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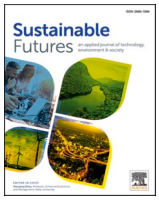

How can derivatives contribute to sustainable development goals? An analysis of synergies, contradictions, and challenges

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ABSTRACT

This paper examines the derivatives' actual and potential effects on the Sustainable Development Goals (SDGs) progress. It explores how derivatives affect the SDGs from a conceptual standpoint, identifying both synergies and contradictions. One significant synergy is the alignment of derivatives supply with the financial risks associated with the SDGs, supported by the regulatory framework that helps control volatility peaks. However, a major contradiction exists in the risk management gap between developed and developing economies. Two actions to narrow this gap arise from the analysis undertaken in this paper: first, strengthening financial literacy by including risk management and basic knowledge on derivatives and, second, fortifying the financial system so that banks in developing countries can provide risk management products and advice to all economic agents, including small producers.

1. Introduction

This paper studies the derivatives' actual and potential effects on the path towards the United Nations (UN) Sustainable Development Goals (SDGs). Such a study must distinguish between the derivatives' potential and practical uses. On their potential side, Shiller [1] praises the capacity of derivatives for better managing personal risks, such as declines in home prices or career incomes, emphasising that they can become instances of finance in the services of the good society ([1], p. 80). On their practical implications, Stiglitz ([2], p. 295), in his analysis of the 2008 crisis, states that "derivatives have played an important role in amplifying the crisis". The same author ([3], p. 365) refers to derivatives as "those risky products that contributed so much to the global financial crisis". This assertion reminds the reader that derivatives enable their traders to treat commodities as financial assets and, thus, become a key element of the financialisation of the economy. Although, later in this paper, we review the different points of view on the derivatives' effects, the contrast between Shiller and Stiglitz's perspectives suggests that derivatives embed opposite properties that may contribute positively or negatively to the SDGs depending on their use and regulation. Therefore, discerning the derivatives' role in the path towards the SDGs requires identifying the synergies and contradictions between derivatives and the SDGs and detecting the challenges generated by their interaction. That is the aim of this paper.

Central in the relationships between derivatives and the SDGs are the core functions of derivatives as risk trading instruments: risk mitigation, namely hedging, and speculation. Hedging generates a demand for derivatives that mitigate different risks of different assets. Speculation, in turn, performs its price discovery function but also embeds the seeds of price bubbles and volatility peaks. However, any analysis of the implications of hedging and speculation still needs to consider the financial inclusion barriers that prevent some economic agents from accessing derivatives trading.

On this basis, we structure the paper as follows. Section 2 depicts the methodology of the paper. Section 3 analyses the links between derivatives and the SDGs, examining the institutional perspectives on these links, the adequacy of derivatives' supply regarding the risks faced by the SDGs, the debate on derivatives trading impact on volatility, and the financial inclusion barrier to derivatives trading. Section 4 presents the results of the paper identifying the synergies and contradictions between derivatives and SDGs and the challenges that derivatives embed, placing particular emphasis on the implications for developing countries. Section 5 discusses these findings and Section 6 concludes the paper.

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2. Methodology

The methodology of this paper centres on identifying how derivatives can contribute to the SDGs in a financialised world that interweaves strong and weak financial systems and very high and very low financial literacy. Since exploring these effects claims an ample perspective on derivatives' markets, financial decisions and financial literacy, we adopt the methodology of a review paper focused on conceptual research bearing integrative thinking in mind. Aven [4] praises the value of conceptual research "founded on reasoning and argumentation" ([4], p. 2417), which this author considers central to the integrative thinking required by risk management. The interaction between derivatives and the SDGs is highly relevant for risk management, while integrative thinking is paramount to understanding the complex and broad relationships embedded in this interaction. Martin ([5], p. 15; also mentioned in [4]) defines integrative thinking as "the ability to face constructively the tension of opposing ideas and, instead of choosing one at the expense of the other, generate a creative resolution in the form of a new idea that contains elements of the opposing ideas, but it is superior to each".

We have focused our first conceptual research on the impact of derivatives on the SDGs 2030 Agenda SDGs reports. This analysis has shown that the following questions were central to our research: the availability of derivatives on sustainability and the knowledge of them, the interaction between derivatives trading and volatility, the state-of-the-art and relevance of financial literacy regarding risk management, and the hedging challenges in developing economies.

The exploration of these questions has called for a literary review of the relevant institutional reports related to them and the academic papers that analyse their features and implications. The central aim of this paper is to link the results of both explorations to unveil the synergies, contradictions, and challenges between derivatives and the SDGs embedded in these reports and articles.

The institutional review focuses on documents issued by the United Nations SDGs Agenda, World Bank, OECD, the United Nations Conference on Trade and Development (UNCTAD), World Federation of Exchanges Regulatory Affairs Team, Committee on Homeland Security and Governmental Affairs United States Senate, FIA (Futures Industry Association), G20, GISD (Global Investors for Sustainable Development Alliance), London Metal Exchange, and Currency Exchange Fund (TCX).

A preliminary search interweaving SDGs and derivatives on the ABI/Inform database (abstracts) has not retrieved significant results for our generic purpose of linking both concepts. A parallel search in the ScienceDirect database interlinking SDGs and hedging has not improved this result. Thus, we have performed separate qualitative reviews of the academic articles for each question mentioned in the first paragraph of this Section to produce the narrative synthesis that structures the paper. Thus, each review has aimed to answer specific research questions, which is one of the goals that Torraco ([6], p. 411) assigns to literature reviews. We have approached each review from the six-stage research process pointed out by Durach et al. [7]: defining the research question, determining the required characteristics of primary studies, retrieving a sample of potentially relevant literature, synthesising the literature, and reporting the result. The selection of the academic sources has been based on the criteria recommended by Byard ([8], p. 69) for bibliographic research:

1. Quantity: Including several sources enough to make the research representative,
2. Credibility: Choosing scholarly contrasted sources,
3. Relevance: Choosing sources that centrally deal with the topics under analysis,
4. Timeliness: Considering the publication dates, and
5. Cumulative merit of all selected sources.

To select the sources, we have performed in-depth searches in the databases ABI/Inform (limited to peer review papers), Science Direct and JSTOR. Next, we have chosen the papers for their relevance to the different parts of our research. Besides, a small number of books from academically trusted publishers have been included in the review. The main outcomes of this literature review are integrated into the Analysis Section (Section 3) as a central support tool for its conceptual research, while other references are directly incorporated into the Results Section (Section 4) when they contribute to frame the consequences of the previous analysis. Besides, we have tested the merit of these sources (in most cases, beyond discussion) through the Scopus database because it calculates the metrics of each article. The total number of academic articles quoted in our paper is 59. Scopus includes 49 of them. Of the other ten articles, three have been published by journals that are not included in Scopus. In contrast, the remaining seven have been published in highly reputed journals not covered by the Scopus metrics at the dates of their publication. These journals are: *Econometrica* (1982), *International Economic Review* (1985), *Journal of Business* (1986), *Journal of Political Economy* (1986), *Review of Economics and Statistics* (1992), and *Journal of Finance* (1992 and 1993). Table 1 presents the aggregate results of this bibliographic contrast.

3. Analysis: identifying the links between derivatives and the SDGs

3.1. Derivatives in the framework of the SDGs

Risk mitigation is essential for smoothing the path towards the SDGs. With this principle in mind, this Subsection centres on answering two questions: Which consideration do derivatives receive in the institutional framework of the SDGs? Do derivatives markets provide a solid supply that enables agents to hedge the most relevant risks embedded in the SDGs? The 2030 Agenda for Sustainable Development [9] underlines that the achievement of SDGs needs financial support, emphasising funding particularly. As for derivatives, the unique explicit mention is in SDG2 (Zero Hunger). Its 2c target expresses the need to "adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate access to market information, including on food reserves, in order to help limit food price volatility" [9]. Besides, the Agenda also makes explicit environmental, economic and social risks related to the SDGs that can be managed with derivatives. On the other hand, access to derivatives is part of the financial inclusion target that the agenda associates with several goals. Table 2 synthesises the institutional perspectives on direct and indirect connections between derivatives and the SDGs. Remarkably, this perspective evolves from regarding derivatives as a threat that may foster volatility peaks to the explicit recommendation to systematically integrate risk considerations into planning the management of disaster risks, whose financial impacts derivates can help to mitigate. Environmental risks and financial inclusion also appear as central concerns on the documents summarised in Table 2.

Regarding the SDGs, from the perspective of derivatives supply, we have to distinguish between specific and generic links. The former embrace derivatives directly related to environmental and social sustainability. The latter includes all derivatives supporting economic development, although without specific sustainability links. Using derivatives for hedging involves longer and less flexible horizons than speculative operations due to the systematic hedging links to the production or consumption activities whose risk it aims to mitigate.

Table 1
Bibliographic analysis.

	Year of publication	Citations	Percentile	FWC
Mean	2013	109	75	3.79
Median	2015	30	84	1.69

The acronym FWC denotes the Field-Weighted Citation Impact.

Table 2
Institutional perspective.

SDGs Agenda		
Goal	Target	Link with derivatives
SDG2: Zero hunger	2c: Limit food price volatility	Volatility peaks
SDG1: No poverty	1.4: Access to financial services	Financial inclusion
SDG5: Gender equality	5.a: Access to financial services	Financial inclusion
SDG7: Clean energy	Generic	Need to mitigate the risks of clean energy
SDG8: Sustainable Economic Growth	8.10 Expand access to financial services.	Financial inclusion
SDG9: Infrastructure, industrialisation, innovation	9.3: Access to financial services	Financial inclusion
SDG10: Reduce inequality	10.3: Improve financial regulation	Regulation to mitigate volatility peaks
SDG13: Climate action	Generic	Need of derivatives on environmental sustainability

Other institutional documents	
Document	Recommendations
World Development 2014 Report [10]	"People, including the poor, need not just credit but a range of financial tools to manage risk and pursue opportunity effectively and responsibly" ([10], p. 193).
How Derivatives Markets Are Helping the World Fight Climate Change [11]	Adapt the actual and potential derivatives trading rules to deal with climate change challenges.
Derivatives in Sustainable Finance ([12], CEPS).	Use derivatives to foster risk management and market efficiency in commodity markets.
Increasing Private Finance Mobilization GISD [13]	Promote blended finance. Private investors need instruments to mitigate currency risk.
How Derivatives Exchanges Can Promote Sustainable Development [14]	Improving the standardisation of sustainability-linked derivatives, Enhancing the transparency of derivatives markets, Requiring sustainability practices to market participants, Introducing new products based on sustainability data, Innovating sustainability derivatives
Overview of ESG-related Derivatives Products and Transactions [15]	Use the potential the role of derivatives in sustainable finance. Mobilise capital to drive climate innovation.
2023 SDGs Report [16]	Reforming the international financial architecture. Urges the financial sector to embrace more risks. Integrate risk considerations into planning to reduce disaster risks.

Source: authors' design.

Therefore, the hedging operations related to the SDGs require an appropriate derivatives supply and a well-grounded knowledge of their properties. For this reason, we review the derivatives' availability to support environmental and social hedging strategies, mainly from the perspective of the academic literature that deepens into their financial features and applicability. This review does not aim to be exhaustive but to show that there is a solid knowledge on the derivatives strategies contributing the SDGs. Table 3 synthesises a set of relevant academic studies on the central facts of environmental sustainability.

On the social side, systematically shared with environmental sustainability, the derivatives on Environmental, Social and Governance (ESG) indexes constitute a stimulus for corporations to adopt the Corporate Social Responsibility rules incorporated into these indexes, aligning firms with sustainable value creation [32], and shared value [33]. Furthermore, the introduction of fair production requirements on underlying assets by certain derivatives exchanges provides a dual support for environmental and social sustainability. In this respect, the Sustainable Stock Exchanges Initiative (SSE) and World Federation of Exchanges (WFE) conjoint report ([14], pp. 15–16) underlines the significance of the rules on the clean production of underlying assets imposed by some derivatives exchanges, as the London Metal Exchange rules on responsible sourcing [34].

From a generic perspective, practically all derivatives can foster economic development through price discovery and risk management functions. Trading derivatives on underlying assets relevant to risk management in developing economies extends these functions to these economies, facilitating their progress. However, the critical point in this respect is to what degree the development that derivatives support is volatility sustainable. Namely, how much they contribute to volatility peaks and price bubbles that hinder progress towards the SDGs. Table 4 synthesises the matches between derivatives and SDGs from the perspective of derivatives supply. Generalising the contents of this table,

Table 3
Derivatives and environmental sustainability: academic studies.

Article	Key contribution
Sharma and Vashishtha [17]	Application of weather derivatives to agriculture and power generation in India.
Muller and Grandi [18]	Application of weather derivatives to weather-sensitive industries.
Pérez-González and Yun [19]	Active risk management through weather derivatives increases firm value.
Pelka and Musshoff [20]	Weather derivatives applications to hedge agricultural risks.
Purnanandam and Weagley [21]	The information generated by financial markets can improve the efficiency of weather governmental agencies
Islip et al. [22]	Application of weather derivatives to construction industry.
Martínez Salgueiro and Tarrazon-Rodon [23].	Application of weather derivatives to tourism industry.
Matsumoto and Yamada [24]	Application of weather derivatives to electricity.
Nakajima and Ohashi [25]	Evaluate derivatives on emission allowances and study their hedging applications.
Gorenflo [26]	Price of futures contracts on emission allowances.
Casula and Masala [27]	Analysis of derivatives on electricity.
Kanamura et al. [28]	Analysis of derivatives on wind power.
Perrakis and Boloorforoosh [29]	Pricing catastrophe derivatives.
OECD [30]	Features of catastrophe-linked securities
Ohashi [31]	Basis risk and adverse selection on trading catastrophe index futures.

Source: authors' design.

Conceptual Map 1 structures the relationship between derivatives' supply and the risk management demands embedded in the SDGs.

3.2. Derivatives and commodity prices

A controversial point in the link between derivatives and the SDGs is the derivatives' impact on commodity markets from the lenses of the SDGs. There has been a broad debate on the effects of derivatives on commodity markets' efficiency, centring on price discovery, volatility, and bubbles. This debate has produced papers with positive and negative views on the consequences of speculation without reaching a unanimous conclusion. Table 5 synthesises the contributions of a set of relevant papers on this controversy. On the one hand (left-hand side column), the reviewed papers show strong evidence of the speculation's capacity to foster market efficiency without being responsible for volatility peaks. On the other hand (right-hand side column), some empirical analyses find punctual relationships between speculation and volatility. Furthermore, others, taking a theoretical perspective, identify potential scenarios that may lead speculation to generate bubbles. This twofold combination conveys that derivatives improve commodities speculation significantly by adding transparency, fostering price discovery, and broadening hedging facilities. However, their impact on the SDGs may be the opposite in some scenarios because the dynamics of derivatives trading embeds the seeds of bubble generation, synthesised in the right-hand column. Thus, although the debate on derivatives' impact on commodity prices has not reached a unanimous conclusion, it provides highly relevant information on the derivatives' effects that may create synergies and contradictions with the SDGs: price discovery, volatility, and increases in correlation among futures and non-oil commodities. Besides, an additional synergy comes from technology innovation that improves price efficiency. In the face of adjusting market design and adopting regulatory measures, Fattouh and Mahadeva [35] recommend adjusting policy decisions to the evolving empirical evidence. These authors point out that different market failures would require different policy solutions, stressing that "it is crucial in the first instance to identify the channels through which financialisation can result in market failure" (p. 39). In this line, Cheng and Xiong [36] stress the need to concentrate on the effects of financialisation on risk sharing and information discovery to understand the nature of volatility in commodity markets, concluding that both have introduced relevant changes in these markets.

Table 4
Matching derivatives with the SDGs targets.

Derivatives	SDGs targets
Weather and disaster derivatives	SDG 2: 2.4. Strengthen capacity for adaptation to climate change SDG 13: 13.1. Strengthen resilience and adaptive capacity to climate-related hazards
Emission allowances Greenhouse emissions	SDG 7: 7.2. Increase renewable energy in the global energy mix SDG 12: 12.4. Environmentally sound management of chemicals and all wastes
Interest rates and currencies	SDG 8: 8.3. Promote development-oriented policies that support productive activities
ESG Indexes	SDG 8: 8.4. Decouple economic growth from environmental degradation SDG 12: 12.6. Encourage companies, to adopt sustainable practices including information
Underlying assets with risk management needs in developing countries	SDG 9: 9.4. Increased resource-use efficiency and greater adoption of clean technologies SDG 9: 9.b. Support domestic technology development, research and innovation in developing countries

Source: authors' design.

3.3. Derivatives and financial inclusion

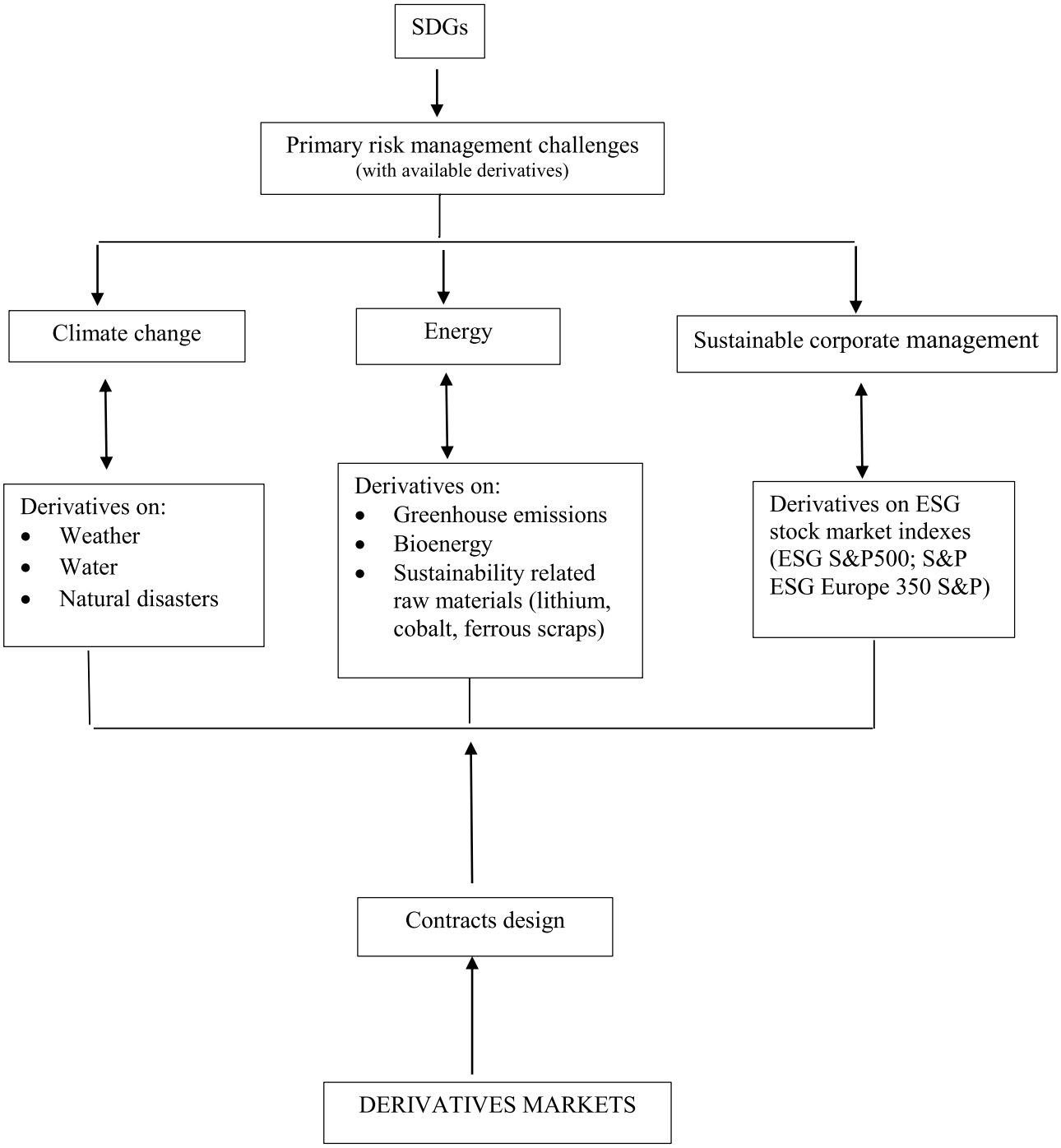
As mentioned in the introduction, weak financial inclusion is widely regarded as a significant barrier to progress towards the SDGs. Demirgüç-Kunt ([66], p. 350) defines financial inclusion as the share of individuals and firms that use financial services. This author points out the need to supply credible and straightforwardly manageable products to foster hedging. Table 6 synthesises relevant academic contributions on the relationship between derivatives, financial literacy, and financial inclusion from the risk management perspective. First, financial literacy constitutes a preliminary barrier to risk management. Dealing with derivatives requires financial proficiency. Financial inclusion is also central to risk management, requiring at least sound access to a financial system able to supply basic OTC contracts. Finally, considering risk management as part of the financial inclusion challenge is paramount for smoothing the financial path towards the SDGs in a world pervaded by financialisation.

Hedging for producers, especially Small and Medium Enterprises (SMEs), requires the help of expert design from specialists with its corresponding cost. To develop a hedging strategy through derivatives, a producer, by himself or through an expert assessment, must identify the risks to be controlled and know which financial instruments to use as well as the process of accessing and using them. Different economic agents, fulfil these conditions to different degrees. To approach the links between derivatives and financial inclusion, we propose the following classification regarding the access of economic agents to hedging strategies:

(1) Strong active agents with full access to derivatives markets and proficiency in designing hedging strategies for themselves and third parties.
(2) Semi-strong active agents who can design their hedging strategies without having direct access to derivatives markets.
(3) Weak active agents who may develop and implement hedging strategies with the help of financial intermediaries.
(4) Passive agents who do not have access to implement hedging strategies due to financial inclusion barriers.

To summarise, risk management through derivatives relies on internal and external pillars. The internal pillar is a basic understanding of how derivatives work directly through the firm's managers or financial advisors. The external pillar consists of practical access to derivatives exchanges or, as best suited for SMEs, having commercial relationships with financial institutions that offer tailored hedging to their customers. Therefore, combining financial education with a reliable financial system is crucial to guarantee financial inclusion from the hedging side. Conceptual Map 2 synthetises the financial inclusion challenge regarding derivatives.

The following clusters illustration (Plot 1) clearly demonstrates that some developing countries experience very low financial inclusion and limited access to financial literacy. Its aim is not to analyse these situations in depth but to highlight their importance. We have organised the available data into four distinct clusters. From the World Bank Group's World Development Indicators database, we selected the percentage of the population with lower secondary education as an indicator of the ability to access financial literacy. To represent basic financial inclusion, we used the percentage of adults who own a bank account. The intersection of education levels and bank account ownership identifies countries that score poorly in both areas. In these countries, a low number of bank branches per one hundred thousand citizens is a sign of a weak financial system. However, this is not the case for some developed countries that also have a relatively low number of bank branches in relation to their population. We have chosen the last available year with relevant information for each series. However, we have restricted the countries for which both indicators are available in education and bank account ownership. As for the clustering techniques, we have



Conceptual Map 1. Linking derivatives with the SDGs:supply vs demand.
Source: Authors' design.

performed several essays to maximise the visual clarity of the results. Tables 7, 8, 9, 10 show the detailed results of this analysis.

4. Results: evidence on the links between derivatives and SDGs

4.1. Interacting derivatives with the SDGs: synergies, contradictions, and challenges

The analysis of the behaviour and properties of derivatives, as explored in the previous sections, underlines the crucial role of derivatives trading in shaping the SDGs landscape. This interaction is rooted in the fact that some of the most critical areas of the SDGs, such as fair prices, risk management, financial inclusion, fair production, and climate action, are also the areas where derivatives exert significant influence. Synergies and contradictions emerge in this landscape. Effective risk management plays a pivotal role in ensuring smooth progress towards the SDGs' achievement. The growth of derivatives markets has led to a wide range of hedging products that help producers to control volatility in the short run. This practical application of derivatives in risk management underscores their synergy with the SDGs, albeit counterbalanced by the complexity and cost of their management. Commodity prices, in turn, are subject to the influence of price discovery, which is facilitated by futures contracts and other derivatives. When functioning optimally, this process can foster economic growth,

Table 5
Derivatives and volatility in commodity markets.

Speculative side of derivatives			
Speculation in perfect markets: Speculation → Price discovery → Market stabilisation Friedman [37],			
Identifying positive contributions and stabilising scenarios		*Identifying destabilising scenarios in speculation*	
Turnovsky&Campbell [38]	Futures markets can redress a non-feasible long-run equilibrium, but producers might need support.	Tirole [39]	Price bubbles rely on the myopia of traders.
Easterbrook [40]	Futures markets protect themselves from monopoly and manipulation.	Hart&Kreps [41]	Speculation may destabilise markets even under rational expectations.
Stein [42]	Shortening information transmission, improving rationality and reducing coweb behaviour.	Stein [43]	Different perspectives from new and old speculators can destabilise markets.
Shiller [1]	Efficiency cannot be conceived without speculation.	Newbery [44]	Price insurance fosters riskier production methods and stimulates innovation, but may increase volatility.
Irwin&Sanders [45]	No evidence of futures causing bubbles.	Froot et al. [46]	Short-termism leading to herding and bubbles.
Irwin&Sanders [47]	New traders have brought better technologies improving the information incorporated into prices.	Ghosh et al. [48]	Huge trading in 2008 fostered bubbles.
Etienne et al. [49]	Index investors are not responsible for bubble generation.	Schmidt [50]	Passive long positions from index funds led the market be in contango position permanently.
Kim [51]	Underlines the positive side of speculation	Weller [52]	Speculation was central in emerging economies financial crises between 1973 and 1998.
Hamilton&Wu [53]	Little evidence on index funds impacting on commodity futures prices.	Tang&Xiong [54]	Financialisation has increased correlation between futures and non-oil commodities.
Irwin&Sanders [55]	There is no reliable evidence on futures markets as volatility triggers.	Basak&Pavlova [56]	Financial markets transmit price shocks to real markets.
Brunetti et al. [57]	Hedge funds have provided stability to futures markets.	Nissanke [58]	Financialisation extends global financial crises to developing economies.
Holmes & Otero [59]	Coffee futures prices as unbiased predictors of spot prices	Bush [60]	Coffee small producers unable to protect themselves from bubbles.
Bohman et al. [61]	Speculation through derivatives has a strong price discovery effect.	Le Pen&Sevi [62]	Futures trading fosters co-movements in commodity markets.
Baffes & Nagle [63]	Governments may use derivatives to smooth fluctuations in commodity prices.	Adams et al. [64] Natoli [65]	Commodity prices have changed from behaving as physical real assets to financial assets. Financialisation has influenced commodity prices.

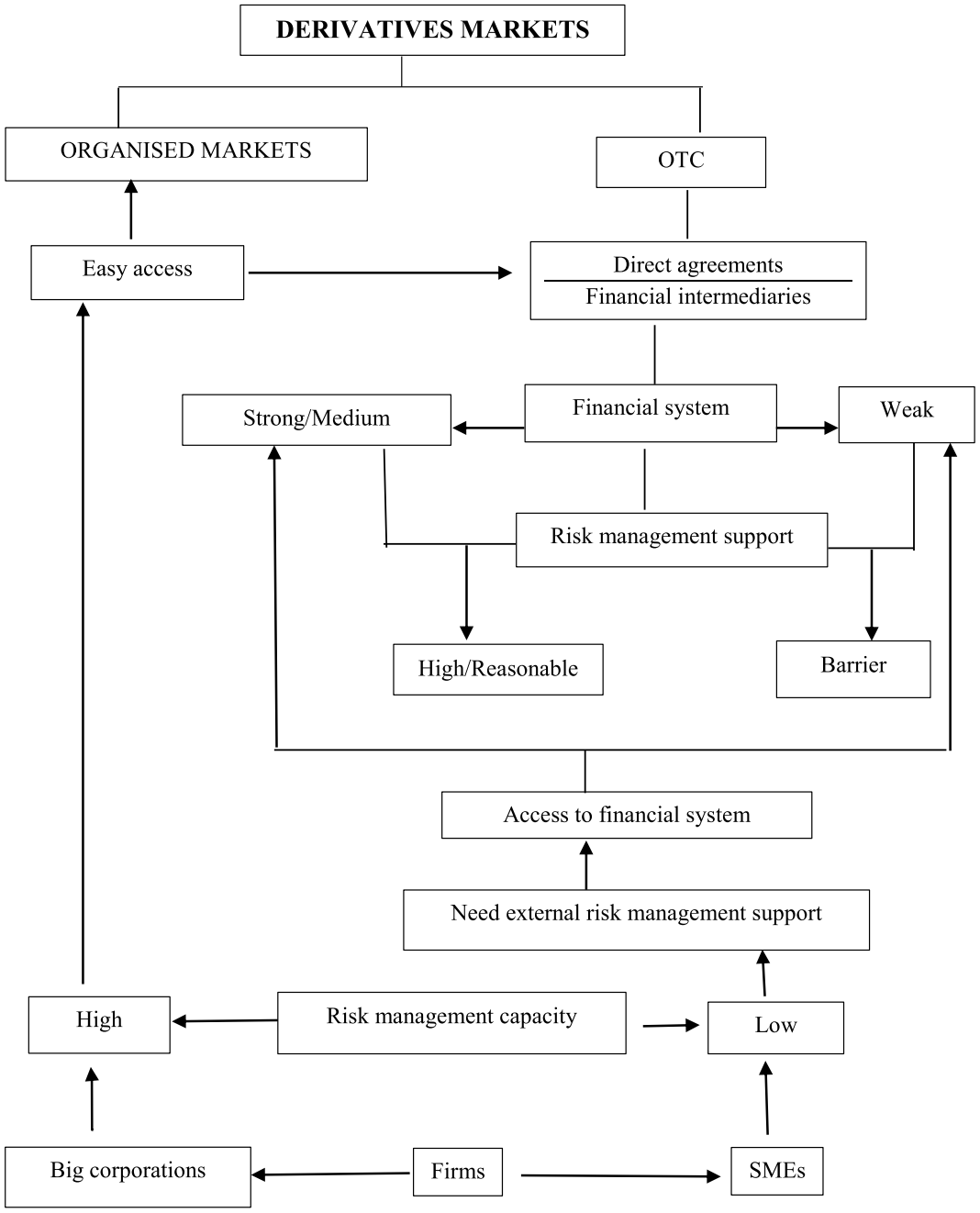
Source: authors' design.

Table 6
Derivatives and financial literacy and inclusion.

Financial Literacy	
Morduch [67]	Relevance of financial literacy for financial inclusion. Financial literacy as a condition for management capacity.
Cole et al. [68]	Effects of financial literacy on financial inclusion.
Chaia et al. [69]	In developing economies the practical use of financial services is lower than the access to them because of weak financial literacy.
Financial inclusion	
Cull et al. [70]	Lack and challenges of financial inclusion.
Demirgüç-Kunt et al. [71–73]	Weak financial inclusion predominates in developing economies.
Risk management and financial inclusion	
UNCTAD [74]	Main barriers: Lack of awareness, institutional weaknesses, weak regulation and sovereign risk.
Bush [60]	Disadvantage of poor access to risk management.
Demirgüç-Kunt et al. [71]	Financial risk relevance in agriculture.
Ayyagari et al. [75]	Recommend reinforcing small firms' managerial skills in developing economies and supporting them through consulting services.
Cicchiello et al. [76]	Strong relationship between low financial inclusion and low development.

Source: authors' design.

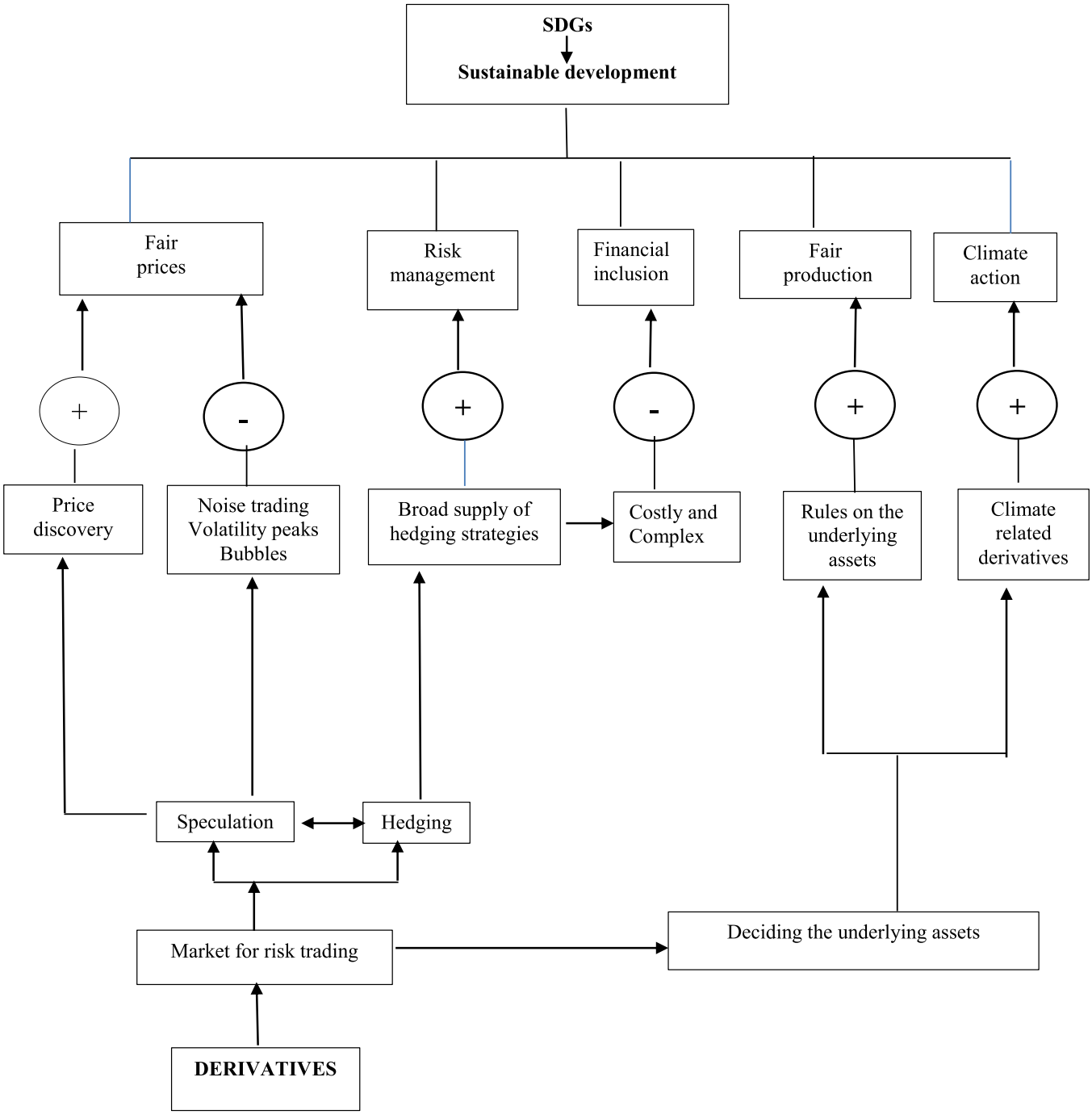
responsible consumption, and production. It also equips firms with better information for long-term decision-making. However, it is crucial to be aware of the financialisation phenomenon, often linked to large derivatives trading, as it can introduce volatility spikes and bubbles, posing risks to market stability. Central in this respect are the intrinsic properties of derivatives, which, in specific scenarios, may move trading away from price discovery and lead to bubble generation. Therefore, price discovery creates synergy between derivatives and the SDGs, whereas the potential volatility spikes become a contradiction. The empirical debate on volatility impacts has observed volatility increases



Conceptual Map 2. Derivates and SMEs.
This conceptual map synthesises the difficulties of SMEs in accessing hedging operations through derivatives contracts. These operations require a proficiency level in risk management, hardly accessible to SMEs. Thus, they need external support, which often consists of tailored OTC contracts offered by financial intermediaries. However, only a robust financial system may provide them. In contrast, big corporations with solid risk management departments can directly design and manage hedging operations through organised and OTC markets. Source: authors' design.

in some periods that negatively affect small producers and consumers. In this line, if the generation of a bubble distorts price discovery, its positive effects turn into negative consequences. Commodity derivative markets also have the crucial function of deciding the features of the underlying assets of their contracts. Through this function, derivative markets can influence the fair production of the commodities accepted as underlying assets. Thus, derivatives create synergy with fair production. Besides, the climate-related derivatives generate an important synergy with climate action risk management. As for corporate social responsibility, derivatives on ESG indexes add value to the corporations included in these indexes, thus fostering the implementation of strategies in line with ESG requirements. Conceptual Map 3 presents a systematised synthesis of the synergies (denoted by the plus sign) and contradictions (indicated by the minus sign) that stem from the interaction between derivatives and the SDGs, emphasising the differences between speculation and hedging. On the one hand, speculation connects with price discovery on the positive side and volatility peaks on the negative side. On the other hand, hedging connects with risk management on the positive side and the financial inclusion challenge on the negative side.

The review and conceptual research developed until this point convey two crucial challenges in aligning derivatives with the SDGs: A supply challenge to hedge all remarkable risks and a context challenge to trade derivatives in an efficient and accessible market. The context



Plot 1. Conceptual Map 3: Synergies vs. Contradictions.
Source: authors' design.

challenge, in turn, presents two sides: A regulatory challenge to ensure the efficiency of derivatives trading and a financial inclusion challenge to deal with the access to risk management through derivatives, including the design of appropriate strategies.

Section 3.1 has analysed the supply challenge. Let us focus now on the context challenge from the perspectives of regulation and financial inclusion, both constituting challenges by their own.

4.1.1. The regulatory challenge

In the year 2015, the 2030 SDGs Agenda, as mentioned in Section 3.1, explicitly identified a regulatory challenge in aligning derivatives with the SDGs by claiming to implement appropriate rules that prevent derivatives trading from fostering food price volatility. From the institutional perspective, the regulatory challenge has its roots in the debates of the Market Risk Advisory Committee of the US Commodity Futures Trading Commission (CFTC). In this forum, the portfolio manager Michael Masters imputed to futures trading the volatility peak observed in commodity markets ([50,77], chapter 1). The G20, in its Pittsburgh 2009 meeting, assumed the goal of improving the OTC derivatives market by combating the excessive volatility generated by price manipulations. In this line, the UNCTAD report on the Global Economic Crisis [78] regards futures commodities trading as a speculative driver of bubbles. This report (p. 27) also points out that financialisation increases uninformed trading and makes hedging more complex.

Table 7
Clusters analysis: education.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Year: 2022. Total data: 89 Method: KMeans Software: Mathematica Measurements: • CalinskiHarabasz: 460 • DaviesBouldin: 0.4497 • Dunn: 0.14 • RSquared: 0.75 • Silhouette: 0.6472
Dimension	48	20	14	7	
Mean	92.52	68.04	48.54	18.17	
St. Dev	5.84	5.88	6.96	4.39	
Median	94.24	66.25	49.94	16.99	
Max	99.98	77.39	57.21	25,41	
Min	80.57	60.14	36.3	12.9	

Composition:
C1: {Albania, Armenia, Bosnia and Herzegovina, Georgia, Malaysia, Moldova, Mongolia, Sri Lanka, Uzbekistan, Zimbabwe, Australia, Austria, Belgium, Bulgaria, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Hong Kong SAR, China, Hungary, Iceland, Ireland, Israel, Italy, Korea, Rep., Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Romania, Russian Federation, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States}
C2: {Bolivia, Brazil, Colombia, Dominican Republic, Iran, Islamic Rep., Jamaica, Kenya, Mauritius, Nigeria, NorthMacedonia, Peru, Philippines, Serbia, South Africa, West Bank and Gaza, Greece, Panama, Portugal, Saudi Arabia, Uruguay}
C3: {Bangladesh, Costa Rica, Ecuador, El Salvador, Ghana, Honduras, India, Indonesia, Lao PDR, Paraguay, Thailand, Togo, Tunisia, Turkiye}
C4: {Afghanistan, Benin, Burkina Faso, Cote d'Ivoire, Mali, Senegal, Tanzania}

Data source: https://databank.worldbank.org/source/world-development-indicators#; 2022 ((Educational attainment, at least completed lower secondary, population 25+, total (%) (cumulative)

Table 8
Clusters analysis: account ownership.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Year: 2021. Total data: 89 Method: KMeans Software: Mathematica Measurements: • CalinskiHarabasz: 448 • DaviesBouldin: 0.4535 • Dunn: 0.044 • RSquared: 0.77 • Silhouette: 0.6510
Dimension	47	16	19	7	
Mean	95.29	73.35	51.23	32.47	
St. Dev	4.67	6.21	5.17	10.15	
Median	96.62	73.7	51.37	36.11	
Max	100	84.04	59.75	37.85	
Min	85.29	64.18	43.5	9.65	

Composition:
C1: {Iran, Islamic Rep., Malaysia, Mauritius, Mongolia, North Macedonia, Serbia, South Africa, Sri Lanka, Thailand, Australia, Austria, Belgium, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, China, Hungary, Iceland, Ireland, Israel, Italy, Korea, Rep., Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Russian Federation, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States}
C2: {Bolivia, Bosnia and Herzegovina, Brazil, Costa Rica, Ecuador, Georgia, Ghana, India, Jamaica, Kenya, Moldova, Turkiye, Bulgaria, Romania, Saudi Arabia, Uruguay}
C3: {Albania, Armenia, Bangladesh, Benin, Colombia, Cote d'Ivoire, Dominican Republic, Indonesia, Mali, Nigeria, Paraguay, Peru, Philippines, Senegal, Tanzania, Togo, Uzbekistan, Zimbabwe, Panama}
C4: {Afghanistan, Burkina Faso, El Salvador, Honduras, Lao PDR, Tunisia, West Bank and Gaza}

Data source: https://databank.worldbank.org/source/world-development-indicators#; 2021.
(Account ownership at a financial institution or with a mobile-money-service provider, older adults (% of population ages 25+).

Similarly, the *Inaugural Report of the Inter-agency Task Force on Financing for Development* [79] focuses on the need for improving derivatives regulation, mainly their OTC transactions, and incorporates the commitments of the Addis Ababa Agenda [9] that stress the need to limit the excess volatility of commodity prices.

Table 9
Clusters analysis: accounts and education intersection.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Years: 2021 (accounts); 2022 (education). Total data: 89 Method: Automatic Software: Mathematica Measurements: • CalinskiHarabasz: 101 • DaviesBouldin: 0.74 • Dunn: 0.084 • RSquared: 0.54 • Silhouette: 0.50
Dimension	53	24	11	1	
Mean	{93/88}	{59/67}	{44/28}	{10/15}	
St. Dev	{8/11}	{12/15	{7/12}	0	
Median	{95/92}	{59/62}	43/25	{10/15}	
Units in percentages					

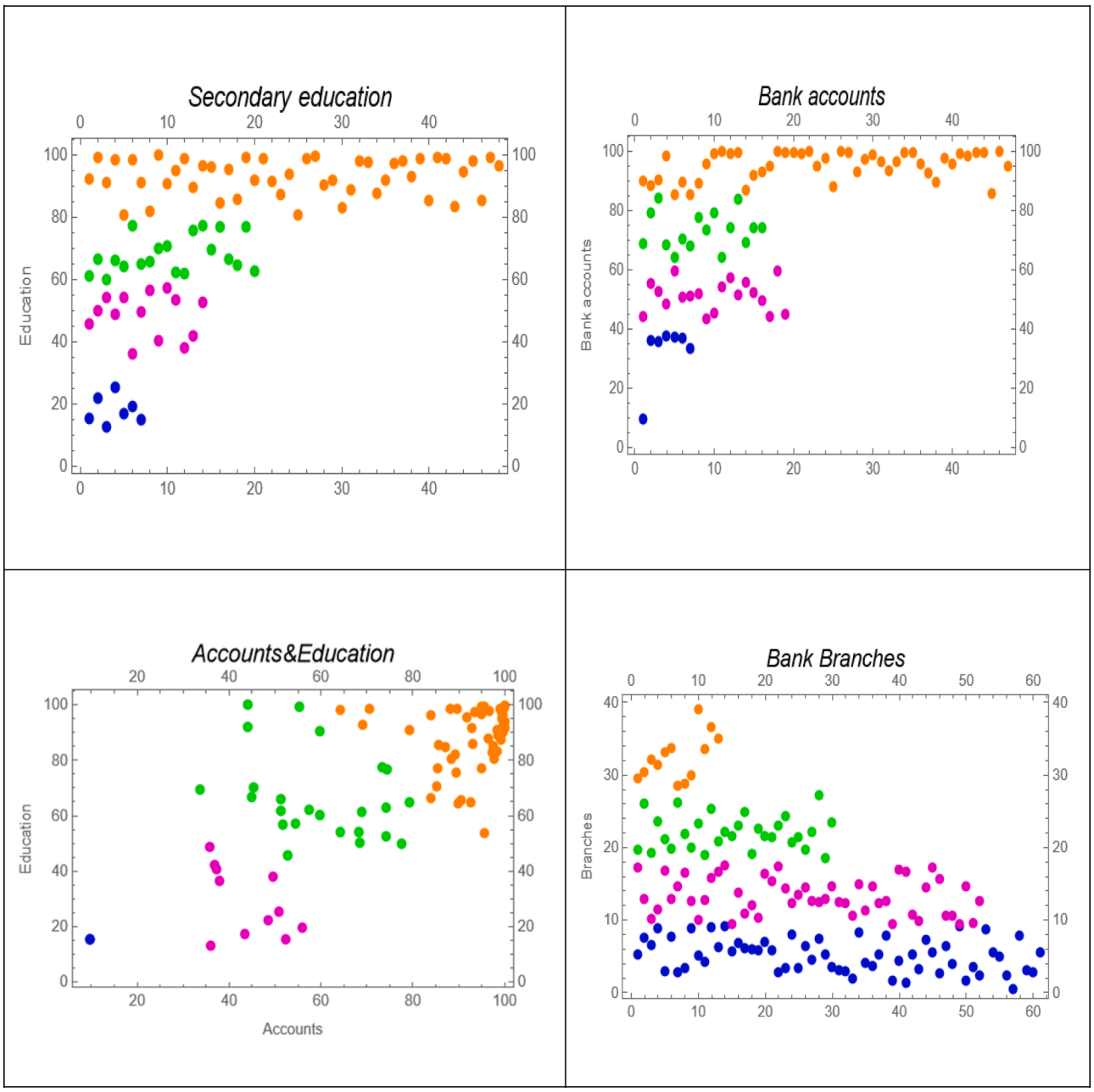
Composition:
C1: {Bosnia and Herzegovina, Brazil, Georgia, Iran, Islamic Rep., Malaysia, Mauritius, Moldova, Mongolia, North Macedonia, Serbia, South Africa, Sri Lanka, Thailand, Australia, Austria, Belgium, Bulgaria, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR, China, Hungary, Iceland, Ireland, Israel, Italy, Korea, Rep., Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States}
C2:{Albania, Armenia, Bangladesh, Bolivia, Colombia, Costa Rica, Dominican Republic, Ecuador, Ghana,India,Indonesia, Jamaica, Kenya, Nigeria, Paraguay, Peru, Philippines, Turkiye, Uzbekistan, West Bank and Gaza, Zimbabwe, Panama, Saudi Arabia, Uruguay}
C3: {Benin, Burkina Faso, Cote d'Ivoire, El Salvador, Honduras, Lao PDR, Mali, Senegal, Tanzania, Togo, Tunisia}
C4: Afghanistan

Table 10
Clusters analysis: bank branches.

Bank branches	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Year: 2022. Total data: 156 Method: KMeans Software: Mathematica Measurements: • CalinskiHarabasz: 626 • DaviesBouldin: 0.4799 • Dunn: 0.023 • RSquared: 0.7189 • Silhouette: 0.5865
Dimension	13	30	52	61	
Mean	32.41	22.08	13	5.09	
St. Dev	3.15	2.32	2.49	2.28	
Median	32.15	21.73	12.81	5.18	
Max	39	27.20	17.54	9.19	
Min	28.40	18.5	9.35	0.39	
Units in number of bank branches per 100,000 adults					

Composition:
C1: {Bosnia and Herzegovina, Cabo Verde, France, Georgia, Italy, Japan, Marshall Islands, Moldova, Portugal, Seychelles, Spain, St. Kitts and Nevis, Switzerland}
C2: {Antigua and Barbuda, Armenia, Australia, Bahamas, The, Belgium, Canada, Croatia, Cyprus, Grenada, Guatemala, Hong Kong SAR, China, Iceland, Lebanon, Malta, Morocco, Nepal, North Macedonia, Panama, Poland, Romania, Russian Federation, Samoa, Serbia, Slovak Republic, Slovenia, St. Vincent and the Grenadines, Tunisia, United States, Euro area, North America}
C3: {Albania, Argentina, Aruba, Austria, Bahrain, Barbados, Belize, Brazil, Cambodia, Chile, Colombia, Costa Rica, Czechia, Denmark, Djibouti, Dominica, Dominican Republic, Ethiopia, Fiji, Greece, Honduras, Hungary, India, Indonesia, Ireland, Israel, Jordan, Kazakhstan, Korea, Rep., Kosovo, Kuwait, Libya, Lithuania, Maldives,Mauritania, Mauritius, Mexico, Micronesia, Fed. Sts., Namibia, New Zealand, Oman, Pakistan, Paraguay, Sao Tome and Principe, Sri Lanka, St. Lucia, Suriname, Sweden, Trinidad and Tobago, Turkiye, Uruguay, West Bank and Gaza}
C4: {Algeria, Angola, Azerbaijan, Bangladesh, Benin, Botswana, Burkina Faso, Burundi, China, Comoros, Cote d'Ivoire, Ecuador, Egypt, Arab Rep., El Salvador, Equatorial Guinea, Estonia, Eswatini, Finland, Gambia, The, Germany, Ghana, Guinea, Guinea-Bissau, Guyana, Iraq, Jamaica, Kenya, Kyrgyz Republic, Latvia, Lesotho, Liberia, Madagascar, Malawi, Malaysia, Mali, Mozambique, Netherlands, Nicaragua, Niger, Nigeria, Papua New Guinea, Peru, Rwanda, Saudi Arabia, Senegal, Sierra Leone, Singapore, Solomon Islands, South Africa, South Sudan, Tajikistan, Tanzania, Thailand, Timor-Leste, Togo, Uganda, Ukraine, United Arab Emirates, Viet Nam, Zambia, Zimbabwe

Data source: https://databank.worldbank.org/source/world-development-indicators#; 2022.
(Commercial bank branches per 100,000 adults).



Conceptual Map 3. Plot 1: Clusters Illustration.
Source: Authors' design

The year 2020 registered relevant acknowledgements of the success of implemented regulatory rules. The 2020 Finance for Sustainable Development Report Agenda [80] summarises the significant advances in derivatives regulation achieved through the SDGs implementation process. This report states: "Derivatives markets have been another focus of regulators. The markets are now simpler and more transparent, although further progress since 2018 has been limited" (p. 142). In addition, the Market Risk Advisory Committee of the US Commodity Futures Trading Commission (CFTC) report on *Managing Climate Change Risk in the US Financial System* [81] considers futures trading as part of the solution (p. vi) of the climate challenge. Paralleling this evaluation, UNCTAD's *World Investment Report 2021* [82] states that, in the face of the sustainability challenge, derivatives "can be an important part of the overall solution" (p. 233). At the same time, this report stresses the need for more work studying the potential derivatives' contributions to sustainability (p. 232).

4.1.2. *The financial inclusion challenge*

According to reviewed institutional reports, derivatives markets have responded well to the supply and regulatory challenges. The diverse contract sizes and settlement facilities have made access to derivatives easier, provided there is financial inclusion. However, from the context perspective, there is a significant difference between speculation and hedging. Financial investors are free to decide whether to enter into speculative operations and, in addition, may diversify them. In contrast, for producers, it is essential to hedge the volatility that markets may bring to the prices of their products and, thus, to the stability of their incomes. The same applies to the inputs of their production processes. Let us take the point of view of a farmer. When he embarks on a crop, the farmer faces market volatility in the positions of being long on his expected output and short on his expected costs. Thus, this farmer becomes an unintentional speculator. The higher the market volatility, the riskier his unintentional speculative position. Medium and small producers

often fall into the categories of weak active or even passive agents, depending on their links with the financial system. Thus, the financial inclusion challenge is of the utmost importance to them. This challenge reaches its peak in developing economies, where weak financial systems and weak financial literacy create barriers to accessing hedging facilities through derivatives. Because of its importance, Section 4.2 centres on this issue from the hedging perspective. Previously, Table 11 summarises the context challenges relating them to the SDGs targets.

4.2. *The financial inclusion challenge in developing economies: the hedging perspective*

The relationship between derivatives and commodities' volatility, examined in Section 3.2, has been addressed from the speculation perspective in exploring the impacts of derivatives trading in developing economies. Section 3.3 has focused on financial inclusion. However, the actual and potential role of derivatives in these countries also has a crucial hedging side that is closely related to the SDGs. The current section extends the financial inclusion challenge to developing economies from the hedging perspective, centring on the institutional channels and actions. Its study must depart from the shared financial features of developing economies that frame risk management in them. Bahgat [83] emphasises that introducing derivatives in developing countries should be accompanied by intermediation and risk control measures to mitigate the risks associated with derivatives trading.

The standard financial features of developing economies interweave governments with high debt burdens and low tax collecting capacity, weak financial systems, weak regulation, low financial inclusion and literacy, volatile currencies, and high inflation and interest rates. The *Sustainable Development Goals Report 2024* [84] qualifies access to financial services as a goal on track and regards debt sustainability as a goal in regression. This adverse setting makes developing economies highly sensitive to natural disasters, economic crises, and financial bubbles. At the same time, it embeds a strong need for accessing hedging tools to mitigate the financial impacts of those risks. Weak financial systems systematically generate weak financial inclusion, leading to poor risk management opportunities. Furthermore, if the education system also suffers from weaknesses, both the financial and the education systems generate a negative synergy that jeopardises the possibility of successful risk management from the public and the private sectors. However, suitable assistance may mitigate these weaknesses and turn derivatives into outstanding support for the developing economies' progress towards the SDGs through three main lines: becoming economic policy instruments, hedging local production, and providing opportunities to participate in global commodity markets.

4.2.1. *Derivatives as economic policy instruments*

Being unable to face hazards through their usual financial sources, governments become potential demanders of hedging tools. As Freeman [85] points out, the financially weak governments of developing countries switch from the generally assumed risk neutrality of solvent governments [86] to risk aversion, namely to the necessary condition to contract hedging and insurance instruments. Their demand for hedging concentrates on natural disasters on public infrastructures, their impact on low-income citizens who cannot afford insurance, the mitigation of the economic crises in the domestic economy, and the impact of

Table 11
SDGs and context challenges.

REGULATION		**SDG 1: 1.4** By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.	⇨	FINANCIAL INCLUSION
	⇦	**SDG2: 2.c** Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility	⇨	
		SDG 4: 4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy.	⇨	
		SDG 5: 5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws.	⇨	
		SDG 8: 8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.	⇨	
		SDG 9: 9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.	⇨	
	⇦	**SDG 10: 10.5** Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations.		
	⇦	**SDG 17: 17.1-17.5** International financial support to developing countries.		

Source: Authors' design.

currency and interest rate volatilities in the country's debt.

The derivatives supply, reviewed in Section 3.1, shows an ample availability of instruments to satisfy this demand. However, the governments of developing countries do not have straightforward access to derivatives markets because of their low proficiency in derivatives trading, which is accompanied by weak solvency in most cases. To compensate for this gap, the World Bank Group (WBG) incorporates financial risk intermediation and technical risk management advice into its mission of ending extreme poverty and boosting shared prosperity. To this end, the International Bank for Reconstruction and Development (IBRD) facilitates risk management through derivatives to middle-income and poor creditworthy countries by acting as an intermediary between its clients (governments and sub-sovereign entities such as local governments and state-owned enterprises) and the markets. Disaster risk management is central in this line, mainly through catastrophe bonds that embed options for disaster impact mitigation. Bennett and Smyth [87] point out the main barriers that prevent governments from entering the catastrophe bond markets: weak knowledge of the products, difficulties in evaluating the risk exposure, discomfort of government officials in dealing with these products, and relatively high transaction costs. Swaps on currencies, interest rates and commodities are also part of IBRD hedging intermediation. The role of these swaps is to mitigate the exposure of the government's debt to interest rates, currency volatility, and commodities price changes in the countries whose income is closely linked to some commodities as exporters or importers. Paralleling the IBRD, the International Development Association (IDA) deals with the poorest countries by assuming, when necessary, losses in its operations due to the weak solvency of its clients. Besides, the Gesellschaft für Internationale Zusammenarbeit (GIZ), on behalf of the German Federal Ministry for Economic Cooperation and Development, undertakes programs on comprehensive risk management centred on disasters and climate change risk primarily, such as the Roadmap for Integrated Climate Risk Management in Ghana [88].

4.2.2. *Hedging local production*

Regarding the private sector, its hedging needs are similar to those of developed countries. For similar financial positions, equal risks call for equal hedging, while the same risk on a weaker financial position calls for stronger hedging. However, the difficulties preventing SMEs and small producers of developing countries from accessing derivatives markets and managing their products are obvious. The WBG has created channels to facilitate private hedging in developing economies through the International Finance Corporation (IFC) and the Global Index Insurance Facility (GIIF) program. Some private initiatives also have adopted this line.

However, hedging is not constrained to derivatives trading exclusively. Instead, risk-sharing is rooted in the farming culture in most developing economies. The knowledge of these traditional hedging tools becomes valuable information about the risk management needs of the farmers who use them. It points out the challenge of how the financial system can use derivatives to design products focused on satisfying this demand. In addition, risk literacy programs may rely on existing practices to relate their contents with the risk vision of the economic agents they train. Bhattamishra and Barnett [89] present a broad panorama of risk management-sharing practices in developing economies. Cervantes-Godoy et al. [90] underline the use of informal mechanisms and community strategies for risk management in developing countries, signalling, at the same time, that futures contracts are not widely available in them. Focusing on agriculture, contract farming is very similar to forward contracts and the oldest form of risk hedging. Abebe et al. [91] study its configuration, while Bellemare et al. [92] identify this hedging instrument as practically the unique partial risk insurance in their sample of 1200 households in Madagascar.

IFC focuses on project finance and facilitating access to finance for individuals and micro, small, and medium enterprises. Financial institutions, mainly banks, are the channels of this access, but private companies also have direct access to IFC facilities. On risk management, the IFC acts as a counterpart for currency, commodities, and interest rate swaps. Besides, the IFC promotes local currency financing by acting again as a counterpart in currency swaps between highly rated international banks and national banks. Similarly, the African Development Bank undertakes an intermediary role in swaps linked with loans.

Index insurance occupies a relevant position in developing economies' risk management. The GIIF program supports the design and implementation of index insurance to hedge extreme weather and other natural disasters in developing countries, benefiting small farmers needing risk management assistance. Local insurance companies function as intermediaries. Furthermore, GIIF supports finance literacy programs which emphasise basic risk management associated with index insurance. Complementing this perspective, the UNCTAD [93] review on commodities risk management in developing countries recommends diversification and evaluating the costs and benefits of hedging strategies in the case of each commodity. On the private side of supporting hedging in developing countries, we find, among others, the Currency Exchange Fund (TCX), centred on currency risk. The TCX fund actions rely on three pillars: De-risking development finance, private sector mobilisation, and increasing awareness and understanding of currency risk [94]. The banks of the Global Alliance for Banking on Values (GABV) assume shared value, as defined by Porter and Kramer [33], among their goals [95]. Central for them is facilitating SME financing in developing countries, including microfinance. Several GABV banks include derivates in their portfolio of products, as many other banks outside this association do. These valuable initiatives confirm weak financial systems as the real barrier to tailored SMEs' hedging in developing economies.

Hedging production also requires an appropriate trading infrastructure. As Petry [96] has noted organised financial markets strongly tend to concentrate on a limited number of global exchange groups that dominate the complex infrastructure required by competitive trading. However, national derivatives markets embed a remarkable potential in hedging local production, especially regarding emerging economies. The United Nations Conference on Trade and Development ([93], p. 8) praises their importance. Atilgan et al. [97] present a literature review on how derivatives markets can influence emerging economies, confirming the relevance of price discovery, risk management, and increased market efficiency. Tsetsekos and Varangis [98] study the conditions for establishing derivatives exchanges in emerging economies thoroughly, underscoring the need for a solid microstructure in trading and clearing processes, and a careful choice of underlying assets and contracts' design. Comparing local markets with global markets, these authors point out the avoidance of currency risk and the higher correlation between the derivatives and cash markets as two central advantages of domestic markets. In contrast, they face the challenge of reaching a minimum trading volume that makes them feasible.

4.3. *Providing opportunities to participate in global commodity markets*

Beyond hedging local production, derivatives trading fosters the developing economies' access to globalised commodity markets. Focusing on the Small Islands Developing States, Angelucci and Conforti [99] explain the importance of enhancing risk management to improve value chains. In this line, the Future of Food Report ([100], p.17) recommends facilitating the access of farms and agribusinesses to risk management instruments to improve their financing conditions. In more general terms, switching from landlocked to open economies integrated into regional and global value chains has contributed to reducing poverty (SDG 1), increasing economic growth (SDG 8), and reducing inequality among countries (SDG 10). The 2020 World Development Report states that "productivity and incomes rose in countries that became integral to GVCs—Bangladesh, China, and Vietnam, among others. The steepest declines in poverty occurred in precisely those countries" ([101], p. 1.). In this line, the UNCTAD "Shaping the futures"

report stresses the importance of integrating developing economies into global value chains. However, it demands structural transformations that prevent these economies from becoming centred on low-value activities ([102] p. 17), also signalled in the 2020 and 2025 World Development Reports. The Aid for Trade initiative of the OECD and World Trade Organisation supports diversification initiatives in developing countries.

The derivatives trading smooths the developing economies' access to globalised markets in two ways. First, through the hedging operations that mitigate the risk of imports and exports. Second, through the benchmarking prices generated by trading and published by organised derivatives markets. Baffes and Nagle ([63], p. 82) analyse the development of price benchmarking in commodity markets. As these authors point out, price benchmarking "assists in the efficient allocation of resources and the reduction of markets risks for producers and consumers alike". Relating price benchmarking to the price discovery function mentioned in Section 3.2, price benchmarking becomes the outcome of price discovery once organised markets structure this function.

The control of currency risk is central to developing economies' financing and incorporation into value chains. However, many currencies of developing economies do not qualify as underlying assets of future contracts because of the very low liquidity these contracts would have. In these cases, the forward FX contracts that the banking system could provide are often unavailable or limited. Thus, most developing economies need additional support to manage exchange risk. Assuming this purpose and as stated in the *Theme Report on Finance and Investment* on SDG 7 (103, p.44), the TCX fund works in line with the SDGs by creating derivatives instruments, specifically forward contracts and cross-currency swaps, for hedging the currency risk of developing countries when no commercial alternatives are available [94]. In this way, it facilitates currency risk-free international investments in these countries. In its 2022 Impact Report ([94], p. 26), the TCX fund states that "TCX believes in the long-term benefits of creating currency risk markets where currency risk is efficiently managed and with significant private sector mobilisation". The EU Aid for Trade program also provides hedging support for developing countries [104]. Table 12 synthesises significant case studies and actions in using derivatives to hedge financial risk in developing countries.

Table 12
Significant case studies and actions in using derivatives to hedge financial risk in developing countries: synthesis.

World Bank Group				
Country	*Year*	*Risk*	*Derivative*	*Main function*
Commodity risk management				
Malawi	2008/9	Weather (drought)	Put option	Mitigate impact of fiscal budget and the whole economy
Uruguay	2014/15	Weather and oil price	Insurance	
Uruguay	2016/2020	Oil price	Asian Call option	
Tunisia	2016	Oil price	Call option	
Catastrophe risk management				
Mexico, Costa Rica, Kenya, Philippines and other countries	Several years	Disaster risk	Cat bonds	Cover earthquakes and hurricanes risk
Interest rate and currency risk management				
Morocco	2012	Currency (USD/EUR)	Swap	External debt
Angola, Colombia, Philippines,Sri-Lanka	2019/22	Interest rate risk	Swap	Reduce the floating rate exposure. Hedge the LIBOR transition uncertainty. Improve
Indonesia		Currency and interest rate risk.	Swap	Convert USD loans to EUR and JPY diversifying the currency composition of its IRBD loan portfolio.
Turkey	2008/10	Currency risk	Swap	Protect a state-owned bank from currency depreciation
TCX Fund: Currency risk				
Actions in different hedging markets (TCX Impact Report 2023)				
Examples		Hedging market		TCX main function
India, Brazil, Indonesia		Developed and liquid		Extending full onshore hedging availability
Vietnam, Kenya, Dominic Republic		Limited		Extending limited offshore hedging availability
Iraq, Madagascar, Papua New Guinea		No market for hedging		Creating a hedging market
TCX Survey for Public Development Banks (PDBs) on "How currency depreciations/risk impact PDB's ability to reach SDG (Sustainable Development Goals) and to be sustainably resilient" [105]				
Currency hedging products available in the local financial market				56 % variety of hedging products, 20 % limited selection available, 20 % no hedging products available.
Currency risk management				54 % PDBshave in-house experts, 21 % basic knowledge, 13 % consults external experts, 13 % no assistance for currency risk management.

5. Discussion

On the one hand, the existence and progress of derivatives markets have constituted a landmark for risk trading. On the other hand, any endeavour towards the SDGs requires identifying and managing the risks it faces. Therefore, the interaction between risk trading and risk management frames the relationship between derivatives and the SDGs. This interaction becomes synergy-creating when it relies on a twofold efficiency: combining efficient risk markets with efficient risk management.

This paper has mainly focused on how derivatives may contribute to the SDGs. However, the SDGs have also been a value-creating driver for the derivatives industry. Section 3.1 has examined the derivatives supply through the lenses of the SDGs. The success of this supply would not have been possible without the shared awareness of sustainability risks in which the SDGs have had a central role. On the trading side, global exchange groups have created powerful and efficient infrastructures. However, local derivatives markets, who also have an important role in improving hedging in emerging economies, face the challenge to overcome the minimum size barrier to consolidate themselves as sound competitive institutions.

The reviewed literature suggests more robust evidence supporting price discovery rather than price distortion in the interactions between derivatives and commodity markets. However, theoretical analyses have identified potential scenarios that could lead to spikes in volatility and bubbles. To this extent, the implemented regulatory rules have avoided uncontrolled volatility distortions successfully. The derivatives market

Table 12 illustrates relevant courses of action from the WBG and TCX fund aimed at hedging financial risk in developing countries by using derivatives. The top part of the table synthesises case studies detailed in the WBG web page. Its bottom part centres on TCX fund support to currency risk management, one of whose main actions is promoting the development of hedging markets. The three bottom rows include two relevant pieces of information from the TCX Survey for Public Development Banks reporting the availability of hedging products and managers.
Source: authors' design.

has also incorporated contracts for managing most sustainability risks commendably. Therefore, our review points out this significant connection between derivatives markets and the SDGs based on the available risk trading instruments and market efficiency.

The speculation and hedging functions of risk trading constitute the main links between derivatives and the SDGs. Fair and informed speculation ensures efficient derivatives markets and leads to efficient price discovery, which, in turn, contributes to the efficiency of real markets. However, the real side of the economy goes beyond price efficiency by requiring efficient risk management. Thus, it demands managers and consultants capable of designing and applying well-structured risk management strategies, where hedging is essential. Relevant in this respect is the fact that hedging usually involves longer horizons and a substantially less flexible products' choice than speculation.

As known, hedging and insurance are rooted in the risk aversion of economic agents, particularly when they face hazards that can put their solvency at stake. Governments and small producers of developing countries often face scenarios that claim for hedging. That is the crucial link between hedging and SDGs.

The growth of derivatives' supply and markets has boosted the range of hedging possibilities, although they are limited to the agents who can manage and access them. Derivatives' management requires mastering their trading rules, contracts' features, valuation, and sensitivity to their value drivers. Thus, specialised knowledge is a prerequisite for dealing with derivatives in depth. Even a basic acquaintance with derivatives is necessary for implementing hedging strategies under external supervision. Regarding this setting, financial literacy at the risk management level constitutes a barrier that weak economies must cross to implement efficient risk management. The clusters' illustration in this paper visually underlines that the weakest developing economies fall on very low positions regarding the potential of their population to access financial literacy and inclusion. The actions from the WBG and other internationally focused institutions, as the TCX fund, are key to progress towards the systematic application of derivatives as a tool to foster economic development through three main lines: their use as economic policy instruments to hedge governments' financial risk, their capacity for hedging local products, and their potential to foster the incorporation of developing economies to global value chains.

Beyond derivatives exchanges, the whole financial system, banking in particular, embeds the capacity to make risk management accessible to the generality of economic agents. Banks, as the most advanced do, may act as financial risk intermediaries by designing tailored forward and swaps contracts for their customers and counterbalancing the remaining open interest by taking positions in derivatives exchanges. However, only a well-grounded banking system, unavailable in weak economies, can perform this function. The Secretary-General of the United Nations foreword to the *Sustainable Development Goals Report 2024* underlines the need for reforming the outdated, dysfunctional and unfair financial architecture to facilitate far greater investment in the SDGs ([84], p. 2).

Summarising, although derivatives and their regulation furnish the capacity for efficient risk trading, progressing in financial literacy and strengthening the financial system of developing countries are key requisites to guarantee efficient risk management.

6. Conclusions

At the inception of the SDGs, the main concern regarding derivatives was their potential contribution to volatility peaks in commodity markets. Nine years later, evidence shows that regulation has controlled this effect. This evolution has placed the centre of attention in the interest of derivatives as risk management tools. Risk management occupies a central place in the progress towards the SDGs, and although risk management strategies go beyond hedging techniques, hedging through derivatives is an essential part of them. This paper has focused on identifying the synergies and contradictions between derivatives and the SDGs and the challenges that stem from their interaction. The derivatives' speculation side brings price discovery as synergy, while the seed for generating volatility peaks embedded in speculation constitutes a notorious contradiction. Hedging becomes the most relevant synergy, but at the same time, its costly and complex access becomes a contradiction for weak economies. In this analysis, the hedging contributions to the SDGs cannot be limited to their microeconomic applications. Instead, its role in mitigating governments' risk and fostering the access of developing economies to global value chains is most important. Financial inclusion and financial literacy contribute to explain how derivatives increase the financial gap between developed and developing economies, although, at the same time, they stimulate the design and implementation of actions to mitigate this gap, as shown in Section 4.2. The evidence of contradictions leads to unveiling the challenges that arise. We have classified them as the supply challenge to hedge all remarkable risks, and the context challenge to trade derivatives in efficient and accessible markets. The context challenge includes the regulatory and financial inclusion challenges. Outstanding progress has marked the evolution of the former, while financial inclusion remains a hindrance in the path towards the SDGs. Further research may focus on the derivatives potential to facilitate the incorporation of SMEs to global markets by mitigating the risk of these international operations. A complementary line would be studying how to foster the private financial industry interest to design hedging products for developing economies. Another research line would focus on how to disseminate financial literacy on risk management through social webs.

All in all, derivatives have dramatically broadened the risk management gap between developed and developing countries. Two courses of action are crucial to narrow this gap: Advancing financial literacy by including risk management and basic derivatives knowledge in it and fortifying the financial system so that banks in developing countries provide risk management products and advice to all economic agents, including small producers. This strengthening of the financial system will provide a more secure and confident future for risk management. The integrative thinking approach mentioned in the introduction is the cornerstone of dealing with these challenges.

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CRediT authorship contribution statement

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Declaration of competing interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Data availability

Data will be made available on request.

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