainability indexes
(Ren et al, 2016)	Integration of methods	AHP, ANP and PROMETHEE.	Multicriteria method	Energy Sector	Judgments of specialist	Green -Evaluation of corporate sustainability
(Lu et al, 2016)	Integration of methods	DEMATEL, ANP and VIKOR.	Multicriteria method	Manufacturing and Assembly Industry	Secondary data	Blue - Evaluation of sustainability of some aspects of the organizations
(Rahdari, 2016)	Integration of methods	AHP and TOPSIS with fuzzy linguistic variables.	Multicriteria method	Energy Sector	Judgments of specialist	Green -Evaluation of corporate sustainability

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Table 3: (Continued)

Reference	Type of model	Methods and techniques	Class	Type of company	Data source	Thematic cluster
(Hsu et al, 2017)	Integration of methods	QFD, Finite-difference methods, Fuzzy Extended-AHP, and TOPSIS.	Multicriteria method + other techniques	Not available	Judgments of specialist	Purple - Corporate social responsibility
(Liu, 2018)	Integration of methods	DEMATEL, ANP and VIKOR.	Multicriteria method	Not available	Judgments of specialist	Purple - Corporate social responsibility
(Bilbao-Terol et al, 2019)	Integration of methods	TOPSIS and Design of Experiments.	Multicriteria method + other techniques	Several	Secondary data	Purple - Corporate social responsibility
(Liern and Pérez-Gladish, 2018)	Integration of methods	TOPSIS and LOWGA.	Multicriteria method	Several	Judgments of specialist	Purple - Corporate social responsibility
(Vivas et al, 2019)	Integration of methods	PROMETHEE, Principal Component Analysis, and Multiple Linear Regression.	Multicriteria method + other techniques	Energy Sector	Secondary data	Blue - Evaluation of sustainability of some aspects of the organizations
(Zhao and Li, 2015)	Integration of methods	TOPSIS and ANP.	Multicriteria method	Energy Sector	Judgments of specialist	Purple - Corporate social responsibility

4 Discussion

Before discussing about the most frequently applied methods, it is important to present the baseline that we consider for the classification of the methods and techniques in the Multi-Criteria Decision Making/Aid (MCDM/A) area.

According to (Youssef, 2020), the use of optimization techniques for dealing with multicriteria problems creates a new branch of models named Multiple Objective Decision Making (MODM), for which there are an indefinite number of alternatives (the continuous case) that are confined by a set of optimal objective constraints. According to this author, a second branch named Multiple Attribute Decision Making (MADM) exist for dealing with situations in which the number of alternatives is predetermined and limited (the discrete case), and both (MODM and MADM) compose the MCDM/A area. However, in this study, as in various studies, the term MCDM/A is used to represent the MADM, that is, the discrete case only. From this point on, we will use only the term MCDM/A to refer to MADM.

Many methods have been drawn up for dealing with MCDM/A, the so called multicriteria methods. But various different type of techniques can be used for supporting multicriteria decision making problems, including Mathematical Programming techniques, AI techniques, qualitative techniques. Despite this, it does not make sense to classify them as multicriteria methods, because their range of application is much wider. Given this, (Schramm et al, 2020) presented a definition for multicriteria methods that is useful for differentiate techniques used in MCDM/A problems: "quantitative techniques that are able to recommend a best compromise solution, from a set of alternatives, to a decision maker based on his/her preferences, in a situation where there is no optimal solution; also, this solution can be presented in terms of ranking of alternatives from the best to the worst (ranking problematic), a classification of them into pre-defined sets (sorting problematic), or a recommendation of a unique alternative (choice problematic)". According to these authors, DEA (Data Envelopment Analysis) is outside the boundary of the multicriteria class of methods, but, in most of studies, however, it is referred as a multicriteria method.

Considering this, we identified three types of techniques used for corporate sustainability evaluation: multicriteria methods; optimization techniques, and a class named others that includes AI techniques, Qualitative techniques, and statistics and other mathematical techniques. These techniques are applied individually (∼63% of the models) or combined with other techniques. In the former group (single models), most of the models (∼74%) are based on multicriteria methods (∼37%); 18.5% used optimization techniques, such as Goal Programming (3 cases), Compromise Programming (1 case), and MOORA (1 case); and AI technique (1 case). Regarding the integrated models, multicriteria methods were combined with other techniques in various ways: two or more multicriteria methods; one or more multicriteria methods + Goal Programming; one or more multicriteria methods + other techniques.

In 43 models, fourteen different types of multicriteria methods were used 46 times: AHP, ANP, TOPSIS, MAUT, SMART, TODIM, OWA, LOWGA, BWM, COPRAS, VIKOR, DEMATEL, ELECTRE III, and PRO-METHEE. In almost half of the cases, the methods applied were AHP and its extension ANP. Moreover, only 7% (3 cases) of the models used outranking methods which are non-compensatory methods: ELECTRE III was applied individually; and PROMETHEE was applied integrated with statistical techniques and integrated with AHP. It is important to emphasize that the effect of compensation in the aggregation of sustainable indicators should be avoided and the use of compensatory multicriteria methods should be encouraged.

In general, these models are applied for evaluation of sustainability in the organizations as a whole and more than one third is concerned with the issue of Corporate Social Responsibility, which is considered by specialists as an effective strategy for improving company's image and reputation. Maybe for this reason, various of the models are intended for manufacturing industries in which the aspect of image and reputation is a critical issue. Only one model is intended for Construction Industry that is a key sector for the sustainable development of any region.

Regarding the assessment of indicators, most of the models (65%) used primary data obtained from judgment of specialists and the remaining (∼35%) used secondary data obtained from public documents, such as corporate reports. If the information is available and its quality is assured, it should be used; that is the case of the information provided by public corporate reports. However, some aspects of corporate

sustainability are subjective in nature, requiring an evaluation that depends on the background of someone who knows the day-to-day of the organization. In this sense, we believe that an evaluation based on the combination of secondary data and judgment of specialists should be encouraged.

4.1 Study limitations

This study focused only on approaches that seek to evaluate the performance of organizations in relation to sustainability. In this sense, this cut excluded works that address sustainability in other thematic areas, such as research on supply chain, waste management, analysis of the life cycle of products, processes and projects, among others. Moreover, this study points out that corporate sustainability is formed by a set of thematic subcategories, however, the themes were not analyzed in a longitudinal perspective, which allows to identify which themes were worked on during the analyzed period or in specific periods.

5 Conclusions

This study provides a literature review of 43 papers, which were published in peer-reviewed journal between 2005 and 2019, concerned with multicriteria evaluation of corporate sustainability. The goal is to identify the most frequently used methods and techniques, to identity the types of organization in which these evaluations are being performed, and to understand the dynamic of research.

The analysis was divided into descriptive analysis and qualitative analysis. In the former, we identified distribution of the papers over the years and the main journals in which the papers were published. The qualitative analysis was performed according to five structural dimensions: (i) type of model, whose analytic categories are single method (to those models that are based on a only single method) and integration of methods (to those models that are based on integration of methods); (ii) class of method to classify the used methods according to its nature (multicriteria method, optimization technique, and others); (i) type of company, for which the models are intended to; (iv) data sources, related to the data used for assess the indicators; and (v) thematic cluster, which organizes the publications according to connections that they have with each other.

Most of the models are based on compensatory multicriteria methods, such as AHP, ANP, and TOPSIS. However, we recommend using non-compen-satory multicriteria methods, such as ELECTRE and PROMETHEE family of methods, to avoid, or at least reduce, the effect of compensation among the sustainability dimensions and criteria. Also, we recommend the combination of corporate reports judgment of specialists to assess the indicators used for evaluation of sustainability. Finally, the evaluation of organizations considering a Corporate Social Responsibility perspective seems to be a research trend.

This study provides a contribution for future research, especially those that seek to develop or adapt methodologies to assess corporate sustainability, as it contributed to: i) indicate different thematic fields related to the theme; ii) present a multiplicity of techniques that can assist in the selection of methodologies; iii) map the main references that operate in this field of knowledge; iv) identify the main journals in the area, which can be used to guide researchers in the selection of publications' sources in the area.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Apêndice II: Revisão da literatura sobre modelos para avaliar a sustentabilidade corporativa

International Journal of Sustainable Engineering

A literature review on models for assessing corporate sustainability

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Keywords:	Sustainable business models, Engineering design for sustainable development, Environmental performance indicators, Sustainable supply chain management
User-Supplied Keywords:	Triple Bottom Line (TBL), Sustainability Evaluation, Corporate Governance, Corporate Sustainability Indicators

REVIEW ARTICLE

A literature review on models for assessing corporate sustainability

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This paper presents a literature review on models for assessing corporate sustainability that were published in peer-reviewed indexed journals in the last two decades. The review aims to identify the dimensions and main indicators used in these models, the sources used for assessing these indicators, and the sectors for which these models are being proposed/applied. Most of the studies are based on the concept of TBL and some of them integrates TBL with a dimension that evaluates aspects of governance. In various cases TBL is not considered and there are some studies in which only one single dimension is considered. In general, the indicators used were collected from specialized literature, corporate sustainability reports, international standards and Specialists' evaluation. We also present the most relevant indicators for each dimension used to assess sustainability and identify that the models were applied to different companies from different sectors.

KEYWORDS
Triple Bottom Line (TBL), Sustainability Evaluation, Corporate Governance, Corporate Sustainability Indicators

[*] Equally contributing authors.

1 | INTRODUCTION

Every year, we observe the increasing in the number of sustainable consumers who incorporate sustainability issues into their consumption behavior. Beyond consumption habits itself, these new class of consumers desire that the value generated by the organizations that produce goods and services should provide gains not only for its shareholders, but it also should have a positive impact for the environment and society as a whole. Eyeing this new market, investors are looking for corporations that have been adopting sustainability practices to their processes and policies.

In this context, instruments for evaluation of corporate sustainability became necessary. Sustainability reports have become popular in the last years and have being proposed by different nonprofit organizations worldwide to evaluate sustainability of companies in different segments and regions. The most widely used is the Global Reporting Initiative (GRI) (Garcia, Cintra, Torres, & Lima, 2016) that is produced by an independent international organization, aiming to produce a global common language for organizations to report their impacts. Other frequently applied instruments are the Dow Jones Sustainability Index (DJSI) to evaluate the sustainability of various publicly traded companies. A similar instrument named Corporate Sustainability Index was developed to evaluate companies listed in the São Paulo Stock Exchange (BM & FBOVESPA). Still in Brazil, we have the indicators proposed by the Ethos Institute, which is civil society organization whose goal is to support private companies to manage their businesses adopting sustainability principles.

Besides these instruments, many models for assessing corporate sustainability have been proposed in the specialized literature. Most of them are based on the Triple Bottom Line (TBL) concept, for which sustainability is assessed considering evaluation criteria that encompass economic, social and environmental perspectives (some examples are: Kubule and Blumberga (2019); Liern and Pérez-Gladish (2018); Vivas, Sant'anna, Esquerre, and Freires (2019); L. Wang and Lin (2007). However, there are models in which the meaning of sustainability is wider, while in others is more restrict, in some cases considering only one perspective.

A. A. Feil, de Quevedo, and Schreiber (2015) affirm that sustainability reports and models have aroused notable interest from academics and business managers, and consequently examining these instruments seems to be a promising field of research. The investigation of these instruments is an exercise that allows the constant development of quality of the indicators that seem to seek more appropriate answers to society's desires (Silva, Freire, & Silva, 2014). Morioka, Iritani, Ometto, and de Carvalho (2018) add that there is a demand for studies on the development, implementation and improvement of tools that integrate the logic of sustainability and business management.

Some researches aimed to analyze and compare these instruments: A. Feil, Schreiber, Haetinger, Strasburg, and Barkert (2019); A. A. Feil and Schreiber (2017); Morioka et al. (2018); Silva et al. (2014). These studies provide an important contribution to this thematic field; however, they are still superficial in terms of analysis of the dimensions and indicators considered and other issues that are relevant for the development, implementation and improvement of these instruments.

In this paper, we performed a literature review on models for assessing corporate sustainability that were published in peer-reviewed indexed journals in the last two decades. The review aims to identify the dimensions and main indicators used in these models for assessing sustainability, the sources used for assessing these indicators, and the sectors for which these models are being proposed/applied. This study contributes to extend the discussion on corporate sustainability evaluation that can be useful for both Academia and Corporations. The remainder of the paper is organized into four sections: Section 2 presents the methodological procedures; Section 3 shows the analysis of the papers; Section 4 presents the discussion of the results; and Section 5 presents the conclusions.

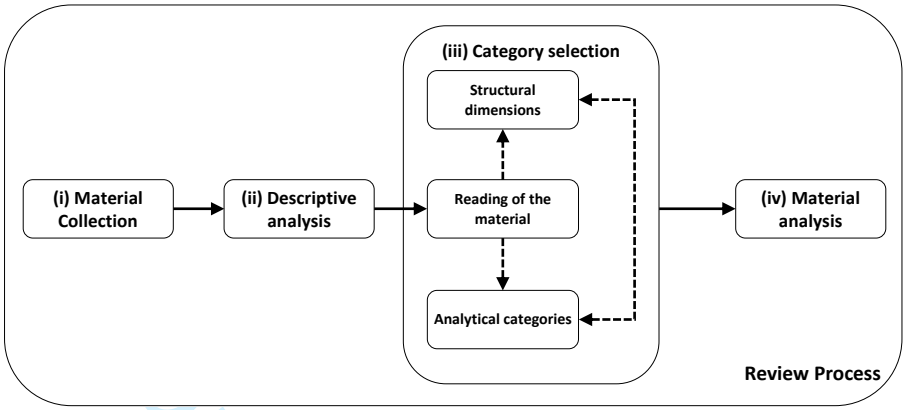

FIGURE 1 The flowchart of the review process.

TABLE 1 Parameters of the search in the Web of Science™

Parameter	Input
Keywords	TS=("sustainab*" OR "sustainab* performanc*" OR "sustainab* ind*" OR "sustainab* dimensio*") AND TS=("business*" OR "compan*" OR "organization*" OR "industr*" OR "supply chain*") AND TS=("triple bottom line" OR "TBL" OR "social dimension*" OR "economic dimension*" OR "environmental dimension*").
Indexes	Science Citation Index - SCI, Science Citation Index Expanded - SCIE, Social Science Citation Index (SSCI), Arts and Humanities Citation Index (A&HCI), and Emerging Sources Citation Index (ESCI).
Document Type	"All document types".
Timespan	1990-2019
Language	English and Portuguese

2 | RESEARCH METHODOLOGY

The review follows the four-step iterative process described in Seuring and Müller (2008): (i) material collection, which includes the definition and delimitation of the materials to be analyzed; (ii) descriptive analysis, which presents the distribution of the papers over the years, the journals with the highest number of publications, and main authors on this topic; (iii) category selection, in which we identified the structural dimensions and analytical categories to evaluate the papers; and (iv) material analysis based on the proposed evaluation framework. Figure 1 shows the review process.

2.1 | Material collection

The review was performed in May 2020 using the Web of Science™ Core Collection database. Table 1 shows the parameters used in the search.

The criteria used for the selection of the papers are set out below: papers should present a model to assess corporate sustainability or apply an approach that already exists in the literature; assessing corporate sustainability includes measuring the performance of organizations and / or the performance of sustainable production practices or processes. Thus, papers that don't meet the boundary limit defined for this study were removed from the base.

The search returned 1,239 papers that had been submitted to a preliminary analysis, by reading the title, keywords, and abstract. After that, 844 papers were removed, resulting in 395 articles that were read in full. Then, more 327 papers were removed, resulting in 68 papers to be analyzed.

2.2 | Category Selection

For supporting the qualitative analysis of the papers, we used the software NVivo. The extent we were reading the papers, we select some relevant fragment of the text and encode it using the NVivo. For each encoded fragment, the NVivo creates a node (or a hierarchy of nodes) that is a structure to store information gathered from the papers. The meaning of the nodes depends on the methodological approach used (Lage, 2010). In our study, we use the content analysis approach and the hierarchy of nodes represent categories of information, that is, the dimensions (1st level) and their respective categories (2nd level). This tree node structure is the framework for analysis of the papers (Table 2). This framework allows to identify the dimensions and main indicators used in the models for assessing sustainability, the sources used for assessing the indicators, the sectors for which the indicators are being proposed/applied.

TABLE 2 Category analysis.

Structural Dimensions	Analytical categories	Description
Sustainability dimensions	Economic	It involves the company's economic performance and the organization's contribution to the economy. Includes profit, cost, investment, etc.
	Social	It refers to beneficial and fair actions taken for employees and the community, such as human rights, diversity, health and safety, etc.
	Environmental	It deals with the efficient use of environmental resources. Includes environmental management system, emission control, water, etc.
	Governance	It deals with the relationship between stakeholders and the structure that directs and controls organizations. It includes ethics and anti-corruption, policy, strategy, etc.
	Social + Environmental	It deals with Social and Environmental dimensions simultaneously.
	TBL	It deals with Economic, Social and Environmental dimensions simultaneously.
	Economic + Social + Governance	It deals with Economic, Social and Governance dimensions simultaneously.
	Social + Environmental + Governance	It deals with Social, Environmental and Governance dimensions simultaneously.
	TBL + Governance	It deals with Economic, Social, Environmental, and Governance dimensions simultaneously.
Input sources	Specialized literature	Specialized literature on the topic (scientific papers, books, and others).
	Corporate sustainability reports	Reports from companies and rating agencies and corporate sustainability assessment.
	Specialists' evaluation	Specialists' evaluation performed through interviews, workshop, questionnaire, etc.
	Specialized literature + Corporate sustainability reports	Integration of Specialized literature and international sustainability reports.
	Specialized Literature + Specialists' evaluation	Integration of Specialized literature and Specialists' evaluation.
	Corporate sustainability reports + Specialists' evaluation	Integration of Corporate sustainability reports and Specialists' evaluation.
	Corporate sustainability reports + Specialized literature + International Standards	Integration of Corporate sustainability reports, Specialized literature, and International standards such as ISO - International Organization for Standardization.
Sectors/Areas	Energy Sector	Includes substances such as fuels, oil products and electricity in general.
	Transport and Logistics	It deals with the transport of people and goods. Includes airlines, airfreight and logistics, transportation infrastructure, etc.
	Materials Sector	It covers production inputs, materials for infrastructure, steel and other goods. Includes mining, metals, forest products, chemicals, etc.
	Commercial and Professional Services	Includes immaterial goods, such as commercial supplies and other diversified support services.
	Automotive Industry	It consists of the auto parts chain and the light and heavy vehicle segment (Includes Automotive Components and Car Manufacturers).
	Discretionary Consumer Goods	It includes consumption sensitive to economic cycles, such as electronics, clothing, accessories, furniture, etc.
	Consumer Goods	It includes non-durable goods, which need to be replaced frequently, such as food, drinks, tobacco, etc.
	Banking and Financial Services	It involves diversified financial services (capital markets, investment bank and brokerage, etc.)

Continued on next page

Table 2: (Continued)

Structural Dimensions	Analytical categories	Description
	Healthcare	Includes health equipment and services provided to individuals, for example, Medical Assistance, Health Technology, Biotechnology, etc.
	Capital Goods	These are necessary goods for the production of other goods and facilities, such as machinery and equipment, construction and engineering, etc.
	Various	The model was proposed/applied to more than one of the above sectors.
Sustainability indicators	Economic	Indicators related to the Economic dimension.
	Social	Indicators related to the Social dimension.
	Environmental	Indicators related to the Environmental dimension.
	Governance	Indicators related to the Governance dimension include operational aspects of organizations' horizontal and vertical departments, the relationship between stakeholders and the company's position in the market.
	Others	Indicators that are not part of the Triple Bottom Line concept (Governance, institutional, internal processes, etc.).

The extent we were reading the papers, we used the NVivo to address each segment of the text to the proper category in the framework, allowing the qualitative analysis the papers as it is presented in the next section.

3 | ANALYSIS

3.1 | Distribution of the papers per year, journals and authors

Although our review encompasses the period 1990-2019, the first paper was published in 2002 and it proposes a model for measuring the progress of institutions based on Agenda 21 (Spangenberg, 2002). Figure 2 presents the evolution of the papers over the years, from 2002 to 2019.

In 2015, the world confirmed its commitment to the 2030 Agenda for Sustainable Development, which is an action program for people, the planet and prosperity with the aim of improving the quality of life (Hristov & Chirico, 2019). This can explain the increasing in the number of publications in the last five years: ~70% of the publications are concentrated between 2015 and 2019 (average of 9,6 articles per year). The papers were distributed into 34 different journals. Only 3 journals have more than 2 publications on this topic: Journal of Cleaner Production (12 papers, ~18%), the Sustainability Journal (8 papers, ~12%), and the Management of Environmental Quality (3 papers, ~4%). Figure 3 presents the journals with the highest volume of publications.

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Four authors appear with at least three different publications concerning corporate sustainability indicators: Goran Svensson, from Norway, who studies corporate sustainability, ethics, marketing, supply chain and service management; Carmen Padin, from Spain, who studies applied economics, tourism and sustainability; Beverly Wagner, from Scotland, who studies supply chain, innovation management and sustainability; and Lu Wang, from Beijing/China, who investigates metal-organic structures. Most of authors (95%) published only one article and while 3% published 2 papers.

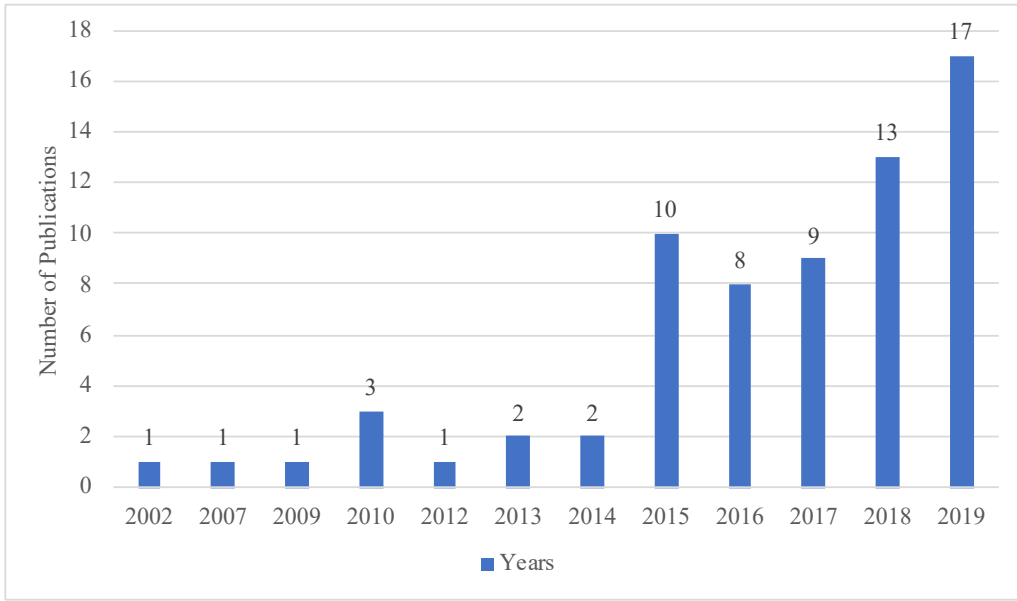

FIGURE 2 Distribution of the papers per year.

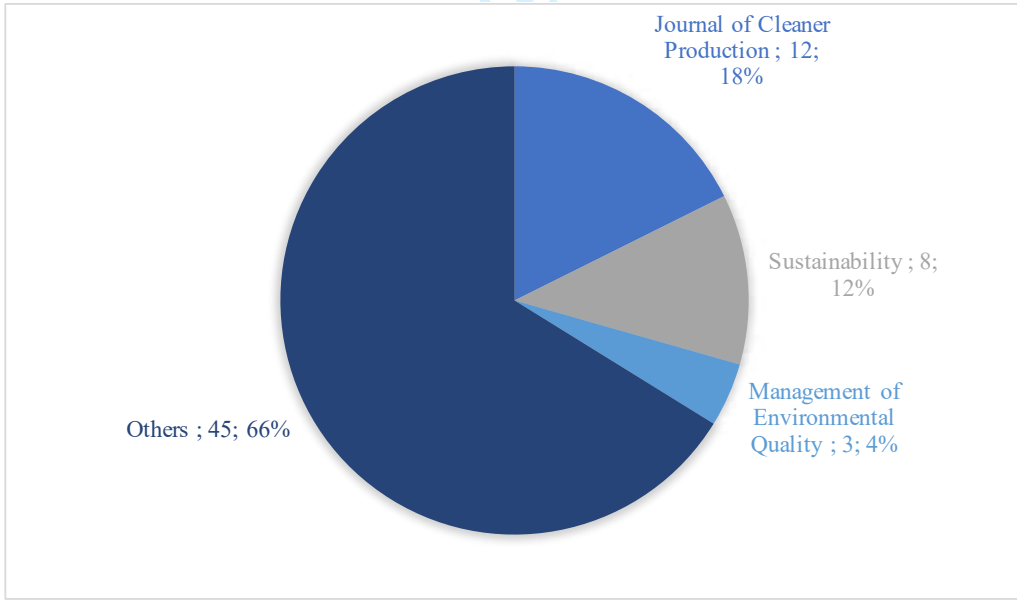

FIGURE 3 Distribution of the papers per journals.

3.2 | Sustainability dimensions

In 66% of the cases (45 papers), corporate sustainability is evaluated considering the triple bottom line, that is, economic, environmental and social dimensions simultaneously: Ahmad, Wong, and Rajoo (2019); Amoako, Lord, and Dixon (2017); Antolín-López, Delgado-Ceballos, and Montiel (2016); Baumgartner and Ebner (2010); Braccini and Margherita (2018); Buys, Mengersen, Johnson, van Buuren, and Chauvin (2014); Charmondusit, Phatarachaisakul, and Prasertpong (2014); da Silva Batista and de Francisco (2018); de Campos and Simon (2019); Dos Santos, Svensson, and Padin (2013); Escamilla-Solano, Fernández-Portillo, Paule-Vianez, and Plaza-Casado (2019); A. Feil et al. (2019); A. A. Feil et al. (2015); Froehlich and Bitencourt (2016); Garcia et al. (2016); Gómez-Navarro, García-Melón, Guijarro, and Preuss (2018); Hilsdorf, de Mattos, and de Campos Maciel (2017); Høgevold et al. (2015); Høgevold, Svensson, Rodriguez, and Eriksson (2019); Hourneaux Jr, Gabriel, and Gallardo-Vázquez (2018); Hristov and Chirico (2019); Huang and Badurdeen (2017); Hubbard (2009); Infante, de Mendonça, Purcidonio, and Valle (2013); Karaman and Akman (2018); Kolk, Hong, and van Dolen (2008); Laurell, Karlsson, Lindgren, Andersson, and Svensson (2019); Lenort, Staš, Wicher, Holman, and Ignatowicz (2017); Lucato, da Silva Santos, and Tadeu Pacchini (2017); Nara et al. (2019); Ocampo, Clark, and Promentilla (2016); Oginni and Omojowo (2016); Oliveira, Zanella, and Camanho (2019); Rai (2015); Reis, Jacomossi, and Casagrande (2015); Sarango-Lalangui, Álvarez-García, and del Río-Rama (2018); Svensson et al. (2016); Svensson and Wagner (2015); Thabrew, Perrone, Ewing, Abkowitz, and Hornberger (2018); C. Wang, Wang, and Dai (2018); L. Wang and Lin (2007); Z. Wang, Subramanian, Gunasekaran, Abdulrahman, and Liu (2015); Zahid and Ghazali (2015).

Madan Shankar, Kannan, and Udhaya Kumar (2017) considered the triple bottom line, but the social dimension was modeled addpoting a perspective that is focused on the healthy and safety of individuals. Instead of using the term social, they named the third dimension as employee safety, encompassing issues such as training and education programs, use of personal protective equipment, etc. Hussain, Alameeri, and Ajmal (2017) extend the focus on healthy and safety to coroporate's customers.

In addition to the triple bottom line, some studies consider an extra dimension that encompasses issues on ethics, strategies, business policies, relationship with stakeholders: Aras, Tezcan, Kutlu Furtuna, and Hacioglu Kazak (2017); Schrippe and Ribeiro (2019); L. Wang, Ma, Wu, Chiu, and Nathaphan (2018). This fourth dimension have been called by its authors governance, corporate governance, corporate sustainability. K. E. K., S., and Gurumurthy (2018) added a dimension named business, for dealing with conflict management and organization image. And Loor Alcívar, González Santa Cruz, Moreira Mero, and Hidalgo Fernández (2020) added to the triple bottom line a dimension named corporate identity, which focuses on the company's vision and mission. Despite the different nomenclature the dimensions also evaluate one or more aspects of governance, which encompasses every sphere of management.

Governance was also considered in the study of Bonsón and Bednárová (2015) and Muñoz-Torres, Fernández-Izquierdo, Rivera-Lirio, and Escrig-Olmedo (2019). However, in the former, the environmental dimension was suppressed, and only economic and social aspects were considered in combination with governance issues. While in the second study, authors suppressed the economic dimension, remaining environmental, social and governance dimensions.

Some studies considered only environmental and social dimensions simultaneously: Amor-Esteban, Galindo-Villardón, and García-Sánchez (2019); Cowper-Smith and de Grosbois (2011); Esteban, Villardón, and Sánchez (2017); Nikolaou, Tsalis, and Evangelinos (2019).

Others studies evaluated sustainability considering a single perspective: Regarding the environmental dimensions, we found the following studies: Cubilla-Montilla, Galindo-Villardón, Nieto-Librero, Vicente Galindo, and García-Sánchez (2020); Nallusamy, Ganesan, Balakannan, and Shankar (2015); Silva et al. (2014). As for social dimension, we

found the following studies: Ajmal, Khan, Hussain, and Helo (2018); Hutchins, Richter, Henry, and Sutherland (2019); Paredes-Gazquez, Rodriguez-Fernandez, and de la Cuesta-Gonzalez (2016). Staniškienė and Stankevičiūtė (2018) evaluated the social dimension over a perspective of relationship with employees, including employee participation, cooperation, equal opportunities, employee development, health and safety, and partnership. Spangenberg (2002) evaluated corporate sustainability considering a governance perspective, based on the idea that organizations have a structure guided by implicit and explicit internal rules. Deng, Wen, Chen, and Lin (2018) and Lu, Kuo, Lin, Tzeng, and Huang (2016) proposed an evaluation of corporate sustainability considering the perspective focused on governance aspects (learning and growth, internal processes, customers and finance) without care about what happens beyond its boundaries; the indicators focus on maintaining and increasing economic performance; some of the criteria are: employee productivity, increasing management efficiency, corporate image, etc.

Roca and Searcy (2012) and Rowley, Geschke, and Lenzen (2015) did not present the dimensions that they user for evaluation of corporate sustainability.

3.2.1 | Input sources

In 43% of the cases (29 papers), sustainably indicators adopted in these studies were obtained from the specialized literature. This group includes: Amor-Esteban et al. (2019); Braccini and Margherita (2018); Charmondusit et al. (2014); Esteban et al. (2017); A. Feil et al. (2019); A. A. Feil et al. (2015); Froehlich and Bitencourt (2016); Hilsdorf et al. (2017); Høgevold et al. (2015, 2019); Hristov and Chirico (2019); Huang and Badurdeen (2017); Hussain et al. (2017); K. E. K. et al. (2018); Karaman and Akman (2018); Loor Alcívar et al. (2020); Lu et al. (2016); Madan Shankar et al. (2017); Nallusamy et al. (2015); Nikolaou et al. (2019); Oginni and Omojowo (2016); Paredes-Gazquez et al. (2016); Spangenberg (2002); Svensson et al. (2016); Thabrew et al. (2018); C. Wang et al. (2018); L. Wang et al. (2018); Zahid and Ghazali (2015).

In 29% (20 papers), authors used indicators obtained from corporate sustainability reports published by companies and specialized agencies. Most of them (~74%) adopted indicators provided by the Global Reporting Initiative (GRI).

The following studies adopted GRI indicators only: Ahmad et al. (2019); Ajmal et al. (2018); Baumgartner and Ebner (2010); Cubilla-Montilla et al. (2020); de Campos and Simon (2019); Garcia et al. (2016); Gómez-Navarro et al. (2018); Infante et al. (2013); Lenort et al. (2017); Rai (2015); Silva et al. (2014).

Beyond GRI, Cowper-Smith and de Grosbois (2011) adopted indicators provided by the United Nations Environmental Program and the World Tourism Organization, which is an agency associated with the United Nations that seeks to promote sustainable tourism. Amoako et al. (2017) adopted GRI and reports from the United Nations Division of Sustainable Development (UNDSD). Finally, Roca and Searcy (2012) adopted GRI and sustainability reports from Canadian companies.

As an alternative do the GRI, Bonsón and Bednárová (2015) adopted a set of non-financial indicators provided by the AECA (acronym in Spanish to Asociación Española de Contabilidad y Administración de Empresas) for evaluation of Eurozone's companies. The AECA's non-financial (NI) indicators aim to reduce the lack of balance between the indicators evidenced by other structures such as the GRI, which focuses on governance guidelines.

Still in the European ambit, Escamilla-Solano et al. (2019) adopted reports from different companies and indicators provides by the European Commission, which is an European institution for promoting economic, political, and social cooperation and integration.

Indicators provided by two Brazilian organizations also appeared: Schrippe and Ribeiro (2019) adopted the Corporate Sustainability Index proposed by the São Paulo Stock Exchange (BM&FBOVESPA); and Sarango-Lalangui et al.

(2018) adopted Indicators of the Ethos Institute.

Ocampo et al. (2016) were based on the Sustainable Manufacturing Indicator Repository (SMIR) which provides different databases and indicators categorized by topics to measure their sustainability performance.

Dos Dos Santos et al. (2013) evaluated the sustainability of a retail chain and adopted indicators collected from annual reports produced by the company itself.

In some cases (9% of the papers), authors used studies published in the specialized literature combined with corporate sustainability reports: GRI, United Nations Environment Program Financial Initiative (UNEP-FI), and Association of Chartered Certified Accountants (ACCA) (Aras et al., 2017); and GRI (Hourneaux Jr et al., 2018; Hubbard, 2009; Reis et al., 2015; Z. Wang et al., 2015).

In 10% of the cases (7 papers), sustainably indicators were proposed based on judgment of specialists collected through interviews, workshop, questionnaire, etc.: Buys et al. (2014); da Silva Batista and de Francisco (2018); Hutchins et al. (2019); Kolk et al. (2008); Laurell et al. (2019); Nara et al. (2019); Staniškienė and Stankevičiūtė (2018).

Some studies (4% of the cases) adopted judgment of specialists combined with corporate sustainability reports (Muñoz-Torres et al., 2019; Rowley et al., 2015; L. Wang & Lin, 2007). Other studies (3%) adopted judgment of specialists combined with specialized literature sources (Deng et al., 2018; Lucato et al., 2017).

Antolín-López et al. (2016) and Oliveira et al. (2019) were based on specialized literature, corporate sustainability reports (GRI, DJSI, etc.), and international standards (ISO 26000), which deals with social responsibility and aims to help organizations to incorporate social and environmental practices.

3.2.2 | Sustainability indicators

The 583 indicators identified were grouped into four analytical categories: economic, social, environmental, and other.

The economic dimension of the TBL is concentrated on the economic value generated by the company and on the organization's contribution to the economy (Elkington, 1999). This dimension comprises 93 sub-indicators and the most relevant are: Profit, Cost, Revenue, Expense, Economy, Investment, and other economic values. Table 3 shows these criteria.

TABLE 3 Indicators based on the economic dimension of the Triple Bottom Line.

Indicator	Description
Profit	It refers to the financial gains achieved by the company. Includes the value created per employee, per share, etc.
Cost	It gathers data and information on the value directed to the production of goods and services. It includes the cost per unit produced, the cost of recycling, etc.
Revenue	It deals with the amount received resulting from the sale of products and services, such as total service revenue., Gross revenue amount, etc.
Expense	Amount that is not intended for the production of goods and services, such as tax expense, customer expense, etc.
Economy	Evaluates the company's contribution to the economy of regions, such as job and income creation.
Investment	Corresponds to the resources applied in order to bring benefits to the company / society, such as investment in research activities, infrastructure, etc.

Continued on next page

Table 3: (Continued)

Indicator	Description
Other economic indicators	It includes other data on the company's equity and the performance of the company's financial capital, such as cash flow, EBITDA margin, total assets, etc.

The social dimension of the TBL includes conducting beneficial and fair practices for employees, human capital and the community (Elkington, 1999). This dimension grouped 174 sub-indicators and the most relevant: Employees, Community, Health and safety, Human capital, Human rights, and Diversity and social equity. Table 4 shows these criteria.

TABLE 4 Indicators based on the social dimension of the Triple Bottom Line.

Indicator	Description
Employees	They explore the company's relationship with its employees. It includes employee participation, performance evaluation, guarantee of labor rights, etc.
Community	It studies the company's relationship with the local community. It includes donations, sponsorships, investments and other actions that positively impact society.
Health and safety	It covers data collection and actions taken by the company to ensure the health and safety of employees and the community, such as health and safety systems, injury rates, occupational diseases, etc.
Human capital	It includes opportunities that the company offers for the development of employees, such as training, qualifications, access to resources, etc.
Human rights	It deals with the company's respect for human rights, such as the number of agreements that incorporate human rights issues, guaranteeing the rights of minority professionals, clients, etc.
Diversity and social equity	It includes offering equal opportunities for employee development and respect for diversity and social equity.

The environmental dimension of TBL involves the efficient use of administrative resources not to compromise future generations (Elkington, 1999). This category gathered 113 sub-indicators and the most relevant are: Biodiversity, Environmental management system, Emissions, Water, Energy, and Waste. Table 5 shows these criteria.

TABLE 5 Indicators based on the environmental dimension of the Triple Bottom Line.

Indicator	Description
Biodiversity	Current planning and actions for managing impacts generated on biodiversity, such as assessing the quality of natural habitat, planting trees, etc.
Environmental management system	It includes environmental practices and tools used by the company to contribute to sustainable development, such as Eco-innovation, Eco-efficiency, Sustainability Forum, etc.

Continued on next page

Table 5: (Continued)

Indicator	Description
Emissions	It involves the registration of total emissions and the prevention and control initiatives carried out by the company. It includes the direct or indirect amount of emissions, air quality, etc.
Water	Water use and efficiency practices considered by the company. It includes direct and indirect water consumption, the proportion of renewable water used, etc.
Energy	Initiatives for energy use and efficiency carried out by the company. It includes investment in energy projects, consumption of renewable energy, consumption of non-renewable energy, etc.
Waste	It studies practices adopted by the company to reduce, reuse, recycle and ensure the correct environmental destination for waste. Includes survey of the amount of waste generated, amount recycled, reverse logistics, etc.

The governance dimension encompasses every sphere of management, from company's objectives, to action plans and internal controls, performance measurement, corporate disclosure, and relationship with its various stakeholders (shareholders, employees, customers, suppliers, financiers, the government, and the community). This group comprises 203 sub-indicators and the most relevant are: Governance, Internal process, Customer, Compliance with legislation, Ethics and anti-corruption, Communication, Policy, Strategy, Supply chain, Company and Product. Table 6 shows these criteria.

TABLE 6 Governance dimension indicators.

Indicator	Description
Governance	It understands the management practices adopted by the company, it mainly considers the management of the relationship with the interested parties.
Internal process	It includes the evaluation of the results of the production processes of goods and services, also considering the management of materials and other resources used in the activities of the companies, example: Total production, investments in new technologies and updating of infrastructure, etc.
Customer / consumer	Relationship management with customers and consumers. Includes customer view, customer retention rate, customer satisfaction survey, etc.
Compliance with legislation	It deals with the company's behavior in relation to social laws and regulations, including product rules, regulatory notices.
Ethics and anti-corruption	It includes an ethical posture in business, the prevention and combating of opportunistic attitudes, such as code of ethics, policy and corporate anti-corruption standard, etc.
Communication	It involves transparent communication with stakeholders, including reports, number of complaints, sustainability certificates, etc.
Policy	It involves the creation of corporate policies and the defense of society's interests, collaborating with the development of public policies. Includes anti-bribery policies, contributions to political parties, etc.

Continued on next page

Table 6: (Continued)

Indicator	Description
Strategy	It deals with the company's position in the market, such as competitiveness, systemic vision, objectives and goals, corporate identity, etc.
Supply chain	It involves resources and actions taken from the acquisition of raw materials to sending products or services to customers / consumers. Includes supplier assessment, storage and logistics, etc.
Company	They consider traditional topics of general administration and for the conduct of associations. It includes organizational culture, organizational structure, marketing practices, etc.
Product	It includes traditional aspects considered in product development and the incorporation of environmental criteria, such as advanced product design, quality and durability, etc.

3.2.3 | Sector

In 46% of cases (31 papers), the studies were intended to only one sector: Materials Sector (Ahmad et al., 2019; Amoako et al., 2017; Braccini & Margherita, 2018; Lenort et al., 2017; Ocampo et al., 2016; Oliveira et al., 2019); Energy Sector (Garcia et al., 2016; Infante et al., 2013; Paredes-Gazquez et al., 2016); Transport and Logistics (Cowper-Smith & de Grosbois, 2011; Karaman & Akman, 2018; Thabrew et al., 2018); Automotive Industry (Hilsdorf et al., 2017; Hussain et al., 2017; Nallusamy et al., 2015; Z. Wang et al., 2015); Discretionary Consumer Goods (Charmondusit et al., 2014; A. A. Feil et al., 2015; Huang & Badurdeen, 2017; Lu et al., 2016; Madan Shankar et al., 2017); Consumer Goods (Buys et al., 2014; Nara et al., 2019); Banking and Financial Services (Aras et al., 2017; Escamilla-Solano et al., 2019; Rai, 2015); Commercial and Professional Services (Deng et al., 2018; Gómez-Navarro et al., 2018; Muñoz-Torres et al., 2019; L. Wang et al., 2018; Zahid & Ghazali, 2015).

Figure 4 shows the distribution of studies in this group based on the sectors evaluated.

Other studies (16% or 11 papers) were concerned with evaluation of sustainability of companies from different sectors: Energy Sector and Materials Sector (Silva et al., 2014); Banking and Financial Services, Healthcare, Energy Sector, etc. (Amor-Esteban et al., 2019); Materials Sector and Discretionary Consumer Goods (Froehlich & Bitencourt, 2016); Banking and Financial Services, Energy Sector, Materials sector, etc. (Reis et al., 2015); Healthcare, Consumer Goods, Materials Sector, among others (Rowley et al., 2015); Commercial and Professional Services and Consumer Goods (Oginni & Omojowo, 2016); Automotive Industry, Banking and Financial Services, Consumer Goods, Healthcare, Materials Sector, Commercial and Professional Services, etc. (Bonsón & Bednárová, 2015); Materials Sector, Energy Sector, Banking and Financial Services, Capital Goods, etc. (Roca & Searcy, 2012); Energy Sector, Transport and Logistics, etc. (Schrippe & Ribeiro, 2019); Discretionary Consumer Good, Consumer Goods, Commercial and Professional Services, etc. (Svensson & Wagner, 2015); Commercial and Professional Services, Capital Goods, etc. (Svensson et al., 2016).

The rest of the studies, 38% of the sample (26 papers) do not show the sector studied.

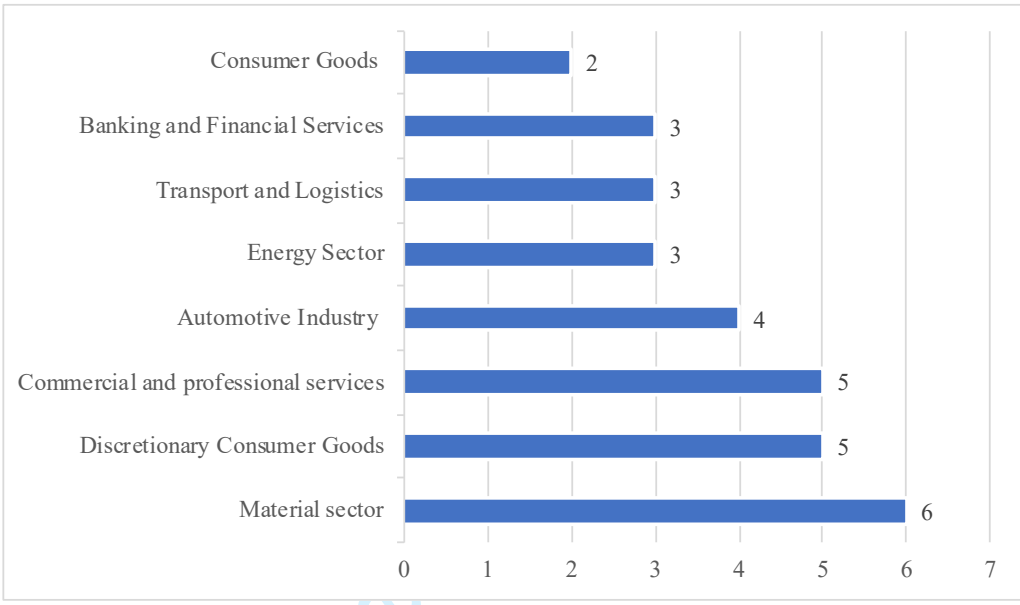

FIGURE 4 Distribution of studies based on the sectors evaluated.

3.2.4 | Category analysis

Table 7 presents a summary of the category analysis.

TABLE 7 Summary of the category analysis.

ID	Dimensions	Source of indicators	Sector	Reference
1	Governance	Corporate sustainability reports + Specialists' evaluation	Commercial and Professional Services	Muñoz-Torres et al. (2019)
2	Environmental	Corporate sustainability reports	N/A	Cubilla-Montilla et al. (2020)
3	TBL	Corporate sustainability reports + Specialized literature + International Standards	N/A	Antolín-López et al. (2016)
4	TBL	Corporate sustainability reports	Commercial and Professional Services	Gómez-Navarro et al. (2018)
5	TBL + Governance	Specialized literature	N/A	Loor Alcívar et al. (2020)
6	TBL + Governance	Specialized literature + Corporate sustainability reports	N/A	Aras et al. (2017)
7	TBL	Specialized literature	N/A	Høgevold et al. (2019)
8	TBL	Corporate sustainability reports	Banking and Financial Services	Escamilla-Solano et al. (2019)
9	TBL	Corporate sustainability reports	Banking and Financial Services	Rai (2015)
10	Environmental	Corporate sustainability reports	Various	Silva et al. (2014)
11	TBL	Specialized literature	Materials Sector	Ahmad et al. (2019)
12	Social	Corporate sustainability reports	N/A	Ajmal et al. (2018)
13	TBL	Specialized literature	N/A	de Campos and Simon (2019)
14	TBL	Corporate sustainability reports	Materials Sector	Amoako et al. (2017)
15	Social + Environmental	Specialized literature	Various	Amor-Esteban et al. (2019)
16	TBL + Governance	Specialized literature	N/A	K. E. K. et al. (2018)
17	TBL	Corporate sustainability reports	N/A	Baumgartner and Ebner (2010)
18	Governance	Corporate sustainability reports	Various	Bonsón and Bednárová (2015)
19	TBL	Specialized literature	Materials Sector	Braccini and Margherita (2018)
20	TBL	Specialists' evaluation	Consumer Goods	Buys et al. (2014)

Continued on next page

Table 7: (Continued)

ID	Dimensions	Source of indicators	Sector	Reference
21	Governance	Specialized Literature + Specialists' evaluation	Banking and Financial Services	Deng et al. (2018)
22	TBL	Corporate sustainability reports	N/A	Dos Santos et al. (2013)
23	TBL	Specialized literature	Discretionary Consumer Goods	Charmondusit et al. (2014)
24	Social + Environmental	Corporate sustainability reports	Transport and Logistics	Cowper-Smith and de Grosbois (2011)
25	Social + Environmental	Specialized literature	N/A	Esteban et al. (2017)
26	TBL	Specialized literature	Discretionary Consumer Goods	A. A. Feil et al. (2015)
27	TBL	Specialized literature	Various	Froehlich and Bitencourt (2016)
28	TBL	Specialized literature	Automotive Industry	Hilsdorf et al. (2017)
29	TBL	Specialized literature	N/A	Høgevold et al. (2015)
30	TBL	Specialized literature + Corporate sustainability reports	N/A	Hourneaux Jr et al. (2018)
31	TBL	Specialized literature	N/A	Hristov and Chirico (2019)
32	TBL	Specialized literature + Corporate sustainability reports	N/A	Hubbard (2009)
33	Social	Specialists' evaluation	N/A	Hutchins et al. (2019)
34	TBL	Specialists' evaluation	N/A	Kolk et al. (2008)
35	TBL	Specialized literature	Discretionary Consumer Goods	Madan Shankar et al. (2017)
36	TBL	Specialists' evaluation	N/A	Laurell et al. (2019)
37	TBL	Specialized Literature + Specialists' evaluation	N/A	Lucato et al. (2017)
38	Environmental	Specialized literature	Automotive Industry	Nallusamy et al. (2015)
39	TBL	Specialists' evaluation	N/A	da Silva Batista and de Francisco (2018)
40	Social + Environmental	Specialized literature	N/A	Nikolaou et al. (2019)
41	TBL	Corporate sustainability reports	Discretionary Consumer Goods	Ocampo et al. (2016)
42	TBL	Specialized literature	Various	Oginni and Omojowo (2016)
43	TBL	Corporate sustainability reports + Specialized literature + International Standards	Materials sector	Oliveira et al. (2019)
44	Social	Specialized literature	Energy Sector	Paredes-Gazquez et al. (2016)
45	N/A	Corporate sustainability reports	Various	Roca and Searcy (2012)
46	TBL	Corporate sustainability reports	N/A	Sarango-Lalangui et al. (2018)
47	TBL + Governance	Corporate sustainability reports	Various	Schrippe and Ribeiro (2019)
48	Governance	Specialized literature	N/A	Spangenberg (2002)
49	Social	Specialists' evaluation	N/A	Staniškienė and Stankevičiūtė (2018)
50	TBL	Specialized literature	N/A	A. Feil et al. (2019)
51	TBL	Specialized literature	Discretionary Consumer Goods	Huang and Badurdeen (2017)
52	TBL	Specialized literature	Various	Svensson and Wagner (2015)
53	TBL	Specialized literature	Commercial and professional services, Capital goods, etc.	Svensson et al. (2016)
54	TBL	Specialized literature	Transport and Logistics	Thabrew et al. (2018)
55	TBL	Specialized literature + Corporate sustainability reports	Automotive Industry	Z. Wang et al. (2015)
56	TBL + Governance	Specialized literature	Commercial and Professional Services	L. Wang et al. (2018)
57	TBL	Specialized literature	Commercial and Professional Services	Zahid and Ghazali (2015)
58	TBL	Specialized literature + Corporate sustainability reports	Various	Reis et al. (2015)
59	TBL	Specialized literature	Automotive Industry	Hussain et al. (2017)
60	TBL	Specialists' evaluation	Consumer Goods	Nara et al. (2019)
61	TBL	Corporate sustainability reports	Energy Sector	Infante et al. (2013)
62	TBL	Specialized literature	Transport and Logistics	Karaman and Akman (2018)
63	Governance	Specialized literature	Discretionary Consumer Good	Lu et al. (2016)
64	TBL	Corporate sustainability reports + Specialists' evaluation	N/A	L. Wang and Lin (2007)
65	N/A	Corporate sustainability reports + Specialists' evaluation	Various	Rowley et al. (2015)
66	TBL	Corporate sustainability reports	Materials Sector	Lenort et al. (2017)
67	TBL	Specialized literature	N/A	C. Wang et al. (2018)
68	TBL	Corporate sustainability reports	Energy Sector	Garcia et al. (2016)

4 | DISCUSSION

Since 2015, when the 2030 Agenda for Sustainable Development was adopted, the number of publications concerned with models for assessing corporate sustainability have increased annually, with around 70% of the publications concentrated in the last five years. These are widely distributed in 34 peer review journals that encompasses issues on Operations Research Management Science, Business Economics, Engineering, Environmental Science Ecology, Scientific Technology, Development Studies, Biodiversity Conservation, and other topics.

In general, the reviewed studies apply models for assessing sustainability in organizations and/or explore standards from corporate sustainability reporting. Most of the reviewed models (66%) are based on the TBL concept, in which economic, social and environmental aspects are considered simultaneously for assessing corporate sustainability, trying to balance the interests in these three dimensions. Others studies (7%) consider TBL and corporate governance for evaluation of aspects such as strategies, ethics, performance measurement, supply chain, relationship with stakeholders, etc.

In some cases (9%) the TBL is not adopted, which means that the concept of sustainability is not being properly evaluated. One of the models consider economic and social aspects in combination with governance issues, without care about environmental aspects; while in five studies, the authors suppressed the economic dimension (in one of them, the governance dimension was added). Finally, 10 models (15%) evaluate corporate sustainability considering a single perspective, in which governance dimension appears in three of them.

All these models, we identified 583 indicators that were grouped into four analytical categories: economic, social, environmental, and governance. The last category involves every sphere of management, encompassing company's objectives, strategies for achieving them, action plans and internal controls, guidelines for monitoring performance, relationship with stakeholders. We infer from the review, governance aspects should be considered in combination with economic, social and environmental aspects to ensure a proper and holistic assessment of corporate sustainability.

The specialized literature (scientific papers, books, and others) is the main source of indicators used to assess corporate sustainability, in some cases combined with other sources, such as reports from companies or rating agencies and specialists' evaluation. Other important source are the corporate sustainability reports, being the GRI the most frequently consulted. Besides in combination with the specialized literature, these reports also appear as single source and combined with specialists' evaluation: specialized literature (43% of the models); specialized literature and corporate sustainability reports (8%); specialized literature and specialists' evaluation (3%); specialized literature and corporate sustainability reports and international standards (3%); corporate sustainability reports (29%); corporate sustainability reports and specialists' evaluation (4%); and specialists' evaluation (10%).

Regarding the sectors, 38% of the studies did not reveal the sector/segment for which these respective models are being proposed/applied. In 16% of the studies presented models that can be applied for assessing sustainability of companies from different sectors, with are very different in nature. The remaining of the reviews models (46%) are intended for a single sector, being materials sector, commercial and professional services, discretionary consumer goods and automotive industry the most frequently investigated. We observed that little attention has been given to the capital goods sector, which includes the civil construction industry, which is one of the most critical activity for sustainable development of a country, particularly developing countries because in these countries it become more complex to balance profits and preferences of stakeholders with social and environmental issues.

Finally, we observed that some studies lacks from foundation on the specialist literature on sustainability. The Bellagio Principles highlight the need to use models with targeted objectives, to adopt a holistic view, to use a simple structure capable of adapting to contingencies, to enable clear and comprehensive communication to support the decision-making of actors- key, etc. (Malheiros, Coutinho, & Philippi Júnior, 2012). However, in various of the

reviewed models, the instruments/metrics for evaluation of indicators are not provided.

5 | CONCLUSIONS

This paper presents a literature review on models for assessing corporate sustainability. The review encompasses 68 articles that were published in peer-reviewed journals between 2002 and 2019. We performed a descriptive analysis of the papers to show their distribution over the years and to present what are the journals and authors with the highest number of publications. The qualitative analysis aims to identify the dimensions of sustainability used in the models, the sectors considered in the application of the models, the indicators used to assess corporate sustainability and the source used by the authors to select the indicators.

Most of the studies are based on the concept of TBL and some of them integrates TBL with a dimension that evaluated aspects of governance. However, in various cases TBL is not considered and there are some studies in which only one single dimension is considered for evaluation of sustainability. In general, the indicators used in the models were collected from specialized literature, corporate sustainability reports, international standards and based on Specialists' evaluation. Our study also presented the most relevant indicators for each dimension used to assess sustainability: Economic (revenue, expenditure, etc.), Social (Community, Health and safety, etc.), Environmental (Water, Energy, etc.), Governance (Ethics and corruption, Strategy, etc.). We identified that the models were applied to different companies from different sectors.

Based on our analysis, we conclude that corporate sustainability should be evaluated over the TBL perspective, but also it is important to evaluate aspects of governance to ensure a proper and holistic evaluation. Moreover, we conclude that the combination of secondary data (specialized literature and/or corporate sustainability reports) with specialists' evaluation to assess sustainability should be encouraged, given the complexity of aspects that make up this assessment and the need to consider the context of organizations. Also, despite the large number of models that exist for evaluation of sustainability of companies from different sectors, the literature lacks from models specific for civil construction industries.

This research analyzed only studies on corporate sustainability assessment. Therefore, it removed different subthemes related to sustainability, such as: supply chain, tourism, human resources and others, because the basic subtopic grouped studies dealt with specific issues in each area. Another limitation of this study refers to the use of the Web of Science database as the only source of data collection. We recommend for further studies to use Scopus database.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Apêndice III: Modelo de multicritérios para avaliação da sustentabilidade corporativa na indústria da construção civil

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A multicriteria model for assessing corporate sustainability in the construction industry

--Manuscript Draft--

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Abstract:	The construction industry is one of the most critical activities for the sustainable development of a country, generating positive and negative economic, social and environmental impacts. These aspects can be measured by Sustainability Indicators and Indices, which are useful tools for society, investors and the government in decision-making, especially when purchasing products and services, as they quantify information about a phenomenon in a given dimension of sustainability. Therefore, the objective of this study is to build a model for assessing the sustainability of civil construction companies, considering economic, social, environmental and corporate governance criteria. These criteria are aggregated into a single index using the PROMETHEE II multicriteria method, which allows to avoid the compensation effect caused by the aggregation operators based on the additive model. The model was used to evaluate four Brazilian construction companies: Alpha, Beta, Delta and Gamma. The data of these companies were collected in a database of the Brazilian Chamber of the Construction Industry and in the sustainability`s reports published by them. We concluded that the companies Alpha and Gamma, followed by the company Beta presented the best performances in corporate sustainability, while the construction company Delta has the worst level of corporate sustainability.
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A multicriteria model for assessing corporate sustainability in the construction industry

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Construction industry.

ABSTRACT

The construction industry is one of the most critical activities for the sustainable development of a country, generating positive and negative economic, social and environmental impacts. These aspects can be measured by Sustainability Indicators and Indices, which are useful tools for society, investors and the government in decision-making, especially when purchasing products and services, as they quantify information about a phenomenon in a given dimension of sustainability. Therefore, the objective of this study is to build a model for assessing the sustainability of civil construction companies, considering economic, social, environmental and corporate governance criteria. These criteria are aggregated into a single index using the PROMETHEE II multicriteria method, which allows to avoid the compensation effect caused by the aggregation operators based on the additive model. The model was used to evaluate four Brazilian construction companies: Alpha, Beta, Delta and Gamma. The data of these companies were collected in a database of the Brazilian Chamber of the Construction Industry and in the sustainability's reports published by them. We concluded that the companies Alpha and Gamma, followed by the company Beta presented the best performances in corporate sustainability, while the construction company Delta has the worst level of corporate sustainability.

1. Introduction

The productive sector has an important role in the sustainable development of a country. Technological innovation, efficiency in the use of natural and energy resources, encouraging the growth of local economies and improving the living standards of communities, ensuring expansion of the labor market and income generation, are the basic principles of a balanced development (Baptista Júnior and Romanel, 2013). On the other hand, it is one of the main sources of pollution of the air, water and soil, and generation of solid waste, etc.

As global inequality and climate change become concerns of the society, consumers and investors are looking for products and services that have been produced through sustainability processes, practices, and policies. As a consequence, plenty of instruments for evaluation of corporate sustainability have developed and applied worldwide. Various of these instruments have been proposed by different nonprofit organizations, being the Global Reporting Initiative (GRI) one of the most frequently adopted. Moreover, many models for assessing corporate sustainability have been proposed and applied in the specialized literature.

Usually, the assessment of sustainability is given by indexes. An index is formed by the aggregation of individual indicators (single variable) and/or composite indicators, which compile two or more single indicators (Siche et al., 2007). Indicators provide quantified information about a given aspect in a given dimension of sustainability and indexes compile this information, revealing a multi-dimensional performance. Sustainability indexes can be useful for the society, investors, and government to make decisions.

Given the importance of sustainability indexes, a question that emerges is "how much they reflect what happens in companies in practice?". In a review on models for assessing corporate sustainability, we observed some critical issues. The first one is related to the dimensions of sustainability - in some cases the triple bottom line (economic, social and environmental) is not adopted, which means that the concept of sustainability is not properly evaluated, and in 10 cases, a single perspective is considered, in which governance dimension appears in three of them. The study also revealed that in various of the reviewed models, the Bellagio Principles were not met. The Bellagio Principles were

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created by a group of experts, at the Rockfeller Foundation in 1996, in the city of Bellagio (Italy), with the objective of guiding the development of instruments for measuring sustainability (Hardi et al., 1997). Finally, we observed that little attention has been given to the civil construction industry; in a previous study by (da Gama et al., 2014), they also pointed out that models to help operationalize sustainability in construction projects are scarce.

The civil construction sector is one of the most critical activities for sustainable development of a country, particularly developing countries, with positive and negative economic, social and environmental impacts. According to the Brazilian National Confederation of Industry (BNCI), the construction industry is the center of a macro sector, moving segments from the extraction of raw materials to the financing and maintenance services of enterprises (NCI, 2017). As for the social dimension, it has an important social role due to its capacity to generate jobs and to reverse the housing deficit and the scarce access to basic sanitation. However, the production of real estate and urban spaces causes environmental impacts throughout the process (from the extraction of raw materials to the operation of buildings and urban management): global emissions of greenhouse gases, consumption of resources and raw materials, waste produced in urban centers and construction processes, etc. In addition, it encourages the swelling of urban centers and demands the use of water, sanitation, mobility and digital information infrastructures.

Therefore, the goal of this paper is to present a model for evaluation of sustainability of civil construction companies, which allows to evaluate sustainability considering the economic, social and environmental perspectives, as well as, observing aspects of corporate governance. These dimensions are evaluated through a set of 9 criteria that were selected based on literature review on business sustainability assessment models published in indexed peer-reviewed journals over the past two decades. This review allowed us to identify the main dimensions, criteria, sectors for which the models were applied.

These indicators are aggregated into a single index using the multicriteria method PROMETHEE II, proposed by Brans and Vincke (1985), which avoid the effect of compensation that is provoked by aggregation operators based on the additive model.

The remaining of the paper is organized into five sections: Section 2 presents a literature review on models for assessing corporate sustainability based on multicriteria methods; Section 3 presents the proposed model; Section 4 presents the discussions; and finally, conclusions are presented in Section 5.

2. Literature Review

We classify the models applied to assess corporate sustainability into two groups: models based on a single multicriteria method and models based on the integration of methods.

2.1. Single method

The AHP (Analytic Hierarchy Process) is the most applied method and in some models, the evaluation of the criteria were performed using secondary data, such as sustainability reports: Krajnc and Glavič (2005) applied AHP for evaluation of corporate sustainability in Chemical Industry; Martins et al. (2015) applied AHP to analyze a socio-economic-environmental strategy in an energy distribution company; and Lenort et al. (2017) applied this method to compare indicators in the metallurgical industry.

In other models, the source used for evaluation of the criteria were specialists: Kluczek (2016) applied AHP to evaluate sustainability of heating boilers companies; Karaman and Akman (2018) applied AHP to classify corporate social responsibility programs in manufacturing industries; Hussain et al. (2017) applied a model, based on AHP, to assess sustainability considering economic, environmental, social management, customer management, and health and safety criteria; Mikušová (2017) applied AHP to identify the position of small companies in relation to sustainability, for which they performed an empirical research with managers of small companies in the Czech Republic; and Pérez et al. (2017) assessed corporate sustainability using the fuzzy version of AHP.

The second most frequently applied method is ANP (Analytic Network Process), which is an extension of AHP. In the ANP-based models, criteria were selected and evaluated based on judgment of specialists. The models by Poplawska et al. (2015) and Debnath et al. (2018) are based on a fuzzy version of ANP. Poplawska et al. (2015) applied ANP to select corporate social responsibility programs in the Mining Industry. Debnath et al. (2018) applied AHP to select strategies, perspectives and indicators of corporate social responsibility.

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was used in the development of models for assessing corporate sustainability for which secondary data were used to evaluate the criteria: Afful-Dadzie et al. (2016) proposed a system to evaluate the efforts of organizations in relation to the goals of sustainable development in Bank

and Financial Institutions; Kubule and Blumberga (2019) proposed a model to assess and classify the manufacturing sub-sectors.

Hsu et al. (2014) incorporated GRA (Gray Rational Analysis) technique to deal with the imprecision in the examination of sustainability indicators used to evaluate organizations. In their model, the criteria were evaluated based on secondary data.

The multicriteria method MAUT (Multi-Attribute Utility Theory) was used in Wang and Lin (2007) in the development of a sustainability index for companies and the criteria were evaluated based on secondary sources. Nara et al. (2019) used MAUT to analyze the indicators published in sustainability reports of multinational companies in Brazil using specialists as a source for evaluation of the criteria.

Lähtinen et al. (2016) used the SMART (Simple Multi-Attribute Rating Technique), which is a MAUT-based method, for evaluation of criteria in a study to assess corporate social responsibility in the forestry industry.

Bilbao-Terol et al. (2018) used secondary data for evaluation of criteria in the assess sustainability in banks and financial institutions based on the aggregation operator OWA (Ordered Weighted Averaging). Chen et al. (2015) used TODIM (acronym in Portuguese for Interactive Multi-criteria Decision Making) to assess the criteria used to assess sustainability in the construction industry.

Raj and Srivastava (2018) used a fuzzy version of the Best-Worst Method (Fuzzy-BWM) to assess manufacturing industries using indicators that were selected in secondary databases. Infante et al. (2013) used secondary data sources for evaluation indicators and applied the ELECTRE method (acronym in French of Elimination and Choix Traduisant la realite) to evaluate companies in the energy sector.

Other models are based on the use of optimization techniques, such as Goal Programming (Zhu et al., 2018; García-Martínez et al., 2019; Garcia et al., 2016), Compromise Programming (Diaz-Balteiro et al., 2011), and MOORA (Multi-Objective Optimization on the Basis of Ratio Analysis) (Küçükbay and Sürücü, 2019). In the study by Venturelli et al. (2017), an Artificial Intelligence technique was applied. In the study by Costa and Menichini (2013) the qualitative technique BSC (Balanced ScoreCard) was applied with the 2-tuple fuzzy linguistic representation model for dealing with imprecision.

2.2. Integration of methods

In this group, we identified that the ANP was combined in several ways: with the AHP (Vinodh et al., 2012); with COPRAS (Complex Proportional Assessment) (Rabbani et al., 2014); with TOPSIS (Zhao and Li, 2015); com AHP e PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations) (Ren et al., 2016). These studies assessed the sustainability of the energy industry using indicators that were selected and evaluated based on evaluation of specialists.

The ANP method was combined with DEMATEL (Decision Making Trial and Evaluation Laboratory) and VIKOR (acronym in Bosnian of Higher Criteria Optimization Compromise Solution) to assess sustainability in Manufacturing and Assembly Industry considering indicators that were selected and evaluated from secondary data(Lu et al., 2016) and to assess the impact of corporate social responsibility on the implementation of internal control based on expert judgment (Liu, 2018). Tsai et al. (2009) proposed a model, based on ANP combined with DEMATEL and an optimization technique, to select sustainability actions in the manufacturing industry based on secondary data.

Other studies combined the AHP and TOPSIS methods: Metaxas et al. (2016) evaluated corporate sustainability based on indicators selected and evaluated by experts; Rahdari (2016) considered the opinion of experts in the context of energy sector companies.

Hsu et al. (2017) incorporated the qualitative QFD (Quality Function Deployment) technique, finite difference methods, Fuzzy Extended-AHP and TOPSIS to assess the sustainability of organizations, the criteria were based on the opinion of experts.

The TOPSIS method was also used in combination with the LOWGA (Linguistic Ordered Weighted Geometric Aggregating Operator) to investigate sustainability in different sectors considering indicators evaluated by experts (Liern and Pérez-Gladish, 2018) and the Design of Experiments technique was also used in the valuation of companies in various segments based on secondary data (Bilbao-Terol et al., 2019). The PROMETHEE resilience method was used in combination with statistical tools to assess companies in the energy sector using indicators collected from secondary sources (Vivas et al., 2019).

3. Proposed Model

The model is divided into three phases: 3.1. problem structuring; 3.2. PROMETHEE II; and 3.3. sensitivity analysis. In the first phase, the criteria, their respective evaluation scales and preference functions associated to each criterion are presented; then, the weights of criteria and other parameters are determined; finally, the matrix of evaluation "companies versus criteria" is constructed. This matrix and remaining parameters of the first phase is the input for the second phase in which the steps of the PROMETHEE method are applied, resulting in a prioritization of the companies according to their performance in terms of sustainability (from the best to the worst). Finally, in the last phase a sensitivity analysis is performed to verify the robustness of the result, which is necessary due to the existence of imprecision and uncertainties in judgments.

3.1. Problem structuring

3.1.1. Criteria

In our research, we verified that most of the models to assess corporate sustainability are based on the Triple Bottom Line (TBL), in which economic, social and environmental dimensions are considered simultaneously. The economic dimension involves the creation of the company's economic value and its contribution to the economy; the social dimension includes performing beneficial and fair actions for employees and the community; and the environmental dimension focuses on the efficient use of natural resources so as not to compromise future generations (Elkington, 1999).

However, in various studies, we observed that corporate sustainability has been evaluated considering aspects of governance. The governance dimension involves all spheres of management, from the organization's objectives, to action plans and internal controls, performance measurement, corporate communication and relationship with its stakeholders. It deals with the relationship between stakeholders and a structure that leads the company. Includes compliance with legislation, ethics and anti-corruption, policy, strategy, supply chain management, etc. In the reviewed papers this dimension appears in combination with the TBL (Wang et al., 2018; Aras et al., 2017; K. E. K. et al., 2018; Loor Alcívar et al., 2019; Schrippe and Ribeiro, 2019); in combination with environmental and social dimensions (Muñoz-Torres et al., 2019); with economic and social dimensions (Bonsón and Bednárová, 2015); some studies evaluated sustainability considering only governance dimension (Spangenberg, 2002; Lu et al., 2016; Deng et al., 2018).

We understand that the combination of the governance dimension with the TBL concept is the most appropriate for a comprehensive assessment of corporate sustainability. In this sense, the proposed model will assess corporate sustainability of construction industry companies considering economic, social, environmental, and governance aspects.

In the reviewed models, we classified the evaluation criteria into clusters according to the similarity of the aspects that these criteria aim to evaluate in each dimension; in other words, we aggregate criteria that have different names but evaluate the same aspect in a given dimension. Then, we observed what are the most frequently applied criteria in each dimension. The result of criteria that we consider relevant for assessing corporate sustainability. These criteria and their respective description are presented in Table 1.

The next section presents the preference functions assigned to each criterion.

3.1.2. Preference Functions

For each criterion, the analyst must assign a preference function $P_j(a, b)$. This function represents how the decision maker's preference changes with the difference between the degrees of performance of two alternatives a and b in that criterion, that is, $g_j(a) - g_j(b)$ (Brans and Vincke, 1985).

For the criteria C3 and C8, it was established that if the performance of company a is slightly higher than the performance of company b, in one of these criteria, then company a is totally preferable to company b. Therefore, for these criteria, the usual function (Type I) (Brans et al., 1986) is the most appropriate.

For the remaining criteria, the preference for one alternative in relation to another one was considered to increase linearly with the difference in performance between them. Based on the preference threshold considered, one alternative was found to be preferable to the others. Consequently, the V-shape criterion function suggested by PROMETHEE (Brans et al., 1986) was associated with these criteria.

The next section shows how weights were assigned to each indicator.

Table 1
Criteria

Dimension	ID	Indicator	Description
Economic	C1	Revenue	The company's gross revenue per year (monetary value). A higher value is preferrable to a smaller value.
	C2	Economy	It assesses the organization's contribution to the local economy, through the generation of jobs and income. The evaluation of this criterion is given by the total number of employees of the company. A higher value is preferrable to a smaller value.
Social	C3	Health and safety	Number of accidents per year. A smaller value is preferable to a higher value.
	C4	Community	The evaluation of this criterion is given by the amount (monetary value) that the company invests per year in benefits for the local community. A higher value is preferrable to a smaller value.
Environmental	C5	Energy	Total of energy (MWh) that is consumer per year by the company. A smaller value is preferable to a higher value.
	C6	Water	Total volume of water consumed per year (m^3). A smaller value is preferable to a higher value.
	C7	Waste	Total weight of waste produced by the company per year (ton). A smaller value is preferable to a higher value.
Governance	C8	Communication	It involves the management of communication with stakeholders (suppliers, customers, community, etc.). The evaluation of this criterion is given by a 5-point Likert scale: (very good (5), good (4), regular (3), poor (2), very poor (1)). A higher value is preferrable to a smaller value.
	C9	Compliance with legislation	The evaluation of this criterion is given by the number of fines (in monetary value) that is paid by the company per year. A smaller value is preferable to a higher value.

3.1.3. Weights of criteria and remaining parameters

The weights represent a measure of relative importance of the dimensions/criteria. For this type of evaluation, Munda (2008) recommends that the dimensions should have the same importance. Thus, in the proposed model, the same weight (0.25) was assigned to each dimension. Regarding the criteria, we also recommend dividing this value equally among the criteria of each dimension, but different values can be assigned according to each situation. Table 2 shows the weights assigned by the analyzes to each criterion.

Some criteria also require the definition of a preference threshold, which is a value above which the decision maker considers an alternative preferable to another one. However, the definition of these values depends on the set of companies that are being evaluated.

In the next section, we present the evaluation matrix that shows the preference relationship between the alternatives for each criterion.

3.1.4. Matrix of Evaluation

At this step, the matrix of evaluation alternatives versus criteria is constructed. Each cell p_{ij} will contain the evaluation of the company i ($i = 1, 2, ..., m$) in relation to the criterion j ($j = 1, 2, ..., 9$). To construct this matrix, we will use data collected from primary sources (interviews and questionnaires with representatives of companies, for

Table 2
Weights of criteria

Dimension	Criteria	Weight
Economic	C1	$\frac{0.25}{2}$
	C2	$\frac{0.25}{2}$
Social	C3	$\frac{0.25}{2}$
	C4	$\frac{0.25}{2}$
Environmental	C5	$\frac{0.25}{3}$
	C6	$\frac{0.25}{3}$
	C7	$\frac{0.25}{3}$
Governance	C8	$\frac{0.25}{2}$
	C9	$\frac{0.25}{2}$

example) and secondary sources (information released by institutions representing the sector, sustainability certifying organizations, sustainability reports published by the companies, etc.). This evaluation must be carried out based on the evaluation scales of each criterion.

3.2. PROMETHEE II

The matrix of evaluation is the starting point for the application of PROMETHEE II method. Firstly, for each criterion, a matrix of alternatives versus alternatives is constructed and each cell g_{ij} contain the difference of performance between the alternative of the row i and the alternative of the line j. Thus, 9 matrixes alternatives versus alternatives are constructed (one for each criterion).

Then, based on the preference function associated to each criterion, the intensity of preference for an alternative a over another b, $P_j(a, b)$ $(j = 1, 2, \ldots, 9)$, is calculated. This is done for all criteria and for each pair of alternatives.

The next step is to determine a preference index $P(a, b)$ for each pair of alternatives using the preference intensity $P_j(a, b)$ and the weights w_j given to the criteria (Table 3). The preference index provides the preference intensity for one alternative over another considering all criteria. The preference of an alternative a over an alternative b is given as follows:

$$P(a,b) = \sum_{j=1}^{9} w_j P_j(a,b) \quad \left(\sum_{j=1}^{9} w_j = 1 \right) \tag{1}$$

After that, for each alternative, two indices are calculated using the preference index: positive outranking flow, $Q^+(a)$, and negative outranking flow, $Q^-(a)$. The positive flow can be interpreted as the sum of all the advantages of one company over the others and the negative flow is the sum of its disadvantages. These indexes are calculated as follows:

$$Q^+(a) = \sum_{a \neq b} \frac{P(a,b)}{8} \tag{2}$$

$$Q^-(a) = \sum_{a \neq b} \frac{P(b,a)}{8} \tag{3}$$

In PROMETHEE II, the ranking of alternatives is obtained from the net flow that was calculated for each alternative.

The net flow is obtained from the difference between the positive and negative flow:

$$Q(a) = Q^{+}(a) - Q^{-}(a) \tag{4}$$

Finally, the companies are ranked in decreasing order of their net flows.

3.3. Sensitivity analysis

A sensitivity analysis should be performed to verify the robustness of the final ranking. For this, we recommend provoking slight changes in the weights if the criteria and then observe the effect this over the final ranking. The weights can be changed as follows:

- 1st analysis - Increase the weight of the economic dimension from 0.25 to 0.30 and decrease the weight of the corporate governance from 0.25 to 0.20; then, divide the weight of each dimension equally among the criteria. Observe the effect of this in the final ranking.
- 2nd analysis - Increase the weight of the social dimension from 0.25 to 0.30 and decrease the weight of the corporate governance from 0.25 to 0.20; then, divide the weight of each dimension equally among the criteria. Observe the effect of this in the final ranking.
- 3rd analysis – Increase the weight of the environmental dimension from 0.25 to 0.30 and decrease the weight of the corporate governance from 0.25 to 0.20; then, divide the weight of each dimension equally among the criteria. Observe the effect of this in the final ranking.

The next section shows an application of the model.

3.4. Numerical application

To apply the model, we selected four Brazilian construction companies, identified in this article by: Alpha, Beta, Gamma, and Delta. These companies are references in construction and engineering in Brazil, they are large construction companies that contribute to the growth of essential sectors of the economy and to the development of the regions. Alpha is located in the State of São Paulo and has been operating in the infrastructure and industrial assembly segments for approximately 70 years. The Beta company is located in the State of Rio de Janeiro and has been operating in the civil construction, infrastructure, industrial assembly, urban mobility and energy segments for over 60 years. Gamma is headquartered in the state of Paraná and has been operating for 50 years in the following segments: infrastructure, energy, port and airport management, and highway concession. The construction company Delta was created in the State of Minas Gerais and operates in the ventures for almost 50 years.

The evaluation of these companies in relation to the economic criteria were obtained from a database provided by the Brazilian Chamber of the Construction Industry. As for the evaluation of social, environmental and governance criteria, we consulted corporate sustainability reports published by these companies: for Alpha and Delta, the source used was reports that were published in 2018; and for Beta and Gamma we collect data published in 2017 and 2016, respectively. The evaluation matrix is presented in Table 3.

The preference threshold of the criteria associated with the V-shaped criterion were defined based on the size of the companies (Table 4).

The PROMETHEE II algorithm was implemented in R Language and the following result was obtained (Table 5).

The first position on the ranking is occupied by the company Alpha whose net flow is slightly higher than the second placed company. A sensitivity analysis was performed to verify a possible inversion of position in the ranking, particularly in the first and second positions: by increasing the weight of the economic dimension and decreasing the weight of the corporate governance (1st analysis), the result does not change; the ranking remains the same when we increase the weight of the social dimension and decrease the weight of the corporate governance (2nd analysis); the same happened when we increased the environmental dimension and decrease the weight of the corporate governance (3rd analysis). Therefore, we can conclude that the result is robust.

The next section presents the discussion.

4. Discussion

The proposed model has a strong conceptual basis. Its steps follows the process proposed by Feil and Schreiber (2017) for elaboration of sustainability indexes: selection of indicators, normalization, weighting, aggregation and

Table 3
Alternatives versus criteria

Criteria/ Alternative	Alpha	Beta	Delta	Gamma
Revenue (R$)	11,087,892	2,388,016	1,284,855	2,301,008
Economy (number of employees)	38,871	4,459	5,650	14,694
Health and safety (number of accidents per year)	134	122	167	340
Community (R$ x106)	39.3	24.4	2.7	4.3
Energy (MWh)	1,974,763.00	16,829,988.37	3,163,013.38	165,380.87
Water (m^3)	398,219.00	160,812.90	334,300.00	2,573,775.42
Waste (ton)	418,952	4,963,015	13,800	357,986.58
Communication	1	4	2	4
Compliance with legislation	550,000,000	66,303	0	0

Table 4
Parameters p.

Criterion	C1	C2	C4	C5	C6	C7	C9
p	2,000,000 (R$/ Year)	5,000	5,000,000 (R$/ Year)	400,000 (t/Year)	500,000 (m^3/Year)	2,000,000 (kWh/Year)	30,000 (R$/ Year)

Table 5
The ranking of alternatives

Alternative	$Q^+(.)$	$Q^-(.)$	$Q(.)$
Alpha	0.444445165	0.342658581	0.101786584
Gamma	0.383127721	0.298260162	0.084867559
Beta	0.325400714	0.384925124	-0.059524411
Delta	0.273883536	0.401013269	-0.127129733

formation of the index and sensitivity analysis. Moreover, the sustainability concept adopted in our model was constructed based on a systematic literature review on models for assessing corporate sustainability, which were published in peer reviewed indexed journals. The TBL perspective was incorporated in combination with an extra dimension, named corporate governance, which encompasses all spheres of management and interaction among actors who run the company.

Finally, in the proposed model, the Bellagio Principles are met: the model provides clear and mensurable evaluation criteria; a holistic perspective is adopted in the evaluation of corporate sustainability, in which aspects of governance is considered in combination with economic, social and environmental dimensions; the data necessary for the evaluation of the criteria are accessible; and the model can be adapted according to the context (for example, by changing the weights of the criteria).

Finally, a multicriteria method is used to aggregate the intra-criteria information and to provide a global performance of each alternative. The PROMETHEE method avoids the effect of compensation during the aggregation of the unidimensional evaluations, that is it reduces the possibility that a poor performance in one of the criteria is compensated by a very good performance in another.

Regarding the application, to evaluate the companies in relation to the set of criteria, we used corporate sustainability reports that were published by the companies themselves; thus, we cannot assure the absence of conflict of interests

in the data. Also, for each company, we search for the most recent report, however, it is important to emphasize that the reports of each were published in different years. These reports follow the Global Reporting Initiative (GRI) guidelines, but for the same criterion, different scales were used for its evaluation; and for the application, we have made some adaptations to ensure the same measuring instrument. These aspects may have impacted on the final ranking and therefore we cannot assure that company Alpha is better than company Gamma in terms of corporate sustainability as it was suggested by the model. However, the application is important to show the applicability of the model. The proposal was applied in the civil construction sector, but it can be used to evaluate companies from different sectors.

5. Conclusion

This paper presented a model for assessing corporate sustainability, based on the use of the multicriteria method PROMETHEE that avoids the effect of compensation during the aggregation of criteria. The multidimensional evaluation encompasses economic, social, environmental and corporate governance aspects that were evaluated based on a set of nine mensurable criteria collected from a systematic literature review on models for assessing corporate sustainability (Revenue, Economy, Health and safety, Community, Energy, Water, Communication, Compliance with legislation). These criteria are the most frequently applied in the reviewed studies. Moreover, in our model, we define a scale for evaluation of each criteria, which allows that the evaluation is performed in the same way, irrespective of the context and the individual who is applying it.

The model was applied to evaluate civil construction companies, but it can be used to evaluate companies from different sectors. We evaluated four Brazilian construction companies. For evaluation of the criteria, we consulted a database of the Brazilian Chamber of the Construction Industry and sustainability reports of these companies.

An important contribution of this work is to allow the proposed approach to be used as a model to support managers of organizations in creating value for their shareholders and in reducing negative environmental and social impacts. In addition, it can assist performance certification organizations in matters of sustainability and other social actors in the role of auditors of the process and transparency of business performance.

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Conflict of interest

The authors declare that they have no conflict of interest.

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