Journal of International Financial Trends
Vol. 1 (2025), No. 1, pp. 01-17
DOI: https://doi.org/10.55578/jift.2504.001

ARTICLE

Systemic Risks of Sophisticated Financial Products: A Critical Review of Post-2008 Innovations and the Impacts on Global Markets

Natália Teixeira[1,*]

[1] *ISG-Business & Economics School, 1500-552 Lisbon, Portugal*

[*]Corresponding author. Email: natalia.teixeira@isg.pt

Received: 13 April 2025, Accepted: 21 April 2025, Published: 28 April 2025

Abstract

This article provides a critical review of systemic risks arising from post-2008 financial innovation, with a focus on sophisticated instruments such as structured products, crypto derivatives and decentralised finance (DeFi). Drawing on recent theoretical developments and empirical insights, the study investigates how these products amplify market instability through leverage, interconnectivity and algorithmic reflexivity. The analysis criticises traditional regulatory frameworks, highlighting their limitations in addressing emerging risks and proposing a shift towards functional, risk-based governance. By consolidating fragmented academic and regulatory perspectives, the article offers a comprehensive conceptual synthesis of how modern financial engineering contributes to systemic vulnerabilities. It also identifies regulatory gaps, in areas such as programmable finance and synthetic tokenisation, that challenge current supervisory mechanisms. This analysis is intended to serve as a reference point for policymakers, researchers and financial institutions in the ongoing effort to mitigate systemic threats in increasingly digital and decentralised financial systems.

Keywords: Financial Innovation; Systemic Risk; Sophisticated Financial Products; Tokenisation; Algorithmic Trading; Decentralised Finance (DeFi); Financial Regulation; Adaptive Markets

1. INTRODUCTION

Financial innovation has transformed markets. This shift has been driven by globalisation, liberalised capital flows, technological advances, and regulatory change. Instruments like credit derivatives, structured products, and ETFs have improved capital allocation [1]. However, they also introduced hidden risks and complex interdependencies [2-5]. Complex derivatives, structured notes, leveraged funds and, more recently, digital assets and Decentralised Finance (DeFi) instruments have emerged as high-yield alternatives, but also with often opaque structures [6-8]. Although these innovations aim to improve market efficiency and financial access, they also introduce new forms of systemic risk [9-13].

The aim of this article is to provide a critical review of the literature on the systemic risks associated with sophisticated financial products since 2008, with an emphasis on transformations after 2020. Both traditional financial structures (such as leveraged ETFs and CDS) and recent innovations such as crypto derivatives, synthetic on-chain products and structured tokens will be addressed. This analysis aims to answer two central questions:

- *How do these products contribute to global financial instability?*
- *What regulatory and methodological measures can be applied to mitigate their adverse effects?*

The approach adopted is qualitative and comparative, bringing together empirical and theoretical evidence from different jurisdictions and historical moments. This review was conducted based on scientific literature, regulatory documents and technical reports published between 2010 and 2025, with an emphasis on studies produced after 2018 on emerging financial risks, DeFi, structured products and regulatory innovation. The sources were selected for their thematic relevance and impact on the fields

https://doi.org/10.55578/jift.2504.001

of finance, economics and financial law. This review is relevant because complex, interconnected risks persist despite major post-2008 reforms, often beyond the reach of conventional supervision.

This review adopts a qualitative and comparative methodology based on an interpretative synthesis of academic, regulatory and institutional sources. The selection of literature focused on publications from 2010 to 2025, with an emphasis on the post-2018 period due to the intensification of financial digitalisation. Sources were retrieved from academic databases (SSRN, JSTOR, Scopus), central bank reports and regulatory documents (e.g. BIS, IOSCO, ESMA). A comparative analysis was used to assess financial instruments in three dimensions: complexity, systemic exposure and regulatory gaps. This approach allows for a cross-jurisdictional view and the identification of functional risks in different technological implementations.

2. SOPHISTICATED FINANCIAL PRODUCTS

Complex financial products have developed in tandem with market liberalisation and financial engineering advances. The literature identifies three major waves of sophistication: securitisation in the 2000s [14], customisation through structured notes and leveraged ETFs in the 2010s [15], and algorithmic and token-based innovations in the post-2020 period [16]. Brunnermeier and Pedersen [17] explore how these instruments incorporate hidden leverage, particularly during periods of low volatility, increasing the risk of sudden deleveraging. Allen et al. [18] develop this issue by analysing the complexity embedded in financial derivatives linked to cryptocurrency markets.

Recent studies also highlight how DeFi's opacity contributes to risk shifting. For example, Schär [19] emphasises the ability of smart contracts to be programmed and composed but warns of the spread of risks through interconnected protocols. Doerr et al. [13] and Auer et al. [20] analyse the vulnerabilities of smart contracts and the systemic implications of oracles and dependencies between protocols. However, current literature tends to adopt a micro-prudential perspective, focussing on individual flaws or vulnerabilities at the protocol level. There is still a lack of an integrated view of systemic risk that considers networks, behavioural synchronisation and feedback loops, especially in AI-driven systems [21].

Several products can be highlighted in the most recent period. On the one hand, Collateralised Debt Obligations (CDOs) and Credit Default Swaps (CDS) which, despite being responsible for triggering the 2008 crisis, continue to be used, albeit more closely monitored [22-24]. However, concentration risk remains high in certain corporate credit niches [25,26].

Also structured notes, instruments that combine derivatives and debt and offer returns indexed to volatile assets [27]. However, the lack of liquidity and some opacity in pricing has made them particularly dangerous in financial crises [28-30]. Leveraged ETFs promise multiple returns from underlying indices, but they also amplify losses exponentially [31-34]. As Decker [35] points out, Bitcoin ETFs can generate an implicit leverage of over 3.2x in contagion events.

Finally, DeFi and crypto-derivative products managed on platforms such as Synthetix, Uniswap and dYdX that introduce synthetic and leverage contracts without central intermediation [9,13,16,36]. The lack of regulation, combined with the risk of code bugs, opens space for systemic failures and cascading liquidations [37,38]. Table 1 evaluates the different financial products in terms of complexity, liquidity and potential systemic risk.

Table 1. Classification of Financial Products in Terms of Complexity, Liquidity and Systemic Risk

Financial Products	Technical Complexity	Average Liquidity	Potential Systemic Risk
CDOs	High	Low	High
CDS	High	Average	High
Structured Notes	High	Low	Average
Leveraged ETFs	Average	High	Average
Crypto Derivatives	High	Average	High
Synthetic Tokens (DeFi)	High	High	High
Smart Contracts	Average	High	Average

Source: Adapted from Norman [39] and Aquilina et al.[40].

3. SYSTEMIC RISK MECHANISMS

The existing body of work points to four fundamental mechanisms that underpin systemic fragility in contemporary financial ecosystems. Brunnermeier and Pedersen [17] point out that the leverage implicit in structured products often triggers mass sales under pressure from volatility, generating liquidity spirals2. Jackson and Pernoud [38] apply network theory to show how structural interdependencies spread the risk of default (contagion) across financial nodes.

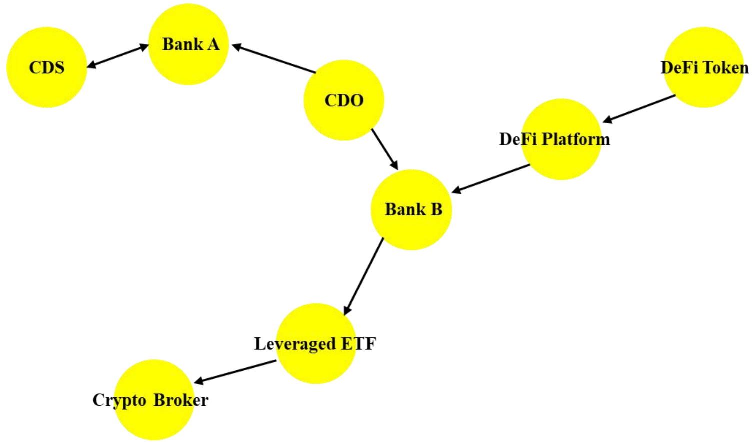
Aramonte et al. [41] show how automated trading creates pro-cyclical market dynamics, especially in feedback-sensitive assets such as leveraged ETFs and synthetic tokens. Finally, Addy et al. [21] and Cohen [15] analyse how algorithmic strategies reinforce volatility by reacting simultaneously to similar signals, forming positive feedback loops. This article organises these aspects under a risk propagation framework, illustrated in Figures 1 and 2 as the layered fragility of digital financial instruments.

The risks associated with these sophisticated products derive from several mechanisms. Firstly, explicit and implicit leverage [42-44]. Jiang [45] emphasises that in contexts of negative shocks, leveraged institutions tend to sell assets to maintain risk limits, which amplifies price movements. Products such as ETFs or crypto lending platforms offer increased returns but make investors vulnerable to forced liquidations and abrupt price movements [1,46,47]. In the case of decentralised finance (DeFi), leverage occurs through loan contracts backed by volatile cryptoassets [48]. When the value of the collateral falls, forced liquidation occurs, triggering further sales referred to by Sydow et al. [49] as endogenous risk amplification. DeMarzo and He [44] point out that the distinction between direct and implicit leverage becomes fundamental in risk modelling. According to Giglio et al. [50], the more complex the asset structure is, the more difficult it is to estimate true risk exposure in stress environments.

Secondly, the increasing interconnectivity of markets and between financial products, institutions and digital platforms creates risk transmission channels that can be latent during normal times and highly active in times of crisis [51-52]. A default on one platform can spread to several others, as observed in the FTX collapse, where derivatives and staking tokens interconnected with lending platforms [53-55]. In this context, Jackson and Pernoud [38] model financial networks as complex systems with central hubs and peripheral links.

In the DeFi universe, this logic is exacerbated: protocols are interconnected through smart contracts and depend on price oracles which, if manipulated, can trigger massive settlement events in multiple protocols simultaneously. Figure 1 shows a network of products and institutions with systemic interconnectivity. CDOs, ETFs and tokens operate as risk transmission vectors for banks, brokers and DeFi platforms. The arrow between Banks A and B represents cross-exposure feedback, a situation that is typical in interbank networks [56]. This type of network, when combined with leverage and a lack of transparency, creates the ideal scenario for endogenous systemic crises. The relationships represented are directional: bankruptcy on one platform can lead to the insolvency of brokers exposed via derivatives, which in turn affect banks with positions in swaps. This is an architecture of hidden fragility.

Figure 1. Theoretical Model of Systemic Contagion in Financial Networks



Source: Own elaboration based on models by Jackson & Pernoud [38].

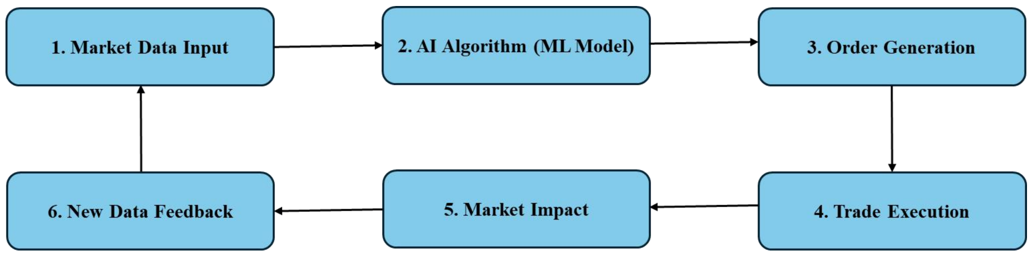
Thirdly, pro-cyclicality which, during shocks, leads investors to try to get rid of structured positions, exacerbating market movements [57-59]. Sophisticated products tend to be more sensitive to market liquidity. As Duarte and Eisenbach [60] point out, during periods of crisis, these products face a sharp drop in buyers, leading to fire sales. Basel III regulation has tried to mitigate these effects by requiring capital buffers, but many non-bank platforms operate outside its scope.

The literature on endogenous liquidity shows that when the required collateral margin rises, investors are forced to sell assets, which reduces liquidity, puts pressure on prices and pushes the margin even higher, as a vicious cycle [61-63] point out that instruments such as leveraged ETFs are particularly exposed to this mechanism, as they carry out daily rebalancing that forces sell or buy operations even in unfavourable contexts, increasing the volatility of the underlying asset. Counterparty risk where the absence of centralised clearing on DeFi platforms implies that contracts are settled directly between peers, often with unstable collateral [64-68].

Finally, with the digitalisation of the markets, trading algorithms have come to dominate short-term operations. Platforms such as quantitative hedge funds, market-making bots and trading systems based on machine learning make decisions based on historical patterns and short-term signals [69-72]. On the other hand, there is the fundamental issue of information asymmetry and opacity in the markets, with structured products being sold with technical language and low transparency, making it difficult for ordinary investors to assess risk [73-78].

Figure 2 illustrates this mechanism. Market data feeds decision algorithms based on machine learning, which generate orders automatically. These orders impact the market, producing new data that is captured by the same algorithms - creating a feedback loop. This process, defined by Lussange et al. [79] as algorithmic reflexivity, can generate instability, especially when several agents use similar strategies, such as momentum trading. Addy et al. [21] argue that AI-based financial systems should be treated as complex adaptive systems. This implies that stability cannot be assumed - it must be monitored dynamically, as small shocks can be amplified non-linearly.

Figure 2. Feedback Loop of Algorithmic Trading Systems



Source: Adapted from Lussange et al. [79] , Addy et al.[21].

4. REGULATION AND GOVERNANCE

Against this backdrop, it is essential to focus on the regulation and continuous monitoring of increasingly innovative and complex financial markets and products. The global regulatory framework, moulded by the lessons of the 2008 financial crisis, has made significant progress in protecting against systemic risks stemming from traditional financial institutions. Laws such as the Dodd-Frank Act in the United States, EMIR and MiFID II in the European Union, and the Basel III standards for international banks have reinforced capital requirements, transparency and leverage control.

However, despite improvements since 2008, regulation remains fragmented [80-82]. Reforms such as Basel III and Dodd-Frank strengthened capital requirements and transparency in the banking and OTC derivatives markets but left out the cryptoasset sector [83,84]. On the other hand, EMIR (EU) and MiCA (2023) seek to mitigate the risk of centralised platforms but still lack specific frameworks for smart contracts and DeFi [85-87].

Finally, the regulation of leveraged ETFs varies widely between the US and Europe, which raises questions about their suitability for retail investors less skilled in assessing financial product risk [88-90]. Thus, regulators designed frameworks before the rise of decentralised platforms or rapid product sophistication. Non-bank financial instruments now operate in regulatory grey zones, making enforcement difficult and fragmenting oversight coherence.

Despite regulatory efforts following the crisis, several authors warn of the functional myopia of financial regulation [91-93]. Maggetti [94] argues that the traditional regulatory system is still centred on institutional categories (banks, brokers, funds), ignoring products and functions that operate outside these boundaries. An example of this is leveraged ETFs, which, being products listed and traded on supervised exchanges, have internal structures that mimic highly risky derivatives strategies. Similarly, DeFi platforms operate through smart contracts that escape the traditional definition of a regulatory body [95,96]. As they have no physical headquarters, identified staff or board of directors, they become unreachable by conventional regulators [97,98].

Financial regulation must evolve towards a model based on functions and risks, rather than legal categories [99-101]. This implies regulating according to what a product does (provide credit, allow leverage, issue currency) regardless of how it is labelled or technologically implemented [102,103,68].

Chiu [104] argues that, when faced with tokens that operate as securities, currencies and/or derivatives, a structure based on systemic risk would be more effective. In this context, platforms that leverage user resources, promise future profitability or process payments at scale should be subject to capital, auditing and transparency requirements, even if they are decentralised [105-107,97,108,109].

The United States of America has adopted an enforcement model centred on the SEC and CFTC, with several lawsuits against platforms such as Ripple, Binance and Coinbase [8]. The European Union, on the other hand, adopted a legislative approach with Markets in Crypto-Assets (MiCA), focused on digital assets, stablecoins and centralised entities [110,111]. China, on the other hand, has adopted a model of exclusion and substitution: it has banned private platforms and encourages the use of state-owned blockchain (BSN), maintaining control over protocols, issuance and tracking [8]. These approaches reflect different views on decentralisation: the US tries to incorporate it via traditional regulation; the EU seeks to integrate it into the existing financial system; and China rejects its autonomy as a principle (Table 2).

Table 2. Comparison of Regulatory Regimes

Jurisdiction	Regulation post-2008	Cryptoassets and DeFi	Leveraged ETFs	Regulatory Challenges
United States of America	Dodd-Frank Act; Volcker Rule	SEC enforcement, commodities vs. securities debates	Permitted with regulatory warnings; FINRA supervises	Conflicting definitions; decentralisation; limited enforcement
European Union	Basel III; EMIR; MiFID II	MiCA (Markets in Crypto-Assets) with a focus on	Stricter restrictions on retail products	Harmonisation between member countries; definition of

		stablecoins and custodians		tokens
China	PBOC oversight; shadow banking regulation	Ban on exchanges; focus on state-owned blockchain (BSN)	High regulation, usually via state-approved channels	Focus on state control, little incentive for open innovation

Source: Alessi et al. [111], Dell'Erba & Ferrarini [110], Meyer et al.[8].

One of the biggest contemporary regulatory challenges lies in the rise of programmable smart contracts [112]. Wang et al. [113] point out that they operate autonomously, performing financial actions based on predetermined conditions, such as interest payments, collateral transfers or position liquidation. Although smart contracts offer efficiency and security (due to the unalterability of the code), they also create risks, such as bugs in the code, dependence on oracles that can lead to manipulation or the lack of an 'emergency button' that makes it difficult to respond to attacks [114-116]. As Allen and Lane [117] argue, autonomous systems need to be designed with built-in governance mechanisms: code updates, independent audits, exposure limits per contract.

Recently, the main regulatory responses have focussed on different approaches. For example, there has been the implementation of innovative solutions under controlled supervision, the regulatory Sandbox, such as those of the FCA in the UK or MAS in Singapore [118-123]. Also, classifications based on systemic risk, focusing on the leverage, concentration and liquidity of products, regardless of the technology used [124-127].

Finally, IOSCO and BIS proposals for global co-operation on DeFi supervised by auditable code and pre-programmed limits have been suggested [128,129]. Bello and Olufemi [130] advocate the creation of an intelligent supervision algorithm capable of monitoring financial networks in real time and identifying risk hotspots based on volume, liquidity concentration and interactions between platforms.

5. FUTURE TRENDS AND PROGRAMMABLE FINANCE

The current scenario points to a convergence between technological innovation and growing risks. The future of finance is increasingly shaped by the convergence of technology, autonomy, and financial engineering [131-133]. Innovation is no longer limited to banks and investment funds, but emerges from decentralised communities, blockchain-based protocols and artificial intelligence platforms [134-136]. This environment gives rise to programmable finance [137].

Jerab [138] states that the emerging financial system is characterised by being adaptive and complex, where multiple agents interact in a non-linear way, with changing rules and continuous feedback. As Lo and Zhang [139] propose, markets are not perfectly efficient, but adaptive and subject to abrupt changes. Managing this system requires innovative tools. Zhu et al. [140] suggest continuous network supervision models. Chaliasos et al. [141] also advocate automated auditing of smart contracts, with formal code verification and programmatic stress testing. Finally, Boudiaf et al. [142] refer to the need to apply exposure limits per protocol, defined by liquidity and interactive complexity metrics. The creation of global technical standards, with interoperability and risk identification standards, is considered essential to avoid enforcement fragmentation and regulatory arbitrage [143-146].

Artificial Intelligence (AI) is used in algorithmic trading, which can cause the automation of decision-making with opaque models to create unpredictable feedback loops [21,147,148, 15,149]. Joshi [131] argues that the incorporation of AI into the financial markets is no longer just a tool for price forecasting but is now acting as an autonomous decision-making agent. Deep learning models are already at work in the automatic rebalancing of ETFs based on technical and sentiment signals, in the creation of portfolios optimised by neural networks or in real-time credit risk assessment based on unstructured big data [150-155]. As proposed by Addy et al. [156], these models act as adaptive financial agents, whose impacts are not fully understood. The presence of multiple automated agents using similar data can create algorithmic races, with rapid, mimetic and often destabilising reactions [157-159].

Asset tokenisation represents the virtualisation of economic rights over real-world elements (real estate, commodities, debt contracts or future income) [159,160]. Baum [161] analyses how the tokenisation of real assets (real estate) with the creation of digitised securities with fragmented liquidity raises questions about fair pricing. Baltais et al. [159] mention that platforms such as Centrifuge, RealT and Brickken already allow the issuance of tokens representing physical assets, transferable on public networks. Synthetic tokenisation, where tokens represent the value of assets without directly owning them, increases the risks of systemic leverage and disconnection between market value and real value [160,161]. Likewise, Serafeim and Yoon [162] point out that ESG structured notes, sold as 'green', are often composed of derivatives with similar risk to pre-2008 products, which raises relevant security issues.

Finally, smart contracts in DeFi are considered vulnerable to attacks, bugs and manipulations, operating without intermediaries, which increases the technical responsibility of users [163,156,9,141,164]. Smart contracts enable the automatic execution of financial functions: payments, maturities, margin calls and even court settlements [165-167].

Xu et al. [167] point out that the fragmentation of traditional financial services into automated micro-components creates a modular, highly efficient but interdependent environment. Allen et al. [18] suggest that this modularisation introduces systemic compatibility risks: if one contract fails, it can disrupt a settlement chain across multiple protocols. Dependence on oracles (external sources of data such as prices, weather or legal events) adds a layer of vulnerability [169-171]. This new trend creates opportunities, such as greater liquidity for illiquid assets and the inclusion of fractional investors, but it also poses new challenges. The legal fragility of ballast contracts, the dependence on off-chain systems to execute guarantees or the asymmetry of information on the quality of the underlying asset are examples of potential problems [172-175,165].

Consolidating the trends discussed in this section makes it possible to identify emerging risks with the potential for systemic amplification, which are not captured by conventional regulatory structures. Table 3 below summarises these risks and presents regulatory proposals consistent with the paradigm of functional risk-based regulation.

Table 3. Emerging Systemic Risks and Regulatory Proposals

Emerging Systemic Risk	Risk Description	Regulatory Proposal
Implicit Leverage on Tokenised Products	Tokens based on volatile collateral generate automatic liquidations, amplifying volatility.	Establishing leverage limits proportional to the value and stability of the collateral.
DeFi Protocol Interdependence	Protocols connected by smart contracts propagate failures between ecosystems.	Mapping of cross-platform networks and preventive auditing of critical dependencies.
Algorithmic Reflexivity in AI Trading	AI models react to the same data, creating high-frequency feedback loops.	Mandatory review of algorithms with regulatory stress testing prior to implementation.
Fictitious Liquidity in Leveraged ETFs	Apparent liquidity is illusory, disappearing in times of stress.	Real-time liquidity indicators and requirement for protection buffers in synthetic ETFs.
Manipulable Price Oracles	Centralised oracles can be manipulated to cause fraudulent liquidations.	Use of multiple decentralised oracles with automatic cross-checking (oracle triangulation).

Source: Adapted form Addy et al. [156], Allen et al. [18] and Brunnermeier et al. [176]

6. CONCLUSIONS AND FUTURE RESEARCH

Sophisticated financial products are both an achievement and a challenge for today's financial system. On the one hand, they bring efficiency, accessibility and customisation. On the other, they carry opacity, contagion risks and systemic amplification effects that are neither well understood nor adequately regulated. While they are vehicles that drive innovation, democratised access and diversification, they are also significant sources of systemic risk. The emergence of digital assets and DeFi structures has exacerbated this complexity by operating in an undefined regulatory space. This study urges a shift towards risk-based regulation focused on leverage and interconnected systems.

This review identifies four main risk drivers: leverage (explicit or implicit), interconnectivity, pro-cyclicality, and algorithmic feedback. It also highlights how recent innovations (such as DeFi, financial AI and tokenisation) introduce new sources of fragility when operating in open, global and automated networks. From a regulatory point of view, it is observed that the model based on institutional categories is becoming obsolete. In its place, a functional and risk-based approach is proposed, which considers the real function performed by assets and contracts, regardless of their legal or technological structure. Future governance must view finance as a digital and dynamic ecosystem, requiring constant monitoring, distributed resilience, and global coordination to prevent unprecedented crises.

This review focuses on conceptual and structural aspects of sophisticated financial products, and does not cover empirical analyses of time series, network simulations or back testing of predictive models. Future research could explore the quantification of systemic risk through dynamic models based on real-time market data, analysis of smart contracts active in public networks, or computer simulations of the propagation of shocks. It is recommended that future research explore the interaction between DeFi platforms and traditional institutions, as well as the impacts of tokenisation on macro-financial stability. For regulators, vigilance must expand beyond the products themselves and consider the underlying technological architectures and their modes of risk propagation.

Funding Statement: This research received no external funding.

Contribution: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft preparation, writing—review and editing, visualization, supervision, project administration, and funding acquisition were all carried out by Natália Teixeira, as the corresponding author. I affirm that I have independently handled all aspects of this research. I have read and agreed to the published version of the manuscript.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflict of Interest Statement: The author declares no conflicts of interest.

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