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Quiñoá Piñeiro

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Building a sustainable future: Examining the impact of sustainable management on financial performance, climate innovation, and value creation in essential sectors

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BUILDING A SUSTAINABLE FUTURE: EXAMINING THE IMPACT OF SUSTAINABLE MANAGEMENT ON FINANCIAL PERFORMANCE, CLIMATE INNOVATION, AND VALUE CREATION IN ESSENTIAL SECTORS

Author

Lara María Quiñoá Piñeiro

Supervisors: Mª Ángeles López Cabarcos and Juan R. Piñeiro Chousa

Tutor: Mª Ángeles López Cabarcos

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PUBLICATIONS INCLUDED IN THE THESIS

ARTICLE 1

a.- Full reference: Piñeiro-Chousa, J., López-Cabarcos, M. Á, Quiñoá-Piñeiro, L., & Pérez-Pico, A. M. (2022). US biopharmaceutical companies' stock market reaction to the COVID-19 pandemic. Understanding the concept of the 'paradoxical spiral' from a sustainability perspective. *Technological Forecasting & Social Change*, *175*, 121365. Elsevier Inc. ISSN 0040-1625. https://doi.org/10.1016/j.techfore.2021.121365

b.- Names and affiliations of authors: The first author, Juan Piñeiro-Chousa, is Professor at the University of Santiago de Compostela and one of the supervisors of this thesis. The second author, M. Ángeles López-Cabarcos, is also Professor at the University of Santiago de Compostela and the other supervisor of this thesis. The third author, Lara Quiñoá-Piñeiro, is PhD student in Economics and Business at the University of Santiago de Compostela and the author of this thesis. Finally, the last author, Ada M. Pérez-Pico, is lecturer at the University of Santiago de Compostela.

c.- Quality indicators:

1. Journal impact indicators:

   Source of impact: Clarivate Analytics (Journal Citation Reports, JCR).
   - Journal Impact Factor (JIF): 12.0 (Year 2022).
   - Categories and rankings:
     - Social Sciences Citation Index (SSCI) – Business:
       - Ranking: 11 out of 154 (Q1, D1).
     - Social Sciences Citation Index (SSCI) – Regional & Urban Planning:
       - Ranking: 2 out of 40 (Q1, D1).

   Source of impact: Scopus.
   - CiteScore: 17.2 (Year 2022).
   - Categories and rankings:
     - Business and International Management:
       - Ranking: 10 out of 436 (Q1, D1).
     - Management of Technology and Innovation:
       - Ranking: 4 out of 281 (Q1, D1).

   Source of impact: SCImago Journal Rank (SJR).
   - SJR indicator: 2.644 (Year 2022).
   - Categories and rankings:
     - Business and International Management:
       - Ranking: 28 out of 454 (Q1, D1).
     - Management of Technology and Innovation:
       - Ranking: 19 out of 285 (Q1, D1).

2. Number of citations of the article:

   Web of Science: 29

   Scopus: 36

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Google Scholar: 44

3. Indexing databases of the journal:

   Scopus (ELSEVIER), Social Sciences Citation Index (Clarivate), DIALNET (Universidad de la Rioja), ABI/INFORM (ProQuest), Advanced Technologies & Aerospace Database (ProQuest), INSPEC (The Institution of Engineering and Technology), Materials Science & Engineering Collection (ProQuest), Technology Collection (ProQuest), Geobase (ELSEVIER), Political Science Complete (EBSCO).

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ARTICLE 2

a.- Full reference: López-Cabarcos, M. Á, Santos-Rodrigues, H., Quiñoá-Piñeiro, L., & Piñeiro-Chousa, J. (2023). How to explain stock returns of utility companies from an environmental, social and corporate governance perspective. *Corporate Social Responsibility and Environmental Management, 30*(5), 2278-2291. ERP Environment and John Wiley & Sons Ltd. ISSN 1535-3958. https://doi.org/10.1002/csr.2483

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- Journal Impact Factor (JIF): 8.3 (Year 2023).
- Categories and rankings:
  - Social Sciences Citation Index (SSCI) – Business:
    - Ranking: 23 out of 304 (Q1, D1).
  - Social Sciences Citation Index (SSCI) – Management:
    - Ranking: 23 out of 407 (Q1, D1)
  - Social Sciences Citation Index (SSCI) – Environmental Studies:
    - Ranking: 14 out of 182 (Q1, D1).

Source of impact: Scopus.

- CiteScore: 17.2 (Year 2023).
- Categories and rankings:
  - Strategy and Management:
    - Ranking: 15 out of 478 (Q1, D1).
  - Management, Monitoring, Policy and Law:
    - Ranking: 8 out of 399 (Q1, D1).
  - Development:
    - Ranking: 5 out of 309 (Q1, D1).

Source of impact: SCImago Journal Rank (SJR).

- SJR indicator: 2.201 (Year 2023).
- Categories and rankings:
  - Strategy and Management:
    - Ranking: 45 out of 481 (Q1, D1).
  - Management, Monitoring, Policy and Law:

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        - Ranking: 15 out of 395 (Q1, D1).
    - Development:
        - Ranking: 8 out of 299 (Q1, D1).

2. Number of citations of the article:
   Web of Science: 8
   Scopus: 7
   Google Scholar: 13
3. Indexing databases of the journal:
   Scopus (ELSEVIER), Social Sciences Citation Index (Clarivate), Natural Science Collection (ProQuest), ABI/INFORM (ProQuest), Business Source Ultimate (EBSCO), Environment Index (EBSCO), Greenfile (EBSCO), Health Research Premium Collection (ProQuest), INSPEC (The Institution of Engineering and Technology), Materials Science & Engineering Collection (ProQuest), Technology Collection (ProQuest).

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a.- Full reference: López-Cabarcos, M. Á, Piñeiro-Chousa, J., Quiñoá-Piñeiro, L., & López-Pérez, M. L. (2024). Water and waste management strategies as drivers of the financial performance of food companies. *Technological Forecasting & Social Change, 200*, 123138. Elsevier Inc. ISSN 0040-1625. https://doi.org/10.1016/j.techfore.2023.123138

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   - Categories and rankings:
     - Social Sciences Citation Index (SSCI) – Business:
       - Ranking: 4 out of 304 (Q1, D1).
     - Social Sciences Citation Index (SSCI) – Regional & Urban Planning:
       - Ranking: 4 out of 54 (Q1, D1).

   Source of impact: Scopus.
   - CiteScore: 21.3 (Year 2023).
   - Categories and rankings:
     - Business and International Management:
       - Ranking: 5 out of 443 (Q1, D1).
     - Management of Technology and Innovation:
       - Ranking: 3 out of 289 (Q1, D1).

   Source of impact: SCImago Journal Rank (SJR).
   - SJR indicator: 3.118 (Year 2023).
   - Categories and rankings:
     - Business and International Management:
       - Ranking: 27 out of 446 (Q1, D1).
     - Management of Technology and Innovation:
       - Ranking: 15 out of 283 (Q1, D1).
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a.- Full reference: Quiñoá-Piñeiro, L., López-Cabarcos, M. Á, & Piñeiro-Chousa, J. (2025). Innovating for sustainability in food and beverage companies: the role of governance and environmental factors in climate change mitigation. *British Food Journal, 127*(1), 54-72. Emerald Publishing Ltd. ISSN 0007-070X. https://doi.org/10.1108/BFJ-03-2024-0315

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c.- Quality indicators:

1. Journal impact indicators:

Source of impact: Clarivate Analytics (Journal Citation Reports, JCR).

- Journal Impact Factor (JIF): 3.4 (Year 2023).
- Categories and rankings:
  - Science Citation Index Expanded (SCIE) – Agricultural Economics & Policy:
    - Ranking: 8 out of 39 (Q1).
  - Science Citation Index Expanded (SCIE) – Food Science & Technology:
    - Ranking: 65 out of 173 (Q2).

Source of impact: Scopus.

- CiteScore: 6.9 (Year 2023).
- Categories and rankings:
  - Business, Management and Accounting (miscellaneous):
    - Ranking: 24 out of 189 (Q1).
  - Food Science:
    - Ranking: 75 out of 389 (Q1).

Source of impact: SCImago Journal Rank (SJR).

- SJR indicator: 0.795 (Year 2023).
- Categories and rankings:
  - Business, Management and Accounting (miscellaneous):
    - Ranking: 86 out of 391 (Q1).
  - Food Science:
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LIST OF ACRONYMS AND ABBREVIATIONS

CBOE – Chicago Board Options Exchange

COVID-19 – Coronavirus Disease 2019

CO_2 – Carbon Dioxide

CSR – Corporate Social Responsibility

DCC-GARCH – Dynamic Conditional Correlation GARCH

ESG – Environmental, Social and Governance

fsQCA – fuzzy-set Qualitative Comparative Analysis

F&B – Food and Beverage

GARCH – Generalized Autoregressive Conditional Heteroscedasticity

GHG – Greenhouse Gas

ICB – Industry Classification Benchmark

ISEE – International Securities Exchange Sentiment Index

JCR – Journal Citation Reports

NASDAQ – National Association of Securities Dealers Automated Quotation

QCA – Qualitative Comparative Analysis

SARS-CoV-2 – Severe Acute Respiratory Syndrome CoronaVirus 2

SDG – Sustainable Development Goal

US – United States

VIX – Chicago Board Options Exchange Market Volatility Index

WEF nexus – Water-Energy-Food nexus

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THESIS SUMMARY

Sustainable development has become one of the most important global goals of our time. Defined in the Brundtland Report in 1987 as development that meets present needs while safeguarding the capacity of future generations to meet their own, numerous efforts have been made to drive a paradigm shift that balances economic growth, environmental protection and social development. Despite notable progress, the effects of prolonged anthropogenic pressure that has exceeded six of the nine known planetary boundaries are becoming increasingly evident and alarming. This is compounded by a 'polycrisis' scenario, marked by the COVID-19 pandemic, geopolitical conflicts that worsen the scarcity of resources and heighten energy and food security challenges, and the intensification of extreme climatic events.

In this context, the need to redirect business efforts towards sustainable objectives can no longer be deferred. Essential sectors, which serve as pillars of economic and social stability, play a central role in this transition. In particular, the biopharmaceutical sector, key in the development of vaccines against COVID-19, alongside the food and beverage sectors and the utilities industry, fundamental to ensuring access to the essential resources addressed by the water-energy-food nexus approach. The vulnerability of these sectors to the impacts of crises and extreme events underscores the urgency of transitioning towards more sustainable business models in order to avoid the collapse of societies and economies.

Despite the increasing academic interest in corporate sustainability, essential sectors have received little attention in the literature, leaving significant knowledge gaps. There is limited understanding of the specific actions companies can implement to balance economic, social and environmental demands. In addition, empirical evidence presents mixed results on the relationship between sustainability and financial performance, with a lack of attention to market-based performance measures and a need to further explore the practices underlying the ESG pillars. Furthermore, the bleak global outlook calls for a deeper understanding of the role of business strategies in managing extreme events and major societal challenges, as well as an exploration of organisational processes and practices capable of creating sustainable value.

Through four complementary studies, this thesis addresses these gaps by providing empirical evidence on how responsible and sustainable corporate management influences financial performance, fosters climate innovation and technologies, and contributes to sustainable value creation in essential sectors. To this end, samples of companies from the biopharmaceutical sector (article 1), the utilities industry (article 2) and the food and beverage production sectors (articles 3 and 4) have been used, with a study period spanning from 2019 to 2022.

The results highlight, first, the role of technological innovation as a mechanism for resilience in the face of global crises. Second, they underline the ability of responsible and sustainable practices to achieve tangible financial benefits and strengthen business resilience, consolidating sustainability as a source of business advantage. Third, they highlight the importance of governance bodies and their commitment to sustainability in fostering climate innovation. Finally, they reinforce the role of business strategy in sustainable value creation.

This doctoral thesis advances knowledge on corporate sustainability, climate innovation, and financial performance within the context of essential sectors, offering specific approaches to facilitate the adoption of more sustainable and resilient business models in an increasingly complex global landscape. The findings provide business managers with guidance for the adoption of responsible and sustainable management strategies that contribute to balancing economic, social and environmental objectives in these sectors. Additionally, they offer

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valuable information for investors' decision-making processes, as well as for the design of public policies by governments and legislators aimed at fostering a more sustainable global economic development.

Keywords: corporate sustainability, business strategy, climate innovation, financial performance, essential sectors.

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THESIS SUMMARY (SPANISH)

El desarrollo sostenible se ha consolidado como una de las metas globales más importantes de nuestro tiempo. Definido en el Informe Brundtland en 1987 como aquel que cubre las necesidades actuales al tiempo que salvaguarda la capacidad de las siguientes generaciones de cubrir las suyas, son numerosos los esfuerzos realizados para impulsar un cambio de paradigma que equilibre el crecimiento económico, la protección del medioambiente y el desarrollo social. Pese a los notables avances logrados, los efectos de una presión antropogénica prolongada que ha traspasado seis de los nueve límites planetarios conocidos se manifiestan de manera cada vez más evidente y alarmante. A esto se suma un escenario de "policrisis", marcado por la pandemia de COVID-19, conflictos geopolíticos que empeoran la escasez de recursos y agudizan los problemas de seguridad energética y alimentaria, y la intensificación de fenómenos climáticos extremos.

En este contexto, la necesidad de reorientar los esfuerzos empresariales hacia objetivos sostenibles es inaplazable. Los sectores esenciales, pilares de la estabilidad económica y social, adquieren un papel central en esta transición. En concreto, el sector biofarmacéutico, clave en el desarrollo de vacunas frente al COVID-19, y los sectores de alimentos y bebidas junto con la industria de servicios públicos, fundamentales para garantizar el acceso a los recursos esenciales abordados por el enfoque del nexo agua-energía-alimentos. La vulnerabilidad de estos sectores a los impactos de crisis y eventos extremos subraya la urgencia de transitar hacia modelos empresariales más sostenibles con el fin de evitar el colapso de sociedades y economías.

A pesar del creciente interés académico por la sostenibilidad empresarial, la literatura ha prestado escasa atención a los sectores esenciales, dejando importantes vacíos de conocimiento. Existe una limitada comprensión sobre qué acciones específicas pueden implementar las empresas para equilibrar las demandas económicas, sociales y ambientales. Además, la evidencia empírica presenta resultados mixtos sobre la relación entre sostenibilidad y desempeño financiero, con una falta de atención a medidas basadas en el mercado y la necesidad de explorar más a fondo las prácticas subyacentes a los pilares ASG. Asimismo, las desalentadoras perspectivas globales demandan una mayor comprensión del papel de las estrategias empresariales en la gestión de eventos extremos y grandes retos sociales, y una exploración de procesos y prácticas organizativas capaces de crear valor sostenible.

A través de cuatro artículos complementarios, esta tesis aborda estas lagunas proporcionando evidencia empírica sobre cómo la gestión corporativa responsable y sostenible influye en el desempeño financiero, impulsa la innovación y tecnologías climáticas, y contribuye a la creación de valor sostenible en sectores esenciales. Para ello, se han empleado muestras de empresas del sector biofarmacéutico (artículo 1), la industria de servicios públicos (artículo 2) y los sectores de producción de alimentos y de bebidas (artículos 3 y 4), con un periodo de estudio que abarca de 2019 a 2022.

Los resultados destacan, en primer lugar, el papel de la innovación tecnológica como mecanismo de resiliencia ante crisis globales. En segundo lugar, subrayan la capacidad de las prácticas responsables y sostenibles para lograr beneficios financieros tangibles y fortalecer la resiliencia empresarial, consolidando a la sostenibilidad como una fuente de ventaja empresarial. En tercer lugar, evidencian la importancia de los órganos de gobernanza y de su compromiso con la sostenibilidad para impulsar la innovación climática. Por último, refuerzan el papel de la estrategia empresarial en la creación de valor sostenible.

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Esta tesis doctoral avanza en el conocimiento sobre sostenibilidad empresarial, innovación climática y desempeño financiero en el contexto de sectores esenciales, ofreciendo enfoques específicos para facilitar la adopción de modelos empresariales más sostenibles y resilientes en un panorama global cada vez más complejo. Los hallazgos proporcionan a los gestores empresariales una guía para la adopción de estrategias de gestión responsable y sostenible que contribuyan a equilibrar los objetivos económicos, sociales y ambientales en estos sectores. Asimismo, proporcionan información valiosa para la toma de decisiones de los inversores, así como para el diseño de políticas públicas por parte de gobiernos y legisladores dirigidas a fomentar un desarrollo económico global más sostenible.

Palabras clave: sostenibilidad empresarial, estrategia empresarial, innovación climática, desempeño financiero, sectores esenciales.

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THESIS SUMMARY (GALICIAN)

O desenvolvemento sostible consolidouse como unha das metas globais máis importantes do noso tempo (Mishra et al., 2024). Definido en 1987 no Informe Brundtland como aquel que "satisfai as necesidades do presente sen comprometer a capacidade das xeracións futuras para satisfacer as súas propias necesidades" (World Commission on Environment and Development, 1987, p. 8), son numerosos os esforzos realizados para impulsar un cambio de paradigma que logre un equilibrio entre o crecemento económico, a protección do medio ambiente e o desenvolvemento social. Entre os grandes fitos destacan o Acordo de París de 2015 (United Nations Framework Convention on Climate Change, 2015), cuxo obxectivo principal é limitar o aumento da temperatura global; e a Axenda 2030 para o Desenvolvemento Sostible (United Nations General Assembly, 2015), que proporciona unha folla de ruta composta por 17 Obxectivos de Desenvolvemento Sostible (ODS) que abordan os principais desafíos económicos, sociais e ambientais aos que se enfronta o planeta (Lafortune et al., 2020; Usmani et al., 2022). A estes acordos internacionais súmanse novos enfoques, como o nexo auga-enerxía-alimentos (Brouwer et al., 2024), que subliña a necesidade dunha xestión integrada destes recursos esenciais, co fin de asegurar a súa dispoñibilidade a longo prazo fronte a intereses contrapostos que os demandan (Food and Agriculture Organization of the United Nations, 2024; Torhan et al., 2022).

A pesar dos notables avances logrados, os efectos dunha presión prolongada da actividade humana sobre o sistema Terra, que traspasou seis dos nove límites planetarios coñecidos (Richardson et al., 2023), maniféstanse de maneira cada vez máis evidente e alarmante. Superar estes límites eleva o risco de alteracións irreversibles nos ecosistemas globais, comprometendo non só a estabilidade ambiental senón tamén o benestar das xeracións presentes e futuras (Rockström et al., 2009; Steffen et al., 2015). A isto súmase un escenario de "policrise" (Henig e Knight, 2023), marcado pola pandemia de COVID-19, conflitos xeopolíticos (como a guerra entre Rusia-Ucraína), que empeoran a escaseza de recursos e agudizan os problemas de seguridade enerxética e alimentaria, así como a intensificación de fenómenos climáticos extremos (Aiginger e Ketels, 2024; Ingram et al., 2023; Wegren, 2023).

Neste contexto, a sostibilidade empresarial convértese nun imperativo ineludible. As organizacións empresariais están chamadas non só a reaccionar, senón a desempeñar un papel protagonista na transición cara a un modelo de desenvolvemento sostible, que contribúa a lograr o equilibrio entre as súas tres dimensións: económica, social e ambiental (Mahajan et al., 2024; Mio et al., 2020; Sullivan et al., 2018). Os sectores esenciais, xestores de recursos críticos para o benestar humano e a estabilidade socioeconómica, adquiren un papel central nesta transición (Agovino et al., 2021; País-Magalhães et al., 2021**)**. En concreto, o sector biotecnolóxico e farmacéutico (biofarmacéutico), clave no desenvolvemento de vacinas fronte á pandemia de COVID-19 (Krammer, 2020), e os sectores de alimentos e bebidas xunto coa industria de servizos públicos, fundamentais para garantir a dispoñibilidade e o acceso aos recursos esenciais abordados polo enfoque do nexo auga-enerxía-alimentos (Cagno et al., 2022; Giacomini et al., 2020). A relevancia e vulnerabilidade destes sectores aos impactos xerados por escenarios de crises e eventos extremos, subliña a urxencia de que estes transiten cara a modelos empresariais máis sostibles co fin de evitar o colapso de sociedades e economías.

Ante esta situación, as empresas enfróntanse ao desafío de equilibrar os seus intereses económicos coas demandas sociais e ambientais (Aibar-Guzmán et al., 2023; García-Sánchez et al., 2023), á vez que se preparan para responder ante escenarios extremos e incertos (Dhanda e Shrotryia, 2021). Este desafío require dunha orientación dos modelos de negocio cara á

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creación de valor sostible, que aliñe as actividades empresariais cos intereses e necesidades das partes interesadas e xere valor nas dimensións económica, social e ambiental (Elkington, 1997; Freeman, 2010; Lüdeke-Freund et al., 2020). Neste proceso, as empresas contan con recursos limitados, polo que deben priorizar prácticas que contribúan aos seus obxectivos tanto a curto como a longo prazo. En consecuencia, a toma de decisións empresariais e o investimento responsable atopan nos criterios ambientais, sociais e de gobernanza (ASG) un marco de referencia para guiar e avaliar as decisións empresariais, estendendo o enfoque máis aló dos resultados financeiros (Gangi et al., 2021; Ritz, 2022; Vitale et al., 2023). Así mesmo, a aposta pola innovación no contexto empresarial recoñécese como un aspecto significativo para o avance cara á consecución dos ODSs, sendo un mecanismo capaz de desenvolver solucións transformadoras nas tres dimensións da sostibilidade (Azmat et al., 2023; Lippolis, 2023).

A pesar do crecente interese académico pola sostibilidade empresarial, a literatura prestou escasa atención aos sectores esenciais (Partalidou et al., 2020; Sandberg et al., 2023) e persisten importantes baleiros no coñecemento. Existe unha limitada comprensión sobre que accións específicas poden implementar as empresas para orientar de maneira efectiva os seus esforzos cara ao logro de obxectivos sostibles (Dhanda e Shrotryia, 2021; PricewaterhouseCoopers, 2019). Ademais, a evidencia empírica arroxa resultados mixtos sobre a relación entre sostibilidade e desempeño financeiro (p. ex. Busch et al., 2022; Guastella et al., 2022; Nirino et al., 2020; Whelan et al., 2021), cunha falta de atención a medidas de desempeño baseadas no mercado (Gangi et al., 2021; Sandberg et al., 2023) e a necesidade de profundar en prácticas subxacentes aos piares ASG (Ehlers et al., 2022; Gull et al., 2022). Así mesmo, as desalentadoras perspectivas globais (Brammer et al., 2023; WEF, 2023) demandan unha maior comprensión do papel das estratexias empresariais na xestión de eventos extremos e grandes retos sociais, e unha exploración de procesos e prácticas organizativas capaces de crear valor sostible.

A través de catro artigos complementarios publicados en revistas indexadas en JCR y SCOPUS, esta tese de doutoramento ten como obxectivo abordar as lagoas identificadas examinando como as prácticas de xestión responsable e sostible inflúen no desempeño financeiro, impulsan a innovación e tecnoloxías climáticas, e contribúen a crear valor sostible en sectores esenciais. Cada un dos artigos analiza estratexias e decisións empresariais destas empresas vinculadas a diferentes desafíos relacionados coa falta de sostibilidade. Para as análises realizadas, utilizáronse mostras de empresas do sector biofarmacéutico (artigo 1), a industria de servizos públicos (artigo 2) e os sectores de produción de alimentos e de bebidas (artigos 3 e 4), cun período de estudo que abarca de 2019 a 2022.

Co propósito de lograr o obxectivo principal deste proxecto investigador, establecéronse catro obxectivos específicos:

- OE1: Analizar como as estratexias corporativas responsables mitigan o impacto da crise multidimensional de COVID-19 nos resultados financeiros.
- OE2: Determinar as combinacións de prácticas responsables e sostibles asociadas a un mellor rendemento financeiro, identificando a prácticas clave.
- OE3: Determinar as combinacións de factores de estrés ambiental e mecanismos de goberno corporativo asociadas á promoción da innovación e as tecnoloxías climáticas, identificando os mecanismos clave.
- OE4: Investigar como a xestión empresarial responsable e sostible contribúe á creación de valor sostible.

Para lograr estes obxectivos específicos formuláronse un total de 23 hipóteses que se identifican na Táboa 1 na sección 2.2 “research hypotheses” da tese de doutoramento. As hipóteses de 1 a 4 corresponden co OE1 e son postas a proba no primeiro artigo. As hipóteses

de 5 a 17 correspóndense co OE2 e son analizadas no segundo e terceiro artigo. As hipóteses de 18 a 23 responden ao OE3 e son avaliadas no cuarto artigo. Finalmente, o OE4 concrétase na análise conxunta de todas as hipóteses expostas.

A análise desenvolvida ao longo dos catro artigos segue unha continuidade temporal que reflicte as preocupacións internacionais do momento como consecuencia de eventos extremos e grandes retos sociais, incluídos a pandemia de COVID-19, as crises de enerxía e de alimentos iniciadas en 2021, e o cambio climático. Este percorrido comeza no artigo 1 (Piñeiro-Chousa, J., López-Cabarcos, M. Á, Quiñoá-Piñeiro, L., e Pérez-Pico, A. M. (2022). US biopharmaceutical companies' stock market reaction to the COVID-19 pandemic. Understanding the concept of the 'paradoxical spiral' from a sustainability perspective. *Technological Forecasting & Social Change, 175*, 121365) onde se analiza a reacción no mercado bolsista de dúas empresas biofarmacéuticas – Pfizer e Moderna – líderes no desenvolvemento e comercialización de vacinas baseadas en ARN mensaxeiro para combater o COVID-19. Considerando un período previo e posterior ao estalido da pandemia, o artigo examina como as estratexias de innovación tecnolóxica destas empresas puideron condicionar o comportamento dos seus rendementos bolsistas e o seu impacto no mercado tecnolóxico. Empregáronse os modelos econométricos GARCH e DCC-GARCH para estudar este comportamento e a posible existencia dun efecto contaxio entre estas e o principal índice tecnolóxico de referencia no mercado. Os resultados obtidos revelan unha influencia distinta da volatilidade do mercado e do sentimento do mercado sobre os rendementos bolsistas destas empresas. Ademais, durante o período COVID, a volatilidade do mercado acumulada afectou significativamente á estabilidade bolsista de ambas as empresas, tendo os shocks diarios un menor impacto. As estratexias das dúas empresas permitiron que Moderna, e en menor medida Pfizer, exercesen un efecto positivo no mercado bolsista, demostrando a existencia dun forte efecto contaxio co índice tecnolóxico NASDAQ, o que axudou a amortecer a súa caída. Deste xeito, a innovación tecnolóxica demostra actuar como un mecanismo de resiliencia empresarial fronte a crises globais.

A continuación, os artigos 2 e 3 céntranse na identificación de prácticas de xestión responsable e sostible que son adoptadas por empresas de sectores esenciais e que contribúen a mitigar os impactos negativos da súa actividade, enfrontar desafíos actuais e futuros, e lograr un equilibrio financeiro. O artigo 2 (López-Cabarcos, M. Á, Santos-Rodrigues, H., Quiñoá-Piñeiro, L., e Piñeiro-Chousa, J. (2023). How to explain stock returns of utility companies from an environmental, social and corporate governance perspective. *Corporate Social Responsibility and Environmental Management, 30*(5), 2278-2291) analiza prácticas ASG no contexto de empresas cotizadas pertencentes á industria de servizos públicos (electricidade, auga, gas, residuos e servizos múltiples). Pola súa banda, o artigo 3 (López-Cabarcos, M. Á, Piñeiro-Chousa, J., Quiñoá-Piñeiro, L., e López-Pérez, M. L. (2024). Water and waste management strategies as drivers of the financial performance of food companies. *Technological Forecasting & Social Change, 200*, 123138) céntrase no sector da produción de alimentos. Empregando unha análise cualitativa comparativa de conxuntos difusos (fsQCA) ambos os estudos identifican combinacións de prácticas responsables e sostibles asociadas a un desempeño financeiro superior. En concreto, demóstrase que a implementación destas combinacións de prácticas conduce de maneira consistente a rendementos bolsistas superiores, entre as empresas de servizos públicos, e a unha sobrevaloración no mercado (Q de Tobin > 1), entre as empresas produtoras de alimentos. No caso das empresas de servizos públicos (artigo 2), esta vantaxe estratéxica recae principalmente na adopción de prácticas que fomentan a ausencia de emisións de CO_2 e equivalentes, o investimento ambiental proactivo, e a ausencia dunha vinculación de obxectivos de

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sostibilidade á compensación dos altos executivos. A formación en xestión ambiental e as políticas de competencia xusta identifícanse como factores secundarios. Dentro desta industria, obsérvanse diferenzas entre as prácticas predominantes entre as empresas do sector da electricidade e as empresas de servizos públicos non eléctricas. En concreto, cuestionase a necesidade de incentivos de compensación á sostibilidade e obsérvase un predominio da formación ambiental dos empregados entre as empresas do sector da electricidade fronte ás políticas e esforzos orientados a promover unha competencia xusta nas empresas de servizos públicos non eléctricas. Pola súa banda, as empresas produtoras de alimentos (artigo 3) atopan na reciclaxe e reutilización de residuos, a eficiencia económica no uso de recursos hídricos e a eficiencia económica na produción de residuos, as súas prácticas máis reproducidas e relevantes para conducir á sobrevaloración no mercado. A definición de obxectivos de eficiencia hídrica e un equilibrado consumo da auga extraída resultan ser factores continxentes, cuxa presencia e ausencia depende do contexto no que se combinen con outras prácticas. Estes resultados revelan a importancia da responsabilidade e a sostibilidade empresarial para incrementar o atractivo financeiro das empresas pertencentes a sectores esenciais e fortalecer a súa posición no mercado. Este beneficio está condicionado ao deseño de estratexias adaptadas aos diferentes contextos sectoriais, integrando combinacións flexibles de prácticas responsables e sostibles para maximizar o seu impacto.

Finalmente, o artigo 4 (Quiñoá-Piñeiro, L., López-Cabarcos, M. Á, e Piñeiro-Chousa, J. (2025). Innovating for sustainability in food and beverage companies: the role of governance and environmental factors in climate change mitigation. *British Food Journal, 127*(1), 54-72) pon o foco de atención na consideración da innovación como unha fonte de solucións e oportunidades a longo prazo. É por iso que neste artigo perséguese analizar que condicións motivan ás empresas de sectores esenciais a investir en innovación e tecnoloxía climática. Empregando de novo a metodoloxía fsQCA, identifícanse combinacións de factores de goberno corporativo e factores ambientais adversos que se asocian cunha ampla integración de innovacións e tecnoloxías para a mitigación do cambio climático en empresas dos sectores de alimentación e bebidas. Os resultados obtidos demostran a existencia de diferentes combinacións de factores que conducen a este resultado. En concreto, contar cun comité de sostibilidade especializado e fomentar o compromiso e a involucración activa das partes interesadas nos procesos de toma de decisións son os mecanismos de gobernanza máis relevantes e estendidos para lograr unha ampla integración de innovación climática. Pola súa banda, a relevancia da presenza dunha ampla representación feminina no consello de administración da empresa varía en función da rexión analizada. Mentres que esta condición prevalece nas mostras global e europea, na asiática ocorre o contrario, sendo requirida a ausencia e non a presenza desta condición, o que parece estar vinculado a factores históricos, económicos e culturais. Aínda que os factores ambientais adversos do país onde se sitúa a sede da empresa son relevantes para deseñar estratexias eficaces de mitigación do cambio climático, tamén se demostra que algunhas organizacións logran integrar a innovación climática independentemente destes contextos ambientais externos. Deste xeito, os resultados subliñan o papel das prácticas e dos órganos de gobernanza, así como o seu compromiso sostible, para impulsar a innovación e tecnoloxías climáticas.

Os achados desta tese de doutoramento achegan contribucións relevantes para a comunidade académica e aplicacións prácticas en contornas empresariais e sociais. Por unha banda, desde un enfoque teórico, a investigación realizada contribúe desde diferentes perspectivas a abordar baleiros de coñecemento e a enriquecer a limitada atención prestada na literatura ao rol da estratexia empresarial en sectores esenciais para adaptarse e crear valor sostible en contextos de incerteza. En concreto, amplíase o coñecemento sobre impulsores do

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éxito empresarial e a supervivencia organizativa en contextos extremos, reforzando o papel da innovación tecnolóxica como un mecanismo clave para a sostibilidade e a resiliencia empresarial. Tamén se valida empiricamente a existencia dunha relación positiva entre a adopción de combinacións de prácticas responsables e sostibles e o desempeño financeiro baseado no mercado en empresas de sectores esenciais. Ponse en valor a importancia dos factores ASG na percepción do mercado e na creación de valor sostible. Ademais, introdúcese unha conexión empírica entre a gobernanza corporativa, os factores ambientais adversos e o impulso da innovación e tecnoloxías climáticas nos sectores de alimentación e bebidas, proporcionando un marco para investigar a influencia destes factores na acción climática da empresa. Así mesmo, o estudo realiza unha achega metodolóxica ao aplicar a técnica fsQCA na investigación da sostibilidade empresarial. FsQCA permite capturar complexidades da implementación de prácticas ASG nas organizacións, considerando relacións asimétricas e heteroxéneas en datos reais, desafiando deste xeito métodos tradicionais que provén de solucións únicas ou universais.

Doutra banda, desde un enfoque práctico, o estudo proporciona información valiosa para o deseño de estratexias empresariais que maximicen a contribución ao desenvolvemento sostible e optimicen o desempeño financeiro, xerando impactos en diversos actores sociais e grupos de interese. En particular, os achados proporcionan aos xestores empresariais de sectores esenciais unha guía para a adopción de prácticas de xestión responsable e sostible que contribúan a deseñar estratexias que equilibren os obxectivos económicos, sociais e ambientais. Entre as prácticas recomendadas inclúense:

- Fortalecer as estruturas de gobernanza corporativa, promovendo a creación de comités de sostibilidade especializados, a participación activa das partes interesadas e a representación feminina nos consellos de administración, esta última tendo en consideración a existencia de variacións rexionais.
- Incluír indicadores ASG na toma de decisións empresariais, co fin de avaliar a efectividade e o impacto das estratexias implementadas.
- Impulsar a formación e capacitación en sostibilidade a todos os niveis organizativos, desde líderes empresariais ata equipos operativos, creando unha cultura empresarial orientada cara ao desenvolvemento sostible.
- Optimizar a eficiencia dos procesos produtivos desde un enfoque sostible, priorizando a xestión eficiente de recursos naturais como a auga, a reutilización e reciclaxe de residuos e o uso de enerxías renovables para reducir as emisións de CO_2 e equivalentes.
- Promover o investimento ambiental, especialmente en innovación e tecnoloxías sostibles, fortalecendo a capacidade da organización para mitigar riscos, actuar fronte a crises globais e mellorar a súa resiliencia.

A integración destas prácticas na organización debe adaptarse ao contexto sectorial e ás demandas da contorna, asumíndose non como un custo adicional senón como un investimento estratéxico capaz de impulsar a sostibilidade e o éxito empresarial. Así mesmo, o estudo proporciona información valiosa para a toma de decisións dos investidores, identificando prácticas específicas útiles para avaliar o potencial de crecemento das empresas e seleccionar aquelas con maior proxección de retorno financeiro. Ao mesmo tempo, o investimento en empresas máis sostibles contribúe a avanzar no cumprimento dos ODSs á vez que reduce a exposición a diversos riscos, como os regulatorios ou ambientais, que poden afectar á estabilidade do investimento realizado. Por último, os achados achegan información relevante para o deseño de políticas públicas por parte de gobernos e lexisladores dirixidas a empresas esenciais, en concreto as de servizos públicos e as produtoras de alimentos e bebidas. Estas políticas deben incentivar a adopción de prácticas que promovan unha xestión máis eficiente

de recursos, un impulso da innovación e tecnoloxías climáticas e a transición a modelos empresariais sostibles, co fin último de fomentar un desenvolvemento económico global máis sostible.

De maneira conxunta, os catro artigos que compoñen esta tese de doutoramento ofrecen unha visión sobre como as empresas pertencentes a sectores esenciais poden crear valor sostible mediante a integración de principios de responsabilidade social e sostibilidade ambiental na súa xestión e estratexia corporativa. Os achados reforzan a transcendencia destes sectores para a transición cara a un modelo de desenvolvemento global sostible. Ademais, demostran que a adopción destas prácticas contribúe ao benestar colectivo, mitiga riscos ambientais e sociais, fortalece a resiliencia de sociedades e organizacións empresariais fronte aos desafíos contemporáneos, e crea valor nas tres dimensións da sostibilidade: económica, social e ambiental.

Palabras clave: sostibilidade empresarial, estratexia empresarial, innovación climática, desempeño financeiro, sectores esenciais.

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1 INTRODUCTION

1.1 CONTEXTUAL OVERVIEW

Sustainable development is widely recognised as one of the most critical global goals of our time (Mishra et al., 2024). The Brundtland Report defined it in 1987 as development that 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987, p. 8). This collective and intergenerational vision proposes a paradigm shift in the way we inhabit the planet, aimed at achieving a balance between economic growth, environmental protection and social development. Since its definition in 1987, various actors have taken significant steps to concretise and coordinate efforts beneficial to the sustainability of the planet. Major milestones include the 2015 Paris Agreement (United Nations Framework Convention on Climate Change, 2015), a legally binding international treaty that aims to limit global temperature rise to 2°C above pre-industrial levels; and the 2030 Agenda for Sustainable Development (United Nations General Assembly, 2015), also adopted in 2015 by UN Member States, which provides a comprehensive roadmap composed of 17 Sustainable Development Goals (SDGs) that address the major economic, social and environmental challenges facing the planet (Lafortune et al., 2020; Usmani et al., 2022). These international agreements are joined by new approaches with relevance in today's sustainable discourse, such as the resource nexus frameworks and especially the Water-Energy-Food (WEF) nexus (Brouwer et al., 2024). This approach underlines the interdependence between these resources that are essential for human well-being, poverty eradication and progress towards sustainable development (Food and Agriculture Organization of the United Nations [FAO], 2014), highlighting the need for their integrated management to ensure their long-term availability in the face of competing interests that demand them (FAO, 2024; Torhan et al., 2022).

Despite the agreements and progress made, the complexity and growth of modern societies continues to pose unprecedented challenges to sustainability. The ever-increasing anthropogenic pressure on the Earth system brings us dangerously close to breaching all planetary boundaries, i.e. the critical thresholds that support the stability of ecosystems and human life on the planet (Richardson et al., 2023). Exceeding these limits increases the risk of irreversible alterations in global ecosystems, compromising not only environmental stability but also the well-being of present and future generations (Rockström et al., 2009; Steffen et al., 2015). Achieving sustainable development implies an unavoidable and shared responsibility among various social and economic actors, including governments, non-governmental organisations, academic institutions, businesses and civil society. In particular, businesses - from microenterprises to multinationals - have been identified by experts and academics as key actors for the achievement of the SDGs and the development of sustainable and inclusive economic models (Mahajan et al., 2024; Mio et al., 2020; Sullivan et al., 2018). Beyond their role in implementing and operationalising sustainability policies and regulations, the undeniable involvement of business in earth system transformation processes, coupled with

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their relevance as drivers of socio-economic growth, gives them a unique potential to correct the current 'unsustainable' path by redirecting their strategies and business models towards effectively building a prosperous and sustainable future (D'Amore et al., 2024).

While all companies share the responsibility to actively participate in this transition, those that manage resources essential for human well-being and socio-economic development are particularly relevant (Agovino et al., 2021; Gilardoni, 2020; País-Magalhães et al., 2021**)**. Specifically, the operations of companies in essential industries and sectors such as utilities (electricity, gas, water...) and food and beverage (F&B), have a significant impact on ecosystems, climate change or ozone layer depletion (Gilardoni, 2020**,** Sovacool et al., 2021). Their activities are a major source of global pollution (Slacik & Greiling, 2020) as well as intensive use of critical resources such as water, energy or land (Cupertino et al., 2021; do Canto et al., 2021; Kucukvar et al., 2019). Their duality as drivers of environmental degradation, as well as agents of transformation with the potential to lead changes towards sustainability on a large scale, underlines the importance of prioritising the adequate management of these sectors at multiple levels (FAO, 2023, Intergovernmental Panel on Climate Change [IPCC], 2023; Pereira et al., 2022). Integrating responsible and sustainable principles throughout the operations of companies in these sectors will contribute not only to mitigating climate change, but also to strengthening their corporate reputation, improving relations with their stakeholders and generating new business opportunities (Gull et al., 2022; Ji et al., 2023; Somlai, 2022).

In this context, the convergence of several global crises, whose interaction amplifies their impacts and collectively transforms them into a 'polycrisis' (Henig & Knight, 2023), reveals a significant paradox: while the need to move towards sustainability is more urgent than ever, attention and resources have been oriented towards the management of other more immediate issues (World Economic Forum [WEF], 2023). The COVID-19 pandemic, geopolitical conflicts (such as the Russia-Ukraine war), the energy and food crises that began in 2021, and extreme weather events around the world (Aiginger & Ketels, 2024; Ingram et al., 2023; Wegren, 2023) have been a turning point. These events, which disrupted progress on the sustainable agenda (Azmat et al., 2023; Sachs et al., 2024), also highlighted the vulnerability of systems critical to the stability and resilience of economies and societies (Sovacool et al., 2020; 2021; Zakeri et al., 2022). Specifically, there was an increased focus on health systems, with an emphasis on the biotechnology and pharmaceutical (biopharmaceutical) sectors driven by the development of vaccines against COVID-19 (Krammer, 2020), and on agricultural and utilities systems, guarantors of availability and access to essential services and resources addressed by the WEF nexus approach (Cagno et al., 2022; Giacomini et al., 2020). These crises have also highlighted possible underlying anthropogenic and environmental drivers (de Paula & Willetts, 2021; Haines & Ebi, 2019), reviving the need for a strong commitment to sustainable development as a comprehensive response to the economic, social and environmental uncertainties generated (Baker et al., 2020; Hale et al., 2020).

The bleak global outlook underscores the need to redirect business efforts towards sustainable goals, especially given the discrepancy between the private sector's long-term view of environmental risks and the immediate urgency perceived by governments and civil society (WEF, 2024). In this environment, companies face the challenge of balancing their short-term economic interests with long-term environmental and social demands (Aibar-Guzmán et al., 2023; García-Sánchez et al., 2023), and of guiding their efforts to prepare for and act upon extreme and uncertain scenarios effectively (Dhanda & Shrotryia, 2021). These challenges make it essential to move towards business models that integrate principles of environmental sustainability and social responsibility into their strategy and decision-making (Domingo-Posada et al., 2024; Mio et al., 2020; Schoenmaker & Schramade, 2019). These models,

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oriented towards sustainable value creation, should align business activities with the interests and needs of all stakeholders and create value in all three dimensions of sustainable development: economic, social and environmental (Elkington, 1997; Freeman, 2010; Lüdeke-Freund et al., 2020). In this process, companies have limited resources and must prioritise practices that contribute to both their short- and long-term goals. As a result, business decision-making and responsible investment have found in environmental, social and governance (ESG) criteria a framework to guide and evaluate business decisions, extending the focus beyond financial performance (Gangi et al., 2021; Ritz, 2022; Vitale et al., 2023). Furthermore, a commitment to innovation in the business context has been recognised as a significant aspect of progress towards achieving the SDGs, being a mechanism capable of developing transformative solutions in all three dimensions of sustainability (Azmat et al., 2023; Lippolis, 2023).

The COVID-19 pandemic has underscored the need for academic studies and approaches to help businesses reduce environmental degradation and prepare for extreme events and societal grand challenges, triggering a rapid proliferation of sustainability-related research in the fields of business and management (Brammer et al., 2020; Mahajan et al., 2024). Several approaches and topics have been addressed, such as the repercussions and impacts of crises and extreme events (Brammer et al., 2023; Shaik, 2020; Zakeri et al., 2022), sustainable investment (Schoenmaker & Schramade, 2019), integration of SDGs into business strategy (Domingo-Posada et al., 2024), climate change mitigation and adaptation strategies (Daddi et al., 2020; Unter et al., 2024), green innovation (García-Sánchez et al., 2021; Issa & Bensalem, 2023), the link between sustainable practices and business performance (Coelho et al., 2023; Nirino et al., 2020; Partalidou et al., 2020; Sandberg et al., 2022), and value creation and sustainable business models (Dhanda & Shrotyia, 2021; Lüdeke-Freund et al., 2020). This research highlights the importance of business in addressing new challenges and promoting progress towards sustainable goals; however, it also highlights the need for more empirical research.

To date, there are significant knowledge gaps on the role of firms in essential sectors in addressing global challenges. In particular, knowledge on how business technology innovation in crisis contexts influences financial performance and sustainable value creation is limited. Further analysis is also needed on the responsible and sustainable practices being implemented by companies in essential sectors, their link to financial performance, and the factors that favour the adoption of innovations and technologies aimed at mitigating climate change. Exploring these aspects empirically is relevant to offer insights on how to maximise the business contribution to sustainable development while strengthening the financial performance of these organisations.

1.2 RESEARCH MOTIVATIONS

The role of business organisations in promoting sustainable development has been widely highlighted in previous academic literature (Mio et al., 2020). Nevertheless, there is limited understanding of the specific actions that companies are implementing, or should implement, to effectively target their investment efforts towards achieving sustainable goals (Dhanda & Shrotryia, 2021; PricewaterhouseCoopers, 2019). Similarly, despite the growing interest of academics and practitioners in the relationship between sustainable business practices and financial performance, research yields mixed findings (e.g. Busch et al., 2022; Guastella et al., 2022; Nirino et al., 2020; Okafor et al., 2021; Whelan et al., 2021). In addition, most studies use accounting-based measures of financial performance, without paying attention to market-based measures (Gangi et al., 2021; Nirino et al., 2020; Partalidou et al., 2020; Sandberg et al., 2023), which better reflect the current value of the firm and its future growth potential

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(Benjamin & Biswas, 2022; Okafor et al., 2021; Vargas-Santander et al., 2023). This constrained approach, coupled with the limited attention paid to sectors that are essential to societies (Partalidou et al., 2020; Sandberg et al., 2023) highlights the need for further sectoral exploration of this relationship. Additionally, the divergence between ESG ratings provided by different agencies can lead to inconsistent assessments of companies' sustainable performance, making it difficult to identify imbalances in the environmental, social and governance pillars (Berg et al., 2019). To overcome these limitations, it is essential to deepen the data underlying these ratings by analysing specific sub-dimensions and indicators of the three ESG pillars (Ehlers et al., 2022; Gull et al., 2022; Hussain et al., 2018). This will enable the identification of best practices and specific areas for improvement in corporate strategy and management.

On the other hand, medium-term projections indicate the possibility of a 'polycrisis' arising from interrelated environmental, socio-economic and geopolitical risks, especially linked to the supply and demand of natural resources (WEF, 2023). This situation, combined with the increasing frequency of extreme and disruptive events, poses unprecedented challenges to organisational survival (Brammer et al., 2023). This scenario calls for a deeper understanding of the role of business strategies in managing current and future social, economic and environmental issues. Among the gaps identified are the relevance of innovation (applied, for example, in the development of vaccines against the SARS-CoV-2 coronavirus) for global economic and social recovery and business success; the impact of natural disasters and adverse physical conditions on business decisions and strategies (Unter et al., 2024); the role of corporate governance in business response to climate change and extreme weather events (Aguilera et al., 2021; Enciso-Alfaro & García-Sánchez, 2023; Unter et al., 2024); and the identification of drivers of climate innovation and the expansion of clean technologies, particularly in highly polluting industries and sectors (Azmat et al., 2023, Enciso-Alfaro & García-Sánchez, 2023). Furthermore, the existing body of literature on business models and sustainable value creation mostly uses a theoretical or conceptual perspective **(**Dhanda & Shrotyia, 2021; Lüdeke-Freund et al., 2020), so there is a lack of exploration of organisational processes and practices capable of leading to sustainable value creation.

Against this background, this research project addresses the identified gaps by generating empirical evidence on three key issues: (RI1) the impact of responsible and sustainable corporate management on financial performance, with a focus on ESG practices; (RI2) the influence of responsible and sustainable corporate management and external environmental factors on the promotion of climate innovation and technologies; and (RI3) the identification of responsible and sustainable practices that contribute to the creation of sustainable value (see Figure 1). This analysis focuses on sectors that are essential to societies and economies, aiming to provide practical implications for the design of business strategies to address emerging and future challenges related to sustainable development.

1.3 THESIS STRUCTURE

The structure of the thesis is organised in six chapters. Chapter 2 develops the general objective and the specific objectives defined in this project. Chapter 3 summarises the methodologies employed in the articles. Chapter 4 includes the final published or postprint versions of the four published manuscripts. Chapter 5 presents a general discussion of the findings and their theoretical and practical implications. Finally, Chapter 6 presents the conclusions of the thesis drawn from the main findings.

The first article (Piñeiro-Chousa, J., López-Cabarcos, M. Á, Quiñoá-Piñeiro, L., & Pérez-Pico, A. M. (2022). US biopharmaceutical companies' stock market reaction to the COVID-19 pandemic. Understanding the concept of the ‘paradoxical spiral’ from a sustainability

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perspective. *Technological Forecasting & Social Change, 175*, 121365) addresses the first specific objective (SO1) where hypotheses 1 to 4 of this thesis are tested. This article analyses the stock market behaviour of the biopharmaceutical companies Pfizer and Moderna, leaders in the development and commercialisation of messenger RNA vaccines to combat COVID-19. Considering a period before and after the outbreak of the pandemic, the article examines how the corporate strategies of both companies (oriented towards technological innovation with a strong social impact), could have conditioned the behaviour of their stock market returns and their impact on the technological market. GARCH and DCC-GARCH econometric models were used to study the behaviour of the stock market returns and volatility of both companies, as well as the possible existence of a contagion effect between them and the main technological benchmark index in the market.

Recognising the importance of responsible and sustainable management to address current challenges and prevent negative and/or disruptive events that threaten human well-being (such as exposure to COVID-19 linked to ecosystem degradation), the second and third articles address the second specific objective (SO2), analysing responsible and sustainable business practices in the utilities industry and the food production sector, respectively. The second article (López-Cabarcos, M. Á, Santos-Rodrigues, H., Quiñoá-Piñeiro, L., & Piñeiro-Chousa, J. (2023). How to explain stock returns of utility companies from an environmental, social and corporate governance perspective. *Corporate Social Responsibility and Environmental Management, 30*(5), 2278-2291) tests hypotheses 5 to 11, while the third (López-Cabarcos, M. Á, Piñeiro-Chousa, J., Quiñoá-Piñeiro, L., & López-Pérez, M. L. (2024). Water and waste management strategies as drivers of the financial performance of food companies. *Technological Forecasting & Social Change, 200*, 123138) analyses hypotheses 12 to 17. Both articles employ fuzzy set Qualitative Comparative Analysis (fsQCA) to identify combinations of responsible and sustainable practices associated with superior corporate financial performance. Collectively, articles 1, 2, and 3 provide empirical evidence on the impact of responsible and sustainable management in essential sectors on financial performance (RI1).

The fourth article (Quiñoá-Piñeiro, L., López-Cabarcos, M. Á, & Piñeiro-Chousa, J. (2025). Innovating for sustainability in food and beverage companies: the role of governance and environmental factors in climate change mitigation. *British Food Journal, 127*(1), 54-72) addresses the third specific objective (SO3). Building on the critical importance of innovation emphasised in article 1 and recognising the increasingly complex environmental challenges faced by companies in essential sectors, this article focuses on climate change mitigation through innovation. It aims to harness this source of opportunities to develop and implement sustainable solutions that address present and future environmental challenges. This article tests hypotheses 18 to 23 through an fsQCA analysis, considering factors internal and external to organisational control that are capable of translating investment in innovation and technology into climate solutions in the F&B sectors. In this way, article 4 provides evidence on the influence of responsible and sustainable corporate management, alongside external environmental factors, on the promotion of climate innovation and technologies (RI2).

Finally, the fourth specific objective (SO4) is addressed in a transversal way in the four articles that make up this PhD thesis. This objective seeks to shed light on the contribution of responsible and sustainable corporate management to the creation of sustainable value (RI3).

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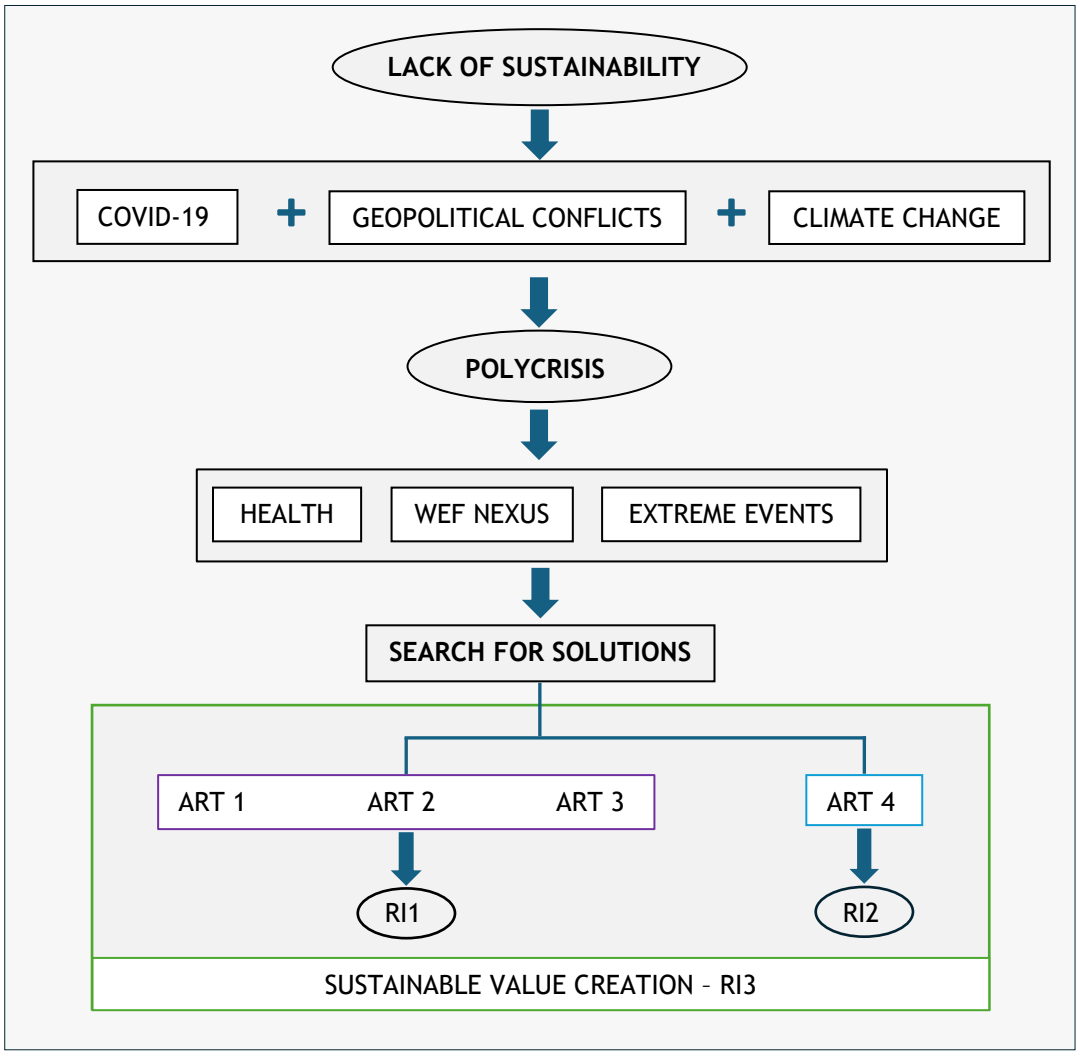

Figure 1. Thematic structure of the doctoral thesis
Source: Own elaboration

1.4 JUSTIFICATION OF THE UNIT AND THEMATIC AND METHODOLOGICAL COHERENCE

This PhD thesis is composed of four scientific articles published in impact journals indexed in Clarivate's Web of Science and Scopus, articulated under a common thematic narrative: sustainable value creation as a key strategy to address global challenges and build a more sustainable and resilient future. Each article analyses business strategies and decisions linked to different challenges related to the lack of sustainability, such as COVID-19, resource and waste management, and climate change, in sectors with high socio-economic and environmental relevance. The temporal continuity of the articles provides a comprehensive overview of how the adoption of responsible and sustainable practices, innovation, and corporate governance contribute to balancing economic, environmental and social objectives. This approach responds to the demands of today's global challenges including the risks arising from the undervaluation of natural ecosystems and planetary health.

The first article focuses on an extreme event: the COVID-19 pandemic. It analyses how technological innovation and corporate responses have been crucial in managing the health crisis and mitigating its negative socio-economic impacts. Particular attention is given to the effect of business strategy on the stock market behaviour of biopharmaceutical companies involved in the development of mRNA vaccines, highlighting their relevant role in pioneering

innovative solutions during a time of global uncertainty. This event marks a turning point in the importance of sustainable business strategies grounded on innovation. On this foundation, the second and third articles explore responsible and sustainable practices adopted by companies in critical industries and sectors, specifically utilities and food, whose significance has been accentuated by the pandemic. Both articles reflect the relevance of these sectors, not only in the context of sustainable development, but also in a context of 'polycrisis' which, with the outbreak of the armed conflict between Russia-Ukraine, has intensified global energy and food challenges. Thus, the second article focuses on practices related to the three ESG pillars adopted by utility companies, while the third article examines water and waste management practices implemented by agri-food companies, underscoring the existence of strategies that balance economic, social, and environmental dimensions. Finally, building on the relevance of technology-based innovation strategies highlighted in article 1, the financial benefits of adopting responsible and sustainable practices outlined in articles 2 and 3, and the contextual challenges previously discussed, the thesis transitions to article 4. This article emphasises the critical dependence of the F&B sectors on climate conditions, underscoring the urgent need for a strategic shift towards the adoption and integration of climate innovations and technologies, driven by the accelerating impacts of extreme weather events and resource scarcity. Collectively, the four articles show how the recent crises have redefined the role of the business community, pointing to innovation, social responsibility and sustainability as essential pillars for addressing global challenges.

In addition to the thematic unity, the thesis presents a solid methodological coherence that reinforces its rigour and allows capturing the complexity of business and market dynamics. The first article uses the quantitative GARCH and DCC-GARCH methodologies, which analyse volatility and dynamic correlations in financial markets under extreme conditions (such as those during COVID-19). The second, third and fourth articles employ the fuzzy set-based fsQCA methodology, which is suitable for exploring and identifying complex causal configurations that lead to positive outcomes (in terms of financial performance or innovation). These three articles, which use indicators and metrics based on the Thomson Reuters EIKON ESG standard, analyse listed companies in the utilities industry, and the F&B production sectors classified according to the Industry Classification Benchmark (ICB). The analysis period of the four articles allows capturing recent dynamics in the management of global challenges based on financial and non-financial information.

The thematic and methodological unity of the four articles is closely aligned with the research plan of this doctoral thesis. This research framework offers a broad and rigorous view on how companies can address global challenges and contribute to sustainable development. The three previously identified research issues (RI1, RI2, and RI3) are further explored through the objectives outlined in this doctoral thesis. Figure 2 illustrates the thematic and methodological unity, highlighting the continuity and coherence between the articles.

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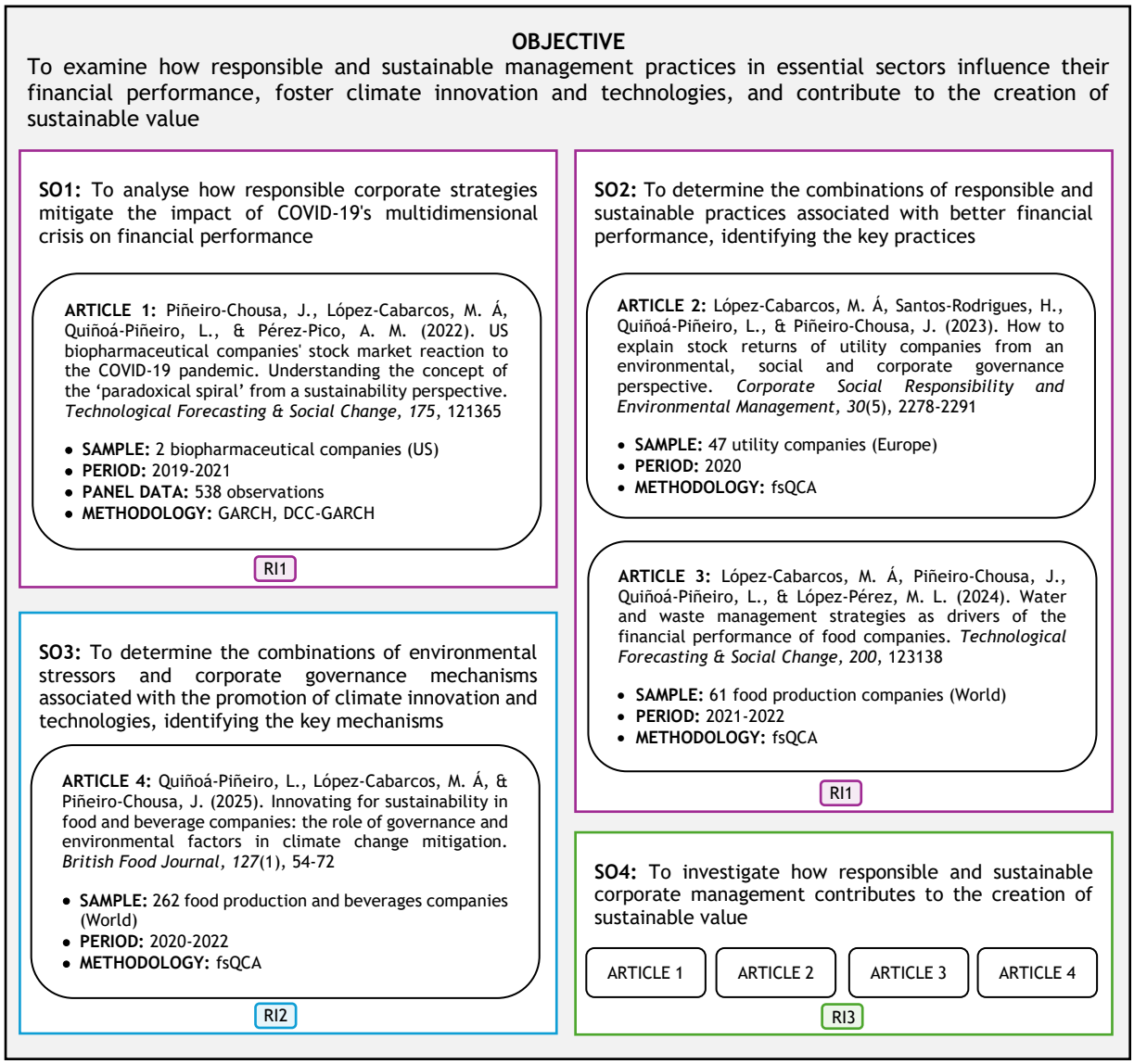

Figure 2. Thematic and methodological unit of the doctoral thesis
Source: Own elaboration

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2 OBJECTIVES AND HYPOTHESES

2.1 OBJECTIVES

The primary objective of this doctoral thesis is to examine how responsible and sustainable management practices in essential sectors influence their financial performance, foster climate innovation and technologies, and contribute to the creation of sustainable value.

This primary objective is concretised in the following specific objectives:

- SO1: To analyse how responsible corporate strategies mitigate the impact of COVID-19's multidimensional crisis on financial performance.
- SO2: To determine the combinations of responsible and sustainable practices associated with better financial performance, identifying the key practices.
- SO3: To determine the combinations of environmental stressors and corporate governance mechanisms associated with the promotion of climate innovation and technologies, identifying the key mechanisms.
- SO4: To investigate how responsible and sustainable corporate management contributes to the creation of sustainable value.

To achieve these objectives, the thesis begins by analysing the stock market reaction to the multidimensional crisis generated by the COVID-19 pandemic of two companies in the biopharmaceutical sector - Pfizer and Moderna -. The aim is to analyse how the strategies of technological innovation with a strong social impact adopted by these two companies have influenced their positions on the stock market and, thus, their resilience to this event. Considering the anthropogenic origin of this pandemic, attributed to a zoonotic transmission resulting from unsustainable practices (de Paula & Willetts, 2021; WHO, 2021a), the aim is to explore the relevance of responsible and sustainable corporate strategies. In particular, it investigates the role of innovation in addressing environmental, social and economic challenges, as well as the role of sustainable engagement of economic and social actors in long-term value creation.

Subsequently, the focus shifts to identifying responsible and sustainable management practices implemented by companies operating within the scope of the WEF nexus, which can help mitigate the negative impacts of their activity and actively contribute to sustainability and environmental preservation. Specifically, it aims to determine and analyse which combinations of practices related to ESG criteria are associated with better financial performance of companies in the utilities industry and the food production sector. Furthermore, it aims to identify which of these practices are key to achieving the intended outcome. To this end, market-based financial performance measures are considered, which express the present and future potential of companies to raise resources (Okafor et al., 2021; Vargas-Santander et al., 2023).

In the subsequent phase, the thesis focuses on business climate innovation as a source of long-term opportunities (Chandaria et al., 2021) and solutions. It aims to analyse the conditions that motivate the F&B sectors to invest in climate innovation and technologies. Specifically, it focuses on identifying the combinations of external environmental factors and corporate governance mechanisms that encourage the integration of innovations and technologies aimed

at mitigating climate change. Furthermore, it seeks to identify which of these factors and mechanisms are key to effectively fostering climate innovation.

Finally, the analyses conducted throughout this doctoral thesis aim to enhance understanding of how the integration of responsible and sustainable principles into the corporate management of companies in essential sectors contributes to the creation of sustainable value. This perspective underscores the importance of generating value beyond the traditional company- and customer-centred view. Instead, it advocates for a broader scope that encompasses a wider range of stakeholders and incorporates all dimensions of sustainable development: economic, social and environmental (Lüdeke-Freund et al., 2020).

2.2 RESEARCH HYPOTHESES

To achieve the objectives of this research, a total of 23 hypotheses are formulated. Specifically, the first specific objective (SO1: To analyse how responsible corporate strategies mitigate the impact of COVID-19's multidimensional crisis on financial performance) is analysed using hypotheses 1 to 4, which are tested in the first article. The second specific objective (SO2: To determine the combinations of responsible and sustainable practices associated with better financial performance, identifying the key practices) is analysed with hypotheses 5 to 17, which are tested in the second and third articles. The third specific objective (SO3: To determine the combinations of environmental stressors and corporate governance mechanisms associated with the promotion of climate innovation and technologies, identifying the key mechanisms) is investigated through hypotheses 18 to 23, assessed in the fourth article. The last specific objective (SO4: To investigate how responsible and sustainable corporate management contributes to the creation of sustainable value) is specified in the analysis of all the hypotheses presented.

The 23 hypotheses proposed, and the publications associated with each of them are listed in Table 1.

Table 1. Research hypotheses and corresponding publications

Hypothesis 1. The responsible corporate strategies of Pfizer and Moderna influence the impact of market volatility on their stock market returns, comparing the pre-COVID and COVID-19 periods.	Piñeiro-Chousa, J., López-Cabarcos, M. Á, Quiñoá-Piñeiro, L., & Pérez-Pico, A. M. (2022). US biopharmaceutical companies' stock market reaction to the COVID-19 pandemic. Understanding the concept of the 'paradoxical spiral' from a sustainability perspective. *Technological Forecasting & Social Change, 175*, 121365.
Hypothesis 2. The responsible corporate strategies of Pfizer and Moderna influence the behaviour of their respective volatilities, comparing the pre-COVID and COVID-19 periods.	
Hypothesis 3. The responsible corporate strategies of Pfizer and Moderna influence the strength of the contagion effect between their stock market performance and that of the NASDAQ-100 index, comparing the pre-COVID and COVID-19 periods.	
Hypothesis 4. The responsible corporate strategies of Pfizer and Moderna influence the impact of market sentiment on their stock market returns, comparing the pre-COVID and COVID-19 periods.	
Hypothesis 5. Different combinations of responsible and sustainable practices lead to better financial performance of utility companies.	López-Cabarcos, M. Á, Santos-Rodrigues, H., Quiñoá-Piñeiro, L., & Piñeiro-Chousa, J. (2023). How to explain stock returns of utility companies from an environmental, social and corporate governance perspective. *Corporate Social Responsibility and Environmental Management, 30*(5), 2278-2291.
Hypothesis 6. The absence of significant CO_2 and equivalent emissions is a key condition in configurations leading to the presence of stock returns in utility companies.	

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Hypothesis 7. The presence of senior executives' incentives linked to sustainability targets is a key condition in configurations leading to the presence of stock returns in utility companies.	
Hypothesis 8. The presence of environmental investments is a key condition in configurations leading to the presence of stock returns in utility companies.	
Hypothesis 9. The presence of environmental management training is a key condition in configurations leading to the presence of stock returns in utility companies.	
Hypothesis 10. The presence of fair competition policies is a key condition in configurations leading to the presence of stock returns in utility companies.	
Hypothesis 11. The causal configurations leading to the presence of stock returns vary between the electricity and non-electricity sectors.	
Hypothesis 12. Different combinations of responsible and sustainable practices lead to better financial performance of food production companies.	López-Cabarcos, M. Á, Piñeiro-Chousa, J., Quiñoá-Piñeiro, L., & López-Pérez, M. L. (2024). Water and waste management strategies as drivers of the financial performance of food companies. *Technological Forecasting & Social Change, 200*, 123138.
Hypothesis 13. The presence of water efficiency targets is a key condition in configurations leading to the presence of market overvaluation of food production companies (Tobin's Q > 1).	
Hypothesis 14. The presence of high consumption of withdrawn water is a key condition in configurations leading to the presence of market overvaluation of food production companies (Tobin's Q > 1).	
Hypothesis 15. The absence of a strong intensity of withdrawn water is a key condition in configurations leading to the presence of market overvaluation of food production companies (Tobin's Q > 1).	
Hypothesis 16. The presence of significant recycling and waste reuse performance is a key condition in configurations leading to the presence of market overvaluation of food production companies (Tobin's Q > 1).	
Hypothesis 17. The absence of a strong intensity of generated waste is a key condition in configurations leading to the presence of market overvaluation of food production companies (Tobin's Q > 1).	
Hypothesis 18. Different combinations of environmental stressors and corporate governance mechanisms lead to the integration of climate change mitigation innovation and technologies in food and beverage companies.	Quiñoá-Piñeiro, L., López-Cabarcos, M. Á, & Piñeiro-Chousa, J. (2025). Innovating for sustainability in food and beverage companies: the role of governance and environmental factors in climate change mitigation. *British Food Journal, 127*(1), 54-72.
Hypothesis 19. The presence of a substantial incidence of natural disasters in the country where the company is headquartered is a key condition in configurations leading to the presence of climate innovation.	
Hypothesis 20. The presence of significant water stress in the country where the company is headquartered is a key condition in configurations leading to the presence of climate innovation.	
Hypothesis 21. The presence of a CSR sustainability committee is a key condition in configurations leading to the presence of climate innovation.	

Hypothesis 22. The presence of a large female representation on the board of directors is a key condition in configurations leading to the presence of climate innovation.	
Hypothesis 23. The presence of an organisational commitment to stakeholder engagement is a key condition in configurations leading to the presence of climate innovation.	

Source: Own elaboration

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3 METHODOLOGY

3.1 JUSTIFICATION OF THE METHODOLOGY

In order to examine how responsible and sustainable corporate management of companies in essential sectors impacts their financial performance, fosters climate innovation and technologies, and contributes to sustainable value creation, different analyses are carried out along the four articles.

Firstly, the potential influence of the innovation-based business strategy of the US biopharmaceutical companies Pfizer and Moderna on their stock market behaviour before and after the outbreak of the COVID-19 pandemic is analysed (article 1). GARCH and DCC-GARCH models are used to analyse the volatility and stock market behaviour of both companies, including the influence of market volatility and market sentiment, as well as the possible existence of a contagion effect between their stock market returns and those of the global innovation benchmark. Different variables are used in this analysis including the daily stock returns of Pfizer and Moderna, market volatility based on the CBOE volatility index (VIX), investor sentiment through the ISEE sentiment index, and the NASDAQ-100 technology market benchmark.

Secondly, combinations of responsible and sustainable practices associated with better financial performance compared to their peers are analysed for 47 companies in the utilities industry (article 2) and 61 companies in the food production sector (article 3). In article 2, the main sample is divided into electricity and non-electricity utilities, in order to compare possible discrepancies between the two groups given the relevance of the European electricity sector for the continent's energy transition (Ribeiro et al., 2023). The fsQCA methodology is used to analyse the effect of combining different practices based on ESG indicators to lead to business success. Article 2 uses indicators on CO_2 and equivalent emissions, sustainability compensation incentives, environmental investments, environmental management training, fair competition policy as well as stock market returns. Article 3 uses indicators on water efficiency targets, water intensity ratio, water consumption ratio, waste intensity ratio, waste recycling ratio, as well as Tobin's Q.

Finally, combinations of environmental stressors and corporate governance mechanisms associated with greater integration of climate innovations and technologies are analysed in 262 companies in the F&B sectors (article 4). Again, the fsQCA methodology is used to determine complex causal configurations that lead to greater investments in climate change mitigation innovation and technologies. Corporate governance factors (CSR sustainability committee, stakeholder engagement and board gender diversity) and external environmental factors (water stress and natural disasters) and are used in the study, as well as a variable representing the innovations achieved and technologies used by companies to mitigate the impacts of climate change.

3.2 METHODOLOGY

To address the research objectives proposed, different empirical methods were applied, both quantitative (GARCH and DCC-GARCH models) and qualitative (fsQCA).

3.2.1 Quantitative analysis

3.2.1.1 GARCH model

Generalised autoregressive conditional heteroscedasticity (GARCH) models, introduced by Bollerslev (1986) as an extension of ARCH models (Engle, 1982), are widely used tools for modelling volatility in financial time series data (Chaudhary et al., 2020), especially in the study of stock market returns (Greene, 2020). These models are effective in capturing volatility clusters, a phenomenon that describes the alternation between periods of high and low volatility in financial asset returns, using daily or intraday data (Alexander, 2008).

A GARCH (m,k) model has two main equations. The mean equation establishes the relationship between the observed variables, describing the behaviour of returns. The variance equation specifies the dynamics of volatility, capturing the dynamic behaviour of the conditional variance (Alexander, 2008). This structure is defined as follows (Bollerslev, 1986; Piñeiro-Chousa et al., 2018):

Mean model:

$$y_t = x_t\beta + \epsilon_t \quad (1)$$

Variance model:

$$\sigma_t^2 = \gamma_0 + \gamma_1\epsilon_{t-1}^2 + \gamma_2\epsilon_{t-2}^2 + \cdots + \gamma_m\epsilon_{t-m}^2 + \delta_1\sigma_{t-1}^2 + \delta_2\sigma_{t-2}^2 + \cdots + \delta_k\sigma_{t-k}^2 \quad (2)$$

where y_t is the conditional mean, σ_t^2 is the conditional variance, ϵ_t^2 are the squared residuals, γ_i are the ARCH parameters, and δ_i are the GARCH parameters.

GARCH models allow the conditional variance to evolve dynamically as a function of present and past information, incorporating lags that reflect the impact of previous shocks and the persistence of volatility (Brooks & Rew, 2002). Their specification, more general than that of ARCH models, achieves equal or superior performance with a smaller number of terms, making them more efficient in capturing volatility clusters (Bollerslev, 1986; Greene, 2020).

Among the different variants, the GARCH (1,1) model is one of the most widely employed due to its simplicity and robustness (Engle, 2001; Setiawan et al., 2021). In this model, the first number refers to the autoregressive lags (ARCH terms) appearing in the equation, and the second number refers to the lags of the moving average (GARCH terms) (Engle, 2001). The GARCH (1,1) model is defined as follows

Mean model:

$$y_t = \beta_0 + \beta_1 x_t + \epsilon_t \quad (3)$$

Variance model:

$$\sigma_t^2 = \gamma_0 + \gamma_1\epsilon_{t-1}^2 + \delta_1\sigma_{t-1}^2 \quad (4)$$

Thus, a high ARCH coefficient (γ_1) indicates that volatility is highly sensitive to new information or news, such as shocks, while a high value of GARCH (δ_1) indicates a higher persistence of volatility over time after a shock (Chaudhary et al., 2020; Rastogi, 2014).

3.2.1.2 DCC-GARCH model

The dynamic conditional correlation (DCC) GARCH models, developed by Engle (2002), are an advanced extension of the GARCH models that allow estimating time-varying

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correlations among time series, facilitating the analysis of the impact of one time series over another (Gupta & Chaudhary, 2022).

Following the specification of Engle (2002), the DCC-GARCH model defines the dynamic conditional variance-covariance matrix (H_t) as:

$$H_t = D_t R_t D_t \tag{5}$$

where D_t is a diagonal matrix of individual conditional variances and R_t is a matrix of conditional correlations (Corbet et al., 2021; Sensoy et al., 2014).

These simplified models allow estimating large covariance matrices in a simpler and more efficient way than multivariate GARCH models, which reduces dimensionality problems (Sensoy et al., 2014).

3.2.2 Qualitative analysis

3.2.2.1 fsQCA

Fuzzy-set Qualitative Comparative Analysis (fsQCA) is an innovative methodological technique that is characterised by bringing together qualitative and quantitative research approaches to the study of asymmetric data (Ragin, 2008). Grounded in Boolean algebra and set theory, fsQCA allows identifying different combinations of causal conditions (antecedent factors) that lead to a specific outcome of interest (the phenomenon investigated) (Legewie, 2013; Roig-Tierno et al., 2016). Unlike traditional quantitative methods, which seek to estimate the net effects of variables within a model and determine a single best solution for most cases, fsQCA assumes the coexistence of multiple causal paths to the same outcome, thus introducing the principle of equifinality (Pappas & Woodside, 2021).

FsQCA interprets causality in terms of minimally necessary or sufficient conditions for a given outcome to occur (Ragin, 2014; Rihoux & Ragin, 2009). A condition is considered necessary when it is found in all cases in which the outcome is observed. That is, the outcome is a subset of the necessary condition, meaning that the outcome cannot occur in the absence of the necessary condition. Alternatively, a condition or set of conditions is considered sufficient if all cases in which it is present exhibit the outcome (Ragin, 2000). However, this does not exclude the possibility that the outcome also occurs under other conditions, since in this case, the sufficient condition (or combination of conditions) is a subset of the outcome (Ragin, 2008; Rihoux & Ragin, 2009).

A key advantage of fsQCA is its ability to handle causal complexity. While regression-based methods assume linear and symmetric relationships between variables (Pappas & Woodside, 2021), fsQCA allows identifying possible feasible recipes that are not only combinations of the presence of the antecedent factors, but also of their absence (Wu et al., 2014). This is crucial in complex settings, as it allows researchers to consider the heterogeneous and asymmetric relationships found in different real-life data (Schmitt et al., 2017; Woodside, 2011).

There are different types of QCA, the most common being crisp-set QCA (csQCA) and fuzzy-set QCA (fsQCA). Unlike csQCA, which classifies conditions in a binary manner (0 or 1), fsQCA allows assigning degrees of set membership between 0 and 1 (Schneider & Wagemann, 2012). This provides greater flexibility when analysing real-world data, where conditions are rarely fully present or absent. For this reason, fsQCA is particularly suitable for handling small to medium-size datasets (Berbegal-Mirabent et al., 2021; Fiss, 2011).

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According to Schneider and Wagemann (2010) the procedure to perform an fsQCA analysis is organised in three main steps. Firstly, a calibration of the data is conducted, defining cut-off points to assign a degree of set membership to each case. Three calibration points are defined: full membership, crossover point (or point of maximum ambiguity), and full non-membership (Ragin, 2008). Secondly, the necessity analysis is performed, identifying whether there are necessary conditions for the outcome to occur. Finally, the sufficiency analysis is performed, which identifies combinations of conditions that are sufficient to generate a given result.

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4 RESULTS: PUBLISHED ARTICLES

This chapter consists of the following published articles:

ARTICLE 1

Piñeiro-Chousa, J., López-Cabarcos, M. Á, Quiñoá-Piñeiro, L., & Pérez-Pico, A. M. (2022). US biopharmaceutical companies' stock market reaction to the COVID-19 pandemic. Understanding the concept of the 'paradoxical spiral' from a sustainability perspective. *Technological Forecasting & Social Change, 175*, 121365. https://doi.org/10.1016/j.techfore.2021.121365

ARTICLE 2

López-Cabarcos, M. Á, Santos-Rodrigues, H., Quiñoá-Piñeiro, L., & Piñeiro-Chousa, J. (2023). How to explain stock returns of utility companies from an environmental, social and corporate governance perspective. *Corporate Social Responsibility and Environmental Management, 30*(5), 2278-2291. https://doi.org/10.1002/csr.2483

ARTICLE 3

López-Cabarcos, M. Á, Piñeiro-Chousa, J., Quiñoá-Piñeiro, L., & López-Pérez, M. L. (2024). Water and waste management strategies as drivers of the financial performance of food companies. *Technological Forecasting & Social Change, 200*, 123138. https://doi.org/10.1016/j.techfore.2023.123138

ARTICLE 4

Quiñoá-Piñeiro, L., López-Cabarcos, M. Á, & Piñeiro-Chousa, J. (2025). Innovating for sustainability in food and beverage companies: the role of governance and environmental factors in climate change mitigation. *British Food Journal, 127*(1), 54-72. https://doi.org/10.1108/BFJ-03-2024-0315

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4.1 ARTICLE 1. US BIOPHARMACEUTICAL COMPANIES' STOCK MARKET REACTION TO THE COVID-19 PANDEMIC. UNDERSTANDING THE CONCEPT OF THE 'PARADOXICAL SPIRAL' FROM A SUSTAINABILITY PERSPECTIVE

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US biopharmaceutical companies' stock market reaction to the COVID-19 pandemic. Understanding the concept of the 'paradoxical spiral' from a sustainability perspective

Juan Piñeiro-Chousa *, M. Ángeles López-Cabarcos, Lara Quiñoá-Piñeiro, Ada M. Pérez-Pico

University of Santiago de Compostela, Spain

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ABSTRACT

In an uncertain and finite world, actions towards the development of a green economy are attracting wider support. The damaging anthropogenic impact on earth systems is leading humanity to devastating situations, jeopardizing its very survival. A new world scenario has emerged with COVID-19, where the biopharmaceutical sector has arisen as a powerful effective solution for the health, economic and social crisis derived from the pandemic. This research aims to study the stock market reaction of the two US biopharmaceutical companies that first developed messenger RNA vaccines against COVID-19 (Pfizer and Moderna), considering two time periods, before and during COVID. In the analysis, the influence of the technological market index, market volatility, and investor sentiment are also considered. The results show an unequal influence of market volatility and market sentiment on the returns of both companies, as well as a different volatility behaviour. Furthermore, a contagion effect is observed during the COVID period between both companies and the technological market. The study's findings provide investors, organizations, policy-makers and society with useful information for the design of policies and strategies that ultimately are called to ensure sustainable growth for future generations.

1. Introduction

In recent years, the importance of the planet's sustainable development embodied in initiatives such as the goals proposed in the 2030 Agenda for Sustainable Development (United Nations, 2015) has aroused increasing interest and concern amongst society and the scientific community. Social and economic agents have tried to offer new answers and solutions to contribute to the achievement of these relevant goals from multiple perspectives, such as green bond issuance (Piñeiro-Chousa et al., 2021), business strategy evaluation (Calabrese et al., 2021), or the design of initiatives in different territories, such as the nature-based solutions promoted by the European Commission (Faivre et al., 2017). Unfortunately, the unlimited growth of the population and the development of the economy based on the intensive use of limited resources have generated multiple negative effects on the planet, such as climate change, with very negative consequences for human survival (Haines and Ebi, 2019). Anthropogenic activities have resulted in increased human exposure to frequent occurrences of natural disasters and the emergence of new infectious diseases (Myers, 2017). The most recent example of the detrimental impact of these activities is the COVID-19 pandemic, which has resulted in the largest global health crisis in recent times.

The COVID-19 disease has forced the design of policy responses and government interventions across regions within countries worldwide. The adopted actions range from containment and closure policies, such as movement restrictions or school and workplace closures; economic policies, such as income support for those who lost their jobs or international aid expenditure for COVID-19 consequences; or health policies, such as emergency spending on health care, mass testing and contact tracing policies, or public investment in vaccine development (Hale et al., 2020). These measures, in some cases belated, that have tried to reduce the transmission of the virus, have in turn generated new economic and social problems.

At the same time, financial markets, including the US market, have reacted in an unprecedented way to the evolution of the virus and the containment measures implemented by countries, reaching or

* Corresponding author at: University of Santiago de Compostela, Facultad de Administración y Dirección de Empresas, Avda. Alfonso X el Sabio s/n–27002–Lugo, Spain

E-mail addresses: j.pineiro@usc.es (J. Piñeiro-Chousa), angeles.lopez.cabarcos@usc.es (M.Á. López-Cabarcos), lara.quinoa@usc.es (L. Quiñoá-Piñeiro), adamaria.perez@usc.es (A.M. Pérez-Pico).

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surpassing levels of volatility similar to other major previous events (Baker et al., 2020). Essential sectors, such as agriculture, water, energy, and food, have also been seriously affected both directly by COVID-19 and indirectly by the consequences that COVID-19 has had on other related sectors. This gives sense to the concept of the 'paradoxical spiral', according to which anthropogenic actions can provoke changes and damage in systems and sectors that are in one way or another interconnected. All this generates large imbalances between sectors that imply uncertain consequences for humanity. This requires considering the implications of the nexus between sectors and the allocation of large amounts of resources in those that can offer effective and innovative solutions in preventing and solving negative situations such as the COVID-19 pandemic.

The search for an effective vaccine has attracted the attention of the media and financial markets in the biopharmaceutical sector as one of the principal solutions to restore a state of "new normalcy". The biopharmaceutical sector, called to develop innovative solutions aimed at preventing and solving problems related to human health, has faced the enormous challenge of developing a vaccine in a short period of time (Krammer, 2020), emerging as one of the great bets of governments, companies, citizens, and investors. As this sector is called to play a decisive role in the fight against the pandemic, this study aims to analyse the stock market behaviour before and during COVID-19 of the two most relevant US biopharmaceutical companies to date, Pfizer and Moderna. Specifically, this study aims to analyse the influence of market volatility and market sentiment on Pfizer and Moderna returns and to compare the volatility behaviour of these companies before and during the pandemic outbreak. It also aims to analyse whether the technological market has been influenced by these companies, which have committed to the development of innovative messenger RNA vaccines. Variables including market volatility (VIX), the technological market index (NASDAQ), and investor sentiment (ISEE) were considered in the analysis. To this end, GARCH (1,1) (Bollerslev, 1986) and DCC-GARCH (1,1) models (Engle, 2002) have been used. The study period considered covers 3rd January 2019 to 12th February 2021, distinguishing between pre-COVID (3rd January 2019 until 10th March 2020) and COVID (from 11th March 2020 to 12th February 2021) periods.

This study contributes to the advancement of the knowledge related to the influence of the COVID-19 pandemic on financial markets, specifically if the biopharmaceutical sector is considered. The study results shed light on the role played by variables such as market volatility and investor sentiment on the returns of the studied companies. This research calls for action at different levels (governments, organizations, investors, society) to work on a natural transition towards a green economy to achieve a joint commitment to avoid and reduce the conditions that favour the occurrence of natural disasters and diseases. Governments to design strategies able to ensure current and future human health and well-being; organizations to comply with strict sustainable protocols and rules; investors to make decisions aimed at rewarding or punishing organizations depending on their responsible behaviour; and society to include sustainability as a cultural value that guides any action.

The remainder of this manuscript is structured as follows. Section 2 develops the theoretical background and states the hypotheses under study. Section 3 explains the research design, data sources and methodology. Sections 4 and 5 present the main results of the study and their discussion. Finally, Section 6 presents the practical implications, limitations, and future lines of research.

2. Literature review

The growing concerns and worries of citizens about environmental protection and care for the planet have been transferred to the business, institutional and governmental spheres, placing sustainability as a priority element for global economic growth. This social awareness has been reflected amongst others in the Global Risks Perception Survey (World Economic Forum, 2021), where for the first time in history, the five risks identified in 2019 as most likely to occur in the next ten years were environmental. In the 2020 survey, four of these environmental risks (extreme weather, climate action failure, human environmental damage, and biodiversity loss) remained amongst the top five risks, with infectious diseases emerging in fourth place. All these environmental risks are related in different ways to human action. The planetary health approach points out human activities as a source of strong biophysical changes in earth systems that severely affect human health and well-being. According to multiple scientists, these changes have given rise to a new geological era, the Anthropocene, characterized by damaging human impacts on the planet (Planetary Health Alliance, 2021) and concretized in six dimensions – climate change; global air, water and soil pollution; biodiversity loss; altered biogeochemical cycles; changes in land use and land cover; and resource scarcity, especially freshwater and arable land –. These changes are increasing human exposure to infectious diseases and other naturally occurring hazards, such as heat waves, floods, droughts, fires or tropical storms (Myers, 2017). According to all this, the main concern relates to the fact that incessant economic growth and the lack of awareness of the connection between humans and nature make the continuity of the current model of life unsustainable in the future.

The results of human and economic activity have had (and will continue to have) multiple negative effects in many areas, sectors, and industries. The concentration of large quantities of greenhouse gases in the atmosphere has led to one of the greatest human-induced consequences, climate change, which has become a serious threat to human health (Haines and Ebi, 2019). In recent years, climate change has been strongly associated with the occurrence of major natural disasters such as hurricanes, heavy rains, floods, fires, heat waves and even diseases. The increased frequency and severity of these events and the remarkable effects of climate change have made visible its influence on human welfare and health, as well as on the supply of one of our most precious commodities, freshwater (Bandh et al., 2021). Ensuring universal access to fresh, clean, and affordable water has become a goal that is unlikely to be achieved in the near future. Inadequate water resource management in the face of an incessant population and economic growth leads to an increase in, for example, energy consumption or the demand for agricultural products. In fact, the close link between these three key industries for human survival, water, energy, and agriculture can be at risk since the changes or bad practices in one of these industries can significantly affect the others, and consequently human and planetary health (Piñeiro et al., 2020).

Humanity has entered what it can be called a 'paradoxical spiral' where human actions provoke changes and cause damage in different systems and sectors that in turn affect other systems and sectors with uncertain consequences for humankind. Thus, global warming can lead to an increase in energy demand (a potential source of greenhouse gas emissions), which increases the need for water resources to produce energy that are no longer used in other industries such as agriculture or food, all of which in turn may result in major resource management imbalances amongst these and other industries. As sectors are strongly related to each other, it is difficult to discriminate which are the causes and the effects along the different interconnection processes, giving rise to a spiral of events whose results in cases are very difficult to decipher and therefore paradoxical. For this reason, human-induced imbalances in different industries and sectors require urgent joint multistakeholder actions to design sustainable management and production models capable of meeting socioeconomic demands while preserving resources for future generations. Governments, organizations and the entire society must work to move towards a greener and more sustainable economy, offering innovative solutions to promote an efficient use of natural resources and implementing actions and initiatives, such as EU Nature-Based Solutions aimed at promoting biodiversity conservation, natural disaster reduction, development of circular economy and energy efficiency models, and resilience to climate change (Faivre et al., 2017).

Understanding the 'paradoxical spiral', according to which large amounts of resources must be assigned to key sectors to reverse or mitigate the damage caused by others, is useful to explain the causes, consequences and most effective solutions to the COVID-19 pandemic.

2.1. Contextualization of the COVID-19 pandemic

The outbreak of coronavirus disease 2019 (COVID-19) began in the Chinese city of Wuhan in Hubei Province in December 2019, when the first cases of pneumonia of unknown cause were reported. The transmission capacity of the virus and its fast spread through different continents and countries around the globe led the World Health Organization (WHO) to classify the outbreak as a global pandemic on March 11, 2020, when the number of detected cases had already exceeded 118,000 in 114 countries (WHO, 2020).

According to the WHO (2021a) global report on the origins of the virus causing COVID-19 disease, the most likely scenario points to a zoonotic transfer of the virus, that is, transmission from animals to humans. amongst others, the human encroachment of natural ecosystems as a result of the necessary expansion of agricultural land, the hunting of wild animals or the trafficking of animals have increased exposure to zoonotic diseases such as coronaviruses, HIV or Ebola (de Paula and Willetts, 2021). As noted above, the emergence of new infectious diseases is largely related to socioeconomic, ecological, and environmental factors (Jones et al., 2008). In fact, the scientific community has been warning for years about the reduction of biodiversity as a catalyst for the transmission of infectious diseases (Keesing et al., 2010), but no significant action has been taken. The COVID-19 pandemic has once again put the spotlight on the connections between the occurrence of dangerous infectious diseases and environmental, climate and health issues, highlighting the imperative need for designing a global strategy focused on preventing such events (Barouki et al., 2021).

Decreasing the spread of COVID-19 disease and achieving the desired herd immunity depends to a large extent on the mass administration of a worldwide effective vaccine, placing the biopharmaceutical sector as a key player in the global recovery process. During these months, multiple biopharmaceutical companies have been working and developing effective vaccines using new technologies at unprecedented speed (Krammer, 2020). While mass administration of vaccines would help drastically reduce the number and severity of infections in the near future, the impacts of COVID-19 are much more far-reaching and will need to be addressed from multiple perspectives with a vision focused on sustainable growth. A phenomenon of this magnitude opens up new research opportunities to analyse the importance of critical industries acting both as cause and consequence of such phenomenon justifying the concept of the 'paradoxical spiral' and the huge consequences of an event of these characteristics on the economy and society. The serious health, social and economic implications of COVID-19 demand the design of an ethical and responsible action plan to regain 'normalcy' and prevent the emergence of new catastrophic events.

2.2. The COVID-19 pandemic and its implications for market behaviour

Drawing an analogy with other previous diseases and natural disasters that have clearly influenced financial market behaviour, it was expected that the same happened with COVID-19 (Goodell, 2020). This pandemic has brought major challenges that have served to test the resilience of governments, sectors, economies, and society as a whole. Since the declaration of a Public Health Emergency of International Concern announced by the WHO on January 30, 2020, the evolution of the novel coronavirus has shaken global stock markets, leading to a decline in market performance and an increase in nervousness and fear amongst investors (Shaikh, 2020). This reaction to the exceptional event has been reflected in unprecedented market volatility, interpreted by policy-makers, financial sector regulators, investment funds and individual investors as a measure of the financial risk and the uncertainty generated around investment in financial assets (Baek et al., 2020). One of the most widely recognized and used ways of measuring the frequency and magnitude of the price movements of a financial instrument is the CBOE Volatility Index (VIX), a globally recognized indicator of US stock market uncertainty (CBOE, 2021). Market volatility soared worldwide by mid-March 2020; specifically, US volatility levels reached or surpassed the levels recorded in events such as the Great Depression in 1929, Black Monday in October 1987 or the Global Financial Crisis in December 2008 (Baker et al., 2020). The closer connection between markets resulted in a significant volatility spillover, predominantly from the European continent to the rest of the world (Shaikh, 2020).

In the first months of the coronavirus, figures reported by the WHO influenced financial markets with different intensities. A study conducted by Albulescu (2020) with data collected during January and February 2020 concluded that although the Chinese figures related to the spread of the virus slightly influenced the VIX of the US financial markets, the notification of new cases outside China and the increasing global death rate contributed to a clear increase of financial volatility. In fact, beyond China, the focus of attention was first on Europe and then on the US due to the great sensitivity of these markets to unusual events and the great transcendence of these markets worldwide. Stock markets of both regions did not react significantly in the short term to the notification of the first cases of COVID; however, a significant negative reaction was registered with the announcement of the first deaths (Heyden and Heyden, 2021). During the first wave of COVID-19, the worldwide figures on the emergence of new cases of infected or dead people had a greater impact on the volatility and liquidity of the US financial markets than the figures reported for their own country (Albulescu, 2021). This situation changed as the number of daily confirmed cases of infected or dead people in the US began to rise, along with the negative sentiment generated by the media and restrictive measures applied by the government on citizens (Baig et al., 2021), all of which provoked an extraordinary reaction of the US stock market to events related to the 2020 pandemic (Baker et al., 2020). According to these authors, the largest daily stock market movements related to pandemics in the last 120 years cannot be attributed solely to the lethality of the virus (at the time of the study, the excess mortality rate of COVID-19 was only 1/25th higher than that recorded during the Spanish flu), but government restrictions on commercial activity and individual mobility, together with the voluntary social distancing of the population. In their study, Zaremba et al. (2020) isolated the effect of restrictive government policies and demonstrated their significant impact on increasing international stock market volatility. From their point of view, two main types of nonpharmaceutical policy interventions have led to this increased volatility. On the one hand, government information campaigns related to COVID-19 have led investors to reposition their portfolios, in some cases with a propensity towards safe assets generating additional trading activity in the market and thus liquidity (Zaremba et al., 2021). On the other hand, the public cancellation of all kinds of events, which was considered an initial response from governments and therefore a sign of possible stricter interventions in the future, was the first opportunity for investors to react to possible future changes (Zaremba et al., 2020). Moreover, in Europe and the US, the monetary policies adopted to reduce the effects of the health emergency proved to have a reassuring effect on the markets, unlike the new fiscal policies that only generated greater uncertainty amongst investors. Some authors have pointed out that the response to these policies depends, amongst other things, on firm-specific features, mainly their relative amount of tangible assets and liquidity (Heyden and Heyden, 2021).

COVID-19 has made the recovery of stock market indices slower and more difficult than other recent disease outbreaks, such as Ebola, MERS and SARS (David et al., 2021). For example, although a rebound occurred between the first and second quarters of 2020 in the stock

indices of the world's top ten economies, only two of them, China and the US, showed a positive return from January to June (Chaudhary et al., 2020). The ongoing rise in global daily infections and deaths recorded during the first and second waves of COVID-19 led to an increase in uncertainty in the US stock market, even when the quarantine restrictions established during the first wave were eased (Yousfi et al., 2021). This situation has led to a greater investor awareness of the importance of sustainability and the minimization of the consequences of natural events of this magnitude. The growing interest in sustainability has been reflected in the investment decisions and the market resilience of some companies and sectors. For example, during the first quarter of 2020, the stock prices of firms with a high rating in environmental and social policies exhibited better performance and lower volatility (Albuquerque et al., 2020).

The impact of the pandemic has been unevenly felt both in essential sectors for global sustainable development and in safe-haven securities that are fundamental in times of financial turbulence. In fact, the COVID-19 outbreak led to a sharp fall in the prices of the main commodity markets (energy, agriculture, metals, etc.), which did not start their recovery until the third quarter of 2020. At the onset of the pandemic, high prices due to production shortfalls led investors to find safe-haven assets amongst the agricultural commodities market, specifically soybean futures (Ji et al., 2020). Agricultural commodities have shown the most balanced performance in 2020 since, despite the restrictions and interruptions in supply chains, food prices have remained broadly stable. Concerning metal commodities, there has been an increase in the price of precious metals due to the application of expansive monetary policies with low interest rates, a weakened US dollar, supply and production disruptions, and the flight of investors to safe-haven assets (World Bank Group, 2020). In particular, gold has been one of the great beneficiaries of the pandemic, demonstrating its safe-haven properties in the face of extreme market conditions (Dutta et al., 2020; Ji et al., 2020). In the same way, the cryptocurrencies market has not been immune to the unfortunate effects of the pandemic. The two main cryptocurrencies, Bitcoin and Ethereum, have exhibited high volatilities in daily returns (higher than those of gold and the S&P 500 index) during the 2020 COVID period (Mariana et al., 2021). Despite the illiquidity, high volatility and high transaction costs associated with these assets, several studies have evaluated their behaviour as potential safe-haven assets. In this sense, Marianna et al. (2021) have shown that Bitcoin and Ethereum show safe-haven features in the short term, with the latter acting as a better safe-haven asset in the face of extreme stock market declines. These results differ from those obtained by Corbet et al. (2020) or Conlon and McGee (2020), who have suggested that during severe economic and financial turmoil periods, cryptocurrencies do not act as safe havens.

The impact of the pandemic on the energy sector has been more severe than in other sectors. In fact, this was the first sector to react to the COVID-19 pandemic, according to the S&P 500 sector indices (Matos et al., 2021). Mandatory shutdowns, travel restrictions or home quarantines have had an apparently unintended effect on reducing energy consumption and greenhouse gas emissions (Sovacool et al., 2020). Border closures and travel restrictions provoked serious problems to the oil demand. In fact, the decrease in energy demand as a result of the paralysis of economic activity has led in turn to a decrease in the profitability of the energy markets, which have also experienced historic volatility levels due to the pandemic (Shaikh, 2021). The crude oil market suffered a serious slump in the first half of 2020 as a consequence of failed negotiations between OPEC member countries and Russia. Insufficient oil storage capacity, along with uncertainty about the future after the pandemic, broke out the potential agreements between both parties. As a result, in April 2020, the West Texas Intermediate crude oil price recorded a negative record for the first time in history (Gharib et al., 2021). The sustainable energy sector has also been severely impacted by the pandemic. In fact, renewable energy manufacturing facilities and businesses have been adversely affected, undermining the positive trend progress towards green energy (Hosseini, 2020). For example, although the impact of COVID-19 on solar stock prices has been mixed, the stock prices of most solar companies have dropped, mainly due to restrictive policies implemented by governments in response to the health crisis (Wang et al., 2021).

According to the 'paradoxical spiral' already mentioned, the occurrence of natural disasters or the emergence of diseases such as the COVID-19 pandemic require a careful analysis of the implications derived from the connections between different sectors from a sustainability perspective. Logically, it also requires searching and allocating resources in sectors capable of offering effective and innovative solutions for emergency situations. Precisely, the complexity of the COVID-19 context has required paying attention, mainly in a first moment, to these other sectors called to play a key role in the fight against the pandemic. Thus, the biopharmaceutical sector based on knowledge, innovation and technology was called to help mitigate the negative health problems caused by the pandemic in the short and medium term. In turn, it must contribute to solving other economic and social problems, helping increase the awareness of citizens, companies and governments about the need to behave under premises based on sustainable criteria.

2.3. *The biopharmaceutical sector as a potential solution to the COVID-19 pandemic*

In recent decades, the environment and industries such as food, agriculture, medicine, and energy have benefited from revolutionary technological breakthroughs. amongst the technological advances arising from the ongoing situation characterized by major economic, social, and environmental changes that are affecting, amongst other issues, the survival of humankind itself, advances in the biotechnology field stand out. Traditionally, biotechnology is characterized by the use of biological systems and living organisms for the development of new products and processes. Continuing scientific advances have resulted in modern biotechnology, which goes a step further by employing a set of techniques known as genetic engineering, which enables genetic material to be modified or transferred between different organisms (Amarakoon et al., 2017). The evolution of biotechnology is helping to address global challenges such as efficient, safe and clean production, energy savings, progress towards food security or the fight against diseases that threaten the planet. In relation to this last challenge, the biotechnology revolution applied to the pharmaceutical industry has enabled the establishment of a new era in the struggle against diseases through an accelerated development of novel vaccines (Defendi et al., 2021). The urgency of halting the worldwide spread of COVID-19 disease and the need to monitor the diagnosis, prevention, and control of this infectious disease has placed the biotechnological and pharmaceutical sector (biopharmaceutical) in the spotlight of society, governments and financial markets.

The international scientific community has turned its attention to the development of effective vaccines in an attempt to put an end to the COVID-19 pandemic. According to the monitoring carried out by the WHO (2021b) in February 2021, the number of experimental vaccines in development exceeded 200. Although it was expected that the development of a vaccine to stop the transmission and lethality of this virus could take several years, the previous knowledge acquired by the biopharmaceutical sector in the initial development of vaccines for SARS and MERS diseases has led it to set a milestone, developing vaccines for the COVID-19 disease in record time (Krammer, 2020). This race for a vaccine has been primarily led by two US companies, Pfizer and Moderna. Although the vaccine developed by Moderna was the first of the COVID-19 vaccine candidates to begin human trials, the first emergency use authorization issued by the US Food and Drug Administration (FDA) on December 11, 2020, was for the vaccine developed by Pfizer-BioNTech. Only seven days later, on December 18, 2020, the FDA authorized the second vaccine for coronavirus disease prevention

developed by Moderna Inc. (FDA, 2020).

These two US companies have been responsible for the development of the first and most advanced RNA-based vaccines against SARS-CoV-2, the coronavirus causing COVID-19 disease. Although the technology used by both companies is similar, the two companies have very different origins. Founded in 1849 in New York, Pfizer Inc. (2021a) is one of the world's largest biopharmaceutical companies. According to the Fortune 500 list published in 2020, the company is ranked 64th amongst the 500 largest corporations in the US (Fortune, 2020). This company has a long history in the discovery, development and manufacture of drugs, vaccines, and consumer health care products. In recent years, Pfizer has undergone a business restructuring process with the aim of focusing entirely on the development of innovative biopharmaceutical products. This reorientation of the company has led it to develop the COVID-19 mRNA vaccine in collaboration with the German biotech company BioNTech, with which it is also working to commercialize the vaccine worldwide except in China, where BioNTech has a strategic collaboration with the health care group Fosun Pharma. In contrast, the biotech company Moderna Inc. (2021a) is a young company established in 2010 in Cambridge, Massachusetts, which is focused on the development of mRNA vaccines and therapies for the treatment and prevention of various diseases. The COVID-19 mRNA vaccine developed by Moderna, which has been supported and funded by the Biomedical Advanced Research and Development Authority (BARDA), is the first and thus far the only product developed by this company that has achieved regulatory agency approval. This vaccine is being commercialized in the US and in other countries around the world. Both companies are listed on the US stock market, while Pfizer's common stock is traded on the New York Stock Exchange, Moderna's shares are traded on the NASDAQ Global Select Market.

This paper is focused on these two relevant companies in the biopharmaceutical sector. The reason that justifies their choice is that these companies have many aspects in common but also substantial differences. In relation to similarities, Pfizer and Moderna are localized and listed on the US market; they have developed the first vaccines approved in the country, they are being administered in many parts of the world, and both vaccines are based on novel messenger RNA technology. The main differences between them relate to the companies' size, the experience and previous achievements, the product portfolio, the collaboration with other companies, or the use of public funding. Therefore, these two companies allow the US market orientated to the research and commercialization of COVID-19 vaccines to be characterized from a wide perspective.

The stock market behaviour of the biopharmaceutical sector in recent decades has shown similarities and differences with pharmaceutical and biotech companies' performance. The study conducted by Thakor et al. (2017) addressed an analysis of the financial performance of 1066 US biopharmaceutical companies from 1930 to 2015 to visualize the main features and behaviour patterns of this sector in the long term. Considering two different sub periods of time, before and after the emergence of modern biotechnology in the 1980s, the authors observed that the pharmaceutical subsector's returns were in general higher (average annual return 3%) than those of the stock market throughout the entire period analysed. Moreover, this performance was very similar to that of the technology sector, which it outperformed from 2000 onwards. The performance of pharmaceutical companies contrasts with biotech companies' underperformance in the period from 1980 to 2015, where less homogeneity is observed in long-term returns along with higher risk and stock volatility. In addition to the companies' product portfolios, general economic factors proved to be a substantial source of risk for the financial performance of the biopharmaceutical sector, which led these companies to show different stock market behaviours. In fact, several studies have suggested that, in the face of health crises such as those resulting from epidemic or pandemic diseases, the stocks of the biopharmaceutical sector are affected in a different way than in other sectors. Chen et al. (2009) showed that during the 2003 SARS epidemic crisis in Taiwan, while most sectors were negatively impacted by the epidemic, investors and fund managers who bought or held biotech stocks obtained profits and saw reduced their investment risks. Ichev and Marinč (2018) found evidence of a strong positive effect of the 2014–2016 Ebola outbreak events on the returns of the US biopharmaceutical and health care equipment industry, which contrasted with the negative impact experienced on stock returns by most US industries. In the same way, Al-Awadhi et al. (2020) more recently found that the COVID-19 outbreak in China influenced technology and medicine sectors' stock returns, which outperformed other sectors in the Chinese stock market. Therefore, the following hypotheses are proposed:

H1a: Market volatility influences Pfizer and Moderna returns during the pre-COVID period.

H1b: Market volatility influences Pfizer and Moderna returns during the COVID period.

The COVID-19 pandemic has affected the American companies Pfizer and Moderna. Considering the period before the outbreak, it can be observed that the overall behaviour of both companies was relatively flat, and there were no significant variations in their share prices. In this pre-COVID period, Pfizer's common stock price came from an uptrend that began in late 2012 and culminated in December 2018. Following this moment, the company's shares entered a complex decline that spanned two years, with a slight rebound in the second half of 2019, just before the outbreak of the pandemic. Moderna's shares journey has been considerably shorter since the company first began trading on December 7, 2018. Moderna's stock market performance did not differ substantially from that of Pfizer in 2019, as Moderna's share price did not show significant changes, except for a slight downtrend that occurred in mid-2019, from which it started to recover by the end of the year.

The onset of the COVID-19 pandemic in China and its subsequent transmission to other countries affected the performance of these companies but not in the same way. At the beginning of the study period, the share prices of Pfizer and Moderna were 42.04 and 15.05 USD, respectively. On March 11, 2020, the day the WHO officially declared the COVID-19 pandemic, Pfizer recorded a price of 32.17, while Moderna reached 23.61 USD. Finally, on February 12, 2021, Pfizer's share price recovered up to 34.72, while Moderna's share price rose to 183.74 USD. Overall, 2020 was a year in which, despite high investor expectations, Pfizer was an unexpected loser with lower stock returns than the broader market. After the pandemic-related plunge in the first quarter of the year, Pfizer's stock prices managed to rebound but without a sustained recovery. The notification on November 9 of the results of the first analyses (pointing to an efficacy of more than 90%) gave a new boost to its stock performance, which was subsequently followed by the FDA authorization of the emergency use of the vaccine in the second half of the same month. This positive trend changed at the end of 2020 with a drop in the company's stock price that remained until the beginning of February 2021. Based on Pfizer's 2020 Form 10-K (Pfizer Inc., 2021b), some of the reasons that justify the company's financial results are (i) the slowdown in demand for non-COVID-19 prescriptions and vaccines and (ii) the loss of revenue related to the consumer health business, which was developed through a joint venture with Britain's GlaxoSmithKline PLC from the summer of 2019. In addition, following the company's restructuring strategy, in 2020, Pfizer launched the spinoff of its off-patent brands and generics business (Upjohn), which was merged with other US pharmaceutical companies (Mylan). These results clearly contrast with those of Moderna, whose share price followed a vertiginous upward trend in 2020 driven by the positive evolution in the development of its vaccine against the new coronavirus. In early April, Moderna's stock price surpassed Pfizer's and continued to soar until February 2021. Following the release on November 16, 2020, of the results of Moderna's preliminary studies (showing an effectiveness of 94.5%), its stock price skyrocketed, peaking in early December 2020. After the subsequent pullback, the FDA authorization of the vaccine in mid-December led the company's shares to recover their uptrend, reaching new highs in early February 2021. It is interesting to note that

since its inception, the biotech company has been accumulating losses, recording a net loss of $747.1 million in 2020, higher than the $514.0 million loss recorded in 2019 (Moderna Inc., 2021b). In 2020, the company's total revenue increased by more than 1200%, largely due to the boost generated by the grant revenue following the BARDA agreement. To date, Moderna's strategy has prioritized the reinvestment of future profits in the development of its own projects and the growth of the company, leaving aside a dividend payout policy such as the one maintained by Pfizer. The success of the messenger RNA technology developed by these two companies is reflected in their stock prices during 2020, although showing very different trends. Those investors with a more aggressive investment style who opted for the more volatile stock performance of Moderna saw the company's shares soar 866% in a year (February 12, 2020 to February 12, 2021). In the same period, Pfizer shares showed a decrease of approximately 8%. Hence, the following hypotheses are proposed:

H2a: Pfizer volatility behaves differently during the pre-COVID and COVID periods.

H2b: Moderna volatility behaves differently during the pre-COVID and COVID periods.

Given the innovative and technological nature of the vaccines developed by these companies, it is interesting to analyse their evolution with respect to one of the most popular US indices and a global benchmark for innovation, the NASDAQ. The NASDAQ-100 is a stock market index that lists the 100 largest domestic and international nonfinancial companies listed on the NASDAQ stock market. It includes the world's largest companies belonging to the technology sector, as well as consumer services companies, health care companies (including biopharmaceuticals), consumer goods companies, and some industrial companies (NASDAQ Inc., 2021). Considering the studied period, it is observed that the positive trend maintained by the index in the pre-COVID period disappeared with a downturn at the beginning of the health crisis in the first quarter of 2020 (just the same that happened with other indices). After this drop, the index started to follow a positive trend due to the excellent performance of the values of the index constituents, including a possible contagion effect by Moderna advances with the COVID-19 vaccine. In fact, during the period February 12, 2020, and February 12, 2021, the NASDAQ-100 price experienced a positive variation of 43.63% (higher than the 16.43% reported by the US S&P 500 index). Considering all this, it is necessary to go deeper in the analysis of the relationship between the technological market and Pfizer and Moderna behaviours, mainly if pre- and COVID-19 periods are considered. Therefore, the following hypotheses are proposed:

H3a: There is a contagion effect between Pfizer and NASDAQ during the COVID period.

H3b: There is a contagion effect between Moderna and NASDAQ during the COVID period.

Considering that stock market movements have been strongly impacted by the major events that happened during 2020, it is important to analyse whether nonrational investor behaviour may have had a significant influence on the financial results.

2.4. Market sentiment and its influence on biopharmaceutical companies' returns

Investor sentiment refers to how investors form beliefs (Barberis et al., 1998). In recent years, the analysis of investor sentiment and how it influences financial markets has become very relevant. In fact, the number of studies that have analysed this relationship has increased considerably, and they have shown that investor sentiment can influence US markets, such as the S&P 500 (Zhang et al., 2011) or the Russell 3000 (Da et al., 2011), as well as other international markets (Schmeling, 2009). It is necessary to consider its influence not only on traditional financial markets but also on new markets focused, for example, on cryptocurrencies (Naeem et al., 2021) or sustainable indices (López-Cabarcos et al., 2019). Moreover, investor sentiment has become a very important variable to be considered when analysing the behaviour of markets under 'normal' conditions, mainly when certain significant events such as economic crises (Wolff, 2013) or pandemics (Chen et al., 2020) occur. One main concern about investor sentiment is how to measure it. Different methods have been used thus far: market proxies such as the closed-end fund discount; NYSE share turnover; the number of and average first-day returns on IPOs; the equity share in new issues, and the dividend (Baker and Wurgler, 2006, 2007); surveys (Giannarakis et al., 2016); news and social networks (Broadstock and Cheng, 2019; López-Cabarcos et al., 2021); or proxies from the China A-share market, Hong Kong stock market and the US market (Zi-long et al., 2021). In 2011, the ISEE Sentiment Index was launched to measure investor sentiment using opening long-call options and opening long-put options purchased on the International Stock Exchange. This index has been used in this paper since it is able to provide a measure of investor sentiment at an international level, unlike other indices that use market-specific variables. In addition, it is based on financial data, its frequency is daily, and it is supported by the International Stock Exchange. The characteristics and evolution of the global crisis of COVID-19 advise considering a measure of investor mood at the international level.

Previous studies have pointed out that events that have a high impact and low probability of happening, such as epidemics or pandemics, tend to be overstated in the media, which leads to irrational behaviours in investors' decisions. The disproportionate media coverage during the severe acute respiratory syndrome (SARS) disease outbreak in Ontario, Canada, in 2003 led to a disproportionate public response in other parts of North America and other Canadian provinces, despite the substantial difference in the number of reported cases (Blendon et al., 2004). The Ebola 2014–2016 outbreak led US stocks with greater media exposure to suffer more intensely than those that received less media coverage due to investors' anxiety and fear (Ichev and Marinč, 2018). The amplified and disseminated information around COVID-19 has significantly influenced investors' behaviour and thus financial markets' performance. In this sense, Baek et al. (2020) concluded that after the onset of the pandemic, the US stock market was more sensitive to news related to COVID-19, especially negative news, than to economic indicators (e.g., expected price fluctuation or monetary policy). Meanwhile, Haroon and Rizvi (2020) found a strong positive association between the huge panic generated by the media and the volatility of indices of sectors severely hit by the pandemic, such as energy, transportation, automobiles, travel and leisure. Smales (2021) proved that retail investors' attention to the COVID-19 crisis (measured by Google search volume for the term 'coronavirus') negatively influenced financial market returns worldwide.

Prior research has analysed how news related to diseases can affect the behaviour of investors interested in biopharmaceutical companies. On the one hand, outbreaks of dangerous diseases can induce fear and anxiety and thus a negative sentiment that affects the stock prices of biopharmaceutical companies; on the other hand, they can also generate just the opposite sentiment, which is a promising investment opportunity (Donadelli et al., 2017). Both potential reactions translate into a polarization of product portfolios of investors, who, in the face of the emergence of an infectious disease, have to consider the positive or the negative influence of the disease on the stocks of biopharmaceutical companies (Ichev and Marinč, 2018). Donadelli et al. (2017) highlighted the positive and significant effect that disease alerts and news published by the WHO can have on investor sentiment and thus on the stock performance of US companies in the biopharmaceutical sector. As the authors pointed out, portfolio investment decisions in this sector are strongly influenced by investors' mood. During health crises with a major impact on the economy and society, some investors are optimistic, as they find profitable investment opportunities; thus, an event of this nature represents good news for certain interest groups. For example, for larger vaccine producers, outbreaks of infectious and dangerous diseases open up new business opportunities, unlike smaller biopharmaceutical

companies, which are at a disadvantage due to the high costs associated with vaccine development. However, as mentioned, the spread of infectious diseases can also generate anxiety and panic amongst the general public and amongst investors, negatively affecting the performance of biopharma stocks. Despite this, the authors demonstrated that both positive and negative investor sentiment induced by disease-related news can have a more pronounced effect on the stock returns of smaller biopharmaceutical companies than large corporations. The latter is consistent with Ichev and Marinč (2018), who found that during the events of the 2014–2016 Ebola outbreak, market sentiment had a stronger effect on the stock returns of smaller companies with higher volatility. Sun et al. (2021) analysed investor sentiment about medical companies in five markets (China, Hong Kong, Korea, Japan and the US) in the first few months of the spread of COVID-19. The authors concluded that, except for the Chinese market, which was the only region where the virus was known to exist thus far, news related to the coronavirus released by China induced positive investor sentiment in the countries considered. According to these authors, the significant and positive effects of COVID-19-related news and economic-related announcements released by China did not trigger irrational investor behaviours but a 'rational' desire to invest in medical companies due to the expected increase in demand for pharmaceutical products, including the development of vaccines.

Continuous overexposure to disease-related information in the media can generate significant changes in the share prices of the biopharmaceutical sector, even if there is a time gap between the fact and the publication of the news. In this sense, in the study performed by Huberman and Regev (2001) on the impact on financial markets of media coverage of a major breakthrough in the development of a cancer drug, the authors observed that the public attention generated by a publication of the scientific advance in the New York Times five months after the event led to a significant rise in the stock price of the company, although the information was not truly new. Interestingly, this reaction in turn had an effect on the share price of other biopharmaceutical companies, in particular biotech stocks that experienced a favourable change in their share price.

The very different possible reactions of investors to events and news, especially to high-impact events, make much more in-depth research necessary on this topic. Considering the context surrounding the evolution of the COVID-19 pandemic, this paper aims to examine whether market sentiment has influenced Pfizer's and Moderna's stock returns before and during the outbreak. Therefore, the following hypotheses are proposed:

H4a: Market sentiment influences Pfizer's returns during the pre-COVID and COVID periods.

H4b: Market sentiment influences Moderna's returns during the pre-COVID and COVID periods.

3. Data and method

3.1. Data and variables

The database used in the analysis consists of daily returns of Pfizer, Moderna, VIX, NASDAQ and ISEE. It comprises 538 observations from 3rd January 2019 to 12th February 2021. For the analysis, two samples were used: the pre-COVID period (from 3rd January 2019 to 10th March 2020) and the COVID period (from 11th March 2020 to 12th February 2021). The day chosen for breaking the sample was the day the WHO officially declared COVID a pandemic (11th March 2020), so the data from 11th March 2020 were included in the COVID period for the analysis.

The daily returns were calculated following the Campbell et al., p.11) method:

$$Ri_t = ln(Pi_t) - ln(Pi_{t-1}) \quad (1)$$

where Pit is the close price of stock/index i (Pfizer, Moderna, VIX, NASDAQ and ISEE) at moment t.

The descriptive statistics for the pre-COVID period are presented in Table 1. During this period, Pfizer returns had a negative mean, suggesting that the tendency was bearish. However, Moderna returns exhibited a positive mean. This is indicative of the different behaviour between these two companies in the analysed period. In the COVID period, the mean for these companies is positive, but the standard deviation shows that Moderna has had a higher volatility than Pfizer, again suggesting a different behaviour between them (Table 2).

3.2. Method

A GARCH (1,1) model (Bollerslev, 1986) was used to test the returns and volatility behaviour of Pfizer and Moderna:

$$y_t = x_t\beta + \in_t \quad (2)$$

$$\sigma_t^2 = \gamma_0 + \gamma_1 \in_{t-1}^2 + \gamma_2 \in_{t-2}^2 + \ldots + \gamma_m \in_{t-m}^2 + \delta_1\sigma_{t-1}^2 + \delta_2\sigma_{t-2}^2 + \ldots + \delta_k\sigma_{t-k}^2 \quad (3)$$

where y_t is the conditional mean; σ_t^2 is the conditional variance; $\in_t^2$ is the squared residuals; γ_i are the ARCH parameters; and δ_i are the GARCH parameters.

Specifically, the model proposed was:

Mean model:

$$Ri_t = \beta_0 + \beta_1 ndq_t + \beta_2 vix_t + \beta_3 isee_t + \in_t \quad (4)$$

Variance model:

$$\sigma_t^i = C_i + \gamma_i \in_{t-1}^2 + \delta_i\sigma_{t-1}^2 \quad (5)$$

where Ri_t is the daily returns of i in (4) being i Pfizer or Moderna. σ_t^i is the variance of the residuals derived from Eq. (4); C_i is the constant, $\gamma_1 \in_{t-1}^2$ is the ARCH parameter, $\delta_1\sigma_{t-1}^2$ is the GARCH parameter, and β_i is the coefficient of the variables (NASDAQ returns, variation of VIX or ISEE).

Dynamic conditional correlations (DCC-GARCH (1,1)) were used to analyse the dynamic co-movements (Engle, 2002). To secure the covariance stationarity of the conditional variance, parameters γ_0, γ_1 *and* δ_1 should be less than one. In the same way, the sum of γ_1 *and* δ_1 should be less than or equal to one to maintain stability (Corbet et al., 2020).

4. Results

Tables 3 and 4 show the correlations between the variables during the pre-COVID (Table 3) and COVID periods (Table 4). Moderna exhibits a positive and significant correlation with NASDAQ and ISEE and a negative and significant correlation with VIX during the pre-COVID period. However, during the COVID period, these correlations are not significant. This suggests a change in the behaviour of Moderna returns, which could mean that Moderna investors did not take the market situation and market sentiment into account in making their investments during the COVID period. Comparing Moderna returns with Pfizer returns, once again, a different behaviour appears, especially in the COVID period, where Pfizer returns have a positive and significant correlation with NASDAQ returns and a negative and significant correlation with VIX and ISEE.

The results for GARCH estimation are shown in Table 5 (pre-COVID period) and Table 6 (COVID period). The LM test for ARCH effects in the residuals for all models provides a p value equal to 0.000. Therefore, GARCH (1,1) models are supported.

In the pre-COVID period, the correlation between Pfizer and the NASDAQ index is significantly positive, which means that when NASDAQ increased, Pfizer returns also increased. However, VIX is

Table 1
Descriptive statistics for the pre-COVID period.

	Obs	Mean	Std. dev.	Min	Max	Skewness	Kurtosis
PFE	299	−.0007473	.0133622	−.0663252	.0594234	−.4360004	6.390873
MRNA	299	.0012594	.0461579	−.1980474	.2453797	.5853983	7.581680
NDQ	299	.0009189	.0128322	−.0707054	.0520000	−.7507324	8.648072
VIX	299	.0023796	.0836996	−.1981435	.3821669	1.125844	6.017840
ISEE	299	−.0006554	.2142144	−.5868115	.7017312	−.0242080	3.116712

PFE: Pfizer returns; *MRNA:* Moderna returns; *NDQ:* NASDAQ returns; *VIX:* variation of VIX; *ISEE:* ISEE returns. Period range: January 3, 2019 – March 10, 2020.

Table 2
Descriptive statistics for the COVID period.

	Obs	Mean	Std. dev.	Min	Max	Skewness	Kurtosis
PFE	238	.0000158	.0221361	−.0805016	.0858171	−.1691605	6.382859
MRNA	238	.0088535	.0567308	−.1786761	.2180603	.2897902	4.318710
NDQ	238	.0021021	.0221400	−.1300316	.0959663	−.8889778	11.06380
VIX	238	−.0036230	.0846518	−.2662277	.4802141	1.807824	10.89668
ISEE	238	.0023575	.2672455	−1.005086	1.079194	−.1690345	4.764586

PFE: Pfizer returns; *MRNA:* Moderna returns; *NDQ:* NASDAQ returns; *VIX:* variation of VIX; *ISEE:* ISEE returns. Period range: March 11, 2020 – February 12, 2021.

Table 3
Correlations pre-COVID period.

	PFE	MRNA	NDQ	VIX
MRNA	0.2213*			
NDQ	0.4905*	0.2144*		
VIX	−0.4531*	−0.1865*	−0.8122*	
ISEE	0.0880	0.1144*	0.1700*	−0.1704*

PFE: Pfizer returns; MRNA: Moderna returns; NDQ: NASDAQ returns; VIX: variation of VIX; ISEE: ISEE returns. Significance level: *0.1. Period range: January 3, 2019 – March 10, 2020.

Table 4
Correlations COVID period.

	PFE	MRNA	NDQ	VIX
MRNA	0.1302*			
NDQ	0.5475*	−0.0166		
VIX	−0.4634*	0.0101	−0.6676*	
ISEE	−0.1146*	−0.0253	0.0551	−0.0288

PFE: Pfizer returns; MRNA: Moderna returns; NDQ: NASDAQ returns; VIX: variation of VIX; ISEE: ISEE returns. Significance level: *0.1. Period range: March 11, 2020 – February 12, 2021.

Table 5
GARCH estimation results pre-COVID period.

Variables	PFE	MRNA
Mean equation		
NDQ	.2057554** (.005)	.7472199** (.005)
VIX	−.0433238*** (.000)	−.0625397* (.059)
ISEE	−.0014641 (.535)	.0205305* (.053)
Cons	−.0001788 (.714)	.0006702 (.750)
Variance equation		
ARCH	.5918407*** (.000)	.4805702*** (.000)
GARCH	.1514514** (.019)	.1975124** (.041)
Cons	.0000488*** (.000)	.0007873*** (.000)
Log likelihood	935.3257	529.0168

PFE: Pfizer returns; MRNA: Moderna returns; NDQ: NASDAQ returns; VIX: variation of VIX; ISEE: ISEE returns; ARCH: ARCH parameter; GARCH: GARCH parameter; Cons: constant. Significance level: ***0.001, **0.05, *0.1. N: 299. Period range: January 3, 2019 – March 10, 2020.

Table 6
GARCH estimation results COVID period.

Variables	PFE	MRNA
Mean equation		
NDQ	.3367661*** (.000)	.400188* (.083)
VIX	−.0491411** (.005)	.0308231 (.641)
ISEE	−.011166** (.008)	−.0027696 (.816)
Cons	−.0008985 (.410)	.0057009 (.114)
Variance equation		
ARCH	.0672161* (.082)	.240279** (.002)
GARCH	.8161816*** (.000)	.6770661*** (.000)
Cons	.0000357 (.254)	.0003265** (.035)
Log likelihood	622.6255	356.9946

PFE: Pfizer returns; MRNA: Moderna returns; NDQ: NASDAQ returns; VIX: variation of VIX; ISEE: ISEE returns; ARCH: ARCH parameter; GARCH: GARCH parameter; Cons: constant. Significance level: ***0.001, **0.05, *0.1. N: 238. Period range: March 11, 2020 – February 12, 2021.

significantly negative, which suggests that when volatility increased, Pfizer returns decreased and vice versa. Market sentiment in the pre-COVID period is not significant, which means that Pfizer was not influenced by market sentiment. During the COVID period, the results are quite different. NASDAQ and VIX are significant (positively and negatively, respectively) as in the pre-COVID period, but in this case, market sentiment is also significant. This suggests that in this period, Pfizer was more sensitive to what was happening. In fact, the sense of the influence is negative, which means that although the sentiment was negative, the Pfizer's returns increased. Thus, although the market sentiment was negative due to the COVID-19 situation, Pfizer's stock prices were not significantly affected. The reason could be the development process of the vaccine.

Regarding Moderna results, in the pre-COVID period, NASDAQ and market sentiment are significantly positive, suggesting that when the sentiment was positive and NASDAQ increased, Moderna returns also increased. In this period, the VIX is significantly negative, which means that when market volatility increased, Moderna returns decreased. During the COVID period, only NASDAQ is significant. In addition, the coefficient of NASDAQ is significantly lower in the COVID period than in the pre-COVID period, suggesting that Moderna behaved differently in both periods. In sum, investors decided to buy Moderna stocks regardless of the crisis situation, volatility, or sense of market sentiment. The reason for this could be their confidence in the development of an

effective COVID-19 vaccine.

The ARCH coefficient is significant in all models, meaning that the volatility of Pfizer or Moderna in the previous day influenced the volatility of Pfizer or Moderna, which is higher in the pre-COVID period. The GARCH coefficient is also significant, indicating that the market volatility of the previous day influenced the volatility of Pfizer or Moderna, which is higher in the COVID period. It can be concluded that the GARCH (1,1) model is suitable for modelling Pfizer and Moderna volatility. Comparing both companies, the market volatility (GARCH coefficients) had a greater influence on Pfizer's volatility than on Moderna's volatility, suggesting a different reaction of them to market volatility during the COVID period.

Fig. 1 shows the dynamic correlations of Pfizer-NASDAQ and Moderna-NASDAQ. During the COVID period, the dynamic correlations increased considerably compared to the pre-COVID period, showing a clear contagion effect between these variables. This result suggests that the biopharmaceutical companies that developed the vaccine could have had a positive effect on the market, avoiding the downturn derived from the lockdown and the activity stoppage in most economic sectors.

5. Discussion

The aim of this paper was to analyse the stock market behaviour of biopharmaceutical companies during the COVID-19 pandemic in comparison with the pre-crisis period. To this end, two companies that were the first to develop the vaccine using the innovative messenger RNA method, Pfizer and Moderna, were considered. Specifically, the paper has analysed the relationship between the returns of both companies and the technology market index (NASDAQ), market volatility (VIX), and market sentiment (ISEE) during the pre- and COVID periods.

The results obtained indicate that the returns of both companies behaved differently depending on the period considered. Before the COVID-19 period, Pfizer's returns were affected by the technology market and market volatility, while during the COVID-19 period, market sentiment also became relevant, affecting the company's returns. This means that investors saw Pfizer's vaccine project as an incentive to invest in the company despite the negative market sentiment and the high market volatility. On the other hand, Moderna's returns in the pre-COVID-19 period were influenced by the technology market, market sentiment, and market volatility, which changed during the COVID-19 period, as they were only affected by the technology market. These results indicate that, in view of the development of its vaccine, during the COVID period, the company was conceived by investors as a clear choice for investment, despite market volatility or market sentiment. In addition, Pfizer is a more experienced, larger company with more divisions than Moderna, a smaller and younger company whose core business is the development of the COVID-19 vaccine. This could also be a powerful reason to understand why market sentiment and volatility did not affect Moderna during the COVID-19 period. Therefore, the fact that these companies decided to innovate and react early to the crisis in developing a vaccine leads to a different behaviour between pre- and COVID-19 periods. This corroborates the idea pointed out by Donadelli et al. (2017), according to which investors can react in a positive way by taking advantage of what they consider a promising investment opportunity. As market volatility is shown to have influenced Pfizer and Moderna during the pre-COVID period, Hypothesis 1a is supported. The fact that during the COVID period, market volatility only influenced Pfizer partially confirms Hypothesis 1b. These results are in line with other authors who have found that biopharmaceutical companies are not as affected by health crises as companies belonging to other sectors (Chen et al., 2009; Ichev and Marinč, 2018).

The role of market sentiment during the crisis has also been a relevant variable. If during the pre-COVID period, market sentiment influenced Moderna's returns, during the COVID period, it influenced Pfizer, but in a negative way. This means that before the crisis Moderna was a company sensitive to market sentiment; that is, investors were influenced by sentiment when making their decisions. However, during the COVID period, Moderna's investors ignored the negative sentiment of the market to make their decisions, probably influenced by Moderna's news about the development of the new vaccine. Regarding Pfizer, the opposite occurred; before the crisis, market sentiment was not a variable that influenced investment decisions. However, during the COVID period, this variable became an aspect considered by investors when making their decisions. Thus, the more pessimistic the market sentiment, the more investors saw Pfizer and its vaccine as the best, or one of the best, options to get out of the crisis, driving up the price of its stocks. Donadelli et al. (2017) found that in the face of health crises arising from infectious diseases, the mood of investors is reflected in the stocks of US pharmaceutical companies. These results are in line with those obtained by Sun et al. (2021) that the COVID situation prompted investors to invest in medical companies, partially supporting Hypotheses 4a and 4b.

The volatility of Pfizer and Moderna was also analysed through a

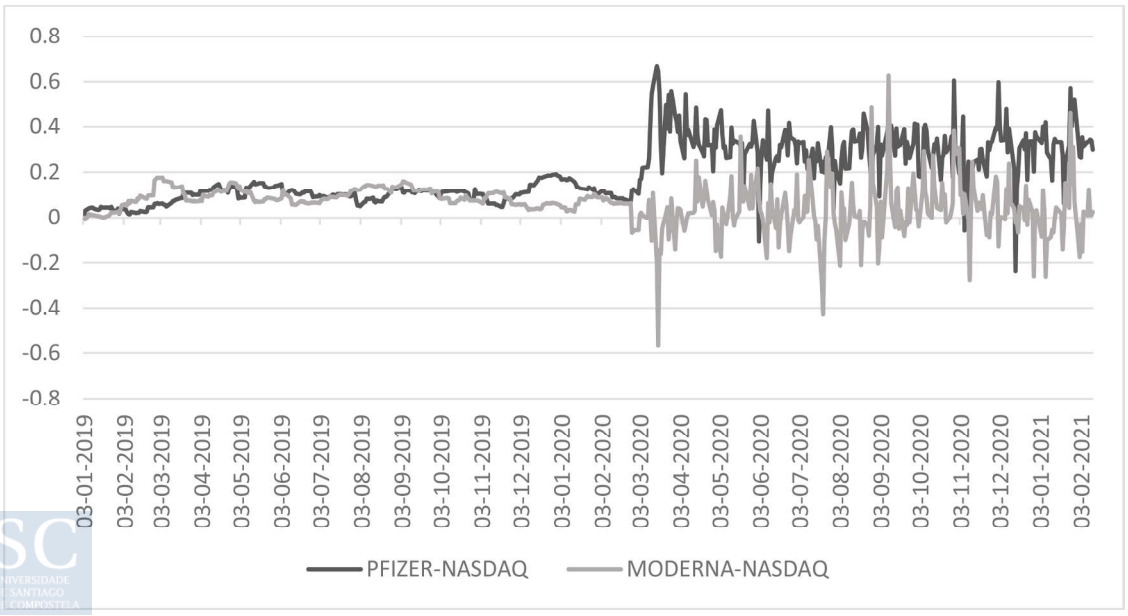

Fig. 1. Dynamic correlations Pfizer-NASDAQ and Moderna-NASDAQ.

GARCH model. The results obtained indicate that the volatility of both companies changed from one period to the next. During the pre-COVID period the influence of the companies' volatilities of the previous day was higher than the influence of the market volatility of the previous day. However, during the COVID period the opposite was true. In line with the study of Baker et al. (2020), this change can be due to the situation of trading and individual mobility restrictions established during the COVID period. Furthermore, it was shown that the influence of market volatility on Pfizer's volatility during the COVID period is greater than the influence on Moderna's volatility, confirming Hypotheses 2a and 2b. Once again, this result highlights that both companies performed differently during the studied period; specifically, Moderna was less affected by market volatility.

These results and the evolution of the stock prices of Pfizer and Moderna and NASDAQ indicate the possibility of the existence of a contagion effect between Pfizer and NASDAQ and between Moderna and NASDAQ. Therefore, an analysis of the dynamic conditional correlations was carried out. The results obtained showed that during the pre-COVID period, there was no co-movement between them. However, during the COVID period, the dynamic correlations increased, demonstrating the existence of a contagion effect between the companies and the technological market index, confirming Hypotheses 3a and 3b. This result means that both companies acted as a kind of "locomotive" for the market, preventing the NASDAQ from dramatic drops and slow recoveries, unlike other market indices.

6. Conclusions and practical implications

According to the 'paradoxical spiral' concept discussed in this article, new scenarios resulting from anthropogenic activities require the action of industries and companies that, based on knowledge, innovation and technological development, are capable of offering new solutions to help mitigate or alleviate the negative impact of disasters on health, the economy and society. In this sense, the biopharmaceutical sector has made an outstanding contribution to the search for effective solutions to the COVID-19 pandemic. Specifically, this study sheds light on the market performance of the American biopharmaceutical vaccine developers Pfizer and Moderna.

The findings of this study have relevant implications for several agents at multiple levels. Despite the unequal influence of volatility and market sentiment on Pfizer and Moderna's returns, as well as the different reactions of their volatility during the pre- and COVID periods, the results highlight the importance of reducing uncertainty and risk in the stock markets. To this end, governments and policy-makers must exercise adequate and accurate control over macroeconomic indicators by formulating policies to soften or avoid extreme volatility situations. Furthermore, policies need to be developed to ensure the stability of relevant sectors, such as those related to water, energy or agriculture, which are key to achieving sustainable development. It is also important to monitor investor sentiment to control potential unjustified panic situations generated by events such as COVID-19. This requires providing investors with accurate and accessible information to help them make decisions according to reality and not assumptions. Above all, the economic, social and environmental policies designed by governments and administrations must prioritize the prevention of such events, establishing effective lines of action to provide a rapid and effective response. The final objective must be the strict observance of the principles capable of guaranteeing sustainable growth. The contagion effect found during the COVID-19 period between Pfizer and Moderna and the NASDAQ-100 index underscores the importance of key technological sectors acting in financial markets to offer solutions to high-impact events beyond traditional safe-haven assets. In this sense, investors must be able to fairly evaluate companies such as Moderna, which have carried out a decided commitment to R&D, innovation and the generation of knowledge to help mitigate the severe effects of the COVID-19 pandemic and other diseases. Investors should consider the existence of significant differences in the financial performance of companies operating in the biopharmaceutical sector, especially in the face of high-impact events and health care crises. As shown in this study, investors have prioritized investing in biopharmaceutical companies that have innovated during the COVID-19 crisis, rewarding, amongst other things, their initiative. Meanwhile, public agents must work on the design of policies to encourage and facilitate business innovation, the generation of knowledge and the natural transition to a green economy.

In this way, governments, organizations, investors and society must not only try to provide rapid and effective responses to natural disasters and diseases with a strong economic and social impact but also show a strong commitment to avoid and reduce the conditions conducive to the occurrence of these negative events. Organizations must change their business models towards others more responsible and sustainable, and develop and apply technological advances that are environmentally friendly and respectful of natural resources in production and commercialization processes. Policy-makers, investors, and society must support this transition, moving together towards a joint commitment to sustainability as a way to ensure the health and survival of humanity.

As with any empirical study, this research has some limitations. First, the analysis of the COVID period in this study can be considered limited, as it only covers from the development of vaccines up to the approval and the first months of vaccines administration. It would therefore be interesting to analyse how these companies have behaved in the market over time as they have obtained new results on the effectiveness of their vaccines, and new vaccine proposals have appeared from other companies. It would also be interesting to conduct a study analysing the effects of COVID-19-related events on biopharmaceutical companies' returns, considering short periods of time before and after each event. Second, only the two most relevant US companies in the race of the vaccine against COVID-19 were considered. Future research could analyse a larger number of biopharmaceutical companies, considering different countries and markets, to provide a broader view and a better understanding of their behaviour in financial markets. Examples of such companies include Johnson & Johnson, Novavax and AstraZeneca. In addition, future research could address the analysis of sentiment extracted from social networks and their influence on the biopharmaceutical sector over a longer period of time. It would also be interesting to analyse how certain pieces of news extracted from renowned publications, well-known media outlets or international institutions affect the stock price and returns of biopharmaceutical companies. Finally, future research should try to go deeper in the study of the linkages between apparently very different and distant industrial sectors, such as biotechnology and agriculture, energy, or water. In this case, the goal would be to delve into the concept of the 'paradoxical spiral' proposed in this paper and its relevance and implications for achieving sustainable growth.

7. Author Statement

Authors	Individual contribution
Juan Piñeiro-Chousa	Conceptualization, Methodology, Formal Analysis, Investigation, Data curation, Writing-Original draft, Writing-Review & Editing, Supervision
M. Ángeles López-Cabarcos	Conceptualization, Methodology, Formal Analysis, Investigation, Data curation, Writing-Original draft, Writing-Review & Editing, Supervision
Lara Quiñoá-Piñeiro	Conceptualization, Methodology, Formal Analysis, Investigation, Resources, Data curation, Writing-Original draft, Writing-Review & Editing
Ada M. Pérez-Pico	Conceptualization, Methodology, Formal Analysis, Investigation, Resources, Data curation, Writing-Original draft, Writing-Review & Editing

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Juan Piñeiro-Chousa is a professor of finance at Santiago de Compostela University (USC), Spain. He has written many articles and papers in national and international journals and has made important contributions to prestigious international conferences. His research interests focus on financial strategy, corporate finance, artificial intelligence, and corporate governance.

M.Ángeles López-Cabarcos is a professor of business administration at Santiago de Compostela University (USC), Spain. She coordinates the Master of Business Administration at USC. As a researcher, she has written many articles and papers in prestigious national and international journals. She has written books and made contributions to international conferences. She has also carried out several technical assistances with important organizations belonging to private sector. Her research lines are focused on corporate social responsibility, firm innovation, behavioural finance, organizational behaviour, and labour climate.

Lara Quiñoá-Piñeiro is a predoctoral researcher with a University Teacher Training contract (FPU) enroled on the PhD programme in Economics and Business at the University of Santiago de Compostela (USC), Spain. She has a degree in Business Administration and Management and an MBA. Her research lines are focused on sustainable value creation, firm innovation, and entrepreneurship.

Ada M. Pérez-Pico, Ph.D. Business Administration by Santiago de Compostela University (Spain). Professor at Faculty of Economics and Business Studies (Santiago de Compostela University - Spain). Her research interest focus on financial markets, behavioural finance, and management.

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4.2 ARTICLE 2. HOW TO EXPLAIN STOCK RETURNS OF UTILITY COMPANIES FROM AN ENVIRONMENTAL, SOCIAL AND CORPORATE GOVERNANCE PERSPECTIVE

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How to explain stock returns of utility companies from an environmental, social and corporate governance perspective

M. Ángeles López-Cabarcos[1] | Helena Santos-Rodrigues[2] | Lara Quiñoá-Piñeiro[1] | Juan Piñeiro-Chousa[3]

[1]Department of Business Administration, Universidade de Santiago de Compostela, Lugo, Spain

[2]Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Viana do Castelo, Viana do Castelo, Portugal

[3]Department of Accounting and Finance, Universidade de Santiago de Compostela, Lugo, Spain

Correspondence
Lara Quiñoá-Piñeiro, Faculty of Business Administration, Universidade de Santiago de Compostela, Alfonso X El Sabio, s/n. 27002 Lugo, Spain.
Email: lara.quinoa@usc.es

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Abstract

Sustainability is a major challenge in today's business world, making environmental, social and governance criteria an indispensable tool for business management and investment decisions. Using 2020 data of 47 companies from the STOXX Europe Total Market Utilities Index and qualitative comparative analysis, this study aims to analyse how the combination of CO_2 equivalent emissions, sustainability compensation incentives, environmental investments, environment management training, and policy fair competition leads to utility companies' stock market returns. Two subsample models (electricity and non-electricity utilities) have been considered in the study. The results point to the absence of CO_2 equivalent emissions, the absence of incentives, and the presence of environmental investment as key variables to lead to stock market returns. The findings provide relevant information for managers and practitioners of utilities industry to achieve improvements in the environmental, social and governance management practices, maintaining profitability in financial markets and facilitating decision-making for investors.

KEYWORDS
business strategy, environmental performance, ESG practices, stock returns, sustainable development, utilities industry

1 | INTRODUCTION

In a world cornered by the global emergency of climate change and chronic shortages of clean air, fresh water, food or energy, efforts to halt the degradation of the planet and the deterioration of social well-being require a strong and sustained international commitment. At European level, regulatory efforts to address these current and future challenges have been intensified (Busch et al., 2022), while society's expectations and requirements demand a determined business action and the establishment of a new business paradigm based on sustainable principles. In this context, the utilities industry—which includes the electricity, gas, water and multi-utilities sectors, as well as waste and disposal services sector—has gained increasing attention for the successful and sustainable development of modern societies (Agovino et al., 2021; Gilardoni, 2020; Pais-Magalhães et al., 2021). Although utility companies play an invaluable role in providing economies with essential public goods and services (Giacomini et al., 2020), their activity is not without controversy, due to its large contribution to the climate crisis (Gilardoni, 2020). Utility companies are now facing the challenge to compete in markets where simultaneously have to create value for their stakeholders, whose demands have forced them to redefine their working practices and business models by initiating

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actions aimed at encouraging a transition towards a green and sustainable development (Nguyen et al., 2021). Among these environmental, social and governance (ESG) actions are (i) progress towards decarbonisation and the establishment of net-zero targets (Busch & Lewandowski, 2018); (ii) linkage of executives' variable remuneration to the fulfilment of sustainability and corporate social responsibility (CSR) targets (Minciullo et al., 2022); (iii) commitment to proactive environmental investments to tackle extreme weather events and global risks, as well as increase future opportunities (Afrifa et al., 2020); (iv) implementation of green training programmes (Marrucci, Iannone, et al., 2022); and (v) establishment of codes of conduct that promote fair competition (Qi et al., 2022). This has led ESG issues climbing positions within organisations, entering the corporate agenda of companies and becoming benchmarks of business sustainability (Ritz, 2022). As a result, ESG scores have become an indispensable investment decision-making tool by collecting and aggregating information that allows companies to be assessed on the basis of their ESG performance (Berg et al., 2019), and providing a measure of a company's responsible behaviour (Dyck et al., 2019). However, the ESG scores have certain shortcomings. One of them relates to the divergence in the ratings published by the ESG data-providing agencies (Berg et al., 2019). Accordingly, the Bank of International Settlements has suggested deconstructing the three ESG rating pillars to allow investors to make a detailed and differentiated assessment of the ESG performance of the companies or assets in which they wish to invest (Ehlers et al., 2022).

Most previous research on ESG has focused on non-financial issues of business management. Little research has studied the impact of ESG on specific financial measures as ROA, ROE, profits, Tobin's Q (Bătae et al., 2021; Yoo & Managi, 2022), firm value (Fatemi et al., 2018); or stock returns (Feng et al., 2022; La Torre et al., 2020; Mănescu, 2011; Yoo et al., 2021). Less research has studied the effect of ESG measures independently considered—for example, greenhouse gas (GHG) emissions (Busch et al., 2022; Choi & Luo, 2021), environmental investment (Grassmann, 2021; Silva-Gao, 2012); employees' green training (Kwon, 2019; Yoo et al., 2022), fair competition policies (Le Roy et al., 2017); or the linkage of non-financial targets to executive compensation (Bachmann et al., 2020; Gan et al., 2020)—on firm performance. The fact that previous research concludes mixed results and that there are very few studies considering the utilities industry justifies the aim of this paper that propose a disaggregated analysis of the ESG pillars to analyse their effect on utilities industry's stock returns. Thus, this study aims to fill this gap by analysing how the combination of five ESG indicators—CO_2 equivalent emissions, sustainability compensation incentives, environmental investments, environment management training and policy fair competition—leads to the presence of stock market returns in the European utilities industry. For this purpose, ESG and stock market data for the year 2020 were gathered from a sample of 47 utility companies included in the STOXX Europe Total Market Utilities Index. The data was analysed using fuzzy set qualitative comparative analysis (fsQCA). To examine the potential discrepancies, the sample was split into two subsamples to consider electricity and non-electricity utilities (gas, water and multi-utilities and waste and disposal services sectors), considering the key role that the electricity sector is expected to play in the European energy transition (Ribeiro et al., 2023).

The research findings are relevant to understanding how companies can manage their efforts to achieve better financial and ESG performance and help them recognise which combinations of ESG factors motivate investors and drive companies' stock market performance. In this way, the paper contributes to the advancement of knowledge on the benefits of ESG practices on corporate stock returns, providing relevant information to assist utilities industry practitioners and investors in making decisions that support the sustainable value creation for the organisation, the environment and the stakeholders.

The rest of the article is structured as follows. Section 2 provides the theoretical background; Section 3 describes the sample, data and methodology used; Section 4 presents the results of the analysis; Section 5 discusses the results obtained; Section 6 outlines the practical implications of the paper; and finally, Section 7 concludes the paper and advances future lines of research.

2 | THEORETICAL BACKGROUND AND RESEARCH QUESTIONS

Utilities industry is the cornerstone of a nation's infrastructure as it provides essential services for the socio-economic and sustainable development of countries, regions and cities (Giacomini et al., 2020; Gilardoni, 2020). The Industry Classification Benchmark (ICB) includes within this industry companies generating and distributing electricity, water and gas, as well as waste management and recycling service providers. The electricity generation and distribution sector is considered a major contributor to the climate change and the environmental stress, placing it in the spotlight of stakeholders and regulators (Slacik & Greiling, 2020). Indeed, the ongoing climate scenario requires these companies to adapt their business models to changing policies and sustainable technological innovations to enable the transition to a low-carbon economy (Pereira et al., 2022). These actions must also be complemented with the revelation of specific sustainability indicators, which in the case of electricity companies is rather limited, making it difficult to assess their progress on the responsible behaviours (Slacik & Greiling, 2020). Gas distribution is other essential service in urban energy systems. This fossil fuel associated with high greenhouse gas emissions is widely used in industrial and domestic consumption, which also requires huge efforts to advance towards climate neutrality (Verhagen et al., 2022). The population growth and concentration in urban areas generates another environmental problem related to waste management. Waste generation, as well as the polluting processes necessary for waste management, turns this sector into another enemy of global ecosystems (Pais-Magalhães et al., 2021). Finally, water is more than a strategic resource, irreplaceable for the existence of living beings (Agovino et al., 2021). Ironically, water is an increasingly scarce resource that represents a major problem for many communities (Zarei et al., 2020). Companies focused on

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the distribution and management of water must keep in mind their public utility role and work to advance in the social and environmental commitment of ensuring the supply of this essential good (Cagno et al., 2022).

With sustainability as one of the biggest challenges facing the modern business world, utilities must pay attention to ESG criteria and their impact on business performance. It has been shown that 'high sustainability companies', that is, those that have voluntarily adopted sustainability policies many years ago, achieve significantly better performance in the long run than traditional companies. This outperformance is stronger in sectors where firms rely heavily on the extraction of large amounts of natural resources (Eccles et al., 2011), such as utilities. Previous research has also concluded that companies' environmental communication can be rewarded with better performance in financial markets (Amores-Salvadó et al., 2022). Although there are several studies focused on the impact of a company's ESG policy on its economic and financial performance (Abdelmotaal & Abdel-Kader, 2016; Hussain et al., 2018), there is hardly any study focused on the utilities industry considering the stock returns as a measure of market-based financial performance. So, it is necessary to delve into the sustainability-stock returns relationship. In fact, the impact of ESG factors on the long-term profitability of companies is leading to consider 'sustainable investments' as 'common investments' (Eccles et al., 2020). Consequently, corporate ESG considerations have become a well-established criterion for evaluating corporate performance and strategy among investors (Morrow Sodali, 2021). Following previous studies' interest in deconstructing the ESG pillars to facilitate a detailed assessment of corporate sustainable performance (Ehlers et al., 2022; Hussain et al., 2018), this study focuses on the analysis of five ESG indicators relevant to the utilities industry, which individually and collectively can affect companies' performance.

2.1 | CO_2 equivalent emissions

In the transition to a sustainable and cleaner planet, the decarbonisation of businesses and economies around the world is an unavoidable requirement. At the European level, legislation and regulation on climate issues and corporate non-financial reporting is increasingly growing (Arvidsson & Dumay, 2022). The spotlight is now on highly polluting industries. The economic activities that generated the highest tonnes of CO_2 equivalent emissions in 2020 in the European Union (EU) include electricity, gas, steam and air conditioning supply, as well as water supply, construction and other service activities (Eurostat, 2022). These data highlight the importance and impact of GHG emissions from utilities. Although recent years show a decline in the GHG emissions intensity of the EU power generators, the electricity sector continues to find difficulties to achieve the climate targets, requiring drastic reductions related to emissions and environmental impacts (Slacik & Greiling, 2020).

From an investor perspective, carbon footprint represents a measure of a company's exposure to climate transition risk (Nguyen et al., 2021). This risk can directly impact on investors' portfolio companies throughout their investment decisions (Krueger et al., 2020). Previous literature provides mixed results regarding the relationship between firms' environmental performance (GHG emissions) and stock market performance. Hsu et al. (2023) find that highly polluting firms have greater exposure to environmental regulatory risks and thus higher average returns. Bolton and Kacperczyk (2021) report that stocks of US companies with the highest CO_2 emissions earn the highest returns. This carbon premium is related to the total level of emissions and to the annual change in company emissions. In the same vein, Busch et al. (2022) observe an association between lower carbon emissions and lower market-based financial performance, suggesting that investors do not perceive a company's enhanced carbon performance as a value driver. Conversely, other authors establish an inverse CO_2 equivalent emissions-stock market performance relationship. In this sense, Guastella et al. (2022) argue that the utilities industry's high GHG emissions have a negative impact on its financial performance. Griffin et al. (2017) conclude that GHG emissions information voluntarily disclosed through the Carbon Disclosure Project by companies in emissions-intensive sectors negatively affects investors' assessment of firms' value. Similarly, Matsumura et al. (2014) find that higher levels of direct carbon emissions are linked to lower values of S&P 500 companies. Likewise, Choi and Luo (2021) claim that companies are penalised in the stock market according to their level of GHG emissions. Aljughaiman et al. (2021) find that the most polluting FTSE350-listed UK companies have a higher probability of extremely negative stock returns, making them more unstable and riskier. The meta-analysis by Busch and Lewandowski (2018) supports the notion of a positive relationship between good corporate carbon performance (low amounts of carbon emissions) and superior financial performance (mainly market-based measures). There are still no conclusive results on the relationship between GHG emissions and corporate stock returns, so the following proposition is tested:

P1. *The absence of CO_2 equivalent emissions in utility companies leads to the presence of stock returns.*

2.2 | Sustainability compensation incentives

From the first corporate social efforts to today's ESG-based initiatives, sustainability has gaining traction on the agenda of corporate boards, progressing towards its integration into companies' strategic planning. Consequently, senior executive compensation requires changes to consider financial and non-financial metrics to better assess longer-term performance (Eccles et al., 2020). Traditionally, executive compensation has been considered a useful tool for reducing agency conflicts (Jenson & Meckling, 1976), approach that coexists with the stakeholder theory (Freeman, 2010) and the stream of research focused on resolving the conflicts between managers and stakeholders through a sustainable performance framework (Ng & Nathwani, 2012). This has encouraged companies to pursue social objectives through initiatives as linking executive pay to sustainability

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targets (Abdelmotaal & Abdel-Kader, 2016). Prior research has concluded a positive and direct relationship between setting ESG targets in senior compensation plans and the sustainable performance of companies (Baraibar-Diez et al., 2019; Eccles et al., 2011; Minciullo et al., 2022). This stance is backed by institutional investors, who support the inclusion of ESG performance metrics in short- and long-term compensation plans (Morrow Sodali, 2021). For this reason, the companies' choice between different metrics turns out to be a very important issue for their business performance (Singer, 2012). However, some authors warn that managers may exercise control over ESG performance measures, so linking their remuneration to these metrics may not be synonymous with engaging in such activities (Qin & Yang, 2022). Moreover, executive remuneration may be boosted without effectively addressing executives' real motivations (Bebchuk & Tallarita, 2022).

Few prior studies have analysed the implications for firm performance of including non-financial measures in the design of executive compensation plans. Said et al. (2003) argue that the combined use of financial and non-financial performance measures leads to higher stock market returns, improving firms' current and future performance in financial markets. Gan et al. (2020) find that the existing marginal relationship between CEO equity-based compensation and higher future firm value becomes stronger when non-financial performance measures are integrated into bonus contracts. For Bachmann et al. (2020) the inclusion of quantifiable non-financial targets or performance targets linked to CSR in CEO bonus contracts is positively related to subsequent firm performance. Lastly, Abdelmotaal and Abdel-Kader (2016) show that the adoption of sustainable incentives leads to higher returns on shareholder funds but not on total shareholder returns. Despite this, the positive association between sustainable incentives and total shareholder returns indicates that these incentives can meet stakeholders' interests without negatively influencing shareholders' needs. Since more research is needed around this issue, the following proposition is tested:

> **P2.** *The presence of senior executives' incentives linked to sustainability targets in utility companies leads to the presence of stock returns.*

2.3 | Environmental investment

Climate change risks extend to business organisations, raising economic, environmental and social challenges and opportunities. The lack of state and regulatory support, the existence of stakeholder or market pressures, the organisational specificities, or the incremental costs are some of the challenges that companies must face, while new opportunities related to environmental, operational and financial improvements as well as new business initiatives are emerging (Lee et al., 2015; Seles et al., 2018). Accordingly, companies are designing strategies to adapt to and/or mitigate the consequences of climate change (Seles et al., 2018) that can affect their business performance and public image (Puertas et al., 2022). Environmental expenditure and investments focus on projects and activities with a positive impact on the environment, ranging from environmental protection (prevention, reduction and control of hazards and other environmental impacts such as waste and emissions management), to innovation through research and development (R&D) of green products or services (Grassmann, 2021). The specific characteristics of the utilities industry, such as its exposure to social and governmental pressures, its rigid regulatory framework or the large number of assets and infrastructure required, can condition the responses of these organisations to the climate crisis. Among the possible business reactions, the literature emphasises the design and development of effective policies that monitor and disclose the costs and benefits associated with mitigating the potential negative consequences of climate change (Lee et al., 2015), the cooperation with other organisations to provide better environmental management solutions (Bicknell & McManus, 2006), the voluntary adoption of practices that promote low GHG production, and the allocation of organisational economic resources to R&D (Seles et al., 2018).

From a proactive perspective, environmental investment and innovation have become a source of solutions for successful environmental management and the generation and exploitation of new opportunities. In this way, Afrifa et al. (2020) show that the investments in innovative technologies help mitigate and reduce the problems caused by climate change. For Ali et al. (2021), R&D investment in clean and renewable energy technologies can contribute to increase economic growth and enhance environmental conditions. Moreover, Shahbaz et al. (2020) argue that while energy consumption and financial development contribute to environmental deterioration, R&D investments help reverse this situation.

Investors seeking to maximise their returns should take into account environmental costs and assess the efficiency of the R&D investments of the target company, since they can have a high positive impact on market capitalization (Puertas et al., 2022). According to Hoang et al. (2020) companies' involvement in sustainable innovation along with an increasing environmental disclosure positively influence market performance. In sectors such as energy, R&D stimulates environmental practices related to the reduction of emissions, the reduction of resources consumption and eco-innovation, which are favourably perceived by shareholders (Uyar et al., 2022). Specifically, the disclosure of environmental capital expenditure in the electricity utility sector is strongly correlated with lower emission rates and superior financial performance (Silva-Gao, 2012). For Lee et al. (2015) the market reacts positively to investments in environmental R&D since they represent a credible corporate environmental commitment. However, according to Grassmann (2021), environmental expenditures follow a U-shaped relationship with firm value. Therefore, companies must exceed a certain threshold in terms of expenditures on environmental protection and environmental R&D to achieve a positive effect on their valuation. Conversely, some authors point out that achieving high environmental performance requires large environmental investments that can lead to assume huge costs not sufficiently rewarded, and consequently lower financial performance (Bénabou & Tirole, 2010). Although most of the previous literature argues that

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environmental expenditure and investments bring benefits to business performance, especially with regard to R&D, more research is needed. Therefore, the following proposition is tested:

P3. *The presence of environmental investments in utility companies leads to the presence of stock returns.*

2.4 | Environment management training

Companies are increasingly engaging in green human resource management (GHRM) involving employees in the company's green initiatives (Ren et al., 2018). GHRM contributes not only to the transition towards the circular economy but also to improve organisational performance (Marrucci et al., 2021; Marrucci, Daddi, & Iraldo, 2022b). GHRM can be understood as a set of human resource management (HRM) practices that aim to promote responsible and environmentally friendly use of resources to foster employees' environmental awareness and engagement (Tang et al., 2018). HRM can play a double role what concerns to environment and sustainability; that is, the medium that can influence changes induced by the environment (Jabbour & Jabbour, 2016) or the end to encourage both attitudinal and behavioural changes among employees to contribute to the organisation's environmental performance (Ren et al., 2018). GHRM can be applied to five functions of HRM; namely, recruitment and selection, training, performance management, pay and reward systems, and involvement (Tang et al., 2018). Environmental training of employees is considered the main HRM practice related to environmental management and is a type of investment to be supported over time (Jabbour, 2011). Specifically, green training encompasses a set of activities that aim to motivate staff to acquire skills and commit to environmental care, including employees' awareness, knowledge management, and creation of a green organisational climate (Tang et al., 2018).

Prior research has addressed the relationship between employees training and organisational performance. Kwon (2019) finds that investment growth in training and development is positively related to the firm's future financial performance. Garavan et al. (2021) establish a direct relationship between training in both quantitative and qualitative terms and firm performance. More recently, Yoo et al. (2022) state that training and development investments lead to a subsequent increase in financial performance and, in turn, higher levels of financial performance also contribute to higher investment in training and development. Green training has also proven to have a positive impact on sustainable organisational performance, developing environmental knowledge and generating awareness and commitment among employees (Marrucci, Iannone, et al., 2022; Yong et al., 2020). In the utilities industry, green training can be relevant at both corporate and societal levels, due to the large environmental impact resulting from its activity and its huge involvement in the daily life of citizens. Pressures from stakeholders on firm's sustainability are positively related to organisational performance and the adoption of GHRM practices (Marrucci, Daddi, & Iraldo, 2022c). Renwick et al. (2013) note that these green practices do not only contribute to improve employees' well-being and environmental performance, but also boost the organisation's financial performance. According to Porter and Kramer (2011), meeting stakeholder demands such as green training of employees, leads to shareholders value creation. The research on green training and its impact on business performance is still at a starting point, so further study on this field is needed. Therefore, the following proposition is tested:

P4. *The presence of environmental management training in utility companies leads to the presence of stock returns.*

2.5 | Policy fair competition

From a management point of view, corporate communication is an indispensable strategy to set and implement the main organisational policies (Chen & Tao, 2020). The 'code of conduct' is a tool used by companies to communicate their policies, detailing desirable corporate behaviours and describing aspects of both business and personal ethics (Ruban & Yashalova, 2021). Therefore, this document can be understood as a roadmap for addressing some aspects related to the social pillar of ESG practices in organisations. It provides trust and reliability to stakeholders, complementing and enhancing existing legal regulations (López Jiménez et al., 2021). The quality of the code of conduct will affect the company's CSR performance, which in turn will affect the effectiveness of the code and its ability to bring about transformations in the organisational culture (Erwin, 2011). As a reliable social indicator embodied in the corporate codes of conduct, fair competition policies express the desired behaviour of companies with respect to their competitors, addressing issues such as respect for patents and intellectual property, antitrust tactics, manipulation and price increases, or anti-competitive behaviours. Fair competition policies lay the foundation for an improved business environment and contribute to economic and environmental performance (Qi et al., 2022). Therefore, in utilities industry it is essential to foster a fair competitive environment conducive to a well-functioning market, since any unethical and unfair competitive behaviour, such as price-fixing collusion or abuse of dominance, can have a strong and negative social, economic, and environmental impact (Duso et al., 2020; Razmi et al., 2020).

Although anti-competitive practices are considered strategies with potential negative impacts on firms' performance and market value, some previous research shows mixed results (Le Roy et al., 2017). Thus, some authors have found that convictions for anti-competitive practices have a negative effect on corporate market value (Bittlingmayer & Hazlett, 2000; De Vany & McMillan, 2004). Le Roy et al. (2017) show that three contingency factors (the amount of the fine, the degree of involvement of the company and the size of the company) can determine the greater or lesser impact of sanctions for anti-competitive behaviours on the beliefs of investors and, consequently, on the company's stock returns. However, other authors have not found that anti-competitive behaviours sanctions have a significant impact on the companies' stock value (Thompson & Kaserman, 2001). As the knowledge around the influence of fair

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competition policies on firms' financial performance is limited, the following proposition is tested:

> **P5.** *The presence of fair competition policies in utility companies leads to the presence of stock returns.*

Considering the open discussion related to the above-commented five relevant ESG indicators affecting utility companies, and to test whether there are differences in the ESG drivers of stock market returns between electricity and other utility companies, the following proposition is tested:

> **P6.** *The causal configurations leading to the presence of stock returns among utility companies are different between electricity and non-electricity sectors.*

3 | METHODOLOGY

3.1 | Fuzzy-set qualitative comparative analysis

A fsQCA approach was adopted to identify the ESG factors that may influence the stock market returns of utility companies. FsQCA is a methodology based on set theory and Boolean algebra, useful for determining which combinations of a set of antecedent conditions (factors considered the cause of a phenomena) are likely to lead to a specific result (the phenomena under study) (Legewie, 2013; Longest & Vaisey, 2008). Therefore, it assumes the coexistence of different causal pathways that may be relevant to lead to a desired outcome. FsQCA explains causality in terms of necessity and sufficiency. A condition is considered necessary for an outcome if the outcome cannot be achieved in the absence of that condition. In turn, a condition or combination of conditions (configuration) is considered sufficient for an outcome if the outcome occurs whenever the condition is present, although the result may also occur in the presence of other conditions (Ragin, 2008). The 3.0 fsQCA software version was used to conduct the analysis.

3.2 | Sample and data

The STOXX Europe Total Market Utilities Index was chosen to identify the 65 companies that make up the initial study sample. This is a regional index resulting from a clustering of country indices representative of the utilities industry based on the ICB, which categorise companies depending on their main source of revenues. The utilities industry comprises all companies generating and/or distributing electricity, water, gas, as well as companies providing waste, recycling, and other environmental services. After removing those companies that lacked the necessary information for the analysis (this data is disclosed on a voluntary basis), the final sample comprises 47 companies with headquarters in Europe. These include 27 from the electricity sector, 16 from the gas, water and multi-utilities sector, and 4 from the waste and disposal services sector. The headquarters of these companies are mainly located in Italy (10), UK (8), Spain (6), France (5) and Germany (4). On average, the total assets reported by these companies amount to 33,689 million euros, with total revenues of around 12,662 million euros, a workforce of 22,774 employees, and an age of 38 years.

The main sample was split to conduct an in-depth analysis to compare possible discrepancies between companies in the electricity sector and other non-electricity utilities. This double approximation provides an interesting approach, since the decarbonisation, digitalisation and decentralisation of the European electricity sector is defining the energy transition strategy in the continent (Ribeiro et al., 2023). Furthermore, as electricity is expected to be the main energy driver for sustainable development (Starace, 2020), the decisions and investments made by electricity companies will have a significant impact in social, economic, and environmental terms for European societies.

The closing price of the stocks, as well as the company-level ESG data were gathered from the Thomson Reuters EIKON database. The study period refers to 2020 considering also the fiscal year of the companies analysed.

3.3 | Outcome, conditions and calibration

Stock returns is a widely used measure of corporate financial performance (Bolton & Kacperczyk, 2021; Feng et al., 2022) capable of capturing the impact of managers' actions on the firm value (Cadman et al., 2010). Hence, the annual stock market return of the utility companies was selected as the outcome. To calculate it, the closing prices in euros of each company's last stock prices of 2019 and 2020 were compiled. In those cases where the same company was listed in more than one market, the country where its headquarters were located was taken as the reference market. The annual company returns were calculated following Campbell et al. (1997, p. 11):

$$Ri_t = \ln(Pi_t) - \ln(Pi_{t-1}) \quad (1)$$

where Pi_t is the close price of the stock i (considering the 47 companies) at time t (2020). In addition, five antecedent conditions related to the three ESG pillars were selected: total CO_2 equivalent emissions, sustainability compensation incentives, environmental investments, environment management training, and policy fair competition (Table 1).

The raw data obtained for the outcome and the antecedent conditions were calibrated to denote the degree of membership of each case to each of the sets (Schmitt et al., 2017). While the dichotomous variables (INCEN, EXP, TRAIN and FAIR) were transformed into crisp sets, the continuous variables (RET and CO_2) were transformed into fuzzy sets. Commonly accepted thresholds in the literature for this kind of data were adopted in this study (López-Cabarcos et al., 2021; Olaya-Escobar et al., 2020) setting the breakpoints at the 90th, 50th and 10th percentiles (full membership, cross-over point and full non-membership).

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TABLE 1 Outcome and conditions.

Type	Label	Description	ESG pillar
Outcome	RET	Annual company stock market return in the country of headquarters.	-
Condition	CO_2	Total carbon dioxide (CO_2) emissions and CO_2 equivalents measured in tonnes. Total CO_2 emissions include scope 1 + scope 2.	Environmental
Condition	INCEN	Whether or not senior executive compensation is linked to CSR, health and safety or sustainability targets.	Governance
Condition	INV	Whether or not the company reports on its environmental expenditures or reports that it makes proactive environmental investments to reduce future risks or increase future opportunities.	Environmental
Condition	TRAIN	Whether or not the company trains its employees on environmental issues.	Social/Environmental
Condition	FAIR	Whether or not the company describes in its code of conduct its efforts to be a fair competitor. This includes respecting other companies' patents, copyrights or intellectual property, or avoiding anti-competitive behaviour, price fixing or other monopolistic tactics.	Social

Note: Descriptions adapted from Thomson Reuters EIKON database.

4 | RESULTS

Three models were analysed: the first includes the 47 companies belonging to the utilities industry (M_utilities); the second includes those 27 companies belonging to the electricity sector (M_elect); finally, the third model (M_noelect) includes those 20 companies belonging to sectors other than electricity (gas, water and multi-utilities, or waste and disposal services).

Table 2 presents the results of the analysis of the necessary conditions. The results show that there are no necessary conditions, since in the three proposed models none of the conditions showed a consistency score exceeding the threshold value of 0.9. However, in M_elect and M_noelect, environment management training and policy fair competition were identified as quasi-necessary conditions, respectively (consistency values close to 0.9) (Schneider et al., 2010).

The sufficiency analysis was also performed. The following models were tested:

$$\text{M_utilities}: \text{RET}_{(\text{utilities industry})} = f(CO_2, \text{INCEN}, \text{INV}, \text{TRAIN}, \text{FAIR})$$

$$\text{M_elect}: \text{RET}_{(\text{electricity sector})} = f(CO_2, \text{INCEN}, \text{INV}, \text{TRAIN}, \text{FAIR})$$

$$\text{M_noelect}: \text{RET}_{(\text{non-electricity sectors})} = f(CO_2, \text{INCEN}, \text{INV}, \text{TRAIN}, \text{FAIR})$$

Table 3 reports the intermediate solutions, including peripheral and core conditions. Peripheral conditions (small circles) indicate a weaker causal relationship of the conditions with the outcome, while core conditions (large circles) indicate a stronger relationship (Fiss, 2011). In M_utilities, configuration 1 [$\sim CO_2$* $\sim$ INCEN*INV*TRAIN] shows that the combination of the absence of CO_2 equivalent emissions, the absence of sustainability compensation incentives, and the presence of environmental investments and environment management training leads to the presence of utility companies' stock returns. Configuration 2 [$\sim CO_2$* $\sim$ INCEN*INV*FAIR] shows that the combination of the absence of CO_2 equivalent emissions, the absence of sustainability compensation incentives, the presence of environmental investments and the presence of a fair competition policy leads to the outcome. In both patterns, $\sim CO_2$, $\sim$INCEN and INV are shown as core conditions. Consequently, propositions P1 and P3 are supported. Proposition P2 is not supported as it is the absence and not the presence of executive incentives that leads to the presence of stock returns. Propositions P4 and P5 are partially supported since environmental training and fair competition policy are present in only one of the two causal configurations.

In M_elect, the first configuration [$\sim CO_2$*INCEN*TRAIN* $\sim$ FAIR] shows that the combination of the absence of CO_2 equivalent emissions, the presence of sustainability compensation incentives and the presence of environment management training leads to the presence of electricity companies' stock returns, even if policy fair competition is absent. The second configuration [$\sim CO_2$*INV*TRAIN* $\sim$ FAIR] shows that the combination of the absence of CO_2 equivalent emissions, the presence of environmental investments and the presence of environment management training leads to the presence of electricity companies' stock returns, once again even if policy fair competition is absent. The third configuration [CO_2* $\sim$ INCEN*INV* $\sim$ TRAIN*FAIR] shows that the absence of sustainability compensation incentives, the presence of environmental investments and the presence of a policy fair competition lead to the outcome, even if total CO_2 equivalent emissions are present and environment management training is absent.

Finally, in M_noelect, the first configuration [$\sim CO_2$* $\sim$ INCEN*INV*FAIR] shows that the combination of the absence of CO_2 equivalent emissions, the absence of sustainability compensation incentives, the presence of environmental investments and the presence of policy fair competition leads to the presence of non-electricity companies' stock returns. The second [$\sim CO_2$*INCEN* $\sim$ INV* $\sim$ TRAIN*FAIR] shows that the combination of the absence of total CO_2 equivalent emissions, the presence of sustainability compensation

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TABLE 2 Analysis of necessary conditions (Outcome: Stock returns).

	M_utilities		M_elect		M_noelect	
Conditions	**Consistency**	**Coverage**	**Consistency**	**Coverage**	**Consistency**	**Coverage**
CO_2	0.484692	0.602570	0.511249	0.551926	0.476757	0.523753
~CO_2	0.728429	0.684348	0.740109	0.633466	0.747027	0.596718
INCEN	0.403976	0.461818	0.424360	0.497273	0.365405	0.307273
~INCEN	0.596024	0.599600	0.575640	0.463750	0.634595	0.652222
INV	0.763817	0.548857	0.787432	0.507500	0.724324	0.446667
~INV	0.236183	0.495000	0.212568	0.391429	0.275676	0.510000
TRAIN	0.792048	0.510769	**0.882079**	0.473750	0.615135	0.379333
~TRAIN	0.207952	0.653750	0.117921	0.506667	0.384865	0.712000
FAIR	0.755865	0.543143	0.666408	0.452105	**0.890811**	0.515000
~FAIR	0.244135	0.511667	0.333592	0.537500	0.109189	0.252500

Note: ~ represents absence of the condition. Bold represents quasi-necessary conditions.

TABLE 3 Analysis of sufficient conditions (Outcome: Stock returns).

	M_utilities		M_elect			M_noelect	
	1	**2**	**3**	**4**	**5**	**6**	**7**
CO_2	○	○	○	○	●	○	◦
INCEN	○	○	●		◦	○	●
INV	●	●		●	●	●	◦
TRAIN	•		•	•	○		○
FAIR		•	○	○	•	•	•
Consistency (incl.)	0.8526	0.8798	0.8075	0.8687	0.8034	0.9105	0.9011
Raw coverage (cov.r)	0.2437	0.2561	0.1171	0.1746	0.0729	0.3081	0.0886
Unique coverage (cov.u)	0.0604	0.0728	0.0590	0.1164	0.0729	0.3081	0.0886
Solution coverage	0.3165		0.3064			0.3968	
Solution consistency	0.8825		0.8386			0.9084	

Note: '●' Denotes the presence of the condition while '○' denotes the absence of the condition. Small circles denote peripheral conditions while large circles denote core conditions (Fiss, 2011). Consistency cutoff, M_utilities: 0.8397; M_elect: 0.8000; M_noelect: 0.8692. Frequency cutoff: 1. Vector of expected directions (0, 1, 1, 1, 1) (Ragin & Davey, 2016).

incentives and the presence of a policy fair competition leads to the presence of the outcome, even if environmental investments and environment management training are absent. So, the results obtained in M_elect and M_noelect support proposition P6.

5 | DISCUSSION

Through an fsQCA analysis this study highlights the importance of some ESG aspects towards the goal of achieving sustainable business models and successful financial market performance. Consistent with the results obtained in M_utilities, combating GHG emissions has been and continues to be a major concern in the fight against climate change in the EU. In fact, the subsample of non-electricity companies shows a strong commitment to low emissions, with the CO_2 condition absent in the two possible configurations. This is also predominant among electricity companies, with CO_2 as a core condition absent in two and present in one of the three paths leading to the presence of stock returns. This strong climate concern has been reflected in investors' decisions, making decarbonisation one of their ESG priorities. These findings are in line with previous studies that point to a penalisation in stock markets for higher levels of GHG emissions (Choi & Luo, 2021; Griffin et al., 2017). This negative relationship is more pronounced in emissions-intensive industries such as utilities. Consequently, this commitment to carbon and equivalent emissions neutrality allows companies to achieve financial improvements by managing an unwanted output in the business value generation process (Nguyen et al., 2021). No less important is the role of environmental investments. The results show that INV condition is present as core in the two causal configurations of M_utilities. In M_elect, INV is present as a core condition in two of the three possible configurations, and in M_noelect in one of the configurations, while it is absent as a peripheral condition in the other one. Climate change and the emergence of extreme weather phenomena are forcing utilities to

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make proactive environmental investments that allow them to mitigate current and future risks or even take advantage of potential future opportunities. The high exposure of this industry to multiple risks, such as those arising from the scarcity of natural resources like water—an essential commodity for the production process and proper functioning of these companies as well as for the human consumption—requires an urgent response to ensure the protection and preservation of the natural environment and the surrounding context in which these companies operate. To this end, utilities should implement environmental management systems that allocate adequate financial resources for activities and projects aimed to cause positive environmental impacts. This includes spending and investing in systems and equipment to treat GHG emissions, waste, soil and water pollution, but also investing in environmental prevention and environmental R&D and innovation (Seles et al., 2018), since, according to study results, both strategies lead to improve stock returns. Indeed, investment in R&D encourages the emergence of environmental practices through which the organisation's environmental commitment is demonstrated to shareholders (Uyar et al., 2022). The results obtained are in line with previous research that positively relates investments in environmental protection and environmental R&D to market performance and business valuation (Grassmann, 2021; Hoang et al., 2020; Puertas et al., 2022). The absence of this condition in one of the configurations of M_noelect can be aligned with the findings of Bénabou and Tirole (2010), who consider that high environmental investment efforts of an organisation can represent a high cost for the company which, if not sufficiently rewarded, can lead to worsen its financial performance.

According to M_utilities results, the absence of sustainability compensation incentives for senior executives is also an important variable for the presence of stock returns, although this seems to be less clear in the subsample models. For electricity utilities, compensation incentives are present as a core condition in one of the three configurations and absent as a peripheral condition in other one. For non-electricity utilities, compensation incentives are present as a core condition in one path and absent in the other. These mixed results show that only for some companies and investors, linking sustainable performance targets to executive incentives can be positive for firm performance. These results partially support those obtained by previous research (Abdelmotaal & Abdel-Kader, 2016; Bachmann et al., 2020). In view of these results, several questions could be raised. Do companies have reliable tools and measures available to quantify the achievement of sustainability objectives? Is known the relationship between what is measured and what is rewarded? Are these criteria standardised and comparable across companies? And above all, are these criteria transparently disclosed to stakeholders? If criteria and targets on the same issue differ substantially between firms, investors may find it difficult to assess and quantify the company's performance. As Berg et al. (2019) point out, the heterogeneity and disparity of criteria used by ESG rating agencies is a drawback for investors, that may hinder any variable remuneration scheme linked to ESG criteria. In addition, Bebchuk and Tallarita (2022) argue that ESG-based compensation has several problems, particularly in terms of ESG metrics focused on narrow and partial measures, and agency problems related to executive compensations, all of which makes these practices of no interest to stakeholders. This can justify the results obtained and the need to continue exploring.

In M_utilities the commitment to TRAIN or FAIR diverge depending on the configurations. Employee training on environmental issues is one of the conditions that can contribute to the presence of stock returns. Environmental training has proven to have a higher acceptance among electricity companies compared to non-electricity companies, as it is present in two of the three configurations and it is also a quasi-necessary condition. This argument is supported by previous research that highlight the positive impact of GHRM practices on the organisational financial performance (Renwick et al., 2013). Conversely, in M_noelect, environmental training only appears as absent in one of the two causal configurations, suggesting that for these firms training is not currently a relevant variable. Nonetheless, environmental education of the organisation's staff can act as a decisive vehicle for strengthening future ESG actions. According to Marrucci, Iannone, et al. (2022) and Yong et al. (2020), the company's commitment to green training leads to increase employees' awareness and engagement to green practices while improving environmental performance. The fact that companies work with limited resources whose scarcity is becoming a major issue for today's societies, underlines the significance of supporting environmental training both inside and outside the company.

The condition related to fair competition policies is other possible way to reach the presence of stock returns in M_utilities. Specifically, non-electricity companies show a clear commitment to establish a 'code of conduct' that demonstrates their loyal behaviour towards competitors. In M_noelect, this is a quasi-necessary condition for the presence of stock returns, present in the two causal configurations leading to the outcome. This supports the idea that anti-competitive behaviours can have a negative impact on the company's share price (Bittlingmayer & Hazlett, 2000; De Vany & McMillan, 2004), so it is necessary to promote and publicise the establishment of fair competition policies. In contrast, in M_elect fair competition policy condition is only present in one of the configurations, while it is absent as a core condition in the other two. This widespread behaviour among electricity companies, which sometimes involves attitudes such as price fixing or the implementation of different monopolistic tactics, is not being penalised in the stock market. This result is in line with the study by Le Roy et al. (2017), which notes that investors consider that the future earnings of larger firms are less affected by convictions for anti-competitive practices than those of smaller ones, affecting also their stock returns in a lesser way. Given the increasing importance of ESG information in investment decision-making, such unethical behaviours may not lead to the presence of stock returns in the near future. Geopolitical interests and events such as the energy crisis in Europe or the war in Ukraine in 2022 could accelerate social unrest and change the investors' perspective around the management of electricity companies.

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6 | THEORETICAL AND MANAGERIAL IMPLICATIONS

The study results allow concluding both theoretical and practical implications. From a theoretical point of view, the novel use of the fsQCA methodology allows to carry out a combined analysis of different variables on the basis of the equifinality principle to define different paths that can lead to the proposed outcome. Hence, the inclusion of conditions belonging to the three ESG pillars is useful to understand how they can complement each other to lead to stock market performance.

The findings also provide relevant information for practitioners and managers of utility companies who can make decisions oriented to ensure higher levels of market profitability without neglecting the commitment to ESG issues. Deconstructing the three ESG pillars provides a better understanding of the specific areas for improvement in organisations, allowing investors to assess companies more accurately and make more informed decisions. Moreover, considering the relevance of the sectors under study for the transition to green economies, adopt sustainability improvements can contribute to companies' sustainable development and provoke ecological benefits for all society.

The paths suggested by the results mostly emphasise the relevance of the absence of CO_2 equivalent emissions and the presence of environmental investments. While in the short term some investors may find it economically attractive to invest in sectors and companies which employ highly polluting technologies and production processes, in the long-term fossil fuels will drastically reduce their weight in the national energy mixes, making room for renewable and low-emission technologies in a transition towards sustainable energy economies. Therefore, managers of utility companies, both electricity and non-electricity utilities, should continue to allocate resources to reduce GHGs to ensure compliance with the EU's climate neutrality goals. These decarbonisation efforts will be supported to some extent by proactive environmental investments. In this sense, companies should strengthen their investment in activities and projects with positive environmental impacts that go beyond regulatory requirements. The objective should be to reduce the occurrence and impact of current and future risks and allow the exploitation of emerging opportunities related to new products, services and ways of doing business focused on sustainable and responsible principles. Although training on environmental issues seems to be less relevant for some utility companies, CEOs of companies in the electricity sector should continue to prioritise and support green training of their staff. It is expected that training will instil in employees an awareness about the management of sustainable natural resources, which in turn will contribute to promoting responsible environmental behaviours for all society. For this reason, this practice could also be relevant for non-electricity companies.

Non-electricity companies show a greater awareness of keeping fair competitive behaviours than electricity utilities. This situation could change in the short term because the socio-economic and geopolitical situation in Europe is changing as are investors' ESG demands and priorities; so, electricity companies should remain very attentive to the needs of the stakeholders. To date, sustainability compensation incentives for senior executives do not seem to be a decisive factor for the presence of stock returns among utility companies; however, they should strive to improve the quality of non-financial ESG reporting as well as the measurement, standardisation, and disclosure of the variable part of the executives' compensation, which could contribute to greater company transparency and help decide on the strategic prioritisation of this practice. Finally, for all these good practices to have a positive impact on companies' stock market performance, adequate disclosure of information is needed to allow all investors to assess and reward companies based on their ESG performance.

7 | CONCLUSIONS

This study examines the possible configurations that lead to stock returns in the utilities industry through a combination of environmental, social and corporate governance conditions. The results suggest different paths to achieve sustainable and profitable performance among utility companies. Most of these pathways have in common the absence of CO_2 equivalent emissions and the presence of environmental investments. The absence of executive compensation incentives linked to sustainability targets also stands out in the general model. In turn, environmental training and fair competition policies show the largest discrepancies between electricity and non-electricity utilities.

ESG criteria have become an invaluable tool for analysing the performance and contribution of organisations to environmental, human, and corporate governance challenges. The findings of this study provide insights for the improvement and development of business strategies that integrate ESG practices capable of creating value for stakeholders and society, favouring business continuity and company reputation. Specifically, the study reports on the effects of different combinations of ESG practices on the stock market performance of companies in the utilities industry. This knowledge can help managers choose and assess which combination of companies' ESG efforts is most beneficial to meet the expectations and demands of stakeholders and the needs of the organisation itself, prioritising those ESG practices that best contribute to the creation of sustainable value. The study also contributes to investors' decision-making by providing relevant information that allows them to carry out a more detailed ESG assessment of the assets in which they intend to invest, thus identifying sustainability-driven companies and projects towards which to channel their funds.

As any empirical study, this research has some limitations that need to be considered and that provide avenues for future research. Firstly, the non-financial ESG information currently provided by companies is rather limited. The growing importance of measuring sustainable performance, expressed in new regulations like the EU Corporate Sustainability Reporting Directive, and the increasing demand of investors for higher quality, quantifiable and comparable information, leads future research to be able to use quantitative sustainable data that can further enrich the analysis of the results obtained. A second

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limitation lies in the periodicity and temporal frame of the data. Sustainability reports have usually an annual periodicity which implies working on the basis of annual data for all variables. Furthermore, the year 2020 has been strongly affected at all levels by the COVID-19 pandemic, so it would be interesting to repeat this study to try to isolate the possible effects of this event. A third limitation refers to the sample size, derived from the lack of other utility industry indices comprising more companies at the European level. Future research could consider companies from countries not included in the index or even from other continents in order to compare the results and evaluate their generalisation. Finally, future research could consider new ESG indicators, such as the use of water resources or the waste generation, to continue supporting the deconstruction of the ESG pillars for better decision-making by investors and CEOs.

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ORCID

M. Ángeles López-Cabarcos https://orcid.org/0000-0001-9844-8767
Helena Santos-Rodrigues https://orcid.org/0000-0002-0442-4447
Lara Quiñoá-Piñeiro https://orcid.org/0000-0002-4173-8998
Juan Piñeiro-Chousa https://orcid.org/0000-0002-4639-8435

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4.3 ARTICLE 3. WATER AND WASTE MANAGEMENT STRATEGIES AS DRIVERS OF THE FINANCIAL PERFORMANCE OF FOOD COMPANIES

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Water and waste management strategies as drivers of the financial performance of food companies

M. Ángeles López-Cabarcos [a], Juan Piñeiro-Chousa [b], Lara Quiñoá-Piñeiro [a,*], M. Luisa López-Pérez [b]

[a] Department of Business Administration, Universidade de Santiago de Compostela, Lugo, Spain
[b] Department of Accounting and Finance, Universidade de Santiago de Compostela, Lugo, Spain

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ABSTRACT

Environmental degradation and resource overuse can affect business operations. Sustainable development is therefore a global economic priority. Food companies must develop strategies to ensure food security and seek business models to provide economic, social, and environmental benefits. This paper presents the combinations of water and waste management practices (water efficiency targets, water consumption ratio, water intensity ratio, waste recycling ratio, and waste intensity ratio) that lead to an overvaluation of food companies in the stock market (Tobin's Q > 1). These combinations of practices were identified using fuzzy-set qualitative comparative analysis (fsQCA) of a global sample of 61 listed companies from the food production sector. No necessary conditions were found for the outcome of a Tobin's Q >1. In contrast, the sufficiency analysis revealed five sufficient configurations for overvaluation. The presence of significant recycling and waste reuse performance and the absence of a strong intensity of water withdrawal and waste production are key conditions to achieve the presence of the outcome. The findings provide useful insights for managers, who can focus their business strategies on sustainable and efficient water and waste management to support high financial performance. The findings can also help investors in their decision making.

1. Introduction

The trend of global population growth and concentration in large urban areas has resulted in the abandonment of traditional sustainable economic models. Industrialized models that intensively use the natural environment and resources have been adopted in their place. Economies around the world are becoming increasingly affected by human action. Examples of the negative effects of human action include climate change; chronic water, energy, and food shortages; and exposure to adverse weather, natural disasters, and infectious diseases (Haines and Ebi, 2019; Piñeiro-Chousa et al., 2022).

The current global environmental crisis places countries and companies at a crossroads. They must define new strategies and business models to create long-term sustainable value (Schoenmaker and Schramade, 2019). Against this backdrop, world leaders have agreed on an action plan. The 2030 Agenda for Sustainable Development sets out 17 Sustainable Development Goals (SDGs) covering economic, social, and environmental dimensions (Usmani et al., 2022). Food-related issues have been identified as crucial to achieve a better and more sustainable future worldwide. These issues are captured by SDG 2: Zero hunger and SDG 3: Good health and well-being (United Nations, 2022a).

Besides being central to people's well-being, cultural identity, and human heritage, food is also an engine of social and economic development (Petersson et al., 2021). However, the food sector faces numerous environmental challenges. These challenges arise in part because this sector is affected by climate change, as well as other social and environmental issues. However, the food sector itself aggravates these challenges through greenhouse gas (GHG) emissions, soil degradation, habitat deterioration, biodiversity loss, waste generation, and water and energy consumption (Cupertino et al., 2021; do Canto et al., 2021). This sector is thus subject to more rigorous and critical public scrutiny than others (Partalidou et al., 2020). Given the need to feed a growing world population, which is estimated to reach 9.7 billion by 2050 (United Nations, 2022b), intensive use of land and resources will

* Corresponding author at: Faculty of Business Administration, Universidade de Santiago de Compostela, Alfonso X El Sabio, s/n. 27002 Lugo, Spain.
E-mail addresses: angeles.lopez.cabarcos@usc.es (M.Á. López-Cabarcos), j.pineiro@usc.es (J. Piñeiro-Chousa), lara.quinoa@usc.es (L. Quiñoá-Piñeiro), mluisa.lopez.perez@usc.es (M.L. López-Pérez).

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only exacerbate this situation (Kucukvar et al., 2019). Food sector growth must therefore be supported by more sustainable practices.

Motivated by the expectations of investors and other stakeholders, the growing interest in aligning business practices with sustainability goals has made environmental, social, and governance (ESG) criteria a benchmark for monitoring and assessing the ESG commitment of the business community, including the food industry (Gangi et al., 2021; Luque-Vílchez et al., 2023; Vitale et al., 2023). The sustainable strategies of food companies, such as improving the efficiency and effectiveness of natural resource use, reducing GHG emissions and waste, or increasing recycling, address climate change while creating business opportunities and fostering trust and relationships with stakeholders (Gull et al., 2022; Somlai, 2022). Some studies have examined the sustainable performance of companies based on the disclosure of corporate social responsibility (CSR) or ESG practices and their scores in these practices (e.g., Gerged et al., 2021; Velte, 2017). However, recent research has also highlighted the importance of detailed analysis of the individual dimensions or subdimensions of the sustainability pillars (Ehlers et al., 2022; Gull et al., 2022; Hussain et al., 2018; López-Cabarcos et al., 2023).

To enrich existing academic knowledge, this study deconstructs the ESG pillars to analyze the combined efforts of the food sector regarding water and waste management. Analysis of the food sector's water management is important because water is an increasingly scarce yet indispensable input for industrial production and processing (Weber and Saunders-Hogberg, 2020). Analysis of the food sector's waste management is also crucial because waste generation is growing exponentially, with devastating implications for the climate (Gull et al., 2022). Resource use and emissions practices linked to the environmental pillar are aligned with the findings of Luque-Vílchez et al. (2023). They showed that examining environmental indicators in the food sector (especially those related to water and waste management) is of great value and interest for stakeholders because of the potential positive impact on corporate reputation (Ji et al., 2023) and the projected scenarios of global resource scarcity (Lasorella and Siggia, 2018). The well-documented intensive use of natural resources and environmental impact of the food sector further underscore the strategic importance of these responsible practices in achieving the SDGs (Luque-Vílchez et al., 2023).

Increasing social awareness of health and food quality has led scholars to examine the effectiveness of sustainable and ethical actions in the food sector and their impact on the financial performance and reputation of companies (Nirino et al., 2020). Scholars and practitioners have shown growing interest in the relationship between ESG practices and corporate financial performance, including accounting and market-based measures. However, research has yielded mixed findings (e.g., López-Cabarcos et al., 2023; Nirino et al., 2020; Okafor et al., 2021; Whelan et al., 2021). These mixed findings highlight the need for further exploration of this relationship.

Despite recognition of the relevance of examining this relationship, few studies have focused on the food sector, as noted by Sandberg et al. (2023). Studies of this topic have predominantly focused on overall ESG scores or those of its pillars. They have not employed individual indicators to assess water or waste management practices. Furthermore, these studies rely on accounting-based measures of financial performance, especially return on assets (ROA) and return on equity (ROE). Market-based measures have generally been overlooked (Gangi et al., 2021; Nirino et al., 2020; Partalidou et al., 2020; Sandberg et al., 2023).

The use of market-based financial measures could be of value because these measures are widely used in the business literature to assess the value and financial performance of firms (Benjamin and Biswas, 2022; Vargas-Santander et al., 2023). Tobin's Q has the advantage of considering both accounting and market inputs, drawing on tangible and intangible factors (e.g., brand image, loyalty, and reputation) that influence firm value (Okafor et al., 2021; Vizcaíno-González and Piñeiro-Chousa, 2016). Moreover, this metric reflects the current value of a firm, while forecasting its long-term financial performance. It is thus a valuable tool for measuring investment and growth potential (Okafor et al., 2021; Shank and Shockey, 2016).

This study makes a unique and valuable contribution by filling several research gaps. It uses fuzzy-set qualitative comparative analysis (fsQCA) of a sample of 61 listed food companies from around the world to explore how the combination of water and waste management practices leads to overvaluation of these companies in the market according to the Tobin's Q ratio. This study thus reflects the interest of numerous authors in analyzing specific sectors, given that each sector has unique features in terms of the relationship between companies' sustainable practices and financial performance (Vitale et al., 2023; Buallay, 2020). The results reveal five configurations that are sufficient for overvaluation of food production companies. The presence of significant recycling and waste reuse performance, the absence of a strong intensity in water withdrawal, and the absence of a strong intensity in waste production are important conditions for the presence of a Tobin's Q >1.

This study makes several original contributions. First, the findings can help food business managers make decisions and combine environmental management measures to improve the market perception of their company and generate long-term sustainable value. Second, it identifies areas for improvement in water and waste management in the food sector, as well as raising awareness of limited resources and responsible resource management, which can promote environmental preservation and waste reduction through recycling and reuse. Third, the study contributes to the literature documenting the positive effects of sustainable practices on firm valuation and business performance. It can thus strengthen the resolve of business managers to implement sustainable strategies that benefit all stakeholders. Finally, the findings can also help investors value food companies based on water and waste management practices and understand how these practices affect these companies' growth prospects.

The manuscript is structured as follows. Section 2 describes the theoretical framework and presents the research propositions. Section 3 explains the methodology, data, and research design. Sections 4 and 5 present and discuss the findings. Section 6 outlines the theoretical and practical implications. Finally, Section 7 presents the main conclusions, limitations, and future lines of research.

2. Theoretical background

2.1. Sustainability and financial performance in the food sector

The food industry provides the world with the food it needs while creating employment, contributing to economic growth, and shaping the natural surroundings (Romanello and Veglio, 2022). It consists of a vast network of companies working to provide food for everybody (Sandberg et al., 2023). Activity in this industry ranges from that of small or family-run businesses to that of firms that rely on large-scale investment (Usmani et al., 2022). This sector and its supply chain provide an essential service for both human survival and world peace (Telukdarie et al., 2020).

Historically, knowledge of the food sector has evolved in four stages. Initially, the focus was on ensuring food integrity and safety (up to the 1950s). Next, attention turned to the improvement of flavors (1950 to 1980). The third stage saw a move to a health focus (1980 to 2000). Finally, the most recent stage is to meet the current challenge of promoting the well-being and health of society now and in the future (Augusto, 2020; Silva et al., 2018).

Human activity associated with the agri-food and beverage sectors heavily influences ecosystem processes, socioeconomic development, and the well-being of societies. The food value chain exerts intense pressure on the environment. This pressure is felt throughout the food value chain, from producers, who require vast natural resources for production, to retailers, who shape the environment through logistics,

packaging, and waste production (Gangi et al., 2021). Every food product has an environmental impact during its life cycle (Petersson et al., 2021). The food chain is responsible for 21 % to 37 % of global GHG emissions (IPCC, 2019), agricultural water use is responsible for 70 % of freshwater withdrawals (FAO, 2020), and up to 5 % of global water use is allocated to food processing (Boretti and Rosa, 2019). In addition, food production has negative effects in terms of deforestation, desertification, biodiversity loss, and mineral depletion (FAO, 2020). Given these figures, efforts to identify and develop solutions to achieve long-term environmentally, socially, and economically sustainable production must not be delayed (Režek Jambrak et al., 2021).

In recent years, the food sector has transformed from a sustainable approach, based on standards and certifications, to a proactive strategy, involving stakeholders (Siems et al., 2021). However, measuring the environmental impact of corporate strategies remains challenging. Therefore, the transition to green economies must promote the disclosure of high-quality non-financial information. Today, the availability of data on the environmental performance and targets of food companies is limited. CSR and ESG initiatives refer to a social good, for which reporting is not required by regulations. Instead, companies themselves must choose whether to disclose this information (Partalidou et al., 2020). The performance indicators that are most commonly disclosed in sustainability reports cover four dimensions: energy, GHGs, water, and waste (Rajic et al., 2022). Yet, unfortunately, the information is often neither quantifiable nor comparable.

Food and beverage sectors focus on sustainable strategies, products, and processes as well as responsible supply chain management (Cupertino et al., 2021). The governance and management of companies, as well as the strategies they adopt, vary and depend on internal and external factors (Blažek, 2016). According to Somlai (2022), current initiatives by food companies focus on cost reduction, water consumption reduction, and waste reduction. These last two considerations are those that are addressed in this study.

To create long-term value, companies' sustainability practices must ensure corporate outcomes that are satisfactory for shareholders. Research has explored the relationship between CSR and ESG and the financial performance of companies. These studies have yielded inconclusive findings, with positive, mixed, neutral, and even negative relationships reported in the findings. However, negative findings are the least representative of studies of this topic. Although most studies that have used metrics such as ROA, ROE, and stock price indicate a positive link between ESG and financial performance, there is no consensus (Whelan et al., 2021). Among the few studies of the food industry, Partalidou et al. (2020) analyzed a sample of 45 food companies listed in the Global Equity Index. Those that adopted emissions reduction, resource reduction, and innovation initiatives (and thus that had a higher environmental performance score) achieved better financial performance. Gangi et al. (2021) found that food companies' commitment to social and environmental responsibility was a positive indicator of improved profitability. More recently, Sandberg et al. (2023) showed that ESG ratings of European food industry companies were positively associated with higher financial performance in terms of ROA and ROE. In contrast, Nirino et al. (2020) observed mixed results. While social performance positively affected the financial performance of food and beverage companies, the effect of environmental performance was non-significant or non-positive.

2.2. Water management

Water problems are acknowledged to be a worldwide issue. The international community has reacted, establishing two SDGs in the 2030 Agenda that focus on water. SDG 14: Life below water and SDG 6: Clean water and sanitation both address this issue. These SDGs are important, given that >40 % of the population lives in places affected by water scarcity and that >80 % of wastewater is discharged uncontrolled into rivers or the sea, exacerbating pollution problems (United Nations, 2022a).

Given these goals, water management by food companies is essential because the food processing industry is one of the largest water consumers and wastewater generators in the world (Asgharnejad et al., 2021). Most of the water data provided by food companies relate to water withdrawal (Rajic et al., 2022). This situation reflects the interest in disclosing information on water withdrawal for monitoring and reduction purposes (Avelino and Dall'erba, 2020). This reporting is widespread in both resource-constrained and resource-rich companies. However, large multinational companies provide more complete information, in some cases including not only water withdrawal but also consumption and discharge.

In food processing, water can be used for process functions, such as processing raw materials, or non-process functions, such as washing, heating, and cooling (Asgharnejad et al., 2021). It is estimated that most of the withdrawn water is used for non-process functions (Compton et al., 2018). All food system operations add to the emission of pollutants into water resources (Linderhof et al., 2021). Every year, vast quantities of untreated wastewater are discharged directly into the environment (Malik et al., 2020). However, few companies in the food sector report information on water discharge (Rajic et al., 2022). This lack of reporting is a barrier to progress in meeting the SDGs, notably with regard to untreated wastewater management (Setty et al., 2020).

Research on the link between corporate water resource management and corporate financial performance is still in its early stages (Ji et al., 2023). However, the critical situation of water undeniably exposes companies to risks to their profits. Therefore, responsible water management can positively affect their reputation and revenue (Lambooy, 2011; Levinson et al., 2008; Porter and Kramer, 2006), in the same way that irresponsible water management can have a negative impact. In this regard, Kleinman et al. (2017) emphasized the need for food and beverage companies to manage water risks to prevent financial losses. Effectively addressing and managing water-related challenges and disclosing related information can not only exert a positive impact on the environment but also lead to improved financial performance in the food and beverage sector (Weber and Saunders-Hogberg, 2020). Therefore, disclosing measurable water efficiency goals is essential for stakeholders to evaluate a company's progress and strategies in this area. Including water management criteria in the decision-making process of investors is also important because investors and companies are responsible for the preservation of future water resources (Hogeboom et al., 2018). Given the importance for companies to set short- and long-term goals to improve their use of water and the potentially positive impact on firm value, the first proposition can be formulated.

P1. The presence of water efficiency targets leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).

Another key issue for stakeholders when evaluating firms' management of water resources is water consumption. Water consumption metrics indicate the volume of water that will no longer be available for the local community and the ecosystem (CDP, 2023). The few existing studies of water consumption and its impact on financial performance have provided mixed results. Ji et al. (2023) observed lower ROA in Chinese manufacturing firms with a deficiency in water innovation and water participation, which encompassed water consumption in daily operations. This finding held true even when companies engaged in water protection. Conversely, Zamil and Hassan (2019) analyzed environmental disclosure, finding that improved financial performance (ROA) was associated with reduced water consumption in a sample of Fortune 500 companies between 2013 and 2017. Given the water-intensive nature of food production (Garrido Arias et al., 2021), decreasing water consumption relative to water withdrawal is expected to have a positive impact on a company's reputation and market valuation in terms of sustainability. This prediction forms the basis of the second proposition.

P2. The presence of high consumption of withdrawn water leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).

Finally, other natural resource management metrics, such as water intensity, are relevant not only for assessing the environmental responsibility of companies but also for understanding how these practices translate into perceptions in financial markets. Interest in analyzing the financial intensity of water is consistent with the approach of Luque-Vílchez et al. (2023). They studied the creation of a composite ESG performance index for the European food industry, highlighting the importance of assessing the ratio of cubic meters of water consumed to revenue generated. Gomes et al. (2023) also provided insights in this regard. Their research focused on the European food and beverage industry. It revealed a significant relationship between water use intensity (cubic meters of water consumed per $1000) and financial performance (ROE, ROA, and profit margin). The third proposition reflects the importance of efficient water management for financial metrics in this industry and thereby its potential impact on firm value.

P3. The absence of a strong intensity of withdrawn water leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).

2.3. Waste management

In addition to the harmful intensive use of natural resources and its impact on the planet, an equally important challenge for individuals and businesses is the production and management of waste. According to the World Bank (2019), waste management and analysis to improve its efficiency play a fundamental role in sustainability. The rate of waste generated by companies is growing. This trend entails severe consequences for the environment. Recently, Clifford (2021) confirmed this situation by showing that inadequate waste management contributed significantly to accelerating climate change.

Urgent action is needed to address this situation. Even countries have been forced to act. For instance, in 2008, the European Commission (2018) issued a Directive (2008/98/EC) encouraging member states to favor recycling over landfill or incineration. Similarly, in SDG 12, the United Nations (2022a) emphasizes the fact that nature cannot purify water at the pace of human contamination. Every year, one third of the food produced in the world ends up rotting. Hence, SDG target 12.5 encourages the substantial reduction of "the generation of waste through prevention, reduction, recycling and reuse activities." SDG 15 offers a reminder that 75 % of new infectious diseases in humans are zoonotic, primarily linked to ecosystem destruction. To achieve these SDGs through innovative solutions, practitioners and academics must work together (Michalec et al., 2018; Sakaguchi et al., 2018).

At the business level, continued waste generation and low recycling of hazardous waste has led to an increase in resource use. This increase has resulted in rising CO_2 emissions, higher energy consumption, and additional production costs (Alam et al., 2019). Over the last decade, companies have adopted environmental practices, including waste reduction, recycling, and reuse initiatives. These efforts have not only reduced the social and environmental impact but also conferred competitive advantages over industry competitors. Thus, firms adopting these initiatives can achieve greater long-term sustainability (Eccles et al., 2014). From this perspective, a Europe-wide study showed that recycling rates for packaging, e-waste, and bio-waste improved companies' competitiveness (Agovino et al., 2020).

Nevertheless, research on waste production and treatment practices and the influence of these practices on financial performance is scarce (Gull et al., 2022). Studies have shown that, for stakeholders, including waste recycling measures in the ecological impact assessment of the food industry is important (Luque-Vílchez et al., 2023). In a cross-country study of listed companies, Gull et al. (2022) observed a significant relationship between waste management practices and financial performance, especially in environmentally sensitive industries such as agriculture. Waste recycling was found to have a positive impact on firms' ROA and Tobin's Q, mainly through operating costs. This finding is aligned with those of Ioannidis et al. (2021), who observed that the adoption of reduction, recycling, and reuse strategies positively influenced short-term (net profit margin) and long-term (Tobin's Q) financial performance in the hospitality industry. Contrastingly, Khunkaew et al. (2023) observed the opposite relationship. They focused on companies predominantly from economically emerging nations in the ASEAN region. They found that divulging sustainable information on waste recycling negatively affected ROA and Tobin's Q. Given the findings in the literature and the relevance of recycling practices for food industry stakeholders, the fourth proposition can be formulated.

P4. The presence of significant recycling and waste reuse performance leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).

Reuse and recycling are pivotal for food companies. However, minimizing waste generation from regular operations is essential to meet stakeholder interests in progressing toward sustainable waste management, while reducing the associated costs. Stakeholders tend to act when concerned about inappropriate business practices such as excessive waste generation (Gull et al., 2022).

Research has explored the connection between waste intensity and financial performance. Eng et al. (2021) found that an increase in emissions of hazardous waste per dollar of sales by manufacturing firms negatively affected long-term financial performance (Tobin's Q). Likewise, Gull et al. (2022) showed that better corporate waste management led to superior financial performance. Considering hazardous and non-hazardous waste, they observed a negative impact of increasing levels of waste on ROA and Tobin's Q.

In contrast to these other studies, Trumpp and Guenther (2017) found evidence of a non-linear relationship between waste management and financial performance. They observed a U-shaped relationship between waste generation intensity and ROA in manufacturing and service firms. Janicka and Sajnóg (2023) observed that the European companies with the highest levels of environmental efficiency (in terms of water and energy consumption, CO_2 emissions, and waste production) were not necessarily those with the highest levels of economic performance (in terms of market capitalization and ROA).

There is therefore a lack of consensus in previous studies. There is also an absence of sector-specific analyses for the food industry. Accordingly, a negative relationship between waste generation and market valuation is expected, given the adverse impacts of waste on stakeholders and the environment. Hence, the last proposition can be formulated.

P5. The absence of a strong intensity of generated waste leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).

3. Methodology

Regression-based methods assume the existence of symmetric linear relationships between variables. They focus on identifying the single best solution for the vast majority of cases (Pappas and Woodside, 2021). In contrast, qualitative comparative analysis (QCA) is based on set theory and Boolean algebra. By applying the principle of equifinality, QCA can be used to identify combinations of conditions (antecedents) that lead to a specific outcome of interest (Legewie, 2013; Roig-Tierno et al., 2016).

QCA assumes complex causality. It focuses on establishing asymmetric relationships in the form of configurations of causal conditions that are minimally necessary or sufficient for a specific outcome to occur (Ragin, 2014; Rihoux and Ragin, 2009). A condition is defined as necessary if it is present in all cases where the outcome occurs. In other

words, the outcome is a subset of the necessary condition. Therefore, the outcome cannot occur in the absence of this condition. In contrast, a condition is defined as sufficient if the outcome of interest is present in all cases where this condition is present. In the case of sufficient conditions, the outcome can also occur in the presence of other conditions. That is, a sufficient condition (or combination of conditions) is a subset of the outcome (Ragin, 2000).

There are several types of QCA. Unlike crisp-set qualitative comparative analysis (csQCA), fuzzy-set qualitative comparative analysis (fsQCA) allows researchers to establish different degrees of set membership of the conditions (Woodside, 2016). FsQCA is suitable for small and medium-sized data samples (Fiss, 2011), as in this study. Version 4.0 of fsQCA software was used to conduct the analysis. The steps of calibration, analysis of necessity, and analysis of sufficiency were followed, as suggested by Schneider and Wagemann (2010).

3.1. Sample and data

Based on the Industry Classification Benchmark (ICB), data for 2073 listed companies worldwide operating in the food production sector were collected. This sector is part of the consumer staples industry. It includes companies for which the subsectors of farming, fishing, ranching, and plantations; food products; fruit and grain processing; and sugar were their main source of revenue.

Relevant and comparable financial and non-financial data were limited. Also, this study had the aim of collecting a diverse sample of companies spanning all five continents and covering the four subsectors of food production. Therefore, the final sample consisted of 61 publicly listed companies within the food production sector. These companies were based in Africa, America, Asia, Europe, and Oceania. This procedure was consistent with that of previous research using small samples of food industry companies, based on the criteria of comparability and availability of complete data on ESG performance (Luque-Vílchez et al., 2023; Sandberg et al., 2023; Vitale et al., 2023).

To conduct the fsQCA, financial and non-financial data were needed. The financial data were necessary for the calculation of Tobin's Q, and the non-financial data were needed to measure water and waste management. These data were retrieved from the Thomson Reuters EIKON database on a fiscal year basis in January 2023. This choice provided the most up-to-date data available, considering the publication and availability of companies' annual reports. The market-based financial performance of the sample companies was calculated manually based on the most recent financial figures corresponding to the year 2021. The data on water and waste management corresponded to the latest available annual disclosure.

3.2. Outcome, conditions, and calibration

Tobin's Q has been used in numerous studies to describe corporate management. It is one of the most commonly used indicators to measure companies' financial performance. The assumption behind Tobin's Q is that the successful management of resources in a company generates added value. Accordingly, the company's assets are more valuable than their replacement cost (Minutolo et al., 2019). Hence, this measure was selected as the outcome of the model to be used as a market-based proxy for the financial performance of food companies.

To calculate Tobin's Q, the formula defined by Giannopoulos et al. (2022) was applied. The market value of assets was divided by the book value of assets. The latter was used as a proxy for the replacement cost of assets in the Tobin's Q formula (Dalal and Thaker, 2019). The market value of assets was calculated as the book value of assets plus the difference between the market value of equity and the book value of equity. Tobin's Q was calculated using Eq. 1:

$$Tobin's\ Q = \frac{(Total\ assets + market\ capitalisation – total\ equity)}{Total\ assets} \quad (1)$$

Tobin's Q was used to estimate whether a company was overvalued or undervalued. A value of Tobin's Q between 0 and 1 would imply that a firm's stock was undervalued. Conversely, a value >1 would imply that the firm's stock was more expensive than the replacement cost of its assets (the book value of assets in Eq. (1)). Hence, the stock would be overvalued (Giannopoulos et al., 2022). Tobin's Q not only reflects the current value of a firm but also predicts its long-term financial performance. It is thus a valuable indicator for evaluating investment and growth potential (Okafor et al., 2021; Shank and Shockey, 2016).

Five environmental management practices relating to companies' water and waste performance, commitment, and management were selected as antecedent conditions: water efficiency targets, water consumption ratio, water intensity ratio, waste recycling ratio, and waste intensity ratio (Table 1). This choice reflected the importance for different stakeholders of studying water and waste management indicators to assess the environmental impact of production by food companies, as noted by Luque-Vílchez et al. (2023). The water consumption ratio was calculated based on the definition of water consumption in the Global Reporting Initiative (GRI – 303) standards. This definition is in turn based on the definition provided by the Carbon Disclosure Project (CDP). Specifically, water consumption was calculated as the difference between total water withdrawn and total water discharged from the company's boundaries over the reporting period.

To transform the data into fuzzy sets, the outcome and antecedent conditions were calibrated. Calibration determines the degree of membership of each case in each set (Schmitt et al., 2017). Three anchors were established for calibration: full membership, the crossover (point of maximum ambiguity), and full non-membership (Ragin, 2008). The commonly accepted thresholds lie at the 90th, 50th, and 10th percentiles, respectively (Kraus et al., 2016). When calibrating the outcome, the point of maximum ambiguity was manually set at 1.001. This point was chosen according to the definition of the variable whereby overvaluation of stock is indicated by a value of Tobin's Q >1.

4. Results

The outcome of the model was the presence of Tobin's Q (value >1). The five antecedent conditions were water efficiency targets, water consumption ratio, water intensity ratio, waste recycling ratio, and waste intensity ratio. Causal asymmetry in fsQCA means that the presence or absence of antecedent conditions associated with the presence of the outcome may differ from the presence or absence of antecedent conditions associated with the absence of the outcome (Schmitt et al., 2017). Therefore, for a more comprehensive analysis and a better understanding of the proposed model, the analysis was conducted considering both the presence and absence of Tobin's Q. Table 2 presents the results of the analysis of necessary conditions for the presence

Table 1
Description of outcome and conditions.

Outcome/ Conditions	Label	Definition
Tobin's Q	tobin	Ratio of a company's market value of assets to book value of assets
Water efficiency targets	wat_t	Whether or not a company sets targets for water efficiency
Water consumption ratio	wat_c	Total water consumed in cubic meters divided by total water withdrawn in cubic meters
Water intensity ratio	wat_i	Total water withdrawn in cubic meters divided by net sales or revenue in millions of U.S. dollars
Waste recycling ratio	waste_r	Total recycled and reused waste produced in tons divided by total waste produced in tons
Waste intensity ratio	waste_i	Total amount of waste produced in tons divided by net sales or revenue in millions of U.S. dollars

Note: Description of conditions, adapted from Thomson Reuters EIKON database.

Table 2
Analysis of necessary conditions (presence and absence Tobin's Q).

	tobin		~tobin	
Condition	Consistency	Coverage	Consistency	Coverage
wat_t	0.558153	0.660667	0.399372	0.339333
~wat_t	0.441847	0.506129	0.600628	0.493871
wat_c	0.564067	0.693320	0.581797	0.513326
~wat_c	0.604055	0.668016	0.652413	0.517907
wat_i	0.477612	0.636398	0.666928	0.637899
~wat_i	0.728246	0.752838	0.619851	0.459971
waste_r	0.686849	0.751155	0.623382	0.489375
~waste_r	0.533089	0.663512	0.683013	0.610235
waste_i	0.535342	0.694303	0.645743	0.601169
~waste_i	0.692481	0.731410	0.671636	0.509221

Note: ~ represents absence of the condition; wat_t = water efficiency targets; wat_c = water consumption ratio; wat_i = water intensity ratio; waste_r = waste recycling ratio; waste_i = waste intensity ratio.

and absence of Tobin's Q for firms from the food production sector.

No condition or absence of that condition had a consistency value greater than or close to 0.9 (Schneider et al., 2010). Hence, the results revealed no necessary conditions for either the presence or the absence of the outcome. Therefore, none of the five conditions in isolation led to the presence or absence of Tobin's Q.

Analysis of sufficiency was conducted to identify which combination of conditions (causal configurations) led to the outcome. The presence and absence of Tobin's Q were considered as outcomes in separate analyses. These sufficiency analyses revealed whether the cases where the causal conditions were present constituted a subset of the cases where the outcome was present (Ragin, 2018). The following models were studied:

$$\text{tobin} = f(\text{wat_t}, \text{wat_c}, \text{wat_i}, \text{waste_r}, \text{waste_i})$$

$$\sim \text{tobin} = f(\text{wat_t}, \text{wat_c}, \text{wat_i}, \text{waste_r}, \text{waste_i})$$

Following the suggestions of Ragin (2008) for meaningful interpretation, the intermediate solutions of both models are presented in Table 3. Peripheral and core conditions are indicated. Five configurations were found to lead to the presence of Tobin's Q in companies in the food production sector. These configurations explained >72 % of the cases in this study. The results also revealed three configurations leading to the absence of Tobin's Q. These configurations explained 45 % of the cases.

4.1. Predictive validity

To examine the model's ability to predict the outcome (Tobin's Q > 1) in other samples, the predictive validity of the proposed model was tested (Gigerenzer and Brighton, 2009; Woodside, 2014). The steps suggested by Pappas and Woodside (2021) for predictive validity of the findings were followed. As in previous studies (Olya and Al-ansi, 2018; Pappas et al., 2016; Sukhov et al., 2023; Wu et al., 2014), the original sample was randomly split into two subsamples: Subsample 1 and a holdout sample. Table 4 presents the solution (models) for Subsample 1. This solution was tested using the holdout sample data.

It is considered that models with a consistency >0.80 are valuable and contribute to the advancement of theory (Woodside, 2017). Models M2 and M4 did not meet the desired threshold (consistency of 0.7957 and 0.5989, respectively). The results from testing M1 and M3 on the holdout sample are presented in Fig. 1. The testing of the predictions made by M1 and M3 revealed high consistency and coverage values (M1: 0.8715, 0.3759; M3: 0.8812, 0.2710). These values did not contradict the consistency and coverage of the models (Pappas and Woodside, 2021). Additional predictive tests are available upon request.

The findings implied that the data were largely consistent (87 %) with the claim that M1 was a subset of the overvaluation of food production firms (Tobin's Q > 1). With a coverage of 0.37, M1 accounted for 37 % of all cases of membership to the overvaluation set. These findings showed that highly consistent models for the Subsample 1 had a high predictive ability for the holdout sample (Wu et al., 2014),

Table 4
Complex configurations indicating companies' overvaluation in Subsample 1.

Models for Subsample 1	Raw coverage	Unique coverage	Consistency
M1. wat_t* ~ wat_i* ~ waste_i	0.3564	0.1294	0.9151
M2. wat_t* ~ wat_c*wat_i	0.2717	0.0335	0.9514
M3. wat_t* ~ wat_c*waste_r	0.3010	0.0271	0.8586
M4. ~wat_t*wat_c*waste_r*waste_i	0.1422	0.1422	0.9020
Solution coverage	0.6526		
Solution consistency	0.8560		

Note: wat_t = water efficiency targets; wat_c = water consumption ratio; wat_i = water intensity ratio; waste_r = waste recycling ratio; waste_i = waste intensity ratio. The multiplication symbol "*" denotes the logical operator AND. The tilde "~" denotes the logical operator NOT.

Table 3
Analysis of sufficient conditions (presence and absence of Tobin's Q).

	tobin					~tobin		
	1	2	3	4	5	1	2	3
wat_t	●		●		◦	○	○	
wat_c			○	•	•	○	○	●
wat_i	○	○		○			•	•
waste_r		●	●	●	●	○		○
waste_i	◦	○			○	◦	●	●
Consistency (incl.)	0.8962	0.8613	0.8271	0.8901	0.8794	0.8794	0.8360	0.8647
Raw coverage (cov.r)	0.3551	0.4410	0.2680	0.3491	0.1582	0.2145	0.1800	0.2683
Unique coverage (cov.u)	0.1120	0.0580	0.0811	0.0625	0.0183	0.0878	0.0345	0.1812
Solution coverage			0.7206				0.4491	
Solution consistency			0.8362				0.8161	

Note: "●" denotes the presence of the condition. "○" denotes the absence of the condition. Small circles denote peripheral conditions. Large circles denote core conditions (Fiss, 2011). Consistency cutoff: 0.8564 and 0.8154. Frequency cutoff: 1. Vector of expected directions (1,1,0,1,0) and (0,0,1,0,1) (Ragin and Davey, 2016). wat_t = water efficiency targets; wat_c = water consumption ratio; wat_i = water intensity ratio; waste_r = waste recycling ratio; waste_i = waste intensity ratio.

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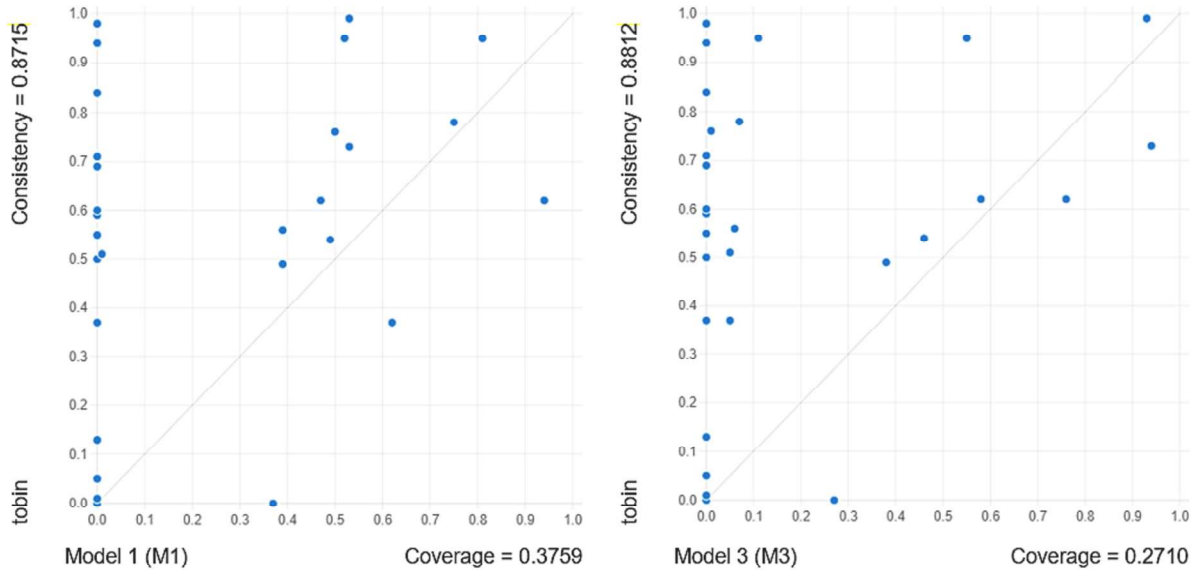

Fig. 1. Fuzzy-plot of M1 and M3 (from Table 4) using data from the holdout sample.

indicating predictive validity for future data (Olya and Al-ansi, 2018).

5. Discussion

The results of the fsQCA presented in this study reveal the combinations of water and waste management practices in food production companies that lead to market overvaluation of these companies and thus superior financial performance. The necessity analysis shows that no individual condition is necessary for the presence of Tobin's Q. The necessity analysis also shows that none of the five causal conditions has to be present or absent for the absence of Tobin's Q.

The sufficiency analysis shows five configurations that are sufficient for the presence of Tobin's Q. The first configuration indicates that the presence of water efficiency targets combined with the absence of a strong water intensity and the absence of a strong waste intensity leads to the presence of Tobin's Q. This combination highlights the importance for companies of making a commitment to water efficiency by setting specific targets in addition to having a general water efficiency policy. Such a system allows companies to measure internal and external progress and compliance with investors and other stakeholders. It should be complemented by low water withdrawals and waste generation in relation to net sales or revenue. Responsible water and waste management thus leads to a reward for companies in the form of overvaluation of assets by the market. This finding is in line with those of Lambooy (2011), Levinson et al. (2008), and Weber and Saunders-Hogberg (2020), who reported a positive impact of responsible water management on reputation and business performance, in this case in conjunction with reduced water withdrawal and the setting of efficiency targets. This finding is also related to those of Gomes et al. (2023), who suggested an inverse relationship between water intensity and Tobin's Q, in this case using a market-based financial measure.

The second configuration implies that the presence of Tobin's Q can be achieved if a company has significant recycling and waste reuse performance, in addition to low water withdrawal and low waste production per million dollars of net sales or revenue. This configuration is similar to the previous one. It indicates that companies can achieve the outcome by minimizing waste intensity and increasing waste recycling, while controlling the impact of intensive water withdrawal (in terms of net sales or revenue) on their business. Partalidou et al. (2020) showed that food companies adopting initiatives to reduce resource use and emissions achieved superior financial performance. Similarly, a positive impact on short- and long-term financial performance has also been observed following the adoption of recycling and reuse practices (Gull et al., 2022; Ioannidis et al., 2021). Waste management strategies such as achieving certain recycling rates have proven effective in boosting business competitiveness (Agovino et al., 2020).

The third configuration links the presence of Tobin's Q with the presence of water efficiency targets, the presence of strong performance in recycling and waste reuse, and the absence of a high consumption of withdrawn water. Zamil and Hassan (2019) observed that this reduction in water consumption acts as an indicator of superior financial performance. However, they did not consider water consumption relative to withdrawal. The extraction of water in the food industry is linked not only to production but also to non-process functions such as cooling and washing (Compton et al., 2018). The nature of water extraction in the food industry could explain why the ratio of consumption to water withdrawal in the sample companies is low and is not interpreted as negative by investors. The reason could be that current technologies and production processes require large quantities of water. Given that this water is not consumed, it is subsequently returned to the system.

The fourth configuration explains that the presence of Tobin's Q is achieved by the combination of high consumption of withdrawn water, strong recycling and waste reuse performance, and the absence of strong intensity of withdrawn water. This configuration again suggests that the market positively values responsible management of water resources, the reduction of water withdrawal to ensure the availability of this resource in the local community, the linking of extraction to consumption, and the creation of a circular process where most waste is recycled and reused. This configuration therefore implies that water management predicts financial success, as suggested by Hogeboom et al. (2018). Sustainable waste management practices are observed to contribute to the environment and enhance the financial performance of companies (Gull et al., 2022).

Finally, the fifth configuration indicates that the presence of Tobin's Q can be achieved with a combination of high water consumption relative to water withdrawn, a significant level of recycling and reuse of waste, and the absence of a strong intensity of waste produced, despite the absence of water efficiency targets. This configuration suggests that companies may focus on achieving effective waste management, minimizing waste generation, and maximizing the recycling and reuse of waste. It should be accompanied by high water consumption in relation to total water withdrawn, which would indicate efficiency and awareness in the use of water so that withdrawal matches consumption. The results show that commitment to waste management in food production

companies is a crucial condition to achieve the presence of Tobin's Q.

A model where the outcome was the absence of a Tobin's Q >1 was also studied. In this model, the absence of significant recycling and waste reuse performance appears in two of the three configurations. It is also a core condition, as in the other model exploring the presence of Tobin's Q. Gull et al. (2022) highlighted the importance of high levels of waste recycling and reuse, considering both hazardous and non-hazardous waste. They observed a positive impact on business performance. Another important condition for the overvaluation of companies in the food production sector is absence of a strong intensity of withdrawn water. This absence appears as a core condition in three of the five causal configurations for the presence of Tobin's Q (overvaluation). Investors expect companies to behave responsibly and withdraw smaller amounts of water per unit of net sales or revenue generated. Such behavior would demonstrate environmental awareness in the use of water resources. A strong intensity of water is present in two of the three configurations leading to the absence of Tobin's Q. Accordingly, a high level of water extraction by companies in relation to their net sales or revenue leads to the absence of overvaluation. This finding illustrates the relevance of water withdrawal and water intensity in the food sector (Avelino and Dall'erba, 2020; Luque-Vílchez et al., 2023).

The intensity of waste also seems to be relevant for the presence of Tobin's Q. It is absent in three of the five configurations leading to a Tobin's Q >1. Moreover, in two of these configurations, it appears as a core condition. This finding underscores the importance of waste management commitment in this sector by rewarding lower waste generation per unit of net sales or revenue generated. According to Gangi et al. (2021), environmental responsibility in the food sector drives improvements in profitability. The model for the absence of Tobin's Q mostly corroborates this idea. This condition appears as a core condition in two of the three configurations leading to the absence of Tobin's Q. In the other configuration, absence of this condition appears only peripherally. This finding largely corroborates those of Gull et al. (2022) and Eng et al. (2021), who observed a negative association between high levels of waste generation and Tobin's Q.

Unlike the previous conditions, setting water efficiency targets and having a high consumption of withdrawn water seem to be less important in explaining the presence of Tobin's Q in food sector companies. However, these secondary conditions are mostly present in the configurations leading to the presence of Tobin's Q and mostly absent in the configurations leading to the absence of Tobin's Q. From an environmental and social point of view, investors who are committed to responsible waste management behavior are also expected to be committed to responsible water management. Therefore, they are expected to attach importance to the efforts of companies to achieve targets designed to improve their efficiency in the use of water resources. Water consumption includes not only water used in products or crop production but also water lost through evaporation, transpiration, animal or human consumption, and pollution to the point of becoming unfit for any other use. The broadness of this definition may explain the lack of clarity regarding the presence or absence of this condition in the configurations leading to the outcome of interest in this study. Overall, the results show the predominant role of responsible and efficient use of water resources in achieving a market overvaluation. Table 5 provides an overview of the results of the empirical analysis to test the propositions.

Table 5
Supported and unsupported propositions.

Proposition	Supported/ unsupported
P1. The presence of water efficiency targets leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).	Partially supported
P2. The presence of high consumption of withdrawn water leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).	Partially supported
P3. The absence of a strong intensity of withdrawn water leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).	Supported
P4. The presence of significant recycling and waste reuse performance leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).	Supported
P5. The absence of a strong intensity of generated waste leads to the presence of market overvaluation of food production companies (Tobin's Q > 1).	Supported

6. Theoretical and practical implications

The findings of this study have theoretical and practical implications. At the theoretical level, this paper contributes to the scarce literature discussing the impact of food sector water and waste management on market-based financial performance. A novel research model was proposed using QCA. This model differed from traditional methods of analysis. By combining qualitative and quantitative methods, QCA enabled identification of configurations of conditions that lead to the market overvaluation of companies in the food sector.

The analysis identified several configurations that food companies can adopt to achieve a high market valuation. These findings provide support for the existence of multiple causal relationships. They also expand the incipient knowledge of the relationships between water management, waste management, and financial performance (Gull et al., 2022; Ji et al., 2023). This approach involved analysis of specific resource (water) and emissions (waste) management practices. It thereby gives deeper insight into the possible effects of individual indicators, which may be hidden when using aggregated sustainability scores. The research also responds to the calls of Sandberg et al. (2023) for studies addressing ESG practices and corporate financial performance in the context of the food sector. Such studies are important given the unique features of this sector that condition the analysis of sustainable practices (Vitale et al., 2023; Buallay, 2020).

At the practical level, the findings offer valuable information for different social actors, mainly food industry managers and investors. First, it provides support for the existence of causal relationships between sustainable environmental practices (water and waste management) and financial performance. In line with the existing literature, managers should be aware of this relationship when defining short- and long-term business strategies. Likewise, the findings give investors further evidence of the relevance of ESG analysis in firm valuation.

Second, the study reveals a range of causal configurations that lead to the overvaluation of food companies in financial markets. This information can help business managers identify how to combine efforts in water and waste management to select the path that best suits the needs of their company. It also highlights key areas that require further attention for the improvement of water and waste management. In most configurations, a significant level of waste recycling and reuse and an absence of a strong intensity in both water withdrawal and waste generation are important conditions. This finding suggests that companies must focus on these three aspects to ensure that their sustainable practices exert a positive impact on the value of the company (i.e., its Tobin's Q ratio). Improvements in production processes that reduce a company's environmental impact in terms of water withdrawal and waste generation are valuable to stakeholders. They support the environmental sustainability of ecosystems and increase the availability of resources for society, thereby contributing to the company's reputation in the public arena and the financial markets. It is impossible for companies to generate zero waste from their business activity. Therefore, initiatives for the treatment of this waste should be a priority for food companies. These environmentally friendly initiatives provide rewards in the long term (Gull et al., 2022), in addition to boosting growth expectations. Sustainable practices that enhance a company's socially responsible image and corporate reputation provide tangible and intangible resources to undertake actions that positively affect company value (Ji

et al., 2023). As proposed by stakeholder theory, companies' financial market performance is a true reflection of the reputational effects resulting from stakeholder engagement (Freeman, 2010). Improvements in environmental performance require time and economic viability. Therefore, allocating financial resources to improve these processes should be seen as an investment in a company's economic and environmental long-term sustainability. Investors also benefit from the findings of this study. The research provides them with relevant information for decision making. This information can assist in the valuation of food companies in terms of specific water and waste management practices. Companies that base their strategies on one of the causal configurations found in the study may be perceived as an investment opportunity. They will be attractive because of their higher future growth expectations than those of their peers.

Finally, basing business and investment decisions on sustainability has benefits at different levels, including social, environmental, reputational, and financial. These benefits can provide additional motivation for managers and investors to raise their awareness of the importance and impact of these practices. This research aims to heighten awareness among food sector companies and investors about the planet's limitations and the benefits of responsible resource and waste management. By aligning decisions with sustainability practices, companies can contribute to the well-being of stakeholders, maximize shareholder value, and advance toward achieving the SDGs for water, waste, and food. This strategic approach not only reduces environmental risks but also enhances resilience to future challenges.

7. Conclusions

This study identifies combinations of water and waste management practices that lead to the market overvaluation of food companies' assets. The findings provide insight for food sector managers and practitioners who seek to design sustainable strategies while achieving superior financial performance. In the food production sector, a genuine commitment to waste management in terms of low waste production with respect to net sales or revenue and significant levels of recycling and reuse is viewed positively by stakeholders and the market. It is thus rewarded by investors. In terms of water management, a weak water intensity drives performance by boosting investor expectations. Setting water efficiency targets or having a high consumption of withdrawn water are secondary drivers of the overvaluation of companies.

In light of the results, food companies should emphasize water and waste management because of its benefits in terms of sustainability and financial profitability. Companies interested in improving their environmental management should invest in research and development of efficient production technologies that minimize waste generation and water resource needs. Improvements should also be made in the treatment of waste by implementing recycling and reuse strategies adapted to the specific operations of each company. Examples might include the reuse of treated wastewater in secondary processes or the reuse of key materials within the production chain. Another recommendation is to attempt to minimize freshwater withdrawal. This recommendation is especially applicable to companies located in water-stressed areas, where the increasing scarcity of this precious resource can interrupt the manufacturing process.

These more sustainable practices are expected to contribute not only to businesses but also to their environment. They can improve social well-being and reduce the dangers of pollution and water scarcity, which affect all industrial sectors. Business actions aimed at long-term sustainable value creation support the SDGs for water, waste, and food. They therefore help in the transition toward green economies.

This study has certain limitations that should offer possibilities for future research. First, the data provided by food companies on water and waste management is limited and varied. This limitation makes it difficult to gather comparable quantitative data. It results in the exclusion of many companies from analysis and the use of small samples. The lack of mandatory standards for corporate sustainability reporting such as those proposed by the Global Reporting Initiative (GRI) means that data and metrics are presented in diverse formats. Recent legislation on the disclosure of non-financial information such as the Corporate Sustainability Reporting Directive promoted by the European Commission in 2021 is expected to help increase disclosure and harmonize data, which can enrich future analyses.

Second, the annual nature of sustainability reports means that data correspond to the fiscal year of each company and are subject to the publication of the reports. Third, the small sample size could be considered to provide limited global coverage of the food industry. To enhance robustness and generalizability, future research should extend the analysis to include a larger number of companies. It should also include other relevant variables, such as cubic meters withdrawn in water-stressed areas, wastewater recycling, and water discharged according to treatment. Exploring geographical diversity and conducting sector-specific and subsector-level analyses would give a more comprehensive understanding of how companies address environmental challenges and how these strategies affect their financial valuation. Finally, there is a need to increase investment in research and development to create more efficient production technologies capable of reducing the intensive use of natural resources and waste generation while facilitating recycling and reuse. Therefore, future research should address how organizational variables can influence sustainable investment decisions.

CRediT authorship contribution statement

M. Ángeles López-Cabarcos: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. **Juan Piñeiro-Chousa:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. **Lara Quiñoá-Piñeiro:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. **M. Luisa López-Pérez:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing.

Data availability

The authors do not have permission to share data.

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M. Ángeles López-Cabarcos is a professor of business administration at Santiago de Compostela University (USC), Spain. As a researcher, she has written many articles and papers in prestigious national and international journals. She has written books and made contributions to international conferences. She has also carried out several technical assistances with important organizations belonging to private sector. Her research lines are focused on corporate social responsibility, firm innovation, behavioural finance, organizational behavior, and labour climate.

Juan Piñeiro-Chousa is a professor of finance at Santiago de Compostela University (USC), Spain. He has written many articles and papers in national and international journals and has made important contributions to prestigious international conferences. His research interests focus on financial strategy, corporate finance, artificial intelligence, and corporate governance.

Lara Quiñoá-Piñeiro is a predoctoral researcher with a University Teacher Training contract (FPU) enrolled on the PhD programme in Economics and Business at the University of Santiago de Compostela (USC), Spain. She has a degree in Business Administration and Management and an MBA. Her research lines are focused on corporate social responsibility, sustainable value creation, business strategy, organizational behavior, and innovation.

M. Luisa López-Pérez is a Graduate of Business Administration and Management by Santiago de Compostela University, Spain, with a specialisation in Banking and Finance and accreditation as an EFPA European Financial Advisor. Her professional career is in finance and accounting-taxation. She is currently a PhD student at the University of Santiago de Compostela.

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4.4 ARTICLE 4. INNOVATING FOR SUSTAINABILITY IN FOOD AND BEVERAGE COMPANIES: THE ROLE OF GOVERNANCE AND ENVIRONMENTAL FACTORS IN CLIMATE CHANGE MITIGATION

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Innovating for sustainability in food and beverage companies: The role of governance and environmental factors in climate change mitigation

Abstract

Purpose: Focusing on the food and beverage (F&B) sectors, this study aims to identify combinations of external environmental factors (natural disasters and water stress) and internal corporate governance factors (corporate social responsibility [CSR] sustainability committee, board gender diversity, and stakeholder engagement) that lead to the integration of climate change mitigation innovation and technologies.

Design: A fuzzy set qualitative comparative analysis (fsQCA) was conducted on a global sample of 262 listed companies in the F&B sectors. Two additional analyses were performed for European and Asian companies.

Findings: In the three models, the presence of CSR sustainability committees and stakeholder engagement was crucial for achieving the integration of climate change mitigation innovation and technologies. The relevance of board gender diversity differs between the European and Asian models, highlighting potential regional influences on corporate climate innovation decisions. The combination of external and internal factors is the key to justifying different approaches to achieving climate innovation.

Originality: This study offers insights into the factors driving the integration of climate change mitigation innovation and technologies into company strategies. Related strategies must combine external and internal factors to enhance the climate resilience and competitiveness of F&B companies, while reducing their environmental impact.

Keywords: Agri-food industry, Climate technologies, Corporate governance, Environmental innovation, Natural disasters, Water stress.

Article classification: Research Paper

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1 Introduction

Climate change (CC) is a major challenge facing humanity. This phenomenon, the result of over a century of greenhouse gas (GHG) emissions caused by unsustainable practices, has had an evident impact on extreme climatic and weather events, affecting global water and food security, human health, and economies (Intergovernmental Panel on Climate Change, 2023). According to the 2015 Paris Agreement, transformative actions are required across all industries, especially in the food and beverage (F&B) sectors, to ensure future food security and reverse environmental degradation impacts (Food and Agriculture Organisation of the United Nations [FAO], 2023). In this challenging context, businesses must balance short-term financial interests with long-term environmental sustainability to navigate a changing landscape that demands innovative solutions and sustainable practices (Aibar-Guzmán *et al.*, 2023; García-Sánchez *et al.*, 2023).

The F&B sectors, commonly comprising production, manufacturing, distribution, and retail companies, play a pivotal role in the climate crisis the world is facing (Sovacool *et al.*, 2021). Characterised by high production volumes, extensive distribution networks, diverse structures (multinational vs. small- and medium-sized enterprises), and diverse products, these sectors are essential for human survival (Sovacool *et al.*, 2021). However, their carbon-intensive activities pose substantial environmental challenges, notably contributing to soil degradation, byproduct and industrial waste generation, food waste production, and GHG emissions (FAO, 2023; Sovacool *et al.*, 2021). They also concomitantly contribute to CC and face major challenges related to the changes, including shifts in precipitation and temperature patterns, water scarcity, and extreme weather events that can disrupt production and damage infrastructure (Singh and Goyal, 2023). This scenario renders the building of climate resilience in these sectors a crucial endeavour, something that can be operationalized by integrating efforts toward CC mitigation in their systems, while reducing the environmental impact of their operations (FAO, 2023; Intergovernmental Panel on Climate Change, 2023).

Ever since the onset of the COVID-19 pandemic, businesses have been focusing on initiatives to face CC, mostly those centred on reducing GHG emissions derived from their productive activities (Daddi *et al.*, 2020). For such purposes, climate innovation and technology are pivotal, especially in the F&B sector, where innovation and technology provide competitive advantages and concomitantly contribute to CC mitigation (Finco *et al.,* 2018). Moreover, reducing emissions and increasing investment in sustainable practices/efficiency strategies can enhance the financial performance of emission-intensive industries (i.e. utilities and food; López-Cabarcos *et al.*, 2024; 2023). The increasing investment in CC mitigation technologies in the F&B sectors also underlines their potential for transformative change (Aibar-Guzmán *et al.*, 2023; García-Sánchez *et al.*, 2021). Nevertheless, while investment in climate technology has increased in the main emitting industrial sectors, there has been a slight decline in such investments in the F&B sectors in recent years, signalling the need for greater attention to tailored climate solutions for food, agriculture, and land use (PricewaterhouseCoopers, 2023).

In this context, a company's ability to innovate and adopt climate technologies is crucial (Dabic *et al.*, 2022). While the debate about the factors influencing the adoption of mitigation strategies in business and management studies is emerging (Daddi *et al.*, 2020), significant research gaps remain in the literature, particularly in linking CC efforts with corporate governance strategies (Aguilera *et al.,* 2021; Enciso-Alfaro and García-Sánchez, 2023). Specifically, research remains lacking regarding the role of sustainability committees (Orazalin *et al.*, 2024), board gender diversity (BGD; Enciso-Alfaro and García-Sánchez, 2023; García-Sánchez *et al.*, 2023), and stakeholder engagement (Aguilera *et al.,* 2021). Additionally, few studies have analysed the impact of physical CC conditions on business mitigation strategies (Unter *et al.,* 2023). There is also the need to explore the drivers of investment and adoption of environmental innovations and technologies in the F&B sectors (Enciso-Alfaro and García-Sánchez, 2023; López-Cabarcos *et*

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al., 2024). Moreover, it is necessary to focus on the application of alternative methodologies, such as qualitative comparative analysis (QCA), in the context of corporate governance and environmental sustainability (Aguilera *et al.,* 2021). Given the complexity of CC, an integrated approach to business strategies—namely, that considers the different factors influencing investments in climate innovations and technologies across any stage of business operations—is essential (García-Sánchez *et al.*, 2023).

Recognising these research gaps, this study aims to close the gap regarding the scarcity of studies on F&B sectors, and propose a novel framework for identifying specific combinations of external environmental factors (natural disasters and water stress) and internal corporate governance factors (corporate social responsibility [CSR] sustainability committee, BGD, and stakeholder engagement) that help explain the adoption of CC mitigation innovation and technologies by companies in the F&B sectors. To achieve this objective, a fuzzy set QCA (fsQCA) was conducted using a global sample of 262 listed F&B companies. Additionally, differentiated analyses of European and Asian subsamples were performed to identify regional similarities and differences. The findings provide valuable insights for managers, climate risk officers, regulators, and policymakers, delivering a better understanding of how F&B companies' decisions related to the governance pillar of the environmental, social, and corporate governance (ESG) criteria contribute to their innovation capacity to address climate challenges and consider their exposure to environmental stressors.

The remainder of this paper is organised as follows. Section 2 presents a literature review and the propositions examined. Section 3 outlines the research methodology. Section 4 presents the main findings, while Section 5 discusses them. Section 6 presents the theoretical and practical implications. Section 7 presents the main conclusions, limitations, and future research avenues.

2 Literature Review

2.1 CC mitigation innovation and technologies

CC mitigation innovation and technologies (hereafter 'climate innovations') comprise a set of business innovation investments across all phases of business operations to reduce GHG emissions and mitigate the impacts of CC (García-Sánchez *et al.*, 2023). Corporate climate innovation portfolios include a combination of innovations and technologies related to low-carbon energy, pollution control, green design, eco-efficiency, and management systems technologies (Wang *et al.*, 2018). These environment-oriented innovations respond to the perceived present and future impacts, risks and opportunities arising from CC (Burton and Otte, 2022; Wang *et al.*, 2018), including new regulations, supply chain disruptions, fluctuations in raw material availability, market pressures, and physical effects (Ramani and Saltman, 2019).

The F&B sectors, heavily reliant on natural resources and product preservation, have traditionally been considered mature, slow-growing, and not particularly innovative compared with other sectors (Bayona-Saez *et al.*, 2017). Notwithstanding, the combination of their vulnerability to CC risks, the resource depletion, the increasing food demand, and their need to obtain competitive advantages and ensure long-term survival have all contributed to their shift in focus towards environmental innovation (FAO, 2023; García-Sánchez *et al.*, 2021; Liao *et al.*, 2019). Climate innovation initiatives in the F&B sectors can vary, including land-use management improvements, energy efficiency, process optimisation, renewable energy adoption, sustainable packaging, and waste reduction (Sovacool *et al.*, 2021). Despite this, these sectors face significant obstacles to engaging in climate innovation initiatives (e.g. financial barriers) that exacerbate environmental impacts (Sovacool *et al.*, 2021).

Several studies have explored effective practices for transforming food systems in response to CC, including the integration of Industry 4.0 technologies to enhance sustainability in agri-food

value chains (Campbell *et al.*, 2023; Corallo *et al.*, 2024). However, research on factors influencing the adoption of CC mitigation strategies in management and business studies is in its early stages (Daddi *et al.*, 2020). Meanwhile, external factors (e.g. governmental policies and environmental regulations) are key drivers of sustainable innovation (Ben Amara and Chen, 2022; Su and Moaniba, 2017). Environmental regulations positively influenced the active adoption of external knowledge, driving green innovation and business sustainability (Zammer *et al.*, 2024). Natural disasters and weather pattern changes are drivers of the demand for climate innovation (Miao, 2020; Miao and Popp, 2014). Additionally, stakeholder pressures, both external and internal, influence eco-innovation implementation (Carchano *et al.*, 2023).

Some authors have highlighted internal business factors as potential drivers of climate innovation. Corporate governance, for example, is pivotal for sustainable strategy integration (Ludwig and Sassen, 2022). Some organisations are actively addressing CC management through 'climate governance', which involves incorporating climate-related issues into governance processes and structures (Aibar-Guzmán *et al.*, 2023). Practices such as establishing dedicated sustainability committees and engaging in dialogue on climate concerns can advance effective climate governance (World Economic Forum, 2019). Climate innovation associates with various aspects of corporate governance, including the delegation of responsibilities to higher positions, incentive policies, and a company's attitude towards CC risks (Albitar *et al.*, 2023; Wang *et al.*, 2018). Climate innovation has also been examined in relation to managerial independence, specialisation, board diversity, ownership, and capital structure (Aibar-Guzmán *et al.*, 2022; García-Sánchez *et al.*, 2021, 2023; Le Loarne-Lemaire *et al.*, 2021).

The lack of definitive conclusions regarding the individual impacts of external and internal factors on climate innovation, along with the absence of studies exploring their combined effects on promoting climate innovation in F&B companies, motivates this research.

2.2 Climate innovation and external environmental factors

The climate crisis has brought with it external factors (e.g. natural disasters) that pose significant challenges to food security (FAO, 2023). Businesses also often see adverse CC conditions, despite their severity, as being beyond their control because of their global scope and the uncertainty about when and where they will manifest, making them seem distant in time and space (Linnenluecke *et al.*, 2012; Unter *et al.*, 2023; Winn *et al.*, 2011). Consequently, there remains a limited understanding of how physical CC conditions affect corporate CC mitigation strategies (Unter *et al.*, 2023), highlighting the need for more related research.

Natural disasters are sudden and unforeseen events (e.g., geophysical events) that significantly damage specific areas (Centre for Research on the Epidemiology of Disasters, 2023). Although CC may not necessarily cause these disasters, it contributes to their increasing intensity and frequency (Unter *et al.,* 2023). These events also significantly impact the production, distribution, and supply chain operations of F&B companies, leading to disruptions and economic losses (Singh and Goyal, 2023).

The private sector is beginning to reactively respond to natural disasters by innovating to address the damage caused (Miao and Popp, 2014), but few studies thus far have explored the role of natural disasters as catalysts of climate innovation. For example, Smithers and Blay-Palmer (2001) emphasised the role of climate as a driver of technological innovation for managing climate risks in agriculture. Miao and Popp (2014) also found a positive correlation between droughts, floods, and earthquakes and the registration of patents for technologies aimed at mitigating their impacts. Similarly, Miao (2020) provides evidence that climate variations, particularly droughts, stimulate an increase in drought-related innovations in the American agricultural sector. Chen *et al.* (2021) showed a negative relationship between natural disasters, both in number and related losses, and their impact on national technological innovation

performance. The limited number of existing studies calls for further research on the subject, and no study has analysed the combined effect of natural disaster occurrence in a country where a company is headquartered with other environmental and corporate governance factors. This leads to Proposition 1:

P1: The presence of a substantial incidence of natural disasters in the country where the company is headquartered leads to the presence of climate innovation.

Water stress is a measure of the pressure exerted by a country's major sectors on the available renewable freshwater resources, and its high level represents potential problems in water availability, sustainability, and conflicts between water users (United Nations, 2023). CC exacerbates related problems by altering precipitation, temperature, and weather patterns, thereby affecting freshwater availability and demand (Intergovernmental Panel on Climate Change, 2023). Water quality and availability are critical for F&B companies because scarcity can disrupt production and supply chains (Singh and Goyal, 2023). The combined effect of potential population growth and intensified CC effects may also exacerbate water stress, requiring solutions to help agri-food systems survive in new climate scenarios (FAO, 2023), while being competitive and financially profitable (López-Cabarcos *et al.*, 2024).

Climate-induced water scarcity drives resource-intensive sectors to invest in resource efficiency and technological innovation (Gasbarro *et al.,* 2016). Although many innovations have been designed primarily for water resource management rather than CC mitigation, some innovations implemented in F&B sectors have contributed to both water use efficiency and GHG reduction. Thus, and considering that CC can be a source of the increasing water scarcity (Ojo and Baiyegunhi, 2020), F&B companies may find in national water stress levels both a threat to their businesses and an incentive to drive climate innovation. Few studies have analysed the influence of water stress on climate innovation, and none have analysed the combined effect of the presence of water stress in the country where the company is headquartered with other environmental and corporate governance factors. This leads to Proposition 2:

P2: The presence of significant water stress in the country where the company is headquartered leads to the presence of climate innovation.

2.3 Climate innovation and internal corporate governance factors

Internal factors are those controllable by the organisation and directly affected by business decisions (Finco *et al.*, 2018). Among these, those related to the corporate governance pillar of ESG practices stand out as fundamental for integrating sustainable strategies into business management. ESG practices allow companies to react to environmental events and ensure long-term continuity (Ludwig and Sassen, 2022).

Specialised CSR sustainability committees are essential for driving companies' environmental focus by planning, executing, and assessing sustainability policies and initiatives while addressing stakeholder interests (Burke *et al.*, 2019; García-Sánchez *et al.*, 2021). These committees help companies seize opportunities, set targets, and make strategic decisions concerning CC (Organisation for Economic Co-operation and Development, 2023), contributing to emissions reduction, resource efficiency, and environmental innovation (Orazalin, 2020). These are essential in the F&B sectors. Research on CSR committees are still emerging (Burke *et al.*, 2019), so their relationship with climate innovation can be approached through the controversy surrounding their role in environmental innovation. For one, Wang *et al.* (2018) found that assigning CC policy responsibilities to positions close to the board fostered green technology adoption, and Nadeem *et al.* (2020) and Farza *et al.* (2022) highlighted the positive influence of board-level CSR committees on environmental innovation. Additionally, Homroy and Slechten (2019) revealed that companies' GHG emissions decrease when a board-level committee oversees

environmental issues, presumably promoted by investment in green technology. For another, Burke *et al.* (2019) argued that CSR committees can seize sustainability-related opportunities but fail to mitigate related risks. In companies with token CC commitments, Orazalin *et al.* (2024) found that sustainability committees act as mere greenwashing tools, ineffectively promoting green innovation. García-Sánchez *et al.* (2021) noted that specialised CSR committees in agri-food firms do not drive proactive environmental innovation strategies, possibly because major decisions are made by the entire board. These mixed conclusions warrant more study. Furthermore, no study has analysed the combined effect of the presence of a specialised CSR sustainability committee with other environmental and corporate governance factors. This leads to Proposition 3:

P3: The presence of a CSR sustainability committee leads to the presence of climate innovation.

The growing recognition of the significance of BGD, driven by mandatory quotas and voluntary targets, is reshaping organisational dynamics globally (Organisation for Economic Co-operation and Development, 2023). Women on boards diversify perspectives, enhance decision-making, board effectiveness in promoting stakeholder interests, and environmental sensitivity and awareness (Issa and Bensalem, 2023).

The evidence on the relationship between BGD and climate innovation adoption is mixed, with various indications of positive contributions. For instance, the percentage of female executives has proven beneficial in encouraging environmental innovation (Farza *et al.*, 2022). Issa and Bensalem (2023) found that the BGD enhances investment in eco-innovation by driving CSR strategies. Liao *et al.* (2019) reported that women on boards in China's manufacturing firms positively associated with environmental innovation strategies. Nadeem *et al.* (2020) observed a stronger positive impact of women on boards on environmental innovation in sensitive sectors, such as agriculture and fisheries. A systematic review highlighted the effectiveness of increased female representation in driving sustainable solutions (Le Loarne-Lemaire *et al.*, 2021). García-Sánchez *et al.* (2023) revealed the positive impact of female board representation, mainly in executive roles, on investment decisions in climate innovations.

Regarding negative associations, Bui *et al.* (2020) argued that conventional corporate governance aspects, such as the percentage of women on boards, do not enhance climate commitment. García-Sánchez *et al.* (2021) found that BGD does not decisively impact the implementation of eco-innovation and eco-design projects in the agri-food industry. These mixed conclusions showcase the need for more investigations, and no study has analysed the combined effect of BGD and other environmental and corporate governance factors. This leads to Proposition 4:

P4: The presence of a large female representation on the board of directors leads to the presence of climate innovation.

Stakeholder engagement refers to organisational efforts to include relevant stakeholders' concerns, needs and expectations in decision-making and policy design (Greenwood, 2007). In the context of CC, the key stakeholders include investors, customers, governments, suppliers, NGOs, and competitors (Sprengel and Busch, 2011). According to stakeholder theory, effective management of stakeholder relationships contributes to a company's long-term success (Freeman, 2010).

Stakeholder groups can influence managers to consider climate issues in their decision-making processes, albeit to varying degrees of influence (Cadez *et al.*, 2019). This influence can manifest through employee or consumer initiatives, shareholder interactions, or legal actions (Organisation for Economic Co-operation and Development, 2022). Climate awareness among stakeholders has also made their concerns a primary incentive for companies to reduce their carbon emissions (Albitar et al., 2023). The incorporation of regulatory and market pressures into top-level strategic

planning of GHG-intensive companies has effectively reduced emissions. This is attributed to senior managers' influence on research and development investment decisions, technological development, new product creation, and process design (Cadez *et al.*, 2019). Thus, environmental innovation has become a way of meeting stakeholder demands (Nadeem *et al.*, 2020). Nevertheless, in F&B sectors, the effects of pressures (both internal and external) on environmental innovation practice adoption remain uncertain (Carchano *et al.*, 2023).

Knowledge of how boards of directors engage with stakeholders and grasp their environmental concerns is limited (Aguilera *et al.*, 2021), as is their impact on climate-related innovation. In this sense, it is important to consider the relevance that knowledge management, specifically knowledge sharing between individuals and the organisation, can have on innovation strategies at various levels (Salehi and Sadeq Alanbari, 2023). Stakeholder engagement is associated with proactive innovation management practices, such as co-creation and open innovation, which are essential for environmental innovation and competitiveness (Giacomarra *et al.*, 2020). Some studies show the positive impact of corporate stakeholder engagement on climate-related innovation. For example, cooperation with stakeholders in the agri-food industry drives technological eco-innovation (Rabadán *et al.*, 2020), and successful stakeholder engagement in F&B packaging promotes eco-innovation (Giacomarra *et al.*, 2020). García-Sánchez *et al.* (2023) further observed that firms engaging actively with stakeholders are more inclined to innovate for CC mitigation. No study has analysed the combined effect of stakeholder engagement and other environmental and corporate governance factors. This leads to Proposition 5:

P5: The presence of an organisational commitment to stakeholder engagement leads to the presence of climate innovation.

3 Methodology

FsQCA involves qualitative and quantitative research approaches to study asymmetric data (Ragin, 2008). While traditional quantitative methods seek to estimate model net effects and determine the best solution for most cases analysed (Pappas and Woodside, 2021), fsQCA, based on set theory and Boolean algebra, attempts to identify different combinations derived from a set of conditions that can lead to the study outcome (Legewie, 2013). Accordingly, fsQCA enables the identification of complex combinations of causal conditions through diverse and asymmetric relationships while considering real-life data (Schmitt *et al.*, 2017; Woodside, 2011). FsQCA is particularly suitable for this study for its aim of analysing how different combinations of environmental stressors and governance mechanisms can lead to climate innovation integration. The analytical procedures proposed by Schneider and Wagemann (2012)—data calibration, analysis of necessity, and analysis of sufficiency—were followed using version 4.1 of the software.

3.1 Sample

Following the Industry Classification Benchmark standard, the sample was drawn from the original population of global companies in the F&B sectors included in the Thomson Reuters EIKON database. Both sectors are part of the consumer staple industry and include companies whose main activities are the manufacturing, distribution, and/or sale of food and/or beverages, and agriculture, ranching, fishing, and milling companies. The following were the inclusion criteria: the most recent non-financial data relevant to the study had to be available in the EIKON database for listed public companies belonging to the F&B sectors. Information from the inventory of risks and disasters contained in the EM-DAT database on the number of natural disasters that occurred in the country where the company's headquarters is located had to be available. An average of natural disasters that occurred between 2020 and 2022 was considered to mitigate annual fluctuations and offer a more consistent measure of the variable. Data on the

SDG 6.4.2 indicator of the level of water stress by country had to be available from the United Nations database. For all the variables, data from 2020–2022 were considered.

The final sample comprised 262 companies headquartered in 39 countries across all five continents. Two subsamples comprising 60 companies from Europe and 137 from Asia were also examined. In recent years, both continents have experienced notable increases in sustainability initiatives, transparency, and reporting. These surges can be attributed to various factors, including stakeholder expectations, regulatory pressures, and a growing awareness of corporate sustainability (Almaqtari *et al.*, 2024), all of which are shaped by their unique historical, cultural, and geographical contexts. Europe has emerged as a leader in global sustainability policies and regulations, with examples being the Directive (EU) 2022/2464 and initiatives promoting gender equality on corporate boards (Lefley and Janeček, 2024).

Conversely, Asia has been the continent most impacted by natural disasters in recent years (Tin *et al.*, 2024). With its highly-dense population, significant greenhouse gas emissions, heavy reliance on fossil fuels, and considerable challenges concerning air pollution and water management (Al-Jaifi *et al.*, 2023), Asia lacks cohesive sustainability regulations across its various landscapes. Given these dynamics, it becomes compelling to explore the potential similarities/discrepancies in the patterns followed by European and Asian F&B companies in integrating climate innovations.

3.2 Outcome, conditions, and calibration

The outcome (InnovClima) represents the innovations achieved and technologies used by companies to mitigate CC impact. Following García-Sánchez *et al.* (2023), InnovClima is derived by aggregating seven components reflecting diverse business initiatives. Dichotomous variables were considered to express a company's investments and innovations in (1) green buildings; (2) the use of natural resources to reduce consumption and enhance efficiency; (3) clean technology use in production planning and management processes; (4) waste technology to reduce waste production, improve treatment through recycling techniques, and reuse recycled materials. It also expresses the company's development of (5) green products and the implementation of initiatives that promote (6) sustainable land use and (7) sustainable mobility of staff on business trips.

Two external environmental factors and three internal corporate governance factors were identified as potential factors influencing climate innovation, as follows:

- Natural disasters (NatDisasters) measure the company's exposure to various hazards (geophysical, meteorological, hydrological, climatological, and biological events) in its home country, quantifying the average number of natural disasters from 2020–2022.
- Water stress (Wstress) captures the pressure exerted by the main economic sectors of a country on renewable freshwater resources. This is calculated as the total freshwater withdrawn by the main economic sectors relative to the total renewable freshwater resources available in the country.
- The CSR sustainability committee (CSRcom) indicates whether the company has a specialised committee in charge of CSR decision-making.
- BGD (GenBoard) represents female director presence (as a percentage) relative to the total number of board members.
- Stakeholder Engagement (StakeEng) identifies whether a company establishes two-way communication to enable stakeholders to participate in decision-making processes (Table I).

Table I

All variables, except dichotomous ones (CSRcom and StakeEng), were transformed into fuzzy sets through calibration (Schmitt *et al.*, 2017). Three calibration anchors were defined, namely

full membership, crossover point, and full non-membership (Ragin, 2008), and three percentiles (i.e. 95th, 50th and 5th) were selected as thresholds (Pappas and Woodside, 2021).

4 Results

The analysis focused on three models, namely the Global Sample (GS), European Sample (ES), and Asian Sample (AS). The first is an analysis of necessity, which examines whether there are necessary conditions for the presence of the outcome (Schneider and Wagemann, 2012). Table II shows that no condition on its own was necessary to lead to the outcome. Nevertheless, the presence of CSRcom emerged as a quasi-necessary condition for the presence of InnovClima in the ES model.

Table II

The joint analysis of external environmental conditions showed them as not being necessary for the presence of InnovClima. Conversely, the presence of one of the three internal corporate governance conditions was necessary for the intended outcome (Table III).

Table III

Sufficiency analysis identified combinations of conditions that lead to the presence of the outcome in the three models under scrutiny:

$$\text{InnovClima}_{GS,\ ES,\ AS} = f\ (\text{NatDisasters, Wstress, CSRcom, GenBoard, and StakeEng}),$$

The results showed different combinations of conditions that led to the presence of InnovClima for each model (Table IV), showing acceptable consistency values (>0.75; Schneider and Wagemann, 2012). In the GS model, 60% of the analysed cases were explained using five configurations. In the ES and AS models, more than 73% and 74% of the analysed cases, respectively, were explained by three and five configurations, respectively (Ragin, 2008).

Table IV

5 Discussion

Commitment to foster climate innovations among F&B companies plays a crucial role in enhancing their climate resilience and competitiveness, while also reducing their environmental footprint. The analysis of necessity revealed that no antecedent condition on its own led to the presence of InnovClima. However, in the ES model, CSRcom emerged as a quasi-necessary condition, emphasising its relevance in the European context. These findings corroborate those in the studies by Farza *et al.* (2022) and Homroy and Slechten (2019) on German and United Kingdom companies, respectively. Furthermore, in the three models, the joint analysis of the corporate governance conditions revealed that the presence of CSRcom, GenBoard, or StakeEng is a necessary condition for the presence of InnovClima. Previous research also supports the key role of governance mechanisms in fostering climate innovation (World Economic Forum, 2019; García-Sánchez *et al.*, 2023; Nadeem *et al.*, 2020).

A sufficiency analysis indicated that the competitive advantages of F&B companies regarding climate innovations depend on the interplay between internal factors and external environmental stressors. In the GS model, companies can lead to InnovClima through different combinations of conditions. GS1 suggests that a wide integration of climate innovations can be achieved if a company has a specialised sustainability committee and promotes the active participation of stakeholders, even in the absence of a large representation of females on corporate boards. This path suggests that certain companies can achieve the outcome based solely on internal governance conditions. Linnenluecke *et al.* (2012), Unter *et al.* (2023), and Winn *et al.* (2011) highlighted that managers may perceive adverse CC conditions as events beyond their control, which may

explain the findings for GS1. Another reason could be that the company's core activities are not located in the country of headquarters, meaning that national environmental stressors would not impact its operations or decision-making. Thus, the significance of a specialised CSR committee and the active involvement of key stakeholders, outlined in prior research (García-Sánchez *et al.,* 2023; Nadeem *et al.,* 2020), seems to override the effect of board composition because it is possible to achieve the outcome even in the absence of BGD.

GS2 suggests that the location of the headquarters in a country prone to natural disasters, without water stress, combined with the presence of a CSR committee and a stronger commitment to BGD, leads to the presence of climate innovation. GS3 mirrors GS2 but swaps the external factors, emphasising the presence of water resource pressure and the absence of substantial natural hazards. GS4 proposes the presence of climate innovation through the presence of a large representation of female directors and engagement with stakeholders, whereas the external conditions remain similar to those in GS3. Finally, in GS5, only one external factor, natural disasters, is present in combination with the presence of a sustainability committee and stakeholder engagement. In these configurations, external environmental factors seem to influence business strategies, probably because business operations are directly affected by the visible impacts of CC, or because managers perceive the potential severity of these adverse conditions. In both scenarios, the existence of at least one of these stressors drives companies to invest in climate innovations. In line with the joint analysis of necessity, the relevance of all three governance mechanisms in driving sustainable practices was confirmed. Thus, the presence, as core conditions, of a CSR committee and stakeholder engagement in four and three of the five configurations, respectively, makes them key variables for achieving the outcome. These findings support those in the studies by Nadeem *et al.* (2020) and Giacomarra *et al.* (2020), questioning the idea that sustainability committees merely generate a positive stakeholder impression without stimulating innovation (Orazalin *et al.*, 2024). The role of BGD seems to be less clear, as it was present in three and absent in one of the five configurations. This observation aligns with divergent findings regarding its positive or null effects on climate innovation (Bui *et al.*, 2020; García-Sánchez *et al.*, 2023).

In the ES model, three possible combinations could lead to InnovClima. ES1 indicates a combination of CSRcom, StakeEng, and Wstress. For companies located in countries without NatDisasters, ES2 supports that the presence of CSRcom, GenBoard, and StakeEng leads to InnovClima. Finally, ES3 suggests that InnovClima can be achieved through the presence of NatDisasters and Wstress, along with CSRcom and GenBoard. Consistent with the findings of the GS model and the analysis of necessity, CSRcom was a core condition in all configurations. Additionally, GenBoard and StakeEng are significant internal conditions that lead to the outcome in two out of the three configurations.

In the AS model, the findings indicate five possible configurations. AS1 revealed that CSRcom was sufficient for the presence of InnovClima, even in the absence of GenBoard and NatDisasters. Both AS2 and AS4 demonstrate that the presence of NatDisasters and Wstress can lead to InnovClima when in the presence of CSRcom (AS2) or when in the presence of StakeEng and the absence of GenBoard (AS4). AS3 indicates the presence of Wstress, CSRcom, and StakeEng. AS5 indicates that the combination of CSRcom and StakeEng leads to InnovClima when NatDisasters is present. While CSRcom and StakeEng prove to be relevant strategies for the presence of InnovClima (present in four and three, respectively, of the five configurations), GenBoard is absent in both configurations in which it appears.

Unlike in Asian companies, GenBoard stands out as a significant condition for causing InnovClima among European companies. The growing number of sustainable and responsible initiatives promoted within the European Union framework—such as the Directive on Gender Balance on Corporate Boards (17/10/2022) (Lefley and Janeček, 2024)—may have influenced

these results. Historical, economic, and cultural contexts, including the national cultural values of societies in both regions, may have also influenced the relevance of gender diversity on boards and its impact on climate innovation integration. This explanation is supported by findings from studies like Bazel-Shoham *et al.* (2024), which emphasise how national cultural values, such as the 'masculinity' prevalent in Asian societies (Hofstede *et al.,* 2010), can negatively impact environmental innovation. Additionally, legal mandates, the demands of investors and other stakeholders, and the growing public awareness of sustainability may contribute to this disparity (Almaqtari *et al.*, 2024). The three models of this study consistently emphasise the importance of CSRcom and StakeEng in InnovClima. This underscores the significance of establishing a dedicated CSR sustainability committee and implementing effective mechanisms that promote stakeholder participation in F&B companies' decision-making (Farza *et al.,* 2022; García-Sánchez *et al.,* 2023).

Regarding external stressors, it is logical to assume that companies in countries facing more natural disasters or pressure from water resources are more inclined towards climate innovation. It is worth noting that although external environmental factors play a similar role in Europe and Asia, European and Asian companies seems to be adopting different strategies to achieve InnovClima (ES2 *vs.* AS1 or ES3 *vs.* AS4). Therefore, F&B companies should consider different combinations of conditions when defining their CC strategies.

The results obtained supported P3 and P5 and partially supported P1, P2, and P4.

6 Theoretical and practical implications

At the theoretical level, this paper enriches the limited literature on F&B sectors (Aibar-Guzmán *et al.*, 2022; Enciso-Alfaro and García-Sánchez, 2023) by exploring the interaction between environmental conditions and corporate governance mechanisms in stimulating climate innovations. It addresses the existing gaps regarding the role of governance-related factors in supporting climate efforts (Aguilera *et al.,* 2021; Enciso-Alfaro and García-Sánchez, 2023). It also adds knowledge as to how physical conditions related to CC can influence corporate climate mitigation strategies (Unter *et al.,* 2023). Furthermore, this study addresses in a novel way the suggestion of Aguilera *et al.* (2021) by proposing the use of QCA in the context of corporate governance and environmental sustainability.

This study represents a significant advancement in the field of food studies by delivering new perspectives on the role of corporate governance factors (e.g. CSR sustainability committees, stakeholder engagement, and BGD) in fostering climate innovations in the agri-food industry. Empirical evidence on the interaction between governance mechanisms and external environmental factors, and their impact on climate innovation in F&B companies, is crucial for understanding and improving sustainability practices within these sectors. This study contributes to the broader discourse on the relevance of corporate responsibility and environmental management in food systems and their contribution to food security. It comprehensively shows how F&B companies can tackle climate challenges, identify drivers and barriers to CC mitigation, and benefit from both academic knowledge and practical applications. The regional diversity in the models analysed underscores the need to consider specific regional contexts when developing theories and approaches for climate innovation studies in the agri-food industry context. The academic community and researchers in the fields of business management (particularly in the F&B sectors), sustainability, and CC will find the findings valuable, as they contribute to a broader understanding of the dynamics of climate innovation adoption among F&B companies.

Practically, the results reveal the strategies currently adopted by F&B companies successfully incorporating climate innovations throughout various stages of business operations, considering the diverse contexts in which external environmental stressors may or may not exist. This provides

valuable insights by identifying the different pathways that other companies can follow to orient their business strategies towards the integration of different CC mitigation innovations and technologies.

The findings underscore the importance of F&B companies establishing a dedicated CSR sustainability committee and fostering active stakeholder participation to drive climate innovation. The committees should be granted sufficient autonomy to make critical decisions regarding climate strategy, while engagement with stakeholders should be intently fostered to enhance their contributions to decision-making processes.

Although BGD seems to play a secondary role, it is essential to recognise, in line with previous literature (e.g. Gull *et al.*, 2023; Le Loarne-Lemaire *et al.*, 2021), the role that women can play in companies' responses to new climate scenarios. This is evident in Europe, which should continue to encourage women's participation in leadership positions, and whose relevance could bring about future changes in regions such as Asia. The lack of consensus calls for further exploration of the impact of gender representation on sustainability decisions.

The findings of this study offer valuable insights for different actors. F&B company managers can leverage these findings to develop tailored strategies that align with external environmental conditions to promote climate innovation, thereby enhancing the resilience and competitiveness of these companies in the context of CC. Climate risk officers benefit from the knowledge provided on the combinations of factors that drive greater investments in the integration of climate innovations into business operations. Finally, regulators and policymakers can apply these findings to formulate effective policies and regulations considering the relevance of each governance mechanism in addressing climate challenges.

7 Conclusions

Focusing on the F&B sectors, this study aimed to identify the combinations of external environmental factors (natural disasters and water stress) and internal corporate governance factors (CSR sustainability committee, BGD, and stakeholder engagement) that lead to the integration of climate innovations into organisations. Three models were analysed while considering a global, a European, and an Asian samples. The findings improve our understanding of how F&B companies can address climate challenges through decisions regarding ESG indicators.

The outlook of new global climate scenarios, the inevitable scarcity of natural resources, and the loss of biodiversity demands a paradigm shift. This study facilitates this transformation by providing valuable insights for F&B companies, stakeholders in organisational climate risk management, regulators, and policymakers. All of them will play crucial roles in shaping a sustainable and balanced future that ensures well-being and resource availability within planetary limits.

This study had the following limitations. First, despite F&B companies' growing interest in measuring and disclosing non-financial information, the current limitations regarding the availability of such data has conditioned the size and characteristics of the study samples. The implementation of new sustainability regulations may open opportunities to expand the findings of this research by including a more extensive, diverse representation of companies in both sectors. Second, focusing on the F&B sectors may limit data representativeness for other industrial sectors. Future research could include other sectors, allowing for comparisons between business practices applicable to climate innovation. Third, the divergences between the European and Asian continents regarding gender diversity may be influenced by regulations and cultural and historical dynamics. However, both these aspects require further research. Finally, the evolution of sustainability expectations may require the exploration of new internal and external

factors that may affect decisions regarding climate innovation and the adoption of sustainable practices.

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Table I

Description and label of outcome and conditions.

Type	Label	Description	Codification
Outcome	InnovClima	Wide integration of innovations and technologies for climate change mitigation.	Fuzzy value
Condition	NatDisasters	Substantial incidence of natural disasters in the country where the company is headquartered.	Fuzzy value
Condition	Wstress	Strong pressure on internal renewable water resources from the main sectors of the country where the company is headquartered.	Fuzzy value
Condition	CSRcom	The company has a specialised sustainability committee responsible for decision-making on corporate social responsibility strategy.	Crisp value
Condition	GenBoard	Large representation of female members on the company's board of directors.	Fuzzy value
Condition	StakeEng	The company engages with its stakeholders and encourages their active participation in decision-making processes.	Crisp value

Note: Description of outcome and conditions based on definitions from United Nation statistics, EM-DAT, and Thomson Reuters EIKON databases.

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Table II

Analysis of necessary conditions (presence of InnovClima).

	GS Model		ES Model		AS Model	
Conditions	Consistency	Coverage	Consistency	Coverage	Consistency	Coverage
NatDisasters	0.584198	0.744132	0.570567	0.798619	0.582188	0.678227
~NatDisasters	0.674707	0.746424	0.723157	0.777719	0.600058	0.749830
Wstress	0.595544	0.745202	0.647027	0.844451	0.582430	0.726319
~Wstress	0.632747	0.711094	0.695889	0.792516	0.657312	0.767204
CSRcom	0.807892	0.652718	0.876459	0.615038	0.805598	0.665400
~CSRcom	0.192107	0.425714	0.123541	0.563500	0.194402	0.433973
GenBoard	0.643248	0.750460	0.695533	0.839008	0.643086	0.734908
~GenBoard	0.625037	0.751378	0.573472	0.703395	0.598145	0.763329
StakeEng	0.763398	0.657888	0.850096	0.620400	0.789968	0.659081
~StakeEng	0.236601	0.447585	0.149904	0.547000	0.210032	0.456526

Note: GS=Global Sample; ES=European Sample; AS=Asian Sample. (~) denotes absence.

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Table III

Analysis of joint necessary conditions (presence of InnovClima).

Model	Conditions	Consistency	Coverage
GS	CSRcom+GenBoard+StakeEng	0.972235	0.629157
ES	CSRcom+GenBoard+StakeEng	0.959359	0.615345
AS	CSRcom+GenBoard+StakeEng	0.984443	0.630374

Note: GS=Global Sample; ES=European Sample; AS=Asian Sample. (+) denotes logical operator 'OR'.

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Table IV

Analysis of sufficient conditions (presence of InnovClima).

GS Model	GS1	GS2	GS3	GS4	GS5
NatDisasters		●	○	○	●
Wstress		○	●	●	
CSRcom	●	●	●		●
GenBoard	○	●	●	•	
StakeEng	●			●	●
Consistency	0.8468	0.9691	0.9751	0.9708	0.8952
Raw coverage	0.4181	0.2261	0.2299	0.2117	0.3590
Unique coverage	0.1077	0.0173	0.0262	0.0247	0.0266
Solution coverage			0.6062		
Solution consistency			0.8585		

ES Model	ES1	ES2	ES3
NatDisasters		○	•
Wstress	●		•
CSRcom	●	●	●
GenBoard		●	●
StakeEng	●	•	
Consistency	0.8984	0.8913	0.9690
Raw coverage	0.5164	0.4743	0.3601
Unique coverage	0.1260	0.1647	0.0536
Solution coverage		0.7347	
Solution consistency		0.8730	

AS Model	AS1	AS2	AS3	AS4	AS5
NatDisasters	○	•		•	•
Wstress		●	●	•	
CSRcom	•	●	●		•
GenBoard	○			○	
StakeEng			•	●	•
Consistency	0.8468	0.9691	0.9751	0.9708	0.8952
Raw coverage	0.4181	0.2261	0.2299	0.2117	0.3590
Unique coverage	0.1077	0.0173	0.0262	0.0247	0.0266
Solution coverage			0.7468		
Solution consistency			0.8073		

Note: GS=Global Sample**;** ES=European Sample; AS=Asian Sample. (●) denotes presence, (○) denotes absence. Small circles represent peripheral conditions, large circles represent core conditions (Fiss, 2011). Frequency cutoff=1. Consistency cutoff=0.8730(GS), =0.9170(ES), =0.8888(AS).

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5 DISCUSSION

5.1 OVERVIEW

In the current global context, the consequences of prolonged anthropogenic activity that has ignored ecosystem stability and exceeded six of the nine known planetary boundaries (Richardson et al., 2023), are becoming increasingly evident and alarming. Against this background, business sustainability is an unavoidable imperative. Business organisations are called upon not only to react, but to play a leading role in the transition towards a sustainable development model (Mahajan et al., 2024; Mio et al., 2020), which contributes to achieving a balance between economic growth, social development and environmental protection, while ensuring corporate resilience and operational viability.

The present thesis examines the role of corporate sustainability from an interdisciplinary perspective, placing the creation of sustainable value as the strategic axis and backbone for addressing today's global challenges and the demands of increasingly extreme and disruptive contexts. It examines how business organisations can lead structural changes by adopting responsible and sustainable practices, fostering innovation and technologies, and implementing corporate governance mechanisms. To this end, the analysis focuses on essential sectors that constitute critical systems for social, economic and environmental stability and resilience, specifically, the biopharmaceutical sector, the utilities industry, and the F&B sectors.

As outlined in Chapter 1, this doctoral thesis is articulated around four scientific articles published in impact journals indexed in Clarivate's Web of Science and Scopus, which form the core of Chapter 4. Through the empirical analysis of different approaches and practices of corporate sustainability, these articles seek to integrate perspectives to understand how companies can mitigate global challenges and adapt to new contexts of uncertainty.

The analysis developed throughout these articles follows a temporal sequence that reflects current international concerns arising from extreme events and major societal challenges. This journey begins in article 1 with the COVID-19 pandemic and its multidimensional impact. Subsequently, articles 2 and 3 address complex interrelated issues, such as the energy and food crises that emerged in 2021. Considering this sequence of events, these three articles generate empirical evidence on the impact of responsible and sustainable corporate management on financial performance (RI1). Building on this foundation, article 4 focuses on the environmental impacts resulting from climate change and examines the influence of responsible and sustainable corporate management, as well as external environmental factors, on the promotion of climate innovation and technologies (RI2). Collectively, the four articles empirically identify responsible and sustainable practices that contribute to the creation of sustainable value (RI3). This analysis takes place against the backdrop of discouraging medium-term projections, pointed out by international organisations such as the World Economic Forum (2023), which warn of a future 'polycrisis' of great impact driven by interconnected geopolitical, environmental, social and economic risks that threaten the availability and accessibility of natural resources vital for global survival.

In this sense, the discussion chapter aims to provide integration and coherence to the four articles that make up this doctoral thesis. In the following subsections, the findings are analysed

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in relation to the general objective and the specific objectives (SO1-SO4), the hypotheses are evaluated, and the theoretical and practical implications of the results are explored, highlighting their relevance for addressing current challenges and identifying strategic opportunities from a sustainable perspective.

5.2 THE ROLE OF BUSINESSES IN THE FACE OF EXTREME EVENTS

The outbreak of the COVID-19 pandemic in December 2019 and its rapid spread to different countries and continents in 2020 suddenly transformed the dynamics of global economies. This event highlighted the fragility of existing systems and placed companies in front of a major challenge: to respond quickly and effectively to an unprecedented global crisis. This is the context of article 1, which analyses the crucial role of innovation in the face of this event, specifically the business strategies of the biopharmaceutical companies Pfizer and Moderna, as well as their role as transformative agents capable of mitigating the negative impacts of the multidimensional crisis triggered at different levels and simultaneously creating value for various stakeholders.

The study carried out in article 1 (Piñeiro-Chousa et al., 2022) centres its main contribution on the analysis of the stock market behaviour of Pfizer and Moderna. Using GARCH and DCC-GARCH models, the article shows how the innovative strategies based on the development of mRNA vaccines of both biopharmaceutical companies, contributed to cushion the negative impact of the crisis triggered by the pandemic on their stock returns. In particular, technological investment in the development of an innovative solution to the health crisis proved to affect the influence that market volatility and market sentiment had on their respective stock market returns after the outbreak of the pandemic, although not in the same way. The strategic investment bets on innovation in vaccine development of both companies generated, with the new pandemic situation, a significant change in the relationship between market volatility and stock market returns, in the case of Moderna, and between investor sentiment and stock market returns in both cases. These findings partially confirm hypothesis 1 and fully confirm hypothesis 4 of this doctoral thesis.

The COVID period was a period in which the stock market returns of the biopharmaceutical company Pfizer suffered greater exposure and sensitivity to market fluctuations compared to Moderna. Nevertheless, despite the influence of high levels of volatility and pessimistic market sentiment, Pfizer managed to maintain its attractiveness through its innovative approach, ensuring that its stock returns were not substantially negatively affected by market conditions. This strategic decision contributed to its ability to adapt and resist the difficulties that much of the business sector was experiencing at the time. Meanwhile, Moderna demonstrated greater independence from general market fluctuations, both in terms of market volatility and investor sentiment, and became an attractive company for investors in times of uncertainty. The positive expectations surrounding its strategy and the development of its mRNA vaccine generated greater confidence among investors who believed in the company's ability to generate future revenues regardless of current market conditions, thus providing an opportunity for diversification. These findings are consistent with Donadelli et al. (2017) who identified infectious disease outbreaks as promising investment opportunities for certain stakeholders, especially investors who, with an optimistic view, find in these scenarios the possibility of profitability by investing in biopharmaceutical companies such as large vaccine producers Likewise, the findings confirm the prioritisation of investment in healthcare companies, including vaccine development, as a consequence of the COVID situation (Sun et al., 2021), and corroborate the discourses of other authors who argue that the impact of health crises on

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returns in the biopharmaceutical sector is lower than in other sectors (Chen et al., 2019; Ichev & Marinč, 2018).

The corporate strategy of Pfizer and Moderna also generated changes in the dynamics of their volatilities and affected the influence that the movements of these financial assets had on one of the global innovation benchmark indices, the NASDAQ 100. The findings achieved in article 1 confirm hypothesis 2 by proving that the ARCH and GARCH coefficients reveal significant changes between the pre-COVID and COVID periods for both companies. In this sense, the fact that the ARCH coefficients were lower during the pandemic suggests that the volatility of each of the firms on the previous day, determined by recent past events, had less immediate impact on the volatility of Pfizer's and Moderna's returns, compared to the pre-COVID period. In contrast, the substantial increase in GARCH coefficients in the pandemic period suggests a change in the persistence of volatility, so that the effects of market volatility accumulated up to the previous day had a greater influence on the volatility of Pfizer and Moderna during the COVID period. This effect is more significant for Pfizer's volatility. The results show higher uncertainty and sustained volatility during the pandemic. This may have been because recent shocks became more frequent so that investors expected such announcements, such as those related to vaccine advances, and therefore paid less attention to these types of individual events. Uncertain systemic factors such as pandemic evolution, public policy or vaccine effectiveness, among others, seem to have generated more persistent and prolonged uncertainty in markets, changing investors' perception of risk and shifting their focus to a more long-term perspective.

The results obtained in the dynamic conditional correlations analysis (DCC-GARCH) confirm hypothesis 3 by demonstrating the existence of a strong contagion effect between biopharmaceutical companies and the technological index in the COVID period. While prior to the pandemic declaration a relatively consistent behaviour was observed among assets, stable and predictable, with small fluctuations and low and positive values, the official declaration of COVID-19 marked the beginning of a period of greater uncertainty and variability, with volatile dynamic correlations and a strong contagion effect among assets. Pfizer and NASDAQ showed a predominantly positive correlation, with some exceptions, indicating that Pfizer shares moved in sync with the NASDAQ index, generally reflecting a more market-aligned behaviour. In contrast, the predominance of negative correlations and the presence of significant negative peaks between Moderna and NASDAQ suggests opposite stock price movement during these periods of de-correlation. These results suggest that both companies, but especially Moderna, had a positive effect on the market, preventing further drops in the NASDAQ index. The wide fluctuations and negative values in the Moderna-NASDAQ correlations positioned Moderna as an important diversification opportunity for investors. Altogether, the results highlight the role of biopharmaceutical assets as shock absorbers during health crises, positioning them as diversifying instruments that can help mitigate risk in contexts of high uncertainty. This aligns with evidence found by Chen et al. (2019), Ichev and Marinč, (2018) and Al-Awadhi et al. (2020) who highlight a better performance of biopharmaceutical assets relative to those of other sectors in the face of health crises such as the SARS epidemic in 2003, the Ebola outbreak in 2014-2016 and even the COVID-19 pandemic in its early months in China.

In addition to the financial impact analysed in the previous paragraphs, article 1 emphasises the social and environmental dimensions of sustainability, stressing the relevance of business and corporate responsibility in the prevention and management of extreme events. Thus, the innovative capacity of Pfizer and Moderna not only ensured their financial viability but also contributed significantly to social welfare on a large scale, mitigating the devastating effects of the pandemic. This social aspect of these companies' strategic commitment to develop, in record

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time, an effective vaccine against COVID-19, seems to have generated a positive perception among investors about the social commitment of both companies, enhancing their resilience and boosting their success in a context characterised by extreme uncertainty. On the other hand, the zoonotic origin of the virus highlighted the interconnections between the occurrence of infectious diseases and environmental unsustainability resulting from human activity (Barouki et al., 2021). This fact reinforced awareness of the importance of sustainability to avoid and reduce the risk of occurrence and the potential consequences of disruptive events, which was reflected in the financial markets after the outbreak of the pandemic, where the companies that were better evaluated in terms of environmental and social performance achieved greater stability and performance of their assets (Albuquerque et al., 2020).

On the other hand, the concept of the 'paradoxical spiral' discussed in article 1 suggests that human actions can trigger a spiral of negative impacts. These impacts, resulting from changes or damage in interconnected systems and sectors, exacerbate existing sustainability problems, even leading to global crises such as COVID-19. It therefore highlights the need to consider the interdependent relationships between sectors and resources, as exemplified by the WEF nexus approach, and points to the human potential to provide sustainable solutions. In particular, the biopharmaceutical sector emerges in this article as an ideal example of how technology and innovation can be used to address immediate challenges and prevent future disruptions.

Finally, article 1 highlights the need for companies to play an active role in building a more sustainable future, providing evidence on how prioritising societal needs through business innovation strengthens corporate resilience while contributing to collective well-being. In this way, Article 1 offers solutions to the problem triggered by COVID-19 by generating empirical evidence on the positive influence of responsible and sustainable corporate management on financial performance (RI1 – see Figure 1). Responsible and sustainable business practices should thus be seen as a strategy for creating long-term sustainable value rather than simply an ethical obligation.

5.3 SUSTAINABILITY AS A DRIVER OF FINANCIAL PERFORMANCE

The persistent effects of the multidimensional crisis resulting from the COVID-19 pandemic, coupled with the growing outbreak of geopolitical conflicts and increasingly frequent extreme weather events, have significantly slowed down the progress proposed in the sustainable agenda. This complex scenario has exposed the fragility of key sectors that are indispensable for global economic, environmental and social recovery and stability. The existence of a resource interdependence between these sectors, whose vulnerability is exacerbated by intensifying energy, food and climate challenges, has reinforced the urgency for businesses to adopt a strategic approach to not only manage current crises, but also to reduce the risk of future disruptions. In this regard, business sustainability assumes crucial relevance, both as a tool for mitigation and adaptation and as a guarantee of operational stability and business financial success. In this context, articles 2 and 3 take a closer look at the central role of sustainability in companies in key sectors. Both articles address the strategic advantage of adopting responsible and sustainable practices that result in effective responses to complex global challenges and contribute to boosting the financial performance of organisations, reinforcing the link between sustainability and profitability.

The research conducted in article 2 (López-Cabarcos et al., 2023) focuses its main contribution on the analysis of environmental, social and governance (ESG) practices that are associated with superior financial performance in listed companies in the utilities industry. In this regard, the practices considered relate to CO_2 and equivalent emissions, sustainability compensation incentives, environmental investments, environmental management training, as

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well as fair competition policies. Based on the fsQCA methodology, the article presents different concrete practices and combinations of responsible and sustainable practices that companies in this industry can integrate into their business strategy to make progress in meeting sustainable objectives and, at the same time, achieve a favourable financial performance in terms of stock market returns.

The analysis of necessary conditions did not identify any ESG practice (condition) that by itself was necessary to explain the presence of stock market returns (outcome). In contrast, the sufficient conditions analysis found two configurations that lead to the presence of stock returns among European utilities. This finding confirms hypothesis 5. The two paths or configurations found present similar patterns, as they agree on the absence of CO_2 and equivalent emissions, the absence of sustainability compensation incentives, and the presence of environmental investments as core or primary conditions. In addition to the above conditions, configuration 1 prioritises the presence of environmental management training, while configuration 2 focuses on the presence of fair competition policies, both being peripheral conditions. The consistency of the solution (0.8825) reflects a robust configurational relationship, suggesting the existence of a causal relationship between compliance with one of the identified configurations and having superior stock returns. This is relevant to the extent that designing and implementing the sustainable strategy of the company based on the observed combinations consistently leads to better stock market performance. On the other hand, the solution coverage (0.3165) reflects the complexity of the phenomenon analysed, highlighting the relevance of the configurations obtained in a context where multiple paths can lead to the desired outcome, and underlining the difficulty of identifying patterns that lead to success.

Analysing ESG factors individually, the absence of CO_2 emissions and equivalents as well as the presence of environmental investment proved to be the most repeated and relevant sustainable practices among utilities achieving superior stock market performance. These findings confirm hypothesis 6 and hypothesis 8. The European utilities represented in the causal configurations show a commitment to the fight against climate change associated with the reduction of CO_2 emissions and other air pollutants, i.e. greenhouse gases (GHGs). The results therefore suggest that the decarbonisation efforts of this highly polluting industry are positively valued by investors. The finding complements previous studies that highlight the stock market penalisation of companies with high levels of GHG emissions (Choi & Luo, 2021; Griffin et al., 2017). It also reinforces the argument made by Nguyen et al. (2021) on the favourable stock market impact of managing a corporate waste such as GHGs. On the other hand, there is also a commitment by this industry to invest in activities and projects with a positive impact on the environment. This environmental investment, both to comply with regulations or stakeholder pressures and in response to or in anticipation of future risks or opportunities, supports the preservation of the natural environment in which the company operates while contributing to its stock market returns. This result is consistent with previous studies that point to a positive relationship between investment in R&D and environmental protection, and corporate valuation and performance (Grassmann, 2021; Puertas et al., 2022).

Linking sustainability objectives to senior executive compensation proved to be a salient practice in the identified configurations, however, it is the absence of this practice and not its presence that leads to the outcome. This finding means that hypothesis 7 is not supported. According to previous studies, the lack of homogeneity in the criteria and methodologies used to calculate ESG scores offered by rating agencies (Berg et al., 2019) may explain this result. As some authors note, this disparity in criteria makes it easier for managers to exert some degree of control over the ESG performance metrics linked to their incentives, by selecting those that are more favourable to meeting their personal objectives. As a result, remunerated metrics

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would not always reflect a real commitment to sustainable activities (Qin & Yang, 2022) and would only drive executive remuneration (Bebchuk & Tallarita, 2022). Considering the subsequent analysis by disaggregating the utilities industry into two groups, electricity and non-electricity utilities, the disincentive to adopt such practices is less clear, as both models show the absence, but also the presence, of this condition in different configurations. The latter results suggest that, for some firms and investors, the inclusion of non-financial metrics in top executive compensation is beneficial for stock returns. This is in line with previous research arguing for a positive impact of such incentives on firm performance (Abdelmotaal & Abdel-Kader, 2016; Bachmann et al., 2020; Said et al., 2003).

Furthermore, employee training on environmental issues, identified as a peripheral condition in configuration 1, and policies and efforts to promote fair competition, also identified as a peripheral condition in configuration 2, partially confirm hypothesis 9 and hypothesis 10. Although these practices are not core conditions, their integration in the causal configurations reinforces the combinations that lead to the stock market performance of utilities. According to previous research, green human resource management practices, such as environmental training, exert a positive influence on financial performance (Renwick et al., 2013). Configuration 1 shows that green training of employees is beneficial for the stock returns of utilities and, according to several authors, contributes to increase employee engagement in sustainable practices, improving the environmental performance of the organisation (Marucci, Iannone, et al., 2022; Yong et al., 2020). According to the analysis by sector, the benefit of this practice is mostly found in companies belonging to the electricity sector. In contrast, fair competition efforts reflected in the 'code of conduct' predominate among the non-electricity group of utilities, where they contribute to superior stock returns. This complements the findings of previous studies on the negative impact of anti-competitive behaviour on the stock price of companies (Bittlingmayer & Hazlett, 2000; De Vany & McMillan, 2004). The existence of differences in the identified configurations and predominant conditions between the group of companies belonging to the electricity sector and the group of other non-electricity utilities confirms hypothesis 11.

On the other hand, the research conducted in article 3 (López-Cabarcos et al., 2024) focused on the analysis within food production companies of water and waste management practices that are associated with superior financial performance, as measured by Tobin's Q. In this respect, indicators on water efficiency targets, water intensity ratio, water consumption ratio, waste recycling ratio and waste intensity ratio were used. The analysis of necessary conditions discarded the existence of any water or waste management practices that would lead on their own and in isolation to the presence of overvaluation of food companies in the market (Tobin's Q > 1). On the contrary, the analysis of sufficient conditions identified five configurations that lead to the presence of the outcome, confirming hypothesis 12. Among the identified configurations, configurations 1, 2 and 4, which support responsible water and waste management to achieve market overvaluation of these companies, stand out for their higher case coverage. Configuration 1 focuses on companies that implement water efficiency targets and that manage to maintain a weak water and waste intensity, i.e. reduced water withdrawal and reduced waste production in relation to their net revenues or sales. Configuration 2 maintains the same stance on weak water withdrawal intensity and waste generation, while prioritising recycling and reuse of waste produced. Meanwhile, Configuration 4 shows the market overvaluation of food producing companies associated with maximising the reuse and recycling of produced waste combined with a responsible use of water resources, with a weak intensity of water withdrawal and a balanced consumption of withdrawn water. The solution consistency (0.8362) indicates a strong configurational relationship, whereby complying with

at least one of the five identified configurations is consistently associated with the overvaluation of the firm in the market (Tobin's Q >1). On the other hand, the solution coverage (0.7206) reflects the robustness of the result, indicating that the solution obtained covers 72.06% of the cases analysed where firms are overvalued. This implies that water and waste management practices are determining factors for the market overvaluation of food producing companies.

At the individual level, waste recycling and reuse, as well as economic efficiency in the withdrawal of water resources and in waste production, proved to be the most replicated and relevant practices in the pathways leading to the presence of Tobin's Q > 1. The results indicate that an adequate management of the waste produced that drives circular economy processes and promotes waste recycling and reuse, combined with other sustainable practices, leads to the overvaluation of food producing companies. This finding confirms hypothesis 16. This result is congruent with what has been pointed out by other authors regarding the positive impact of adopting recycling and reuse practices on financial performance (Gull et al., 2022; Ioannidis et al., 2021) and on boosting the competitiveness of companies (Agovino et al., 2020). The absence of a strong intensity in water withdrawal suggests a higher efficiency in water use from an economic perspective, which implies a better management of this resource in terms of economic value generated. This result confirms hypothesis 15 and highlights the importance of water withdrawal for food companies (Avelino & Dall'erba, 2020) as well as the relevance of this variable and its relationship with financial performance in this sector (Gomes et al., 2023; Luque-Vílchez et al., 2023). Similarly, most of the identified configurations require the absence of a strong intensity in waste production to lead to the presence of overvaluation in the market. This implies greater economic efficiency of the waste produced, where the company generates a smaller amount of waste per unit of revenue or net sales, resulting in higher efficiency and sustainability in the production process. This result supports hypothesis 17 and complements the findings of Gull et al. (2022) and Eng et al. (2021) regarding the existence of an inverse relationship between high levels of waste produced and Tobin's Q.

In contrast to the previous practices, the consumption of withdrawn water and the setting of water efficiency targets are conditions whose presence or absence varies according to the identified configuration, being presented in most of the configurations as conditions present to lead to the overvaluation of food companies. This participation in most of the configurations leading to the outcome partially confirms hypothesis 13 and hypothesis 14. The variability between presence and absence of both conditions demonstrates the flexibility of the methodology to identify different causal configurations leading to the outcome where the importance and occurrence of each condition may vary depending on the context. According to the results, these conditions can act as complementary, since the absence of one requires the presence of the other, as exemplified by configurations 3 and 5. In summary, a predominant role of responsible and sustainable water use is demonstrated, corroborating the role of water management as a predictor of corporate financial success, as suggested by Hogeboom et al. (2018). Likewise, it strengthens the idea that responsible water management positively impacts the revenue, reputation and financial performance of companies in the food sector (Gomes et al., 2023; Weber & Saunders-Hogberg, 2020).

Together, the results of articles 2 and 3 underline the relevance of corporate sustainability as a driver of financial performance, competitiveness, and operational stability in essential sectors. Both studies show that companies with superior financial performance are those that design strategies adapted to their operating contexts, integrating flexible combinations of responsible and sustainable practices. This approach not only mitigates risks and optimises resource management but also increases the attractiveness of the company by building confidence in financial markets, strengthening its ability to attract funding and its market

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position. Therefore, regardless of the sector, ESG practices are proving to be key to business success. In a context marked by the energy, food and climate crises, both studies reinforce, in line with article 1, that prioritising general welfare generates tangible benefits and strengthens the strategic, operational and financial resilience of companies in the face of future challenges. Building on this foundation, articles 2 and 3 provide empirical evidence of the influence—positive in this case—of responsible and sustainable corporate management on financial performance (RI1 – see Figure 1).

5.4 Climate innovation as a response to global challenges

Business innovation plays a central role in the ability of economies and societies to respond to disruptive events, as exemplified in article 1 with the management of the pandemic. Beyond isolated crises, structural problems represented by major societal challenges such as climate change, biodiversity loss and natural resource scarcity require transformative solutions that only sustainable innovation can provide. In the sectors analysed in articles 2 and 3, innovation and technology emerge as a fundamental basis for organisations' ESG practices. Among other functions, innovation allows optimising the management and efficiency of critical resources such as water, energy or waste, contributing significantly to operational sustainability and reducing business environmental impact. In a world increasingly exposed to extreme weather events and climate change-related crises, implementing sustainable strategies based on climate innovation is no longer an option anymore, but a necessity. Their adoption and feasibility will be partly conditioned by the corporate governance structure and environmental conditions in which each company operates. For these reasons, article 4 examines the role of governance and adverse environmental stressors as drivers of the development, implementation and/or adoption of climate innovations and technologies.

The study carried out in article 4 (Quiñoá-Piñeiro et al., 2025) focuses its contribution on the analysis of corporate governance mechanisms and adverse environmental factors that are associated with a wide integration of innovations and technologies for climate change mitigation (climate innovation) in companies in the F&B sectors. In this regard, corporate governance mechanisms - comprising the CSR sustainability committee, board gender diversity and stakeholder engagement - as well as external environmental stressors - including natural disasters and water stress - were considered. The necessary conditions analysis did not identify any conditions that, in isolation, would lead to the presence of a wide integration of climate innovation. However, the analysis of joint necessary conditions revealed that, taken together, at least one of the three corporate governance mechanisms must be present for the outcome to occur. That is, at least one of these three factors combines with other factors in the configurations of sufficiency that lead to the outcome, but the simultaneous presence of all three is not required. The analysis of sufficient conditions corroborated the above and identified five configurations that lead to the outcome in F&B companies around the world, which confirms hypothesis 18. To achieve a wide integration of climate innovation, configuration 1 supports the existence of a specialised sustainability committee together with the promotion of active stakeholder engagement, even in the absence of a large representation of women on the company's board of directors. On the other hand, configuration 5 combines the presence of the sustainability committee and stakeholder engagement with an external environmental factor, a substantial incidence of natural disasters in the country of the company's headquarters. Configurations 2, 3 and 4 are characterised by a combination of internal and external factors, which agree on the presence of gender diversity on the board, complemented by the presence and absence of external factors, and a second governance mechanism. The solution consistency (0.8585) supports that complying with at least one of the five identified configurations is

consistently associated with the presence of the outcome. Solution coverage (0.6062) evidences the relevance of governance mechanisms and environmental stressors for the integration of climate innovation in F&B firms.

When analysing internal and external factors individually, the existence of a specialised sustainability committee and the engagement with stakeholders proved to be the most relevant and replicated factors in the configurations conducive to the presence of climate innovation. These results confirm hypotheses 21 and 23. Specialised sustainability committees prove to be indispensable in the governance structure to implement strategic innovation decisions that promote the fight against climate change. This finding is consistent across the European and Asian subsamples studied and aligns with previous studies that underline the positive impact of board-level CSR committees on environmental innovation (Farza et al., 2022; Nadeem et al., 2020), going a step further by suggesting the existence of a causal relationship between the creation of the committee and investment in innovation and technology for climate change mitigation. The results also challenge previous research that attributed to these committees limited effectiveness in mitigating sustainability-related risks and driving environmental innovation (Burke et al., 2019; García-Sánchez et al., 2021; Orazalin et al., 2024). On the other hand, the promotion of active stakeholder involvement in the decision-making processes of F&B companies is shown to influence managers' consideration of climate issues, and its presence is consistent across European and Asian samples, which validates the observations made by studies such as García-Sánchez et al. (2023) or Cadez et al. (2019).

The existence of a gender diversity on the board of directors emerges as a relevant factor in most of the causal configurations identified in the global model, except for one. This result partially confirms hypothesis 22. While this predominance is supported by the European subsample, where a large female representation stands out as a core condition, in the Asian case its absence is a characteristic feature of the configurations, reflecting contextual differences. These results are in line with previous studies showing mixed findings (both positive and null) regarding the impact of gender diversity on the board on climate innovation (Bui et al., 2020; García-Sánchez et al., 2023). The promotion of initiatives within the European Union to ensure gender balance (Lefley & Janeček, 2024) and the existence of historical, economic and cultural differences (Almaqtari et al., 2024; Bazel-Shoham et al., 2024) may explain this disparity.

On the other hand, adverse environmental conditions play an indispensable role in a large part of the configurations obtained, showing how the incidence of natural disasters and the pressure on water resources affect different countries differently through the presence and absence of these factors in the configurations. This variability partially confirms hypotheses 19 and 20. Apart from configuration 1 identified in the global sample which only requires the interaction of governance factors, the adverse environmental context faced by the country where the company is headquartered seems to be a determining factor in designing effective climate change mitigation strategies in F&B companies. It is worth noting that, when exposed to similar external threats, Asian and European companies adopt different combinations of governance mechanisms that are successful in driving climate innovation, reflecting regional differences in the effectiveness of sustainable strategic approaches.

Accordingly, article 4 stresses the relevance of corporate governance as a key factor within the ESG pillars for enabling corporate sustainability. The combination of operational contexts and a strong corporate commitment is fundamental to fostering effective climate innovation, thereby supporting the need to design corporate policies that link corporate governance to global environmental challenges. In line with articles 1, 2 and 3, driving climate innovation generates benefits for both society and the organisations themselves, reflecting their commitment to sustainability, reducing regulatory risks, optimising operational efficiency,

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reducing costs and enhancing their reputation, thus facilitating the attraction of responsible investors and conscientious customers. On this foundation, article 4 empirically demonstrates the existence of an influence of responsible and sustainable corporate management, along with external environmental factors, on the promotion of climate innovation and technology (RI2 – see Figure 1).

5.5 JOINT CONTRIBUTION TO SUSTAINABLE VALUE CREATION

The four articles discussed offer a joint view on how companies in essential sectors can create sustainable value by integrating principles of social responsibility and environmental sustainability into their corporate management and strategy.

Article 1 highlights how technological innovation and corporate response drive business resilience. Pfizer and Moderna's ability to develop COVID-19 vaccines in record time alleviated the health and socio-economic impacts of this multidimensional crisis, reinforcing stakeholder confidence in their ability to lead global solutions. As a result, both companies strengthened their stock market position, contributed to the recovery of the NASDAQ index, improved public health and helped mitigate the consequences of the health crisis. They also demonstrated the human potential to provide sustainable solutions, making innovation an indispensable tool to ensure long-term social and organisational survival.

In this vein, articles 2 and 3 underline the ability of responsible and sustainable practices to translate into tangible financial benefits and strengthen business resilience in the face of future challenges. Utilities and food production companies that adopt ESG practices such as emissions reduction, environmental investment, or efficient water and waste management, are able to preserve the resources and the environment in which they operate and position themselves in the markets as sustainable benchmarks. In this way, sustainability is detached from being an economic burden and is consolidated as a competitive advantage in the markets.

Finally, article 4 expands on the previous framework by highlighting the role of corporate governance as a fundamental pillar of sustainability among F&B companies. It stresses the need to integrate climate innovation into business thinking and strategy given its ability to provide solutions to global challenges and open new opportunities to build competitive advantage and ensure long-term success. The creation of more integrative, inclusive and transparent governance structures contributes to improving the effectiveness and ensuring the continuity of organisations, promoting active engagement of the organisation at different levels and of its stakeholders in sustainable management.

Overall, the findings reinforce the central role of companies in essential sectors as key actors in the transition to a sustainable global development model. The adoption of responsible and sustainable practices not only contributes to collective well-being, but also mitigates environmental and social risks, and strengthens the resilience of societies and business organisations in the face of contemporary challenges, creating social and environmental value beyond immediate economic benefits. Together, the four articles empirically identify responsible and sustainable practices that effectively contribute to the creation of sustainable value in essential sectors (RI3 – see Figure 1).

5.6 IMPLICATIONS OF THE THESIS

The results of this doctoral thesis have theoretical and practical implications that deepen the role of business strategies in the management of economic, social and environmental issues. These implications reinforce and broaden the knowledge on business sustainability, innovation and financial performance, proposing specific approaches to guide the implementation of more sustainable and resilient business models in essential sectors, adapted to an increasingly

challenging global environment. Furthermore, the thesis underscores the potential for creating a social impact that transcends academic and managerial boundaries.

5.6.1 Theoretical implications

At a theoretical level, the four articles that make up this research project contribute, from different perspectives, to address knowledge gaps and enrich the limited attention paid in the literature to the role of business strategy in essential sectors to adapt and create sustainable value in contexts of uncertainty.

The first article establishes a connection between investment in technological innovation and resilience in disruptive contexts, generating empirical evidence on the role of business innovation in mitigating financial risks and creating sustainable value. It therefore demonstrates the potential for firms to adapt to and thrive in extreme contexts, such as the COVID-19 pandemic, by relying on innovation. This study expands the knowledge on drivers of business success and organisational survival in extreme contexts and reinforces the literature that positions innovation as a central pillar of business sustainability.

The second and third articles extend the existing literature on the relationship between the adoption of responsible and sustainable practices and financial performance, empirically supporting the existence of a positive relationship between the two in the context of utilities and food companies. By focusing on market-based measures of financial performance, the results expand the theoretical understanding of the influence of ESG factors on the perception of companies in financial markets and their ability to create sustainable value. Both articles contribute to the narrative on the importance of assessing indicators underlying the three ESG pillars as a useful tool to analyse and promote practices that favour sustainable value creation, overcoming the dichotomy between sustainability and profitability.

The fourth article draws an empirical connection between corporate governance, adverse environmental factors and the promotion and expansion of innovation and climate technologies in the F&B sectors. This study expands the literature on corporate governance by identifying specific key mechanisms for dealing with environmental challenges considering the existence of regional differences. It also provides a framework for investigating how governance structure and environmental context can affect corporate climate action.

In addition to the theoretical contributions derived from the four articles, this thesis makes a methodological contribution by applying fsQCA in corporate sustainability research. FsQCA allows capturing the complexities of implementing ESG practices in organisations by considering asymmetric and heterogeneous relationships in real data. Based on the principle of equifinality, this technique shows the complexity and diversity of effective business strategies to achieve the analysed outcomes, challenging traditional methods that provide one-size-fits-all or universal solutions.

5.6.2 Practical implications

On a practical level, the four articles provide valuable information for business managers, investors, and policymakers, offering evidence-based guidance on how to design business strategies that maximise the contribution to sustainable development and optimise financial performance. These strategies generate both direct and indirect impacts on environmental sustainability, social actors, and economic stability.

For business managers, the findings provide sector-specific recommendations for the adoption of responsible and sustainable management strategies that contribute to balancing

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economic, social and environmental objectives in essential sectors. Among the recommended practices are:

- To strengthen corporate governance structures. This includes promoting the creation of specialised sustainability committees to oversee environmental and social performance and ensure their integration into business strategy; encouraging the active participation of stakeholders in decision-making, including employees, investors, suppliers and local communities; and prioritising diversity by increasing the representation of women on the board of directors, the latter considering the existence of regional variations. These measures enable strategic decision-making aligned with climate innovation and the SDGs.
- To include ESG indicators in corporate decision-making to assess the effectiveness and impact of implemented strategies. This allows informed decision-making that balances environmental, social and economic outcomes.
- To promote sustainability training at all organisational levels, from business leaders to operational teams. A corporate culture oriented towards sustainable development can be fostered through continuous learning programmes, enhancing awareness and implementation of sustainable practices.
- To optimise the efficiency of production processes through sector-specific sustainable approaches, prioritising the efficient management of natural resources such as water, the reuse and recycling of waste and the use of renewable energies to reduce CO_2 emissions and equivalents. These actions alleviate pressure on global ecosystems, promote circular production models and ensure long-term availability and accessibility to natural resources.
- To promote environmental investment, particularly in sustainable innovation and technologies, strengthening the capacity of the organisation to proactively mitigate risks, act in the face of global crises, and improve its resilience.
- To adopt sustainable and regenerative business models, which not only minimise harm but actively restore ecosystems, enhance community development, and improve overall well-being. Such practices can include regenerative agriculture, the use of biodegradable and recycled materials, and the promotion of water conservation initiatives.
- To foster strategic alliances for sustainability, enabling resource sharing and collaboration across companies, NGOs, and governments to address community environmental challenges and implement sustainable solutions.
- To build resilience to global crises, through business continuity planning for identified risks (such as climatic, health-related, or geopolitical risks). Integrating resilience into strategic planning ensures operational stability in times of uncertainty.
- To enhance transparency and accountability in corporate sustainability by standardising the measurement, management, and disclosure of ESG performance. Companies should report on key sustainability metrics such as carbon footprint, water consumption/withdrawal, pollution, waste generation, as well as gender representation and workforce diversity, aligning with international frameworks such as the Global Reporting Initiative, Carbon Disclosure Project, or United Nations Global Compact. Participation in these initiatives strengthens the credibility of sustainability efforts, builds stakeholder confidence, and facilitates informed decision-making by investors, policymakers, and society at large.

The integration of these practices should not be seen as an additional cost, but rather as a strategic investment that drives long-term sustainability and business success. Furthermore, it

is critical for managers to adapt strategies to the sectoral context and to the demands and events in their environment, recognising that there is no one-size-fits-all approach to create sustainable value.

On the other hand, the results reinforce the need to incorporate ESG criteria and underlying indicators into investment evaluation. The combinations of sustainable practices identified in the fsQCA models provide investors with specific indicators to assess the growth potential of companies and select those with the greatest projected financial return. In addition, investing in more sustainable companies contributes to the achievement of the SDGs and reduces exposure to risks, such as regulatory and environmental risks, that can affect the stability of the investment.

Finally, the results of this research project provide relevant information to governments and legislators for the design of public policies aimed at essential companies, in particular utilities and F&B producers. These policies should incentivise the adoption of responsible and sustainable practices that promote more efficient resource management, a drive for climate innovation and the transition to sustainable business models, creating low-carbon economies and fostering more sustainable global economic development.

5.6.3 Social implications

Beyond its theoretical and practical implications, the research conducted in this doctoral thesis has a significant social impact by addressing global challenges from an interdisciplinary perspective. It demonstrates how corporate sustainability and responsibility mitigate risks, create economic opportunities, and enhance social well-being. This social impact is particularly evident in:

- The contribution to public health and social well-being. The COVID-19 pandemic highlighted how investments in technological innovation by biopharmaceutical companies generates social benefits, safeguarding public health by saving lives while also supporting the recovery of economic stability.
- Reducing inequalities and improving access to essential goods and services in vulnerable communities. Implementing ESG strategies in essential industries and sectors such as utilities and F&B enhances social inclusion by ensuring broader access to fundamental resources.
- Education and awareness on sustainability issues. These initiatives drive change not only within companies but also beyond their boundaries, fostering positive sustainable transformations in communities.
- Improving quality of life in regions heavily affected by climate change and its extreme effects. The adoption of climate resilience strategies, including innovation and technologies for climate change adaptation and mitigation, helps reduce negative impacts and strengthens the resilience of vulnerable communities.
- Gender diversity in corporate governance. Increasing female representation in decision-making bodies promotes a more inclusive and equitable society, brings new perspectives that drive corporate sustainability, strengthens risk management, and accelerates the adoption of ESG practices.
- Fostering resilient economies that are better adapted to unstable and crisis-prone environments, promoting more stable long-term growth.
- Driving large-scale transformations through the integration of ESG strategies in essential sectors, reducing environmental impact, improving financial performance, and inspiring change across other industries.

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5.7 LIMITATIONS OF THE THESIS

Although this doctoral thesis provides relevant contributions to corporate sustainability in essential sectors, it also presents some limitations inherent to the studies that comprise it. First, the sectoral scope is restricted to the utilities industry and the biopharmaceutical, food producers and beverages sectors, which makes it difficult to extrapolate the findings to other industries and sectors with different dynamics. Second, the study period (2019-2022) is marked by global crises such as the COVID-19 pandemic, which raises uncertainties about the applicability of the results in contexts of greater stability, and makes it difficult to assess longer-term effects, although projections point to an environment of sustained instability in the coming years. Finally, the lack of homogenisation in the measurement of ESG indicators and the limited disclosure of non-financial information by companies have conditioned the size of the samples studied in the articles, which may limit the generalisability of the results.

5.8 SUGGESTIONS FOR FUTURE RESEARCH

The limitations identified in this thesis offer new possibilities for further research in this area. First, future research could explore other sectors and assess the consistency of the findings of this doctoral thesis in different contexts. Secondly, future studies could consider adopting a longitudinal approach to analyse the impact of responsible and sustainable practices in these sectors over time. Third, the increasing implementation and regulation of non-financial disclosure standards will allow the findings to be expanded by including a more diverse and representative sample of companies in the sectors analysed. Finally, future research could explore regional variations by examining the influence of cultural, economic or regulatory differences on the effectiveness of the practices analysed.

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6 CONCLUSIONS

Sustainability in the business sphere has gained prominence in recent years, driven by the effects of prolonged anthropogenic pressure on earth systems that threaten planetary stability. In this context, companies in essential sectors play a crucial role in their ability to mitigate risks, drive socio-economic development and contribute to human well-being. In a 'polycrisis' scenario, marked by the COVID-19 pandemic, armed conflicts that have intensified energy and food challenges, and the rise of extreme weather events, this thesis analyses how the adoption of responsible and sustainable practices in essential sectors influences their financial performance, fosters climate innovation and technologies, and contributes to the creation of sustainable value.

Through four complementary studies, this doctoral thesis provides empirical evidence on the role of essential sectors in the transition towards a more sustainable development, demonstrating that the adoption of responsible and sustainable practices, innovation, and corporate governance contribute to balancing economic, social and environmental objectives in increasingly extreme and disruptive contexts.

The COVID-19 pandemic revealed the fragility of global systems and the vital role of the biopharmaceutical sector in managing this multidimensional crisis. Following the stock market performance of Pfizer and Moderna, both companies reacted differently to the triggered crisis due to a different influence of volatility and market sentiment on their stock market performance. During the COVID period, cumulative market volatility significantly affected the stock market stability of both companies, while daily shocks had a smaller impact. This suggests that daily news and events affected the volatility of both companies to a lesser extent, with the overall crisis evolution being a stronger determinant of their performance, which was improving with the prospect of finding an effective vaccine. Despite this, both companies managed to maintain their stock market attractiveness thanks to their technological innovation in vaccine development. Their business strategies, together with investor confidence and their ability to resist and provide solutions, enabled Moderna, and to a lesser extent Pfizer, to exert a positive effect on the stock market. Indeed, the existence of a strong contagion effect between biopharmaceutical companies and the technological index helped to cushion the decline of the NASDAQ index. The innovation of Pfizer and Moderna not only ensured the financial viability of these companies but also contributed to social welfare on a large scale and was instrumental in mitigating the health, economic and social crisis triggered by COVID-19. These findings demonstrate that technological innovation acts as a resilience mechanism in the face of global crises.

Increasing global economic, social and environmental instability has underlined the urgency of moving towards more sustainable business models and highlighted the vulnerability of essential sectors whose activity is critical to prevent the collapse of economies. Given the urgent need for these companies to adopt business approaches that help reduce their environmental impact and prepare to respond effectively to extreme events and societal grand challenges, business strategies based on a combination of responsible and sustainable practices were identified as being associated with improved financial performance in the utilities industry

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and the food production sector. Specifically, it was shown that the implementation of responsible and sustainable practices consistently leads to superior stock market returns among utilities and to market overvaluation (Tobin's Q>1) among food production companies. In the case of utility companies, this strategic advantage lies primarily in decarbonisation efforts, with the absence of CO_2 emissions and equivalents, a proactive environmental investment, and the absence of a linkage of sustainability targets to the compensation of senior executives. Environmental management training and fair competition policies are identified as secondary factors. Within this industry, differences were observed between electricity and other non-electricity utilities, where the need for sustainability compensation incentives is questioned, and a predominance of employee environmental training among the former versus policies and efforts to promote fair competition among the latter. In turn, food production companies find waste recycling and reuse, economic efficiency in the use of water resources and economic efficiency in the production of waste, their most replicated and relevant practices to lead to overvaluation. The definition of water efficiency targets and the balanced consumption of withdrawn water prove to be contingent factors, whose presence and absence depend on the context in which they are combined with other practices. These findings reveal that corporate sustainability increases the financial attractiveness of companies and strengthens their market position. This benefit is conditional on the design of strategies adapted to sectoral contexts, integrating flexible combinations of responsible and sustainable practices to maximise their impact.

In addition to their central role in responding to disruptive events, as evidenced during the COVID-19 pandemic, the implementation of innovation-based approaches and sustainable technologies in business strategy is unquestionable to address major societal challenges such as climate change. For this reason, corporate governance mechanisms and adverse environmental factors that affect the development, implementation and/or adoption of innovations and technologies for climate change mitigation in companies in the F&B sectors were identified. For these companies, having a dedicated sustainability committee and fostering the engagement and active involvement of stakeholders in decision-making processes are the most relevant and widespread governance mechanisms for achieving a wide integration of climate innovation. The presence of large female representation on the board of directors varies according to the region analysed, being predominant in the global and European samples, but absent in the Asian sample, which seems to be linked to historical, economic and cultural factors. While the adverse environmental context of the country where the company is headquartered is relevant for designing effective climate change mitigation strategies, it is also shown that some organisations manage to integrate climate innovation independently of external environmental factors. These findings underline the role of governance bodies and their sustainable engagement in driving climate innovation.

While future developments are uncertain, the dangerous crossing of planetary boundaries presents unknown risks and implications for water, energy and food security, threatening the survival of business and humanity as a whole. In this sense, this doctoral thesis makes a substantial contribution by offering a guide for sustainable business action in essential sectors that have been scarcely studied. These companies have the potential to lead the transition towards a more sustainable model of global development that creates economic, social and environmental value.

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APPENDIX

Journal authorisations for publications.

ARTICLE 1

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In the context of a global 'polycrisis', corporate sustainability is imperative. The biopharmaceutical, food, beverage, and utility sectors are key to global stability yet remain underexplored in the literature. This doctoral thesis examines, through four empirical studies (2019-2022), how responsible and sustainable management practices influence financial performance, foster climate innovation, and create sustainable value in essential sectors. The findings reveal the role of innovation in enhancing resilience during crises, the financial benefits of sustainability, and the critical importance of governance in climate innovation strategies. These insights guide companies, investors, and policymakers in promoting business models that create sustainable value in a challenging global environment.